White Biotechnology

A Roadmap for Efficient Implementation and Economic Success

Project Analysts

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1 Executive Summary

1.1 Background

Over the past decades Egypt made substantial progress in its development from a rural society to a balanced modern state with a lively industrial and public sector. Investments in the industrial sector have been strong and focused on the built-up of industries necessary for the advancement and modernisation of a growing country. Following the Barcelona declaration, Egypt is assisted by the EU under the umbrella of its good neighbourhood policy to facilitate the process of stronger integration into the world economy. This process calls for a proactive approach by Egypt to respond to the increasing competitiveness in many sectors and has to define and implement winning strategies. Egypt disposes of resources such as human and natural ones, location, political and social stability, all of which might allow the further build-up of an industrial sector, considered being a key element in Egypt's macro-economic development. The Industrial Modernisation Program is an initiative of the Government of Egypt to help develop internationally competitiveness of its industry so that it can benefit from new opportunities that follow the liberalisation of trade, exposure to global markets and stronger integration with Europe. The implementation arm of the Industrial Modernisation Program is the Industrial Modernisation Centre (IMC), which has the objective to facilitate the development of the private sector by proposing to the Government investment schemes and adjustments of political-economic framework conditions. One of the core elements of Egypt's industrial development policy is to put more emphasis on biotechnology as it has identified this sector as one of the potential growth areas for the future. A study was commissioned by IMC to explore in more detail the possibilities and potentials for Egypt to develop that sector[1].

1.2 Mandate and Project Objectives

Specifically the main objectives of the study were:

- The assessment of framework conditions relevant for the biotech industry.
- The determination of technology packages of market driven biotechnology and fermentation products for Egyptian investors.
- The setting up of a sector investment program.
- The lineout of a clear development strategy to enhance the competitiveness of the industry with detailed focus on a limited number of technology choices and
- The setting up of action plans to improve the indigenous capabilities of industrial biotech in Egypt.

[1] The project teams wishes to thank the members of the Steering Committee and IMC for the collaboration and support in the different phases of project development. The input of these key players has been invaluable for the understanding of the underlined dynamics of the Egyptian economy and specifically of macro-economic framework conditions, relevant for biotechnology development. The project also wishes to thank Ahmed Rizk, responsible manager in IMC, who critically reviewed the draft reports and gave valuable advice for their amendments. Finally the team is also grateful to members of different organisations and private companies, contacted in the course of the study preparation for their input.

Overall this study work aims at contributing to the strategy formulation of IMC in a global context and at supporting Egypt in setting up a master plan for its move to integrate into the international biotech community.

1.3 Research Methodology applied and Report Structure

In general terms biotechnology is understood as any technological application that uses biological systems, living organisms or derivatives thereof to make or modify products or processes for specific use. This broad definition encompasses biotechnological procedures for pharmaceutical, agricultural (crop protection), analytical and industrial fermentation products. In a start-up workshop in November 2006 together with key IMC staff, it was agreed to concentrate the study on exploring opportunities in industrial fermentation, meeting IMC's objectives to support industry relevant technology development and transfer and attract foreign investments, rather than embarking on R&D driven projects. Supplementary and following special requests from IMC, selected areas from other biotech sectors, that already reached some commercial relevance in Egypt are briefly reviewed as well and appraised in the international context.

Analysing the global fermentation industry and deriving consequences for Egypt's sector strategy has to consider a number of aspects and a seven steps approach, also agreed during the start-up workshop, has been employed:

- Review and appraisal of the global fermentation industries, describing quantitatively and qualitatively global trends such as markets and market dynamics, production technologies, quality criteria of products, value chains, regulations and support policies.
- Assessment of current performance of the Egyptian fermentation industry, describing and characterising key companies active in that sector, identifying factors for success and failure, historic development, relevance of foreign investments, determination of domestic consumption and resources.
- Detailed description of technical requirements and markets of fermentation derived products, highlighting product by product major characteristics.
- Benchmarking of Egypt's conditions to the requirements for setting up suitable productions for each of the appraised products.
- Singling out most promising fermentation products which can be set-up in Egypt at a high probability of success by applying a multi-dimensional decision matrix approach.
- Suggestion of a development strategy describing in detail selected fermentation projects and
- Proposing action plans for translating the suggestions made into implementations.

Following the start-up workshop, interim presentations on the progress of work were given to IMC in February and April 2007, which results were approved by the Steering Committee and key managerial staff of IMC. This final report documents in detail the various analytical steps and the results.

- **In part one of the report** a comprehensive review of all internationally and commercially relevant fermentation derived products is given, highlighting economic, marketing and technical parameters. Such products are then compared with each other in a number of characteristics and ranked according to their current and future attractiveness in international markets and according to the sophistication of setting up such industries and to marketing resulting products. Additionally a global comparison of tech venture policies from successful biotech-economies is discussed.
- **In part two of the report** the macro-economic framework conditions of Egypt are reviewed with respect to biotechnology and the existing landscape of fermentation industry is characterised. Such country-specific findings are benchmarked against the prioritised fermentation products from part one of the study and compared under a SWOT consideration of the egyptian economy and R&D landscape.
- **In part three of the report** the strategy is layed out for the implementation of the recommended biotech products and the necessary incentive structures and legislative measures are detailed further. Parameters and prereqisites for a successful implemenation are analysed in many details. Investment calculations are carried out and implications for the macro-economy of Egypt are highlighted. Detailed action and implementation plans for these projects conclude the main body of this report.
- **In part four** the situation of the veterinary vaccine production and markets in Egypt are reviewed.

1.4 Characteristics of Internationally Important Fermentation Products - Findings of Part I

The global fermentation industry currently operates on about 26 different products which show a combined market value of over € 50 billion.

Summary Overview 1: Fermentation Products of International Relevance and reviewed in the Study

Acetic Acid	Iso-ascorbic Acid
Amylase	Lactic Acid
Ascorbic Acid	L-Lysine
Aspartic Acid	Monosodiumglutamate
Astaxanthin	Poly-hydroy-buturate
Beta-Carotene	Poly-lactic Acid
Cellulase	Protease
Citric Acid	Riboflavin
Curdlan	Threonine
Cyanocobalamin	Tryptophan
Ethanol	Welan
Gelan	Xanthan
Gluconic Acid	Yeast

- **Such products are applied in five different industries.** In food it is primarily citric acid, iso-ascorbic acid, monosodium glutamate (MSG), gellan and curdlan. In feed it is cyanocobalamin (Vitamin B12), threonine, lysine, tryptophane and astaxanthin. Industrial products comprise aspartic acid, proteases, ethanol, acetic acid, welan, poly-lactic acid and PHB. Multi-use products which are used in different market segments of equal importance are riboflavin, beta-carotene, ascorbic acid, lactic acid, xanthan, gluconic acid, amlysases and cellulases. Lycopene is the only product which is primarily used in the pharmaceutical and supplement sector.

- **The market size** of these products differs considerably. Ethanol, acetic acid but also MSG, citric acid and lysine are manufactured and sold in the range of 1 Mio tons or more. In contrast, vitamins and carotenoids are sold in quantities of a few to a few hundred tons. All others show markets sizes between 10.000 to 200.000 tons.
- **Volume growths** of most products over the past years have been in the range of 5-10%. Lysine, threonine, xanthan, lycopene, PHB and ethanol showed growth rates exceeding 10% and poly-lactic acid enjoyed doubling of volumes every year since 2003.
- However, in most cases **volume growth was associated with strong price decreases.** Annual decreasing prices of more than 5% were not exceptional and it was only MSG, acetic acid and ethanol which showed a clear price trend up. Ethanol is the single product for which exceptionally high volume growth was combined with strong price increases.
- **Unit prices** are strongly correlated to the volumes manufactured. For all products exceeding global production of several thousand tons the standard price is in the range of € 1/kg to € 10/kg.
- Manufacturing of fermentation products is always **capital intensive and economy of scale effects play a high role in economics.** Consequently the global market for individual products is very concentrated. A few companies dominate in almost every product category and it is only ethanol, MSG, acetic acid and lysine for which the manufacturer landscape is more divers.
- Industrial fermentation is still a **domain of Western countries** with Chinese or Indian companies being present in a limited number of products only. Citric and ascorbic acid, xanthan and cyanocobalamin are clearly the domain of Chinese manufacturers, while amino acids to a large extent are manufactured by Asian companies with Chinese participating but not dominating.
- Fermentation products used in foods, feeds and pharmaceuticals are **regulated either by the European or the North American FDA system.** Such regulations are employed by virtually all other countries and deviations from these systems are marginal. For all other products internationally applying regulations don’t exist but quality standards govern their use on a global scale.
- **Distribution and value chains for all fermentation products are short.** Traders and distributors play a role but in general terms larger quantities are always sold from the producer directly to the user.
- Fermentation products are **intermediates and never sold to the consumer as such.** This implies that in many cases products are formulated in order to meet technical requirements for being mixed together with other ingredients and to sustain manufacturing processes of consumer products.
- The usage of all fermentation products is driven on a global scale by the general increase of the population and rising income levels. **Volume growth is predicted to remain robust** over the next years and considering that demand for many products will overshoot supply, **prices will no longer decrease but tend up.** Such trend will be substantiated by increasing raw material prices, primarily of carbohydrates on which all fermentation products depend.
- **The economics of fermentation processes therefore is strongly related to carbohydrate conversion rates.** Strain selection and optimisation of processes over the last decades allows manufacturing of many products at conversion rates exceeding 50%. This applies especially for the large-scale products, while for vitamins and carotenoids conversion rates are still very low.

- **Carbohydrate conversion rate and economy of scale together decide on the margin of manufacturing.** For all products considerable margins are still possible. For products manufactured in minor volumes margins can exceed 25%. However, large-scale fermentation products show typically smaller margins, which are characteristic for commodities.
- Despite the commodity character of fermentation products, **marketing is sophisticated** and requires highly specialised sales force and access to specific industries. Therefore a successful market entry not only depends on the optimisation of technical parameters but specifically on the understanding of the market dynamics of the employing industries.

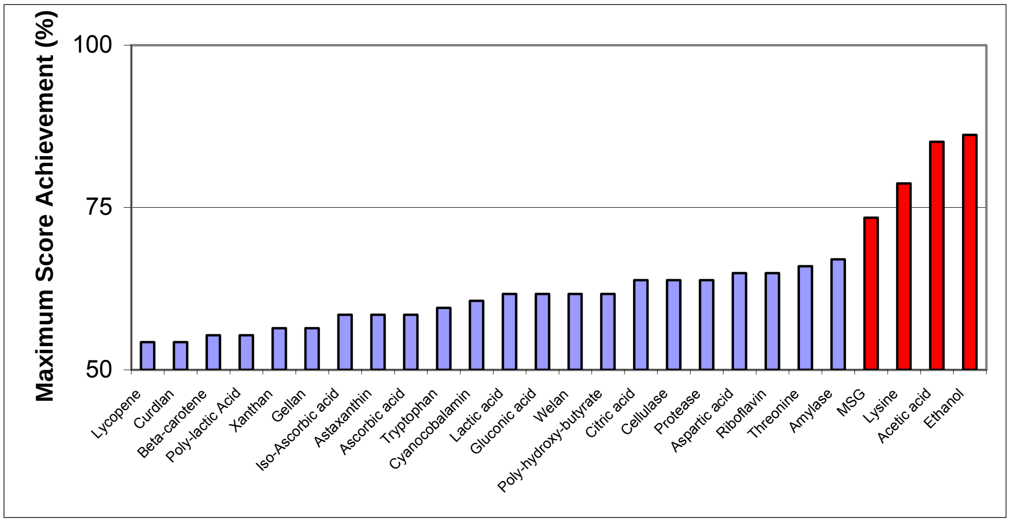
1.5 Benchmarking of Fermentation Products according to Technical-Economic Parameters- Findings of Part I

Characterising the analysed fermentation products by a numeric evaluation grid, considering 25 parameters shows that **the most internationally attractive products are ethanol, acetic acid, lysine and monosodiumglutamate.** These products are ranked highest because they consistently show across technical, economic and marketing parameters favourable characteristics. Volumes produced and demand are high, technological requirements are moderate, processes are patent-free and marketing requirements are less sophisticated – thus specifically suitable for Egypt.

Summary Overview 2: Parameters used for Product Benchmarking

Historic market growth	Carbohydrate conversion
Unit price	Valuable by-product
Share of product converted	Overcapacity
Powder/liquid	Min. size of plant
Regulation free	Investment costs
Share of three main producer	Margin
Share of Chinese/Indian	Patent
Steps in value chain	Flexibility in using carbohydrates
Formulation	Degree of sophistication
Future market growth	Dedication of plant
Organism	Market requirements
No. of carbohydrates	Know-how requirements

Summary Overview 3: Scoring of screened Fermentation Products



1.6 Development of a Fermentation Industry in Egypt – Findings of Part III

1.6.1 Macro-economic Environment and Framework Conditions relevant for Biotechnology

Egypt's economy shows a robust growth of GDP which however is largely based on non-production sectors. Despite massive foreign and domestic investments this picture did not change over the last years. The balance of trade is strongly negative and exports are based on raw materials and low-tech products. Labour force is growing strongly and despite relatively low salaries unemployment is specifically high among academic staff. The country is still self-sufficient in energy but domestic consumption is so high that within a couple of years Egypt will develop to a net-importer. The agricultural sector is dominated by cereals, cotton and sugar crops but the country is with the exception of rice not self-sufficient and imports are constantly rising. Developments in the fermentation industry therefore have to respect such main characteristics of the macro-economic environment, supporting positive trends and counterbalance negative ones.

Therefore, developments in the fermentation industry in Egypt have to:

- Support growth of GDP, primarily by manufacturing higher valued goods, which not only can be used on the domestic market but also integrate successfully internationally.
- Absorb a substantial number of labours and contribute to an improved interface between research and commercialisation.
- Build on existing resources and strongly refrain from imports.

1.6.2 The Relevance of the Existing Fermentation Industry in Egypt

Fermentation is currently employed in five major product categories: cephalosporin, ethanol, citric acid, acetic acid and yeast. Most traditional are ethanol and yeast fermentations while citric acid and cephalosporin are considered as newer developments. Yeast fermentation is carried out in middle sized and small companies and produces fresh baker's yeast, consumed locally. Ethanol and acetic acid are combination products as manufacturing of acetic acid requires ethanol as the starting material. The dominant player is **manufacturer 2** a Government controlled company, which also controls Egypt's supply in carbohydrates, specifically molasses. Citric acid is manufactured based on imported carbohydrate raw material and cephalosporins on imported vegetable oils.

It is consequently without question that basic know-how in fermentation exists in Egypt. This industry can much more than other biotechnology sectors, for which a commercial and industrial basis is more or less absent, serve as the seed for further sector development with the potential to successfully stimulate applied R&D at universities and institutes.

However, only the ethanol industry can serve to some extent as an example to further develop the sector:

- Cephalosporin manufacturing by manufacturer 1 is new; operating only since two years and it is too premature to assess the company comprehensively. However, cephalosporin manufacturing in Egypt does not rely on country specific resources or markets. It imports all raw materials, all hardware and exports virtually all cephalosporin as intermediate for antibiotic manufacturing to Asia.
- Yeast companies prepare a product which requires fresh and immediate consumption. Export of yeast is only possible in the spray-dried formulation and such set-up and technology does not exist. Internationally the dried yeast market is controlled by three companies only, indicating that the technology is highly sophisticated. Despite invitations, such companies did not invest in production in Egypt, suggesting that from technical, raw material and market points of view Egypt is not appropriate.
- Citric acid manufacturing by Manufacturer 3 is a failure. The company is bankrupt and offered for sale. A technology relying on imported raw material, coinciding with an increased competition for manufactured products, rendered the process uneconomical and forced the company to give up.
- Manufacturer 2, Manufacturer 4 and a few more are active in ethanol fermentation. It can be assumed that ethanol manufacturing is economically attractive. Egypt is a small market for ethanol but Europe requires considerable imports to meet its demand resulting from bio-fuel. Ethanol producers rely on domestic resources of molasses and in the case of manufacturer 2 strongly control them. Additionally, existing ethanol plants are constructed based on local engineering know-how.

1.6.3 The Relevance of Foreign Direct Investments

Apart from manufacturer 1, which to a great extent employs foreign direct investment funds, no other company in the fermentation industry could be identified using such funds.

Apart from general political economic framework conditions, which are considered to be favourable in Egypt for investments, the key decision criterion for selecting a manufacturing site for fermentation is the **availability of competitive raw material carbohydrates**.

In international dimensions availability of starches and sugar resources in Egypt are small. Until recently Brazil, Eastern Europe, South-East Asia but especially North America and Europe were supplied with sufficient resources of such raw materials and did not explore alternative countries. Due to the strongly increasing demand from the ethanol industry, globally available carbohydrates are now shortened, prices increase and alternative sites for production plants are investigated. This offers Egypt a **unique opportunity** to build-up a considerable fermentation industry based on locally available molasses and adding value to such product before exporting.

1.6.4 Markets for Fermentation Products and Relevance of MENA Countries

Fermentation products are ingredients for manufacturing consumer products demanded primarily in countries with high income levels. Consequently the demand in Egypt is relatively small for virtually all fermentation derived products with the exception of lysine and citric acid. Lysine is an ingredient for compound feed for poultry and that industry is expanding in Egypt since many years. Citric acid is primarily used for manufacturing foods and soft drinks and the changing diet in Egypt drives the demand for such product. Within the MENA group of countries, Egypt is, in many economic and political parameters, the most advanced country and consumption for both products is highest. Considering further the resource base of other MENA countries and their current political constellations, it is obvious that no fermentation industry with the exception of a few ethanol plants i.e. in Syria and Morocco were set-up in the past. Consequently citric acid and lysine are currently imported. Reliable statistics on such imports are not available but estimates suggest imports of 25-30.000 tons citric acid and 12-15.000 tons of lysine to all MENA countries out of which Egypt is supposed to have the largest share.

It is primarily Europe as a market which is of relevance for a potential Egypt fermentation industry.

The market is large, can not satisfy its demand with local productions, and depends on imports primarily from Asia. New capacity additions are unlikely to happen for a number of political and economic reasons.

With respect to ethanol, the potential market in Europe is in the range of several hundred thousand tons, for lysine and other amino acids it is in the range of more than 50.000 tons.

1.6.5 Decision Matrix and Product Recommendations

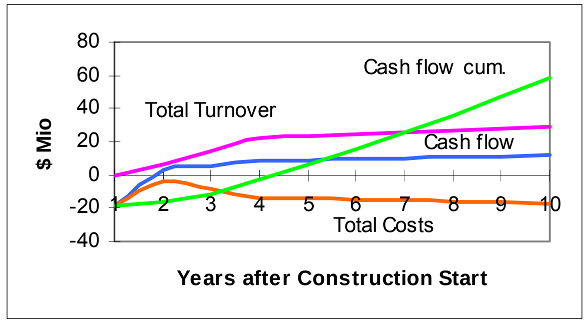
Given the need to satisfy the macro-economic objectives for biotechnology, the market environment and the availability or resources, three products are recommended to develop in Egypt: **lysine, monosodiumglutamate and especially ethanol**.

These products can be produced with locally available molasses, profit from low energy and labour costs and especially from the geographic location of Egypt being close to Europe. For bio-ethanol the conditions are especially favourable as technical know-how for manufacturing plants and for production already exist. Further bio-ethanol can not only be produced based on molasses but also based on **processed rice straw**, which is the only raw material beyond molasses, available in large quantities as a by-product from rice cultivation. This technology however **would require further development** but upon success, it would catapult Egypt to the forefront of international research in that sector and allow the country not only to become a player in the international ethanol industry but also in engineering and technology.

1.7 Techno-economic Feasibility of Selected Products

1.7.1 Feasibility of Lysine

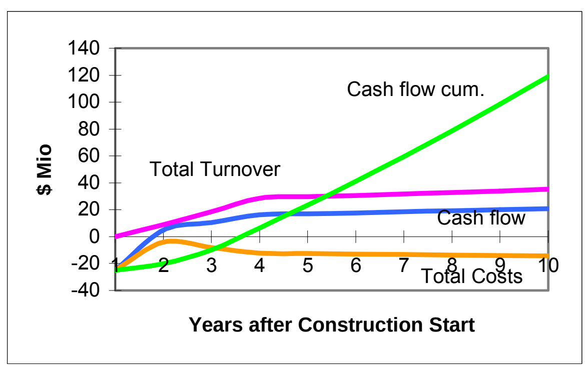
Summary Overview 4: Cash flow Development for a Lysine Plant



The review of the current and future market dynamics for lysine suggests the setting-up of a lysine plant with a capacity of 20.000 tons based on molasses. In international dimensions, a 20.000 ton plant is relatively small, entailing high investment costs but due to the availability of competitive molasses and electricity, the plant will show an Internal Rate of Return (IRR) of more than 30% and a payback period of less than five years. Lysine will be partly used in Egypt to supplement poultry diets but mostly be exported to Europe, which is not self-sufficient. As the technology for lysine is not available in Egypt, it is proposed to attract an international investor, which might be Ajinomoto, currently looking for a new site for a lysine plant supplying European markets.

1.7.2 Feasibility MSG

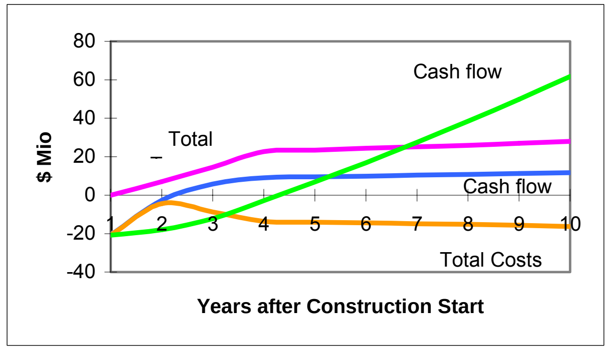
Summary Overview 5: Cash flow Development for a MSG Plant



The review of the current and future market dynamics for MSG suggests the setting-up of a MSG plant with a capacity of 20.000 tons based on molasses. In international dimensions, a 20.000 ton plant is relatively small, entailing high investment costs but due to the availability of competitive molasses and electricity, the plant will show an IRR of more than 45% and a payback period of less than four years. MSG consumption in Egypt is small but the demand in Europe is high. Consequently an MSG plant will primarily supply European markets. As the technology for MSG is not available in Egypt, it is proposed to attract an international investor, which might be Ajinomoto, currently looking for a new site for a MSG plant to supply European but also African markets.

1.7.3 Feasibility Bio-Ethanol based on Molasses

Summary Overview 6: Cash flow Development for a Bio-Ethanol Plant based on Molasses

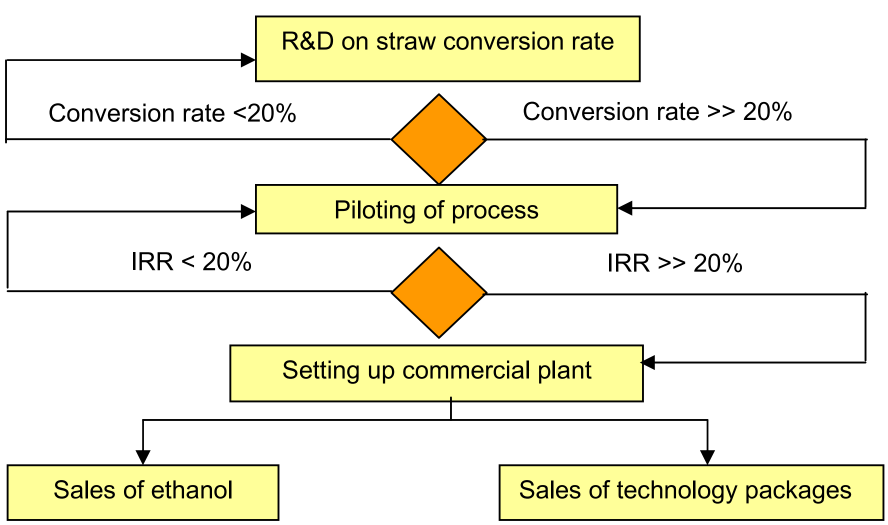


The review of the current and future market dynamics for bio-ethanol suggests the setting-up of an ethanol plant with a capacity as high as possible. However, the availability of molasses restricts the dimension of an ethanol plant and thus a 20 – 30.000 tons plant is proposed. Considering that Egypt has engineering know-how for ethanol plants, it can be expected that even at such small size investment costs are tolerable and given the availability of price competitive molasses and energy an IRR of more than 30% and a payback period of less than five years can be expected. Bio-ethanol might be produced in the coming years for the European market but in the longer run also for the domestic market, substituting to some extent gasoline. As the technology for bio-ethanol based on molasses is available in Egypt, it is proposed to attract a local investor and in the case needed supplement the technology by international transfer.

1.7.4 Feasibility Bio-Ethanol based on Rice Straw

A technology package for setting-up a large-scale rice straw based ethanol plant is internationally not available. It is suggested that Egypt embarks on a **R&D and piloting program**, primarily to optimise the pre-treatment of straw, so that a high enough technical efficiency and economic attractiveness results. Preliminary calculations show that upon optimising chemical and enzymatic pre-treatment of straw, an IRR of more than 20% and a payback period of five years can be expected. The main benchmark for such an economic feasibility is a conversion rate of more than 20% of the fermentable sugars in rice straw.

Summary Overview 7: R&D and Piloting Procedure for Optimising a Bio-Ethanol Process based on Rice Straw

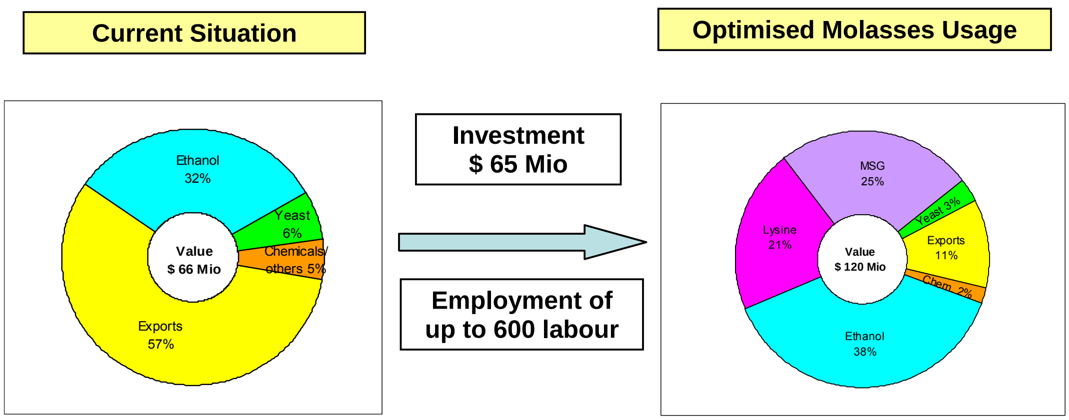


1.8 Political Implications and Recommendations - Findings of a Sector Analysis

1.8.1 Macro-economic Effects

Overall a **more intensive use of the available molasses** by investments in lysine, MSG and ethanol plants would result in an annual value addition of almost $ 60 Mio and create 600 permanent jobs.

Summary Overview 8: Macro-economic Effects of Optimising Molasses Usage



At a later stage and upon having established successfully running such fermentation industries, they might unfold a **biotechnological cluster effect**. Serving as nuclei, more sophisticated products building on fermentation know-how of amino acids and ethanol can be developed. At this current stage, start-up and R&D driven companies related to fermentation do not exist in Egypt. They require technological and marketing related mentors to develop and grow. Success of IMC in attracting larger scale investments in the mentioned fermentation products will thus not only contribute to improved usage of existing raw materials and resources, but also lay the foundation for the development of related start up companies in a number of disciplines.

A fermentation industry is raw material driven and without its provision and/or availability no major industry will develop. The preconditions for setting up a fermentation industry is therefore that access to molasses is granted and in the case of ethanol from raw materials others than molasses, that a process for converting straw into fermentable feed stock is developed.

1.8.2 Technology Ventures and Public R&D Programs

The comparison of international biotech support policies shows, that the North American biotech success story is exceptional and could so far not be repeated in other countries. It was built on a unique combination of facilitated access to risk capital, industry interest, a high number of scientists and researchers willing to become entrepreneurs and massive public funding.

Countries like China, Brazil and India were also successful to some extent in developing larger scale biotechnology industries by setting up publicly funded technology clusters and providing start-ups with financial and technical resources. Major effects of such approaches could be seen first after more than ten years. But the starting points in all of these countries were large scale fermentation industries, using locally available resources and raw materials. In none of these transition countries a biotech industry developed only from start up companies. And also in North America, the basis for the success were existing large scale industries with sufficient interest in new developments.

1.8.3 Recommendations

The analysts recommend to focus national activities for building a biotechnology industry on fermentation technology. Government policies therefore shall focus on:

- Reviewing the local sugar regime in order to improve availability of molasses for conversion into fermentation products outside public sector.
- Attracting local investors for setting up an ethanol industry based on molasses, primarily by the provision of incentives related to cost competitive and guaranteed raw material sources.
- Attracting foreign investors for establishment of amino acid plants, primarily for manufacturing lysine by highlighting availability of cost competitive resources, specifically molasses and energy.
- Supporting the setting up of applied research for straw conversion into fermentable sugars and the construction of pilot plants.
- Governmental support of longterm sector programs supporting dedicated applied research, enabling a loan program and grants system for construction of biorefineries, foster the infrastructure for feedstock supply for the use of agricultural residues and measures for market expansion.
- Setting up a publically funded Small Business Innovation Program to stimulate the innovation in the private sector and link academia and industry in a competetive approach. This can be designed in order to specifically appraise the most practical ideas from academia or industry by funding only proposals that have a concept for commercial implementation. Foreign financial support should not been sought for to ensure independence and true local development of ideas.
- Organizing a short term training program to boost the availability of labour in biotechnology with industry defined skills
- Initiating a long term skill development program following the priorities that will be adressed by the industry, i.e. by establishing targetted chemical engineering curriculae etc.

Such financially propelled incentives, not related to raw materials, and an improved education of university graduates will be highly welcome by investors in the fermentation sector, but will not be sufficient in the short run to attract investments in fermentations in Egypt.

Most imporantly the provision of raw materials is the unique and overriding decision criterion for any kind of domestic or international investment in the fermentation industry.

1.9 Activity and Implementation Plans

A single implementation plan can not be proposed as the requirements for setting up an ethanol and amino acid fermentation industry are too divers.

Consequently **four action plans, separately for lysine (amino acid), MSG (amino acid), ethanol based on molasses and ethanol based on rice straw** are proposed**.**

Action plans **for amino acids** focus on:

- the provision of molasses
- the attraction of foreign investments as adequate technology does not yet exist in Egypt.

For **ethanol based on molasses** the plan focuses on

- the provision of raw material
- the optimised exploitation of existing engineering know-how
- the attraction of a local investor.

For **ethanol based on rice straw** the plan focuses on

- setting up a R&D scheme for converting straw into fermentable sugars
- piloting such process on a smaller scale.

1.9.1 Action plan for implementation of white biotechnology

	Tasks	Term	Responsibility
Result 1: Biotechnology Industry Coordinator in place (30 days)			
1.1	Obtain general approval for the job	Carry out and follow up all activities related to this position	IMC
	Prepare job description/ Prepare job requirement		
1.2	Public announcement for the job		
1.3	CV received by selection committee/ CV Short listed		
1.4	Interview / Identify the candidate		
1.5	Hiring		
Result 2: Maintain cost competitiveness (Labour, utilities)			
		Maintain competitive advantages on short term	Biotechnology Coordinator
Result 3: Biotechnology products priority list (45 days)			
3.1	Mandates and time frame for a taskforce to be prepared by Biotech Coordinator	Setup of a taskforce white industrial fermentation cooperation technology transfer and identify products priorities (EU Partnership Agreement)	IMC, HCST, Ministry of Trade and Industry
	Taskforce for white biotechnology products assembled		
3.2	Local, regional and international markets orientation report for a list of expected biotechnology products (EU market screened)		
	Taskforce prepare a presentation of the expected output		
3.3	Steering committee to evaluate the expected output and short listed the products		
3.5	A final priority list of biotechnology products adopted		

	Tasks	Term	Responsibility
Result 4: New technologies have been developed for production of fermentable raw materials based on biomass (10 years)			
4.1	Concept paper for the new funding program prepared by Biotechnology Coordinator	More fund should be allocated for R&D to improve biomass production (Non-feed and non-food), biomass collection, biomass storage, biomass pre-treatment, and industrial enzymes production, in order to establish a commodity fermentable raw materials industry.	IMC+ Higher Consul for Science and Technology (Prime Minister)
	Concept approved by the relevant officers at both IMC and Higher Counsel for Science and Technology (HCSI)		
4..2	Study - Priority list of R&D areas to be funded		
4..3	Presentation by the Biotech Coordinator for the stockholders – Awareness (objectives, goals expected output)		
4.4	Steering committee for the program, assembled from biotechnology tech transfer experts (Industry, IMC, HCST, academia)		
	Application format and eligibility criteria for approval been adopted by steering committee		
4.5	Workshop for industry and entrepreneurs- program concept application, technical aspects, funding available		
4.6	Call for proposals/approval from relevant committee/contracting		
4.7	Technology transfer and licensing		
Result 5: New trained professional in Industrial fermentation (5 years)			
5.1	Program concept to be prepared by Biotech Coordinator	A long term program to enrich labour market with industry-trained biotechnology professionals in a short term (post-graduate training) and in a long term (post graduate diploma)	IMC+ Minister of Trade and Industry + Minister of Labour + Higher Consul for Sciences and Technology
	Approval from relevant IMC officers and industry		
5.2	Study- Training objectives / content / target group / duration /policy / eligibility based on cost sharing 20/80 for trainee and IMC respectively		
5.3	Call for training delivery /qualifications / cost and contracting		
5.4	Five rounds of training per year 10 trainees/round		

	Tasks	Term	Responsibility
Result 6: New academic Diploma established for Industrial fermentation experts (5 years)			
6.1	Concept paper prepared by Biotech Coordinator		IMC, HCST, Minister of Higher Education, Universities Supreme Counsel
	Industry, HCST and IMC approved and Min Higher Education endorsed		
6.2	Study- objectives / syllabus for the diploma / duration / intra-collages participation / internship / eligibility		
6.3	Universities Supreme Counsel approved		
6.4	Delivery		
Result 7: Industrial Fermentation Association or Chamber (60 days)			
7.1	Call for FEI to promote either ideas	IMC should support establishing either a national association for industrial fermentation industries or a new chamber for that industry at FEI.	IMC, UNIDO, Minister of Trade and Industry
7.2	Legal status granted of the Association according to NGO law		
Result 8: Two Biotechnology Clusters established within 10 years as pilot business (10 years)			
8.1	TOR for bidding/announcement	As a knowledge intensive industry, biotechnology required to establishing of two clusters of new technologies for raw materials industry development using locally available biomass (Rice straw, corn stover and sugarcane residues). The experience and the success of other countries with similar-based economy should be called	IMC and Higher Consul for Science and Technology (Prime Minister) and Minister of Environmental Affairs
8.2	Selection and contracting		
8.3	Establishing the two clusters		

<table>
<tr><th></th><th>Tasks</th><th>Term</th><th>Responsibility</th></tr>
<tr><td colspan="4">Result 9: Two new legislations to be proposed from the relevant (2 years)</td></tr>
<tr><td>9.1</td><td>Study : Gasoline Blending Law</td><td rowspan="4">For biofuel industry to be expanded two main pieces of legislations need to be issued by relevant Minister and adopted by Parliament:
1. Gasoline Blending Law to allow sale gasoline/biofuels blends
2. Ease up issuing ethanol production license
3. Setup an incentive tax package on production of renewable fermentable raw materials from either agricultural and solid municipal wastes (biomass value add tax)</td><td rowspan="4">Ministry of Environmental Affairs, Ministry of Trade and Industry, Parliament, Min Finance, Min Petroleum and Minerals resources</td></tr>
<tr><td>9.2</td><td>Study: Incentive tax package for renewable fermentable raw mater4ials from biomass</td></tr>
<tr><td>9.3</td><td>Cabinet Ministers to approve the measures and the bill</td></tr>
<tr><td>9.4</td><td>Parliament to approve</td></tr>
</table>

1.9.2 Log-frame for setting up a Lysine 60 Plant with an annual Capacity of 20.000 Tons (Result System)

Objective Level	Output	Success Measures	Pre-requisites
Overall Objective	Sustainable growth of Egypt's economy is supported by fostering the industrial sector with investments in manufacturing of higher valued biotechnological products	A set of key macro-economic criteria is positively influenced	Egypt remains politically and socially stable, continues reforming the economy and stays investor friendly
Project Objective	A Lysine 60 plant is set-up and economically operated	A Lysine 60 plant with a production of not less than 18.000 tons per year operates at an IRR of not less than 35% over 10 years	Basic assumptions with respect to availability and pricing of resources as well as to demand and market prices of lysine remain valid over longer periods of time
Result 1	Proposal and concept are approved by relevant ministries and official bodies	Key ministries and governmental institutions consider the setting up of a lysine factory as one of the targets over the next five years	Key ministries find proposal of setting-up a lysine factory attractive and strategically important enough to include it in political frame
Result 2	Suitable investor is identified and attracted	A suitable investor announces an investment into a Lysine 60 plant in Egypt	Identified competitiveness of Egypt as a site for lysine production is appreciated by investor
Result 3:	Pre-feasibility is revised and extended to full techno-economic feasibility study	Technical and economic blue prints for the construction and operation of a Lysine 60 plant are available not later than 2008	Suitable consulting and engineering firm can be hired for carrying out feasibility study and does not come to totally different conclusions as the pre-feasibility study.
Result 4	Plant is constructed within 18 months and successfully started up	The Lysine 60 plant comes on stream not later than 2010 and operates according to business plan	Bureaucracy in Egypt does not restrict advancements in planning, construction and operation of the plant; markets for lysine develop as envisaged

1.9.3 Log-frame for setting up a Lysine 60 Plant with an annual Capacity of 20.000 Tons (Activity & Resource System)

Action		Timeline (months after process-start) 1	2	3	4	5	6	7	8	9	10	11	12	Costs	Responsible
Result 1: Proposal and concept are approved by relevant ministries and official bodies															
1.1	Prepare presentation Highlight macroeconomic relevance Highlight need to free the molasses market	—													IMC
1.2	Obtain general approval for concept		▲												IMC
1.3	Prepare study on macro- and micro-economic impact of a privatisation of the molasses market													$ 100.000	Egyptian/ international consultants
1.3.1	Set-up concept and layout			—											
1.3.2	Tender study				—										
1.3.3	Identify study group and implement analysis work					—	—								
1.4	Present results to relevant ministries for decision making							—							IMC
1.5	Arrange for a binding decision								▲						IMC
Result 2: Suitable investor is identified and attracted															
2.1	Prepare dossier on opportunities in Egypt	—													IMC
2.2	Present Egypt as an investment site for fermentation on relevant international events		—	—	—	—	—	—	—	—	—	—	—	$ 50.000	
2.3	Contact directly possible investors e.g. Ajinomoto		—	—											IMC/ business community
2.4	Start negotiations				—	—	—	—							
2.5	In the case needed, prepare incentive package				—	—	—	—							
2.6	Conclude negotaitions with letter of intent								▲						
Result 3: Pre-feasibility is revised and extended to full techno-economic feasibility study															
3.1	Accompany investor in carrying out feasibility study					—	—	—	—						IMC
3.2	Establish required links to insitutions as required and wanted					—	—	—	—						IMC
3.3	Contribute to the conclusion of the feasibility study with pre-investment contract									▲					IMC
Result 4: Plant is constructed within 18 months and successfully started up															
4.1	Coordinate construction work with investor											—	→		IMC
4.2	Facilitate setting-up organisational and company structures											—	→		IMC
4.3	Facilitate access to local and regional customers											—	→		IMC/Traders

1.9.4 Log-frame for setting up a MSG Plant with an annual capacity of 20.000 tons (Result System)

Objective Level	Output	Success Measures	Prerequisites
Overall Objective	Sustainable growth of Egypt's economy is supported by fostering the industrial sector with investments in manufacturing of higher valued biotechnological products	A set of key macro-economic criteria is positively influenced	Egypt remains politically and socially stable, continues reforming the economy and stays investor friendly
Project Objective	A MSG plant is set-up and economically operated	A MSG plant with a production of not less than 18.000 tons per year operates at an IRR of not less than 40% over 10 years	Basic assumptions with respect to availability and pricing of resources as well as to demand and market prices of MSG remain valid over longer periods of time
Result 1	Proposal and concept are approved by relevant ministries and official bodies	Key ministries and governmental institutions consider the setting up of a lysine factory as one of the targets over the next five years	Key ministries find proposal for setting-up a MSG factory attractive enough to include it political frame
Result 2	Suitable investor is identified and attracted	A suitable investor announces an investment into a MSG plant in Egypt	Identified competitiveness of Egypt as a site for lysine production is appreciated by investor
Result 3:	Pre-feasibility is revised and extended to full techno-economic feasibility study	Technical and economic blue prints for the construction and operation of a MSG plant are available not later than 2008	Suitable consulting and engineering firm can be hired for carrying out feasibility study and does not come to totally different conclusions as the pre-feasibility study.
Result 4	Plant is constructed within 18 months and successfully started up	The MSG plant comes on stream not later than 2010 and operates according to business plan	Bureaucracy in Egypt does not restrict advancements in planning, construction and operation of the plant; markets for lysine develop as envisaged

1.9.5 Log-frame for setting up a MSG Plant with an annual capacity of 20.000 tons (Activity & Resource System)

		1	2	3	4	5	6	7	8	9	10	11	12		
Result 1: Proposal and concept are approved by relevant ministries and official bodies															
1.1	Prepare presentation Highlight macroeconomic relevance Highlight need to free the molasses market	—													IMC
1.2	Obtain general approval for concept		?												IMC
1.3	Prepare study on macroeconomic impact of a privatisation of the molasses market													$ 100.000	Egyptian/ international consultants
1.3.1	Set-up concept and layout			—											
1.3.2	Tender study				—										
1.3.3	Identify study group and implement analysis work					—	—								
1.4	Present results to relevant ministries for decision making							—							IMC
1.5	Arrange for a binding decision								?						IMC
Result 2: Suitable investor is identified and attracted															
2.1	Prepare global review of current and future ethanol market/identify possible customers													$ 100.000	
2.1.1	Set-up concept and layout	—													Egyptian/ international consultants
2.1.2	Tender study		—												
2.1.3	Identify study group and implement analysis work			—	—										
2.1.4	Conclude on opportunities in ethanol					?									
2.2	Present investment opportunities in ethanol to local business community				—	—	—	—	—	—	—	—	—		
2.3	Contact directly possible local investors				—	—									IMC
2.4	Start negotiations					—	—	—	—						IMC/ business community
2.5	In the case needed, prepare incentive package					—	—	—	—						
2.6	Conclude negotaitions with letter of intent									?					
Result 3: Pre-feasibility is revised and extended to full techno-economic feasibility study															
3.1	Accompany investor in carrying out feasibility study						—	—	—	—					
3.2	Establish required links to insitutions as required and wanted						—	—	—	—					IMC
3.3	Contribute to the conclusion of the feasibility study with pre-investment contract										?				
Result 4: Plant is constructed within 18 months and successfully started up															

1.9.6 Log-frame for setting up a Bio-Ethanol Plant based on Molasses with an annual capacity of 20.000 tons (Result System)

Objective Level	Output	Success Measures	Prerequisites
Overall Objective	Sustainable growth of Egypt's economy is supported by fostering the industrial sector with investments in manufacturing of higher valued biotechnological products	A set of key macro-economic criteria is positively influenced	Egypt remains politically and socially stable, continues reforming the economy and stays investor friendly
Project Objective	A state-of-the-art bio-ethanol plant is set-up and economically operated	A state-of-the-art bio-ethanol plant with a production of not less than 18.000 tons per year operates at an IRR of not less than 30% over 10 years	Basic assumptions with respect to availability and pricing of resources remain valid over longer periods of time
Result 1	Proposal and concept are approved by relevant ministries and official bodies	Key ministries and governmental institutions include the setting up of a bio-ethanol factory as one of the targets over the next five years	Key ministries find proposal of setting-up a state-of-the-art bio-ethanol factory attractive and strategically important enough to include it in political frame
Result 2	Suitable investment scheme is identified and implemented	A suitable investment scheme is announced and published	Identified competitiveness of Egypt as a site for state-of-the-art bio-ethanol production is appreciated by investor
Result 3:	Pre-feasibility is revised and extended to full techno-economic feasibility study	Technical and economic blue prints for the construction and operation of a state-of-the-art bio-ethanol plant is available not later than 2008	Suitable consulting and engineering firm can be hired for carrying out feasibility study and does not come to totally different conclusions as the pre-feasibility study.
Result 4	Plant is constructed within 12 months and successfully started up	The state-of-the-art bio-ethanol plant comes on stream not later than 2010 and operates according to business plan	Bureaucracy in Egypt does not restrict advancements in planning, construction and operation of the plant; markets for bio-ethanol develop as envisaged

1.9.7 Log-frame for a Bio-Ethanol Plant based on Molasses annual capacity of 20.000 tons

3.2	Establish required links to insitutions as required and wanted														IMC
3.3	Contribute to the conclusion of the feasibility study with pre-investment contract									?					IMC
Result 4: Plant is constructed within 18 months and successfully started up															
4.1	Coordinate construction work with investor														IMC
4.2	Facilitate setting-up organisational and company structures														IMC
4.3	Facilitate access to local and regional customers														IMC/Traders

Action		Timeline (months after process-start)												Costs	Responsible
		1	2	3	4	5	6	7	8	9	10	11	12		
Result 1: Proposal and concept are approved by relevant ministries and official bodies															
1.1	Prepare presentation														IMC
	Highlight macroeconomic relevance														
	Highlight need to free the molasses market														
1.2	Obtain general approval for concept		?												IMC
1.3	Prepare study on macroeconomic impact of a privatisation of the molasses market													$ 100.000	
1.3.1	Set-up concept and layout														Egyptian/ international consultants
1.3.2	Tender study														
1.3.3	Identify study group and implement analysis work														
1.4	Present results to relevant ministries for decision making														IMC
1.5	Arrange for a binding decision								?						IMC
Result 2: Suitable investor is identified and attracted															
2.1	Prepare global review of current and future ethanol market/identify possible customers													$ 100.000	
2.1.1	Set-up concept and layout														Egyptian/ international consultants
2.1.2	Tender study														
2.1.3	Identify study group and implement analysis work														
2.1.4	Conclude on opportunities in ethanol					?									
2.2	Present investment opportunities in ethanol to local business community														
2.3	Contact directly possible local investors														IMC
2.4	Start negotiations														
2.5	In the case needed, prepare incentive package														IMC/ business community
2.6	Conclude negotaitions with letter of intent									?					
Result 3: Pre-feasibility is revised & extended to full techno-econom. Feasib. study															
3.1	Accompany investor in carrying out feasibility study														
3.2	Establish required links to insitutions as required and wanted														IMC

1.9.8 Log-Frame for setting up a bio-Ethanol Plant based on Rice Straw with an annual capacity of 20.000 tons (Result System)

Objective Level	Output	Success Measures	Prerequisites
Overall Objective	Sustainable growth of Egypt's economy is supported by fostering the industrial sector with investments in manufacturing of higher valued biotech products	A set of key macro-economic criteria is positively influenced	Egypt remains politically and socially stable, continues reforming the economy and stays investor friendly
Project Objective	An innovative bio-ethanol plant based on rice straw is set-up and economically operated	An innovative bio-ethanol plant based on rice straw with a production of not less than 18.000 tons per year operates at an IRR of not less than 25% over 10 years	Governmental and private bodies in Egypt as well as international technology owners cooperate efficiently.
Result 1	Proposal and concept are approved by relevant ministries and official bodies	Key ministries and governmental institutions include the setting up of a straw-based bio-ethanol factory as one of the targets over the next five years	Key ministries find proposal of setting-up an innovative rice straw-based bio-ethanol factory attractive and strategically important enough to include it in political frame
Result 2	Suitable R&D scheme for the pre-treatment of rice straw is set-up and leads to desired results	The conversion of rice straw to ethanol can be increased to more than 20%	Suitable R&D institute in Egypt can be identified and limited funding ensured.
Result 3	The pre-treatment of rice straw is piloted and leads to the desired results	Pilot trials lead to the conclusion that a commercial plant can be operated successfully with respect to technical feasibility and economic sustainability.	Suitable engineering company can be identified and funding for a pilot plant can be ensured.
Result 4	The results of a feasibility study considering the optimised pre-treatment of rice straw justify investments in a commercial plant	Techno-economic scenarios and pressure testing of key parameters show robust economics even under adverse frame-work conditions.	Basic assumptions with respect to availability and pricing of resources remain valid over longer periods of time.
Result 5	Suitable investment scheme for a rice straw based ethanol plant is identified and implemented	A suitable investment scheme, involving governmental and/or private bodies is announced and published.	Official and/or local private investors recognise the micro- and macroeconomic potential of a straw-based ethanol process.
Result 6	Plant is constructed within 12 months and successfully started up	A innovative straw-based bio-ethanol plant comes on stream not later than 2010 and operates according to business plan	Bureaucracy in Egypt does not restrict advancements in planning, construction and operation of the plant; markets for bio-ethanol develop as envisaged

1.9.9 Log-Frame for setting up a bio-Ethanol Plant based on Rice Straw with an annual capacity of 20.000 tons (Activity & Resource System)

Action		Timeline (months after process-start)															Costs	Responsible
		2	4	6	8	10	12	14	16	18	20	22	24	26	28	30		
Result 1: Proposal and concept are approved by relevant ministries and official bodies																		
1.1	Prepare presentation on rice straw-to-alcohol concept																	IMC
	Highlight macroeconomic relevance																	
	Highlight micro-economic and agricultural relevance																	
1.2	Obtain general approval for concept	▲																IMC
1.3	Prepare study on international ethanol market																$ 100.000	
1.3.1	Set-up concept and layout																	Egyptian / Internat Consultants
1.3.2	Tender study																	
1.3.3	Identify study group and implement analysis work																	
1.4	Present results to relevant ministries for decision making																	IMC
1.5	Arrange for government support of a straw-to-ethanol-project				▲													IMC
Result 2: Suitable R&D scheme for the pre-treatment of rice straw is set-up and leads to desired results																		
2.1	Prepare technical design study, reviewing and amalgamating current know-how on straw conversion																$ 150.000	
2.1.1	Set-up concept and layout																	Egyptian / Internat Consultants
2.1.2	Tender study																	
2.1.3	Identify study group and implement analysis work																	
2.1.4	Conclude on technical design, define size and mode of operation			▲														
2.2	Present study and recommendations			▲														
2.3	Obtain agreement on setting-up pilot plant			▲														IMC

1.9.10 Log-Frame for setting up a bio-Ethanol Plant based on Rice Straw with a annual capacity of 20.000 tons (Activity & Resource System)

No.	Action	Timeline (months after process-start) 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30	Costs	Responsible
Result 3: The pre-treatment of rice straw is piloted and leads to the desired results				
3.1	Define ownership of pilot plant and local coordination			IMC
3.2	Prepare engineering of pilot plant			
3.2.1	Set-up tender documents			IMC/
3.2.2	Tender engineering			Egyptian/
3.2.3	Identify and contract engineering company			internat.
3.2.4	Set-up pilot plant		$ 0,3-0,8 Mio	engineers
3.2.5	Monitor pilot plant construction and start-up			
3.3	Implement R&D program accompaning pilot runs		$ 100.000	
3.3.1	Define priority topics			
3.3.2	Set-up R&D plan			Egyptian
3.3.3	Define management of R&D			scientific
3.3.4	Adjust operation of pilot plant according to R&D results			institute
3.3.5	Define optimised technical straw treatment system			
3.4	Set-up economic monitoring		$ 50.000	IMC/
3.4.1	Select responsible economist			Egyptian/
3.4.2	Define key parameters to monitor			internat.
3.4.3	Evaluate economically R&D results and feedback to engineers			consultants
3.5	Define concept for straw collection		$ 30.000	
3.5.1	Identify sites with highest straw production			
3.5.2	Identify and appraise current practices			IMC/
3.5.3	Benchmark current practices agianst needs			Egyptian
3.5.4	Define optimum straw collection and logistic system			consultants
3.5.5	Estimate straw prices delivered to plant			
3.6	Set-up comprehensive techno-economic report on experiences with pilot plant		$ 50.000	IMC/
3.6.1	Conclude on design and summarise technical parameters on which commercial plant can be built			Egyptian/ internat.
3.6.2	Run investment model and conclude on economics			consultants

1.9.11 Log-Frame for setting up a bio-Ethanol Plant based on Rice Straw with an annual capacity of 20.000 tons (Activity & Resource System)

Action		Timeline (months after process-start)															Costs	Responsible
		2	4	6	8	10	12	14	16	18	20	22	24	26	28	30		
Result 4: The results of a fesibility study considering the optimised pre-tretment of rice straw justify investments in a commercial plant																		
4.1	Amalgamate results from studies under result 3 to business case																	
4.2	Carry out scenario building and pressure testing																	as for result 3.6
4.3	Translate findings into dossier for political approval																	
4.4	Present results to political decision makers and local business community																	IMC
Result 5: Suitable investment scheme for a rice straw-based ethanol plant is identified and implemented																		
5.1	Review agricultural policy instruments in favour of rice straw collection																$ 50.000	IMC/ alternatively Egyptian/ internat. study group
5.1.1	Identify possibilities to support setting-up rice straw collection farmer associations																	
5.1.2	Introduce strategy as component of agricultural extension																	
5.1.3	Integrate extension service with commercial rice straw users																	
5.2	Set-up promotional dossier to attract private contributions to setting-up commercial rice straw-based ethanol plant																	IMC
5.3	Define Government's role																	IMC
5.4	Set-up coordinating and supervising body																	IMC
5.5	Identify & implement support schemes for investment & balancing risk																	IMC
5.6	Conclude promotional efforts by attracting a local private lead investor																	IMC
Result 6: Plant is constructed within 12 months and successfully started-up																		
6.1	Accompany investor in administrative procedures																	IMC
6.2	Coordinate construction work with investor																	IMC
6.3	Facilitate setting-up organisational and company structures																	IMC
6.4	Facilitate access to international customers																$ 100.000	
6.4.1	Select and contract marketing consultant																	Egyptian/ Internat. consultants
6.4.2	Arrange for customer meetings																	
6.4.3	Moderate meetings with the objective to conlcude long-term delivery contracts																	
6.5	Support investor in obtaining adequate deliveries of raw materials																	MOA

2 Review of Globally Important Products, Markets and Policies

2.1 Summary

This part reviews and prioritizes globally important industrial biotech products manufactured by fermentation according to technical, economical and market relevant parameters. The 26 products analysed represent more than 90% of the global market value generated in 2005/06. The analysis captures step 1 and 3 and a part of step 5 of the commissioned work on setting up a blueprint for Egypt's biotechnology strategy. The report unfolds in three chapters: Description of the 26 individual products by market and technology parameters; setting up a multi-dimensional scoring system comparing and ranking the analysed products; identification and suggestion of products for further analysis of their goodness of fit to Egypt's framework conditions. Highlights of this analytical study are:

- There are only three products for which volumes and prices increased in the past ten years (MSG, bio-ethanol and acetic acid). For all other products, volume sales increased, but prices decreased.
- There are only four products which are not dominated by a few global players and for which Chinese/Indian competition is still tolerable: Bio-ethanol, acetic acid, lysine and MSG.
- In most cases, margins are still considerable. However for products like xanthan, citric acid and gluconic acid, competition is so fierce, that hardly any margin can be expected under the current conditions.
- Future growth rates for many products are expected to be high. However only bio-ethanol, bio-polymers, threonine, lysine and lactic acid will see exceptional volume growth until 2015 of more than 100%.
- Many fermentation processes convert carbohydrates efficiently. Conversion rates of above 50% could be identified for 40% of the screened products. However valuable and marketable by-products (residue from fermentation) can only be obtained from acetic acid and bio-ethanol.
- Fermentation is not a small business. Typical plant sizes are usually large. For most products it has to be above 10.000 tons, and for bio-ethanol well above 100.000 tons per year for generating a reasonable economics.
- Plant sizes correlate with specific investment needs. The lowest specific investments are with € 500/ton capacity found with bio-ethanol plants and the highest with more than € 1 Mio for carotenoid and vitamin plants.
- Fermentation products are partly commodities but skills needed to run processes and to market resulting products successfully demand high skills. Only in the case of acetic acid, xanthan, gluconic acid, lysine, bio-ethanol, MSG and vitamin B12 the requirements for marketing and process management are considered to be moderate.

The result of scoring 25 characteristics for each product is that an ideal fermentation product does not exist. However there are four products with 70 - 80% score achievement: Lysine, MSG, acetic acid and bio-ethanol; the last ones ranking clearly at the top. It is therefore suggested to analyse bio-ethanol and acetic acid in more detail and screen their relevance and feasibility with respect to the framework conditions and easiness of setting up such industries in Egypt.

2.2 General Background

Over the past decades Egypt made substantial progress in its development from a rural society to a balanced modern state, with a lively industrial and public sector. Investments in the industrial sector have been strong and focused on the build-up of industries necessary for the advancement and modernisation of a growing country. Following the Barcelona Declaration, Egypt initialled a partnership agreement with the EU in 2001 covering cooperation in economic, social and political issues and stipulating the progressive establishment, during a transition period of twelve years of a free trading Euro-Mediterranean zone between Egypt and the EU. The agreement entered into force in June 2004.

The process of integration calls for a pro-active approach from Egypt to respond to the increasing competitiveness pressure and has to define and implement winning strategies for its industry. Egypt disposes of resources such as human and natural ones, location, political and social stability, which might allow to further build-up an industrial sector, which is considered to be a key element in the macro-economic development of Egypt. The Industrial Modernisation Programme (IMP) is an initiative of the Government of Egypt to help develop international competitiveness in the industrial sector so that it can benefit from the new opportunities that will follow the liberalisation of trade and exposure to global markets. It is the first phase of the Government's long-term industrial development strategy. To achieve this aim of modernisation, the Industrial Modernisation Centre (IMC) will be the agent for achieving the Government's vision of a globally competitive industrial sector. The aim is to create an environment in which the private sector can lead growth and make Egyptian industries growing progressively and actively into global competitiveness.

Historically, within the industrial sector the development of the pharmaceutical industry played a prominent role as it allowed Egypt to gain certain self-sufficiency in essential drugs. Antibiotic as well as insulin production are considered as the core of this development, supplemented by successful production and marketing of fermentation derived products. In view of the globally growing and profitable biotechnological and fermentation industry, the Egyptian Government identified biotechnology and fermentation as one of the potential growth areas in future, allowing Egypt to participate in global developments, which are to a substantial extent driven by biotechnology and fermentation. The Egyptian Government shows a strong interest to develop that sector via strengthening relevant resources and by technology transfer from cooperating countries. Egypt undertook some research and development work on industrial biotechnology and fermentation[2], reformed its university and education system and increased the number of well-trained chemical engineers, pharmaceutical technologists and biotechnologists to be prepared for a major move in biotechnology and fermentation.

Such a coordinated effort led to the building-up of a still small, but active pharmaceutical-independent industrial biotech and fermentation cluster.

[2] The terms industrial biotechnology and fermentation are used in this paper interchangeable. They denote the industrial production of feedstock and chemicals by micro-organisms.

2.3 Review of the Global Biotech Industry

2.3.1 Criteria Selection for Product Profiles

For almost all internationally relevant industrial products (26) which can be produced by fermentation, profiles structured in seven sections are indicated:

- Historic and current market parameters,
- Future developments,
- Process characteristics,
- Size and cost structure of typical plants,
- Patent situation,
- Flexibility of process,
- Success factors.

The rational for selecting the various parameters is:

2.3.1.1 Historic and Current Market Parameters

- *Market size:* This is an indication of the volumes[3] produced on a global scale. The parameter gives an estimation of the importance of the product.
- *Growth rates of market size*: A time series of more than ten years on volume development is analysed and historic annual growth rates are calculated. They indicate the development of importance of the product over past years.
- *Main usage*: All fermentation products are either used for food, feed, supplement and pharmaceutical or industrial applications. The distribution of usage indicates the main outlets and has relevance for the marketing system.
- *Share of base product converted*: Many products manufactured by fermentation can be sold as such but in a few cases derivatives in the form of salts are important. Such conversion implies an additional manufacturing step of various degree of sophistication. Also a high proportion of the base material converted points at the need for more sophisticated marketing systems.
- *Product form*: In most cases products are sold either as powders or as liquids. Powders are easier to store and the handling is usually more convenient than of liquids.
- *Prices and price trends*: Low unit prices indicate that the product might have a strong commodity character and the historic price trend shows how the competitive situation developed in the past.
- *Market value*: This is the amalgamation of current volumes and prices.
- *Regulation*: If a product is not regulated it is easier to introduce it to markets than when a product is restricted in its main consumption areas such as the

[3] Expressed as crude product; salts and derivatives are converted to basic material

EU and North America. A regulated product frequently implies that specific registration processes have to be pursued prior to free selling.

- *Image of product*: This is an indicator to what extent a product is welcome by consumers or whether it needs specific efforts to convince customers to use it. Most fermentation products are still high in image, except those which are manufactured by GMOs.
- *Number and market share of main producers*: This is an indication on how concentrated the market is. It is more difficult to break into a highly concentrated market rather than in a fragmented one.
- *Market share of Chinese/Indian producer*: The more Indian and Chinese manufacturers dominate the market, the more the product is under price pressure and the more unpredictable the whole market set-up is.
- *Distribution system and value chains*: As many fermentation products are commodities, margins are tight. Longer distribution chains imply that at every step a certain margin is extracted. The shorter the distribution chain is the more margin remains with the producer.
- *Requirement of formulation*: Formulating a product needs an additional manufacturing step and in many cases formulations are more complicated to manufacture than the base product as such. A product needing formulation to be sold requires usually a higher degree of technological sophistication and consequently specific know-how.

2.3.1.2 Future Developments

By nature future developments are estimates on how the market might proceed. Therefore indications on volume and price trends are prone to uncertainties and to a high degree of variability. However based on the development of framework conditions, indications on further volume growth are given.

- A high *volume growth* points at a strong further need of the product and vice versa.
- *Price trends* are more difficult to estimate as many factors, which developments are not known, influence them. In many cases prices for fermentation products are seen to be at the bottom and no major price changes are expected. For a few cases the development of framework conditions are clear enough to indicate increasing or decreasing prices.

2.3.1.3 Process Characteristics

In this section parameters are indicated which define major elements of the fermentation process.

- *Organism used*: Well known organisms indicate that micro-biological procedures are known, while more exotic ones might require a more intensive base work in micro-biology.
- *Process steps*: The description of the main process steps indicates the complexity of a fermentation procedure and allows estimation of the capital and know-how intensity.
- *Carbohydrates used*: Type and number of different carbohydrate substrates used show how flexible an organism is in converting the feed stock into the

desired product. The higher the number of different carbohydrates which can be used is, the more robust is the process. If only one specific carbohydrate can be used, a high degree of sensitivity is assumed.

- *Carbohydrate conversion*: The carbohydrate conversion rate is an indicator of the efficiency of the process.
- *Valuable by-products* have an influence on the economics of a fermentation process. In many cases the extraction of the desired product is based on using solvents, which does not allow the usage of the remaining broth for valuable purposes. However, in a few cases the by-product can additionally be sold and supports the profitability of the system.

2.3.1.4 Size and Costs Structure of typical Plants

These parameters are decisive for the economics of a plant and show the financial implications of setting-up and running a process.

- *Typical size*: Typical size indicates the current industry standard. A plant size below the indicated value usually shows an unfavourable cost structure, mainly due to the over proportional relevance of investment costs.
- *Capacity utilisation*: Capacity utilisation shows to what extent the currently installed global capacity is utilised for manufacturing. A value of below 90% points at overcapacities with strong implications on current and future prices.
- *Investment costs*: Typical investment costs indicate the capital intensity of setting up a plant. The values indicated are linked to the site. Therefore also the sites, to which the investment costs refer to, are shown. Investment costs can vary from region to region. However, lower investment costs frequently correlate with higher maintenance costs and a reduced lifetime of the plant.
- *Production costs*: A comparison of production costs with market prices indicates margins. Such margins are not only profits but must be used for marketing and logistics as well. A very tight margin reduces the flexibility of the product and increases its susceptibility vis-à-vis changes in the markets for the product and main costs parameters.
- *Structure of main costs*: The structure of manufacturing costs shows how important individual items for the total costs are and ultimately which ones are decisive. In the case capital is scarce, a capital-extensive process might be more attractive than a process which is capital intensive. If cheap carbohydrate is available, such process might be attractive, specifically when the carbohydrate conversion rate is high. If low cost electricity and water are available, a process which standard costs are dominated by utility costs might be looked at closer.

2.3.1.5 Patent Protection

This criterion is highlighted as it indicates to what extent the technology is under control by patent holders. Patent protection is in many cases a high barrier of entry. Patent protection is linked to the process itself, the strain and to applications. If a process, parts of it and/or specific important applications are protected by patents of global players and these are not willing to provide licenses, it might be difficult to set up a process line.

2.3.1.6 Flexibility of Process

Flexibility of process is defined in terms of using various carbohydrates, degree of sophistication of technology and whether a set-up plant can be used for the manufacturing of additional products beyond the main one. A highly flexible process reduces the investment risk and allows a faster and less cost intensive reaction vis-à-vis market developments in the case they occur.

2.3.1.7 Success Factors

This table rates those elements deemed to be important for the success of a process and the resulting product. Criteria include process and marketing related ones. The higher the rating of a criterion is the more it influences the probability of success.

2.3.1.8 Data Sources

Most of the data used are numeric and reflect estimations of the author. Such estimations are based on time series of parameters collected over many years. Partly these data are published by the author's BCC reports to be found under www.bccresearch.com.

The arrangement of the data and the tabular presentation has never been published before and will be the property of the client.

Future growth rates and also the rating of success factors are subjective and solely reflect the opinion of the author. It is underlined here that the data provided have not been copied from any other published market research report such as from Frost & Sullivan or Freedonia. It is the experience of the author working in the fermentation industry for over 20 years, which guarantees that the data provided reflect reality.

2.3.2 Data Profiles

2.3.2.1 L-Lysine[4]

I General and Market Characteristics (Lysine)

No	Parameter	Unit	Value
1	**Historic and current market parameters**		
1.1	Market size	Tons	850.000
1.2	Annual growth of market size (1990-2006)	%	10,1
1.3	Main usage		
	Food	%	1
	Feed	%	96
	Supplements/Pharmaceuticals	%	2
	Chemical/ intermediate	%	1
1.4	Share of base product converted to derivative[5]	%	1
1.5	Main product forms		powder[6] and liquid
1.6	Price of base product	€/kg	1,5
1.7	Price of main derivative	€/kg	5
1.8	Annual price trend (Ø1990-2006) of base product	%	-5
1.9	Annual price trend of main derivative (Ø 1990-2006)	%	0
1.10	Market value (2006)	Mio €	1150
1.11	Regulation (EU, NAFTA[7])	Free/regulated	Free
1.12	Image of product	High/low	High
1.13	No of producers	No	>25
1.14	Market share of three main producers	%	51
1.15	Market share of Chinese/Indian producer	%	32
1.16	Distribution system		Trader
1.17	Steps in value chain[8]	No	3
1.18	Requirements of formulation	y/n	N
2	**Future developments**		
2.1	Volume trend[9]	%	+8
2.2	Price trend[10]	%/a	0

[4] The terms l-lysine and lysine are used in this text interchangeably and refer to active lysine
[5] Building block in sport and clinical nutrition
[6] Powder: l-lysine-HCL; liquid: L-lysine 60%
[7] North American Free Trade Associatin (USA, Canada, Mexico)
[8] Producer – trader – feed compounder
[9] Mostly because of the booming poultry and pig industry in South-East Asia
[10] Prices are considered to be at the bottom; a price increase might happen due to increasing raw material prices; a real shortage of lysine is unlikely to happen, as various plants are under construction

2.3	Expected market value in 2015	Mio €	2.300

II Production Characteristics (lysine)

No	Parameter	Unit	Value
3	**Process characteristics**		
3.1	Type of organism used		Corynebacterium glutamicum, and ssp.
3.2	Type of process		Fermentation-removal of cells – ion exchange-crystallisation[11]
3.3	Main carbohydrate		Starch, glucose, saccharose
3.4	Carbohydrate conversion rate	%	55
3.5	Valuable by-product	y/n	no
4	**Size and cost structure of plant**		
4.1	Typical size	Tons/a	15.000
4.2	Global capacity utilisation	%	> 90
4.3	Typical investment	€/ta[12]	1700
4.4	Total cost of production[13]	€/kg	1,4
4.5	Importance of cost items		
	Depreciation[14]	%	25
	Carbohydrate	%	50
	Labour	%	5
	Utility	%	15
	Overhead/others	%	5
4.6	Margin fc[15] (sales price – costs)	%	7
5	**Patent protection of main process steps**	**y/n**	**N**
6	**Flexibility of process**		
6.1	Flexibility in using carbohydrates	h/l	High
6.2	Degree of sophistication	h/m/l	L
6.3	Dedication of plant	d/nd	D, suitable for threonine

[11] Lysine in liquid form avoids crystallisation. Only a concentration step is needed.
[12] ta = tons/year
[13] This is the summary of costs for feedstock, utilities, labour, packaging, administration and depreciation. Values apply for a plant in South Africa.
[14] Depreciation time: five years. This depreciation time is used for all products.
[15] fc = free on carrier

III Success Factors (lysine)

Parameter	**Degree of importance (1 = lowest, 3 = highest)**		
	1	2	3
Economy of scale			X
Quality	X		
Low selling price			X
Specialisation on specific derivatives	X		
Availability of specific know-how (base process)	X		
Availability of specific know-how (formulation)	X		
Availability of spec. carbohydrates	X		
Low priced carbohydrates			X
Low priced labour		X	
Low prices utilities		X	
Availability of excess of water		X	
Availability of specific reaction chemicals	X		
Availability of special sales force/network	X		
Need for customer training	X		
Need for specialized distribution network	X		
Patent protection	X		
Elaborate product/derivative portfolio	X		
Requirement of flexibility vis-à-vis market/consumer developments	X		
Specific permissions/regulations	X		

IV Summarizing comment:

Lysine (feed grade) is a high volume, low priced and well established commodity for the international compound feed market (poultry and swine). The product is highly competitive and in competition with the soy cakes to wheat price relationship. Processes are established and gains in efficiencies are expected to be limited in future. Future demand is exceptionally high, mainly in Asia. Future prices are expected to remain low, as long as abundant soy cake is around and wheat remains expensive. Therefore the main deciding factor for success in lysine is plant size and low cost feed stock.

2.3.2.2 Citric Acid

I General and Market Characteristics (citric acid)

No	Parameter	Unit	Value
1	**Historic and current market parameters**		
1.1	Market size[16]	Tons	1.400.000
1.2	Annual growth of market size (1993-2006)	%	6,0
1.3	Main usage		
	Food	%	68
	Feed	%	2
	Supplements/Pharmaceuticals	%	8
	Chemical/ intermediate	%	22
1.4	Share of base product converted[17]	%	70
1.5	Main product forms		powder
1.6	Price of base product	€/kg	0,8
1.7	Price of main derivative	€/kg	1,1
1.8	Price trend (Ø1990-2006) of base product	%	-2
1.9	Price trend of main derivative (Ø 1990-2006)	%	-2
1.10	Market value (2006)	Mio €	1.414
1.11	Regulation (EU, NAFTA)	Free/regulated	Free
1.12	Image of product	High/low	high
1.13	No of producers	No	37
1.14	Market share of three main producers	%	41
1.15	Market share of Chinese/Indian producer	%	50
1.16	Distribution system		Trader/direct
1.17	Steps in value chain[18]	No	2/3
1.18	Requirements of formulation	y/n	N
2	**Future developments**		
2.1	Volume trend	%	4
2.2	Price trend[19]	%	0
2.3	Expected market value in 2015	Mio €	2.012

[16] As citric acid monohydrate summarizing also salts, derivatives, etc.
[17] Mono-, anhydride-, citrates and esters; the base product is citric acid monohydrate
[18] Producer – trader – user; it is rare for Chinese product, that citric acid is sold directly from the producer to the user. For Western producer such direct sales is more common
[19] Prices for citric acid are considered to be at the bottom. Overcapacities exist and will prevent that prices rise in the near future considerably.

II Production Characteristics (citric acid)

No	Parameter	Unit	Value
3	**Process characteristics**		
3.1	Type of organism used		Aspergillus niger
3.2	Type of process		Pan/submerged fermentation – precipitation with Ca(OH)2 – purification
3.3	Main carbohydrate		Molasses, starch
3.4	Carbohydrate conversion rate	%	75
3.5	Valuable by-product	y/n	No[20]
4	**Size and cost structure of plant**		
4.1	Typical size	Tons/a	50.000
4.2	Global capacity utilisation	%	< 90
4.3	Typical investment[21]	€/ta	1.400
4.4	Total cost of production[22]	€/kg	0,8
4.5	Importance of cost items		
	Depreciation	%	30
	Carbohydrate	%	30
	Labour	%	15
	Utility	%	11
	Overhead/others	%	14
4.6	Margin fc (sales price – costs)	%	0
5	**Patent protection of main process steps**	**y/n**	**N**
6	**Flexibility of process**		
6.1	Flexibility in using carbohydrates	h/l	H
6.2	Degree of sophistication	h/m/l	M
6.3	Dedication of plant	d/nd	D

[20] The main by-product is gypsum
[21] Submerged fermentation and site in Western Europe
[22] At this moment, there is, even for larger plants no way to make profits with citric acid mono hydrate

III Success Factors (citric acid)

Parameter	**Degree of importance (1 = lowest, 3 = highest)**		
	1	2	3
Economy of scale			X
Quality[23]		(X)	X
Low selling price			X
Specialisation on specific derivatives			X
Availability of specific know-how (base process)		X	
Availability of specific know-how (formulation[24])			X
Availability of spec. carbohydrates	X		
Low priced carbohydrates			X
Low priced labour	X		
Low prices utilities	X		
Availability of excess of water		X	
Availability of specific reaction chemicals	X		
Availability of special sales force/network		X[25]	
Need for customer training	X		
Need for specialized distribution network	X		
Patent protection	X		
Elaborate product/derivative portfolio			X
Requirement of flexibility vis-à-vis market/consumer developments		X	
Specific permissions/regulations	X		

IV Summarizing Comment

Citric acid is a well established large ingredient for the food and many other industries. Basic citric acid is produced by a number of, mostly Asian companies. Overcapacities exist. Most of the citric acid produced is used in food or related applications. Therefore quality criteria are important. As citric acid is converted to some extent into derivatives and salts, sales force for different applications is different and must be able to explain differences of various types of citric acid products. But overall, size of the plant, availability of low cost raw materials and additionally a high quality produce decide on marketing success. Emerging niches are found in citric acid esters to be used as plasticizers. This market is still small and requires specific technology and know-how on all levels. It's future growth is assumed to be exceptionally high.

[23] High for food, and medium for technical applications such as in washing powders
[24] For manufacturing of higher valued derivatives
[25] Not needed for standard products, but essential for products such as esters

2.3.2.3 Ascorbic Acid

I General and Market Characteristics (ascorbic acid)

No	Parameter	Unit	Value
1	**Historic and current market parameters**		
1.1	Market size	Tons	150.000
1.2	Annual growth of market size (1993-2006)	%	8
1.3	Main usage		
	Food	%	49
	Feed	%	13
	Supplements/Pharmaceuticals	%	30
	Chemical/ intermediate	%	8
1.4	Share of base product converted to derivatives[26]	%	40
1.5	Main product form		powder
1.6	Price of base product	€/kg	3,8
1.7	Price of main derivative	€/kg	4,0
1.8	Price trend (Ø1990-2006) of base product	%	-13
1.9	Price trend of main derivative (Ø 1990-2006)	%	-21
1.10	Market value (2006)	Mio €	582
1.11	Regulation (EU, NAFTA)	Free/regulated	Free
1.12	Image of product	High/low	High
1.13	No of producers	No	11
1.14	Market share of three main producers	%	45
1.15	Market share of Chinese/Indian producer	%	78
1.16	Distribution system		Direct/trader
1.17	Steps in value chain[27]	No	2-4
1.18	Requirements of formulation	y/n	N[28]
2	**Future developments**		
2.1	Volume trend	%	4
2.2	Price trend	%/a	0[29]
2.3	Expected market value in 2015	Mio €	828

[26] Ca, K, and Na-Ascorbates, Ascorbylpalmitate and ascorbyl-polyphosphates
[27] Producer – user; producer – trader – user; producer – manufacturer of derivatives – trader - user
[28] For some applications ascorbic acid is coated. But the volumes of coated ascorbic acid relative to the overall production is small
[29] There is still an overcapacity in the market, which will prevent a major upswing of prices in the next years

II Production Characteristics (ascorbic acid)

No	Parameter	Unit	Value
3	**Process characteristics**		
3.1	Type of organism used		Gluconobacter, Corynebacterium, Ervinia, Bacillus
3.2	Type of process		2-stage fermentation or bioconversion of sorbitol and chemical conversion of KGA[30]
3.3	Main carbohydrate		Sorbitol, sorbose, glucose
3.4	Carbohydrate conversion rate	%	45
3.5	Valuable by-product	y/n	n
4	**Size and cost structure of plant**		
4.1	Typical size	Tons/a	20.000
4.2	Global capacity utilisation	%	< 90
4.3	Typical investment	€/ta	4.100
4.4	Total cost of production	€/kg	3,3
4.5	Importance of cost items		
	Depreciation	%	25
	Carbohydrate	%	11
	Labour	%	17
	Utility	%	32
	Overhead/others	%	15
4.6	Margin fc (sales price – costs)	%	15
5	**Patent protection of main process steps**	**y/n**	**N**
6	**Flexibility of process**		
6.1	Flexibility in using carbohydrates	h/l	L
6.2	Degree of sophistication	h/m/l	H
6.3	Dedication of plant	d/nd	D

[30] KGA = Keto-Gluconic-Acid produced by fermentation

III Success Factors (ascorbic acid)

Parameter	Degree of importance (1 = lowest, 3 = highest)		
	1	2	3
Economy of scale			X
Quality			X
Low selling price			X
Specialisation on specific derivatives		X	
Availability of specific know-how (base process)			X
Availability of specific know-how (formulation[31])		X	
Availability of spec. carbohydrates			X
Low priced carbohydrates		X	
Low priced labour	x		
Low prices utilities			X
Availability of excess of water			
Availability of specific reaction chemicals			X
Availability of special sales force/network		X	
Need for customer training	X		
Need for specialized distribution network		X	
Patent protection	X		
Elaborate product/derivative portfolio		X	
Requirement of flexibility vis-à-vis market/consumer developments	X		
Specific permissions/regulations	X		

IV Summarizing comment

Ascorbic acid became a Chinese product, after Merck and BASF closed their European plants recently. There is only DSM left in Western world. The product is growing fast, but still overcapacities exist, prices are low and it is not expected that such prices recover soon. As a typical food and pharmaceutical product, quality requirements are high. Processes in use are mainly modifications of the Reichstein process, based on bio-conversion of sorbitol and of sorbose to keto-gulonic acid. The last step is a chemical conversion. Successful sales of ascorbic acid require a full range of salts and of derivatives. Size of plant, quality of the product, full portfolio and prices decide on a success. Trained and knowledgeable sales force is an asset as there are no bulk sales.

[31] For derivatives

2.3.2.4 Monosodium Glutamate

I General and Market Characteristics (monosodium glutamate)

No	Parameter	Unit	Value
1	**Historic and current market parameters**		
1.1	Market size (as MSG)	Tons	1.900.000
1.2	Annual growth of market size (1993-2006)	%	4,1
1.3	Main usage		
	Food	%	99
	Feed	%	0,4
	Supplements/Pharmaceuticals	%	0,1
	Chemical/ intermediate	%	0,5
1.4	Share of base product converted[32]	%	1
1.5	Main product form		powder
1.6	Price of base product	€/kg	1
1.7	Price of main derivative	€/kg	4,5
1.8	Price trend (Ø1990-2006) of base product	%	2
1.9	Price trend of main derivative (Ø 1990-2006)	%	1
1.10	Market value (2006)	Mio €	1.900
1.11	Regulation (EU, NAFTA)	Free/regulated	free
1.12	Image of product	High/low	high
1.13	No of producers	No	> 25
1.14	Market share of three main producers	%	32
1.15	Market share of Chinese/Indian producer	%	30
1.16	Distribution system		Direct/trader
1.17	Steps in value chain	No	2-3
1.18	Requirements of formulation	y/n	no
2	**Future developments**		
2.1	Volume trend	%	4
2.2	Price trend	%/a	0
2.3	Expected market value in 2015	Mio €	2.704

[32] gluamin

II Production Characteristics (monosodium glutamate)

No	Parameter	Unit	Value
3	**Process characteristics**		
3.1	Type of organism used		Coryne-bacterium
3.2	Type of process		Fermentation, addition of NAOH, crystallisation, purification
3.3	Main carbohydrate		molasses/starch
3.4	Carbohydrate conversion rate	%	85
3.5	Valuable by-product	y/n	n
4	**Size and cost structure of plant**		
4.1	Typical size	Tons/a	50.000
4.2	Global capacity utilisation	%	> 90
4.3	Typical investment[33]	€/ta	1.150
4.4	Total cost of production	€/kg	0,9
4.5	Importance of cost items		
	Depreciation	%	24
	Carbohydrate	%	28
	Labour	%	10
	Utility	%	28
	Overhead/others	%	10
4.6	Margin fc (sales price – costs)	%	20
5	**Patent protection of main process steps**	**y/n**	**no**
6	**Flexibility of process**		
6.1	Flexibility in using carbohydrates	h/l	h
6.2	Degree of sophistication	h/m/l	m
6.3	Dedication of plant	d/nd	d

[33] Site: Western Europe

III Success Factors (monosodium glutamate)

Parameter	Degree of importance (1 = lowest, 3 = highest)		
	1	2	3
Economy of scale			X
Quality			X[34]
Low selling price			x
Specialisation on specific derivatives	X		
Availability of specific know-how (base process)		x	
Availability of specific know-how (formulation)	X		
Vicinity of market		X	
Availability of spec. carbohydrates		X[35]	
Low priced carbohydrates			X
Low priced labour	x		
Low prices utilities			X
Availability of excess of water		x	
Availability of specific reaction chemicals	X		
Availability of special sales force/network	X		
Need for customer training	X		
Need for specialized distribution network	X		
Patent protection	X		
Elaborate product/derivative portfolio	X		
Requirement of flexibility vis-à-vis market/consumer developments	X		
Specific permissions/regulations	X		

IV Summarizing comment

MSG is an Asian product. However in line with the North American and European trend to convenient and ethno products, demand is rising also in these regions. MSG is the largest amino acid produced by fermentation and in consequence plant sizes are also big. Ajinomoto is dominating the market, but also in China many smaller manufacturers are present. MSG price over the years was always in the range of € 1/kg, fluctuating between € 0,8/kg and € 1,8/kg[36]. The process is well established but MSG is tricky to crystallize and demands some additional chemicals (NaOH). Selling of MSG is not difficult; every food ingredient trader must offer MSG. Due to the strong rise of income in Asia over the last years and the subsequent trend to better foods, installed MSG capacity is at its limits. There is reason to assume that demand growth in the next years continues with fairly stable or even increasing prices. Ultimately it is the economy of scale in combination with a constant high product quality deciding on the market success of MSG.

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34 Type of crystals limits application (for spices, dry soups etc)
35 Molasses types have to be chosen in relation to the strain.
36 In several countries MSG is a market regulated product with high import duties and threshold taxes. Several Asian countries have MSG prices at 60% higher levels than the normal market.

2.3.2.5 Threonine

I General and Market Characteristics (threonine)

No	Parameter	Unit	Value
1	**Historic and current market parameters**		
1.1	Market size	Tons	50.000
1.2	Annual growth of market size (1993-2006)	%	13
1.3	Main usage		
	Food[37]	%	2
	Feed	%	95
	Supplements/Pharmaceuticals	%	3
	Chemical/ intermediate	%	0
1.4	share of base product converted to derivative	%	0
1.5	Main product form		powder
1.6	Price of base product	€/kg	1,7
1.7	Price of main derivative	€/kg	-
1.8	Price trend (Ø1990-2006) of base product	%	-10
1.9	Price trend of main derivative (Ø 1990-2006)	%	-
1.10	Market value (2006)	Mio €	85
1.11	Regulation (EU, NAFTA)	Free/regulated	free
1.12	Image of product	High/low	high
1.13	No of producers	No	6
1.14	Market share of three main producers	%	90
1.15	Market share of Chinese/Indian producer	%	6
1.16	Distribution system		trader
1.17	Steps in value chain	No	3
1.18	Requirements of formulation	y/n	no
2	**Future developments**		
2.1	Volume trend	%	10[38]
2.2	Price trend	%/a	0[39]
2.3	Expected market value in 2015	Mio €	200

[37] Clinical and sport nutrition
[38] This figure strongly depends on the further customer training and also to what extent high performing animals can be fed with competitive soy protein
[39] Current price is seen at the bottom. Further decreases are unlikely. As the number of producer is limited, a severe competition does not exist. A rise in carbohydrate prices might induce a rise in threonine prices

II Production Characteristics (threonine)

No	Parameter	Unit	Value
3	**Process characteristics**		
3.1	Type of organism used		Coryne-bacterium glutamicum
3.2	Type of process		lysine type
3.3	Main carbohydrate		sucrose
3.4	Carbohydrate conversion rate	%	30
3.5	Valuable by-product	y/n	n
4	**Size and cost structure of plant**		
4.1	Typical size	Tons/a	10.000
4.2	Global capacity utilisation	%	> 90
4.3	Typical investment[40]	€/ta	3.100
4.4	Total cost of production	€/kg	1,6
4.5	Importance of cost items		
	Depreciation	%	39
	Carbohydrate	%	30
	Labour	%	9
	Utility	%	15
	Overhead/others	%	7
4.6	Margin fc (sales price – costs)	%	6
5	**Patent protection of main process steps**	**y/n**	**yes**
6	**Flexibility of process**		
6.1	Flexibility in using carbohydrates	h/l	l
6.2	Degree of sophistication	h/m/l	high
6.3	Dedication of plant	d/nd	d, lysine

[40] Western Europe

III Success Factors (threonine)

Parameter	**Degree of importance (1 = lowest, 3 = highest)**		
	1	2	3
Economy of scale			X
Quality	X		
Low selling price			x
Specialisation on specific derivatives	X		
Availability of specific know-how (base process)			X
Availability of specific know-how (formulation)	X		
Availability of spec. carbohydrates		X	
Low priced carbohydrates			X
Low priced labour	X		
Low prices utilities		X	
Availability of excess of water			
Availability of specific reaction chemicals	X		
Availability of special sales force/network		X	
Need for customer training			X
Need for specialized distribution network		X	
Patent protection			X
Elaborate product/derivative portfolio	X		
Requirement of flexibility vis-à-vis market/consumer developments	X		
Specific permissions/regulations	X		

IV Summarizing comment:

Threonine is an amino acid used to supplement feeding rations and to substitute plant protein. It is the third most important amino acid in feed. The product is fairly new and thus price decreases correlate with building up capacities. Prices are now very close to those of lysine and also production processes are almost identical. Since threonine is more sensitive to changes/errors in process management than lysine, production requires high skilled and experienced technicians. Also threonine is not yet sold as a commodity and thus some customer training and a knowledgeable and appropriate sales network will be needed for successful selling. The process is not yet as efficient as that of lysine. Economy of scale but especially low and appropriate carbohydrates plays an immense role for success.

2.3.2.6 Tryptophan

I General and Market Characteristics (tryptophan)

No	Parameter	Unit	Value
1	**Historic and current market parameters**		
1.1	Market size	Tons	4.000[41]
1.2	Annual growth of market size (1993-2006)	%	22
1.3	Main usage		
	Food	%	0
	Feed	%	99
	Supplements/Pharmaceuticals	%	1
	Chemical/ intermediate	%	0
1.4	Share of base product converted to derivatives	%	0
1.5	Main product form		powder
1.6	Price of base product	€/kg	10
1.7	Price of main derivative	€/kg	-
1.8	Price trend (Ø1990-2006) of base product	%	-17
1.9	Price trend of main derivative (Ø 1990-2006)	%	-
1.10	Market value (2006)	Mio €	20
1.11	Regulation (EU, NAFTA)	Free/regulated	Regulated
1.12	Image of product	High/low	High
1.13	No of producers	No	4
1.14	Market share of three main producers	%	95
1.15	Market share of Chinese/Indian producer	%	5
1.16	Distribution system		trader, direct
1.17	Steps in value chain	No	2-3
1.18	Requirements of formulation	y/n	No
2	**Future developments**		
2.1	Volume trend	%	7
2.2	Price trend[42]	%/a	-3
2.3	Expected market value in 2015	Mio €	28

[41] After Ajinomoto has extended the French enterprise

[42] For larger scale use, the product is still too expensive. It is expected that main producers lower price in order to stimulate volume sales. The product is only needed for high performing animals and is economically viable if soy protein is high in price and if highest productivity of animals (pigs, poultry) must be obtained. Thus the market is confined to some countries in Europe, North America and a few countries in Asia.

II Production Characteristics (tryptophan)

No	Parameter	Unit	Value
3	**Process characteristics**		
3.1	Type of organism used		Coryne-bacterium glutamicum
3.2	Type of process		lysine type
3.3	Main carbohydrate		sucrose
3.4	Carbohydrate conversion rate	%	25
3.5	Valuable by-product	y/n	n
4	**Size and cost structure of plant**		
4.1	Typical size	Tons/a	1.000
4.2	Global capacity utilisation	%	< 90
4.3	Typical investment[43]	€/ta	1.200
4.4	Total cost of production	€/kg	5
4.5	Importance of cost items (excl. investment/financing)		
	Depreciation	%	48
	Carbohydrate	%	25
	Labour	%	11
	Utility	%	11
	Overhead/others	%	5
4.6	Margin fc (sales price – costs)	%	100
5	**Patent protection of main process steps**	**y/n**	**yes**
6	**Flexibility of process**		
6.1	Flexibility in using carbohydrates	h/l	l
6.2	Degree of sophistication	h/m/l	m
6.3	Dedication of plant	d/nd	d

[43] In Western Europe: dedicated plant. With some modifications, tryptohpane can be produced on Treonine lines.

III Success Factors (tryptophan)

Parameter	**Degree of importance (1 = lowest, 3 = highest)**		
	1	2	3
Economy of scale		x	
Quality		x	
Low selling price			x
Specialisation on specific derivatives	X		
Availability of specific know-how (base process)		x	
Availability of specific know-how (formulation)	X		
Availability of spec. carbohydrates		X	
Low priced carbohydrates		x	
Low priced labour	X		
Low prices utilities	X		
Availability of excess of water		x	
Availability of specific reaction chemicals	X		
Availability of special sales force/network			X
Need for customer training			X
Need for specialized distribution network			X
Patent protection			X
Elaborate product/derivative portfolio	X		
Requirement of flexibility vis-à-vis market/consumer developments	X		
Specific permissions/regulations		X	

IV Summarizing comments

Tryptophan is the fourth most important amino acid for compound feed. The product is even younger than threonine, and as the limited number of producer shows, the process is not yet installed on a wide scale. The efficiency of the process is relatively low and requirements in process managements are very high. Further, for a feed ingredient tryptophan is still expensive and requires a very convincing sales staff for marketing. It is expected that over the next years, process research will allow a lower price which will then make marketing easier. Thus the economy of scale and a highly professional micro-biological and technical process engineering staff for optimisation is supposed to be needed for market success in addition to a knowledgeable and dedicated sales force.

2.3.2.7 Aspartic Acid and Aspartame

I General and Market Characteristics (aspartic acid (AA) and aspartame (AM))

No	Parameter	Unit	Value
1	**Historic and current market parameters**		
1.1	Market size	Tons (AM[44])/(AA)	35.000 / 24.000
1.2	Annual growth of market size (1993-2006)	%	5 (AM)
1.3	Main usage		
	Food[45]	% (AM) / (AA)	96 / 03
	Feed	% (AM) / (AA)	00 / 05
	Supplements/Pharmaceuticals	% (AM) / (AA)	04 / 07
	Chemical/ intermediate for (AM)	% (AM) / (AA)	00 / 85
1.4	share of base product converted to derivative	% (AM) : (AA)	45-50
1.5	Main product form		powder
1.6	Price of base product	€/kg (AM)/(AA)	30 / 4
1.7	Price of main derivative	€/kg (AA base)	6-9
1.8	Price trend (Ø1990-2006) of base product	%	-3
1.9	Price trend of main derivative (Ø 1990-2006)	%	-
1.10	Market value as AA (2006)	Mio €	96
1.11	Regulation (EU, NAFTA)	Free/regulated	regulated
1.12	Image of product	High/low	low
1.13	No of producers	No	12
1.14	Market share of three main producers	%	80
1.15	Market share of Chinese/Indian producer	%	30
1.16	Distribution system		direct
1.17	Steps in value chain[46]	No	2
1.18	Requirements of formulation (AA)	y/n	n
2	**Future developments**		
2.1	Volume trend[47]	%	2
2.2	Price trend[48]	%/a	0
2.3	Expected market value in 2015	Mio €	115

[44] Total market for aspartam irrespective of production route
[45] As an intensive sweetener in the form of aspartame
[46] For aspartic acid: Producer – customer; for aspartame: producer of aspartic acid – converter to aspartame – trader - customer
[47] The demand for high intensive sweeteners is strongly rising. Aspartame is one of the oldest sweeteners. Therefore the product is not in high demand, except for those applications where price is key.
[48] There are no indications that prices will rise in future. The market seems to be consolidated and even Chinese manufacturers are not fighting for shares at this moment.

II Production Characteristics (aspartic acid)

No	Parameter	Unit	Value
3	**Process characteristics**		
3.1	Type of organism used		Fuso bacterium, E.coli
3.2	Type of process		Bioconversion of fumaric acid, to NH4-aspartate and chemical conversion to L-aspartic acid
3.3	Main carbohydrate		Fumaric acid
3.4	Carbohydrate conversion rate	%	65
3.5	Valuable by-product	y/n	n
4	**Size and cost structure of plant**		
4.1	Typical size	Tons/a	5.000
4.2	Global capacity utilisation	%	> 90
4.3	Typical investment[49]	€/ta	2.200
4.4	Total cost of production	€/kg	3,5
4.5	Importance of cost		
	Depreciation	%	33
	Carbohydrate	%	30
	Labour	%	10
	Utility	%	16
	Overhead/others	%	11
4.6	Margin fc (sales price – costs)	%	13
5	**Patent protection of main process steps**	**y/n**	**no**
6	**Flexibility of process**		
6.1	Flexibility in using carbohydrates	h/l	low
6.2	Degree of sophistication	h/m/l	low
6.3	Dedication of plant	d/nd	d

[49] USA

III Success Factors (aspartic acid)

Parameter	**Degree of importance (1 = lowest, 3 = highest)**		
	1	2	3
Economy of scale		X	
Quality			X
Low selling price			X
Specialisation on specific derivatives	X		
Availability of specific know-how (base process)		X	
Availability of specific know-how (formulation)	x		
Vicinity of market		X	
Availability of spec. carbohydrates		X	
Low priced carbohydrates			X
Low priced labour	X		
Low prices utilities		x	
Availability of excess of water			
Availability of specific reaction chemicals		X	
Availability of special sales force/network		X	
Need for customer training	X		
Need for specialized distribution network			X
Patent protection	X		
Elaborate product/derivative portfolio	X		
Requirement of flexibility vis-à-vis market/consumer developments	X		
Specific permissions/regulations		X	

IV Summarizing comment

Aspartic acid is not produced by fermentation as such. One of the building blocks, fumaric acid can be converted by micro-organisms to aspartic acid. For a decent economics of aspartic acid low fumaric acid prices[50] are of key importance. Although most of the aspartic acid is still produced in North America, it develops to a Chinese product and thus the reference is China. The main application of aspartic acid is in foods as an intensive sweetener in the form of aspartame. The intensive sweetener market is vast, but new and more convenient products are in the market. Aspartame is used because of its low price and because the product is well known, researched and registered. Future growth rates will be relatively small. Overall for a successful selling of aspartic acid, it is essentially only cost of production, a reliable food approved quality and access to customers who convert the product to aspartame.

[50] Fumaric acid is a by-product of the petro-chemistry based production of maleic acid and of phtalate production

2.3.2.8 Iso-Ascorbic Acid51

I General and Market Characteristics (iso-ascorbic acid)

No	Parameter	Unit	Value
1	**Historic and current market parameters**		
1.1	Market size	Tons	23.000
1.2	Annual growth of market size (1993-2006)	%	9
1.3	Main usage		
	Food	%	80
	Feed	%	0
	Supplements/Pharmaceuticals	%	0
	Chemical/ intermediate[52]	%	20
1.4	Share of base product converted to derivative[53]	%	55
1.5	Main product form		powder
1.6	Price of base product	€/kg	3,5
1.7	Price of main derivative	€/kg	2
1.8	Price trend (Ø1990-2006) of base product	%	-5
1.9	Price trend of main derivative (Ø 1990-2006)	%	-5
1.10	Market value (2006)	Mio €	75
1.11	Regulation (EU, NAFTA)	Free/regulated	regulated
1.12	Image of product	High/low	low
1.13	No of producers	No	<10
1.14	Market share of three main producers	%	>75
1.15	Market share of Chinese/Indian producer	%	37
1.16	Distribution system		trader, direct
1.17	Steps in value chain	No	2-3
1.18	Requirements of formulation	y/n	no
2	**Future developments**		
2.1	Volume trend	%	3
2.2	Price trend	%/a	0
2.3	Expected market value in 2015	Mio €	98

[51] Also called erythorbic acid
[52] e.g. as a coating material in photographic papers
[53] Ca-, K- , Na- and other salts

II Production Characteristics (iso-ascorbic acid)

No	Parameter	Unit	Value
3	**Process characteristics**		
3.1	Type of organism used		Penicillium, Pseudomonas, Serratia
3.2	Type of process		direct fermentation and purification or fermentation of KGA and chemical conversion
3.3	Main carbohydrate		glucose
3.4	Carbohydrate conversion rate	%	<55
3.5	Valuable by-product	y/n	n
4	**Size and cost structure of plant**		
4.1	Typical size	Tons/a	3.000
4.2	Global capacity utilisation	%	< 90
4.3	Typical investment	€/ta	3.800
4.4	Total cost of production[54]	€/kg	2,4
4.5	Importance of cost items		
	Depreciation	%	32
	Carbohydrate	%	26
	Labour	%	5
	Utility	%	22
	Overhead/others	%	15
4.6	Margin fc (sales price – costs)[55]	%	20
5	**Patent protection of main process steps**	**y/n**	**no**
6	**Flexibility of process**		
6.1	Flexibility in using carbohydrates	h/l	l
6.2	Degree of sophistication	h/m/l	m
6.3	Dedication of plant	d/nd	d

[54] Western Europe
[55] Based on main derivative

III Success Factors (iso-ascorbic acid)

Parameter	Degree of importance (1 = lowest, 3 = highest)		
	1	2	3
Economy of scale			x
Quality			X
Low selling price			X
Specialisation on specific derivatives		X	
Availability of specific know-how (base process)	X		
Availability of specific know-how (formulation)	X		
Availability of spec. carbohydrates			X
Low priced carbohydrates			X
Low priced labour	X		
Low prices utilities			X
Availability of excess of water			
Availability of specific reaction chemicals	X		
Availability of special sales force/network		X	
Need for customer training		X	
Need for specialized distribution network			X
Patent protection	X		
Elaborate product/derivative portfolio		X	
Requirement of flexibility vis-à-vis market/consumer developments		X	
Specific permissions/regulations	X		

IV Summarizing comment

Iso-ascorbic acid was developed as a substitute for ascorbic acid at the time vitamin C was very expensive for some applications. A sizable market developed as an anti-oxidant in foods (for ham, bacon and sausages mostly in Europe) and also as a reagent in photochemistry and for the coating of photographic paper (e.g. inkjet paper). Iso-ascorbic acid has no vitamin character and thus in foods, as an anti-oxidant it is only used, when the price differential to ascorbic acid is substantial. As ascorbic acid prices came down, the attractiveness of iso-ascorbic acid suffered. It is becoming a Chinese affair. In Europe there are only Roquette and Cargill and in the USA it is Fujisawa. As the market is limited, a further economy of scale also comes to its limits. It is more a perfect management of the process (lowest input costs) which decides on the product success. As the application of iso-ascorbic acid are two specialized segments: processed meat and photochemistry, sales require specialized staff and distribution.

2.3.2.9 Xanthan

I General and Market Characteristics (xanthan)

No	Parameter	Unit	Value
1	**Historic and current market parameters**		
1.1	Market size	Tons	140.000
1.2	Annual growth of market size (1993-2006)	%	13
1.3	Main usage		
	Food	%	40
	Feed	%	6
	Supplements/Pharmaceuticals	%	4
	Chemical/ intermediate[56]	%	50
1.4	Share of base product converted	%	0
1.5	Main product form		powder
1.6	Price of base product	€/kg	4
1.7	Price of main derivative	€/kg	-
1.8	Price trend (Ø1990-2006) of base product	%	-6
1.9	Price trend of main derivative (Ø 1990-2006)	%	-
1.10	Market value (2006)	Mio €	560
1.11	Regulation (EU, NAFTA)	Free/regulated	regulated
1.12	Image of product	High/low	Low
1.13	No of producers	No	20
1.14	Market share of three main producers	%	43
1.15	Market share of Chinese/Indian producer	%	54
1.16	Distribution system		trader
1.17	Steps in value chain	No	3
1.18	Requirements of formulation	y/n	No
2	**Future developments**		
2.1	Volume trend	%	4
2.2	Price trend	%/a	0
2.3	Expected market value in 2015	Mio €	797

[56] Petroleum industry

II Production Characteristics (xanthan)

No	Parameter	Unit	Value
3	**Process characteristics**		
3.1	Type of organism used		Xanthomonas campestris[57]
3.2	Type of process		fermentation-alcohol precipitation-purification
3.3	Main carbohydrate		Glucose
3.4	Carbohydrate conversion rate	%	21
3.5	Valuable by-product	y/n	N
4	**Size and cost structure of plant**		
4.1	Typical size	Tons/a	2.000
4.2	Global capacity utilisation	%	< 90
4.3	Typical investment	€/ta	12.500
4.4	Total cost of production	€/kg	5,2
4.5	Importance of cost items[58]		
	Depreciation	%	30
	Carbohydrate	%	30
	Labour	%	5
	Utility	%	20
	Overhead/others	%	15
4.6	Margin fc (sales price – costs)	%	- 23 (negative!)
5	**Patent protection of main process steps**	**y/n**	**No**
6	**Flexibility of process**		
6.1	Flexibility in using carbohydrates	h/l	L
6.2	Degree of sophistication	h/m/l	H
6.3	Dedication of plant	d/nd	D

[57] This organism is a plant pathogen and thus difficult to handle
[58] If full costs including depreciation are considered, no xanthan plant at this moment runs economically!!!

III Success Factors (xanthan)

Parameter	Degree of importance (1 = lowest, 3 = highest)		
	1	2	3
Economy of scale			X
Quality		X	
Low selling price			X
Specialisation on specific derivatives	X		
Availability of specific know-how (base process)		X	
Availability of specific know-how (formulation)	X		
Availability of spec. carbohydrates		X	
Low priced carbohydrates			X
Low priced labour	X		
Low prices utilities			X
Availability of excess of water			X
Availability of specific reaction chemicals	X		
Availability of special sales force/network		X	
Need for customer training	X		
Need for specialized distribution network			X
Patent protection	X		
Elaborate product/derivative portfolio	X		
Requirement of flexibility vis-à-vis market/consumer developments		X	
Specific permissions/regulations		X	

IV Summarizing comment

Xanthan is a hydrocolloid used mostly in foods and in oil drilling. It has outstanding rheological properties and in consequence volume growth in the past years was outstanding. However volume growth was correlated with strongly decreasing prices. Such price development was spurred by many Chinese companies coming on the market. For oil drilling no specific grade is needed; for food, requirements are fairly high. Therefore the oil drilling market is even more competitive than the food segment. Economy of scale, low carbohydrate and low energy prices are key. As the number of service companies for the petroleum firms is a small and closed club, a specific effort is needed to penetrate this market. In the food sector sales occur via traders in the commodity style. However, rheological needs of many food products change. Therefore xanthan producer develop modifications of the base molecule in order to obtain competitive edges and fetch slightly higher prices. Although xanthan is a commodity with substantial growth also in future, successful selling of larger quantities is tricky and for a standard plant, there is no way at this moment to sell at prices recovering full costs[59].

[59] Chinese economics might be different. There way of calculation frequently excludes investment, capital and finance costs.

2.3.2.10 beta-Carotene

I General and Market Characteristics (beta-carotene)[60]

No	Parameter	Unit	Value
1	**Historic and current market parameters**		
1.1	Market size	Tons	360
1.2	Annual growth of market size (1993-2006)	%	3
1.3	Main usage		
	Food	%	50
	Feed	%	6
	Supplements/Pharmaceuticals	%	44
	Chemical/ intermediate	%	0
1.4	Share of base product converted	%	0
1.5	Main product form		powder, oils
1.6	Price of base product	€/kg	600[61]
1.7	Price of main derivative	€/kg	0
1.8	Price trend (Ø1990-2006) of base product	%	-2[62]
1.9	Price trend of main derivative (Ø 1990-2006)	%	-
1.10	Market value (2006)	Mio €	216
1.11	Regulation (EU, NAFTA)	Free/regulated	regulated
1.12	Image of product	High/low	high
1.13	No of producers	No	6
1.14	Market share of three main producers	%	90
1.15	Market share of Chinese/Indian producer	%	<2
1.16	Distribution system		direct
1.17	Steps in value chain	No	2
1.18	Requirements of formulation	y/n	yes
2	**Future developments**		
2.1	Volume trend	%	2
2.2	Price trend	%/a	-2
2.3	Expected market value in 2015	Mio €	216

[60] The market overview refers to all beta-carotene produced, irrespective of the production route
[61] There is a high variability of prices in the market depending on the formulation and type of origin. Unformulated beta-carotene has only a small market. More than 98% of global production is offered in formulations. Synthetic product in oil (30%) is sold at € 90/kg; 10% tablet grade at € 65/kg, 20% tablet grade at € 90/kg, 1% powder at € 15/kg and 10% powders for food sell at € 68/kg. Ultimately it is the formulation which is paid. Product from Blakeslea trispora sells in the same price range as the synthetic. 20% oil suspension from algae sells at € 180/kg
[62] Depending on the type of formulation, price trends varied substantially over the past years. Prices for powders remained stable since more than a decade, while prices for 30% oil suspensions came down from € 120/kg to € 90/kg within the last three years.

II Production Characteristics[63] (beta-carotene)

No	Parameter	Unit	Value
3	**Process characteristics**		
3.1	Type of organism used		Blakeslea
3.2	Type of process		fermentation-purification-crystallisation-formulation
3.3	Main carbohydrate		glucose, starch
3.4	Carbohydrate conversion rate	%	8
3.5	Valuable by-product	y/n	Y[64]
4	**Size and cost structure of plant**		
4.1	Typical size	Tons/a	20
4.2	Global capacity utilisation	%	< 90[65]
4.3	Typical investment[66]	€/ta	1.000.000
4.4	Total cost of production	€/kg	375[67]
4.5	Importance of cost items		
	Depreciation	%	53
	Carbohydrate	%	16
	Labour	%	13
	Utility	%	11
	Overhead/others	%	7
4.6	Margin fc (sales price – costs)	%	60
5	Patent protection of main process steps	y/n	yes
6	Flexibility of process		
6.1	Flexibility in using carbohydrates	h/l	L
6.2	Degree of sophistication	h/m/l	H
6.3	Dedication of plant	d/nd	d, lycopene

[63] Refers to fermentation process only
[64] This is biomass, containing various amounts of residual beta-carotene. Such biomass can be produced if the extraction process is based on oil, and not on solvents. Biomass with a decent content of beta-carotene can be sold into the aquaculture and feed industry at fairly attractive prices.
[65] There is not much experience with fermentation of blakesela fermentations available. Two existing plants operate well below capacity.
[66] Western Europe
[67] Such figure can vary and depends on the formulation of the end product. In this case, the figure refers to the manufacturing of biomass, 30% oil suspension, 1% powder and emulsions of various strengths. If higher concentrated powders should be produced, investment costs increase and thus total manufacturing costs.

III Success Factors (beta-carotene)

Parameter	**Degree of importance (1 = lowest, 3 = highest)**		
	1	2	3
Economy of scale			x
Quality			X
Low selling price		X	
Specialisation on specific derivatives			X
Availability of specific know-how (base process)			X
Availability of specific know-how (formulation)			X
Availability of spec. carbohydrates		X	
Low priced carbohydrates		X	
Low priced labour	X		
Low prices utilities	X		
Availability of excess of water		X	
Availability of specific reaction chemicals			X
Availability of special sales force/network			X
Need for customer training			X
Need for specialized distribution network			X
Patent protection			X
Elaborate product/derivative portfolio			X
Requirement of flexibility vis-à-vis market/consumer developments			X
Specific permissions/regulations			X

IV Summarizing comment

Beta-carotene is a high tech product. Most of the currently sold product is manufactured based on chemical reactions. There are only three plants operating fermentation processes: Vitatene in Spain, Vitan in combination with DSM in the Ukraine and Star Bio in China. All three suffer from the difficulties of formulating the crystalline product. Crystalline product as such has only a very limited market. Oil suspensions, the least sophisticated formulation is in competition with the standard chemical product, and more sophisticated powders are complicated to manufacture. In order to run fermentation based beta-carotene processes successfully a whole range of basic parameters must be met: quality as high as DSM's product, production costs as low as of the chemical material, formulations as reliable as of the chemical product and a highly skilled and dedicated sales force. However, as there is no fermentation plant operating properly, an efficient Blakeslea plant in combination with a state-of-the-art fermentation plant might offer a unique option for the future. Beta-carotene is also produced by algae. Prices for such products came down in the past considerably. A perfect control of the production system and a very intimate relationship to customers is essential for selling such product successfully.

2.3.2.11 Lycopene

I General and Market Characteristics (lycopene)

No	Parameter	Unit	Value
1	**Historic and current market parameters**		
1.1	Market size	Tons	14
1.2	Annual growth of market size (1993-2006)	%	15,5
1.3	Main usage		
	Food	%	7
	Feed	%	0
	Supplements/Pharmaceuticals	%	93
	Chemical/ intermediate	%	0
1.4	Share of base product converted	%	0
1.5	Main product form		powders, oils
1.6	Price of base product	€/kg	1.300
1.7	Price of main derivative	€/kg	-
1.8	Price trend (Ø1995-2006) of base product	%	-7
1.9	Price trend of main derivative (Ø 1990-2006)	%	-
1.10	Market value (2006)	Mio €	18
1.11	Regulation (EU, NAFTA)	Free/regulated	regulated
1.12	Image of product	High/low	high
1.13	No of producers	No	5
1.14	Market share of three main producers	%	94
1.15	Market share of Chinese/Indian producer	%	5
1.16	Distribution system		direct
1.17	Steps in value chain	No	2
1.18	Requirements of formulation	y/n	yes
2	**Future developments**		
2.1	Volume trend	%	6
2.2	Price trend	%/a	0
2.3	Expected market value in 2015	Mio €	30

II Production Characteristics (lycopene)

No	Parameter	Unit	Value
3	**Process characteristics**		
3.1	Type of organism used		Blakeslea
3.2	Type of process		beta-carotene type
3.3	Main carbohydrate		glucose, starch
3.4	Carbohydrate conversion rate	%	2
3.5	Valuable by-product	y/n	n
4	**Size and cost structure of plant**[68]		
4.1	Typical size	Tons/a	3
4.2	Global capacity utilisation	%	< 90
4.3	Typical investment	€/ta	1.000.000
4.4	Total cost of production	€/kg	700
4.5	Importance of cost items		
	Depreciation	%	28
	Carbohydrate	%	34
	Labour	%	11
	Utility	%	23
	Overhead/others	%	4
4.6	Margin fc (sales price – costs)	%	54
5	**Patent protection of main process steps**	**y/n**	**yes**
6	**Flexibility of process**		
6.1	Flexibility in using carbohydrates	h/l	l
6.2	Degree of sophistication	h/m/l	h
6.3	Dedication of plant	d/nd	d, beta-carotene

[68] A dedicated lycopene plant does not exist. Lycopene is manufactured in the same plant as beta-carotene. For estimating investment costs, proportional rates of the respective beta-carotene values are used

III Success Factors (lycopene)

Parameter	Degree of importance (1 = lowest, 3 = highest)		
	1	2	3
Economy of scale		X	
Quality			X
Low selling price		X	
Specialisation on specific derivatives		X	
Availability of specific know-how (base process)			X
Availability of specific know-how (formulation)			X
Availability of spec. carbohydrates		X	
Low priced carbohydrates			X
Low priced labour	x		
Low prices utilities		X	
Availability of excess of water		X	
Availability of specific reaction chemicals			X
Availability of special sales force/network			X
Need for customer training			X
Need for specialized distribution network			X
Patent protection			X
Elaborate product/derivative portfolio			X
Requirement of flexibility vis-à-vis market/consumer developments			X
Specific permissions/regulations			X

IV Summarizing comment

Lycopene was introduced as an extract from tomato skin and such product still dominates the market. DSM and BASF operate synthetic routes and it is only Vitatene from Spain running a fermentation process in a beta-carotene plant. Like beta-carotene, lycopene can only be sold formulated to oil suspensions or powders, which require specific technology and skills. Typical economic process parameters do not play a major role for success in lycopene; it is more the high quality, formulation and the marketing approach deciding. Since there is only one player in the market, which operates a fermentation process, experience is limited. Lycopene from fermentation is not a commodity and entering into that business by a fermentation process is a pioneering move.

2.3.2.12 Astaxanthin

I General and Market Characteristics (astaxanthin)[69]

No	Parameter	Unit	Value
1	**Historic and current market parameters**		
1.1	Market size	Tons	150
1.2	Annual growth of market size (1993-2006)	%	10
1.3	Main usage		
	Food	%	0
	Feed	%	99
	Supplements/Pharmaceuticals	%	1
	Chemical/ intermediate	%	0
1.4	Share of base product converted to derivative	%	0
1.5	Main product form		powder
1.6	Price of base product	€/kg	1.300
1.7	Price of main derivative	€/kg	-
1.8	Price trend (Ø1990-2006) of base product[70]	%	0
1.9	Price trend of main derivative (Ø 1990-2006)	%	-
1.10	Market value (2006)	Mio €	195
1.11	Regulation (EU, NAFTA)	Free/regulated	regulated
1.12	Image of product	High/low	high
1.13	No of producers	No	6
1.14	Market share of three main producers	%	99
1.15	Market share of Chinese/Indian producer	%	<1
1.16	Distribution system		direct
1.17	Steps in value chain	No	2
1.18	Requirements of formulation	y/n	yes[71]
2	**Future developments**		
2.1	Volume trend	%	5
2.2	Price trend	%/a	0
2.3	Expected market value in 2015	Mio €	302

[69] This part summarizes all astaxanthin irrespective of the production route
[70] Prices in USD fluctuated strongly over the years. But in €, prices are stable since 1984
[71] There are two types of products in the market: astaxanthin crystalline formulated to 10% liquid or powder by the standard carotenoid formulation technology and a dried biomass containing astaxanthin.

II Production Characteristics (astaxanthin)

No	Parameter	Unit	Value
3	**Process characteristics**		
3.1	Type of organism used		Phaffia
3.2	Type of process[72]		fermentation-drying together with broth
3.3	Main carbohydrate		starch
3.4	Carbohydrate conversion rate	%	1
3.5	Valuable by-product	y/n	n
4	**Size and cost structure of plant**		
4.1	Typical size	Tons/a	3
4.2	Global capacity utilisation	%	> 90
4.3	Typical investment[73]	€/ta	3.000.000
4.4	Total cost of production	€/kg	580
4.5	Importance of cost items		
	Depreciation	%	34
	Carbohydrate	%	15
	Labour	%	15
	Utility	%	26
	Overhead/others	%	10
4.6	Margin fc (sales price – costs)	%	45
5	**Patent protection of main process steps**	**y/n**	**yes**
6	**Flexibility of process**		
6.1	Flexibility in using carbohydrates	h/l	low
6.2	Degree of sophistication	h/m/l	high
6.3	Dedication of plant	d/nd	d

[72] Described process details refer to the dried biomass which contains some astaxanthin. The process producing crystalline astaxanthin which is subsequently formulated shows completely different costs.
[73] Western Europe

III Success Factors (astaxanthin)

Parameter	Degree of importance (1 = lowest, 3 = highest)		
	1	2	3
Economy of scale		X	
Quality			X
Low selling price		X	
Specialisation on specific derivatives	X		
Availability of specific know-how (base process)			X
Availability of specific know-how (formulation)			X
Availability of spec. carbohydrates			X
Low priced carbohydrates		X	
Low priced labour		X	
Low prices utilities			X
Availability of excess of water		X	
Availability of specific reaction chemicals	X		
Availability of special sales force/network			X
Need for customer training			X
Need for specialized distribution network			X
Patent protection			X
Elaborate product/derivative portfolio	X		
Requirement of flexibility vis-à-vis market/consumer developments	X		
Specific permissions/regulations			X

IV Summarizing comment

The main market for astaxanthin is the colouring of salmonid fish and of crustaceans. 90% of all astaxanthin sold is manufactured by chemical synthesis and it is only Tate & Lyle and ADM operating successfully fermentation processes. The process is based on a cold fermentation as Phaffia does not react positive to temperature increases. Yields are exceptionally low and improvements so far failed. The specialisation of the market requires highly knowledgeable staff and specific sales networks for success. Due to the industry structure prices are stable since many years. As it is expected that the colouring of fish will in future comprise more species, the market might expand strongly in terms of volumes.

2.3.2.13 Lactic Acid

I General and Market Characteristics (lactic acid)

No	Parameter	Unit	Value
1	**Historic and current market parameters**		
1.1	Market size	Tons	320.000
1.2	Annual growth of market size (1993-2006)	%	5,0
1.3	Main usage		
	Food	%	51
	Feed	%	0
	Supplements/Pharmaceuticals	%	14
	Chemical/ intermediate	%	35
1.4	Share of base product converted to derivatives[74]	%	30
1.5	Main product form		liquid
1.6	Price of base product	€/kg	1,1
1.7	Price of main derivative	€/kg	1,5
1.8	Price trend (Ø1990-2006) of base product	%	-2
1.9	Price trend of main derivative (Ø 1990-2006)	%	-2
1.10	Market value (2006)	Mio €	390
1.11	Regulation (EU, NAFTA)	Free/regulated	regulated
1.12	Image of product	High/low	high
1.13	No of producers	No	6
1.14	Market share of three main producers	%	97
1.15	Market share of Chinese/Indian producer	%	25[75]
1.16	Distribution system		direct, trader
1.17	Steps in value chain	No	3
1.18	Requirements of formulation	y/n	no
2	**Future developments**		
2.1	Volume trend	%	6[76]
2.2	Price trend	%/a	1[77]
2.3	Expected market value in 2015	Mio €	720

[74] 20% Lactates and 10% for poly-lactic acid

[75] BBCA jv with Galactic seen as Chinese and Main producer

[76] The main future demand will not come from standard applications but mostly from poly-lactic acid. That demand is just rising.

[77] There are indications that lactic acid prices will rise across all qualities and grades. Overcapacities do not exist and demand is supposed to stress current capacities strongly. However there might also be some pressure from Asian production and thus only a moderate price increase is seen over the next years.

II Production Characteristics (lactic acid)

No	Parameter	Unit	Value
3	**Process characteristics**		
3.1	Type of organism used		Lactobacillus
3.2	Type of process		fermentation-precipitation with H2SO4, ion exchange, purification-concentration
3.3	Main carbohydrate		glucose
3.4	Carbohydrate conversion rate	%	85
3.5	Valuable by-product	y/n	n
4	**Size and cost structure of plant**		
4.1	Typical size	Tons/a	20.000
4.2	Global capacity utilisation	%	> 90
4.3	Typical investment[78]	€/ta	1.500
4.4	Total cost of production	€/kg	1
4.5	Importance of cost items		
	Depreciation	%	20
	Carbohydrate	%	40
	Labour	%	5
	Utility	%	30
	Overhead/others	%	5
4.6	Margin fc (sales price – costs)	%	10
5	**Patent protection of main process steps**	**y/n**	**no**
6	**Flexibility of process**		
6.1	Flexibility in using carbohydrates	h/l	low
6.2	Degree of sophistication	h/m/l	high
6.3	Dedication of plant	d/nd	d

[78] Western Europe

III Success Factors (lactic acid)

Parameter	Degree of importance (1 = lowest, 3 = highest)		
	1	2	3
Economy of scale			X
Quality			X
Low selling price			X
Specialisation on specific derivatives			X
Availability of specific know-how (base process)			X
Availability of specific know-how (formulation)	X		
Availability of spec. carbohydrates			X
Low priced carbohydrates			X
Low priced labour	X		
Low prices utilities		X	
Availability of excess of water		X	
Availability of specific reaction chemicals	X		
Availability of special sales force/network		X	
Need for customer training	X		
Need for specialized distribution network		X	
Patent protection	X		
Elaborate product/derivative portfolio	X		
Requirement of flexibility vis-à-vis market/consumer developments	X		
Specific permissions/regulations	X		

IV Summarizing comment

Lactic acid is a standard acidulant for many food and industrial applications. In pharmaceuticals it is more the salts which are used. A major upswing came with the development of poly-lactic acid as a base material for manufacturing bio-plastics. As a large-scale commodity, production as such is not very complicated. However, for most applications a clear transparent liquid is needed which requires de-colouring of the base liquor. That de-colouring step is sophisticated and a major cost item. The industry is concentrated with Purac, Galactic, ADM and Cargill dominating. Special sales force is needed for the salts and for selling into the poly-lactic industry. Overall the product is sold on price given a high quality standard. Economy of scale and low priced raw materials are decisive.

2.3.2.14 Gluconic Acid[79]

I General and Market Characteristics (gluconic acid)

No	Parameter	Unit	Value
1	**Historic and current market parameters**		
1.1	Market size	Tons	90.000
1.2	Annual growth of market size (1993-2006)	%	3
1.3	Main usage		
	Food	%	35
	Feed	%	0
	Supplements/Pharmaceuticals	%	9
	Chemical/ intermediate	%	56
1.4	Share of base product converted to derivative[80]	%	20
1.5	Main product form		liquid[81]
1.6	Price of base product	€/kg	1
1.7	Price of main derivative	€/kg	2
1.8	Price trend (Ø1990-2006) of base product	%	0
1.9	Price trend of main derivative (Ø 1990-2006)	%	0
1.10	Market value (2006)	Mio €	108
1.11	Regulation (EU, NAFTA)	Free/regulated	regulated/free[82]
1.12	Image of product	High/low	low
1.13	No of producers	No	10
1.14	Market share of three main producers	%	73
1.15	Market share of Chinese/Indian producer	%	5
1.16	Distribution system		direct/trader
1.17	Steps in value chain	No	2
1.18	Requirements of formulation	y/n	no
2	**Future developments**		
2.1	Volume trend	%	2-3
2.2	Price trend	%/a	0
2.3	Expected market value in 2015	Mio €	167

[79] The terms D-gluconic acid and gluconic acid are used in this text interchangeably.
[80] Partly gluconates but mainly gluco-delta-lactones
[81] Mostly the technical grade is sold as a liquid; for food applications salts are more common
[82] Technical Applications are not regulated

II Production Characteristics (gluconic acid)

No	Parameter	Unit	Value
3	**Process characteristics**		
3.1	Type of organism used		Gluconobacter
3.2	Type of process		fermentation-filtration precipitation-purification-concentration
3.3	Main carbohydrate		glucose
3.4	Carbohydrate conversion rate	%	60
3.5	Valuable by-product	y/n	n
4	**Size and cost structure of plant**		
4.1	Typical size	Tons/a	15.000
4.2	Global capacity utilisation	%	> 90
4.3	Typical investment[83]	€/ta	1.500
4.4	Total cost of production	€/kg	1
4.5	Importance of cost items		
	Depreciation	%	20
	Carbohydrate	%	50
	Labour	%	5
	Utility	%	20
	Overhead/others	%	5
4.6	Margin fc (sales price – costs)	%	0
5	**Patent protection of main process steps**	**y/n**	**no**
6	**Flexibility of process**		
6.1	Flexibility in using carbohydrates	h/l	l
6.2	Degree of sophistication	h/m/l	m
6.3	Dedication of plant	d/nd	d

[83] Western Europe

III Success Factors (gluconic acid)

Parameter	**Degree of importance (1 = lowest, 3 = highest)**		
	1	2	3
Economy of scale			X
Quality		X	
Low selling price			X
Specialisation on specific derivatives		X	
Availability of specific know-how (base process)		X	
Availability of specific know-how (formulation)	X		
Availability of spec. carbohydrates		X	
Low priced carbohydrates			X
Low priced labour	X		
Low prices utilities		X	
Availability of excess of water		X	
Availability of specific reaction chemicals	X		
Availability of special sales force/network		X	
Need for customer training	X		
Need for specialized distribution network		X	
Patent protection	X		
Elaborate product/derivative portfolio	X		
Requirement of flexibility vis-à-vis market/consumer developments	X		
Specific permissions/regulations		X	

IV Summarising Comment

The main outlet for gluconic acid is the construction industry where it is used as a retarding agent in the manufacturing of plasterboards, special concretes and mortars. In foods it is gluco-delta-lacton which is used as a meat analogue and taste enhancer. As an industrial commodity it is price and therefore economy of scale and the availability of cheap raw material which is decisive. The process as such is relatively simple and does not require specialised know-how. However, selling into the construction industry requires specific access and sales outlets. It is expected that the market is developing in line with the international construction industry. Many years ago prices were consolidated and major decreases in the next years are not expected.

2.3.2.15 Welan

I General and Market Characteristics (Welan)

No	Parameter	Unit	Value
1	**Historic and current market parameters**		
1.1	Market size	Tons	2.000
1.2	Annual growth of market size (1993-2006)	%	10
1.3	Main usage		
	Food	%	0
	Feed	%	0
	Supplements/Pharmaceuticals	%	0
	Chemical/ intermediate	%	100
1.4	Share of base product converted to derivative	%	0
1.5	Main product form		powder
1.6	Price of base product	€/kg	8
1.7	Price of main derivative	€/kg	-
1.8	Price trend (Ø1990-2006) of base product	%	-5
1.9	Price trend of main derivative (Ø 1990-2006)	%	-
1.10	Market value (2006)	Mio €	16
1.11	Regulation (EU, NAFTA)	Free/regulated	free
1.12	Image of product	High/low	low
1.13	No of producers	No	2
1.14	Market share of three main producers	%	100
1.15	Market share of Chinese/Indian producer	%	< 1
1.16	Distribution system		direct
1.17	Steps in value chain	No	2
1.18	Requirements of formulation	y/n	no
2	**Future developments**		
2.1	Volume trend	%	3
2.2	Price trend	%/a	-3
2.3	Expected market value in 2015	Mio €	16

II Production Characteristics (Welan)

No	Parameter	Unit	Value
3	**Process characteristics**		
3.1	Type of organism used		Pseudomonas, Sphingomonas
3.2	Type of process		xanthan type
3.3	Main carbohydrate		glucose
3.4	Carbohydrate conversion rate	%	10
3.5	Valuable by-product	y/n	n
4	**Size and cost structure of plant**[84]		
4.1	Typical size	Tons/a	1.000
4.2	Global capacity utilisation	%	< 90
4.3	Typical investment[85]	€/ta	4.000
4.4	Total cost of production	€/kg	6
4.5	Importance of cost items		
	Depreciation	%	50
	Carbohydrate	%	20
	Labour	%	5
	Utility	%	20
	Overhead/others	%	5
4.6	Margin fc (sales price – costs)	%	25
5	**Patent protection of main process steps**	**y/n**	**yes**
6	**Flexibility of process**		
6.1	Flexibility in using carbohydrates	h/l	low
6.2	Degree of sophistication	h/m/l	high
6.3	Dedication of plant	d/nd	d, xanthan, other hydrocolloids

[84] A dedicated welan plant does not exist. Xanthan plants can be used. Thus proportional rates are used as indications for production costs.
[85] USA

III Success Factors (welan)

Parameter	**Degree of importance (1 = lowest, 3 = highest)**		
	1	2	3
Economy of scale			X
Quality			X
Low selling price			X
Specialisation on specific derivatives	X		
Availability of specific know-how (base process)			X
Availability of specific know-how (formulation)	X		
Availability of spec. carbohydrates			X
Low priced carbohydrates			X
Low priced labour		X	
Low prices utilities			X
Availability of excess of water		X	
Availability of specific reaction chemicals	X		
Availability of special sales force/network			X
Need for customer training			X
Need for specialized distribution network			X
Patent protection			X
Elaborate product/derivative portfolio	X		
Requirement of flexibility vis-à-vis market/consumer developments	X		
Specific permissions/regulations	X		

IV Summarizing Comment

Welan is a derivative of xanthan and used exclusively as controlling agent in special concretes. It's principle market is North America. The product is available since more than a decade but did not develop to a major product as the market is restricted and the construction industry very price conscious. The manufacturing process is complicated and requires a high level of knowledge in fermentation and precipitation. Due to the specialised application, welan can only be sold via a dedicated and knowledgeable sales force and distribution network. The principle process steps are patented by Kelco (today Huber).

2.3.2.16 Gellan

I General and Market Characteristics (Gellan)

No	Parameter	Unit	Value
1	**Historic and current market parameters**		
1.1	Market size	Tons	1.650
1.2	Annual growth of market size (1993-2006)	%	3
1.3	Main usage		
	Food	%	100
	Feed	%	0
	Supplements/Pharmaceuticals	%	0
	Chemical/ intermediate	%	0
1.4	Share of base product converted to derivative	%	0
1.5	Main product form		powder
1.6	Price of base product	€/kg	12
1.7	Price of main derivative	€/kg	-
1.8	Price trend (Ø1990-2006) of base product	%	-5
1.9	Price trend of main derivative (Ø 1990-2006)	%	-
1.10	Market value (2006)	Mio €	20
1.11	Regulation (EU, NAFTA)	Free/regulated	regulated
1.12	Image of product	High/low	low
1.13	No of producers	No	1
1.14	Market share of three main producers	%	100
1.15	Market share of Chinese/Indian producer	%	0
1.16	Distribution system		direct
1.17	Steps in value chain	No	2
1.18	Requirements of formulation	y/n	no
2	**Future developments**		
2.1	Volume trend	%	3
2.2	Price trend	%/a	-3
2.3	Expected market value in 2015	Mio €	20

II Production Characteristics (gellan)

No	Parameter	Unit	Value
3	**Process characteristics**		
3.1	Type of organism used		Pseudomonas, Sphingomonas
3.2	Type of process		xanthan type
3.3	Main carbohydrate		glucose
3.4	Carbohydrate conversion rate	%	10
3.5	Valuable by-product	y/n	n
4	**Size and cost structure of plant**		
4.1	Typical size	Tons/a	2.000
4.2	Global capacity utilisation	%	< 90
4.3	Typical investment[86]	€/ta	4.000
4.4	Total cost of production	€/kg	8
4.5	Importance of cost items		
	Depreciation	%	50
	Carbohydrate	%	20
	Labour	%	5
	Utility	%	20
	Overhead/others	%	5
4.6	Margin fc (sales price – costs)	%	34
5	**Patent protection of main process steps**	**y/n**	**yes**
6	**Flexibility of process**		
6.1	Flexibility in using carbohydrates	h/l	low
6.2	Degree of sophistication	h/m/l	high
6.3	Dedication of plant	d/nd	d

[86] USA

III Success Factors (gellan)

Parameter	Degree of importance (1 = lowest, 3 = highest)		
	1	2	3
Economy of scale			x
Quality			X
Low selling price			X
Specialisation on specific derivatives	X		
Availability of specific know-how (base process)			X
Availability of specific know-how (formulation)	X		
Availability of spec. carbohydrates			X
Low priced carbohydrates			X
Low priced labour	X		
Low prices utilities			X
Availability of excess of water		x	
Availability of specific reaction chemicals	X		
Availability of special sales force/network			X
Need for customer training			X
Need for specialized distribution network			X
Patent protection			X
Elaborate product/derivative portfolio	X		
Requirement of flexibility vis-à-vis market/consumer developments	X		
Specific permissions/regulations			X

IV Summarizing Comment

Gellan was developed by Kelco (today Huber) as a special hydrocolloid mostly for suspending cocoa and of fruit chunks in milk drinks and yoghurts. The product however, did not out-perform xanthan to the extent needed for a major market inroad and in consequence the product is not widely used. The process is complicated and not very efficient. It requires highly sophisticated process management. Selling of gellan is a difficult task and requires special sales force and distribution network. Main process steps are patented.

2.3.2.17 Curdlan

I General and Market Characteristics (curdlan)

No	Parameter	Unit	Value
1	**Historic and current market parameters**		
1.1	Market size	Tons	1.000
1.2	Annual growth of market size (1993-2006)	%	2
1.3	Main usage		
	Food	%	100
	Feed	%	0
	Supplements/Pharmaceuticals	%	0
	Chemical/ intermediate	%	0
1.4	Share of base product converted in derivative	%	0
1.5	Main product form		powder
1.6	Price of base product	€/kg	20
1.7	Price of main derivative	€/kg	-
1.8	Price trend (Ø1990-2006) of base product	%	0
1.9	Price trend of main derivative (Ø 1990-2006)	%	-
1.10	Market value (2006)	Mio €	20
1.11	Regulation (EU, NAFTA)	Free/regulated	regulated
1.12	Image of product	High/low	low
1.13	No of producers	No	1
1.14	Market share of three main producers	%	100
1.15	Market share of Chinese/Indian producer	%	0
1.16	Distribution system		direct
1.17	Steps in value chain	No	2
1.18	Requirements of formulation	y/n	no
2	**Future developments**		
2.1	Volume trend	%	1
2.2	Price trend	%/a	0
2.3	Expected market value in 2015	Mio €	22

II Production Characteristics (curdlan)

No	Parameter	Unit	Value
3	**Process characteristics**		
3.1	Type of organism used		Alcaligenes
3.2	Type of process		fermentation-precipitation
3.3	Main carbohydrate		glucose
3.4	Carbohydrate conversion rate	%	5
3.5	Valuable by-product	y/n	n
4	**Size and cost structure of plant**		
4.1	Typical size	Tons/a	1.500
4.2	Global capacity utilisation	%	< 90
4.3	Typical investment[87]	€/ta	4.000
4.4	Total cost of production	€/kg	16
4.5	Importance of cost items		
	Depreciation	%	50
	Carbohydrate	%	20
	Labour	%	5
	Utility	%	20
	Overhead/others	%	5
4.6	Margin fc (sales price – costs)	%	20
5	**Patent protection of main process steps**	**y/n**	**yes**
6	**Flexibility of process**		
6.1	Flexibility in using carbohydrates	h/l	low
6.2	Degree of sophistication	h/m/l	high
6.3	Dedication of plant	d/nd	d

[87] Japan

III Success Factors (curdlan)

Parameter	Degree of importance (1 = lowest, 3 = highest)		
	1	2	3
Economy of scale		X	
Quality			X
Low selling price		X	
Specialisation on specific derivatives	X		
Availability of specific know-how (base process)			X
Availability of specific know-how (formulation)	X		
Availability of spec. carbohydrates			X
Low priced carbohydrates			X
Low priced labour	X		
Low prices utilities		x	
Availability of excess of water		x	
Availability of specific reaction chemicals	X		
Availability of special sales force/network			X
Need for customer training			X
Need for specialized distribution network			X
Patent protection			X
Elaborate product/derivative portfolio	X		
Requirement of flexibility vis-à-vis market/consumer developments	X		
Specific permissions/regulations			X

IV Summarizing Comment

Curdlan was developed as a texture modifier for typical Asian dishes including noodles, surimi and jellies. It never obtained the gras status in Europe or in the USA. In consequence the main markets of curdlan are Japan, Taiwan and Korea. The process is complicated and not very efficient. Selling requires specific sales force and distribution network.

2.3.2.18 Riboflavin

I General and Market Characteristics (riboflavin)

No	Parameter	Unit	Value
1	**Historic and current market parameters**		
1.1	Market size	Tons	4.000
1.2	Annual growth of market size (1993-2006)	%	3
1.3	Main usage		
	Food	%	26
	Feed	%	54
	Supplements/Pharmaceuticals	%	20
	Chemical/ intermediate	%	0
1.4	Share of base product converted to derivative[88]	%	5
1.5	Main product form		powder
1.6	Price of base product	€/kg	35
1.7	Price of main derivative	€/kg	150
1.8	Price trend (Ø1990-2006) of base product	%	-3
1.9	Price trend of main derivative (Ø 1990-2006)	%	-5
1.10	Market value (2006)	Mio €	163
1.11	Regulation (EU, NAFTA)	Free/regulated	regulated
1.12	Image of product	High/low	high
1.13	No of producers	No	10
1.14	Market share of three main producers	%	80
1.15	Market share of Chinese/Indian producer	%	24
1.16	Distribution system		trader
1.17	Steps in value chain	No	3
1.18	Requirements of formulation	y/n	no
2	**Future developments**		
2.1	Volume trend	%	3
2.2	Price trend	%/a	0
2.3	Expected market value in 2015	Mio €	213

[88] Riboflavin-5-phosphate

II Production Characteristics (riboflavin)

No	Parameter	Unit	Value
3	**Process characteristics**		
3.1	Type of organism used		Ashbya gossipii, Bacillus
3.2	Type of process		fermentation-extraction-purification
3.3	Main carbohydrate		Glucose, vegetable oil
3.4	Carbohydrate conversion rate	%	18
3.5	Valuable by-product	y/n	n
4	**Size and cost structure of plant**		
4.1	Typical size	Tons/a	2.000
4.2	Global capacity utilisation	%	> 90
4.3	Typical investment[89]	€/ta	10.000
4.4	Total cost of production	€/kg	17
4.5	Importance of cost items		
	Depreciation	%	60
	Carbohydrate	%	10
	Labour	%	15
	Utility	%	10
	Overhead/others	%	5
4.6	Margin fc (sales price – costs)	%	52
5	**Patent protection of main process steps**	**y/n**	**no**
6	**Flexibility of process**		
6.1	Flexibility in using carbohydrates	h/l	low
6.2	Degree of sophistication	h/m/l	medium
6.3	Dedication of plant	d/nd	d

[89] Western Europe

III Success Factors (riboflavin)

Parameter	Degree of importance (1 = lowest, 3 = highest)		
	1	2	3
Economy of scale			X
Quality			X
Low selling price			X
Specialisation on specific derivatives	X		
Availability of specific know-how (base process)		X	
Availability of specific know-how (formulation[90])		X	
Availability of spec. carbohydrates			X
Low priced carbohydrates			X
Low priced labour	X		
Low prices utilities			X
Availability of excess of water		X	
Availability of specific reaction chemicals	X		
Availability of special sales force/network	X		
Need for customer training	X		
Need for specialized distribution network	X		
Patent protection	X		
Elaborate product/derivative portfolio	X		
Requirement of flexibility vis-à-vis market/consumer developments	X		
Specific permissions/regulations			X

IV Summarizing Comment

Riboflavin, vitamin B2 originally was produced by a chemical process but all major manufacturers changed during the 90s to the fermentation route. Fermentation is more economical and the process can be managed efficiently under the condition an appropriate strain is available. BASF managed to train his Ashbya strain to highest productivity, while DSM is using a genetically modified Bacillus. Riboflavin is a typical vitamin added to all compound feed for non-ruminants. It is also an ingredient for many vitamin preparations in foods and pharmaceuticals. The product developed to a commodity. Economy of scale and low priced carbohydrates are the main deciding factors for competitive prices. Occasionally riboflavin is formulated in order to reduce the dustiness of the product.

[90] In order to reduce the dustiness of the product, a fat coating is standard

2.3.2.19 Cyanocobalamin

I General and Market Characteristics (cyanocobalamin)

No	Parameter	Unit	Value
1	**Historic and current market parameters**		
1.1	Market size	Tons	20
1.2	Annual growth of market size (1993-2006)	%	3,5
1.3	Main usage		
	Food	%	3
	Feed	%	72
	Supplements/Pharmaceuticals	%	25
	Chemical/ intermediate	%	0
1.4	Share of base product converted to derivative	%	0
1.5	Main product form		powder
1.6	Price of base product	€/kg	4.000
1.7	Price of main derivative	€/kg	-
1.8	Price trend (Ø1990-2006) of base product	%	-8
1.9	Price trend of main derivative (Ø 1990-2006)	%	-
1.10	Market value (2006)	Mio €	80
1.11	Regulation (EU, NAFTA)	Free/regulated	regulated
1.12	Image of product	High/low	high
1.13	No of producers	No	10
1.14	Market share of three main producers	%	50
1.15	Market share of Chinese/Indian producer	%	100
1.16	Distribution system		trader
1.17	Steps in value chain	No	3
1.18	Requirements of formulation	y/n	no
2	**Future developments**		
2.1	Volume trend	%	5
2.2	Price trend	%/a	0
2.3	Expected market value in 2015	Mio €	124

II Production Characteristics (cyanocobalamin)

No	Parameter	Unit	Value
3	**Process characteristics**		
3.1	Type of organism used		Propionibacterium, Pseudomonas
3.2	Type of process		fermentation-purification-crystalisation
3.3	Main carbohydrate		Glucose, molasses
3.4	Carbohydrate conversion rate	%	5
3.5	Valuable by-product	y/n	n
4	**Size and cost structure of plant**		
4.1	Typical size	Tons/a	2
4.2	Global capacity utilisation	%	< 90
4.3	Typical investment[91]	€/ta	5.000.000
4.4	Total cost of production	€/kg	2.500
4.5	Importance of cost items		
	Depreciation	%	80
	Carbohydrate	%	2
	Labour	%	15
	Utility	%	2
	Overhead/others	%	1
4.6	Margin fc (sales price – costs)	%	60%
5	**Patent protection of main process steps**	**y/n**	**no**
6	**Flexibility of process**		
6.1	Flexibility in using carbohydrates	h/l	low
6.2	Degree of sophistication	h/m/l	medium
6.3	Dedication of plant	d/nd	d

[91] China

III Success Factors (cyanocobalamin)

Parameter	Degree of importance (1 = lowest, 3 = highest)		
	1	2	3
Economy of scale		X	
Quality			X
Low selling price			X
Specialisation on specific derivatives	X		
Availability of specific know-how (base process)		X	
Availability of specific know-how (formulation[92])	X		
Availability of spec. carbohydrates			X
Low priced carbohydrates			X
Low priced labour	X		
Low prices utilities			X
Availability of excess of water		X	
Availability of specific reaction chemicals			x[93]
Availability of special sales force/network	X		
Need for customer training	X		
Need for specialized distribution network	X		
Patent protection	X		
Elaborate product/derivative portfolio	X		
Requirement of flexibility vis-à-vis market/consumer developments	X		
Specific permissions/regulations	X		

IV Summarizing Comment

Cyanocobalamin, vitamin B12, became a Chinese affaire. Originally it was Rhone-Poulenc dominating the market but after the separation of the feed ingredient division in the process of the merger with Hoechst, a new company Adisseo, was formed which was recently sold to Chinese investors. The product is an integral part of many feed premixes and currently enjoys a high popularity as a food and supplement ingredient for energy preparations. The process is relatively simple with the most sophisticated step being the crystallisation. Price erosion with the market entry of Chinese companies was dramatic. Since several years prices are constant.

[92] The product is sold as pure, in 1% and 0,1% dilutions. The carrier is a carbohydrate and the process is simple mixing

[93] Dimethylbenzimidazol

2.3.2.20 Ethanol

I General and Market Characteristics (ethanol)

No	Parameter	Unit	Value
1	**Historic and current market parameters**		
1.1	Market size	Mio Tons	45
1.2	Annual growth of market size (2000-2006)	%	12
1.3	Main usage		
	Food	%	3
	Feed	%	0
	Supplements/Pharmaceuticals	%	1
	Chemical/ intermediate	%	96
1.4	Share of base product converted	%	30[94]
1.5	Main product form		liquid
1.6	Price of base product	€/kg[95]	0,7
1.7	Price of main derivative	€/kg	2
1.8	Price trend (Ø1990-2006) of base product	%	15
1.9	Price trend of main derivative (Ø 1990-2006)	%	5
1.10	Market value (2006)	Mio €	32.000[96]
1.11	Regulation (EU, NAFTA)	Free/regulated	free
1.12	Image of product	High/low	high
1.13	No of producers	No	> 100
1.14	Market share of three main producers	%	<10
1.15	Market share of Chinese/Indian producer	%	<5
1.16	Distribution system		direct/trader
1.17	Steps in value chain[97]	No	3-5
1.18	Requirements of formulation	y/n	no
2	**Future developments**		
2.1	Volume trend[98]	%	8
2.2	Price trend[99]	%/a	4
2.3	Expected market value in 2015	Mio €	125.000

[94] ETBE = Ethyl-Tertiary-Butyl-Ether, European additive; in other parts of the world not widespread
[95] 1,25 l = 1 kg. Prices normally given are without duty!
[96] As ethanol disregarding conversion to ETBE, this normally takes place in refineries.
[97] Producer – trader – refinery – filling station – consumer or producer – refinery – filling station – consumer or producer – filling station - consumer
[98] Volume trends are fairly unpredictable. There is currently every 11 days a new ethanol plant started up in the USA and countries like Russia, China and many more started to implement similar programs. A buffering effect might come from the availability of raw material. Already now prices for grains and tubers are strongly increasing.
[99] Also prices for ethanol are unpredictable. It is only clear that prices will not decrease. Many analysts see ethanol prices in the range of USD 1/KG in 2010 - 2015

II Production Characteristics (ethanol)

No	Parameter	Unit	Value
3	**Process characteristics**		
3.1	Type of organism used		Saccharomyces
3.2	Type of process		fermentation-distillation-rectification
3.3	Main carbohydrate		starch, glucose, molasses, cane-, beet-, wheat-, rye-starch
3.4	Carbohydrate conversion rate	%	49
3.5	Valuable by-product[100]	y/n	Y
4	**Size and cost structure of plant**		
4.1	Typical size	Tons/a	200.000
4.2	Global capacity utilisation	%	> 90
4.3	Typical investment[101]	€/ta	500
4.4	Total cost of production	€/kg	0,4
4.5	Importance of cost items		
	Depreciation	%	21
	Carbohydrate	%	64
	Labour	%	3
	Utility	%	10
	Overhead/others	%	2
4.6	Margin fc (sales price – costs)	%	30
5	**Patent protection of main process steps**	**y/n**	**No**
6	**Flexibility of process**		
6.1	Flexibility in using carbohydrates	h/l	high
6.2	Degree of sophistication	h/m/l	low
6.3	Dedication of plant	d/nd	D

[100] Distillers' grain syrup to be used in the feed industry. The value of this product has a strong influence on ethanol production costs. Thus the impact of the carbohydrate price on ethanol economics can be buffered when an attractive market for such distillers grain is available.
[101] Western Europe

III Success Factors (ethanol)

Parameter	Degree of importance (1 = lowest, 3 = highest)		
	1	2	3
Economy of scale			X
Quality			X
Low selling price			X
Specialisation on specific derivatives	X		
Availability of specific know-how (base process)	X		
Availability of specific know-how (formulation)	X		
Availability of spec. carbohydrates	X		
Low priced carbohydrates			X
Low priced labour	X		
Low prices utilities	X		
Availability of excess of water			X
Availability of specific reaction chemicals	X		
Availability of special sales force/network	X		
Need for customer training	X		
Need for specialized distribution network		x	
Patent protection	X		
Elaborate product/derivative portfolio	X		
Requirement of flexibility vis-à-vis market/consumer developments	X		
Specific permissions/regulations	X		

IV Summarizing Comment

Bio-ethanol was always produced. But the main impetus for the product came with the increasing awareness on the reducing availability of petroleum and on greenhouse gases. In 1990 Brazil, in 2000 the USA and in 2004/05 the EU started large-scale ethanol programs, mostly based on the conversion of sugar in Brazil and wheat and corn in the other regions. In Asia it is cassava and cane which is converted with countries such as Thailand, Indonesia and Pakistan leading. Manufacturing costs totally depend on the economy of scale and the availability of cheap carbohydrates. Saccharomyces is able to convert almost every raw material into alcohol as long as it can be broken down to a mono- or disaccharide. Alcohol processes are well established. The technology is relatively simple to operate and the most sophisticated parts are distillation and rectification. Due to the run on bio-fuel the market for ethanol is booming and both, volume and price trends are up for the next years.
Bio-ethanol is typically sold from the producer to ETBE manufactures or refineries, which use the product for mixing with gasoline and further distribution to filling stations.

2.3.2.21 Amylases

I General and Market Characteristics (amylases[102])

No	Parameter	Unit	Value
1	**Historic and current market parameters**		
1.1	Market size	tons[103]	230.000
1.2	Annual growth of market size (1993-2006)	%	3
1.3	Main usage		
	Food	%	61
	Feed	%	1
	Supplements/Pharmaceuticals	%	0
	Chemical/ intermediate	%	38
1.4	Share of base product converted	%	0
1.5	Main product form		powder, liquids
1.6	Price of base product[104]	€/kg	1,5
1.7	Price of main derivative	€/kg	
1.8	Price trend (Ø1990-2006) of base product	%	-3
1.9	Price trend of main derivative (Ø 1990-2006)	%	-
1.10	Market value (2006)	Mio €	345
1.11	Regulation (EU, NAFTA)	Free/regulated	free
1.12	Image of product	High/low	high
1.13	No of producers	No	20
1.14	Market share of three main producers	%	95
1.15	Market share of Chinese/Indian producer	%	15
1.16	Distribution system[105]		direct, captive
1.17	Steps in value chain	No	1-2
1.18	Requirements of formulation	y/n	No
2	**Future developments**		
2.1	Volume trend	%	4
2.2	Price trend	%/a	0
2.3	Expected market value in 2015[106]	Mio €	490

[102] Product family consisting of alpha- and beta-amylase, amyloglucanase.
[103] Volumes are difficult to estimate as concentrations vary strongly. Data given here refer to validase FAA 40L from Valley Research. The product volumes indicated represent formulated and diluted ones and not pure proteins.
[104] Exact prices are difficult to indicate, as there are numerous products in the market with different strength of the main and different strength of side enzymatic activities. Enzymes form different producers are difficult to compare, as every enzyme is more or less unique. The price indicated has to be used as an approximation. In reality and for a specific product, major deviations up and down are possible.
[105] Very big starch manufacturers (ADM) and especially corn wet milling companies who use amylases produce and use the product in-house. Such product is not traded.
[106] The market is expanding strongly in line with the increasing demand for starch and glucose.

II Production Characteristics (amylase)

No	Parameter	Unit	Value
3	**Process characteristics**		
3.1	Type of organism used		Bacillus, fungus[107]
3.2	Type of process		Fermentation-purification-dilution-formulation
3.3	Main carbohydrate		Starch
3.4	Carbohydrate conversion rate	%	3
3.5	Valuable by-product	y/n	N
4	**Size and cost structure of plant**		
4.1	Typical size	Tons/a	10.000
4.2	Global capacity utilisation	%	> 90
4.3	Typical investment[108]	€/ta	1.600
4.4	Total cost of production	€/kg	0,8
4.5	Importance of cost items		
	Depreciation	%	40
	Carbohydrate	%	15
	Labour	%	16
	Utility	%	21
	Overhead/others	%	8
4.6	Margin fc (sales price – costs)	%	53
5	**Patent protection of main process steps**	**y/n**	**no**
6	**Flexibility of process**		
6.1	Flexibility in using carbohydrates	h/l	low
6.2	Degree of sophistication	h/m/l	medium
6.3	Dedication of plant	d/nd	d

[107] Depending of the application, there are many different micro-organisms used to produce special amylases. The standard is however a product resulting from fermentation a bacillus subtilis strain and the product is used in corn wet milling

[108] USA

III Success Factors (amylase)

Parameter	Degree of importance (1 = lowest, 3 = highest)		
	1	2	3
Economy of scale			X
Quality			X
Low selling price			X
Specialisation on specific derivatives		x	
Availability of specific know-how (base process)		x	
Availability of specific know-how (formulation)		x	
Availability of spec. carbohydrates		x	
Low priced carbohydrates		X	
Low priced labour	X		
Low prices utilities			X
Availability of excess of water			x
Availability of specific reaction chemicals	X		
Availability of special sales force/network		X	
Need for customer training		X	
Need for specialized distribution network			X
Patent protection	X		
Elaborate product/derivative portfolio		X	
Requirement of flexibility vis-à-vis market/consumer developments	X		
Specific permissions/regulations	X		

IV Summarizing Comment

Despite the fact that amylases are widely used in many food and industrial applications and the product shows characteristics of a commodity, manufacturing and selling are still not yet standard operations. Depending on the process management, yields and thus costs of production can fluctuate strongly and without appropriate formulation/ dilution system the enzyme proteins are neither stable nor utilisable. The main users of such enzymes are the starch processing and paper manufacturing industries and to a lesser extent detergent manufacturers. Market access requires highly skilled labour and specific approaches and networks. Amylases are mostly produced in North America and Western Europe, including those companies which use the enzyme in-house. The market size of traded product is much smaller than indicated.

2.3.2.22 Cellulases

I General and Market Characteristics (Cellulases[109])

No	Parameter	Unit	Value
1	Historic and current market parameters		
1.1	Market size	tons[110]	23.000
1.2	Annual growth of market size (1993-2006)	%	4
1.3	Main usage		
	Food	%	5
	Feed	%	50
	Supplements/Pharmaceuticals	%	0
	Chemical/ intermediate	%	45
1.4	Share of base product converted	%	0
1.5	Main product form		powder, liquid
1.6	Price of base product	€/kg[111]	10
1.7	Price of main derivative	€/kg	0
1.8	Price trend (Ø1990-2006) of base product	%[112]	-6
1.9	Price trend of main derivative (Ø 1990-2006)	%	-
1.10	Market value (2006)	Mio €	230
1.11	Regulation (EU, NAFTA)	Free/regulated	regulated
1.12	Image of product	High/low	high
1.13	No of producers	No	20
1.14	Market share of three main producers	%	80
1.15	Market share of Chinese/Indian producer	%	5
1.16	Distribution system		direct
1.17	Steps in value chain	No	2
1.18	Requirements of formulation	y/n	yes
2	**Future developments**		
2.1	Volume trend	%	5[113]
2.2	Price trend	%/a	0
2.3	Expected market value in 2015	Mio €	357

[109] Product family comprising cellulase, hemi-cellulase, beta-glucanase and xylanase
[110] Volumes are difficult to estimate as concentrations vary strongly. Data given here refer to Iogene's cellulose-xylanase unit produced by a Trichoderma strain. The product is used in the paper and feed industry.
[111] Pure protein
[112] Prices are picking up again as the product is since two years in short supply.
[113] Volume increases can be much higher in the case celluloses become a major ingredient for bio-ethanol manufacturing. Otherwise the market is strongly driven by applications in the feed industry.

II Production Characteristics (cellulases)

No	Parameter	Unit	Value
3	**Process characteristics**		
3.1	Type of organism used		Trichoderma
3.2	Type of process		Fermentation-precipitation - purification-dilution-formulation
3.3	Main carbohydrate		starch
3.4	Carbohydrate conversion rate	%	20
3.5	Valuable by-product	y/n	n
4	**Size and cost structure of plant**		
4.1	Typical size	Tons/a	2.000
4.2	Global capacity utilisation	%	> 90
4.3	Typical investment[114]	€/ta	1.300
4.4	Total cost of production	€/kg	7
4.5	Importance of cost items		
	Depreciation	%	37
	Carbohydrate	%	20
	Labour	%	8
	Utility	%	25
	Overhead/others	%	10
4.6	Margin fc (sales price – costs)	%	30
5	**Patent protection of main process steps**	**y/n**	**no**
6	**Flexibility of process**		
6.1	Flexibility in using carbohydrates	h/l	low
6.2	Degree of sophistication	h/m/l	medium
6.3	Dedication of plant	d/nd	d

[114] USA

III Success Factors (cellulases)

Parameter	Degree of importance (1 = lowest, 3 = highest)		
	1	2	3
Economy of scale			X
Quality			X
Low selling price			X
Specialisation on specific derivatives	X		
Availability of specific know-how (base process)		X	
Availability of specific know-how (formulation)		X	
Availability of spec. carbohydrates			X
Low priced carbohydrates			X
Low priced labour	X		
Low prices utilities			X
Availability of excess of water			x
Availability of specific reaction chemicals	X		
Availability of special sales force/network		X	
Need for customer training	X		
Need for specialized distribution network		X	
Patent protection	X		
Elaborate product/derivative portfolio	X		
Requirement of flexibility vis-à-vis market/consumer developments	X		
Specific permissions/regulations			X

IV Summarizing Comment

Traditionally cellulases were used in technical applications such as paper manufacturing and textiles. The major upswing of the product came with the introduction to the feed industry. Non-corn grains are better utilised by non-ruminants if such cellulases are added. The feed market is regulated and therefore permissions are needed. Like with all other industrial enzymes it is Novo and Danisco dominating the market. Chinese players are not important so far. However, the price pressure on the feed industry also influenced prices of cellulases. It is expected that grains in future will be more expensive and in consequence cellulase type enzymes might see a certain increase in price as well. Already now the need for better utilising cellulases in feed and the booming paper industry induced a revision of the long-term price trend. Prices for cellulases are picking up again. The importance of cellulases is supposed to increase in future also because of the need for breaking down celluloses to be used as base substrate in ethanol fermentation.

2.3.2.23 Proteases

I General and Market Characteristics (proteases)

No	Parameter	Unit	Value
1	**Historic and current market parameters**		
1.1	Market size	tons	144.000
1.2	Annual growth of market size (1993-2006)	%	5
1.3	Main usage		
	Food	%	10
	Feed	%	2
	Supplements/Pharmaceuticals	%	0
	Chemical/ intermediate[115]	%	88
1.4	Share of base product converted	%	0
1.5	Main product form		powder
1.6	Price of base product	€/kg	3
1.7	Price of main derivative	€/kg	-
1.8	Price trend (Ø1990-2006) of base product	%	
1.9	Price trend of main derivative (Ø 1990-2006)	%	-
1.10	Market value (2006)	Mio €	433
1.11	Regulation (EU, NAFTA)	Free/regulated	
1.12	Image of product	High/low	low
1.13	No of producers	No	15
1.14	Market share of three main producers	%	90
1.15	Market share of Chinese/Indian producer	%	4
1.16	Distribution system		direct
1.17	Steps in value chain	No	2
1.18	Requirements of formulation	y/n	y
2	**Future developments**		
2.1	Volume trend	%	2[116]
2.2	Price trend	%/a	0
2.3	Expected market value in 2015	Mio €	518

[115] Detergents (incl. Washing powders and dish washer salts) and leather
[116] The global demand for protease containing washing powders is not increasing much and also the leather industry is not booming. Therefore it is expected that the protease market does not expand too much. Other applications only play a minor role.

II Production Characteristics (protease)

No	Parameter	Unit	Value
3	**Process characteristics**		
3.1	Type of organism used		Bacillus, Penicillium
3.2	Type of process		Fermentation-purification-dilution-formulation
3.3	Main carbohydrate		glucose
3.4	Carbohydrate conversion rate	%	
3.5	Valuable by-product	y/n	n
4	**Size and cost structure of plant**		
4.1	Typical size	Tons/a	
4.2	Global capacity utilisation	%	< 90
4.3	Typical investment	€/ta	1.000
4.4	Total cost of production	€/kg	9
4.5	Importance of cost items		
	Depreciation	%	22
	Carbohydrate	%	25
	Labour	%	8
	Utility	%	25
	Overhead/others	%	10
4.6	Margin fc (sales price – costs)	%	10
5	**Patent protection of main process steps**	**y/n**	**n**
6	**Flexibility of process**		
6.1	Flexibility in using carbohydrates	h/l	l
6.2	Degree of sophistication	h/m/l	m
6.3	Dedication of plant	d/nd	d

III Success Factors (protease)

Parameter	Degree of importance (1 = lowest, 3 = highest)		
	1	2	3
Economy of scale			X
Quality		X	
Low selling price			X
Specialisation on specific derivatives	X		
Availability of specific know-how (base process)		X	
Availability of specific know-how (formulation)			X
Availability of spec. carbohydrates			X
Low priced carbohydrates			X
Low priced labour	X		
Low prices utilities			X
Availability of excess of water			X
Availability of specific reaction chemicals	X		
Availability of special sales force/network		X	
Need for customer training		X	
Need for specialized distribution network		X	
Patent protection	X		
Elaborate product/derivative portfolio		X	
Requirement of flexibility vis-à-vis market/consumer developments	X		
Specific permissions/regulations		X	

IV Summarizing comment

The market for proteases is large, due to their application in washing powders. They are, like most other industrial enzymes commodities and marketing is largely price driven. Production is, in contrast to other enzymes trickier, as proteases can cause strong allergic reactions. Specific precautions are necessary. Future market growth depends strongly on the use of protease containing washing powders, and for the moment this is a domain of Western countries in which the market is saturated. However, the rising standard of living in many Asian countries including China will induce a major upswing in the demand for washing powders and subsequently also for proteases.

2.3.2.24 Acetic Acid

I General and Market Characteristics (acetic acid)[117]

No	Parameter	Unit	Value
1	**Historic and current market parameters**		
1.1	Market size[118]	Mio Tons	2
1.2	Annual growth of market size (1993-2006)	%	5
1.3	Main usage		
	Food	%	1
	Feed	%	0
	Supplements/Pharmaceuticals	%	0
	Chemical/ intermediate	%	99
1.4	Share of base product converted	%	0
1.5	Main product form		liquid
1.6	Price of base product	€/kg	1,2
1.7	Price of main derivative	€/kg	./.
1.8	Price trend (Ø1990-2006) of base product	%	5
1.9	Price trend of main derivative (Ø 1990-2006)	%	./.
1.10	Market value (2006)	Mio €	2.400
1.11	Regulation (EU, NAFTA)	Free/regulated	free
1.12	Image of product	High/low	low
1.13	No of producers	No	> 50
1.14	Market share of three main producers	%	< 50
1.15	Market share of Chinese/Indian producer	%	5
1.16	Distribution system		direct
1.17	Steps in value chain	No	2
1.18	Requirements of formulation	y/n	n
2	**Future developments**		
2.1	Volume trend	%	3
2.2	Price trend	%/a	0
2.3	Expected market value in 2015	Mio €	3.131

[117] Pure acetic acid with an acid content of min 96%. The product is mainly used as a chemical intermediate but also in diluted form for food applications.
[118] Acetic acid diluted as used for food applications is consumed in a quantity of > 200 Mio tons.

II Production Characteristics (acetic acid)[119]

No	Parameter	Unit	Value
3	**Process characteristics**		
3.1	Type of organism used		Acetobacter sp and others
3.2	Type of process		fermentation/ distillation/ rectification
3.3	Main carbohydrate		All
3.4	Carbohydrate conversion rate	%	Up to 80%
3.5	Valuable by-product	y/n	y
4	**Size and cost structure of plant**		
4.1	Typical size	Tons/a	20.000
4.2	Global capacity utilisation	%	> 10
4.3	Typical investment	€/ta	2.000
4.4	Total cost of production	€/kg	0,5
4.5	Importance of cost items		
	Depreciation	%	20
	Carbohydrate	%	55
	Labour	%	10
	Utility	%	10
	Overhead/others	%	5
4.6	Margin fc (sales price – costs)	%	58
5	**Patent protection of main process steps**	**y/n**	**n**
6	**Flexibility of process**		
6.1	Flexibility in using carbohydrates	h/l	h
6.2	Degree of sophistication	h/m/l	l
6.3	Dedication of plant	d/nd	d

[119] This chapter only refers to acetic acid manufactured by fermentation. Most of the currently commercialized acetic acid is manufactured by chemical synthesis (oxidation of ethylene ore CO addition to methanol)

III Success Factors (acetic acid)

Parameter	Degree of importance (1 = lowest, 3 = highest)		
	1	2	3
Economy of scale			X
Quality			X
Low selling price			X
Specialisation on specific derivatives	X		
Availability of specific know-how (base process)		X	
Availability of specific know-how (formulation)	x		
Availability of spec. carbohydrates	x		
Low priced carbohydrates			X
Low priced labour			X
Low prices utilities			X
Availability of excess of water		X	
Availability of specific reaction chemicals	X		
Availability of special sales force/network		X	
Need for customer training		X	
Need for specialized distribution network		X	
Patent protection	X		
Elaborate product/derivative portfolio	X		
Requirement of flexibility vis-à-vis market/consumer developments	X		
Specific permissions/regulations		X	

IV Summarizing Comment

Today the market for acetic acid anhydrous is covered by synthetic production. Since the oil price went up sustainable above USD 40 per barrel the fermentation route is becoming competitive. With a suitable strain and technology high conversion rates can be achieved. Marketing of acetic acid obtained by fermentation should target the chemical industry mostly in Germany and in other European countries with strict regulation on environment, high demand and high imports of petroleum. Although the overall demand for acetic acid is supposed to be moderate in future, fermentation derived product might show higher growth rates as it will increasingly substitute product resulting from petroleum industry.

2.3.2.25 Poly-Lactic-Acid

I General and Market Characteristics (poly-lactic acid)

No	Parameter	Unit	Value
1	**Historic and current market parameters**		
1.1	Market size	Tons	65.000
1.2	Annual growth of market size (1993-2006)	%[120]	> 100%
1.3	Main usage		
	Food	%	0
	Feed	%	0
	Supplements/Pharmaceuticals	%	0
	Chemical/ intermediate	%	100
1.4	Share of base product converted	%	0
1.5	Main product form		Powder
1.6	Price of base product	€/kg	1,6
1.7	Price of main derivative	€/kg	./.
1.8	Price trend (Ø1990-2006) of base product	%[121]	-10%
1.9	Price trend of main derivative (Ø 1990-2006)	%	./.
1.10	Market value (2006)	Mio €	104
1.11	Regulation (EU, NAFTA)	Free/regulated	Reg
1.12	Image of product	High/low	High
1.13	No of producers	No	3
1.14	Market share of three main producers	%	100
1.15	Market share of Chinese/Indian producer	%	0
1.16	Distribution system		Direct
1.17	Steps in value chain	No	2
1.18	Requirements of formulation	y/n	Y
2	**Future developments**		
2.1	Volume trend	%	15%
2.2	Price trend	%/a	0
2.3	Expected market value in 2015	Mio €	366

[120] Long historic price series fort his product do not exist. The market doubled in the past three years every year.
[121] Price trends refer to 2003 – 2006.

II Production Characteristics (poly-lactic acid)

No	Parameter	Unit	Value
3	**Process characteristics**		
3.1	Type of organism used		chemical/enzymatic polymerisation
3.2	Type of process		polymerisation
3.3	Main carbohydrate		Lactic acid
3.4	Carbohydrate conversion rate	%	80
3.5	Valuable by-product	y/n	n
4	**Size and cost structure of plant**		
4.1	Typical size	Tons/a	50.000
4.2	Global capacity utilisation[122]	%	<<90
4.3	Typical investment	€/ta	6.000
4.4	Total cost of production	€/kg	1
4.5	Importance of cost items		
	Depreciation	%	40
	Carbohydrate[123]	%	40
	Labour	%	5
	Utility	%	10
	Overhead/others	%	5
4.6	Margin fc (sales price – costs)	%	60
5	**Patent protection of main process steps**	**y/n**	**y**
6	**Flexibility of process**		
6.1	Flexibility in using carbohydrates	h/l	l
6.2	Degree of sophistication	h/m/l	h
6.3	Dedication of plant	d/nd	d

[122] Although the market is booming, there are still large overcapacities notably in the US. They will be used up over the next two to three years.
[123] As lactic acid

III Success Factors (poly-lactic acid)

Parameter	Degree of importance (1 = lowest, 3 = highest)		
	1	2	3
Economy of scale			X
Quality			X
Low selling price			X
Specialisation on specific derivatives			X
Availability of specific know-how (base process)			X
Availability of specific know-how (formulation)			X
Availability of spec. carbohydrates			X
Low priced carbohydrates			X
Low priced labour		X	
Low prices utilities			X
Availability of excess of water	X		
Availability of specific reaction chemicals			X
Availability of special sales force/network			X
Need for customer training			X
Need for specialized distribution network			X
Patent protection			X
Elaborate product/derivative portfolio			X
Requirement of flexibility vis-à-vis market/consumer developments			X
Specific permissions/regulations			X

IV Summarizing Comment

Poly-lactic-acid is a biopolymer developed as an alternative to poly-ethylene foils. The main application is packaging of fresh fruits and vegetables. The French supermarket chain Carrefour is the driving force behind commercial usage, which was followed recently by the British Marks & Spencer chain. Toyota cooperates with Purac for developing dashboards based on poly-lactic manufactured in Thailand. For a long time commercial application was hampered by the relatively high price compared to poly-ethylene derived from petroleum. Poly-lactic prices however came down considerably while at the same time petroleum prices increased to over $ 40 per barrel, which is considered as the equilibrium price. The main producer Cargill built up huge capacities, which are still not fully utilised. However, it is assumed that the trend to use poly-lactic in food packaging is set and the market will grow in future strongly. The precondition however is, that a clear transparent product with similar physical-chemical properties as poly-ethylene can be manufactured, which requires a perfect control of the process and a colourless lactic acid product as the starting material. Selling of poly-lactic-acid can not be done in the commodity style but requires high skilled professional staff and access to large-scale users. As the main application is food, food regulations must be met. Key steps in manufacturing are protected by patents.

2.3.2.26 Poly-hydroxy-butyrate (PHB)

I General and Market Characteristics (poly-hydroxy-butyrate)

No	Parameter	Unit	Value
1	**Historic and current market parameters**		
1.1	Market size	Tons	40.000
1.2	Annual growth of market size (1993-2006)	%	15[124]
1.3	Main usage		
	Food	%	0
	Feed	%	0
	Supplements/Pharmaceuticals	%	0
	Chemical/ intermediate	%	100
1.4	Share of base product converted	%	./.
1.5	Main product form		powder
1.6	Price of base product	€/kg	1,5
1.7	Price of main derivative	€/kg	./.
1.8	Price trend (Ø1990-2006) of base product	%	-5
1.9	Price trend of main derivative (Ø 1990-2006)	%	
1.10	Market value (2006)	Mio €	60
1.11	Regulation (EU, NAFTA)	Free/regulated	regulated
1.12	Image of product	High/low	high
1.13	No of producers	No	5
1.14	Market share of three main producers	%	90
1.15	Market share of Chinese/Indian producer	%	30
1.16	Distribution system		direct
1.17	Steps in value chain	No	3
1.18	Requirements of formulation	y/n	y
2	**Future developments**		
2.1	Volume trend	%	15
2.2	Price trend	%/a	0
2.3	Expected market value in 2015	Mio €	211

[124] This product is new in the market and growth rates refer to the past years only. The growth rate indicated is not representative as the product just starts up.

II Production Characteristics (poly-hydroxy-butyrate)

No	Parameter	Unit	Value
3	**Process characteristics**		
3.1	Type of organism used		Alcaligenes
3.2	Type of process		fermentation
3.3	Main carbohydrate		glucose
3.4	Carbohydrate conversion rate	%	>50
3.5	Valuable by-product	y/n	y
4	**Size and cost structure of plant**		
4.1	Typical size	Tons/a	10.000
4.2	Global capacity utilisation	%	> 90
4.3	Typical investment	€/ta	2.500
4.4	Total cost of production	€/kg	1,0
4.5	Importance of cost items		
	Depreciation	%	40
	Carbohydrate	%	40
	Labour	%	5
	Utility	%	10
	Overhead/others	%	5
4.6	Margin fc (sales price – costs)	%	34
5	**Patent protection of main process steps**	**y/n**	**y**
6	**Flexibility of process**		**n**
6.1	Flexibility in using carbohydrates	h/l	l
6.2	Degree of sophistication	h/m/l	h
6.3	Dedication of plant	d/nd	d

III Success Factors (poly-hydroxy-butyrate)

Parameter	**Degree of importance (1 = lowest, 3 = highest)**		
Economy of scale			X
Quality			X
Low selling price			X
Specialisation on specific derivatives			X
Availability of specific know-how (base process)		X	
Availability of specific know-how (formulation)		X	
Availability of spec. carbohydrates		X	
Low priced carbohydrates		X	
Low priced labour		X	
Low prices utilities		X	
Availability of excess of water		X	
Availability of specific reaction chemicals	X		
Availability of special sales force/network		X	
Need for customer training		X	
Need for specialized distribution network		X	
Patent protection		X	
Elaborate product/derivative portfolio		X	
Requirement of flexibility vis-à-vis market/consumer developments		X	
Specific permissions/regulations		X	

IV Summarizing Comment

Commercial poly-hydroxy butyrate is a very new product and overall the know-how of production is patent protected and treated secretively. There is not much known on the market mechanisms of such product only that for the moment the main application is in bottle manufacturing for cosmetics and personal care products. In depth research would be necessary to elaborate the product profile further.

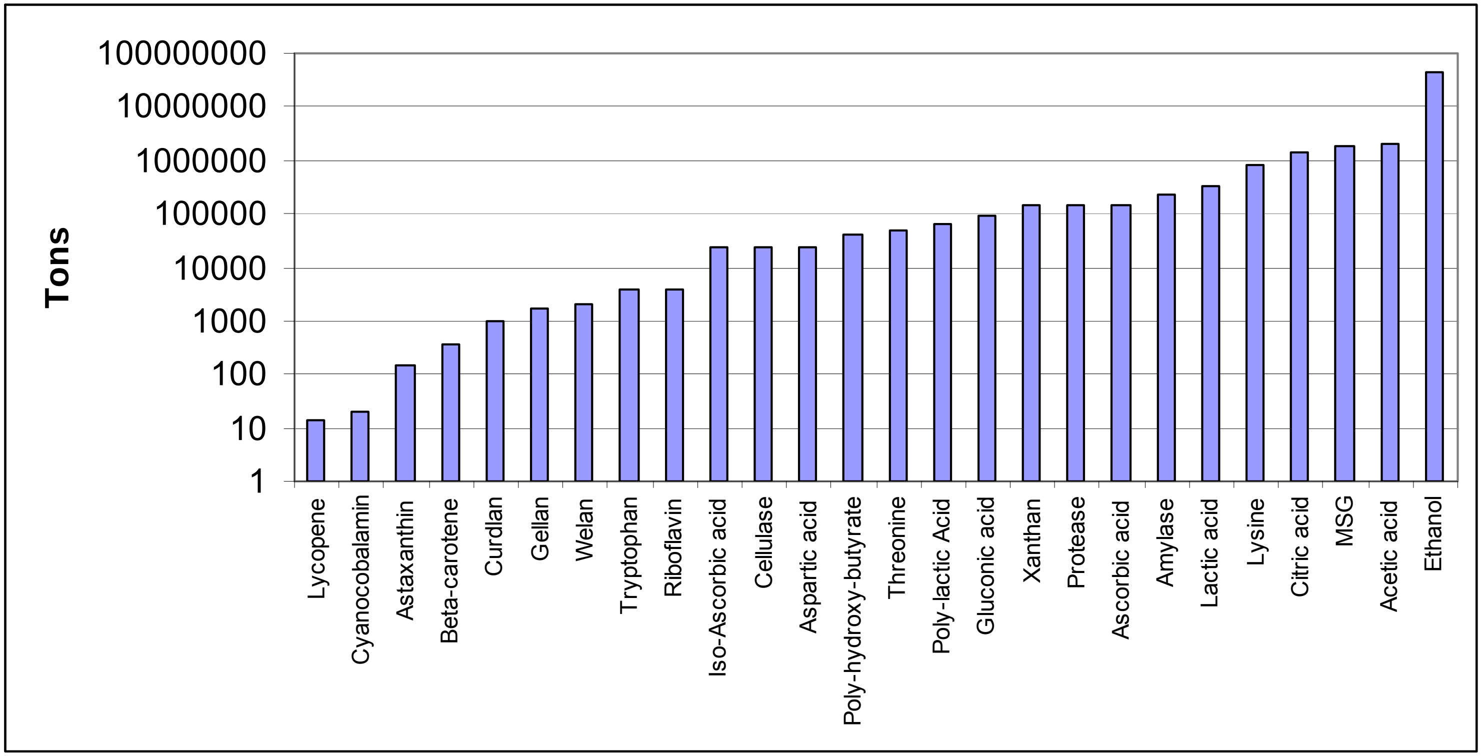
2.3.3 Comparison of Biotech Products according to Main Techno-Economic Characteristics

The multitude of techno-economic parameters given allows the comparison of individual products from different angles.

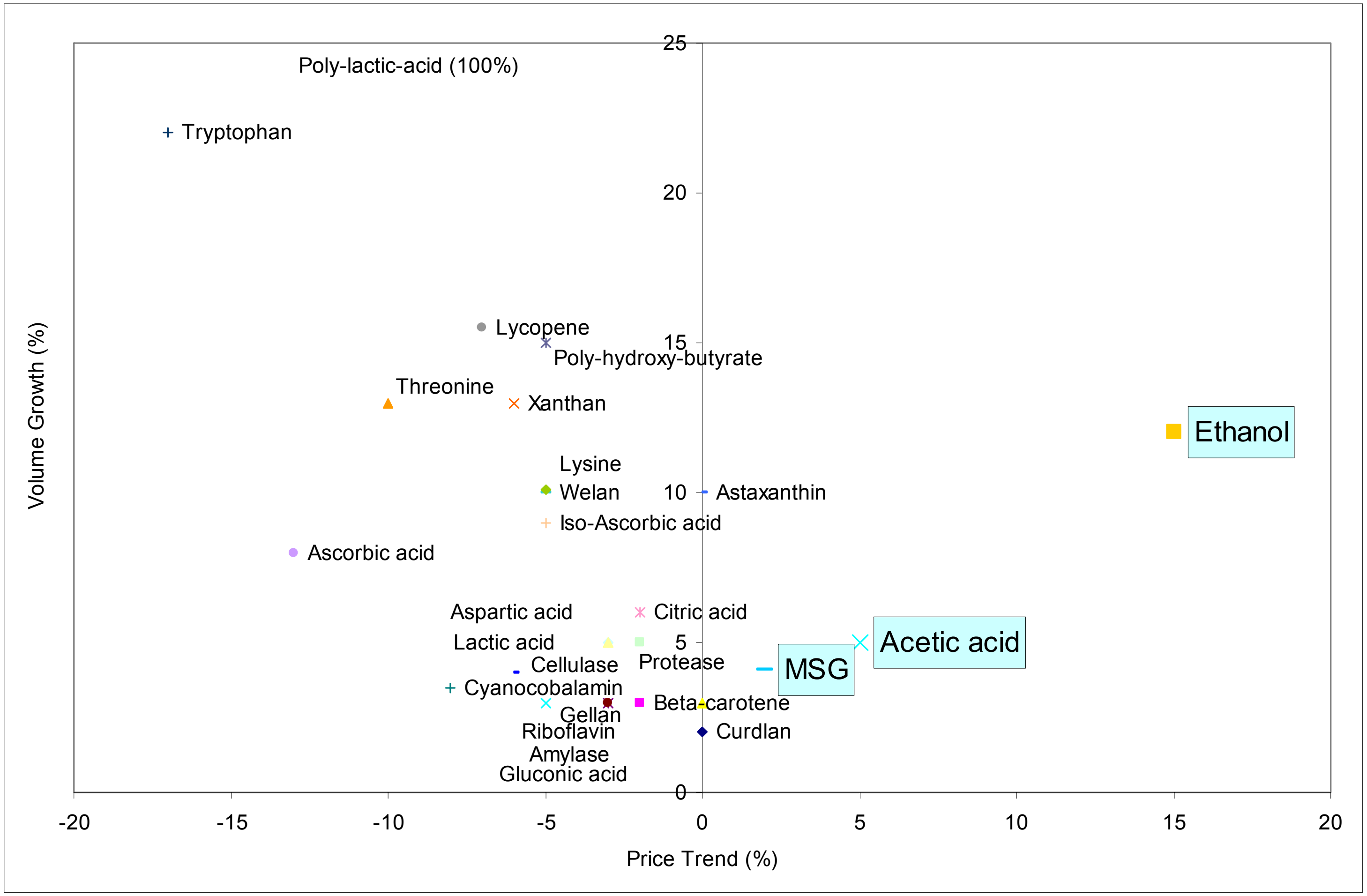
2.3.3.1 Market Related Criteria

- The *market size* of the screened products differs considerably. Ethanol as well as acetic acid but also products such as MSG, citric acid and lysine are manufactured and sold in the range of one million tons or more. In contrast most vitamins and carotenoids are sold in quantities of a few to a few hundred tons. Most other products range between 10.000 to 200.000 tons (Overview 2).
- *Volume growth* of most products over the past years has been in the range of less than 10%. Only Lysine, threonine, xanthan, lycopene, PHB and Ethanol showed growth rates of between 10-15%. Exceptional growth can be identified for tryptophan and Poly-lactic-acid. The boom on poly-lactic-acid is so strong that in the past three years production doubled every year (Overview 3) .
- However, in most cases stormy *volume growth was associated with strong price decreases.* Annually decreasing prices of more than 5% were not exceptional. MSG, Acetic acid and Ethanol are the only products which showed a clear price trend up. Ethanol is the product which shows both, a volume growth and a price growth of above 10% per year (Overview 3).
- *Five different product categories can be identified*. Products which use is primarily food comprise citric acid, iso-ascorbic acid, MSG, gellan and curdlan. Typical feed ingredients are cyanocobalamin, threonine, lysine, tryptophan and astaxanthin. Industrial products comprise aspartic acid, protease, ethanol, acetic acid, welan, poly-lactic and PHB. Multi use products, these are products which are used in different market segments of equal importance, are riboflavin, beta-carotene, ascorbic acid, lactic acid, xanthan, gluconic acid amylase and cellulase. Lycopene’s market is essentially the supplement industry and thus the only product which main market is pharmaceutical related (Overview 4).
- *Unit price* is not strongly related to the main application segments. Astaxanthin, a typical feed ingredient is one of the highest priced products like beta-carotene, lycopene and cyanocobalamin. Ethanol, citric acid, MSG and gluconic acid are all in the price range of below or around € 1/kg. Most other products sell between €1/kg and € 10/kg (Overview 5).
- *Manufacturing of derivatives* only plays a role for six products: citric acid, ascorbic acid, aspartic acid, iso-ascorbic acid, gluconic and lactic acid. In these product categories the successful manufacture of salts and of speciality derivatives decides to a large extent on the marketing success. For all others, the base product as such is sold. Ethanol is also converted to a speciality, but not in the ethanol production plant. It is the refinery to which the ethanol is sold for preparing ETBE (Overview 6).

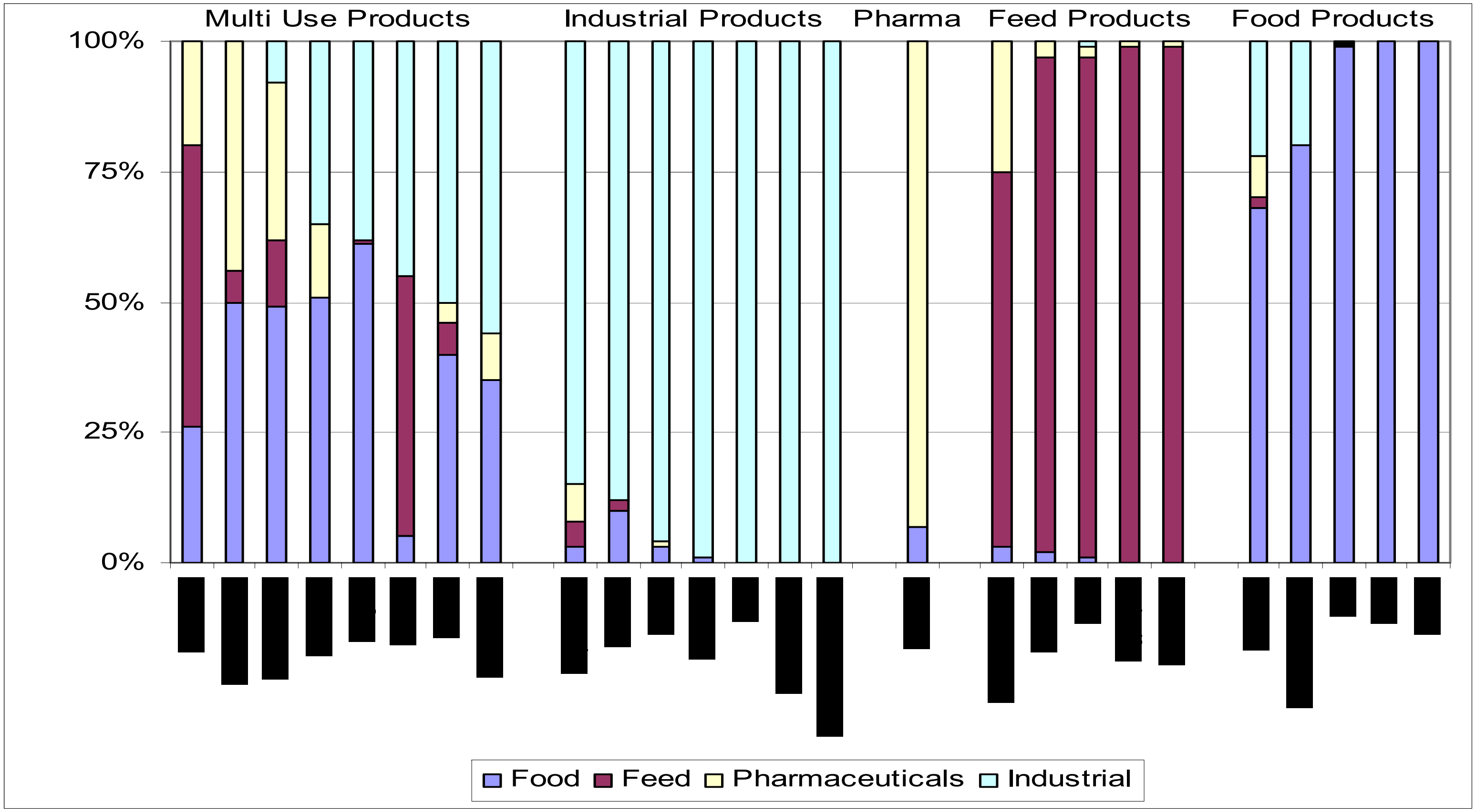
Overview 2: Market Size of screened Fermentation Products



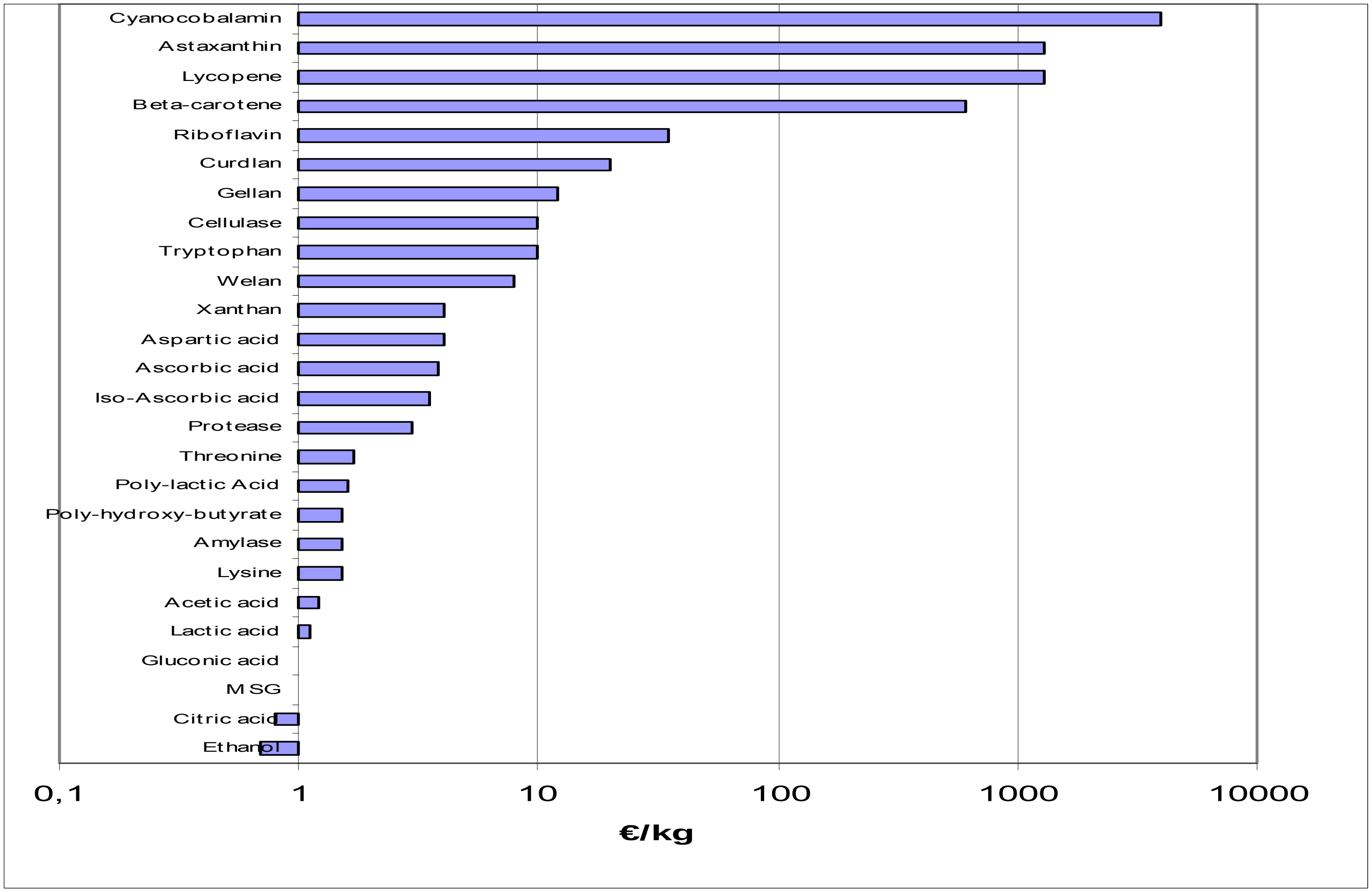
Overview 3: Relationship between Historic Price and Volume Trends



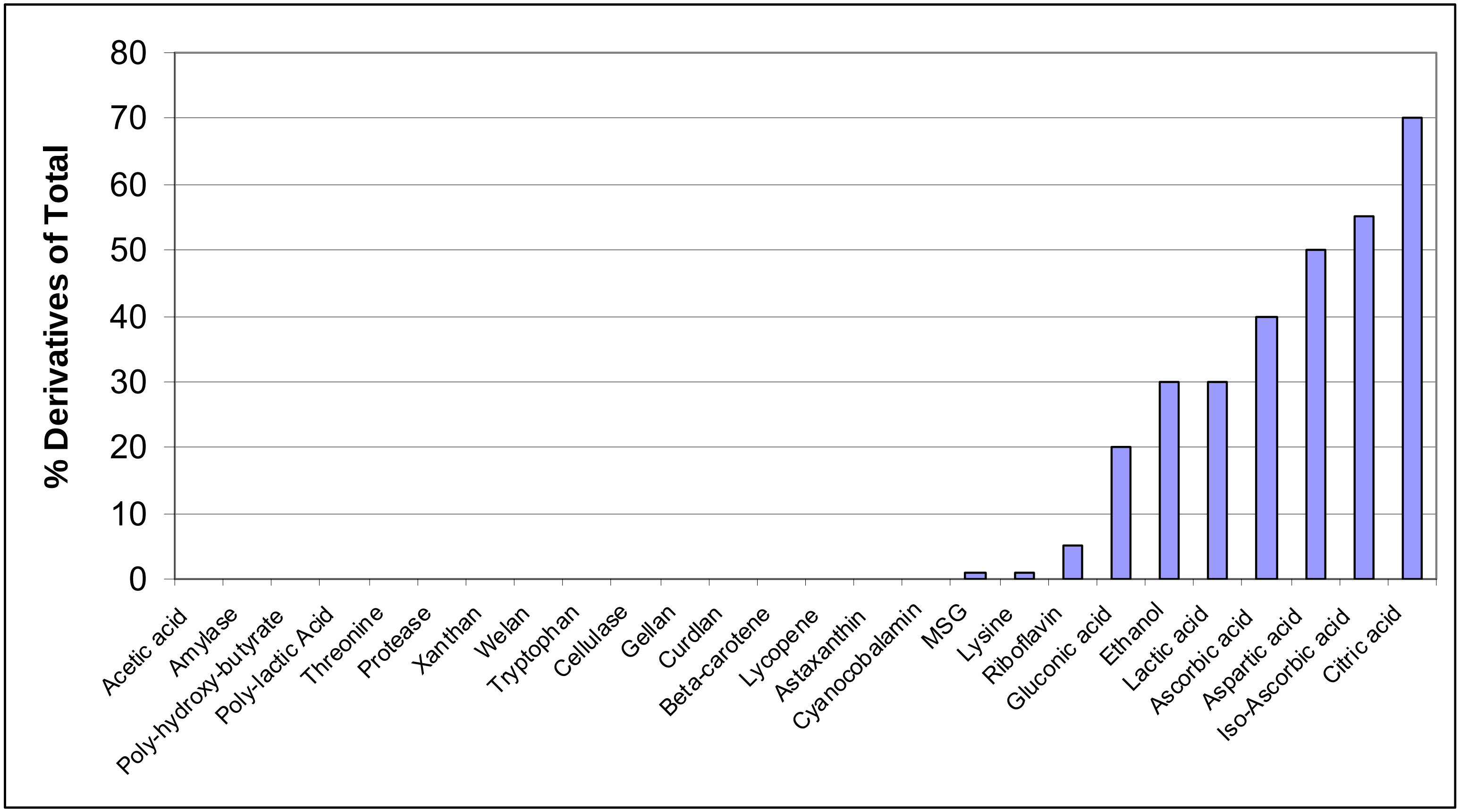
Overview 4: Fermentation Products by Category



Overview 5: Unit Prices of screened Fermentation Products



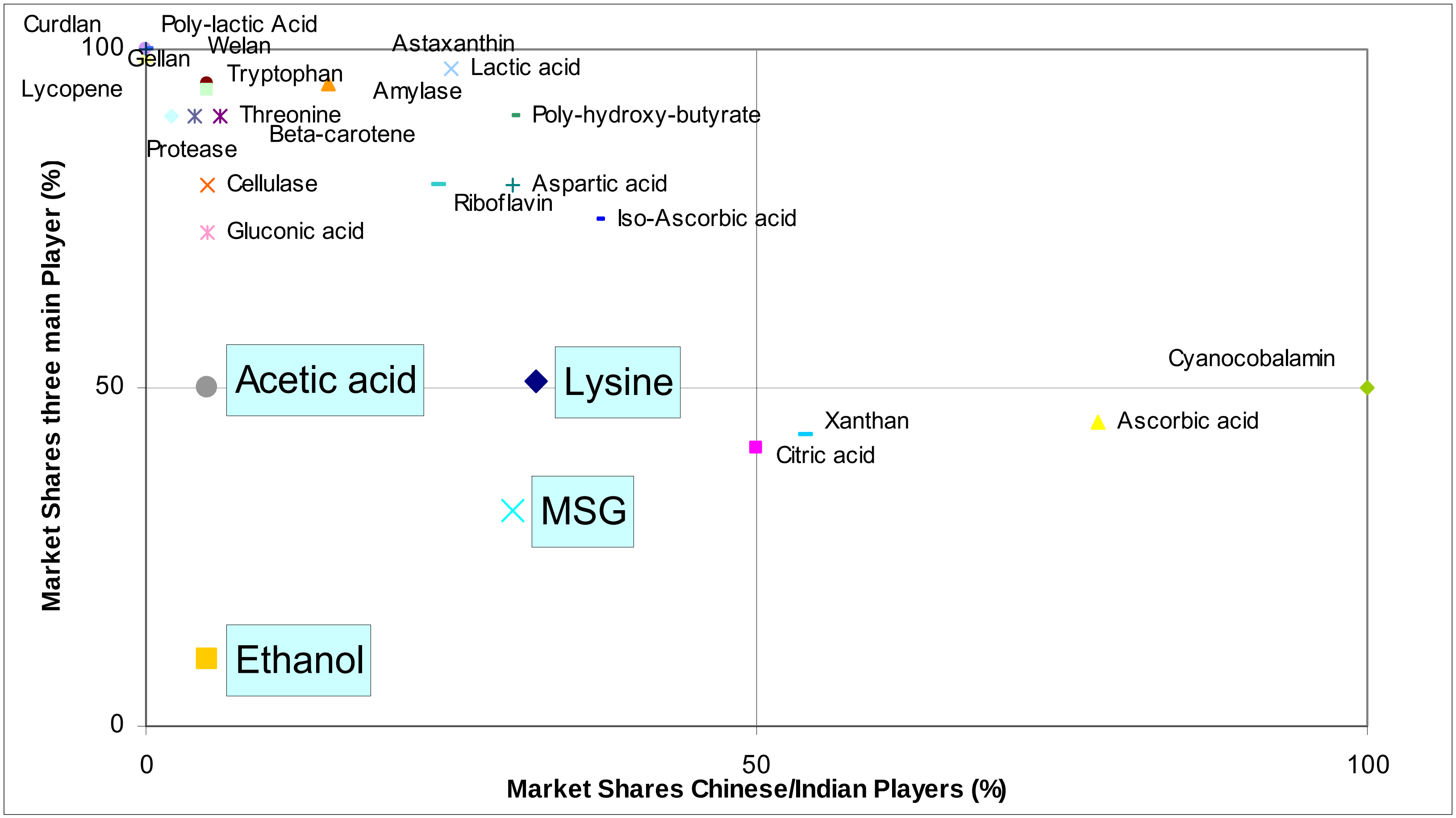
Overview 6: Importance of Derivatives by Base Product (% of Product converted to Salts or Building Blocks)



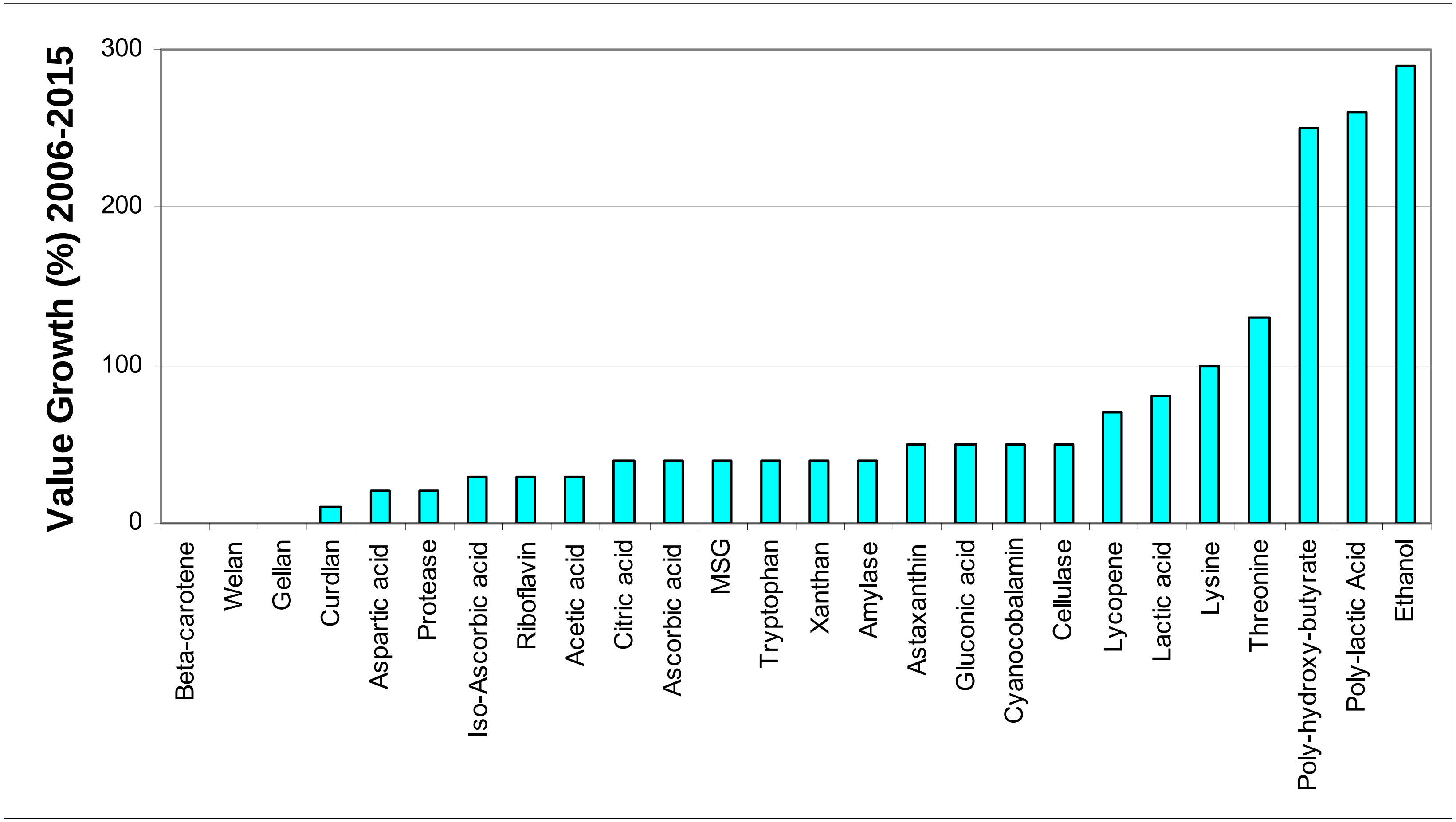
- *Five products are commercialized as liquids:* lactic acid, gluconic acid[125], acetic acid and ethanol. All others are commercialized more in the powder form.
- *Industrial fermentation is not yet a strong domain of Chinese or Indian companies.* There are only a few products in which Chinese clearly dominate: Xanthan, citric and ascorbic acid as well as Vitamin B12. MSG but also lysine is not yet dominated by Chinese companies. However there are various plants under construction and when these come on stream, the picture for these products will change considerably in favour of China (Overview 7).
- However *the global market for most fermentation products is very concentrated.* A few manufacturers dominate and hold market shares well above 75%. Only the markets for ethanol, MSG, acetic acid and lysine are fragmented and at the same time without strong Chinese or Indian presence (Overview 7).
- *Most fermentation products destined for use in food, feed and pharmaceuticals are regulated.* Industrial applications are mostly without restrictive regulation. Ethanol, acetic acid, welan and protease but also most amino acids are without regulation. Biopolymers are however regulated in the case the products are used for food packaging.
- *Distribution chains of almost all products are short*. Many products are either sold directly from the producer to the customer or via a single trading step.
- *Formulation* play a role for those products which are either not stable or require a specific condition for use. The typical examples are the carotenoids and some enzymes. But also biopolymers must be conditioned for use in packaging.
- *Most fermentation products will also in future see substantial growth*. In many cases such growth is fuelled simply by the expanding demand resulting from population and income growth all over the world, notably in Asia. Exceptional growth rates can be expected for ethanol as well as biopolymers (Overview 8).

[125] The technical grade is sold as liquid with 50% dry substance

Overview 7: Market Concentration and Competitive Environment



Overview 8: Future Growth (Value of screened Products) through 2015



2.3.3.2 Process Related Criteria

- *It is mostly bacteria which are used for fermentation*. Fungal based production systems are in tendency easer to operate, but show longer cycles and their productivity is only in exceptional cases (e.g. citric acid) high.

Overview 9: Structuring of Fermentation Processes by Type of Organism used

Fungal Fermentations	Bacterial Fermentations
Citric acid	Lysine
Iso-ascorbic acid	Ascorbic acid
Beta-carotene	MSG
Lycopene	Threonine
Astaxanthin	Tryptophan
Ethanol	Aspartic acid
Amylase	Iso-ascorbic acid
Cellulases	Xanthan
Protease	Lactic acid
PHB	Gluconic acid
	Welan
	Gellan
	Curdlan
	Riboflavin
	Cyanocobalamin
	Amylase
	Protease
	Acetic acid

- *Carbohydrates used are mostly glucose, starch hydrolysates, sucrose or molasses*. Only in a few cases other raw materials can be used for high productivities. The more selective a process is, the more sophisticated it is to manage it.

Overview 10: Structuring of Fermentation Processes by Type of Raw Material

Primarily glucose or starch hydrolysate	Glucose, starch hydrolysate and/or other raw materials
Iso-ascorbic acid	Lysine
Xanthan	Citric acid
Beta-carotene	Ascorbic acid
Lycopene	MSG
Astaxanthin	Threonine
Lactic acid	Tryptophan
Gluconic acid	Aspartic acid
Welan	Cyanocobalamin
Gellan	Ethanol
Curdlan	Acetic acid
Riboflavin	
Amylase	
Cellulases	
Proteases	

- *Carbohydrate conversion rates* of many products are exceeding 50%. These processes are considered to use scarce carbohydrates efficiently, while processes such as beta-carotene with a very low conversion rates are not very efficient and thus don't use the raw material appropriately (Overview 11).
- *Moreover, none of the screened processes yields valuable by-products except ethanol and acetic acid*. The reason is that in most other cases, chemicals are added to the broth for the downstream which prevent the usage of by-products. In the case of ethanol and acetic acid, the by-products, distillers' grains can be used for cattle feeding and usually fetch a considerable price in the market.
- *Fermentation is not a small-scale business*. Typical plant sizes are large, exceeding several thousand tons or even larger (Overview: 12). Such minimum sizes much be considered in the design of plants, as otherwise the economics will not be favourable.
- Despite the fact that over all products considerable capacities are installed, *there is not much idle capacity around*. The most prominent exception might be citric acid, for which a true global overcapacity exists.
- *Investment costs correlate with plant size and with the sophistication of the process*. The larger the plant and the less sophisticated the process, the less are specific investment needs. Ethanol shows with € 500 per ton installed capacity the lowest specific investment needs, while for beta-carotene, an amount of approx. € 1 Mio per ton of pure product is needed (overview 13).
- *Total production costs are a reflection of plant size, specific investments and carbohydrate conversion rate*. In most cases, depreciation is the key cost item, but for large scale plants such as ethanol, it is virtually only the raw material price which is important (Overview 14).

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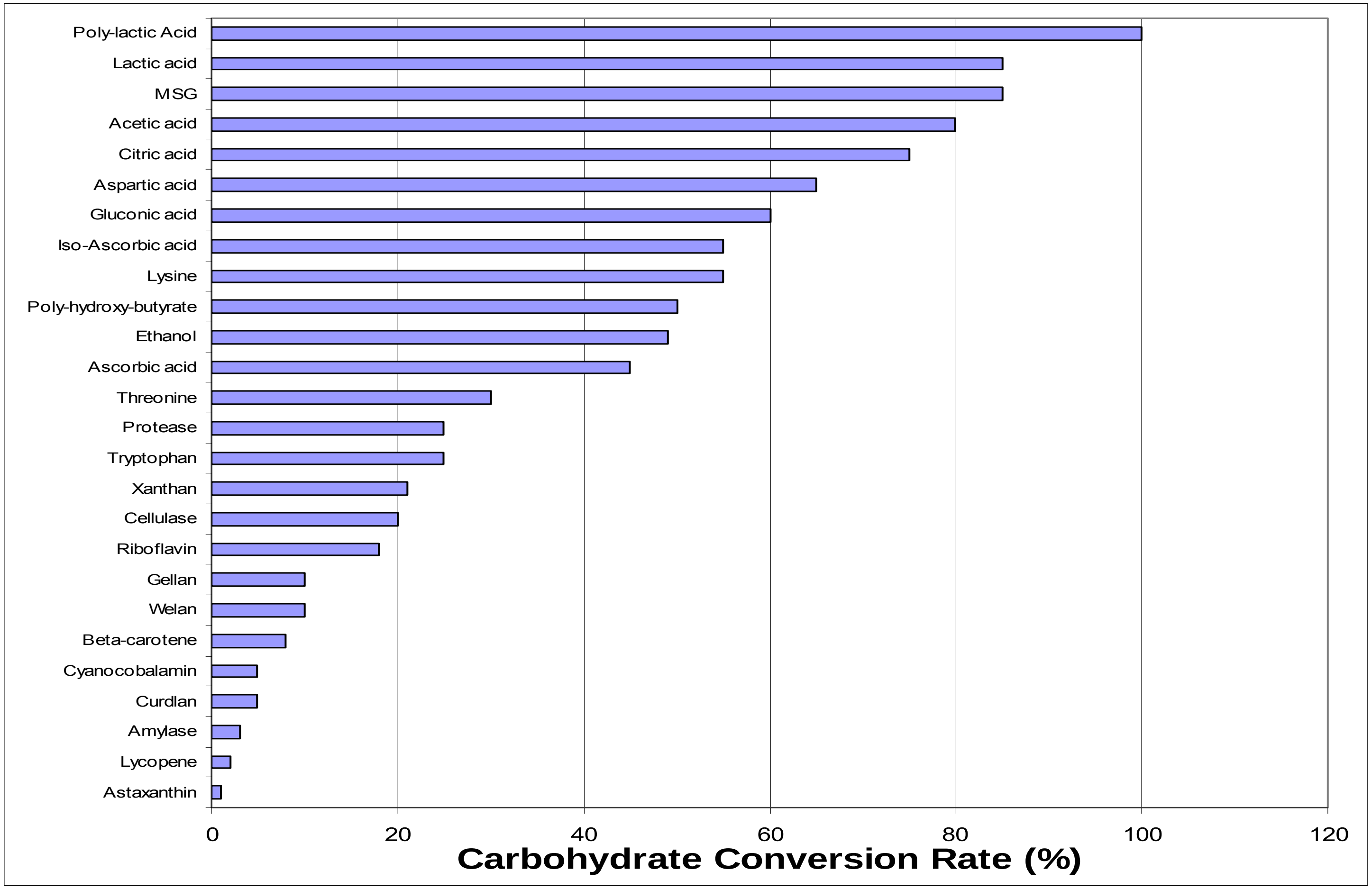
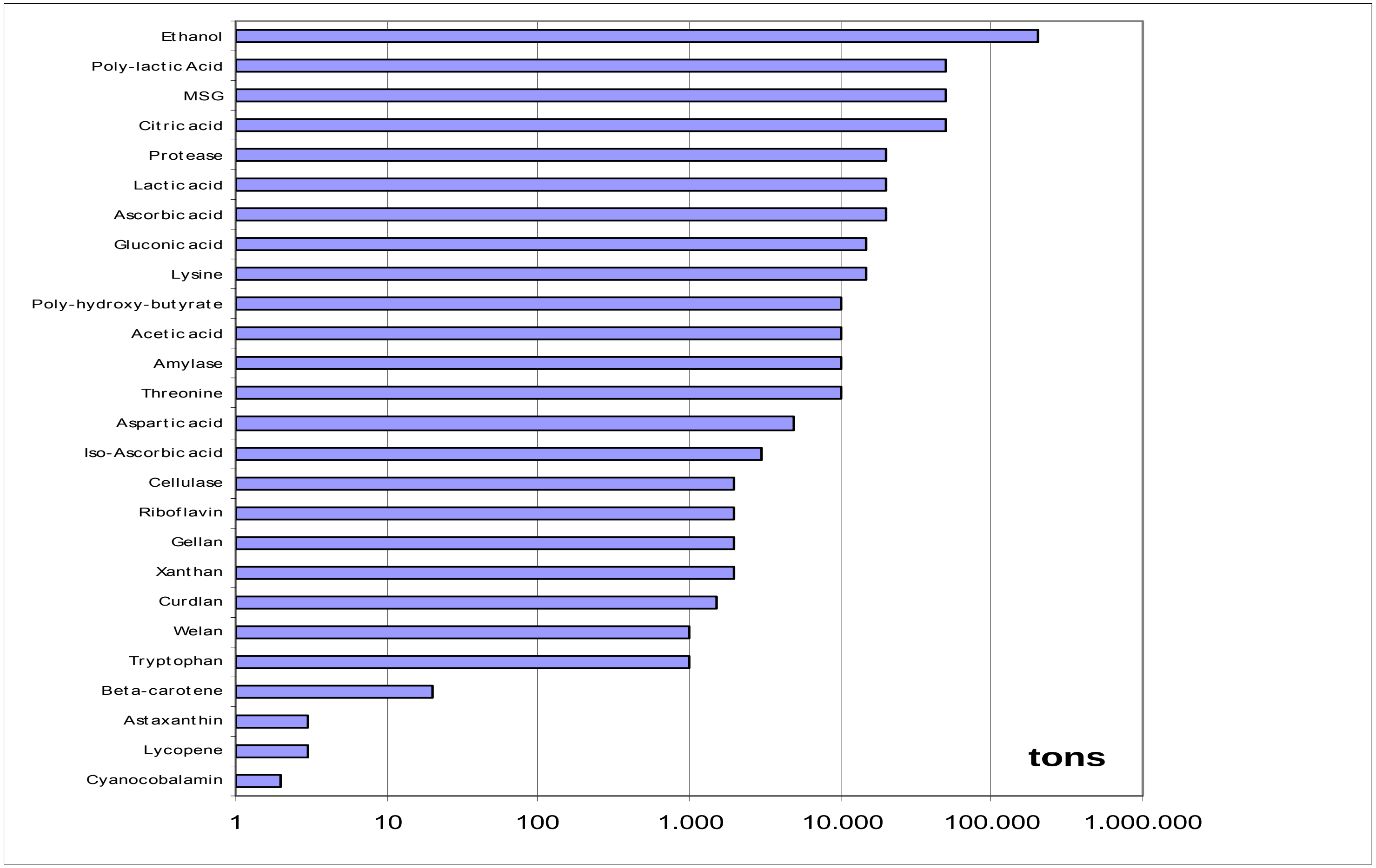
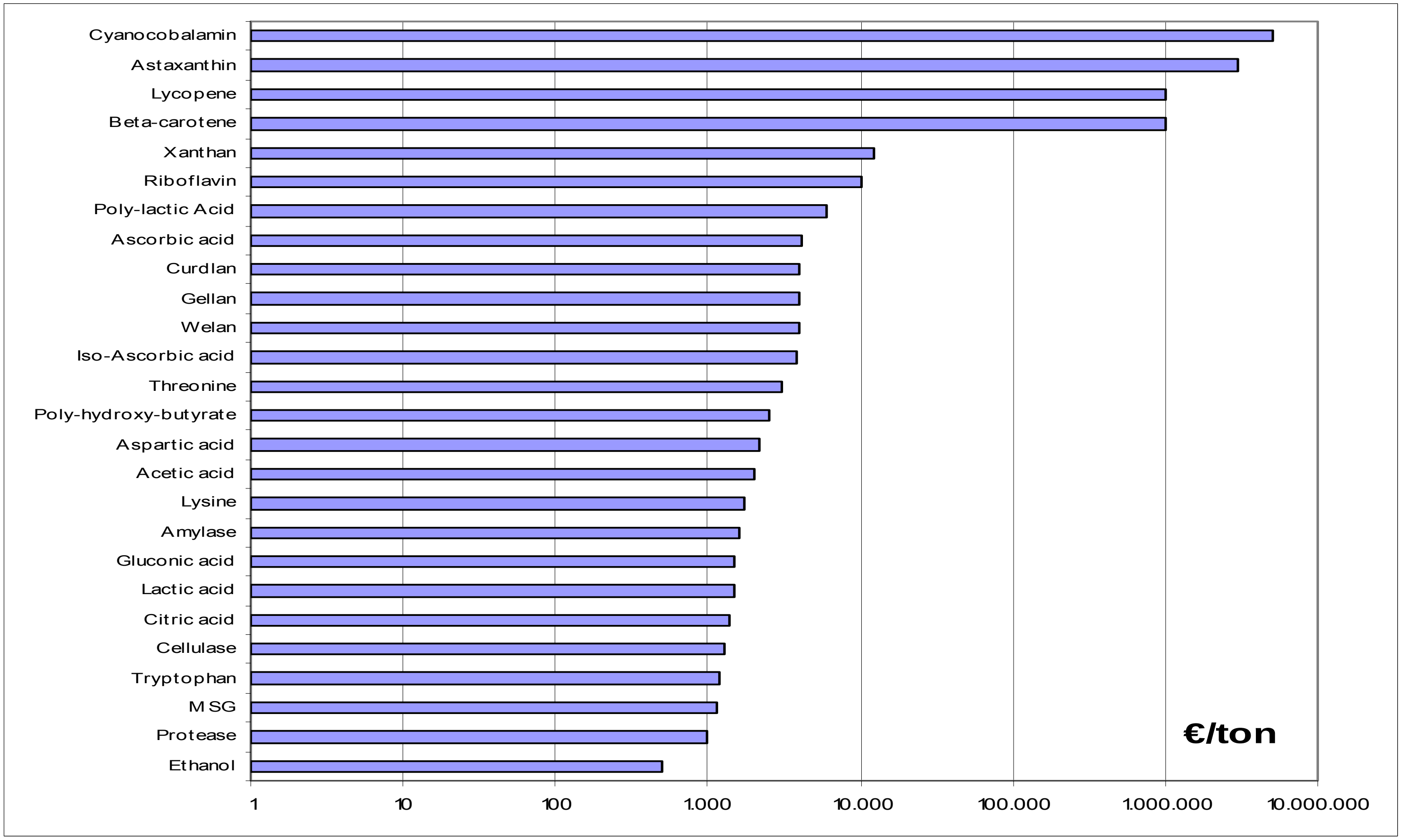
Overview 11: Carbohydrate Conversion Rates



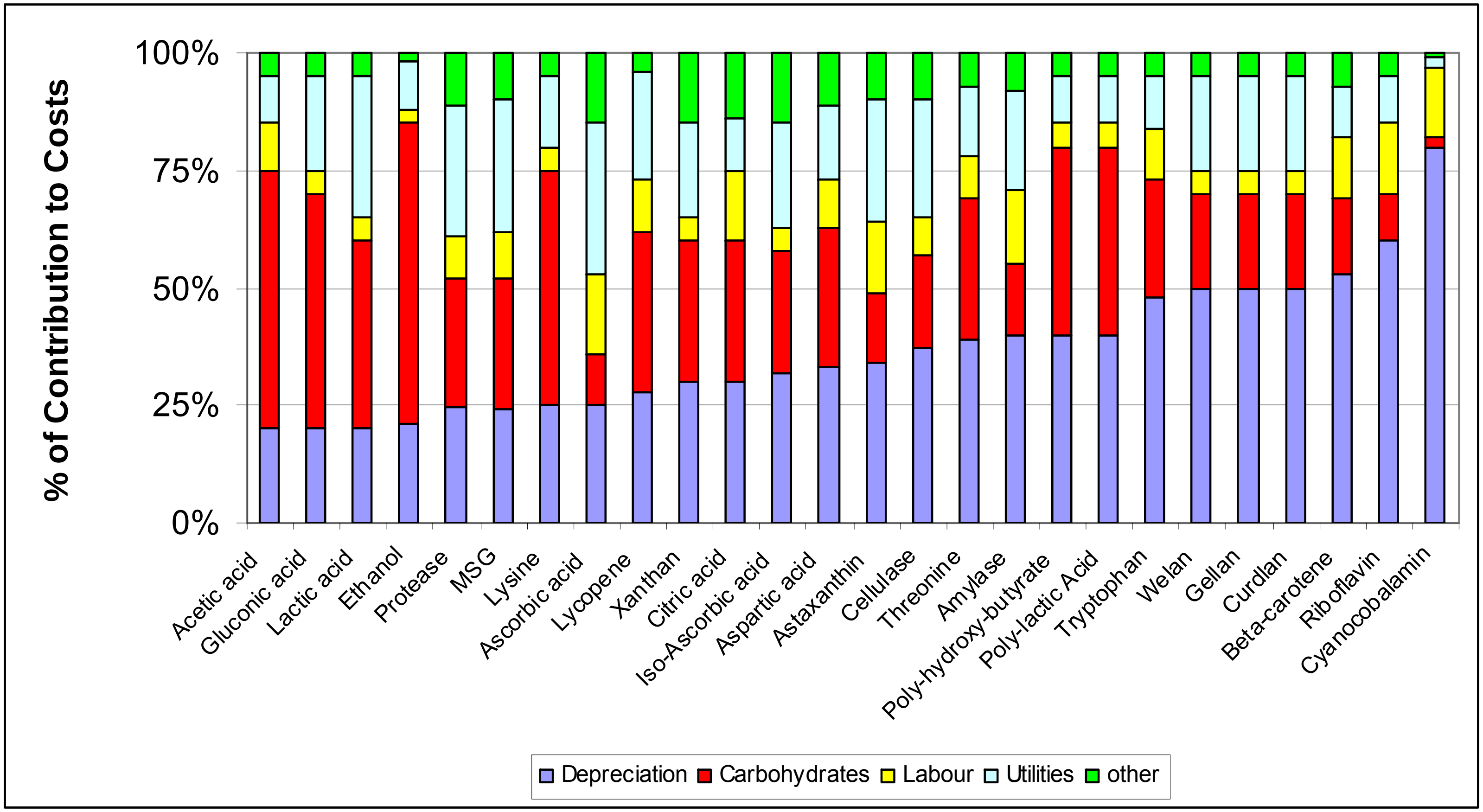
Overview 12: Typical Plant Size



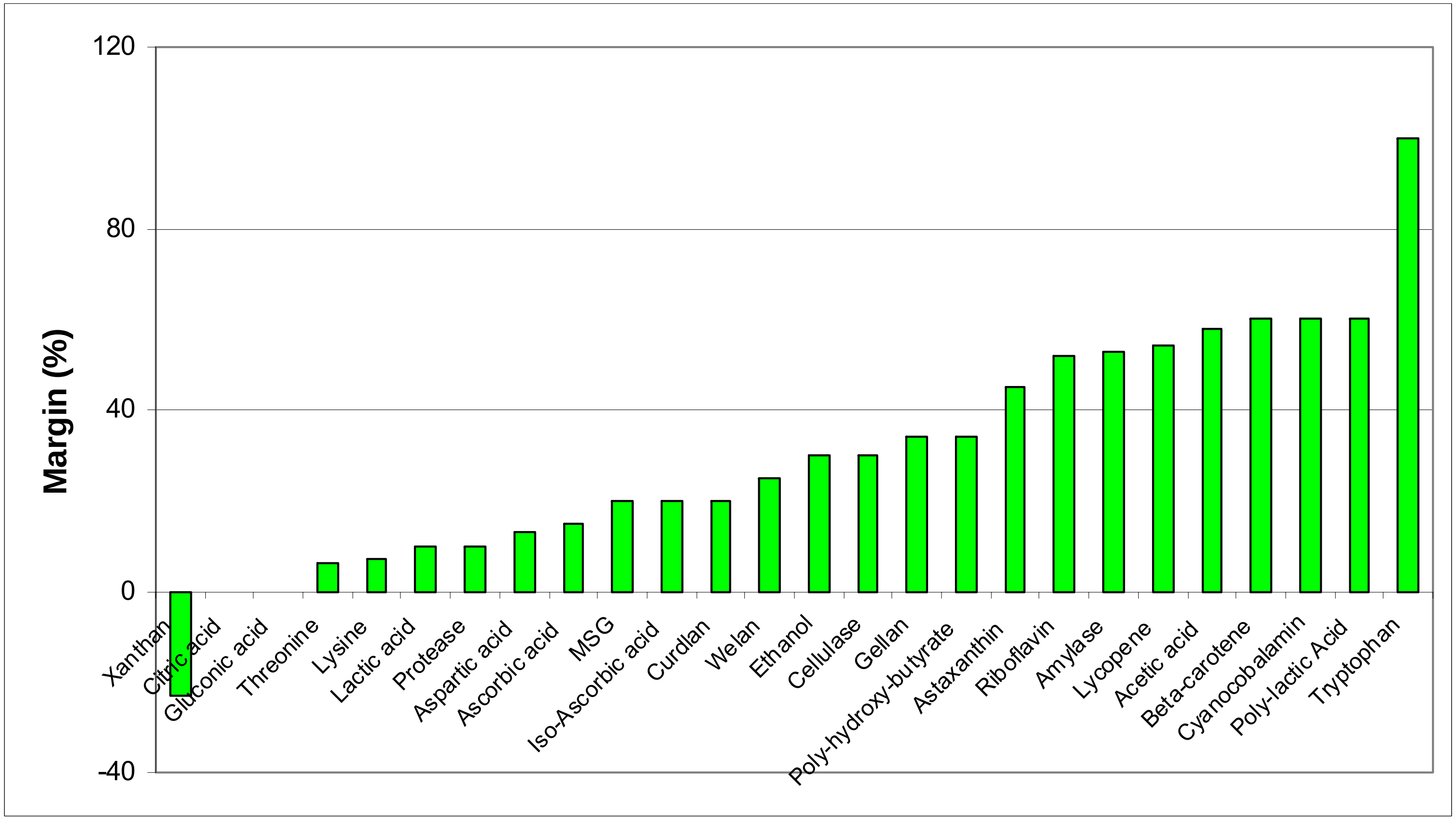
Overview 13: Specific Investment Costs by Product



Overview 14: Distribution of Total Costs by Product



Overview 15: Estimated Margins by Product



- *Margins estimated as the difference between production costs and average selling price fluctuate in wide ranges*. A margin below 10% is considered to be delicate, as in such case already small changes in price or costs can reduce the economics of a plant to zero. Margins exceeding 25% are considered to be robust enough also to sustain typical fluctuations of the market (overview 15).
- Patent protection is an important issue to be considered in technology transfer. *Most large scale processes are not or no longer patent protected*; for more high tech products, patents are issued by the leading producer and enforced on a global scale.

Overview 16: Structuring of Fermentation Processes by Patent Situation

Process patent protected	**Process not patent protected**
Threonine	Lysine
Tryptophan	Citric acid
Iso-ascorbic acid	Ascorbic acid
Xanthan	MSG
Lactic acid	Aspartic acid
Gluconic acid	Beta-carotene
Riboflavin	Lycopene
Cyanocobalamin	Astaxanthin
Ethanol	Welan
Amylase	Gellan
Cellulases	Curdlan
Protease	Poly lactic acid
Acetic acid	PHB

- Flexibility of processes summarizes parameters, indicating how difficult it is to manage a process and how dedicated, an investment in a plant is. Following overview 10, *most fermentation processes react sensitive if not fed with the right feed stock.* Only ethanol and acetic acid processes are fairly insensitive. *Also many fermentation processes are sensitive vis-à-vis management errors*.

Overview 17: Structuring of Fermentation Processes according to 8Degree of Sophistication

Degree of Sophistication		
High	**Medium**	**Low**
Ascorbic acid	Citric acid	Lysine
Threonine	MSG	Aspartic acid
Xanthan	Tryptohan	Ethanol
Beta-carotene	Iso-ascorbic acid	Acetic acid
Lycopene	Gluconic acid	
Astaxanthin	Riboflavin	
Lactic acid	Cyanocobalamin	
Welan	Amylase	
Gellan	Cellulase	
Curdlan	Protease	
Poly lactic acid		
PHB		

2.3.3.3 Success Factors

Economy of scale always is important like low price. So these factors don't discriminate well.

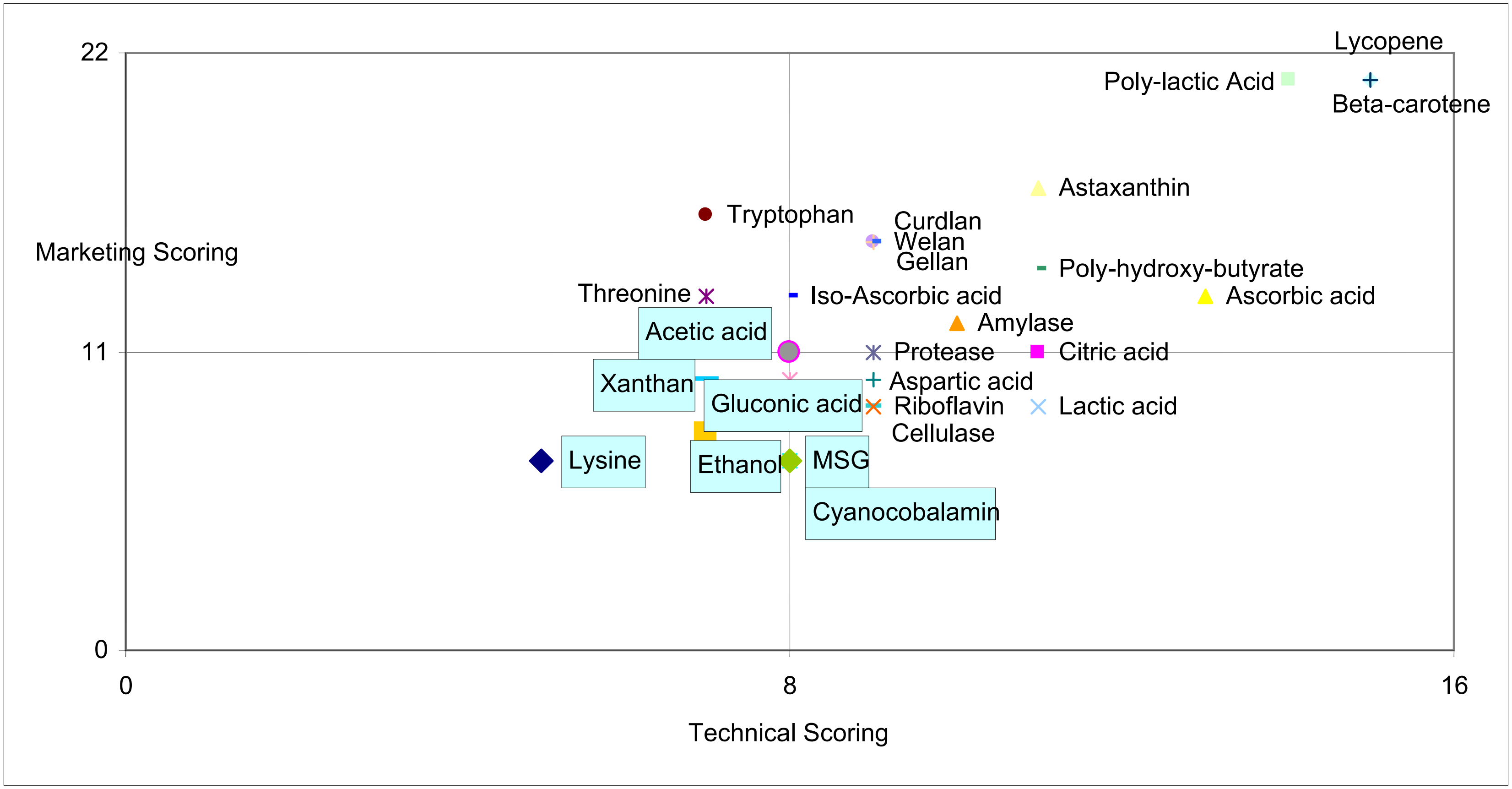
- However quality and specialisation on specific derivatives are important. *The higher the need for specialisation and perfect quality the more sophisticated it is usually to manufacture.*

Overview 18: **Structuring of Fermentation Processes according to Quality Requirements of manufactured Products**

Product Quality Requirement		
High	**Medium**	**Low**
Citric acid	Tryptophan	Lysine
Ascorbic acid	Xanthan	Threonine
MSG	Gluconic	
Aspartic acid	Proteases	
Iso-ascorbic acid		
Beta-carotene		
Lycopene		
Astaxanthin		
Lactic acid		
Welan		
Gellan		
Curdlan		
Riboflavin		
Cyanocobalamin		
Ethanol		
Amylase		
Cellulases		
Acetic acid		
Poly-lactic acid		
PHB		

- *Only the interaction between production know-how and marketing-know-how make the process work and the resulting product to a marketing success.* There are only a few products for which both requirements are moderate. For most fermentation products, the demand for such skills is high or exceptionally high (Overview 19).

Overview 19: Marketing and Technical Know-how Requirements



2.4 Amalgamating Marketing, Process and Success Related Factors

The tool which is applied to synthesise individual technical and economic parameters is scoring. Each of the relevant parameters is assigned a score, and these scores are summed up. Products are ranked according to the percentage of scores reached. An ideal product shows a 100% score achievement. Scoring is subjective and reflects the opinion of the analyst. For scoring procedure applied here the parameterisation and ratings as given in overview 20.

Overview 20: Scoring Parameters applied

Parameter	Unit	Score			
		1	**2**	**3**	**4**
Historic market growth	%	<0	0-3	3-6	>6
Unit price	Euro/kg	< 1	1-10	10-100	> 100
Share of product converted	%	75-100	50-75	25-50	< 25
Powder/liquid		liquid	powder		
Historic price trend	%	<-5	-5-0	0-5	>5
Regulation/free		reg			free
Share of three main producer	%	> 60	30-60	10-30	<10
Share of Chinese/Indian	%	>60	30-60	10-30	< 10
Steps in value chain		< 4	4	3	2
Formulation		yes			no
Future market growth	value 15/06	< 1	1-1,5	1,5-2	>2
Organism		exotic	known		
No of carbohydrates		1	2	3	>3
Carbohydrate conversion	%	<10	10-30	30-60	> 60
Valuable by-product		no			yes
Overcapacity		yes			no
Min. size of plant	1000 tons	> 100	10-100	1-10	< 1
Investment costs	1000 €ton	> 100	10-100	1-10	< 1
Margin	%	< 5	5-20	20-50	> 50
Patent		yes			no
Flexibility in using carbohydrates		low			high
Degree of sophistication		high	med		low
Dedication of plant		ded.	not ded		
Marketing requirements	total scores	> 18	14-18	10-14	< 10
Know-how requirements	total scores	> 12	10-12	7-10	< 7

Note: Marketing requirements = total scores[126] from:

- Availability for special sales force/network,
- Need for customer training,
- Need for specialised distribution network,
- Need for patent protection,
- Elaborate product/derivative portfolio,
- Requirement of flexibility vis-à-vis market/consumer developments,
- Specific permissions/regulations

Note: Know how requirements = total scores from:

- Quality,
- Specialisation on specific derivatives,
- Availability of specific know-how (base process),
- Availability of specific know-how (formulation),
- Availability of specific reaction chemicals.

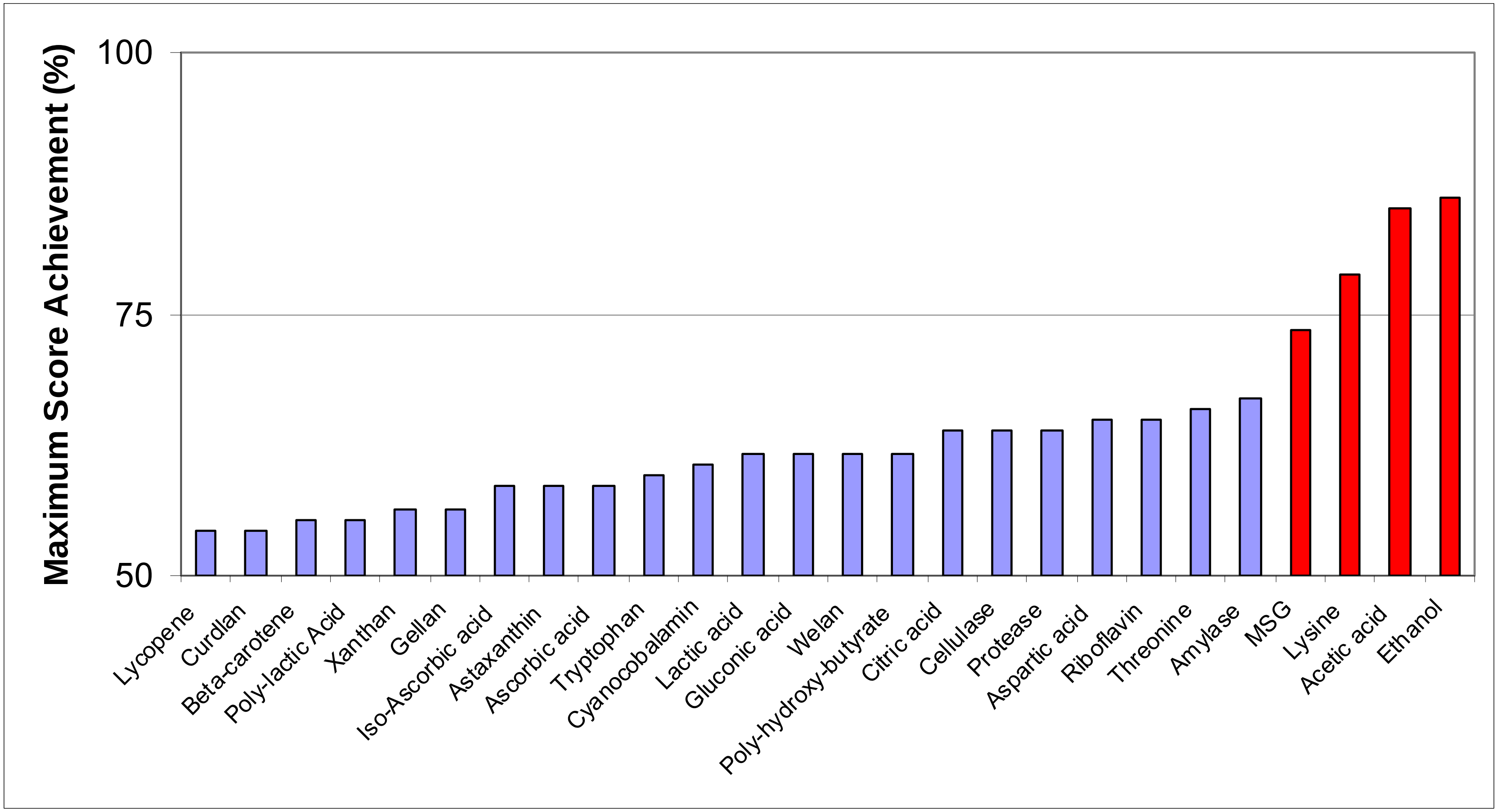
The scoring result shows, that there is no product reaching 100% score achievement, but there are four products which reach more than 70%: MSG, Lysine, Acetic acid and Bio-Ethanol. The highest ratings show bio-ethanol and acetic acid (overview 21)

Such high scoring is reached because these products show favourable production and marketing characteristics.

It is therefore suggested to analyse the top two products: bio-ethanol and acetic acid in more detail and screen their relevance and feasibility with respect to the framework conditions and easiness of setting- up such industries in Egypt.

[126] See success factor tables of individual products

Overview 21: Ranking of Fermentation Products by Multi-dimensional Scoring



2.5 Global comparisons tech-venture policies - Analysis of differences internationally:

2.5.1 U.S.-factors that work as a blend for success

The US biotechnology industry has:
1. strong scientific, industrial and technological basis with communication and transfer of technology are facilitated
2. financial system that promotes starting risky ventures
3. Strong intellectual property protection
4. culture of personal entrepreneurship

Those factors gave US a large absolute competitive advantage in innovative activities in biotechnology. Many patents in biotechnology invented in US and assigned to EU companies: research conducted in US by European organizations. On the other hand, US biotechnology industries are more specialized in R&D compared to EU and Japan with little investment outside US.

2.5.2 Europe vs. the U.S.

Some EU-centers of scientific excellence exist, but less elaborated than in US due to lack of :
1. organizational diversity,
2. integration of teaching and fundamental research,
3. interconnection between research areas, pluralism in funding sources,
4. bureaucratic research system, not enough interregional collaboration
5. integration of academic with industrial research system (lack of clustering)

EU Industry started relying on US medical research early on, often integrated, multi-branch-operations with traditional chemical background that have hesitated for many years to take on biologists and "new trends" and much less public funding in total figures
Recommendations for BioTech development in EU:
1. Strengthen academic research / building an European research system
2. Integration of Research and Industry (Clustering)
3. Strengthen and harmonize intellectual property rights, avoid unnecessary hindering regulation

- Create more dedicated biotech firms with public support and develop them to reach critical size[1]

2.5.3 Brazil

National Biotechnology program had set up 1981 and continuing since then and coordinated by Ministry of Science and Technology. The main objectives of that program are:

1. Integrating institutions and budgets in agriculture, energy and health biotechnology
2. Training of scientists, develop scientific infrastructure, promote linkages between universities, institutes and the industry
3. Revise regulatory system, TRIPS compliance 1997, biosafety 1995, etc

There are some success Stories out of these programs which include:

1. Development of patented technology for recombinant human insulin; by BioBras Company and had been aquired by Novo Nordisk
2. Production of conventional human vaccines elaborated today
3. Largest global Fuel-Ethanol producer
4. Strong diagnostic sector

The Brazilian Biotechnology programs are facing some challenges**:**

1. Instable economy with high inflation, discouraging for risk capital investors, causing lack of funding
2. Knowledge flow between institutions not functioning, no linkages between biotechnology firms
3. Lack of governmental industry policies hindering industrial development
4. Development of biotechnology sector was limited due to just one ministry (Science and technology)
5. Insufficient protection of intellectual property within the country
6. Too slow patent application process and weak attitude towards contract enforcement

2.5.4 India

Concerted administrative multi-institutional approach

A Department of Biotechnology was set up in 1986 under the Ministry of Sciences and Technology; a concerted R&D development program was funded by the government. In recent years private companies have developed. The companies focus on molecular biology and genetic engineering for developing recombinant proteins, in order to meet the demand of the large pharmaceutical sector both national and internationally. Instable economy with high inflation, discouraging for risk capital investors, causing lack of funding on the other hand, IP-protection and contractual compliance are major issues for international investors

An example of a successful infrastructure project

1. Life Science Entrepreneurship and Increased focus on R&D:
    - Providing infrastructure, Facilities & Services at a local university-independent center
    - Shared wet lab infrastructure-research parks and incubators
    - Adoption of product patent regime locally (teaching and advising)
    - Increased focus on Contract Research & Manufacturing Service
    - Attracting Life Science focused venture capital funds/ international company acquisitions and joint venture triggered by expatriates returning/ marketing alliances
2. Establishment of knowledge park
    - Mission: to create a world-class centre for leading-edge business-driven research
    - Objective: To encourage and nurture an environment for innovation by developing an innovation cluster
    - Focus areas: biotechnology, pharmaceuticals, chemistry, new materials and telecommunications
    - First Wet Lab Research Park in India – Operational in June 2000
    - Partnership between Bank & the State Government of Andhra Pradesh
    - Not-for-Profit company
    - Part of the "Genome Valley" Cluster in Hyderabad
    - Green field venture – not next to the university (to establish the right work culture)
    - Ready-to-use modular wet laboratories
    - Core, Shell & Utilities and fully furnished options
    - 84,000 sq ft of lab space in 140,000 sq ft building fully occupied
    - 50,000 sq ft being planned
    - Developed land to create custom-built research centres
    - incubation Centre for Startups

As a result:

1. more Indian Pharma, bio-pharma, and agri-biotech companies investing in Technology development
2. Non Resident Indians returning/investing in India
3. Foreign companies wanting to enter India through renting labs in the centre (SMEs seeking support for global reach)

2.5.5 Korea

The Korean biotechnology program went through three historic phases of public funding

1. **Phase I (**1981 – 1990) "learning and R&D Establishment" Period
2. **Phase II** Bio-industry based start-up period – 1995
   a. Bio-industry introduction from 1986 until now
   b. Government directed effort, developing a concert of government agencies and industrial development in the sector, plus national R&D institutes and universities in a synergistic and planful manner
3. Phase III Today Korea has a developed sector with approx 390 companies, not counted companies that only sell imported goods (63). Examples of products made in Korea: Human Growth Hormone, Amino Acids, Hepatitis Vaccine, Oligosaccharides, etc

2.5.6 China

Until 1996 the government was providing continuous funding to close the gap with western technologies in fermentation and modern biotechnologies. After 1996 the government aggressively funded 863 projects with commercial relevance and commercial partners. Today China has a developed sector with approx 500 companies in total with about 300 in medicinal sector. Still barriers for further success are addressed in:

1. Insufficient protection of intellectual property within the country
2. Weak attitude towards contract enforcement

2.5.7 Germany - Funding of biotechnology research

Public funding plays the key role in establishing high-quality competitive research. The best example of funding in USA where National Institutes of Health (NIH) led the funding efforts for many years and spending $8 billion alone in 1998 for biomedical research programs. During 2003 NIH budget on research spending account for $17.5 billion. EU had funded the 5th FRAMEWORK Programme 1998-2002 for **€** 15 Billion (5 years) and the 6th

FRAMEWORK Programme 2002-2006 for **€** 17,5 Billion. This drastic gap in funding helps to consider the leading position of US BioTech. In Germany in total 360 "technology centers" exist today (start the early 80s), offer dedicated lab and office space to technology companies, and serve as incubators for start up.

Further specific cluster formation in Germany was initiated successfully by a national competition in 1996, called "BIOREGIO COMPETITION". They funded project proposals from consortia from joint teams of academic, small and medium sized companies and industry. The total budget of the program was **€**100 Million. As a result of the above public initial funding, over the past 10 years a landscape of biotech companies and publicly funded cooperation projects have been developed nationwide. Recently, a similar nationwide initiative has been repeated triggered by the "Bio=Industry 2010" initiative of the federal government

In 2007, regional initiatives formed including "CLIB 2021", a federation of companies and academia receiving funding and creating project proposals for dedicated public support of dedicated applied research in the sector[8]

2.5.8 What does it mean for Egypt

Egypt lacks behind and should take India and similar other countries as role model to learn from their historic development. As example:

1. Cluster formation (Techparks) is a prerequisite for successful transfer of innovation from R&D into commercial application by entrepreneurs. clusters can successfully combine R&D know how, entrepreneurial spirit, risk capital and cooperate with large international corporations
2. Public bank funded incubator systems, like introduced in India, motivate entrepreneurs and industry partners to invest on neutral grounds – outside university campuses and public R&D habits, creating commercial attitude
3. IMC needs to focus on already existing technology seeds with commercial relevance, like fermentation and chemical engineering, micro-and molecular biology, and implement a cluster and incubator system to improve this industrial sector within a shorter time horizon
4. IMC should set up project teams for practical implementation of the feasible projects outlined in this study-following the implementation plans developed here
5. Foreign funding can prove harmful for national cluster development
6. For achieving cluster development in Egypt, nationwide competitions for the formation of cooperation between industry, entrepreneurs and R&D - funded by the public sector are clearly recommended for Egypt

3 Development of a Biotech (Fermentation) Industry in Egypt

3.1 Profile of Egypt's Macroeconomic Settings, relevant for Biotechnology

After the collapse of oil prices in the mid 1980s, Egypt became more vigorously engaged in a process of structural reforms whose aim was to increase the role of the private sector, the market and international trade in the economy. Since then, Egypt's growth performance has varied from a declining phase in the latter half of the 1980s to acceleration through much of the 1990s, followed by another declining phase during 1999 to 2002. The years 2003-2006 give a mixed impression and the future of Egypt's development will depend on the successful management of a variety of factors and influences.

3.1.1 Historic Overview[127]

Historically, Egypt's economy has developed in cycles with six phases to be distinguished.

Phase 1: 1961 – 1973: Low growth and divergence from industrialised countries

During this period, the state dominated the economy, the share of the private sector in GDP was low and the government pursued import substitution policies. Egypt invested heavily in public infrastructure and social services but could not sustain high economic growth. Business efficiency and labour productivity stagnated as the country's development plan aimed at physical output targets and its industrial exports were oriented most towards communist countries with low quality requirements.

Phase 2: 1974 – 1985: High growth and convergence to industrialised countries

Two factors played a prominent role in Egypt's growth performance over this period. The government launched the open-door-policy, which allowed a greater role for the private sector, started to liberalise the trade sector and the exchange rate regime. National income was boosted by strong increases from revenues of the Suez Canal and from petroleum exports. In addition, the tourism industry developed and an increasing migration of Egyptians to work in other countries resulted in strong remittances. However, while GDP grew strongly, the government's expenditures rose even faster than its revenues and inflation increased to over 15 %.

Phase 3: 1986 – 1991: Low growth and divergence from industrialised countries

[127] Anton Dobronogov and Farrukh Iqbal, 2005: Economic Growth in Egypt: Constraints and Determinants. The World Bank, Middle East and North Africa Working Paper No 42.

The collapse of the oil prices revealed the unsustainability of the prevailing fiscal policy as deficits averaged 15 % of GDP throughout this phase. Deficits were automatically accommodated by expansionary monetary policy, which resulted in inflation rates above 20 %. Stagnation of exports and large current account deficits endangered Egypt's ability to serve its external debts. Confidence in the economy decreased and the government's attempts to maintain a fixed exchange rate resulted in two peaks in the black market premium, when it exceeded 70 %. Since the mid 80s, Egypt accelerated the policy of opening the economy. Effective protection due to implicit energy subsidies was greatly reduced by the fall of oil prices. In the early 90s the economy moved further towards openness through reduction in tariff rates. Egypt became increasingly integrated into the global market economy and its growth pattern started to move in tandem with those of industrialised countries.

Phase 4: 1992 – 1998: High growth and convergence with industrialised countries

In 1992 Egypt launched a successful stabilisation effort. The fiscal deficit fell from 15 % to 1,3 % of GDP and inflation returned to single digit values. Devaluation of the pound resulted in a major improvement in the current account position and rapid accumulation of foreign exchange reserves. The government also launched a major privatisation effort, which resulted in about one third of all state-owned enterprise assets being privatised between 1991 and 1998. Macro-economic stabilisation and privatisation were complemented by the establishment of a free foreign exchange market for current account transactions, by the easing of capital account restrictions and the successful conclusion of negotiations with the WTO in which Egypt is a member since 1995. These measures eliminated exchange rate misalignments and the black market premium contributing to the growth acceleration experience in that period. The quality of fiscal adjustment achieved over this period was however mixed. The reduction of budget deficits in the first half of 1990s was obtained largely through a fall in public investment, particularly in the central government's capital expenditure. Infrastructural maintenance and expansion was neglected and subsequently private investment rates and gross fixed domestic investments decreased strongly. The system of producer and consumer subsidies was modified only slightly and their overall burden on the budget prevailed. Public employment and the corresponding public wage bill continued to rise.

Phase 5: 1999 – 2002: Lower growth and slow-down in convergence with industrialised countries

This phase was initiated by several shocks including the terrorist attacks in 1997, the global financial crisis to the end of the 90s and a domestic financial scandal. All of these events had severe repercussions for Egypt and the economy embarked on a decelerating growth phase. Negative shocks continued with the September 11 attack, resulting in reduced private spending and investments. The Egyptian government reacted by expansionary fiscal policies, which resulted in a worsening fiscal stance. Budget deficits increased to over 6

% to the end of 2002 but investments and private expenditure did not recover vigorously.

3.1.2 Egypt's Current Macroeconomic Situation[128]

Egypt's long-run growth performance during 1980 to 2002 was strong compared to the average emerging market economies, although well below the high growth emerging market countries in Asia. Since 2002, Egypt's economy grew less than most of its regional neighbours and much less than the average of a typical developing country or emerging market. Since 2004 growth has again being accelerating in steps with the implementation of a series of ambitious reforms.

Overview 1: Key Structural Reforms 2004 - 2007

Year	Category	Measure
2004	Exchange rate system	Liberalisation of foreign exchange trade
		Abolishment of the surrender require-ment of export proceeds
2004-2007	Trade regime	Reduction of tariff rates
2004-2006	Public sector	Reduction of subsidies of fuel and elec-tricity
		Simplification of income tax law
		Restructuring of tax and finance administration
2004-2006	Financial sector	Restructuring of banking sector
2004-2007	Privatisation	Continuation of public sector com-panies, of public stock in joint ventures
2005	Transparency	Publication of staff reports, monetary policy statements and of communiqués following monetary policy

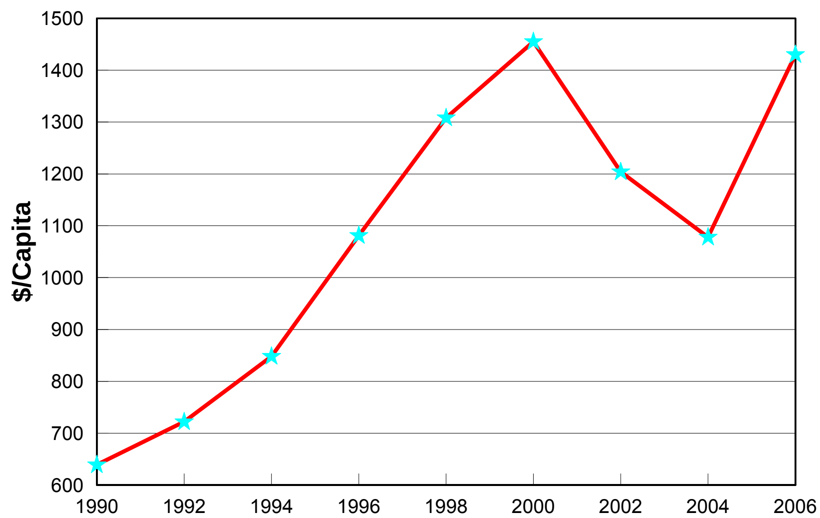
3.1.2.1 GDP Growth, Structure and Business Climate

In 2002 GDP per capita was in the range of $[129] 1.200, recovering to $ 1.430 in 2006. Although this growth is remarkable, the value for 2006 is still slightly lower than that of the year 2000.

[128] If not mentioned otherwise, sources for this chapter are: Enders Klaus 2007: Egypt – Searching for Binding Constraints on Growth, IMF Working Paper 57; Srinivasan T.N. 2005: Challenges of Economic Reform in Egypt. Stanford Centre for International Development, Working Paper No. 253; The Economist Intelligence Unit 2007: Egypt: Macro-Economic Indicators

[129] Throughout the whole report a conversion rate of $ 1,3 = € 1,0 is used

Overview 2: Development of GDP per Capita ($)



1990	1992	1994	1996	1998	2000	2002	2004	2006	AAGR, %, 1990-2006
639	722	848	1.081	1.308	1.455	1.204	1.078	1.430	5,2

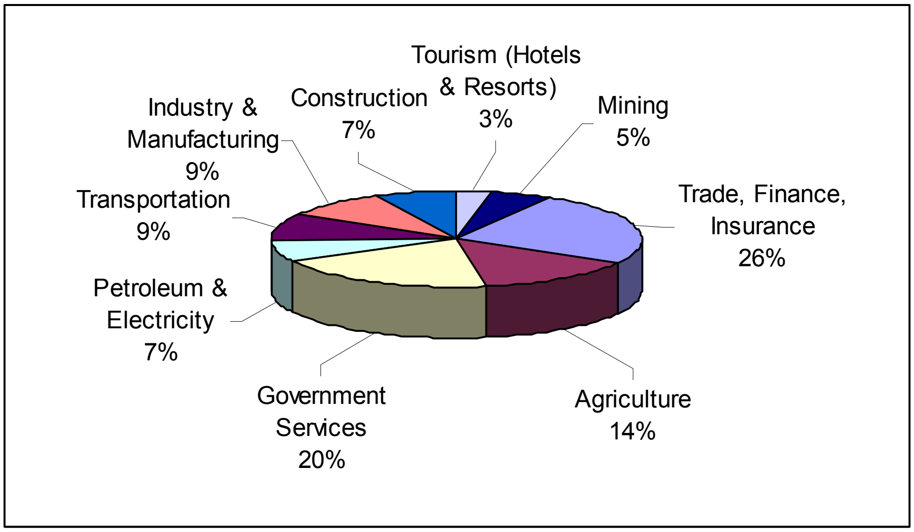
The composition of Egypt's GDP did not change much over the last decade. 50 % of it is generated by services, 14 % by the agricultural sector and the balance of 36 % by industrial operations. However, a detailed breakdown reveals that industrial manufacturing and true production only contributes very little to GDP.

Overview 3: Detailed Composition of GDP in 2000 and 2006

Sector and Sub-sector	% of GDP in 2000[130]	% of GDP in 2006
Trade, Finance and Insurance	22	26
Agriculture	16	14
Government Services	18	20
Petroleum and Electricity	10	7
Transportation and Suez Canal	9	9
Industry and manufacturing	8	9
Construction	6	7
Mining/others	8	5
Tourism (Hotels & Resorts)	3	3

[130] OECD 2002: Egypt – African Economic Outlook

Overview 4: Structure of GDP in 2006



In the course of privatisation, which accelerated after 2003, net direct investments in Egypt increased strongly. The inflow of capital was mainly used to finance takeovers, which became possible as a result of the government's privatisation initiative. Investments in land and real estate as well as for participation in the banking sector were exceptionally high. Historically net direct investments have been relatively small, fluctuating in the range of $ 0,5-1 billion per year. Only in 2005 and 2006 such capital inflow climbed up to over $ 6 billion.

Overview 5: Development of Net Direct Foreign Investments ($ billion)

1996	1998	2000	2002	2004	2005	2006
0,63	1,03	1,18	0,62	1,09	5,28	6,68

Despite various improvements in the business environment, Egypt, in typical business and investment climate indicators, remained ranked in a middle position. Some key factors are considered by the national and international business community as adequate, while others still influence the business climate negatively:

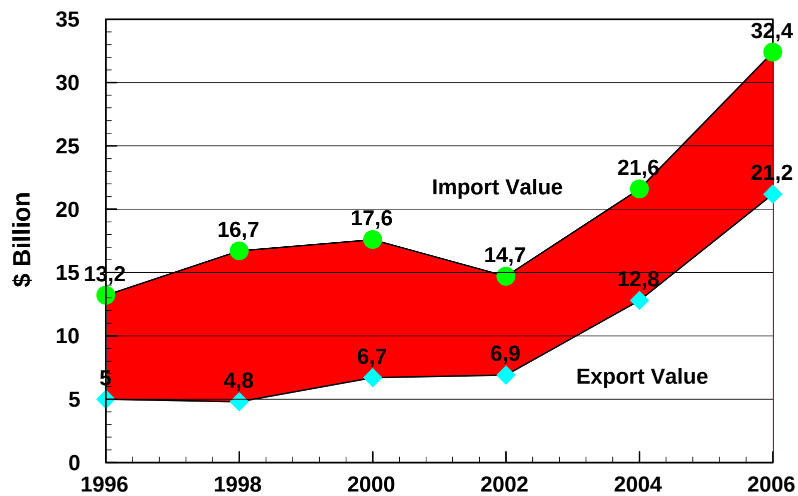
- The risk for crime and theft is ranked low, government stability and appropriateness of labour regimes are ranked high, the risk for inflation is considered to be low, tax rates as adequate and the government's attitude vis-à-vis investments as friendly. But
- Access to finance is regarded as a major problem, bureaucracy is still inefficient, the available workforce is inadequately educated, working ethics is low and corruption widespread.

Consequently entrepreneurs, especially in the manufacturing sector which is characterised by high and long-term investments, expect higher returns on investment than in comparable countries and payback periods must be shorter. Investments in manufacturing are typically closely related with innovation and the development of new and better products, product that have higher value added than traditional ones or are better geared to fast growing markets. Costs of developing such new products are considered to be especially high in Egypt and might constitute a critical constraint for growth. Such constraints are partly found in the business environment, but are also related to the cost of discovery and adaptation of production technology. Even assuming that the technology is available from advanced countries, its absorption in domestic production processes requires exploring new combinations of local factors. Such exploration is costly and risky. The perception of risks and the willingness to accept risks constitute obstacles that are bigger the less entrepreneurs are endowed with capital and the more risky the business environment is perceived by investors, because failure could push them back below achieved income levels. Consequently only 0,2% of the GDP are typically invested in R&D. This share did not change much over the past decades and did not help to develop a lively and innovative industrial sector, particularly not in those areas which competitiveness is based on continuous innovations.

3.1.2.2 Balance of Trade

The result of such business environment is also reflected in Egypt's trading pattern. Although exports increased strongly in the past 15 years, they are still largely dominated by raw materials and by finished goods of low technical standard. Imports over the last 15 years increased even further than exports and the trade balance is with over $ 10 billion strongly negative in 2006. The structure of imports is characterised by higher valued intermediates and consumer goods, investment goods but also by basic raw materials, primarily food and agricultural commodities.

Overview 6: Development of Trade Balance ($ billion)



Parameter	1996	1998	2000	2002	2004	2006
Value of Exports	5,0	4,8	6,7	6,9	12,8	21,2
Value of Imports	13,2	16,7	17,6	14,7	21,6	32,4
Balance	**-8,2**	**-11,9**	**-10,9**	**-7,8**	**-8,8**	**-11,2**

Overview 7: Structure of Exports by Level of Technology (%)

Level of Technology	1985	1995	2005
Raw Materials	86	54	63
Low Tech Products	9	26	17
Medium Tech Products	4,8	18,5	18,7
High Tech Products	0,2	1,5	1,3

Overview 8: Development and Composition of Trade by Category (%)

Category	Exports		Imports	
	2004	2006	2004	2006
Fuel	39,6	56,5	10,1	8,5
Raw Materials	5,2	3,6	17,9	17,0
Intermediates	5,6	6,4	28,1	27,7
Finished Goods	38,7	28,0	13,2	11,6
Investment Goods	-	-	20,2	25,9
others	10,8	5,4	10,4	9,3

3.1.2.3 The Labour Market

Egypt's population is growing since many years at an annual rate of about 2%, resulting in a total of 75 Mio in 2006. Parallel Egypt's labour force increased even further. While in 1995, 36 Mio people at an age between 15 and 65 years were available for the labour market, the number increased to almost 50 Mio in 2006, which equals to an annual growth rate of 2,7%. The government is still the major employer, followed by agriculture, trading and some industrial sectors.

Overview 9: Development of Egypt's Population and Labour Force (Mio)

Parameter	1996	1998	2000	2002	2004	2006	AAGR, %, 1996-2006
Population	62,4	64,8	67,3	69,9	72,6	75,4	1,9
Labour Force	37,2	39,0	40,9	43,1	45,2	48,5	2,7

The official unemployment statistics indicates slight decreases in the past 10 years. For 1996 it is indicated with 11,3%, while for the year 2000 the official figure is 9%, climbing up to 9,4% in 2006[131].

Over the past 10 years an average of 450.000 new jobs were created per year and about 90.000 Egyptians were leaving the country every year. The number of new job seekers over the same period of time, however, increased by 650.000 per year, leaving annually more than 100.000 jobless[132]. Additionally the government's privatisation programs resulted in the setting-free of additional labour. A survey by ILO[133] (International Labour Organisation) indicates for the privatisation wave in the 90s an increasing labour productivity (4,4% per year between 1996 and 2006), but mainly because privatised companies retrenched 10-20% of the labour force.

An additional major structural challenge of the Egyptian labour market traditionally is the dislocation between supply and demand. Educational and training systems continue to produce graduates taking little or no account for the actual demand for labour. The labour demand for the majority of the unemployed, those with intermediate education, is minimal. The demand for unskilled labour is however relatively high and consequently the share of those with academic degrees among the unemployed is particularly high[134].

[131] Depending on the source, the unemployment figures vary substantially. GTZ estimates the true unemployment rate at approx. 20% accounting for hidden unemployment mainly in the service and agricultural sectors (GTZ country representative 2006).
[132] Radwan S. 2002: Employment and Unemployment in Egypt: Conventional Problems, Unconventional Remedies. ECES Working Paper No 70.
[133] www.aucegypt.edu/src/macroecnomics/Economic_Reform_Labour_Egypt.htm
[134] El-Mahdi A. 2003: GPN Global labour market data base: Egypt. Global Policy Network, Cairo University

Unemployment is essentially a problem of the youth. Total unemployment for those aged 15-29 is over 80% and did not much change over the past years. As the educational system is improving and the share of graduates among the first-time-job-seekers is increasing, it is only logical that unemployment is concentrated among the graduates of intermediate and higher education with more than 60%. Due to the competition intensity on the labour market, average wages did not increase in the past five years but tended down. Only recently wages started to increase again.

Overview 10: Development of Average Wages and Labour Costs in the Industry

Parameter	1996	1998	2000	2002	2004	2006	AAGR, %, 1996-2006
Average monthly wage ($)	326	400	521	451	367	445	3,2
Labour costs in manufacturing ($/hour)	1,8	2,2	2,2	1,9	1,6	1,9	0,5

3.1.2.4 The Energy Sector[135]

The energy sector plays an important role for Egypt's economy and contributes substantially to GDP and export earnings. It is essentially made up of petroleum, natural gas and electricity, generated at the hydroelectric Aswan dam. However, with increasing economic development, Egypt is consuming more and more of the energy resources domestically and at least for petroleum and electricity, domestic consumption and production are converging very fast. Domestic consumption of energy is supposed to exceed local production within the next few years.

Overview 11: Development of Energy Production and Consumption

Parameter	1996	1998	2000	2002	2004	2006
Petroleum (1.000 barrels/day)						
Consumption	501	555	561	570	590	619
Production	920	880	812	752	712	695
Balance	419	325	251	182	122	76
Electrical Energy (kwh/head)						
Consumption	772	859	995	1.084	1.163	1.290
Production	830	923	1.071	1.168	1.262	1.310
Balance	58	64	76	84	99	20
Gas (billion m^3)						
Consumption	13,4	13,7	18,3	25,0	31,5	32,3

[135] Most of the data in this section is taken from The Economist's macro-economic indicator data base, but see also: Abdel Gelil I. 2002: Energy Situation in Egypt, Efficiency perspectives. Paper presented at the Egypt Energy Day Executive Assembly WEC 24.10.2002

Production	13,4	13,7	18,3	26,6	-	-
Balance	0	0	0	1,6	-	-

Egypt is undertaking substantial efforts to increase energy efficiency but so far with only marginal success.

Overview 12: Development of Energy Efficiency

Parameter	1996	1998	2000	2002	2004	2006
GDP/capita ($)	1.081	1.308	1.455	1.204	1.078	1.430
Energy Consumption (kilo oil equivalent/head)	655	675	706	769	823	875
Energy Consumption per GDP (kg/$)	0,6	0,5	0,5	0,6	0,75	0,6

In international comparison energy is still very cheap in Egypt and heavily subsidised.

Overview 13: Energy Prices in Egypt compared to Germany, 2006[136]

Parameter	Egypt	Germany
Electricity ($/kwh)	0,033	0,16
Gas ($/m3)	0,05	0,52
Gasoline ($/l)	0.2-0,3[137]	1,8

3.1.2.5 The Agricultural Sector

Egypt's total land area is 995.000 km^2, out of which only 5% can carry vegetation. The agricultural area is estimated at 3,5 Mio ha in 2006, developing from 3,3 Mio ha in 1995 due to some efforts in land reclamation. Arable land is only 3 Mio ha in 2006, developing from 2,8 Mio ha in 1995. That land is planted with a limited number of crops, partly two times per year, out of which cotton and cereals dominate.

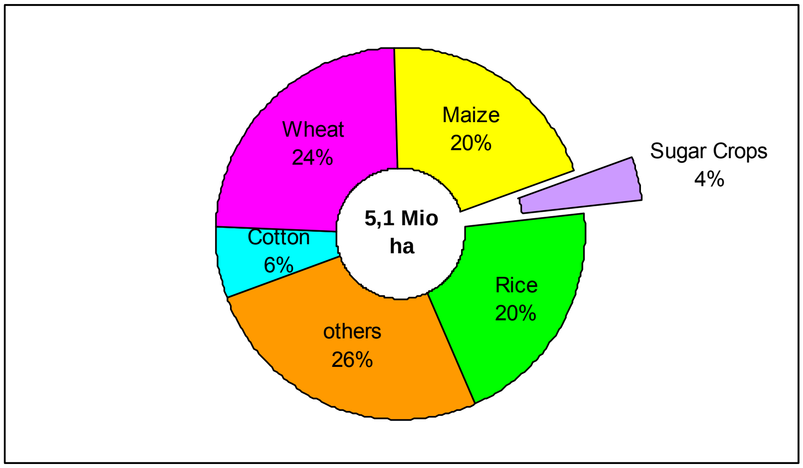
Overview 14: Development of Arable Land Use (Mio ha)[138]

Parameter	1995	1997	1999	2001	2003	2005
Total Land	2,8	2,8	3,0	2,9	2,9	3,0
Land Use Intensity	1,7	1,7	1,7	1,7	1,7	1,7
Land cultivated	4,8	4,8	5,1	4,9	4,9	5,1
Cotton	0,3	0,4	0,2	0,3	0,2	0,3
Wheat	1,0	1,0	1,0	1,0	1,0	1,2

[136] Complied by the authors in January 2007
[137] Depending on the octane value
[138] www.fao.org

Maize	0,7	0,8	0,8	0,9	0,8	1,0
Rice	0,8	0,8	0,9	0,9	1,0	1,0
Sugar Crops	0,15	0,15	0,18	0,19	0,16	0,2
other	1,85	1,65	2,02	1,61	1,74	1,4

Overview 15:Structure of Land Use in 2005



For none of these crops, except rice and cotton, Egypt is self-sufficient and imports of cereals, sugar crops and of oil seeds are substantial. This situation did not change over the last decade.

Overview 16:Development of Trade Balance of Selected Agricultural Products (Mio tons)[139]

Crop	1995	1997	1999	2001	2003	2005
Cotton	<0,1	<0,1	<0,1	<0,1	<0,1	<0,1
Wheat	-6	-7	-6	-4	-4	-7
Maize	-2,5	-3,4	-3,8	-5,3	-4,5	-5,9
Rice	+0,2	+0,2	+0,5	+1,2	+0,8	+0,7
Sugar Beet	-0,3	-0,6	-0,1	+0,05	+0,28	-0,2
Sugar Cane	-2,6	-2,8	-3,0	-0,4	+0,9	-8,4
Cotton Seed	-1,0	-0,1	-0,1	<-0,1	<-0,1	<-0,1
Sunflower	-0,5	-0,7	-0,5	-0,2	-0,3	-0,9
Soy Beans	-0,5	-0,3	-0,9	-1,3	-0,7	-1,9

(-) Imports; (+) Exports

Wheat, maize and rice are the basic staple crops and almost exclusively used for human consumption. Oil seeds are crushed, the oil is used for human consumption and the cake for animal feeding. Sugar beet and cane are processed to sugar and molasses. Sugar is consumed in large amounts domestically.

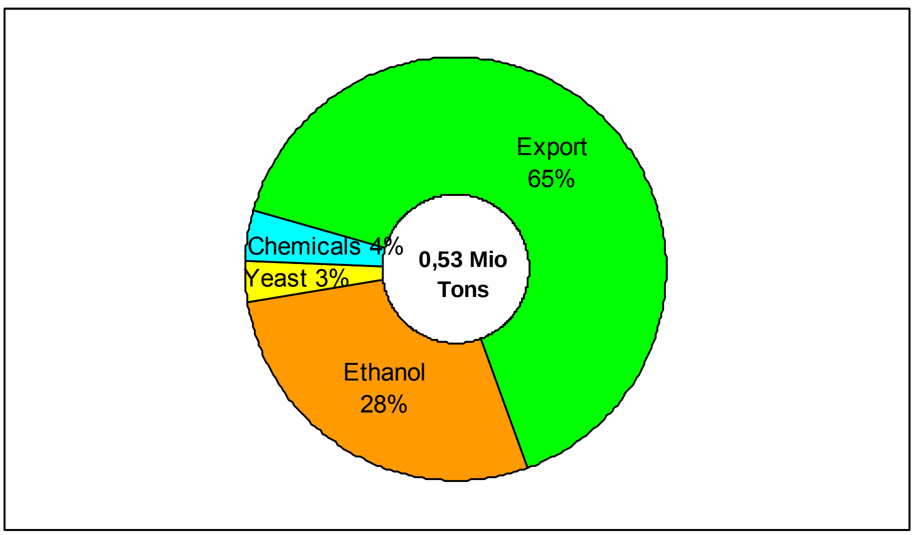
139 www.fao.org

Molasses is partly used by local fermentation of ethanol, yeast and other products such as acetic acid, acetone and butanol. A considerable amount of molasses is exported. Surprising is the trade balance for cotton[140]. Egypt is exporting large amounts of basic lint but at the same time importing almost equivalent amounts of different lint grades for the garment, textile and apparel industry.

Overview 17: Structure of Sugar Crop Use, 2005[141]

Parameter	Sugar Beet	Sugar Cane	Total
Local Production (Mio tons)	3,4	16,5	19,9
Balance from Trade (Mio tons)	0,2	8,4	8,6
Total available (Mio tons)	3,6	25,1	28,7
Extractable sugar (Mio tons)	0,5	1,9	2,4
Molasses (Mio tons)	0,14	0,39	0,53
Sugar content in molasses (%)	44	50	
Sugar equivalents in molasses (Mio tons)	0,06	0,19	0,25

Overview 18: Usage of Molasses in Egypt, 2006[142]



Usage	Quantity (Tons)	% of Total
Ethanol	150.000	28
Yeast	15.000	3
Chemicals (Acetic Acid, Butanol, Aceton)	20.000	4
Export	345.000	65
Total	**530.000**	**100**

[140] Such picture is reported from USDA (www.fas.usda.org) as well as by FAO (www.fao.org)
[141] Calculated by the author based on information given from Südzucker/Germany, 2006; Note: the content of extractable sugar can vary from year to year and depending on the cultivation practice. Thus figures given in this table have to be considered as approximations.
[142] Calculated by the authors based on information provided by Sugar & Integrated Industries Company, February 2007

Cereal cultivation also results in the production of straw. During processing, hulls and brans are additionally produced. These by-products are, in the case of wheat, barley and some other grains to almost 100% used as animal feed. Rice straw and rice by-products are only to 20% used for feeding of ruminants because the silica content is high, which makes rice waste unpalatable and difficult to digest for animals[143]. Out of a total production of approx. 6 Mio tons of rice, almost 5 Mio tons of rice waste is generated[144]. Only 1 Mio ton is used for feeding; the balance is either burned or recycled on the field.

The production of feed in general is important in Egypt as meat consumption increases in relation to population growth and disposable income since many years. Meat consumption in 2006 is estimated at 18 kg/capita, out of which less than 1 kg is from sheep and goats, 9 kg from beef and 8 kg from chicken.

Overview 19: Development of Meat Consumption (kg/capita)[145]

Type of meat	1995	1997	1999	2001	2003	2005
Chicken	5,2	7,0	7,5	8,0	8,0	7,7
Beef	9,2	11,5	11,0	7,4	8,5	9,5
Sheep and Goats	1,5	1,5	1,1	1,3	1,0	0,8
Total	**15,9**	**20,0**	**19,6**	**16,7**	**17,5**	**18,0**

Meat consumption is largely based on local production with the exception of beef meat. Beef, since many years, is imported in high, although decreasing amounts, and stood in 2005 at 95.000 tons. For broiler meat imports are small compared to local production and fluctuated in the past years substantially. All other types of meat play relative little role in local production as well as for imports.

Meat consumption is closely related to the disposable income. In the years 1995-1999 average disposable income increased, while falling in the following years and only started to rise again after 2003. This is reflected in per capita meat consumption and best shown in the equation:

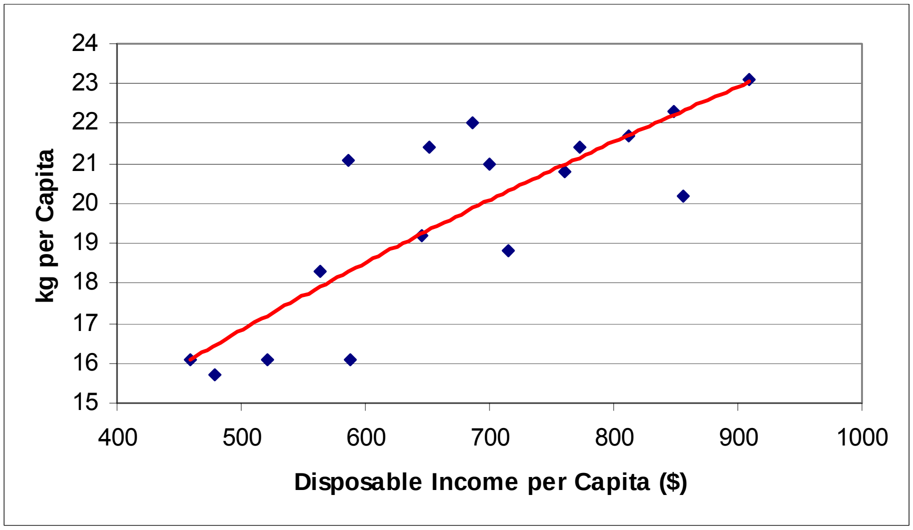
Meat consumption (kg/capita) = 0,64 x (disposable income/capita)^{0,53}, (R^2 = 0,7, n = 17)

[143] National Animal Feeding Program, Animal Production Research Institute, Agric. Research Center 2006: Agricultural Residues in Egypt

[144] Estimates by the authors

[145] www.fao.org and The Economist Intelligence Unit

Overview 20: Meat Consumption in Relation to disposable Income in Egypt



Sheep and goats are usually not intensively farmed and consequently the amount of industrial feed used for these species is assumed to be small. Similarly the productivity values for beef indicate that feeding is based on an extensive system with little input of compound feed. The situation is different with chicken. Although a substantial number of chicken is assumed to be kept by farmers in the backyard, an intensive chicken industry exists, which produces broiler at a feed conversion ration of 2-2,3. Given that most of the broiler meat is produced in intensive husbandry systems, a total amount of almost 2 Mio tons of compound feed are consumed per year[146]. Based on standard rations such amount is based on 1 Mio tons of cereals and an equivalent amount of proteins supplied usually in the form of oil cakes.

3.1.2.6 The Biotechnology Sector

The UN convention on biological diversity defines biotechnology as *any technological application that uses biological systems, living organisms or derivatives thereof to make or modify products or processes for specific use*. On a global scale biotechnology has developed into a versatile tool for the invention of new products and substitution of established chemical processes. It is not an industry in itself but a powerful technique and science that has developed fundamentally over the last decades. Biotechnology is found in various industries and applications, notably in pharmacy, agriculture and industrial chemistry. Consequently the biotechnology sector is subdivided in three categories:

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[146] Estimates by the authors

- *Green Biotechnology*: This is the engineering, design and manufacturing of tailored plants that withstand but adverse climatic conditions and increased concentrations of pesticides. The ultimate goal of green biotechnology is the improvement of farm economics and in some cases improvement of yield levels.[147]
- *Red Biotechnology*: This is the development and manufacturing of innovative therapeutic concepts and remedies, based on molecular biology and gene modifications. The ultimate goal of red biotechnology is the successful development of drugs and techniques against diseases, which so far could not be treated and which at the same time provide pharmaceutical companies high profit margins needed for the justification of the intensive R&D efforts underlying such biotechnological products.
- *White Biotechnology*: This is the manufacturing of chemical products by biological or enzymatic processes. The objective of white biotechnology is to produce such chemicals either more cost effective than traditional synthesis and/or to develop and manufacture new ones, which by chemical processes are too difficult to establish.

Since more than a decade, Egypt is active in all three biotechnology sectors and reached different stages of development.

- In green biotechnology, Egypt hosts some internationally renowned academic institutes and focuses on the development of crop species with higher yield and which tolerate saline and dry conditions. Such R&D work is government propelled while private companies are not active in that area. Due to the disconnect between research and industry but also because of the strong dominance of international agricultural supply companies, commercial success of these efforts have been very limited so far.

- Similar to the agricultural sector red biotechnology is advanced on the academic level in some areas. Applied research in molecular biology and on diseases of national and international relevance, such as diabetes, are going-on on a high and international competitive level. However, the link to commercialisation has been weak so far and innovative drugs were not developed until now. The exception might be the implementation of a manufacturing line of recombinant human insulin in one Egyptian pharmaceutical company and the professional development of animal vaccines in the government controlled VSVR institute. The sector in general is suffering from strong international competition, high costs for R&D but at the same time from government interference on price settings. On international levels, Egyptian pharmaceutical companies have to a large extent not yet integrated

[147] A review of the yield effects of GM maize under American farming conditions shows that so far yield increases are not statistically significant compared to standard maize. However, as GM maize allows the application of higher dosages of glyphosate and thus improves weeding, farm economics are positively affected (see various review reports by USDA). It is different for cotton. GM cotton resistant to higher dosages of insecticides results in higher yields, although the on-farm effects are much smaller than predicted from experiments (see various reports of USDA and cotton board).

successfully into marketing and selling activities. Their presence on globally important fares (e.g. CPhI) is still weak and much weaker than of countries with a comparable stage of development such as Turkey.

A pharmaceutical sector study commissioned by IMC in 2006 comes to the following conclusions:

- The policy framework is of high relevance for the pharmaceutical sector and political interferences in various areas such as pricing of drugs on the local market are very strong. Since such prices are low to support affordability for the majority of the population, no pharmaceutical company at this moment can recover its R&D and manufacturing costs from local sales.
- Due to that market set-up interest from international companies in installing basic pharmaceutical production is low and global players see Egypt at best as a packaging and distribution site.
- Despite Egypt's commitment to fulfil completely WTO regulations, the implementing of TRIPS (Trade in Intellectual Property Rights) is still pending, refraining pharmaceutical research activities to be set-up.
- In order to revive and develop the pharmaceutical sector a number of framework conditions have to be changed among which the most important are: liberalisation of the pharmaceutical market and allowing higher flexibility in pricing, facilitating and supporting the development of drugs based on domestically available raw materials, attracting foreign investments by setting up a package of incentives and developing Egypt as an R&D as well as manufacturing site for products relevant for the Middle East and Africa.

The third sector, white biotechnology, is clearly different in development from the other two. Several attempts have been made in the last few years to implement commercial production and attract foreign invesments. Noteworthy in this context are:

- **Manufacturer 1** manufacturing 500 tons of Cephalosporin C per year mainly for exports. The company also embarked on the manufacturing of recombinant insulin together with a Brazilian partner.
- **Manufacturer 2** producing ethanol, acetic acid, yeast and some more chemicals in amounts of several thousand tons per year.
- **Manufacturer 3** manufacturing citric acid and citrates for use in food, beverage and detergent industry.

In addition to these companies there are at least three smaller factories manufacturing baker's and feed yeast as well as ethanol.

The detailed review of activities in industrial biotechnology of Egypt shows that although the current status is noteworthy and efforts undertaken so far point at the right direction, the economics of production is strongly challenged. Cephalosporin and other antibiotics with very few exceptions are almost exclusively manufactured in Asia, notably India and China. Production in these countries is at state-of-the-art but products are offered at very low prices. Consequently any manufacturer in Egypt is under continuous cost and innovation pressure. In the absence of strong international partners, any expansion opportunity will be even more strongly challenged in future. Manufacturer 3 started up only a couple of years ago based on submerged fermentation of an Aspergillus strain, which is selective on the feed stock and is only high yielding, when fed on imported glucose. As glucose prices increased over the last years, citric acid manufacturing shows higher costs than in other parts of the world and in consequence Manufacturer 3 is faced with price pressure, strong competition, decreasing sales and serious economic problems. Ethanol manufacturers however profit form the current global popularity of bio-ethanol as transportation fuel, entailing high international demand and increasing prices. Most probably Manufacturer 2 is operating its ethanol activities on economic grounds, although the potential for improvements primarily in energy saving are considered to be high. Acetic acid manufacturing is an extension of ethanol production. Considering the high price of ethanol and the low price of acetic acid it is only logical that Manufacturer 2 is concentrating on ethanol primarily.

A review of the *Institute for Biotechnology Information*[148] of the biotechnology sector in Egypt from 1997 comes to the conclusion that the most promising product category, for which manufacturing should be installed in Egypt, are enzymes. It is true that Egypt consumes a considerable amount of enzymes in the food, beverage, textile, leather and detergent industry. However, the international enzyme market over the last decade became so concentrated with two players (NOVOZYME and Danisco) dominating that international competitiveness of local production is difficult if not impossible to achieve. It was therefore right not to embark on a program to establish an enzyme industry in Egypt.

In summary the biotechnology sector in Egypt is advanced on an academic level but not so much on an industrial scale. Lessons to be learned on which further development can be build on, are the long experience in fermenting ethanol and related products but also the negative experience made with producing citric acid based on imported raw materials.

3.1.3 Consequences for Biotechnology Development

The above brief review of selected macro-economic trends shows, that any kind of biotechnology investment in Egypt should be geared to support macro-economic development, specifically by contributing to and accounting for the following ten elements:

- ***Supporting sustainable GDP growth***: Egypt's economy in principle is growing fast. In order to ensure such growth also in future, investments in biotechnology must be focused on those products which international

[148] Institute for Biotechnology Information 1997: An Assessment of Biotechnology in Egypt: Opportunities for U.S. Cooperation in Health, Agriculture and Industry.

markets are growing strongly and to which production from Egypt can integrate successfully.

- ***Fostering the manufacturing sector***: Egypt's economic growth has been particularly strong in the non-production sectors. Biotechnology investments must be focused on setting up basic local production in order to foster the manufacturing sector. Trading, packaging and reformulation of products is not sufficient.
- ***Improving balance of trade***: The balance of trade is strongly negative and exports are dominated by raw materials. Biotechnology investments must either be directed on import substitution and/or on increasing exports of higher valued goods.
- ***Employing of academic staff and stimulating of applied R&D***: The official overall unemployment rate is moderate. But unemployment among higher educated staff is high. Academic education is largely theoretical and the interface between universities and companies is weak. Biotechnology investments must be focused on absorbing a substantial number of staff, primarily of higher educated ones, and be able to stimulate and master applied R&D at universities and other institutes of higher education.
- ***Making use of low wages***: Egypt's labour costs are low compared to international standards. Those biotechnology investments might be prioritized which can benefit strongly from such low wage rates.
- ***Targeting at high energy efficiency and profiting from low energy costs***: Egypt is still self-sufficient in most energy sources but domestic consumption is increasing so fast, that self-sufficiency in petroleum and electricity will cease over the next years. Thus those biotechnology investments must be preferred which show a high return on energy but at the same time gain a competitive advantage in international comparison due to still low energy costs.
- ***Using locally available raw materials and refraining from imported resources***: With the exception of rice and some sorts of meat, Egypt is not self-sufficient in basic food or agricultural products. Large and increasing quantities of cereals, oils and oil cakes but also of sugar are imported. The only domestically available raw materials for usage in biotechnological processes are molasses and straw. Biotechnological investments therefore must be based on usage of such local raw materials and by all means avoid dependency of imported raw materials.
- ***Building on existing biotechnology know-how***: The biotechnological know-how base in Egypt is weak. However extensive experience in fermenting cephalosporines, ethanol, yeast and acetic acid exists. Strategic biotechnology investments should be based on this existing know-how and develop from that base.
- ***Benefiting from technology transfer***: For various biotechnological products, a limited but capable academic R&D base exists, which so far is disconnected with markets and commercial production. In the case framework conditions are favourable for setting up a biotechnological industry for which practical experience does not exist, such investments should be based on direct foreign investments including temporarily foreign management and plant control. In the case only minor elements of a profitable technology are missing, the technology transfer should be focused

on obtaining patent-free know-how so that an own Egyptian industry can develop without restrictions.

3.2 Review of Existing Biotechnology Industries in Egypt with Identification of Success Stories

Traditionally biotechnological industries in Egypt have been involved in production of a broad variety of food and beverage products (baker yeast, ethanol, wine, acetic acid, beer, vaccines (human and veterinary), cheese, amylase and protease enzymes, etc). Companies producing biotechnology products are very limited in both list of products and production capacity. Egypt lacks adequate funding sources to promote biotechnology startups. With only limited government funding, no venture capital to speak of and scant interest from the banking sector, most biotechnology enterprises spring from existing companies that have an interest in specific products. The country's implementation of the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) in 2005 and questions as to how the government will approach biotechnology patenting is also likely to compromise the ability of the local industry to continue to benefit and learn from biotechnologies largely developed abroad (Egypt's new IP law permits the protection of microorganisms in addition to non-biological and microbiological processes). Firms have traditionally found public research institutes to be ineffective in transfer of technology, expertise and experience. Although this is partly due to a legacy of mistrust, it is also due to the general inability of universities and public research institutes to sustain active links with industry and society at large.

3.2.1 SWOT features of Egyptian biotechnology industries

The common SWOT features of these industries are:

Strengths

1. Low cost of production input (water, energy, sewer service and other utilities)
2. Availability of non-food agriculture materials with high fermentable energy content at low prices
3. Abundant of local supply companies for bio-industries equipment
4. Technology absorbing capacity within the Egyptian workforce is medium to high

Weaknesses

1. Mismatch between output of the education system and industry skills needs
2. R&D activities are overlooked from both funding side and experts
3. Week interest within local investors and venture capitals to invest in industrial fermentation industry (long term investment)
4. Using convention technologies and less developed microbial stains
5. No available semi-pilot facilities for new products development, scaling up production protocol, promote spin-off, and market entry production
6. No institution communication between industry and academia

7. Mismatch between research programs at academia and industry needs

Opportunities

1. Recent Egyptian industry development strategy has recognized industrial biotechnology as a leading mechanism to enhance GDP
2. Bi-lateral and regional (MENA) trade agreements for white biotechnology
3. Large capital surplus in the Gulf region
4. Outsourcing policy for biotechnology products of EU (ethanol and MSG) and Egypt partnership agreement with EU
5. Build up an export oriented industry (joining global value chain)

Threats

1. Intense competition from China and India
2. Declining competitiveness due to weak technology transfer programs
3. Biotechnology industries norm mandates minimum production capacity for economic business management (e.g. 20,000 Tons capacity for lysine)'
4. Regulation and custom duties of specific international markets as part of protection policy for their national industries (USA for Ethanol industry).
5. Continuation of price increase of locally produced molasses due to high demand in EU.

3.2.2 National demand for biotechnological products

The white biotechnological products are widely utilized in Egypt in diverse industries including pharmaceuticals, bio-fertilizers, vaccines, food processing, paints, leather, animal feeds, bio-fuel, and food supplements. There are some local production capabilities through public-government owned companies as well as private enterprises. Most of the biotechnological products utilizing in Egypt are fully imported (table) with a small market size for each. On the other hand, the poultry production is a medium size industry and has mandated and created a fair market size for different poultry vaccines. (see details Chapter 4). Animal feed industry is the biggest consumers of imported biotechnological products (Lysine, Methionine, vitamins) with a market size of 3.5 million tons per year, second to that the tanning industry (lipase enzyme)

***Egyptian National Demand (imported) for Biotechnological Products*[1] (tons/year)**

Item	2002	2003	2004	2005	2006
Acetic[2]	2688	2487	2501	2392	2225
Lactic	81	87	290	348	114
Citric	2218	1665	3275	3283	3522
Lysine	935	1038	1616	3413	1543
Methionine	3190	3147	3554	4225	2849
Vitamin A	48	74	74	71	665
Vitamin B_1	44	49	28	64	39
Glutamic	517	536	670	847	1022
Vitamin B_2	9	10	23	9	3
Vitamin C	227	232	294	299	162

(1) Source: CAPMAS-Egypt- Total Import database
(2) Add to that 2400 Tons produced locally annually

Examples of Companies producing biotechnological products in Egypt

Products	Companies	Company's Name
Yeast (dry, fodder, and compressed)	3	Sugar & Integrated Industries
		Alexandria for Starch and Yeast
		El Obour Yeast
Ethanol	2	Sugar & Integrated Industries
		Al Masria Al Alamia Co for Touristic Supplies and Beverages
Antibiotic	1	Pharmaceuticals
Acetic acid	1	Sugar & Integrated Industries
Enzymes (lipase and amylase)	1	El-Nasr Pharmaceutical Chemicals Co
Wine and beverages	3	Al Masria Al Alamia Co for Touristic Supplies and Beverages
		El Ahram Beverages
		Ganakles
Veterinary vaccines	3	Veterinary Vaccines and Serum Research Inst
		El-Nasr Pharmaceutical Chemicals Co
		VACSERA
Human Vaccines	2	VACSERA
		EIPICO
Hormone	1	EIPICO

3.2.3 Examples of Biotechnology producers in Egypt

The above 11 companies are known to have biotechnology-based production activities. Through questionnaire, phone calls, internet search or direct visit, the analysis gathered data regarding their operations.

Five companies have been identified which operate fermentation plants in Egypt.

- **Manufacturer 1**: is a new company operating since two years only and thus is considered to be still in the start-up phase. Any appraisal is premature. The plant is built according to international state-of-the-art but is not FDA certified.
- **Manufacturer 2:** is a state company. The company presents itself as a very diversified corporation with interests in sugar factories, engineering, paper production, MDF manufacturing, card boards, perfumes, fermentation and molasses handling and transformation.
- **Manufacturer 3:** has stopped production due to unfavourable marketing conditions and
- **Manufacturer 4:** The Company is the only producer of ethanol 99.9% in Egypt. The companies operations are in danger due to difficult access to existing domestic molasses.
- **Manufacturer 5:** The Company is building a Biotechnology Center with objective to produce active raw materials and formulation of Biopharmaceutical products using biotechnology techniques.
- There are numerous supplies local companies capable to support biotechnology industries by providing vital services (components, consultancies, materials, design, etc)

3.2.3.1 Companies Providing Services for Biotechnology Industries

Biotechnology industry required a diverse of locally available suppliers for manufacturing components, consultants, R&D semi pilot facilities, formulation knowledge, local and regional market information, biotechnology products' users list. Our companies' survey and analyses of different records have revealed that biotechnological products are widely used Egypt in:

1. Animal feed formulation (lysine, methionine, and tryptophane),
2. Textile industries (amylase)
3. Food processing (amylase, citric, lactic, MSG, Amino acids, xanthan, , B_2 , B_{12} , C, Beta carotene, Lycopene)
4. Leather Industry (Lipase, Lactic)
5. Pharmaceuticals (LACTIC, CITRIC, Beta carotene, amino acids, antibiotics, ethanol, hormones
6. Vaccines (human and animals)

Here are some examples of local companies either users of biotechnological products or suppliers for biotechnological manufacturing equipment.

Biotechnology Products' Users (Animal Feed; Vaccines, Pharmaceuticals; Chemicals (Ethanol))

Company Name	Activity	Address
Al Ektissadia Co. for Food Development	Lysine, Methionine, Tryptophan	13 Sphinx SQ Mohandessin Giza 8 "Floor" Mohandessin, Giza, Egypt
Misr Agricultural and Chemical CO.	Animal feed additives	54 Shaehab St., Mohandessein, Giza, Egypt
Pfizer Egypt	Amino acids	▪ 47 Ramses St., PO Box: 2357, Attaba, Zip Code 11511, Cairo, Egypt ▪ Thawra St., Almaza, Cairo, Egypt
SCIB Chemical	Amino acids	▪ 17 Bahgat Ali St., Zamalek, Zip Code 11211, Cairo, Egypt ▪ 6th October City, 4th Industrial Area
Golden Co Animal Production	Feed additives	10 Emmarat Emdad Nasr City Cairo
Eastern Co Poultry	Chicken Feed	4 Hussein Pasha, Kasr El Nile Cairo
Arabia Pharmaceuticals and Chemical Industries	Animal Feed, Vet Vaccines	5 Masaieaa Sr, America, Cairo

Equipment Suppliers

(Processing Equipment, Bioelectronics, Bioengineering, Extraction. Pumps, Hydraulics / Pneumatics Control, Plant Design, Material Handling, Water treatment, waste Treatment, Compressor, Motors, Generators, Boiler, Liquid Filtration, Handling equipments).

Company Name	Address
AFRI Medical Co.	▪ 13 Obur Bldgs., Salah Salem St., Heliopolis, Cairo, Egypt ▪ 10th of Ramadan City. Industrial Area C3
ElFouly Company	▪ 20 Adly St., Cairo
Alkan group of Companies	o 2 Mesaha Sq., Dokki, Giza, Egypt
Arab Engineering & Distribution Co. (AEDCO)	o 2 Al Saray El Kobra St., Garden City, Cairo, Egypt
Carlin Middle East	▪ 2 A Bani Amer St., Zip Code 12211, Giza, Egypt ▪ 6th October city; Sadat City; Kaha Facility
CHEMIPHARM LTD.	13 Ahmed Orabi St., Mohandessin, Cairo, Egypt
Compumed for Medical products	Road 18 No. o, Maadi, Cairo, Egypt
Dr. Ahmed Abdel – Warith: Consulting Engineers (AAW)	37 Babel St., Dokki, PO Box: 12311, Cairo, Egypt
Egyptian Engineering Center (EEC)	A – Riaset El Gomhuria Mataria St., Mataria, Cairo, Egypt
Egyptian Italian Engineering & Constructon Joint Stock CO. (EGITALEC)	143 Omar Ibn El –Khatab st., Almaza, Heliopolis, PO Box: 11341 Heliopolis, Cairo, Egypt
Egyptian Trading & Engineering CO. (ETE)	3 Hassan Sadek St., Ouroba, Heliopplis, Cairo, Egypt
El Arabbeya for electronic Industries (BERGO)	▪ 12 Nasr Khesro st., Naser city PO Box: 68 Andalos, Cairo, Egypt ▪ 125 Helwan – Cairo – Egypt – 58 Industrial City
El Radwan Trading & Engineering CO.	14 Hadayek El Obour, Salah Salem St., FL. 9, Appt. 1, Cairo, Egypt
Engineering CO. for Water technology (WATERTECH)	▪ 10 Housny metwally St., El Haram, Zip Code 12111, Giza, Egypt ▪ Bourg El Arab – Alex
Gabtic International Business CO.	6 Kamal El Shenawy St., Garden City, cairo, Egypt
GAFA Industrial Equipment	2 Sherif st., Lewa Bldg., Downtown, Cairo, Egypt
GESCA	45 Abd El Khalik Sarwat st., Downtown, Cairo, Egypt
Industrial and Commercial Consultants (INCONSULT)	27 Talaat Harb St., Downtown, PO Box: 28, Zip Code 11511, Cairo, Egypt
International Trading Company (ITC)	42 Kalaky St., Bab El LOuck PO Box: 78, Zip Code 11513, Cairo, Egypt
Projects & Investment Consulting Group. (PICO)	▪ 3 Shagaret El Dor St., Zamalek, Cairo, Egypt ▪ 6th Ocober City
Setcore Group	6 Dar El Shifa St., Garden City, PO Box: 1578, Cairo, Egypt
Tawakol Enterprises	70 El Thawra St., Heliopolis, Zip Code 11341, Cairo, Egypt
Sugar & Integrated Industries Company (SIIC)	Hawamdia, Giza

3.2.4 Relation between Industry and Research & Development

Egypt has an extensive scientific and technological infrastructure,. Despite these, there is not yet a critical mass of high-caliber professionals in designated areas, and this has slowed the development of Egypt's science and technology system. The excessive number of individuals combined with budgetary and other resource constraints, has undoubtedly hindered the potential for the small number of high-caliber (usually foreign-educated) individuals. Thus, although much of the research undertaken within the science and technology system remains rudimentary and low-level, biotechnology sector in Egypt thus far has been based on the successful exploitation of knowledge already in the public domain more than on novel contributions by its research community.

Another problem is the traditional focus of the country's universities on teaching and basic research, rather than applied research. Of all the country's scientists and engineers, 75% are employed in the higher education sector, leaving only 25% to operate in the other sectors of the society. This situation limits the potential contribution of Egypt's science and technology, both in terms of research outcomes and in producing qualified professionals who are capable of solving practical problems. These problems are compounded by poor collaboration among academic groups and centers on projects.

It is globally understood that universities and research institutions are sources of both the biotechnology products and the expertise. In turn, researchers are among the first to recognize the commercial potential of their techniques. Most of funding for biotechnological R&D programs in Egypt is coming from external sources (USAID and EU). External funding of research activities typically involves interference of the donor to some extent. On the other hand, only 0.3% of GNP is allocated from Government's budget for all scientific research programs. Within all institutions (research or education) we did not recognize any institutional technology transfer mechanisms which could encourage interaction between industry and R&D institutions. Most industry/academia is done through personal contact with no professional match-making processes. The biotechnology strategy issued by the Egyptian Academy for Scientific Research and Technology started only this year (2007) to incorporate "product development" as a main criterion for national funding acceptance.

Our survey questionnaire to study the current R&D activities within the academic institutions has revealed the existence of high "qualified biotechnological R&D spots" within different research and academia institutions. With the fact that biotechnology industry is an integration of different branches of science and technology, e,g, microbiology, biochemistry, general chemistry, physics, engineering, and computer science. We did not find one institution could carry all of these activities. Table (4-3) illustrates education institutions offering industrial biotechnology degrees and table (4-4) illustrates some examples of biotechnology R&D programs with either academia and research institutions.

3.2.5 SWOT analyses of Egyptian R&D institutions

Strengths:

1. There are biotechnology programs (Table 4) within each of agriculture, sciences, pharmaceuticals, biotechnology and veterinary as well as medical education- institutions (governmental or private).
2. Industrial biotechnologists are among graduates programs than among under graduates
3. We recognize industrial fermentation programs at 8 programs (Table 5) mostly with research center (National Research Center and Agricultural Research Center). Some objectives of these programs are industry-based, e.g., *Optimization of industrial production of rifamycin B by Amycolatopsis mediterranei; The role of colony morphology and nitrogen sources in productivity;(OM El-Tayeb, Microbial Biotechnology Center, Faculty of Pharmacy, Cairo University, Cairo, Egypt (2004))*
4. The established Microbial Strain Data Network (MSDN) as well as the existence of Cairo MIRCEN (Microbial Resources Center) offers the opportunity for small institutional culture collection with limited to moderate facilities can act as an active two-way node in the network.
5. Egypt's human resources in biotechnology are trained and educated in either European and US universities. considerable, as 14.5 per cent of the total of 27,500 scientists are active in biotechnology-related fields, of which many have been educated at European and US universities.
6. Conventional biotechnologies, such as fermentation and plant tissue culture techniques are well mastered in Egypt.

***Weaknesses*:**

1. Egyptian education system is more basic (theoretical) than practical curricula.
2. Vocational and university educations whatever within governmental and non-governmental institutions are concern more with mass education than with quality education.
3. Most of academia research projects do not have commercial value or application
4. There is no any established mechanisms to facilitate communication between researchers and business community
5. Technology transfer, License agreement, patent right are not seriously enforced to protect licensees and do not have priority in academia agenda
6. Nine out of 10 biotechnology research programs are basic molecular biology and tissue culture with no connection with "industrial fermentation"
7. There is no any R&D semi pilot fermentation

Opportunities

1. The extremely rapid pace of biotechnology development puts a premium on staying at the fore front of the field. One of the best way to do this is through exposure of industry staff to people working on basic research problems and providing these companies with windows on the technology while not necessarily requiring large investments in facilities and personnel.
2. Egypt as a full member of World Trade Organization had been issued a Intellectual Property Rights Law (Law 82 for 2002) which is complying with TRIPS agreement.
3. Biotechnology industries across the region it is not developed because in-availability of trained human resources which gives Egypt competitive advantages
4. The survey has revealed that there are long lists of companies capable to provide useful services to promote establishment of industrial fermentation facilities in Egypt. We list only some examples of these companies in Table 7 (a,b,c,d). include

***Threats*:**

1. Most of academia research projects do not have commercial value or application
2. Academia do not expose to problems and opportunities in industry, mostly because there is no any established mechanisms to facilitate communication between researchers and business community
3. Technology transfer does not have priority in academia agenda
4. Biotechnology is a team-work based activities which it is not a common practice within Egyptian academia
5. License agreement, patent right are not seriously enforced to protect licensees
6. The education system still does not recognize that individual skills are the core for population and human development. Biotechnology depends mostly on individuals with skills which enhance their creativity for products design and innovations
7. Nine out of 10 biotechnology research programs are basic molecular biology and tissue culture with no connection with "industrial fermentation"
8. You can see industrial fermentation programs at 7 programs mostly with research center (National Research Center and Agricultural Research Center). It is globally understood that universities and research institutions are sources of both the biotechnology products and expertise. In turn, researchers are among the first to recognize the commercial potential of their techniques.

Egyptian colleges and institutions with industrial biotechnology education

Institute for Technology of Sugar Industry	Assiut University
Genetic Engineering Institute	Menoufeya University, Sadat City
Faculty of Agriculture	Sohag University, Sohag
	Cairo University, Giza
	Ain Shams University, Shubra El-Khama
	Zagazig University, Zagazig
	Saba Basha-Alexandria
	Alexandria University, Alexandria
	Mansoura University, Mansoura
	Fayoum University, Fayoum
	Asiut University, Asuit
	Tanta University, Tanta
	Minia University, Minia
	Suez Canal University, El Arish
	Suez Canal University, Ismaeilia
Faculty of Science	University Tanta, Tanta
	Zagazig University, Zagazig
	Zagazig University, Banha
	Ain Shams University, Abbassia, Cairo
	Cairo University, Giza
	Alexandria University, Alexandria
	Helwan University, Ein Helwan, Cairo
	Fayoum University, Fayoum
	Suez Canal University, Ismaeilia
	Aswan University, Aswan
	Mansoura University, Damietta
	Minia University, Minia
	Mansoura University, Mansoura
	Beni Suef University, Beni Suef
	Qena University, Qena
	Sohag University, Sohag
	Assiut University, Assuit
	Menoufeya University, Shybien El Kom Menoufeya
Faculty of Technology & Engineering	Helwan University, Ain Shams , Cairo
Faculty of Engineering	Ain Shams University
	Cairo University

R&D institutions with activities related to industrial biotechnology

Affiliation	Discipline	Program/Unit	Area (s) of Interest
Agriculture Research Center	Soil, Water & Environment Institute	Dept Agriculture Bacteriology	- Agriculture residues fermentation - Industrial fermentation for ethanol, lactic, acetic and industrial enzymes production (cellulase, Xylase, etc) - Yeast fermentation technology
	Agriculture Genetic Engineering Research Institute (AGERI)		Tissue culture techniques, biological control agent (microbial)
	Horticulture, field crops, plant pathology, palm treesfeed and food, animal health, vaccines, animal reproduction, animal production, fish, cotton, food technology, and avian research institutes		Plant varieties development, finger printing for selection programs, tissue culture using modern molecular biology tools.
Desert Research Center	The biotechnology programs	Desert Gene Bank	Desert plant (medicinal) identification for propagation (using tissue culture) and breeding (DNA tools)

Affiliation	Discipline	Program/Unit	Area (s) of Interest
Mubarak Center for Scientific Researches	Genetic Engineering and Biotechnology Institute.		Different research programs related to medical and environmental biotechnology as well as industrial biotechnology development. Example of target product is lipase enzyme for industrial use.
National Research Center	Sector for Genetic Engineering and Biotechnology Research	Dept Microbial Genetics	Running different research programs for modification of microbial agent for industrial use, production of pharmaceutical active molecules, and recycling of industry bi-products for production of value add products (Ethanol, bio-fertilizers) as well as improved baker yeast.
		Dept Microbial Biotechnology	Focusing their resources for improvement of microbial fermentation industries.
	Sector for Basic Sciences	Dept Genetics and cytology	Conducting research programs for genetic modification of industrial fermentation microbial agents
Cairo University	Fac Agriculture	Center for Genetic Engineering Research and Studies	Plant variety modification
		Plant Dept-Biotechnology laboratory	Tissue culture technology
	Fac Pharmaceutical-	Center for Biotechnology	Industrial biotechnology Tissue culture technology
Monofyia University	Institute for Genetic Engineering and Molecular Biology-Sadat City		Beside teaching duties they do have expertise in microbial biotechnology and industrial fermentation

Affiliation	Discipline	Program/Unit	Area (s) of Interest
Ain Shams University	Fac Agriculture	Center for Genetic Engineering and Biotechnology	The center is equipped to do basic research programs for micro-algae and other molecular biology works
		Microbial Resources Center (MIRCN)	A regional source and reference laboratory for microbial classification, source for microbial strains for fermentation industries and dairy products processing. The center is supported by UNISCO.
	Fac Sciences	Molecular Biology laboratory	The laboratory is specialized for medical biotechnology research for disease diagnostics, and human vaccines
Alexandria University	Post graduate Research Institute	Biotechnology Department	Development of microbial strains for agriculture residues utilization and to produce economic feed materials and veterinary materials
	Fac Agriculture-Shatbi	Biotechnology Laboratory	Food microbiology development
Assut University	Center Genetic Engineering and Molecular Biology	Molecular Biology Unit	Using molecular tools for animal disease diagnostics
		Genetic Engineering and Tissue Culturing	Plant Tissue culture technology
Menia University	Fac Agriculture	Center for Genetic Enginseering and Biotechnology	Draught resistant and tissue cultures for field crops and horticulture
Suez Canal University		Biotechnology laboratory	Food Microbiology Tissue culture for horticulture
Tanta University	Fac Agriculture	Genetic Dept-Biotechnology laboratory	Microbial strains for Biological control
Modern Science and Technology University	Fac Biotechnology	Industrial Fermentation and Biotechnology Dept	Protease Enzyme Lipase Enzymes

4 Recommended Biotechnology Projects and Strategic Approach

Biotechnology has opened opportunities beyond the world of agriculture, medicine, and health care and across many traditional boundaries. On the other hand, the biotech industry is extremely knowledge-intensive. Within US biotech industry 47% of venture-backed biotech firm founders were university professors, scientists at research institutes or newly minted Ph.D.s, 40% of the CEOs hold doctoral degrees. More than 80 percent of biotech R&D officers hold doctoral degrees, and the percentage is even higher for chief scientists. Academic research and federal funding are particularly important for growth in the biotech industry. The biotech industry, far more than IT industries, relies on research universities as a source of technological innovation. Thus, it is important for policymakers to address the issue of technology transfer from universities/research institutes to the industry as well as human skill development. The following components are part of our suggested strategy for implementation of biotechnology industry in Egypt.

Egypt’s economy shows a robust growth of GDP which - significantly and largely- is based on non-manufacturing sectors.

Among the main sectors of modern biotechnology only industrial white biotechnology has a significant product volume output. Therefore, due to its foreseeable employment impact, industrial biotechnology (i.e. fermentation) has been identified as the relevant leverage for Egypt development of this sector.

As detailed in this study, Egypt disposes of resources such as human and natural ones, location close to European market, political and social stability, all of which allow a further build-up of a biotechnological industrial sector, considered being as key for Egypt’s macro-economic development

Any new industry sector strategy has to :

- **Support growth of GDP, primarily by manufacturing higher valued goods, which not only can be used on the domestic market but also integrate successfully internationally.**
- **Absorb a substantial number of labours**
- **Contribute to an improved interface between research and development and commercialisation**
- **Build on existing resources of raw materials and strongly refrain from imports.**

4.1 Main strategy elements:

- There are two main limiting factors facing the economic implementation of biotechnology industry in Egypt:
- Availability of low cost highly fermentable raw materials with an acceptable grade for industry norm.
- Availability of industrial fermentation experts and professionals.
- It is primarily Europe as a market which is of relevance for a potential Egypt fermentation industry. Accordingly all products proposed for implementation in this study are being exported to the European Union
- Apart from general political economic framework conditions, which are considered to be favourable in Egypt for investments, the key decision criterion for selecting a manufacturing site for fermentation is the availability of competitive fermentable raw material.
- It is obvious that basic know-how in white industrial fermentation already exists for many years in Egypt. This industry can serve as the seed for further sector development and can successfully stimulate applied R&D at universities and institutes- much more than other biotechnology sectors, for which a commercial and industrial basis is almost absent in Egypt.
- Apparently, today the available molasses are not sufficiently used for the benefit of the national biotech sector development. The analysts estimate that a more intensive use of the available molasses by investments in lysine, MSG and ethanol plants would result in an annual value addition of almost $ 60 Mio and create 600 permanent jobs.
- Given the need to satisfy the macro-economic objectives for biotechnology, the market environment and the availability of resources, three products are recommended to develop in Egypt: lysine, monosodiumglutamate and especially ethanol. These products can be produced with locally available molasses, profit from low energy and labour costs and especially from the geographic location of Egypt being close to Europe.
- For bio-ethanol the conditions are especially favourable as practical know-how for manufacturing plants and for production already exist in Egypt. Bio-ethanol and other alcohols can not only be produced based on molasses but – in future- also based on processed biomass (Lignocellulosic materials), which is the only raw material beyond molasses, available in large quantities as a by-product from cultivation. This technology however will require further technology development, but has potential -upon success- to catapult Egypt to the forefront of international R&D in that sector.
- By establishing fermentation industries, the analyst expect them to unfold a biotechnological cluster effect, if supported by government. Serving as nuclei, more sophisticated products building on fermentation know-how of amino acids and ethanol will then be developed, as the example of China and other countries shows. At this current stage, start-up and R&D driven companies related to biotechnology or fermentation do not exist in Egypt.
- The analysts recommendation to IMC to start attracting larger scale investments in the mentioned fermentation products -mainly by enabling improved access of existing raw materials- will definitely lay the foundation for the development of private sector companies in a number of related disciplines.

4.2 R&D Program for biotechnology industries

Before benchmarking is looking for innovation program and concepts which can impact on the success and the expansion of the industrial fermentation business (white biotechnology). Small Business Innovation Research (SBIR) is one of the most US successful modernization industry programs. SBIR is helping to provide early-stage Research and Development funding to small technology companies (or individual entrepreneurs who can set-up a company). SBIR have been providing innovative concepts from academia/research institutions to the industry in the U.S. In the line with Egyptian industrial development strategy (technology transfer tasks) we herunder suggest an Egyptian-adopted version of such program.

4.2.1 Small Business Innovation Program (SBIP)

Objectives

SBIP program objectives include stimulating technological innovation in the private sector, strengthening the role of small business in Egyptian economy, and fostering, encouraging and increasing the commercial application of local innovations.

Program Phases

Phase I	Evaluation scientific technical merit & feasibility of an idea.	Fund allocated to small business partner Peer reviewed solid scientific data with business-proved and market-product orientation
Phase II	Expand the results of, and further pursue the development of, Phase I work, awarded to Phase I projects that are the most promising.	Further fund allocated to small business Product prototype, IPR protection in place, mass production protocol, market niche recognition and business development program
Phase III	Commercialize results of Phase II	No fund allocated from the program Mass production, market entry, and business development

Criteria for topics funded:

- Industry needs
- National priority

Eligibility for SBIP participation

- Small business (not more than 25 employees, including affiliates)
- At least 51% owned & controlled by Egyptians
- Can be any business form (proprietorship, partnership, corporation, joint venture, association, trust or cooperation.
- Must be for profit
- Member of IMC and FEI network

4.2.2 Critical mass build up for biotechnology expertise and professionals

The availability of white and blue labor forces with proper biotechnology industrial training is a must to implement this technology. Most of industrial fermentation staff in Egypt are government trained and not widely available. In addition they have been diminished by retirement or by moving to other start up private companies. The table summarizes skill labors needed for that kind of industry.

Table: Basic skills needed for Biotechnological Industries

Area of expertise	**Basic education**
Microbiologists	Agriculture, science, veterinary, medicine,
Fermentation operation	Agriculture, science, veterinary, medicine, Engineering, computer science, biotechnology
Product recovery and formulation	Science (biochemistry, chemistry), agriculture (biochemistry), Engineering (chemistry)
Quality control/Assurance	Agriculture, science, veterinary, medicine,
Equipment design, specification	Engineering,
Molecular biologist	Agriculture, science, veterinary, medicine, biotechnology

4.2.2.1 Short Term Training Program

Objectives

- Expanding the pipeline of youth entering the biotechnology industry
- Helping alternative labor pools gain industry-defined skills and competencies

Education and vocational institutions develop training programs to ensure the human resources needed for the development of new biotechnology enterprises. As an example University of Maryland, Maryland USA is offering a skill development training program comprised of A. Fermentation Microbiology Workshop. This is a laboratory intensive workshop providing hands-on experience and instruction with a variety of fermentation systems. Included are teaching important techniques, methodologies, principles and applications of aerobic bacterial and fungal fermentation. B. Downstream Processing & Protein Purification Workshop This provides hands-on experience with recovery and purification strategies for biotechnology products, especially proteins.

Pharmaceuticals Company (Egypt) is offering one month full time and residence vocational training for all university graduates (science, agriculture, medicine, veterinary) in industrial fermentation technology through their state of the art production facility located in Qaft, Quna. The facility is well equipped with all training tools

IMC- Job Training Grants as part of Egypt's Industrial Development Strategy ("Part 3- Building Domestic Capabilities-Upgrading the skills of Egyptian Workers: The New Industrial Training System") are designed to serve the workforce needs of the biotechnology industry. These investments can address the image, outreach, recruitment, and training workforce issues identified by the biotechnology industry.

The programs have to provide innovative solutions, leadership, and can be modelled in partnership with local and international training providers.

4.2.2.2 Long term Skill development Program

Another set of innovative workforce solutions is based on the biotechnology industry's priorities that address issues such as:

- Developing alternative training strategies for educating and training industry-specific professionals, such as apprenticeship, distance learning, and accelerated training;
- Developing tools and curricula for enhancing the skills of industry-specific professionals for nationwide distribution;
- Enhancing the capacity of educational institutions to train to industry-defined competencies (as a model below);
- Developing industry-defined career ladders and lattices and corresponding competency models and curriculae;

- Developing strategies to retain and help incumbent workers move into higher level positions;
- Assisting transitioning individuals from declining industries to high growth industries by building on their existing skills and training for high growth biotechnology occupations.

A possible model of University Master curriculum for (Bio)Chemical Engineering is an example from the University of Dortmund, Germany: Since Chemical Engineering came into existence during the early decades of the 20th century it has developed as an interdisciplinary subject out of the cooperation of classical disciplines such as engineering technology, chemistry, physics, maths and special subjects areas. It expanded to an independent field of study. This development began when people realized that the variform production processes of the chemical engineering and industries associated with it can be resolved into single steps, so called root processes. These root processes – detached from the mass and its producting process – can be implemented according to the same legalities and with similar institutions.

Neighbouring sciences cooperate in chemical engineering as it is required by technical preparations of processes in the laboratory, in the test facility, by the planning, the construction and the operation of a chemical plant. In the broadest sense the word chemistry stands for mass conversion and mass upgrading. The word technology stands for the industrial machined solution of the mass conversion processes.

About half of the German industrial output is produced with the help of chemical or biotechnical mass conversion processes (for example the conversion from sugar into alcohol). Also mere physical operations such as the mass combine or the mass separation are decisive involved in procedural processes. That way the separation of mass mixtures for the pharmaceutical production, oils and plastics for example is as important as for the pollutants removal from exhaust air, wastewater and recycling in closed loops. Food technology from brewing to the potato crisps production and energy management also belong to the areas of application of the chemical engineering processes.

Medicine, biology, physics and chemistry are commonly used terms: But where should chemical engineering be integrated? Chemical engineering overlaps with natural science but also with engineering science studies. The level of overlapping results in a smooth transition; on the one hand from chemistry over technical chemistry to chemical engineering and on the other hand from mechanical engineering to process engineering but these demarcations vary from university to university.

A chemical engineering engineer who after his education is ranged between a process engineering engineer and a technical chemist, controls inner life as well as outside life of chemical-technical-plant: compared to process engineering the mechanical engineering part benefits the natural science orientated chemist and the stronger engineering science orientated mechanical engineer.

4.2.2.2.1 Fields of teaching in chemical engineering (leading to master degree)

Rates of the specific areas in the study course chemical engineering, without assignment, group work and degree dissertation

Specific area		Rates of hours in %	Hours sum
Mathematics / Informatics	High-level mathematics for engineers; Programming	11	11
Natural sciences	Physics basics, inorganic, organic ans physical chemistry	6 15	21
Engineer sciences (also multidisciplinary areas)	Thermodynamics,Transportation processes; Technical mechanics, Fluid mechanics; Materials science; Business management; Plant safety, System analysis, Process automation, Electrical engineering	6 7 3 1 1 5	23
Chemical engineering	Mechanical processes and bio-technology; Thermal processes; Introduction into chemical engineering,Process/reaction technology; Systems engineering and apparatus engineering; Group project (planning of a procedural plant)	3 3 4 6 5	21
Optional area	Optional subjects, predominantly chemical engineering	24	24
Proportion Lectures:Exercises is 1:1,3			100

4.2.2.2.2 Fields of teaching in biochemical engineering (leading to master degree)

Rates of the specific areas in the study course biochemical engineering

Specific area		Rates of hours in %	Hours sum
Mathematics / Informatics	High-level mathematics for engineers; Programming	11	12
Natural sciences	Physics basics, inorganic, organic chemistry, Microbiology and Biochemistry	7 13 7	27
Engineer sciences (also multidisciplinary areas)	Thermo dynamics; Transportation processes; Technical mechanics, Fluid mechanics; Materials science, Business management Plant safety, System analysis, Process automation, Electrical engineering	7 4 3 1 1 3	19
Biochemical engineering	Apparature of biotechnological Processes Bioreaction Engineering Biochemical Engineering Biophysics/Molecular Biology Technical Chemistry II Mechanical Engineering I Thermal Engineering I Cell Biology Systems Internship Biochemical Engineering I Internship Biochemical Engineering II	2 2 2 2 2 2 2 2 3 2	21
Optional area	Optional subjects, predominantly biochemical engineering	21	21
Proportion Lectures:Exercises is 1:1,3			100

4.3 Legislation reform

What Policies Will Help Bioethanol meet the challenge of the "Advanced Energy Initiative"?

The rapid commercialization of ethanol from cellulose will require government support in four key areas:

- **Advanced research and development** The cost of ethanol production from cellulose has declined dramatically over the past five years with breakthroughs in industrial biotechnology. However, production at prices competitive with the mature petroleum industry still depends on advances in new crop varieties, sustainable harvesting, storage, transportation and processing. This will require an intensive, focused R&D and demonstration program. The Alternative Energy Policy Act should provide a strong funding for R&D programs

- **Biorefinery construction** The single greatest hurdle to commercialization of ethanol from cellulose is construction of the first integrated biorefineries. Potential refiners are unable to secure private financing for construction of the first plants without some government assurance/participation. A government loan program is proposed to fund at a level sufficient to mobilize private financing:
  - Biorefinery Loan Guarantee Program: For the construction of up to two demonstration cellulosic ethanol facilities
  - Biorefinery Grants Program: Authorizes grants over three years for the commercial production of ethanol from cellulose

- **Infrastructure to supply feedstock to Biorefinery**. Sustainable production and collection of cellulosic agricultural feedstocks will require considerable infrastructure incl. construction and upgrading. Therefore the government should consider implementing the following policy measures:
  - Fund R&D and provide incentives for the development of one-pass harvesting equipment and other new harvesting equipment for collection of cellulosic agricultural feedstocks;
  - Fund regional demonstration projects to streamline the collection, transport and storage of cellulosic feedstocks;
  - Fund programs to help farmers identify and grow the most suitable crops for both food production and cellulosic biomass production.

- **Market Creation/Expansion** Even with ethanol production from cellulose underway, a government policy is needed to ensure penetration into the petroleum-dominated market for transportation fuels. The following programs should be fully implemented:
  - New Fuels Standard (E95-E80)
  - National Off take Agreement – government will award cellulosic ethanol producers a per liter incentive until production reaches 1 million tons per year
  - Government Procurement – Requires the use of renewable fuels in all government fleet vehicles capable of their use.
  - Flex Fuel Pumps – Fueling stations will receive a tax credit for 30 percent of the cost of installing pumps dispensing ethanol blends of at least 85 percent.

- To review the local sugar regime in order to improve availability of molasses to the private sector
- Improve usage of molasses inside the country and reduce exports of any fermentable raws that can be converted with local employment effect

4.4 Action Plan for implementation

	Tasks	Term	Responsibility
Result 1: Biotechnology Industry Coordinator in place (30 days)			
1.1	Obtain general approval for the job	Carry out and follow up all activities related to this position	IMC
	Prepare job description/ Prepare job requirement		
1.2	Public announcement for the job		
1.3	CV received by selection committee/ CV Short listed		
1.4	Interview / Identify the candidate		
1.5	Hiring		
Result 2: Maintain cost competitiveness (Labour, utilities)			
		Maintain competitive advantages on short term	Biotechnology Coordinator
Result 3: Biotechnology products priority list (45 days)			
3.1	Mandates and time frame for a taskforce to be prepared by Biotech Coordinator	Setup of a taskforce white industrial fermentation cooperation technology transfer and identify products priorities (EU Partnership Agreement)	IMC, HCST, Ministry of Trade and Industry
	Taskforce for white biotechnology products assembled		
3.2	Local, regional and international markets orientation report for a list of expected biotechnology products (EU market screened)		
	Taskforce prepare a presentation of the expected output		
3.3	Steering committee to evaluate the expected output and short listed the products		
3.5	A final priority list of biotechnology products adopted		

	Tasks	Term	Responsibility
Result 4: New technologies have been developed for production of fermentable raw materials based on biomass (10 years)			
4.1	Concept paper for the new funding program prepared by Biotechnology Coordinator	More fund should be allocated for R&D to improve biomass production (Non-feed and non-food), biomass collection, biomass storage, biomass pre-treatment, and industrial enzymes production, in order to establish a commodity fermentable raw materials industry.	IMC+ Higher Consul for Science and Technology (Prime Minister)
	Concept approved by the relevant officers at both IMC and Higher Counsel for Science and Technology (HCSI)		
4..2	Study - Priority list of R&D areas to be funded		
4..3	Presentation by the Biotech Coordinator for the stockholders – Awareness (objectives, goals expected output)		
4.4	Steering committee for the program, assembled from biotechnology tech transfer experts (Industry, IMC, HCST, academia)		
	Application format and eligibility criteria for approval been adopted by steering committee		
4.5	Workshop for industry and entrepreneurs- program concept application, technical aspects, funding available		
4.6	Call for proposals/approval from relevant committee/contracting		
4.7	Technology transfer and licensing		
Result 5: New trained professional in Industrial fermentation (5 years)			
5.1	Program concept to be prepared by Biotech Coordinator	A long term program to enrich labour market with industry-trained biotechnology professionals in a short term (post-graduate training) and in a long term (post graduate diploma)	IMC+ Minister of Trade and Industry + Minister of Labour + Higher Consul for Sciences and Technology
	Approval from relevant IMC officers and industry		
5.2	Study- Training objectives / content / target group / duration /policy / eligibility based on cost sharing 20/80 for trainee and IMC respectively		
5.3	Call for training delivery /qualifications / cost and contracting		
5.4	Five rounds of training per year 10 trainees/round		

	Tasks	Term	Responsibility
Result 6: New academic Diploma established for Industrial fermentation experts (5 years)			
6.1	Concept paper prepared by Biotech Coordinator		IMC, HCST, Minister of Higher Education, Universities Supreme Counsel
	Industry, HCST and IMC approved and Min Higher Education endorsed		
6.2	Study- objectives / syllabus for the diploma / duration / intra-collages participation / internship / eligibility		
6.3	Universities Supreme Counsel approved		
6.4	Delivery		
Result 7: Industrial Fermentation Association or Chamber (60 days)			
7.1	Call for FEI to promote either ideas	IMC should support establishing either a national association for industrial fermentation industries or a new chamber for that industry at FEI.	IMC, UNIDO, Minister of Trade and Industry
7.2	Legal status granted of the Association according to NGO law		
Result 8: Two Biotechnology Clusters established within 10 years as pilot business (10 years)			
8.1	TOR for bidding/announcement	As a knowledge intensive industry, biotechnology required to establishing of two clusters of new technologies for raw materials industry development using locally available biomass (Rice straw, corn stover and sugarcane residues). The experience and the success of other countries with similar-based economy should be called	IMC and Higher Consul for Science and Technology (Prime Minister) and Minister of Environmental Affairs
8.2	Selection and contracting		
8.3	Establishing the two clusters		

	Tasks	Term	Responsibility
Result 9: Two new legislations to be proposed from the relevant (2 years)			
9.1	Study : Gasoline Blending Law	For biofuel industry to be expanded two main pieces of legislations need to be issued by relevant Minister and adopted by Parliament: 4. Gasoline Blending Law to allow sale gasoline/biofuels blends 5. Ease up issuing ethanol production license 6. Setup an incentive tax package on production of renewable fermentable raw materials from either agricultural and solid municipal wastes (biomass value add tax)	Ministry of Environmental Affairs, Ministry of Trade and Industry, Parliament, Min Finance, Min Petroleum and Minerals resources
9.2	Study: Incentive tax package for renewable fermentable raw mater4ials from biomass		
9.3	Cabinet Ministers to approve the measures and the bill		
9.4	Parliament to approve		

4.5 Specific Action plans for recommended industries

A single implementation plan has not be proposed as the requirements for setting up an ethanol and amino acid fermentation industry are too diverse. Consequently **distinctive action plans**, separately for investment in lysine, MSG, ethanol, based on molasses and on rice straw, respectively are outlined in this paragraph.

Action plans for **amino acids** focussing on the provision of molasses and on the attraction of foreign investments do not exist in Egypt as of today. Neither adequate technology does yet exist in Egypt.

For **ethanol based on molasses** the plan focuses on the provision of raw material, the optimised exploitation of existing engineering know-how and on the attraction of a local investor.

For **ethanol based on rice straw** the plan focuses on setting up a R&D scheme for converting straw into fermentable sugars and piloting such process on a smaller scale.

Then additional measures to build up the industry in Egypt, as outlined in this study, are necessary. This is to foster the academic sector and the entrepreneurial environment. By learning form other countries that have successfully implemented a strong governmental support for biotechnology, a dedicated programme for funding entrepreneurs with market driven business plans, is crucial for Egypts further success in this sector. However the prerequisite for government spending being effective is again the completion of at least one fermentation industry investment in one of the proposed technologies or very similar.

4.5.1 Pre-Feasibility Lysine

4.5.1.1 Global Market Review[149]

Lysine is a traditional fermentation derived amino acid. It was developed in order to supplement feed diets. In pig and poultry feed lysine is typically one of the most limiting amino acids. Soy cake rich in lysine can potentially substitute it. As a consequence lysine demand traditionally depends on the market structure for compound feed and at the same time on the availability and pricing of protein, specifically of soy.

4.5.1.1.1 Development of Consumption

For many years lysine's consumption on a global scale increased. While in 1993 worldwide consumption was in the range of 220.000 tons[150], it developed to 400.000 tons in 1998, stood at 650.000 tons in 2004 and is coming close to 800.000 tons in 2006. While in the early 90s demand growth was mostly seen in the industrialised countries such as Europe and North America, current growth is driven mainly by demand from Asia. Specifically in China, growth of the compound feed sector started to develop forcefully at the end of the 90s, mainly based on the expansion of the poultry and pig industry and entailed a large demand for lysine.

Overview 21: Global Development of Lysine Consumption (1.000 tons)

1993	1995	1998	2000	2004	2006	AAGR, %, 1993-2006
220	300	400	450	650	800	10,4

[149] If not stated otherwise, data are taken from: BCC Inc. (Analyst: U. Maerz) 2006: FOD037 – World Market for Starches/Glucose, emphasizing Cassava and BCC Inc. (Analyst: U. Maerz) 2005: GA-103R – World Markets for Fermentation Ingredients.
[150] If not stated otherwise, Lysine figures refer to Lysine HCl.

Overview 22: Development of Lysine Consumption by Region (1.000 tons)

Region	2000	2004	2006	AAGR, %, 2000 - 2006
Europe	150	180	200	4,9
North America	125	150	170	5,3
Asia excl. China	85	140	190	14,3
China	34	90	130	25,0
Latin America	30	50	60	12,2
RoW	29	40	50	9,5
Total	**453**	**650**	**800**	**9,9**

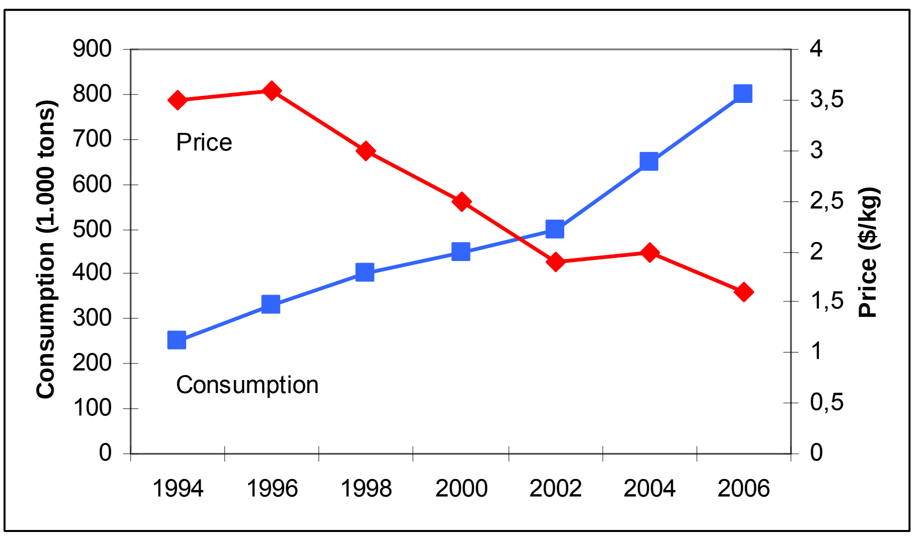
4.5.1.1.2 Price Developments

Like many commodity products, lysine has seen a strong degradation of price during the 90s and in recent years.

Overview 23: Price Development of Lysine ($/kg)

1988	1990	1995	2000	2004	2006	AAGR, %, 1988-2006
3,8	1,8	4,0	1,9	2,0	1,6	-4,7

Overview 24: Relationship between Lysine Consumption and Price



Such price development was mostly a consequence of an imbalance of demand and supply and of relatively low soy cake prices. In the early 90s all projections on future growth of meat consumption, especially in Europe and North America, were high and demand for poultry and pork meat was grossly overestimated. Consequently also projections for compound feed were overly optimistic, resulting in unrealistic future demands for all ingredients including lysine. Many companies entered the market and established or extended capacities. Such overcapacities brought the price down to the level of $ 2/kg. As low soy prices prevailed in the early years 2000, several lysine factories could not operate economically and shut down again. After 2004 however, China started a major investment program to become self-sufficient in lysine and a 200.000 tons plant came on stream to the end of 2006, which brought the global lysine price down to a level not seen before.

4.5.1.1.3 Industry Structure

Until 2005, the undisputed global market leader was Ajinomoto with a global production of 190.000 tons. Since the start-up of the Chinese plant (Global Biochem), Ajinomoto's dominant position became challenged. Overall there are approx. 10 companies supplying the global demand of lysine.

Overview 25: Market Shares of Lysine Producers, 2006

Company	Production (1.000 tons)	Capacity (1.000 tons)	Market Shares (%)
ADM	130	130	16
Ajinomoto	190	190	24
BASF[151]	80	100	10
Cheil	90	100	11
Kyowa	85	100	11
Degussa	60	80	7
China (incl. Global Biochem)	80	200	10
Others	85	100	11
Total	**800**	**1.000**	**100**

Although global capacity is currently 20% higher than production, the strong growth of lysine consumption will necessitate full use of the available capacity within the next three to four years.

4.5.1.1.4 Global Market Developments through 2015

Lysine demand essentially depends on the growth of compound poultry and pig feed production and is therefore indirectly depending on the global consumption

[151] BASF announced in April 2007 to close its Korean operation due to high raw material costs, making the plant uneconomical.

pattern for meat. Additionally the availability and price competitiveness of soy protein has a strong influence. Price settings are consequently driven mainly by the global equilibrium of demand and supply but also influenced by the raw materials needed to manufacture lysine.

Future Demand for Poultry and Pig Meat[152]

The global demand for such meat is directly related to a growing population but especially to increasing standards of living. The global population is still growing on average at a rate of 1,3%. In high income countries population growth is small with 0,5%, while in low income countries it is between 1,7 and 2%. The global per capita income is growing since 1985 at 1,4% per year and is currently at $ 6.000. The strongest growth in meat consumption is seen with an average annual income up to $ 10.000. Beyond that income level, meat consumption is only growing slightly. Since almost 95% of the world's population is still in an income category below $ 10.000, the demand for meat products is high and growing on a global scale by 2,7% per year. Poultry demand was especially high with growth rates of 5-5,5% per year over the last two decades, while beef and lamb growth rates were only in the range of 1% per year. As many poultry systems are already operated at a high standard, strong improvements of the feed conversion rates are not expected.

Consequently it can be assumed that poultry and pork consumption will also grow in future at a rate between 2-5% per year driving the demand for compound feed and thus for lysine at least proportionally.

Overview 26: Development of Poultry and Pig Meat Consumption through 2015

Type of Meat	2000	2005	2010	2015	AAGR, %, 2005-2015
Poultry	68	84	108	140	5,2
Pig	91	102	112	123	3,0

Availability and Pricing of Soy Cake[153]

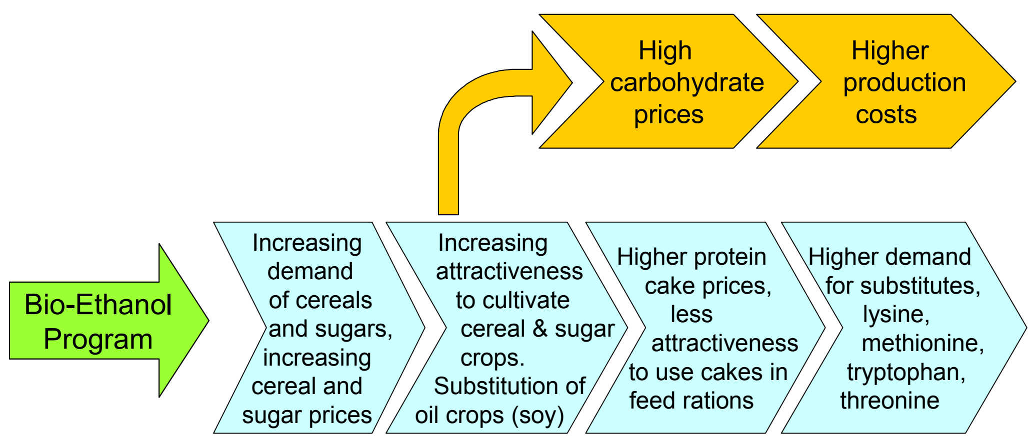
The protein source of choice for poultry and pig diets since many years is soy cake. In developed countries usage of such cakes increased over the past 15 years on average by 2-3% per year, while in developing countries growth rate was in the range of 9-10%, resulting in a global consumption of more than 230 Mio tons. That consumption was met by production increases primarily in North America, Brazil and Argentina and only to a minor extent in other countries. Production increased only to a small extent by productivity gains but mostly by extending the area planted.

[152] Alberto Weisser (Bunge Ltd) 2005: Partnering fort the Future. Opening Speech fort he Annual Meeting of the American Seed Trade Association

[153] Alberto Weisser (Bunge Ltd) 2005: Partnering fort the Future. Opening Speech fort he Annual Meeting of the American Seed Trade Association

With the politically motivated re-direction of the energy policy in many countries, ethanol production became a primary target. In North America ethanol production is mainly based on corn, in Europe on cereals and sugar, in Asia on cassava and in Latin America, notably Brazil, on molasses, sugar and corn. The increasing demand for ethanol is driving the demand for such raw materials. Consequently corn and sugar cane production are becoming more competitive and subsequently acreage for these crops is extended. As even in Brazil land reserves are limited, other crops will be substituted, which in the case of North America and Brazil is mostly soy beans. Consequently the amount of soy cake and of globally traded soy cake will decrease and prices will tend up. This trend started in 2005/06 with a reduction of soy acreage in North America and increasing soy and soy cake prices. Brazil announced in January 2007 to construct another 50 ethanol plants based on sugar cane, which will drive the extension of sugar cane and corn acreage and trigger a reduction of soy acreage. China, the first time in recent history became a net importer of soy beans in 2006, after having achieved self-sufficiency in the early 90s. Countries other than North America and Brazil still continue to expand soy acreage, but latest in 2008 will no longer be able to compensate production reductions in Brazil and North America.

Overview 27: Effects of Ethanol Programs on Lysine and other Amino Acid Consumption and Production Costs



As it is not expected that such trends level off soon, long-term increasing soy cake prices can be anticipated. The result will be that lysine becomes more competitive in feed rations and also lysine prices will recover[154]. Parallel the strong demand for sugars and grains for alcohol fermentation limits the availability of such raw materials for other usage such as fermentation. Consequently feed stock prices also for lysine in many key production areas will tend up and further boost lysine prices. Such price trends also apply for China as already now China is not self-sufficient in grains neither in oil cakes. Lysine from China will therefore also follow the global price pattern.

[154] Kyowa and others already announced that latest to mid 2007 prices for lysine across all grades will increase by 10-30%. Supportive to that increase is that BASF has announced to shut down its Korean operation.

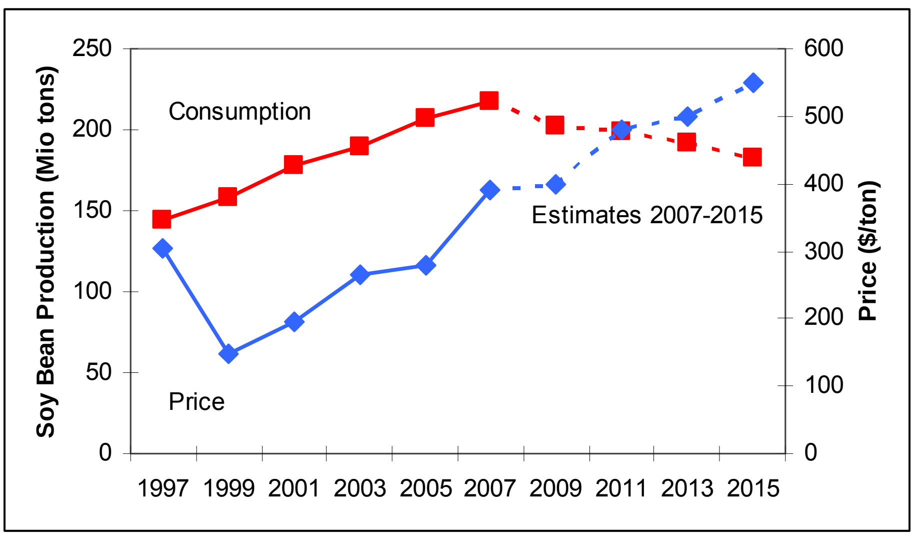
Overview 28: Development of Soy Bean Production through 2015 (Mio tons)[155]

Region	1997	1999	2001	2003	2005	2006	2010	2015
North America	73	72	78	66	83	80	75	60
Brazil	26	31	39	52	51	49	45	40
Argentina	11	20	27	35	38	40	42	42
others	34	35	34	37	35	36	38	40
Total	**144**	**158**	**178**	**190**	**207**	**205**	**200**	**182**

Overview 29: Development of Soy Bean and Cake Price through 2015 ($/ ton)[156]

Product	1995	1997	1999	2001	2003	2005	2006	2010	2015
Soy beans	258	305	148	195	264	278	380	470	> 500
Soy cake	199	283	153	184	213	216	236	301	> 400

Overview 30: Development of Soy Bean Consumption and Price through 2015



Based on this background it is estimated that lysine consumption over the next years will keep the strong growth seen in the past but parallel prices are expected to increase to a level of more than $3/kg.

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[155] Historic data: www.fao.org, extrapolations to 2015: Rabobank 2006: Thoughts for Food. Presentation on the occasion of publishing the Annual Report
[156] Alfred C. Töpfer International, Hamburg

Overview 31: Development of Global Lysine Consumption and Prices through 2015

Parameter	2005	2006	2010	2015	AAGR, %, 2005-2015
Consumption (1.000 tons)	740	800	1.100	1.600	8,0
Price ($/kg)	1,8	1,6	2,5	3,5	6,9

4.5.1.1.5 Specific Demand for Lysine in Egypt and Export Potential

Based on historic developments and considering the economic growth pattern, it is expected that chicken meat consumption in Egypt will continue to grow in future. This will entail an increasing demand for compound feed. As most compounds for poultry feed are imported, the global developments in the soy cake market will have a price increasing effect on compound feed in Egypt, which will be transferred to increasing feeding costs and ultimately to increasing broiler prices for consumers. Already now, broiler feed in Egypt is enriched with lysine. For 2006, imports of lysine are estimated at 2.000-3.000 tons[157]. Prices of lysine to farmers are with $ 3,5/kg[158] high and might reflect substantial trading margins.

One way to buffer upward price trends in soy cakes and ultimately higher consumer prices for broiler is to optimise feed rations by using more lysine, combined with more cereals or other oil cakes lower in protein value. Under such conditions the potential for lysine in Egypt is estimated to be in the range of 4.000 tons per year over the next five years.

A lysine plant with less than 20.000 tons annual production is from an economic point of view not recommended[159]. Therefore also in future Egypt will not be in a position to consume all produced lysine domestically. Regional or international exports are therefore necessary. The direct neighbours have a certain poultry industry, which is smaller than Egypt's. However the EU is already now a net importer of about 80.000 of lysine per year. Imports to the EU will further increase, partly due to an expanding feed industry in Eastern Europe but mainly due to the cease of production of one lysine plant in Italy.

Consequently, the main market for Egypt's lysine will be the EU with which the country already keeps close relationships and intensive trading. In fact within a radius of 5.000 km of Egypt, there are six lysine plants out of which only those in Europe have more than a local importance.

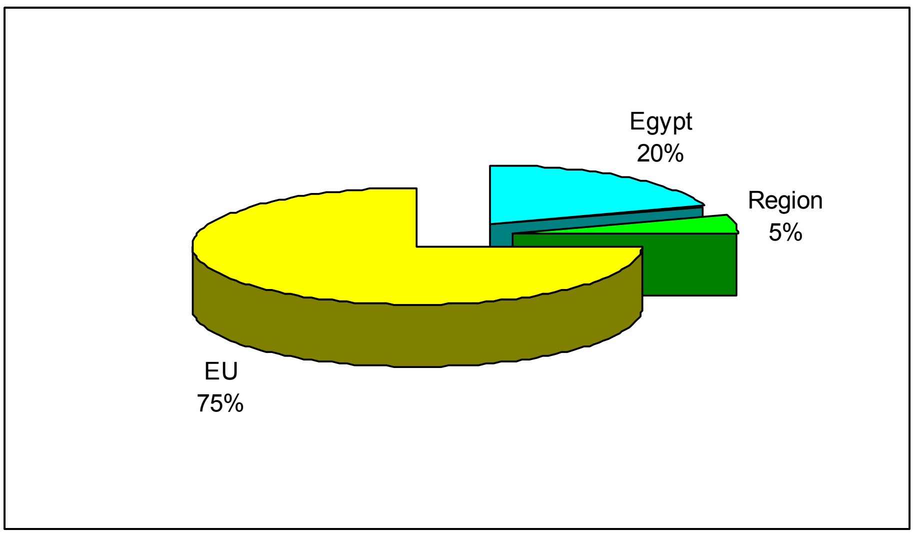
Overview 32: Lysine Plants within 5.000 km Radius from Egypt

Plant	Location	Production	Comment

[157] Estimates by the authors based on typical lysine additions of 2-3 kg/ton for standard broiler rations
[158] Estaimate by the author based on market survey, January 2007
[159] Ajinomoto 2006: personal communication

		(1.000 tons)	
Ajinomoto	Italy	20	Will be closed in 2007
Ajinomoto	France	60	Main supplier for Europe
	Saudi-Arabia	5	Supplies Saudi Arabia and the Golf states
Lizin Charent-savan	Armenia	6	Supplies mostly Iran
Agroferm	Denmark	6	Supplies only Denmark and Nordic countries
Degussa	Slovakia	10	Main supplier for Eastern Europe
Total		**102**	

Overview 33: Possible Regional Sales Structure of Lysine 60 produced in Egypt



4.5.1.2 Production Technology[160]

4.5.1.2.1 Basic Outline and Availability of Technology

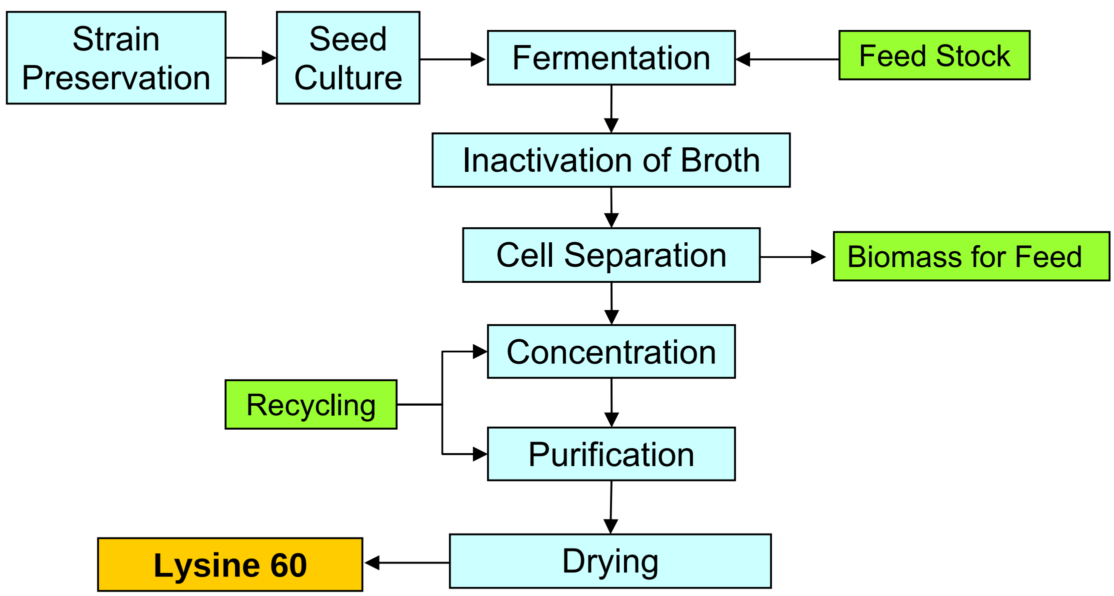
Lysine is a bacterial fermentation based on the micro-organism *Coryne-bacterium glutamicum* and subspecies. The process can be run on glucose, saccharose or molasses, which in the case of Egypt is recommended as molasses is locally available. Historically lysine is supplied as lysine HCL in powder form. Since several years liquid lysine is in the market, which for Egypt is not recommended due to the difficult handling of a liquid product under sub-

[160] In not stated otherwise, data refer to information provided by Ajinomoto and see also chapter 3.2

tropical conditions. The latest development in lysine production technology does no longer crystallise lysine but supply the product as a dried concentrate of lysine broth, containing 60% lysine and 40% fermentation residues. The advantage of this product, *Biolys 60*[161], is that its production is more cost effective due to energy savings in concentration and crystallisation and additionally contains valuable and easily digestible proteins and other micro-nutrients.

The standard lysine process is not patent protected. It can well be that for state-of-the-art plants some minor process steps are patent protected, but there are various companies such as from South Africa, offering complete processes and technical assistance in engineering.

Overview 34: Production Flowchart for Lysine 60



4.5.1.2.2 Resources needed

Mass Balance

Molasses contains about 80% solids and approx. 50% fermentable sugars. Consequently one ton of molasses contains 63% fermentable sugars in the dry substance. Such fermentable sugars can be converted to Lysine 60 at 40% efficiency.

Overview 35: Mass Balance of a Lysine 60 based on Molasses

Parameter	Value

[161] Trademark by Degussa

Dry matter of molasses	80%
Fermentable sugars in molasses	50%
Fermentable sugars in dry matter	63%
Conversion of fermentable sugars to Lysine	40%
Lysine 60 production per ton of molasses	200 kg
Usable by-products (bacterial biomass)	4% (8 kg)

Utilities

Lysine production is energy and water intensive. Based on Ajinomoto's technology one ton of Lysine 60 requires 1.166 kwh energy, mainly in the form of electricity and/or steam, 22 m^3 of water for fermentation[162] and 200 m^3 water for cooling. Water for fermentation has to have a drinking water quality, while water for cooling requires only processed water quality.

Labour

Due to the long history of fermenting lysine, process technology is well elaborated and automatised. The labour requirement is relatively low and per 1.000 tons of lysine only three blue collar and one white collar labour are needed in production plus administration and sales staff. Depending on the degree of computerisation the number of employees can be reduced even further, which is however from a macro-economic point of view neither needed nor recommended. In total and as a first approximation, 10 labour, working in three shifts are needed for a Lysine 60 plant per 1000 tons capacity.

Overview 36: Labour Requirement for a Lysine 60 Plant

Process Step	Category	Number/1.000 tons
Production	Blue collar	3
	White collar	1
Packaging & Logistics	Blue collar	2
Administration	White collar	1
Sales	White collar	1
Auxiliary	Blue collar	2
Total		**10**

4.5.1.2.3 Cost Structure

Investment Costs and Maintenance

There is a considerable economy of scale for investment costs of all fermentation plants. In the case of lysine, a capacity below 20.000 tons is not recommended as in this case capital costs are overly high and below 10.000 tons

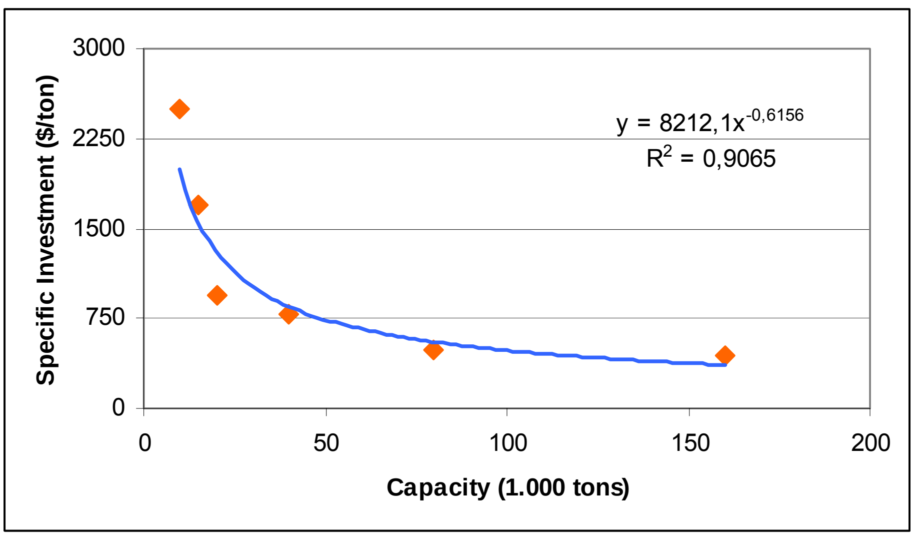
[162] This is the maximum the process needs. Modern plants can recycle up to 70%.

even exceed \$ 2.500/ton of installed capacity, making production uncompetitive. Above 20.000 tons there is still an economy of scale effect. However, that effect progresses in smaller increments than up to 20.000 tons. At the same time the probability for problems and size depending inefficiencies increases.

Therefore a capacity of 20.000 tons is recommended, which shows investments of approx. \$ 950/ton of Lysine 60.

Maintenance costs are relatively small as lysine 60 is not an aggressive chemical as the process operates without HCl. Still annual rehabilitations and repairs are necessary and the globally accepted cost estimate for maintenance is in the range of 0,3% of investments.

Overview 37: Investments Cost for a Lysine 60 Plant as a Function of Capacity.



Raw Material and Utility Costs

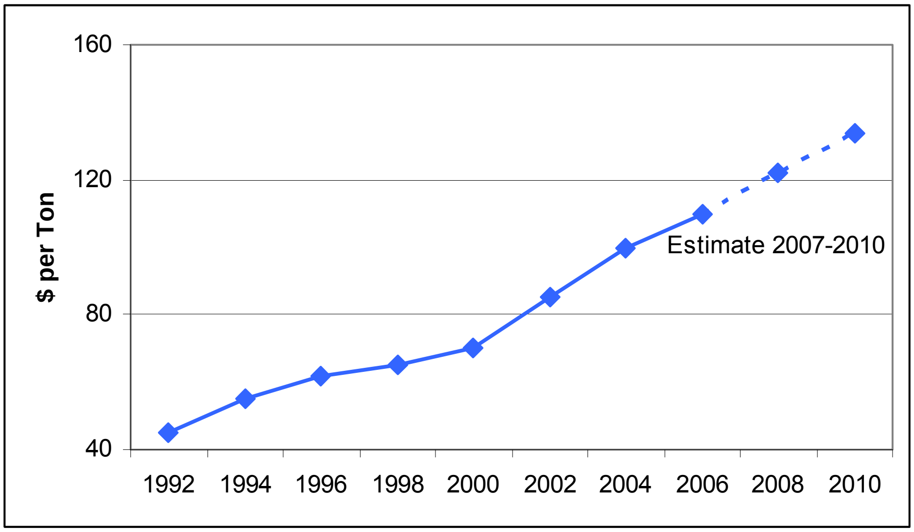
Lysine 60 is running on molasses. There is a need to supplement molasses with ammonia salts, vitamins, phosphoric acid and other micro-nutrients which however only account for less than 1% of the total feed stock costs. The same applies for water. Clean, fermentation-suitable water is not available for free and either must be bought or processed based on Nil-river-water. A detailed water price can only be given when the type of water processing is defined. As a first approximation the standard water price for industrial use of \$ 0,25/m^3 [163] is used.

The main raw material cost results from molasses. Molasses is an international traded product and up to now Egypt exports considerable quantities. Consequently the international molasses price applies also for a fermentation plant in Egypt. Due to the increasing shortage of fermentable carbohydrates on a global

[163] Estimate by the authors. The figure seems to be low and must be verified

scale, molasses prices increased over the last years. Ex factory prices are estimated to be currently in the range of $ 110/ton. There are minor variations of molasses price according to content in fermentable sugars and type (beet molasses usually fetches a higher price). In this case cane molasses price is assumed, as this is the type most available in Egypt.

Overview 38: Development of Global Molasses Prices excl. Transport ($/ton)



1992	1995	1998	2000	2002	2004	2006
45	60	65	70	85	100	110

In summary, total raw material and utility costs for one ton of Lysine 60 are estimated to $ 600, based on prices for 2006.

Overview 39: Total Raw Material Costs for one Ton Lysine 60, 2006

Raw Material	Quantity/ton Lysine 60	Unit price ($/unit)	Total ($/ton Lysine 60)
Molasses	5 tons	110[164]	550
other nutrients	1% of molasses costs		5,5
Drinking water	22 m^3	0,25	5,5
Cooling water	200 m^3	0,025	5,0
Electricity	1.166 kwh	0,035[165]	40,8
Total			**606,8**

Labour and Administration Costs

Overview 40 estimates that about 7 blue collar and 3 white collar staff are needed per 1000 tons installed Lysine 60 capacity. Blue collar staff costs about $ 500/month and white collar staff about $ 1000/month[166]. Consequently per ton of Lysine 60 labour costs in the range of $ 78 arise.

[164] Selling price in 2006 of Sugar and Integrated Industries Company, Cairo
[165] Estimates by the authors for 2006 based on information provides by the Ministry of Energy, Cairo
[166] Estimates by the authors for 2006

Overview 40: Labour Costs per Ton of Lysine 60, 2006

Process Step	Category	Number/ 1.000 tons	Unit cost ($/year)	Costs/year ($)
Production	Blue collar	3	6000	18000
	White collar	1	12000	12000
Packaging & Logis-tics	Blue collar	2	6000	12000
Administration	White collar	1	12000	12000
Sales	White collar	1	12000	12000
Auxiliary	Blue collar	2	6000	12000
Total		**10**		**78000**

Additional administration and sales costs for a commodity product like lysine are estimated to be small and not higher than 0,5% of turnover.

4.5.1.2.4 **Cash flow**

Based on these figures a basic cash flow model over 10 years is established. The calculations show, that at the current price settings, an Internal Rate of Return (IRR) of 33% can be achieved and the payback period is between four and five years. Molasses and lysine prices decide about the economics of a Lysine 60 plant. All other parameters are of very subordinate importance. The overview further shows, that the ratio of Lysine 60 price to molasses prices is 10:1. If that ratio narrows, the economics is strongly affected. At a ratio of below 7:1, the plant becomes uneconomic and will produce consistent losses. Consequently operating a Lysine 60 plant economically largely depends on the successful management of the Lysine 60: molasses price ratio.

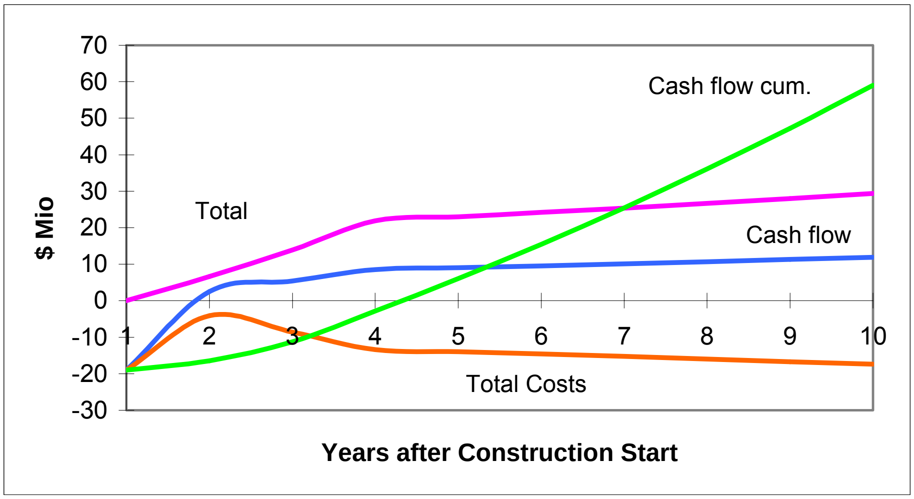
Overview 41: Basic Parameters applied in the Cash flow Model

Parameter	Model value
Lysine 60 price	70% of standard lysine HCL, progressing by 5% per year
Residue value	4% of Lysine 60 production at $ 100/ton, progressing by 2% per year
Investment costs	See overview 37
Molasses and utility costs	See overview 39, and progressing by 5% per year
Labour, other costs	See overviews 40
Start up phase	3 years until full utilisation of production, which is 90% of designed capacity

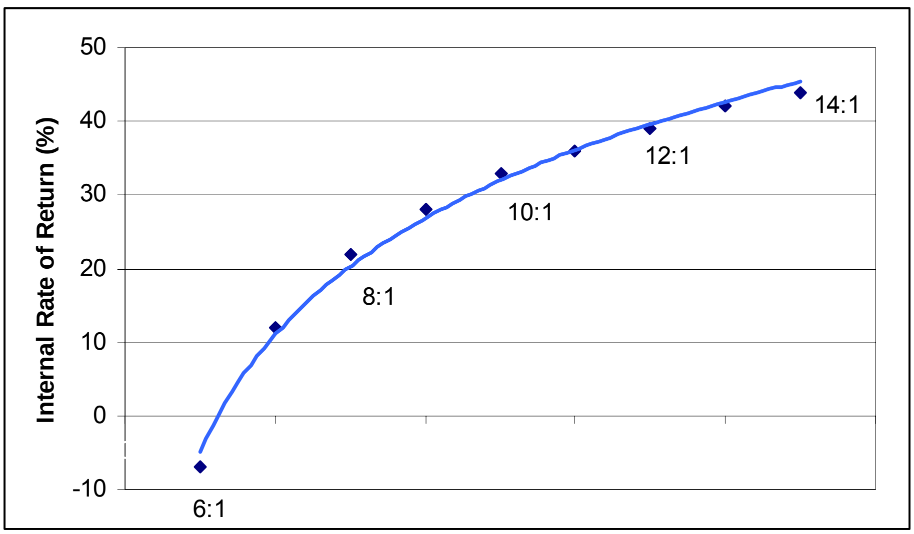
Overview 42: Cash flow Model of a Lysine 60 Plant (20.000 tons)

No	Parameter/Year	1	2	3	4	5	6	7	8	9	10
1	**Turnover Parameter**										
1.1	Production (t)	0	6.000	12.000	18.000	18.000	18.000	18.000	18.000	18.000	18.000
1.2	Selling Price ($/kg)	1,05	1,10	1,16	1,22	1,28	1,34	1,41	1,48	1,55	1,63
1.3	Turnover Lysine 60 ($)	0	6.615.000	13.891.500	21.879.113	22.973.068	24.121.722	25.327.808	26.594.198	27.923.908	29.320.103
1.4	Residue value ($/ton)	100	102	104	106	108	110	113	115	117	120
1.4	Turnover protein residue ($)	0	24.480	49.939	76.407	77.935	79.494	81.084	82.705	84.359	86.047
1.5	Total turnover ($)	0	6.639.480	13.941.439	21.955.519	23.051.003	24.201.215	25.408.891	26.676.903	28.008.267	29.406.150
2	**Cost Parameter**										
2.1	Investment Costs ($)	19.000.000									
2.2	Maintenance Costs ($)		57.000	57.000	57.000	57.000	57.000	57.000	57.000	57.000	57.000
2.3	Raw materials and utilities										
	Molasses quantity (t)		29.760	59.520	89.280	89.280	89.280	89.280	89.280	89.280	89.280
	Molasses price ($/t)		110	116	122	128	134	141	148	155	163
2.3.1	Molasses Costs ($)		3.281.040	6.890.184	10.852.040	11.394.642	11.964.374	12.562.593	13.190.722	13.850.258	14.542.771
2.3.2	Other nutrients ($)		32.810	68.902	108.520	113.946	119.644	125.626	131.907	138.503	145.428
2.3.3	Drinking water costs ($)		33.000	66.000	99.000	99.000	99.000	99.000	99.000	99.000	99.000
2.3.4	Cooling water costs ($)		30.000	60.000	90.000	90.000	90.000	90.000	90.000	90.000	90.000
	Electricity price ($/kwh)		0,035	0,036	0,036	0,037	0,038	0,039	0,039	0,040	0,041
2.3.5	Electricy costs ($)		244.860	499.514	764.257	779.542	795.133	811.036	827.256	843.802	860.678
2.4	Labour										
	Labour number white collar/1000 tons		3	3	3	3	3	3	3	3	3
	Labour number blue collar/1000 tons		7	7	7	7	7	7	7	7	7
	Labour costs blue collar ($/unit/year)		6.000	6.120	6.242	6.367	6.495	6.624	6.757	6.892	7.030
	Labour costs white collar ($/unit/year)		12.000	12.240	12.485	12.734	12.989	13.249	13.514	13.784	14.060
	Total labour costs ($)		468.000	954.720	1.460.722	1.489.936	1.519.735	1.550.129	1.581.132	1.612.755	1.645.010
2.5	Other Costs (Admin & Sales)		33.197	69.707	109.778	115.255	121.006	127.044	133.385	140.041	147.031
2.6	Total costs ($)	19.000.000	4.179.908	8.666.027	13.541.316	14.139.321	14.765.891	15.422.428	16.110.402	16.831.358	17.586.917
3	**Cash flow and IRR**										
3.1	Cash flow ($)	-19.000.000	2.459.572	5.275.412	8.414.203	8.911.682	9.435.324	9.986.463	10.566.501	11.176.909	11.819.233
3.2	Cumulative cash flow ($)	-19.000.000	-16.540.428	-11.265.016	-2.850.813	6.060.869	15.496.193	25.482.656	36.049.157	47.226.066	59.045.299
3.3	IRR	33%									

Overview 43: Cash flow Development for a Lysine 60 Plant (20.000 tons)



Overview 44: Relationship between Internal Rate of Return for a Lysine 60 Plant and the Lysine to Molasses Price Ratio



Lysine to Molasses price ratio	IRR (%)
14:1	44
13:1	42
12:1	39
11:1	36
10:1	33
9:1	28
8:1	22
7:1	12
6:1	-7

4.5.1.2.5 Macroeconomic Considerations

With a high Internal Rate of return, a secured raw material and electricity base and the vicinity of Egypt to Europe, the setting up of a lysine plant seems to be highly attractive, fulfilling most of the set macro-economic criteria, identified to be relevant for biotechnological investments:

Overview 45: Macroeconomic Assessment of a Lysine 60 Plant

Parameter	Appraisal
Support to sustainable GDP growth	Lysine will continue to be highly demanded in future, prices are expected to rise and sustainability of plant with an IRR of more than 30% is given.
Fostering the manufacturing sector	Lysine is basic, although high-tech production. It will contribute to a substantiation of the manufacturing sector and at the same time support the shift from lower valued manufactured to higher valued goods.
Improvements of balance of trade	The net improvement effect on the trade balance is estimated to be in the range of $ 10-15 million per year.
Employment of academic staff and stimulation of applied R&D	The plant employs approx. 180 staff, out of which 50-60 are academics and higher educated technicians.
Usage of low wages	The competitiveness of the plant is also based on the low wages in Egypt. The share of wages in the total costs is less than 10% and in the range of international standard.
High energy efficiency and low energy costs	Due to low energy prices, energy costs are less than 5% of total costs, and thus well below international standards
Usage of locally available raw materials and refrain from imported resources	The plant is based on molasses, one of the few locally available raw materials for fermentation. The molasses prices decides on the economics of the plant and thus must be carefully managed.
Usage of existing biotechnology know-how	Know-how in amino acid fermentation does not exist in Egypt. Thus the development of an own process technology is not recommended.
Technology transfer	Know-how transfer is key to setting up a lysine plant in Egypt. Due to the competitive electricity, labour but especially molasses availability and pricing, investors can successfully be identified and attracted to invest, mainly for exporting lysine to Europe.
Biotechnological cluster effect	Setting up a lysine factory under market conditions can develop to a model case, for demonstrating how high tech biotechnology can successfully be operated under Egyptian conditions. The lysine process is similar to that of MSG, threonine and other amino acids, thus can be seen as a nucleus for setting up a wider amino acid production park.

As basic know-how in amino acid fermentation does currently not exist in Egypt, it is recommended to identify and attract a foreign investor. Such investor can be attracted based on a number of criteria relevant for lysine production, and which are in international comparison in favour of Egypt. Such competitive advantages might presumably outweigh by far some negative criteria, which also prevail in Egypt and might be removed gradually by further Government actions.

Overview 46: International Competitiveness and Attractiveness of a Lysine 60 Plant in Egypt

Positives	Negatives
Reliable and very competitive energy supply	Bureaucratic structures and difficult banking system
Reliable source of molasses	Work ethics suboptimum compared to Europe or South-East Asia[167]
Competitive molasses prices	Academic graduates might not have sufficient basic knowledge and require training before taking over responsible positions in plant
Vicinity to main consumption area (EU) and increasing domestic demand for lysine	
Adequate logistic to Europe and Asia	
Adequate trading regime with membership in WTO	
Remote control[168] of plant (e.g. from France) possible, as Egypt is connected to the relevant satellite system	
Favourable and flexible tax regime	

4.5.1.2.6 Recommendations for Investment Policy

Lysine appears to be a highly attractive investment candidate. As Egypt does not dispose of the basic know-how of lysine production, it is recommended to attract a foreign investor. The candidate of choice might be Ajinomoto. The company is active in Europe since many years, knows the market and operates with two plants there but considers closing its Italian operation as the plant is outdated and operational costs are too high. As Europe is deficient in lysine production, Ajinomoto is looking for an alternative site, which could be Egypt, based on the previously mentioned criteria list. Ajinomoto's main selection criteria for a future lysine site are a reliable supply of energy and molasses, cost competitiveness of molasses and of energy as well as vicinity to major consumption areas and easiness of logistics. These criteria are all in favour of a

[167] See e.g. World Bank 2007: Doing Business, Annual Report

[168] Modern plants are equipped with a control system which allows the centralised monitoring and management of main process parameters. The precondition is that the country, in which the plant is situated, is connected to a specific satellite. This is the case for Egypt and remote control might be carried out in the case needed by Ajinomoto's European headquarter in Paris.

site in Egypt, especially when a location can be identified which is close to a sugar factory and close to a harbour which allows fast and easy access to the Mediterranean Sea.

As Ajinomoto is a Japanese company, supplementary criteria for site selection are safety of the country and low criminality rate, suitability of hierarchical management style and an industry friendly macro-economic policy frame. Also these criteria are largely met in Egypt.

Investment support is appreciated by all companies and Ajinomoto will be no exception. However of higher, presumably decisive importance for Ajinomoto will be the convincing demonstration that a competitive raw material and utility supply can be guaranteed over longer periods of time.

4.5.1.2.7 Log-frame for setting up a Lysine 60 Plant with an annual Capacity of 20.000 Tons

	Intervention Logic	Objectively Verifiable Indicators	Assumptions
Overall Objective	Sustainable growth of Egypt's economy is supported by fostering the industrial sector with investments in manufacturing of higher valued biotechnological products	A set of key macro-economic criteria is positively influenced	Egypt remains politically and socially stable, continues reforming the economy and stays investor friendly
Project Objective	A Lysine 60 plant is set-up and economically operated	A Lysine 60 plant with a production of not less than 18.000 tons per year operates at an IRR of not less than 35% over 10 years	Basic assumptions with respect to availability and pricing of resources as well as to demand and market prices of lysine remain valid over longer periods of time
Result 1	Proposal and concept are approved by relevant ministries and official bodies	Key ministries and governmental institutions consider the setting up of a lysine factory as one of the targets over the next five years	Key ministries find proposal of setting-up a lysine factory attractive and strategically important enough to include it in political frame
Result 2	Suitable investor is identified and attracted	A suitable investor announces an investment into a Lysine 60 plant in Egypt	Identified competitiveness of Egypt as a site for lysine production is appreciated by investor
Result 3:	Pre-feasibility is revised and extended to full techno-economic feasibility study	Technical and economic blue prints for the construction and operation of a Lysine 60 plant are available not later than 2008	Suitable consulting and engineering firm can be hired for carrying out feasibility study and does not come to totally different conclusions as the pre-feasibility study.
Result 4	Plant is constructed within 18 months and successfully started up	The Lysine 60 plant comes on stream not later than 2010 and operates according to business plan	Bureaucracy in Egypt does not restrict advancements in planning, construction and operation of the plant; markets for lysine develop as envisaged

4.5.2 Pre-Feasibility Monosodiumglutamate

4.5.2.1 Global Market Review[169]

Monosodiumglutamate (MSG) is the most widely used flavour enhancer in food and the largest volume amino acid produced by fermentation. The history of MSG goes back to 1908 when glutamic acid was identified and shortly afterward Ajinomoto started its production by fermentation based on molasses. Even now MSG is typically an Asian product although it has found a considerable market in the Western world.

4.5.2.1.1 Development of Consumption

For many years MSG consumption has grown strongly and reached a level of 1,8 Mio tons in 2006. Most of that volume is consumed in Asian countries. Europe and North America are comparable small consumers, while China is one of the largest.

Overview 47: Development of Global MSG Consumption (Mio tons)

1985	1990	1995	2000	2004	2006	AAGR, %, 1985-2006
0,7	0.9	1,1	1,3	1,5	1,8	4,6

Overview 48: MSG Consumption by Region 2006 (Mio tons)

Region	Consumption	% of Total
Europe	0,09	5
North America	0,07	4
Latin America	0,09	5
China	0,5	28
Japan	0,42	23
Rest of Asia	0,59	33
Rest of World	0,04	2
Total	**1,8**	**100**

4.5.2.1.2 Price Developments

The huge quantities of MSG consumed since many decades resulted in traditionally low prices. Since 1995 prices fluctuate in the range of $ 1/kg, depending on the price of raw materials and international currency exchange rates. Historically the lowest price for MSG was seen at the end of the 90s with $ 0,7/kg and

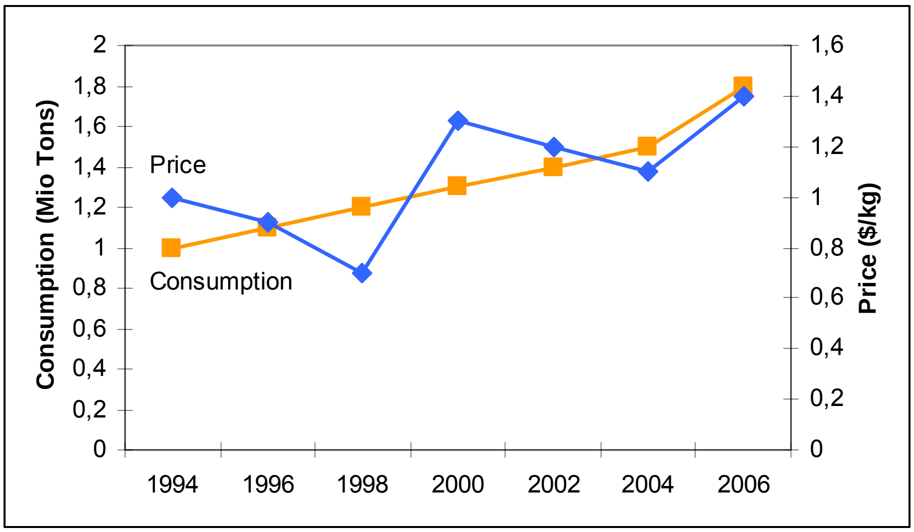
[169] If not stated otherwise, data are taken from: BCC Inc. (Analyst: U. Maerz) 2006: FOD037 – World Market for Starches/Glucose, emphasizing cassava and BCC Inc. (Analyst: U. Maerz) 2005: GA-103R – World Markets for Fermentation Ingredients

shortly after the year 2000 prices went up to $ 1,3/kg. Since 2005, prices tend up again mainly because of an increasing shortage of raw materials and subsequent increase of production costs. In 2006, prices for MSG were in the range of $ 1,4/kg.

Overview 49: Price Development of MSG ($/kg)

1985	1990	1995	1998	2000	2005	2006
1,2	1,1	1,0	0,7	1,3	1,2	1,4

Overview 50: Relationship between MSG Consumption and Price



4.5.2.1.3 **Industry Structure**

Due to the long history of MSG production, its technology is well known and widespread. In order to be competitive, manufacturing takes places in larger plants to profit from economy of scale. The market is dominated by the typical global players in the field of amino acids such as Ajinomoto. In recent years Chinese and other Asian companies have successfully set-up several plants, primarily in China and Vietnam. Due to the geographic characteristics of MSG consumption, most of the production sites are in Asia. Outside Asia, there is only one plant by Ajinomoto in France, another one by ADM in the USA and two plants by Ajinomoto in Latin America.

All MSG plants run at full capacity and the little overcapacity which existed in 2006 is mainly due to the addition of new plants in 2005, which are not yet started up fully.

Overview 51: Market Shares of MSG Producers, 2006

Company	Production, 1.000 tons	Capacity, 1.000 tons	Market Shares (%)
Ajinomoto	520	540	29
Cheil	100	100	5
Deasang	240	240	13
Kyowa	50	50	3
Sewon	60	60	3
Vedan	140	150	8
others	690	720	39
Total	**1.800**	**1.860**	**100**

Overview 52: Regional Breakdown of MSG Production, 2006

Region	Production (1.000 tons)	Share of Total (%)
Europe	65	4
North America	60	3
Latin America	150	8
Asia	1.525	85

4.5.2.1.4 **Global Market Developments through 2015**

MSG is a food additive and its growth is strongly related to the development of population and disposable income. This applies especially for Asian countries. Despite the fact that MSG is in the market since many decades, the income elasticity for MSG in Asia is still positive and higher than for many other food additives.

Overview 53: Income Elasticity for MSG and other Food Additives in Asia[170]

Product	Elasticity Value
Standard food products	0,82
Cassava flour	0,84
Glucose & saccharose	1,22
MSG	1,91
Paper & Textiles	1,55

[170] Fuglie K.O. et. Al. 2005: Root Crops, Starch and Agro-Industrialisation in Asia. In: Proceedings of the International Symposium on Agro-Industrialisation in Asia, Bogor/Indonesia, July 2005

The Asian population is still growing at a rate of 1-2% and income growth is expected to be in the range of 1,7%. As income elasticity is 1,9, demand growth for Asia over the next years is estimated to be in the range of 5%.
In Europe MSG was introduced with Nestlé's Maggi spice blend during the middle of the twentieth century and further promoted with Chinese food and the growing popularity of spicy, ethnic and pre-prepared foods. Recent surveys[171] show that these types of food enjoy high growth and consequently MSG's market development over the next years is estimated to be in the range of 3,5% per year.

In North America the trend to ethnic and pre-prepared food started earlier than in Europe and stronger growth rates in the 90s are cooling off to moderate ones of 3% per year over the next decade.

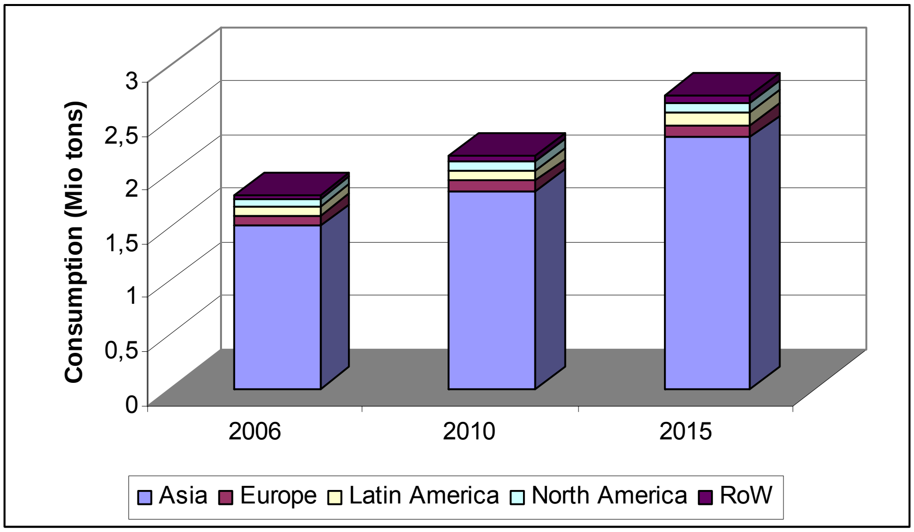
In Latin America growth rates are not much different from the North American ones. Spicy food is traditional in many Latin American countries and MSG together with red chilli sauce is part of almost every diet.

The main underdeveloped parts of the world for MSG are India, Arab countries and Africa. For Arab countries, the main reason is that traditional dishes are spiced with natural herbs and flavours and MSG was never needed to enhance tastiness and palatability. In many African countries diets are based on corn and cassava porridge, both of which have only poor or no taste. However, MSG like many other food ingredients could not be introduced so far on a large extent due to difficult logistical distribution structures. Ajinomoto, operating a distribution centre for MSG in Nigeria tries since many years to increase popularity of MSG but claims that even the low price is too high for many Africans to use it on a regular basis.

Consequently MSG will continue to grow until 2015, mainly in the established markets.

[171] Buisson D., 2006: The Changing Consumer: Trends in Preferences and Taste (www.conferenz-co.nz)

Overview 54: Development of Global MSG Consumption through 2015



Parameter	**2006**	**2010**	**2015**
Europe	0,09	0,10	0,12
North America	0,07	0,08	0,09
Latin America	0,09	0,10	0,12
Asia	1,51	1,83	2,33
RoW	0,04	0,05	0,06
Total	**1,8**	**2,16**	**2,72**

Although prices for MSG fluctuated in the past, a clear price trend up over several decades is not detectable. The industry structure and the large scale usage of it prevented price increases until 2005. This is about to change, not so much because the industry structure will change but more because the main cost item in MSG production, carbohydrates, tends up in price very strongly. Essentially MSG can be produced based on molasses but also from starch, saccharose and glucose. In fact in many Asian countries MSG production is based on cassava starch. However, all of these raw materials are also the basis for ethanol production and consequently the same argumentation as for lysine price trends applies:

- Ethanol programs in Asian countries such as Thailand, Indonesia, China and Pakistan absorb substantial amounts of molasses and of starches, like these programs do in Europe, North America and Brazil.
- Grains and tuber crops rise in price and subsequently also starch, saccharose and glucose.
- These price increases affect all fermentations including MSG.

It can therefore well be that MSG prices increase gradually to $ 1,8-2/kg until 2015.

4.5.2.1.5 Specific Demand for MSG in Egypt and Export Potential

The domestic demand for MSG in Egypt is supposed to be very small. Even the import statistic does not show MSG separately, indicating that the amounts imported do not justify a separate statistic. As already lined out, the main reason is that Egyptian food does not need flavour enhancer and the promotional efforts of MSG companies so far did not succeed.

Gradually this will also change in Egypt with the increasing popularity of fast food and pre-prepared Western and Asian dishes. The small local demand does not justify the setting up of a MSG plant and also the demand in neighbouring countries is considered to be very small.

However, the demand in Europe is with 90.000 tons considerable and production in France is only 65.000 tons. Ajinomoto's distribution centre in Nigeria is supplied with MSG from Asia and has an annual turnover of 20.000 tons. Further there are indications that due to increasing costs of production in France, Ajinomoto considers reducing production there and in this case the potential for MSG exports from Egypt would further increase.

Such export potential, even if it can not be exploited to 100%, can justify a plant with an annual capacity of at least 20.000 tons.

4.5.2.2 Production Technology[172]

4.5.2.2.1 Basic Outline and Availability of Technology

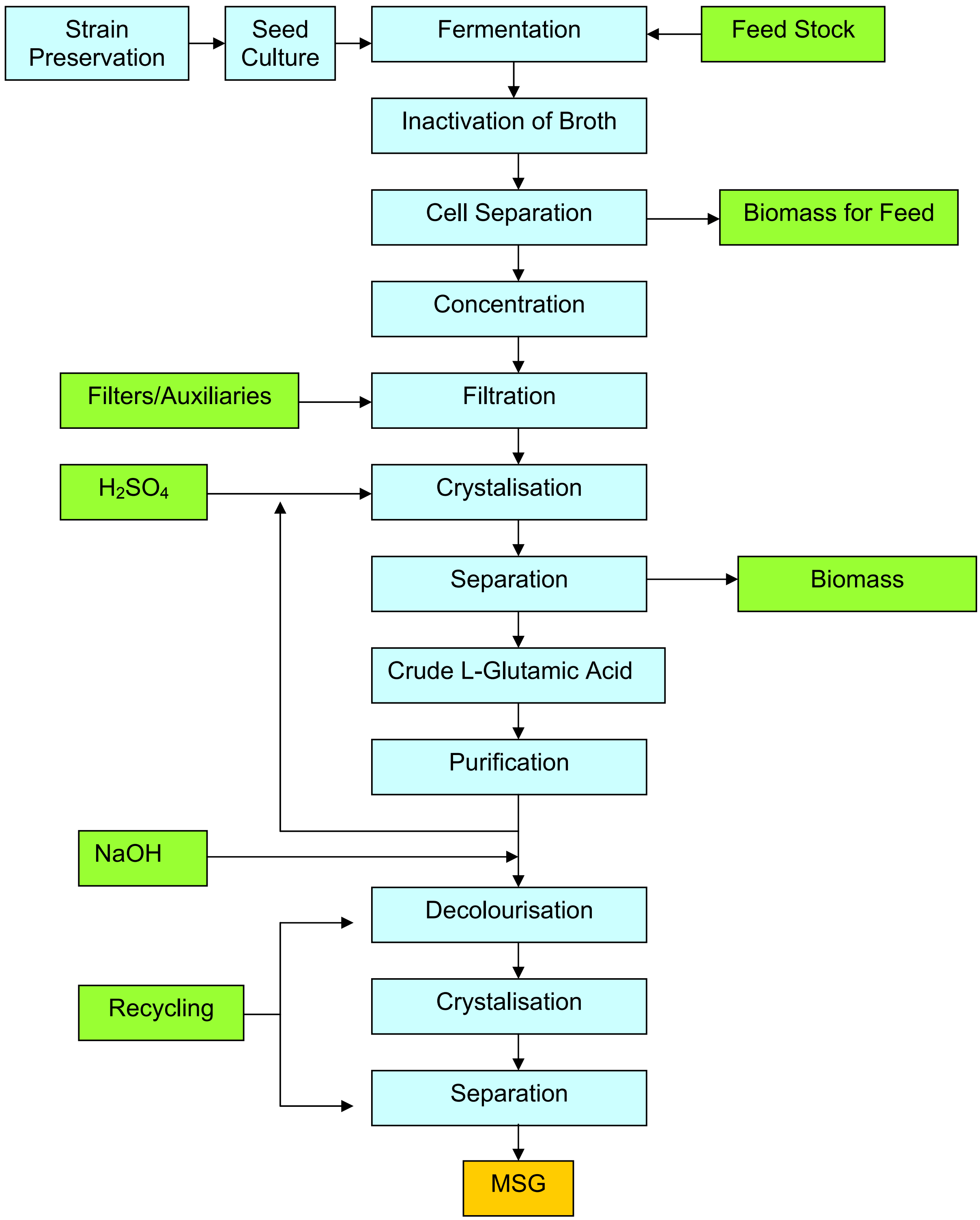
MSG is a bacterial fermentation based on the micro-organism *Corynebacterium glutamicum* and subspecies*.* The process can be run on glucose, starch or molasses, which in the case of Egypt is recommended as molasses is locally available. Historically MSG is supplied in powder form and this has not changed up to now.

MSG production is more complex than that of lysine. Fermentation of molasses yields glutamic acid, which has is separated from the broth and crystallised. In a next step, glutamic acid is reacted with sodium-hydroxide to MSG, which needs to be crystallised again and decolourised. Consequently the process is more energy intensive than lysine's and raw material and utilities are more diverse as several chemicals are required.

The standard MSG process is not patent protected. It can well be that innovative process steps are patent protected, but there are various companies, especially from Asia, offering complete processes and technical assistance in engineering.

[172] If not stated otherwise, data provided is based on information given by Ajinomoto and referring to price and costs basis of 2006

Overview 55: Production Flowchart for MSG



4.5.2.2.2 Resources needed

Mass Balance

Molasses contains about 80% solids and approx. 50% fermentable sugars. Consequently one ton of molasses contains 63% fermentable sugars in the dry substance. Such fermentable sugars can be converted to glutamic acid at up to 64% conversion rate. Glutamic acid is converted to MSG at an efficiency of 100%. Like Lysine 60 fermentation, MSG production results in a sizeable amount of fermentation residues. However, only the cell cream has a high feeding value, as it essentially consists of proteins, cell remnants and some minerals. The main fermentation residue contains all the fibres and insoluble compounds, which remain after removal of the fermentables from molasses. Such product has not a high feeding value. It might be burnt, discarded or converted to bio-energy in a biogas plant. The calorific usage of this residue is not considered further here.

Overview 56: Mass Balance of a MSG Process based on Molasses

Parameter	Value
Dry matter of molasses	80%
Fermentable sugars in molasses	50%
Fermentable sugars in dry matter	63%
Conversion of fermentable sugars to glutamic acid	64%
MSG production per ton of molasses	280 kg
Usable by-products (bacterial biomass)	10% (28 kg)

Utilities

MSG production is energy and water intensive. Based on Ajinomoto's technology one ton of MSG requires 1.620 kwh energy, mainly in the form of electricity and/or steam, 33 m^3 of water for fermentation and 200 m^3 water for cooling. Water for fermentation has to have a drinking water quality, while water for cooling requires only processed water quality.

Labour

Due to the long history of fermenting MSG, process technology is well elaborated and automatised. The labour requirement is relatively low and per 1.000 tons of MSG only seven blue collar and four white collar labour are needed. The high number of technicians and engineers required results from the management of the crystallisation process. Depending on the degree of computerisation the number of employees can be reduced even further, which is however from a macro-economic point of view neither needed nor recommended. In total and as a first approximation, 11 labour, working in three shifts are needed for a MSG plant per 1.000 tons capacity.

Overview 57: Labour Requirement for a MSG Plant

Process Step	Category	Number/1.000 tons
Production	Blue collar	3
	White collar	2
Packaging & Logistics	Blue collar	2
Administration	White collar	1
Sales	White collar	1
Auxiliary	Blue collar	2
Total		**11**

4.5.2.2.3 Cost Structure

Investment Costs and Maintenance

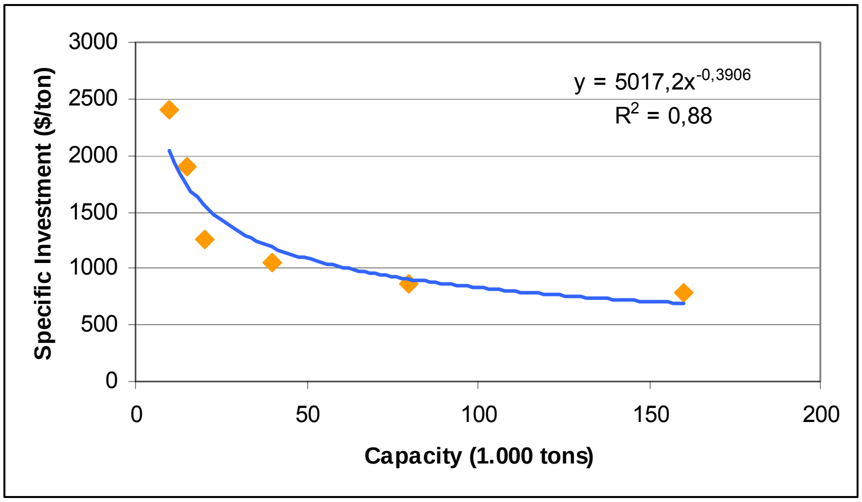
There is a considerable economy of scale for investment costs of all fermentation plants. In the case of MSG, a capacity below 20.000 tons is not recommended as in this case capital costs are overly high and below 10.000 tons even exceed $ 3.000/ton of installed capacity, making production uncompetitive.

Above 20.000 tons there is still an economy of scale effect, although that effect progresses in smaller increments than up to 20.000 tons. At the same time the probability for problems and size depending inefficiencies increases. Nevertheless the standard size of a MSG plant tends to exceed 50.000 tons. With respect to marketing such quantities a compromise is proposed, which builds on a high probability of success for marketing 20.000 tons in Europe, a secured molasses availability but at the same time sacrificing a certain economy of scale.

Therefore a capacity of 20.000 tons is recommended, which shows investments of approx. $ 1.250/ton of MSG. A 50.000 tons plant would require specific investments of about $ 1.000/ton.

Maintenance costs are higher than for lysine. MSG is also not an aggressive chemical but the machinery for filtration, crystallisation and spray-drying is maintenance intensive. Maintenance costs are estimated to be in the range of 0,6% of investments.

Overview 58: Investments Cost for a MSG Plant as a Function of Capacity



Raw Material and Utility Costs

The MSG process is running on molasses. There is a need to supplement molasses with ammonia salts, vitamins, phosphoric acid and other micro-nutrients which account for less than 1% of the total feed stock price. Clean, fermentation-suitable water is not available for free and either must be bought or processed based on Nil-river-water. A detailed water price can only be given when the type of water processing is defined. As a first approximation the standard water price for industrial use of $ 0,25/m^3 applies.

Crystallisation requires acidification with H_2SO_4. Per ton of MSG, 50 kg H_2SO_4 are required, which can be made available at $ 0,26/kg. The reaction of glutamic acid to MSG requires the addition of 236 kg NaOH per ton of glutamic acid. NaOH is supplied in a 50% solution at $ 234/ton[173].

The main raw material cost results from molasses. Molasses is an international traded product and so far Egypt exports considerable quantities. Consequently the same statements as for Lysine 60 apply for MSG.

In summary, total raw material and utility costs for 1 ton of MSG are estimated to be in the range of $ 540 at prices of 2006.

[173] Prices refer to Egypt, March 2007. However, NaOH prices currently tend-up strongly. If that trend substantiates the cost of production calculations have to be reviewed.

Overview 59: Total Raw Material and Utility Costs for one Ton MSG

Raw Material	Quantity/ton MSG	Unit price ($/unit)	Total ($/ton MSG)
Molasses	3,6	110	396
other nutrients	1% of molasses costs		4
Drinking water	33 m^3	0,25	8,2
Cooling water	200 m^3	0,025	5
Electricity	1.620 kwh	0,035	56,7
NaOH (50% solution)	0,236 tons	234	55,2
H_2SO_4	50 kg	0,26	13
Total			**538,1**

Labour and Administration Costs

Overview 57 estimates that about 7 blue collar and 4 white collar staff are needed per 1.000 tons installed MSG capacity. Blue collar staff costs about $ 500/month and white collar staff about $ 1.000/month. Consequently per ton of MSG labour costs in the range of $ 90 arise.

Overview 60: Labour Costs per Ton of MSG

Process Step	Category	Number/ 1.000 tons	Unit cost ($/year)	Costs/ year ($)
Production	Blue collar	3	6.000	18.000
	White collar	2	12.000	24.000
Packaging & Logistics	Blue collar	2	6.000	12.000
Administration	White collar	1	12.000	12.000
Sales	White collar	1	12.000	12.000
Auxiliary	Blue collar	2	6.000	12.000
Total		**10**		**90.000**

4.5.2.2.4 Cash flow

Based on these figures, a cash flow model over 10 years is established. The calculations show, that at the current price settings, an Internal Rate of Return of 46% and a payback period between three and four years can be achieved. Molasses and MSG prices decide about the economics of a MSG plant. However, MSG due to the additional chemical conversion step is more depending on other costs than lysine 60. Molasses costs account to 64% of the total in contrast to lysine 60 for which the value was over 80%. Chemicals account for an additional 11%, electricity for 8% and labour for 13%.

Still the ratio of MSG to molasses prices is decisive. In the basic model the ratio is 13:1. If that ratio narrows, the economics is slightly affected until a ratio of 8:1 and becomes negative below 5:1. Such analysis shows that MSG production is not only more profitable than Lysine 60 but also more stable vis-à-vis fluctuating and unpredictable molasses prices.

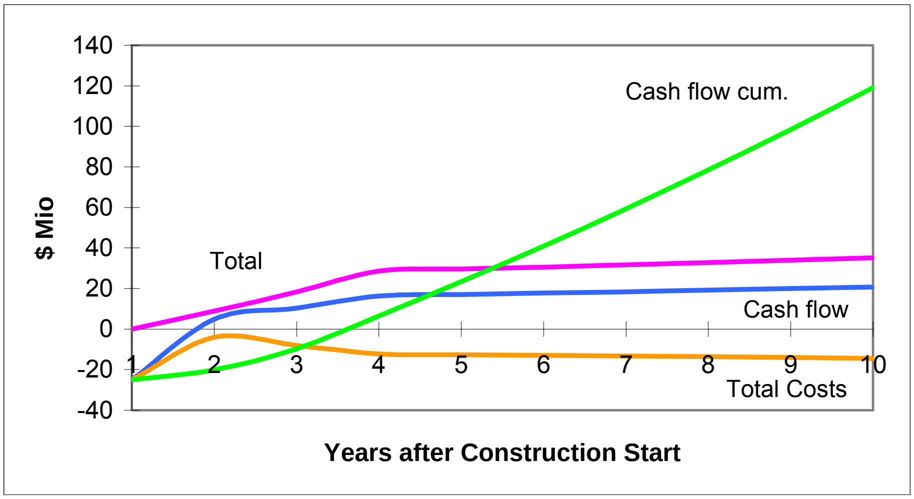
Overview 61: Basic Parameters applied in the Cash flow Model

Parameter	Model Value
MSG price	$ 1,43/kg in base year, progressing by 3,5% per year
Residue value	10% of MSG production at $ 100/ton, progressing by 2% per year
Investment costs	See overview 58
Molasses and utility costs	See overview 59, and progressing by 3% per year
Labour and other costs	See overview 60
Start up phase	3 years until full utilisation of production, which is 90% of designed capacity

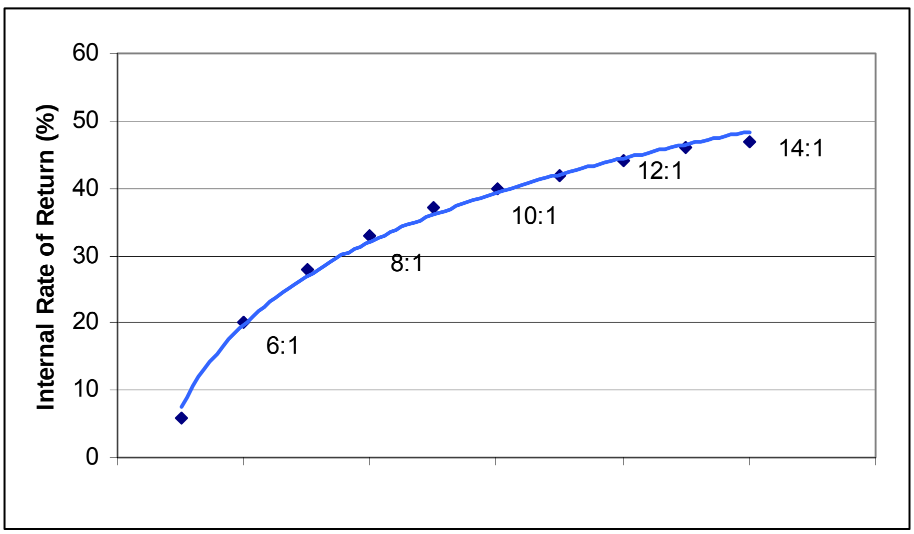
Overview 62: Cash flow Model for a MSG Plant with 20.000 Tons Annual Capacity

Parameter/Year	1	2	3	4	5	6	7	8	9	10
Turnover Parameter										
Production (t)	0	6.000	12.000	18.000	18.000	18.000	18.000	18.000	18.000	18.000
Selling Price ($/kg)	1,43	1,48	1,53	1,59	1,64	1,70	1,76	1,82	1,88	1,95
Turnover MSG ($)	0	8.880.300	18.382.221	28.538.398	29.537.242	30.571.046	31.641.032	32.748.468	33.894.665	35.080.978
Residue Value ($/ton)	100	102	104	106	108	110	113	115	117	120
Turnver protein residue ($)	0	24.480	49.939	76.407	77.935	79.494	81.084	82.705	84.359	86.047
Total turnover ($)	0	8.904.780	18.432.160	28.614.805	29.615.177	30.650.539	31.722.116	32.831.174	33.979.024	35.167.025
Cost Parameter										
Investment Costs ($)	25.000.000									
Maintenance Costs ($)		150.000	150.000	150.000	150.000	150.000	150.000	150.000	150.000	150.000
Raw materials and utilities										
Molasses quantity (t)		21.360	42.720	64.080	64.080	64.080	64.080	64.080	64.080	64.080
Molasses price ($/t)		110	113	117	122	126	130	135	139	144
Molasses Costs ($)		2.341.768	4.847.460	7.525.681	7.789.080	8.061.698	8.343.857	8.635.892	8.938.149	9.250.984
Other nutrients ($)		23.418	48.475	75.257	77.891	80.617	83.439	86.359	89.381	92.510
H2SO4 ($)		78.000	159.120	238.680	243.454	248.323	253.289	258.355	263.522	268.792
NaOH ($)		442.728	885.456	1.328.184	1.328.184	1.328.184	1.328.184	1.328.184	1.328.184	1.328.184
Drinking water costs ($)		49.620	99.240	148.860	148.860	148.860	148.860	148.860	148.860	148.860
Cooling water costs ($)		30.000	60.000	90.000	90.000	90.000	90.000	90.000	90.000	90.000
Electricity price ($/kwh)		0,035	0,036	0,036	0,037	0,038	0,039	0,039	0,040	0,041
Electricy costs ($)		340.200	694.008	1.061.832	1.083.069	1.104.730	1.126.825	1.149.361	1.172.349	1.195.796
Labour										
Labour number white collar/1000 tons		4	4	4	4	4	4	4	4	4
Labour number blue collar/1000 tons		7	7	7	7	7	7	7	7	7
Labour costs blue collar ($/unit/year)		6.000	6.120	6.242	6.367	6.495	6.624	6.757	6.892	7.030
Labour costs white collar ($/unit/year)		12.000	12.240	12.485	12.734	12.989	13.249	13.514	13.784	14.060
Total labour costs ($)		540.000	1.101.600	1.685.448	1.719.157	1.753.540	1.788.611	1.824.383	1.860.871	1.898.088
Other Costs (Admin. & Sales)		17.810	36.864	57.230	59.230	61.301	63.444	65.662	67.958	70.334
Total costs ($)	25.000.000	4.013.543	8.082.223	12.361.172	12.688.925	13.027.253	13.376.509	13.737.057	14.109.274	14.493.548
Cash flow and IRR										
Cash flow ($)	-25.000.000	4.891.237	10.349.938	16.253.633	16.926.252	17.623.286	18.345.607	19.094.117	19.869.751	20.673.477
Cumulative cash flow ($)	-25.000.000	-20.108.763	-9.758.826	6.494.807	23.421.060	41.044.346	59.389.953	78.484.069	98.353.820	119.027.297
IRR	46%									

Overview 63: Cash flow Development for a MSG Plant (20.000 tons)



Overview 64: Relationship between Internal Rate of Return for a MSG Plant (20.000 tons) and the MSG to Molasses Price Ratio



MSG to Molasses price ratio	IRR (%)
14:1	47
13:1	46
12:1	44
11:1	42
10:1	40
9:1	37
8:1	33
7:1	28
6:1	20
5:1	6

4.5.2.2.5 Macroeconomic Considerations

With a high Internal Rate of Return, a secured raw material and electricity base and the vicinity of Egypt to Europe, the setting up of a MSG plant seems to be highly attractive, fulfilling most of the set macro-economic criteria, identified to be relevant for biotechnological investments:

Overview 65: Macroeconomic Assessment of a MSG Plant in Egypt

Parameter	Appraisal
Support to sustainable GDP growth	MSG will continue to be highly demanded in future, prices are expected to rise and sustainability of plant with an IRR of approx. more than 45% given.
Fostering the manu-facturing sector	MSG is basic, although high-tech production. It will contribute to a substantiation of the manufacturing sector and at the same time support the shift from lower to higher valued goods
Improvements of bal-ance of trade	MSG demand in Egypt remains presumably small also in future. The product improves primarily the export values by on average $ 25 Mio/year.
Employment of aca-demic staff and stimu-lation of applied R&D	The plant employs approx. 200 staff, out of which 75 are academics and higher educated technicians
Usage of low wages	The competitiveness of the plant is also based on the low wages in Egypt. The share of wages in total costs is about 13% and comparable to international standard
High energy efficiency and low energy costs	Due to low energy prices, energy costs are about 8% of total costs and well below international standards
Usage of locally avail-able raw materials and refrain from imported resources	The plant is based on molasses, one of the few locally avail-able raw materials for fermentation. The molasses price decides on the economics of the plant. Additionally the plant uses chemicals, which are cost competitively produced by Egypt's petroleum refineries.
Usage of existing bio-technology know-how	Know-how in amino acid fermentation does not exist in Egypt. Thus the development of an own process technology is not recommended.
Technology transfer	Know-how transfer is key to setting up a MSG plant in Egypt. Due to the competitive electricity, labour, chemical and espe-cially molasses availability and pricing, investors can suc-cessfully be identified and attracted, mainly for exporting MSG to Europe.
Cluster effect	Setting up a MSG factory under market conditions can develop to a model case, for demonstrating how high tech biotechnology can successfully be operated under Egyptian conditions. The basic MSG process is similar to that of Lysine but due to the crystallisation step production is more sophisti-cated. Upon controlling, MSG production, other amino acid processes and the manufacturing of other chemicals, which require crystallisation, can profit from the gained know-how.

As basic know-how in amino acid fermentation does currently not exist in Egypt, it is recommended to identify and attract a foreign investor. Such investor can be attracted based on a number of criteria relevant for MSG production, and which are in international comparison in favour of Egypt. Such competitive advantages might presumably outweigh by far some negative criteria, which also prevail in Egypt and might be removed gradually by further Government actions.

Overview 66: International Competitiveness and Attractiveness of a MSG Plant in Egypt

Positives	Negatives
Reliable and very competitive energy supply	Bureaucratic structures and difficult banking system
Reliable source of molasses	Work ethics suboptimum compared to Europe or South-East Asia
Competitive molasses prices	Academic graduates might not have sufficient basic knowledge and require training before taking over responsible positions in plant
Vicinity to main consumption area (EU) and gateway to African markets	
Adequate logistic to Europe and, in the case needed, to Asia	
Adequate trading regime with membership in WTO	
Remote control of plant (e.g. from France) possible, as Egypt is connected to the relevant satellite system	
Favourable and flexible tax regime	

4.5.2.2.6 Recommendations for Investment Policy

MSG appears to be a highly attractive investment candidate. In contrast to lysine a sizeable domestic demand does not exist and is supposed not to develop in future. An MSG plant in Egypt will therefore almost exclusively produce for the international market and consequently has to integrate successfully in the global market settings.

As Egypt does not dispose of the basic know-how of MSG production, it is recommended to attract a foreign investor. The candidate of choice might be Ajinomoto. The company is active in Europe since many years, knows the market and operates one plant in France. Similarly Ajinomoto is the only MSG producer attempting to develop the African markets from its distribution centre in Nigeria. As Europe is deficient in MSG production and the Nigerian site can presumably be easier supplied from Egypt rather than from South-East Asia, Ajinomoto might consider Egypt as a production site supplementary to that in Europe and supportive to the supply of its Nigerian affiliate.

Ajinomoto's main selection criteria for a future MSG site are reliability of energy supply and of molasses, cost competitiveness of molasses and of energy as well as vicinity to major consumption areas and easiness of logistics. These criteria are all in favour of a site in Egypt, especially when a location can be identified which is close to a sugar factory and close to a harbour allowing fast and easy access to the Mediterranean, Red Sea and Indian Ocean.

As Ajinomoto is a Japanese company, supplementary criteria for site selection are: safety of the country and low criminality rate, suitability of hierarchical management style and an industry friendly macro-economic policy frame. Also these criteria are largely met in Egypt.

Investment support is appreciated by all companies and Ajinomoto will be no exception. However of higher, presumably decisive importance for Ajinomoto will be the convincing demonstration that a competitive raw material and utility supply can be guaranteed over longer periods of time.

4.5.2.2.7 Log-frame for setting up a MSG Plant

	Intervention Logic	Objectively Verifiable Indicators	Assumptions
Overall Objective	Sustainable growth of Egypt's economy is supported by fostering the industrial sector with investments in manufacturing of higher valued biotechnological products	A set of key macro-economic criteria is positively influenced	Egypt remains politically and socially stable, continues reforming the economy and stays investor friendly
Project Objective	A MSG plant is set-up and economically operated	A MSG plant with a production of not less than 18.000 tons per year operates at an IRR of not less than 40% over 10 years	Basic assumptions with respect to availability and pricing of resources as well as to demand and market prices of MSG remain valid over longer periods of time
Result 1	Proposal and concept are approved by relevant ministries and official bodies	Key ministries and governmental institutions consider the setting up of a lysine factory as one of the targets over the next five years	Key ministries find proposal for setting-up a MSG factory attractive enough to include it political frame
Result 2	Suitable investor is identified and attracted	A suitable investor announces an investment into a MSG plant in Egypt	Identified competitiveness of Egypt as a site for lysine production is appreciated by investor
Result 3:	Pre-feasibility is revised and extended to full techno-economic feasibility study	Technical and economic blue prints for the construction and operation of a MSG plant are available not later than 2008	Suitable consulting and engineering firm can be hired for carrying out feasibility study and does not come to totally different conclusions as the pre-feasibility study.
Result 4	Plant is constructed within 18 months and successfully started up	The MSG plant comes on stream not later than 2010 and operates according to business plan	Bureaucracy in Egypt does not restrict advancements in planning, construction and operation of the plant; markets for lysine develop as envisaged

4.5.3 Pre-Feasibility Bio-Ethanol

4.5.3.1 Global Market Review[174]

For many years ethanol production denoted the manufacturing of alcohol for chemical applications and of alcoholic beverages for human consumption. Since the late 1990s it denotes mainly the usage as bio-fuel. While Brazil started to produce bio-ethanol based on sugar cane already in the 1980s, no other major industrial country followed that example for the next decade.

With the ratification of the Kyoto Protocol and the increasing awareness on CO_2 production and its effects, the discussion on alternatives to petroleum started. The main impetus however came in 2004 when the American president announced an initiative to build 400 ethanol plants in North America, to become less dependent on petroleum imports, to diversify energy resources and to contribute to the initiatives of controlling global warming. The Europeans followed shortly after with a similar directive, which demands the addition of bio-ethanol to fuel of 2% in 2005 and 5,75% in 2010. Asian countries such as China, Thailand, Indonesia and Pakistan also started ethanol programs for similar reasons.

The consequence of all these programs is that currently every two weeks a new ethanol plant is started up adding a capacity of 30-40.000 tons.

Historically, global bio-ethanol production for a long time was in the range of 5-6 Mio tons per year, strongly dominated by Brazil. In 2000, production jumped to 20 Mio tons and in 2006 exceeded 39 Mio tons.

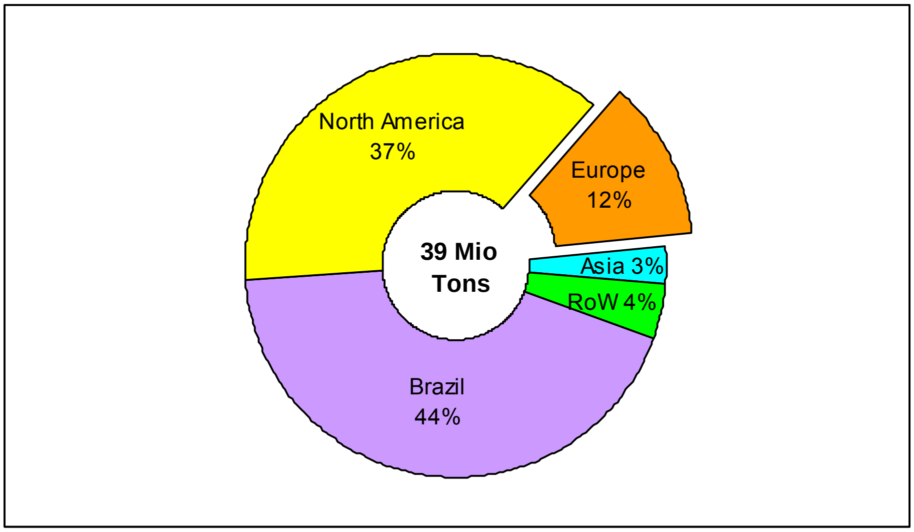
4.5.3.1.1 Development of Consumption

Overview 67: Development of Bio-Ethanol Consumption (Mio tons)

1980s	1995	2000	2004	2005	2006	AAGR, %, 1995-2006
6	18	20	32	37	39	7,3

[174] If not stated otherwise, data are taken from: BCC Inc. (Analyst: U. Maerz) 2006: FOD037 – World Market for Starches/Glucose, emphasizing Cassava, Südzucker 2006: Bioethanol Produktion heute und morgen, Seminar given at the University of Braunschweig and Rabobank 2005: Thought for Food.

Overview 68: Bio-Ethanol Consumption by Region, 2006 (Mio tons)



Region	Consumption	% of Total
Brazil	16,7	43
North America	14,3	37
Europe	4,5	12
Asia	1,4	3
RoW	2,1	4
Total	**39,0**	**100**

Bio-ethanol can be produced from a variety of crops as long as these crops contain fermentable sugars or starches. On a global scale four types of raw materials play a major role: corn, wheat, sugar cane and molasses and cassava. The Brazilian program is still based on sugar cane and molasses, the American on corn, the European on wheat and other non-corn cereals and Asian countries ferment bio-ethanol based on cassava.

Overview 69: Raw Materials used for Bio-Ethanol Production by Region, 2006 (% of Total)

Region	Corn	Wheat/ non-corn cereals	Sugar Cane/ Molasses	Cassava
Brazil	2	0	98	0
North America	78	20	2	0
EU	10	70	20	0
Asia	10	2	15	73
RoW	5	0	33	62

The consequence of such usage structure is that in total about 100 Mio tons of starch and sugar containing crops are used in 2006 for ethanol production.

Conversion rates are different and the highest ones are obtained from corn and wheat, while molasses as well as cassava show conversion rates of 4:1 to 6:1.

4.5.3.1.2 Price Developments

Traditionally the bulk of the ethanol in the market is produced from petroleum cracking. Ethanol's price therefore was closely correlated to petroleum price, which until recently was low and in many years not higher than $ 15-30/barrel. That situation prevailed until the mid 90s and ethanol's price was in the range of $ 0,3/l. Since the year 2000 ethanol prices increased continuously from $ 0,45/l to $ 0,9/l in 2006[175].

4.5.3.1.3 Industry Structure

In contrast to many other chemical products, the bio-ethanol industry is not concentrated. In 2006 there were more than 1.000 bio-ethanol plants operating in various countries. Due to the pricing of ethanol, transport and logistic costs play a major role. In order to keep transport and logistic costs low, ethanol factories are mainly set-up in grain and sugar belts. Consequently bio-ethanol factories are also operated mainly by grain processing and sugar refining companies, having traditionally good access to such raw materials.

4.5.3.1.4 Global Market Developments through 2015

Ethanol production is not only driven by governmental regulations on CO_2 reduction and on decreasing dependency on petroleum imports, but also by increasing petroleum and fuel prices. There is no reason to assume that in the next years the average price for petroleum falls consistently below $ 60/barrel.

Both together will drive ethanol consumption very strongly over the next years and RABO Bank[176] estimates the demand in 2015 to almost 90 Mio tons[177]. At that time North America will be the largest consumption area, followed by Brazil and Europe. Asia like other parts of the world will, at that time, be relatively small consumers, mostly because the raw materials to produce ethanol will not be available to the extent needed for these countries.

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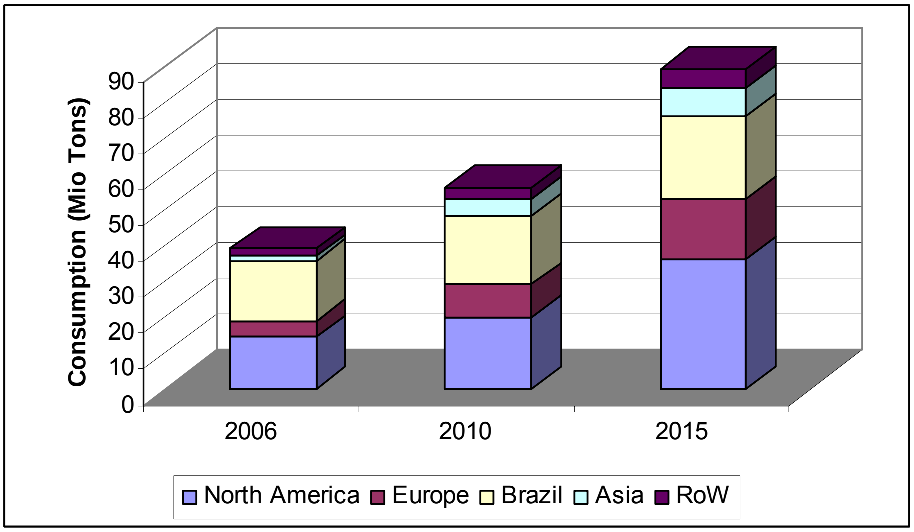
[175] Note: 1 l of ethanol is equal to 0,75 kg!
[176] RABO Bank 2005: Thought for Food
[177] Other estimates such as by WTO see the demand in the range of 250 Mio tons.

Overview 70: Development of Bio-Ethanol Consumption through 2015

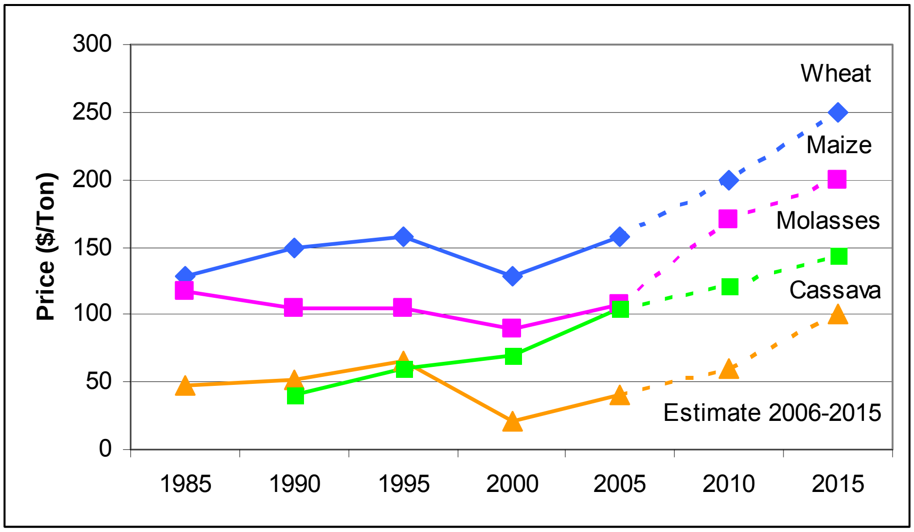


Region	2006	2010	2015	AAGR, %, 2006-2015
North America	14,3	20	36	10,8
Europe	4,5	9	17	15,9
Brazil	16,7	19	23	3,6
Asia	1,4	5	8	21,4
RoW	2,1	3	5	10,1
Total	**39,0**	**56**	**89**	**9,6**

Such increasing demand will strongly affect the markets of the raw materials used. North America has announced to continue using its corn and sacrificing exports, the Europeans set-up plans to increase acreage of cereals and of sugar beets, Brazil will expand its sugar cane area but increasingly switch to corn and Asian countries will still continue to use cassava supplemented by sweet potato. On an international scale, 9% of the global wheat harvest, 13% of the global corn harvest and 18% of the global cassava and sweet potato harvest will be used for bio-ethanol production in 2015. Molasses according to the set-up conversion plans for ethanol will not be sufficiently available in 2015 and consequently there is a strong likelihood that in addition to molasses, saccharose will be used.

Such strong demand over all starch and sugar crops will presumably have a dramatic effect on prices. The wheat price from 2005 to 2006 jumped by 14%, the corn price by 39%, the cassava price by 34% and molasses by 20%. There is no model available which reliably predicts cereal, tuber crop and molasses prices until 2015 but it is not excluded that wheat price exceed $ 250/ton, corn $ 200/ton and cassava $ 100/ton in 2015.

Overview 71: Development of Raw Material Prices for Bio-Ethanol[178]



Raw Material	1985	1990	1995	2000	2005	2006	2010	2015
Wheat	128	150	157	129	158	180	200	250
Corn	117	105	104	90	108	150	170	200
Cassava	47	-	65	21	41	59	60	100
Molasses	-	40	60	70	105	110	122	144

Such price development will have a strong effect on ethanol prices, as ethanol production costs are to a large extent depending on raw material prices. There is no doubt that ethanol prices will increase in future but the possibly dampening effect of increasing raw material prices on ethanol consumption is difficult to estimate. An ethanol price of $ 1,5-2/l in 2015 is very likely.

4.5.3.1.5 Specific Demand for Bio-Ethanol in Egypt and Export Potential

Egypt is already producing ethanol, currently in the range of 50.000 tons[179], out of which the bulk is exported to the EU. Local consumption so far is confined to chemical applications and the usage as additive to fuel does not yet exist.

However, as shown in Chapter 2.2.4, crude oil reserves of Egypt will be exploited within the next years and the energy sector in Egypt will consequently strongly change. It is not only that exports of petroleum and petroleum products will cease, Egypt will also become a strong importer of petroleum and of derivatives thereof. Currently 75% of Egypt's domestic consumption in petroleum is converted into fuels. Egypt must have an interest to diversify fuel provision and to keep future dependency from petroleum imports as low as possible. Consequently and although the current bio-ethanol production is strongly export oriented, it might in future be more focused on supplying the domestic market. Similar to the European program, Egypt might consider adding ethanol to fuel.

[178] Töpfer Internationl 2006: Market Outlook
[179] Sugar and Integrated Industries Comapany, Cairo

Petroleum products are highly subsidised by the government to keep fuel prices at the gas station low. One litre of fuel sells at $ 0,3, which presumably is below production costs. Egypt, already in the past, made several attempts to increase energy costs, to increase its efficient use and to lower the subsidy burden. It is expected that Egypt will continue these efforts, gradually increasing local fuel prices to international standards.

It is obvious that at the current consumer price of $ 0,3/l fuel, ethanol can not be produced. But the question might not be only, whether ethanol production is competitive in the international context but more to what extent government subsidies can be reduced with the addition of ethanol to standard fuel[180].

4.5.3.2 Production Technology: Molasses Based

4.5.3.2.1 Basic Outline and Availability of Technology

Ethanol production is based on yeast fermentation. Ethanol is toxic for yeasts in higher concentrations and the maximum level tolerated in the broth is 12%. In order to obtain concentrations suitable as fuel (99%), the diluted ethanol must be distilled and dewatered. The final step is the denaturation of the concentrated alcohol with chemicals to avoid human consumption.

When grains are used as raw material for fermentation valuable by-products, *distiller's grain*, are obtained in addition to ethanol. Such by-products mainly consist of protein and are suitable for animal feeding. Over the past 10 years the average price of the distiller's grain was in the range of $ 100/ton and had a decisive influence on the economics of ethanol plants. In the case of molasses fermentation, which is proposed as one option for Egypt, such by-product can not be obtained as molasses residues are not rich in protein or easily digestible for animals. By-products from molasses can be discarded, burned or converted to biogas. In the following the further use of by-products is not considered but might be an additional option to improve the profitability of the plant and to comply with environmental regulations.

The basic technological challenge for ethanol production is moderate. However, operating a plant at highest economic efficiency is a challenge as it requires the optimisation of various process steps notably fermentation and distillation. In alcohol fermentation it is not only the conversion rate of sugars which counts but especially the energy efficiency in distillation to highest concentrated ethanol. Due to the widespread experience in ethanol manufacturing, state-of-the-art engineering know-how is widely available also in Egypt[181].

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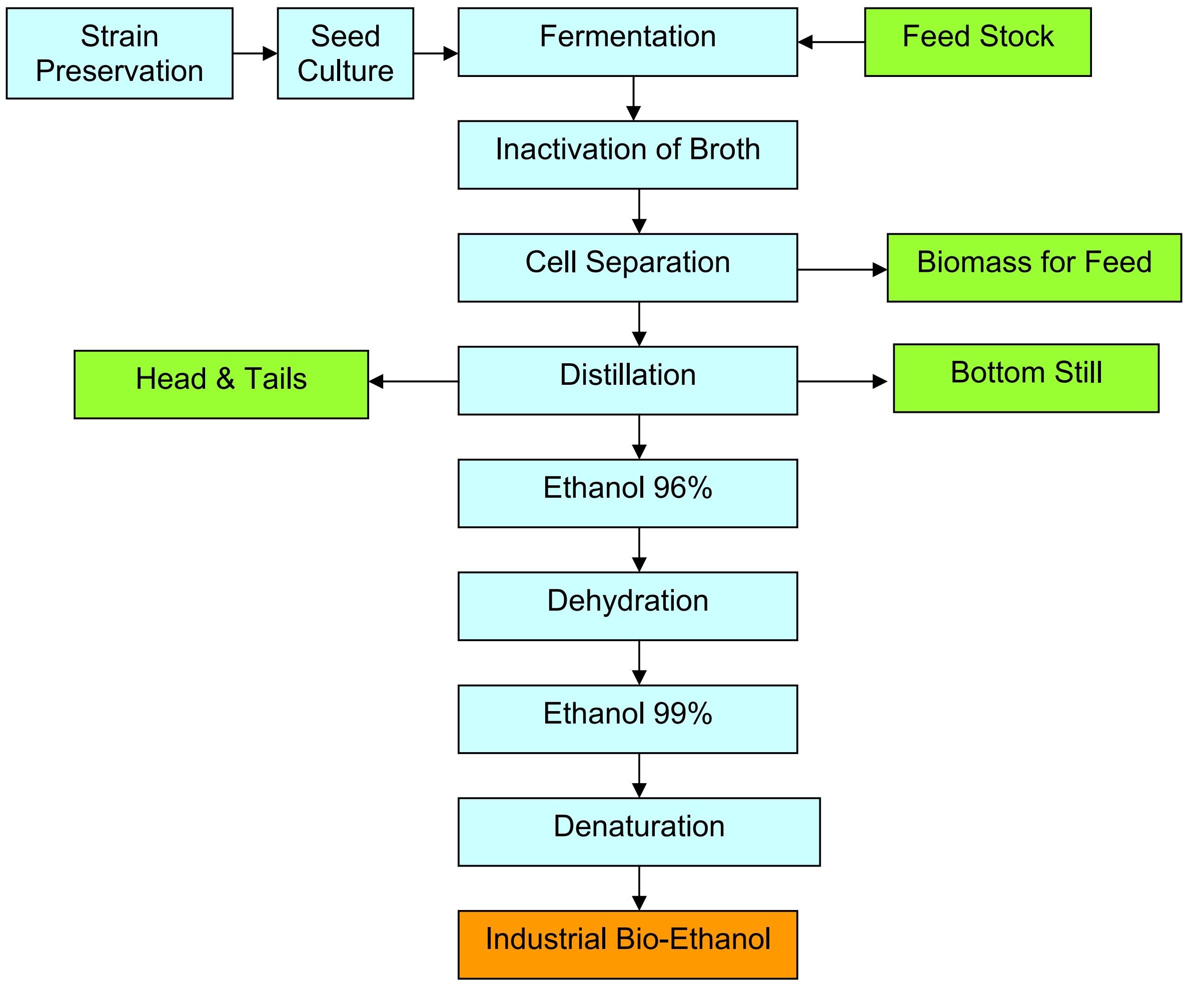
[180] Current subsidies for energy amount to $ 1-2 billion. It is however not known to what extent fuel prices are supported.

[181] It has to be verified whether the available know-how also comprises the technology for bio-ethanol suitable as fuel.

Overview 72: Production Flowchart for Bio-Ethanol



4.5.3.2.2 Resources needed

Mass Balance

Molasses contains about 80% solids and approx. 50% fermentable sugars. Consequently one ton of molasses contains 63% fermentable sugars in the dry substance. Such fermentable sugars can be converted to ethanol at 49% efficiency. Per ton of molasses 240 kg of ethanol can be obtained. As already mentioned by-products can not be used to a large extent for feeding with the exception of the yeast cream.

Overview 73: Mass Balance of Bio-Ethanol based on Molasses

Parameter	Value
Dry matter of molasses	80%
Fermentable sugars in molasses	49%
Fermentable sugars in dry matter	63%
Ethanol production per ton of molasses	240 kg
Usable by-products (bacterial biomass)	2% (4,8 kg)

Utilities

Ethanol production is energy intensive due to distillation. Based on Südzucker's technology one ton of ethanol requires 5.644 kwh energy, mainly in the form of electricity and steam. However, modern plants can save up to 70% of such energy requirement due to process optimisation and steam recycling. As a first approximation, it is assumed, that 30% energy can be saved and the energy demand is reduced to 3.951 kwh. Water requirement is relatively modest with 15 m^3 of water for fermentation and 200 m^3 for cooling. Water for fermentation has to have a drinking water quality, while water for cooling requires only processed water quality.

Labour

Due to the long history of ethanol production, process technology is well elaborated and automatised. The labour requirement is low and per 1.000 tons of ethanol only four blue collar and three white collar labour are needed. The high number of technicians and engineers required results from the management of the distillation process. Depending on the degree of computerisation the number of employees can be reduced even further, which is however from a macro-economic point of view neither needed nor recommended. In total and as a first approximation, 7 labour, working in three shifts are needed for a ethanol plant per 1.000 tons capacity.

Overview 74: Labour Requirement for an Bio-Ethanol Plant

Process Step	Category	Number/1.000 tons
Production	Blue collar	2
	White collar	2
Packaging & Logistics	Blue collar	1
Administration	White collar	0,5
Sales	White collar	0,5
Auxiliary	Blue collar	1
Total		**7**

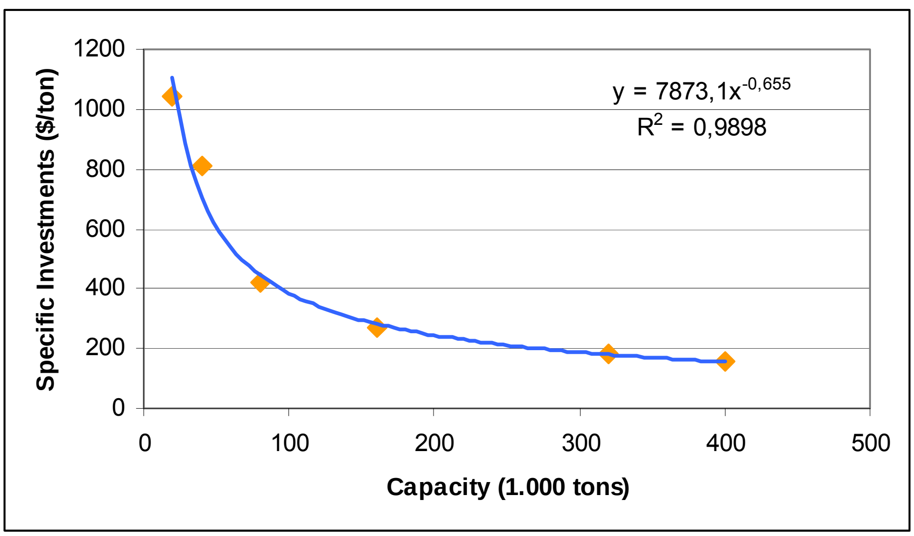
4.5.3.2.3 Cost Structure

Investment Costs and Maintenance

There is a considerable economy of scale for investment costs of all fermentation plants. But in the case of bio-ethanol, the economy of scale is more drastic than for others. Small plants with a capacity of 20.000 tons or less show specific investments cost of more than \$ 1.000/ton, while for a plant with 300.000 tons the capital investment is reduced to \$ 180/ton. Plants with such a high capacity are in contrast to other fermentations of equivalent size not much more prone to inefficiencies or technological problems and the global trend is clearly to construct plants exceeding 100.000 tons.

However, as the conversion rate form molasses to ethanol is more than 4:1, such a plant requires more than 400.000 tons of molasses which in the case of Egypt is not available. The maximum amount of molasses available for ethanol production is estimated to be in the range of 100.000-150.000 tons and consequently ethanol factories with a capacity of between 20.000-40.000 tons can be considered.

Overview 75: Investments Cost for a Bio-Ethanol Plant as a Function of Capacity



Maintenance costs are higher than for lysine and equal to a MSG plant. The relatively high maintenance costs of 0,6% of investment result from the distillation facilities and not so much from the basic fermentation machinery.

Raw Material and Utility Costs

When operating a bio-ethanol on molasses, there is a need to supplement the broth with ammonia salts, vitamins, phosphoric acid and other micro-nutrients which account for less than 1% of the total feed stock price. Clean, fermentation-suitable water is not available for free and either must be bought or processed based on Nil-river-water. A detailed water price can only be given when the type of water processing is defined. As a first approximation the standard water price for industrial use of $ 0,25/m^3 is used.

For distillation no further chemicals or additives are needed. For denaturation approved additives can be used in amounts of up to 1% entailing costs of a maximum of $ 13 per ton of ethanol.

In summary, total raw material and utility costs to produce 1 ton of ethanol are estimated to be in the range of $ 630 for 2006. Such variable production costs are comparable to production costs of $ 600/ton for bio-ethanol plants in North America.[182]

Overview 76: Total Raw Material Costs for one Ton Bio-Ethanol

Raw Material	Quantity/ton bio-ethanol	Unit price ($/unit)	Total ($/ton bio-ethanol)
Molasses	4,2	110	462
other nutrients	1% of molasses costs		4,6
Yeast	$ 0,01/l ethanol		13,5
Drinking water	15 m^3	0,25	3,8
Cooling water	200 m^3	0,025	5
Electricity	3.951 kwh	0,035	138,3
Denaturant[183]	10 kg	1,3	13
Total			**640,3**

Labour and Administration Costs

Overview estimates that about 4 blue collar and 3 white collar staff are needed per 1.000 tons installed ethanol capacity. Blue collar staff costs about $ 500/month and white collar staff about $ 1.000/month. Consequently per ton of bio-ethanol labour costs in the range of $ 60/ton arise.

[182] USDA 2002: Ethanol cost of production survey. In this survey the average ethanol cash costs excluding labour and maintenance are estimated at $ 0,60/kg, data updated to 2006 costs by the author.
[183] Di-ethyl-phthalate or simply gasoline.

Overview 77: Labour Costs per Ton of Bio-Ethanol

Process Step	Category	Number/ 1.000 tons	Unit cost ($/year)	Costs/ year ($)
Production	Blue collar	2	6.000	12.000
	White collar	2	12.000	24.000
Packaging & Logistics	Blue collar	1	6.000	6.000
Administration	White collar	0,5	12.000	6.000
Sales	White collar	0,5	12.000	6.000
Auxiliary	Blue collar	1	6.000	6.000
Total		**7**		**60.000**

Administration, marketing and sales costs are presumably small and not higher than 0,3% of turnover.

4.5.3.2.4 Cash flow

Based on these figures a cash flow model over 10 years is established. The calculations show, that at the current price settings and a 20.000 tons plant, an internal rate of return of 32% and a payback period of four to five years can be achieved.

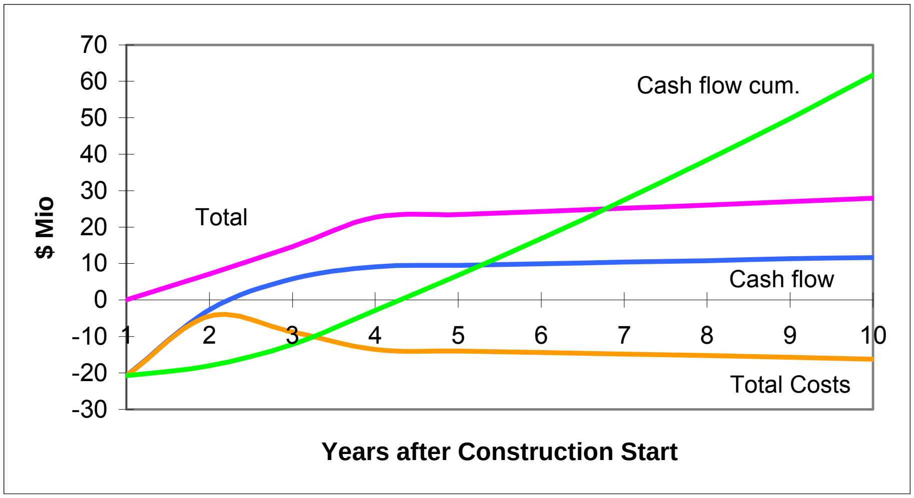
Overview 78: Basic Parameters applied in the Cash flow Model

Parameter	Model value
Ethanol price	$ 0,9/l in base year, progressing by 3% per year
Residue value	2% of ethanol production at $ 100/ton, progressing by 2% per year
Investment costs	See overview 75
Molasses and utility costs	See overview 76, and progressing by 3% per year
Labour and other costs	See overview 77
Start up phase	3 years until full utilisation of production, which is 90% of designed capacity

Overview 79: Cash flow Model for a Bio-ethanol Plant based on Molasses with 20.000 Tons Annual Capacity

No	Parameter/Year	1	2	3	4	5	6	7	8	9	10
1	**Turnover Parameter**										
1.1	Production (t)	0	6.060	12.120	18.180	18.180	18.180	18.180	18.180	18.180	18.180
1.2	Selling Price ($/kg)	1,13	1,16	1,21	1,25	1,29	1,34	1,38	1,43	1,48	1,53
1.3	Turnover EOH ($)	0	7.056.113	14.606.153	22.676.052	23.469.714	24.291.154	25.141.345	26.021.292	26.932.037	27.874.658
	Residue Value ($/ton)	100	102	104	106	108	110	113	115	117	120
	Turnver protein residue ($)	0	12.362	25.219	38.586	39.357	40.144	40.947	41.766	42.602	43.454
	Total turnover ($)	0	7.068.475	14.631.372	22.714.638	23.509.071	24.331.299	25.182.292	26.063.058	26.974.638	27.918.112
2	**Cost Parameter**										
2.1	Investment Costs ($)	20.800.000									
2.2	Maintenance Costs ($)		124.800	124.800	124.800	124.800	124.800	124.800	124.800	124.800	124.800
2.3	Raw materials and utilities										
	Molasses quantity (t)		25.452	50.904	76.356	76.356	76.356	76.356	76.356	76.356	76.356
	Molasses price ($/t)		110	114	118	122	127	131	136	140	145
2.3.1	Molasses Costs ($)		2.809.068	5.814.772	9.027.433	9.343.393	9.670.412	10.008.877	10.359.187	10.721.759	11.097.020
2.3.2	Other nutrients ($)		28.091	58.148	90.274	93.434	96.704	100.089	103.592	107.218	110.970
2.3.3	Denaturant (1%, $ 1,3/kg)		78.780	157.560	236.340	236.340	236.340	236.340	236.340	236.340	236.340
2.3.4	Drinking water costs ($)		22.422	44.844	67.266	67.266	67.266	67.266	67.266	67.266	67.266
2.3.5	Cooling water costs ($)		22.725	45.450	68.175	68.175	68.175	68.175	68.175	68.175	68.175
	Electricity price ($/kwh)		0,035	0,036	0,036	0,037	0,038	0,039	0,039	0,040	0,041
2.3.6	Electricy costs ($)		837.965	1.709.448	2.615.455	2.667.764	2.721.120	2.775.542	2.831.053	2.887.674	2.945.428
2.4	Labour										
	Labour number white collar/1000 tons		3	3	3	3	3	3	3	3	3
	Labour number blue collar/1000 tons		4	4	4	4	4	4	4	4	4
	Labour costs blue collar ($/unit/year)		6.000	6.120	6.242	6.367	6.495	6.624	6.757	6.892	7.030
	Labour costs white collar ($/unit/year)		12.000	12.240	12.485	12.734	12.989	13.249	13.514	13.784	14.060
	Total labour costs ($)		363.600	741.744	1.134.868	1.157.566	1.180.717	1.204.331	1.228.418	1.252.986	1.278.046
2.5	Other Costs (Admin & Sales)		21.205	43.894	68.144	70.527	72.994	75.547	78.189	80.924	83.754
2.6	Total costs ($)	20.800.000	4.308.656	8.740.660	13.432.756	13.829.266	14.238.528	14.660.967	15.097.020	15.547.142	16.011.799
3	**Cash flow and IRR**										
3.1	Cash flow ($)	-20.800.000	2.759.819	5.890.713	9.281.882	9.679.806	10.092.771	10.521.325	10.966.038	11.427.497	11.906.312
3.2	Cumulative cash flow ($)	-20.800.000	-18.040.181	-12.149.469	-2.867.587	6.812.219	16.904.990	27.426.315	38.392.352	49.819.849	61.726.161
3.3	IRR	32%									

Overview 80: Cash flow Development for a Bio-Ethanol Plant based on Molasses (20.000 tons)

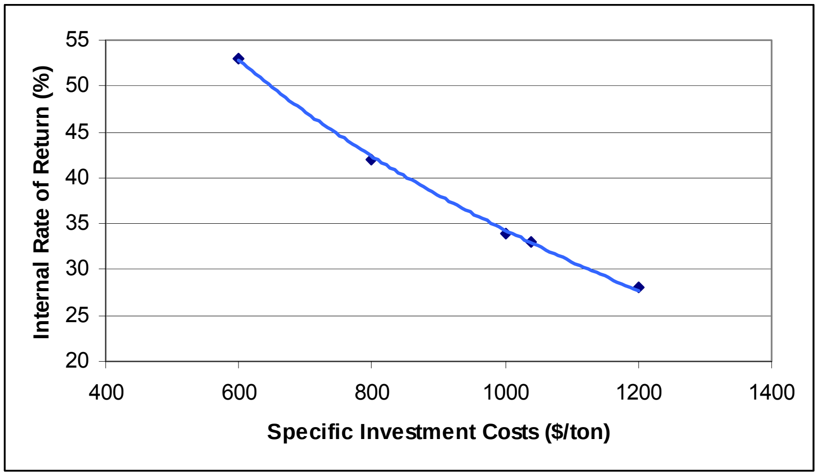


High specific investment costs have a strong impact on the Internal Rate of Return and prevent it from being higher. The economy of scale in ethanol plants has a dramatic effect on its profitability. A 40.000 tons plant already shows an Internal Rate of Return of 40%, increasing further to 100% for a 160.000 tons plant.

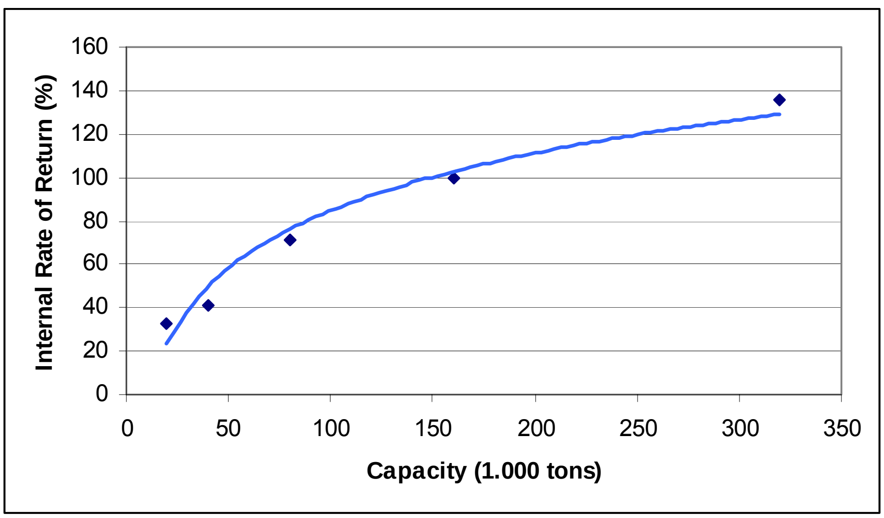
Egypt however, has a long tradition in engineering ethanol plants and it is expected that specific investment costs, which apply for Europe, are lower in the case Egyptian technology is applied. For the proposed 20.000 tons plant an Internal Rate of Return of above 40% is realistic in the case specific investments are in the range of $ 800/ton ethanol installed.

The second main influencing factor for the profitability of the plant is the ethanol-molasses-price ratio. If that ratio exceeds 11:1, the Internal Rate of Return is higher than 35%, while in the case the ratio narrows to less than 9:1, the Internal Rate of Return is below 30% and at a ratio smaller than 7:1, the plant becomes totally unprofitable.

Overview 81: Relationship between Specific Investment Costs and Internal Rate of Return for a 20.000 tons Bio-Ethanol Plant based on Molasses



Overview 82: Relationship between Size of a Bio-Ethanol Plant based on Molasses and Internal Rate of Return



4.5.3.2.5 Macroeconomic Considerations

Even with a moderate Internal Rate of Return but a secured raw material and electricity base, the setting up of a bio-ethanol plant seems to be strategically attractive for Egypt. The plant does not only fulfil most of the set macro-economic criteria, identified to be relevant for biotechnological investments but also can support Egypt's effort to diversify its energy sources and prepare for the time when petroleum is no longer abundantly available.

Overview 83: Macroeconomic Assessment of a Bio-Ethanol Plant based on Molasses in Egypt

Parameter	Appraisal
Support to sustainable GDP growth	Bio-ethanol will be highly demanded in future in Egypt but also in other countries such the EU. Prices are expected to rise and sustainability of the plant with an IRR of more than 30% is even given for the relatively small plant size proposed.
Fostering the manufacturing sector	Bio-ethanol is basic, although high-tech production. It will contribute to a substantiation of the manufacturing sector and at the same time support the shift from lower valued manufactured to higher valued goods. A new state-of-the-art plant can also serve as an example to modernise the existing bio-ethanol factories.
Improvements of balance of trade	Bio-ethanol can be used for both, domestic consumption and for exports. In the case exporting is preferred, the plant will contribute with about $ 5 Mio to the export value. In the case addition to fuel in Egypt is preferred, one litre of ethanol will cost approx. $ 1/l. This seems to be high for 2006 but considering increasing petroleum prices, costs of production might become acceptable in a few years and then contribute to decrease subsidies.
Employment of academic staff and stimulation of applied R&D	The plant employs approx. 140 staff, out of which 60 are academics and higher educated technicians
Usage of low wages	The competitiveness of the plant is also based on the low wages in Egypt. The share of wages in the total costs is about 8% and comparable to international standard
High energy efficiency and low energy costs	Energy costs are about 18% of the total and relatively high. An improvement can be obtained in the case a full energy recycling is carried out and in this case not only energy costs can be reduced to below 10% but at the same time the plant's profitability increased.
Usage of locally available raw materials and refrain from imported resources	The plant is based on molasses, one of the few locally available raw materials for fermentation. Molasses availability restricts the size of the plant and consequently its economics. Still ethanol production is more profitable than just exporting molasses. The molasses price largely decides on the economics of the plant.
Usage of existing biotechnology know-how	Know-how in ethanol production exists in Egypt and therefore the plant can be build to a large extent based on available engineering technology. Some elements of a state-of-the-art plant, especially in energy recycling, might be imported and this technology transfer can also be used for rehabilitating existing ethanol factories.
Technology transfer	Know-how transfer to a large extent is not needed. Due to the strategic importance of energy, ethanol manufacturing should be controlled by the Egyptian government and/or by companies close to it. A foreign investor is neither needed nor recommended.
Cluster effect	Setting up a state-of-the-art ethanol factory can support Egypt's engineering sector and foster export possibilities for such know-how. Egypt maintains friendly relationship also with those countries to which Western companies have only limited access but which at the same time still dispose of unexploited molasses resources.

4.5.3.2.6 Recommendations for Investment Policy

In summary bio-ethanol production based on molasses is considered as an attractive investment. For strategic reasons investments in the energy sector should be made by the government and/or by companies close to it. Egypt disposes of basic know-how and experience in engineering ethanol plants and only needs a technology update in efficient energy use for the process. Such additional know-how is available from many engineering companies in Europe and North America.

4.5.3.2.7 Log-frame for setting up a Bio-Ethanol Plant based on Molasses (20.000 tons)

	Intervention Logic	**Objectively Verifiable Indicators**	**Assumptions**
Overall Objective	Sustainable growth of Egypt's economy is supported by fostering the industrial sector with investments in manufacturing of higher valued biotechnological products	A set of key macro-economic criteria is positively influenced	Egypt remains politically and socially stable, continues reforming the economy and stays investor friendly
Project Objective	A state-of-the-art bio-ethanol plant is set-up and economically operated	A state-of-the-art bio-ethanol plant with a production of not less than 18.000 tons per year operates at an IRR of not less than 30% over 10 years	Basic assumptions with respect to availability and pricing of resources remain valid over longer periods of time
Result 1	Proposal and concept are approved by relevant ministries and official bodies	Key ministries and governmental institutions include the setting up of a bio-ethanol factory as one of the targets over the next five years	Key ministries find proposal of setting-up a state-of-the-art bio-ethanol factory attractive and strategically important enough to include it in political frame
Result 2	Suitable investment scheme is identified and implemented	A suitable investment scheme is announced and published	Identified competitiveness of Egypt as a site for state-of-the-art bio-ethanol production is appreciated by investor
Result 3:	Pre-feasibility is revised and extended to full techno-economic feasibility study	Technical and economic blue prints for the construction and operation of a state-of-the-art bio-ethanol plant is available not later than 2008	Suitable consulting and engineering firm can be hired for carrying out feasibility study and does not come to totally different conclusions as the pre-feasibility study.
Result 4	Plant is constructed within 12 months and successfully started up	The state-of-the-art bio-ethanol plant comes on stream not later than 2010 and operates according to business plan	Bureaucracy in Egypt does not restrict advancements in planning, construction and operation of the plant; markets for bio-ethanol develop as envisaged

4.5.3.3 Production Technology: Straw Based

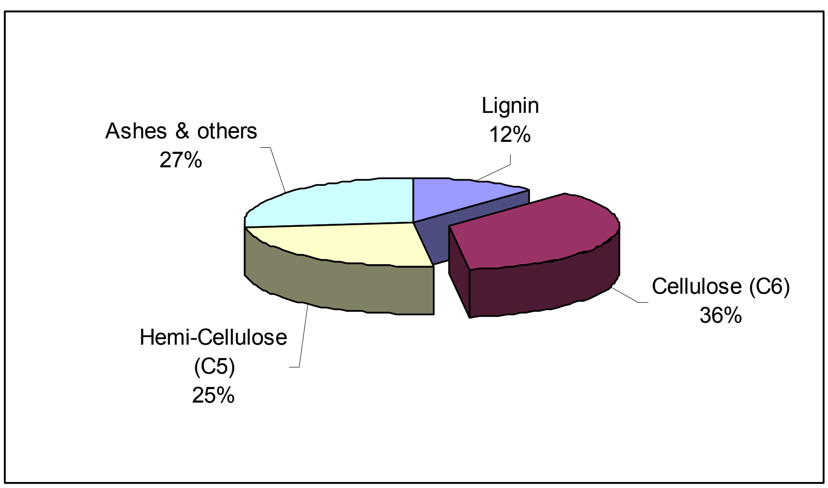
A second raw material, which is locally available for fermentation in addition to molasses, is straw. Straw is a composite of lignin and of polysaccharides and in theory all polysaccharides can be converted to sugars and consequently fermented.

The difficulty with straw is that celluloses are strongly linked with lignin and in that basic structure micro-organisms can not split-up such celluloses and use them as energy source. Therefore, prior to its use in fermentation, straw needs to be treated in such a way that the basic structure breaks-up and the cellulose fraction becomes available. Further, most micro-organisms used in fermentation can digest C6-sugars and only to a very small amount C5-sugars. These C5-sugars in the form of xylan and arabinan represent a major part of the hemi-cellulose fraction in straw. As a basic rule, yeasts can digest C6-compounds while it is mainly bacteria which can use C5-sugars.

Overview 84: Typical Composition of various Types of Straw[184]

Type of Straw	Lignin, %	Cellulose (C6-fraction, %)	Hemi-Cellulose (C5-fraction, %)	Ashes and others, %
Rice	12	36	25	27
Barley	14	34	25	27
Wheat	17	40	28	15
Rye	19	38	30	13

Overview 85: Composition of Rice Straw



Although wheat is cultivated in Egypt in significant amounts, its straw is widely used for feeding and therefore not available for industrial usage. Rice straw however is not much used for feeding mainly because of the high ash content, which to a large extent consists of silica. Consequently it is rice straw which is

[184] Jeroch H. et al. 1993: Futtermittelkunde, Fischer Verlag, Germany

available for fermentation but which at the same time poses a technological challenge due to the high silica content.

4.5.3.3.1 Basic Outline and Availability of Technology

The availability of rice straw for technical usage is not only confined to Egypt. Consequently many countries predominantly in the developing world and in Asia are researching on using such raw material for various purposes[185]. In the Western world the usage of straw as a fermentation raw material concentrates on wheat straw as that type plays a larger role. Industrial ethanol plants with a sizable capacity, using rice straw, do not exist. The technical outline of an industrial ethanol factory which is based on rice straw therefore has a pioneering character and no analogue in any other country. Embarking on such a technology can not be achieved by technology transfer alone but needs some further development of individual steps, primarily in pre-treatment of straw. The technology proposed is based on acid hydrolysis of the straw, a subsequent enzymatic saccharification of the released celluloses and yeast fermentation of the C6-fraction. The process is based on the wood saccharification process, which was installed until the early 90s in Eastern Germany on industrial scale (Blankenstein process) and adapted to straw based on the German patent No. 196 27 505.9-41 by ECO SYS GmbH, filed in 1996[186].

The process proceeds in the following steps.

- Rice straw is treated with sulphuric acid under elevated temperature and high pressure.
- Spontaneous reduction of the pressure cracks the structures of the straw and separated the lignin fraction from the rest.
- Addition of a specific enzyme cocktail[187][188] consisting of various fungal cellulases and xylanases converts the C6-fraction and a small amount of the C5-fraction into glucose and other related compound.
- As such sugars are soluble, the solids including the silica can be decanted and the liquid transferred to a standard ethanol plant for fermentation.
- The following steps are similar to those shown for the molasses process.

---

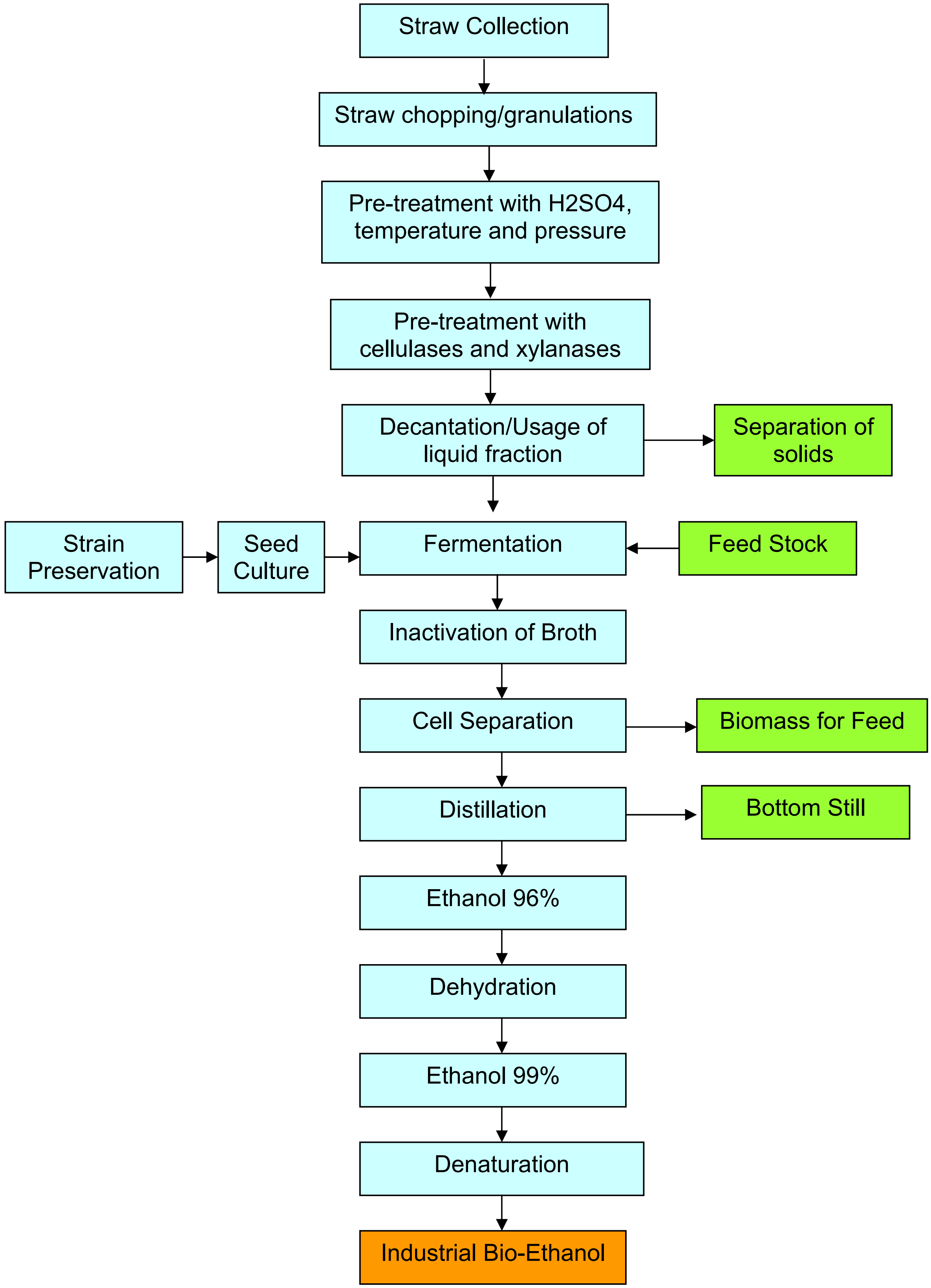
[185] For example: Karimi K. et al. 2006: Ethanol production from dilute-acid pre-treated rice straw by simultaneous saccharification and fermentation with *Mucor indicus, Rhizopus oryzae* and *Saccharomyces cerevisiae*. In: Enzyme and Microbial Technology, 40, pp 138-144

[186] Reviews of this technology can also be found in: Walch et. Al: Enzymatic Saccharification of hemi-cellulose Obtained from Hydrothermally Pre-treated Sugar Cane Bagasse and Beech Bark. In: Bio-resource Technology 39, pp. 173-177; Weil et. Al. 1994: Cellulose Pre-treatments of lignocellulosic substrates. In: Enzyme Microb. Technol. 16, pp 1002 – 1004; Omar S.A. 1994: Degradation and mineralization of wheat straw by some cellulolytic fungi in pure cultures. In: Microbiol. Res. 149, pp 157-161; ECO SYS 1994: Nutzung von Reisstroh als Viehfutter; Technical description of Pre-treatment of Rice straw; Internal Working Paper.

[187] Moeder 2007: Bio-Ethanol: Is it green and economical? Internal presentation of NOVOZYME (www.atv.dk/b/).

[188] Companies like NOVOZYME propose specific enzymes in order to develop a new business areas an propose value-added new product. There is a certain likelihood that standard feed enzymes (cellulases and xylanases) as offered by companies such as GNC in Canada result in similar effects, but at much reduced costs. The technology by ECO SYS is based on the usage of such feed enzymes, which are derived from a Trichoderma strain.

Overview 86: Production Flowchart for Bio-Ethanol from Rice Straw



4.5.3.3.2 Resources needed

Mass Balance

Rice straw contains about 90% dry matter and 36% fermentable sugars. However, not all of these can be made available by the pre-treatments of the straw. The liquid which is used for fermentation contains in addition to sugars other compounds which so far have shown that the fermentation efficiency is reduced to 45%.

Consequently under practical conditions, 28% fermentable sugars in rice straw can be converted with 45% efficiency to bio-ethanol. Per ton of rice straw 126 kg of ethanol can be obtained. Due to the high silica content and the additional lignin, the decanted solids can not be used for feeding. As with all other fermentations a yeast cream is obtained, which has a feeding value. The amount is however small and not higher than 2% of the ethanol production.

Overview 87: Mass Balance of Bio-Ethanol based on Rice Straw

Parameter	Value
Dry matter of rice straw	90%
Fermentable sugars	36%
Usable fermentable sugars	28%
Conversion rate of sugars into ethanol	45%
Ethanol production per ton of rice straw	126 kg
Usable by-products (bacterial biomass)	2% (2,5 kg)

Utilities

Ethanol production based on rice straw is not only energy intensive due to distillation but additionally because of the pre-treatment. Pilot plants of Südzucker and experiments by ECO SYS show that for one ton of ethanol 6.615 kwh energy, mainly in the form of electricity and/or steam are required. However, modern plants can save up to 70% of such energy requirement due to process optimisation and steam recycling. As a first approximation, it is assumed, that 30% energy can be saved and the energy demand is reduced to 4.280 kwh. Water requirement with 30 m^3 for fermentation and for straw pre-treatment is high, as the straw pre-treatment takes place in an aqueous environment. The requirements for cooling do with 200 m^3 not change. Water for fermentation has to have a drinking water quality, while water for cooling requires only processed water quality.

Labour

Due to the long history of ethanol production, process technology is well elaborated and automatised. The labour requirement also for a straw based plant is low and per 1.000 tons of ethanol five blue collar and three white collar labour are needed. This labour requirement is based on the assumption that straw is supplied to the plant and does not consider the number of labour needed to collect, chop and transport the straw. Such assumption is justified as an elaborate straw collection, chopping and pelleting systems exists in Egypt. Straw therefore has a price but extra labour does not need to be accounted for in the plant design.

Overview 88: Labour Requirement for an Bio-Ethanol Plant based on Straw

Process Step	Category	Number/1.000 tons
Straw handling	Blue collar	1
Production	Blue collar	2
	White collar	2
Packaging & Logistics	Blue collar	1
Administration	White collar	0,5
Sales	White collar	0,5
Auxiliary	Blue collar	1
Total		**8**

4.5.3.3.3 Cost Structure

Investment Costs and Maintenance

The basic investment costs for a standard ethanol plant do not change with straw but the pre-treatment of straw requires additional investments. Those are high as stainless steel and high pressure resistant vessels are needed, like an automatised process control system. In total, an ethanol factory based on straw technology can entail specific costs of $ 2.450/ton of ethanol for a 20.000 tons plant. Since there are not many large-scale factories of that type operating, experience with economy of scale does not exist extensively. Given that Egypt's engineering sector is experienced in designing ethanol factories based on molasses, it is expected that investment in a straw based ethanol factory are also lower under Egyptian conditions.

Maintenance costs are estimated to be higher than for any other proposed fermentation plant. The reason is that rice straw with high silica content is highly abrasive. That property in addition to the acid related corrosion entails maintenance costs of at least 0,8% of investment costs per year.

Raw Material and Utility Costs

As the process is running on pre-treated straw, it is not only the straw costs which have an effect on the total but also costs of several chemicals and additives. Straw does not contain valuable nutrients which can be utilised in the fermentation process and therefore in the direct fermentation the amount of additional salts to be added is at least double that of the standard. However, the main chemical costs come from the pre-treatment of the straw. Sulphuric acid is added in an amount of 33 kg/ton of straw at costs of $ 260 per ton[189]. The enzyme cocktail was, until 2005, the main raw material cost and priced at $ 1/l ethanol. In 2006, NOVOZYME announced that it is now in a position to offer such cocktail at $ 0,26/l of ethanol. Straw, even rice straw, in Egypt has a price which is estimated at $ 32/ton of straw delivered in pelletised form to an ethanol plant within a distance of 30 km.

Clean, fermentation-suitable water is not available for free and either must be bought or processed based on Nil-river-water. A detailed water price can only be given when the type of water processing is defined. As a first approximation the standard water price for industrial use of $ 0,25/m^3 is used.

For distillation no further chemicals or additives are needed. For denaturation an approved additive can be used in amounts of up to 1% entailing costs of $ 13 per ton of ethanol.

In summary, total raw material and utility costs to produce 1 ton of ethanol from straw are estimated to be in the range of $ 850 in 2006. Such production costs are considerably higher than for ethanol produced based on molasses.

Overview 89: Total Raw Material Costs for one Ton Bio-Ethanol based on Rice Straw

Raw Material	**Quantity/ton bio-ethanol**	**Unit price ($/unit)**	**Total ($/ton bio-ethanol**
Rice straw	7,9	32	253
other nutrients	2% of rice straw costs		5
Drinking water	30 m^3	0,25	7,5
Cooling water	200 m^3	0,025	5
H_2SO_4	0,261 tons	260	67,9
Enzymes	$ 0,26/l ethanol		347
Electricity	4.280 kwh	0,035	149,8
Denaturant[190]	10 kg	1,3	13
Total			**848,2**

Labour and Administration Costs

Overview 90 estimates that about 5 blue collar and 3 white collar staff are needed per 1.000 tons installed ethanol capacity. Blue collar staff costs about $ 500/month and white collar staff about $ 1.000/month. Consequently per ton of bio-ethanol labour costs in the range of $ 66/ton arise.

[189] It is not clear at this moment to what extent the acid must be nutralised so that the following enzyme treatment can be effective. In the case NaOH needs to be added, further costs occur.
[190] Di-ethyl-phthalate or simply gasoline.

Overview 90: Labour Costs per Ton of Bio-Ethanol based on Rice Straw

Process Step	Category	Number/ 1.000 tons	Unit cost ($/year)	Costs/ year ($)
Straw handling	Blue collar	1	6.000	6.000
Production	Blue collar	2	6.000	12.000
	White collar	2	12.000	24.000
Packaging & Logistics	Blue collar	1	6.000	6.000
Administration	White collar	0,5	12.000	6.000
Sales	White collar	0,5	12.000	6.000
Auxiliary	Blue collar	1	6.000	6.000
Total		**8**		**66.000**

Other administration and sales costs are like for any other ethanol plant not higher than 0,3% of total turnover.

4.5.3.3.4 Cash flow

Based on these figures a cash flow model over 10 years is established. The calculations show, that at the current price settings and a 20.000 tons plant, an Internal Rate of Return of 2% can be achieved. The payback period is very long and close to 10 years, rendering the plant uneconomical.

Overview 91: Basic Parameters Applied in the Cash flow Model

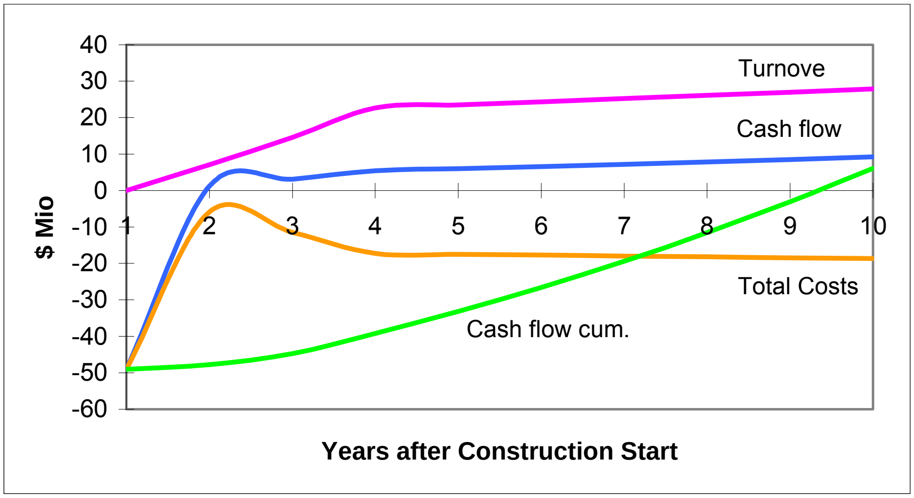
Parameter	Model value
Ethanol price	$ 0,9/l in base year, progressing by 3% per year
Residue value	2% of ethanol production at $ 100/ton, progressing by 2% per year
Investment costs	$ 2.450/ton ethanol
Straw costs	$ 32/ton ethanol, progressing by 2% per year
Labour, utility and other costs	See overviews 89 and 90
Start up phase	3 years until full utilisation of production, which is 90% of designed capacity

Overview 92: Cash flow for a Bio-ethanol Plant based on Rice Straw with 20.000 Tons Annual Capacity (basic model)

No	Parameter/Year	1	2	3	4	5	6	7	8	9	10
1	**Turnover Parameter**										
1.1	Production (t)	0	6.060	12.120	18.180	18.180	18.180	18.180	18.180	18.180	18.180
1.2	Selling Price ($/kg)	1,13	1,16	1,21	1,25	1,29	1,34	1,38	1,43	1,48	1,53
1.3	Turnover EOH ($)	0	7.056.113	14.606.153	22.676.052	23.469.714	24.291.154	25.141.345	26.021.292	26.932.037	27.874.658
	Residue Value ($/ton)	100	102	104	106	108	110	113	115	117	120
	Turnver protein residue ($)	0	12.362	25.219	38.586	39.357	40.144	40.947	41.766	42.602	43.454
	Total turnover ($)	0	7.068.475	14.631.372	22.714.638	23.509.071	24.331.299	25.182.292	26.063.058	26.974.638	27.918.112
2	**Cost Parameter**										
2.1	Investment Costs ($)	49.000.000									
2.2	Maintenance Costs ($)		392.000	392.000	392.000	392.000	392.000	392.000	392.000	392.000	392.000
2.3	Raw materials and utilities										
	Fermentables in straw (%)		28	28	28	28	28	28	28	28	28
	Conversion rate to alcohol (%)		45	45	45	45	45	45	45	45	45
	Straw quantity (t)		48.095	96.190	144.286	144.286	144.286	144.286	144.286	144.286	144.286
	Straw price ($/t)		30	31	32	33	34	35	36	37	38
2.3.1	Straw costs ($)		1.442.857	2.972.286	4.592.181	4.729.947	4.871.845	5.018.001	5.168.541	5.323.597	5.483.305
2.3.2	H2SO4 (33 kg/t of straw)		412.657	833.567	1.250.351	1.250.351	1.250.351	1.250.351	1.250.351	1.250.351	1.250.351
2.3.3	Enzymes ($ 0,26/l ethanol)		2.121.000	4.242.000	6.363.000	6.363.000	6.363.000	6.363.000	6.363.000	6.363.000	6.363.000
2.3.4	Other nutrients ($)		28.857	59.446	91.844	94.599	97.437	100.360	103.371	106.472	109.666
2.3.5	Denaturant (1%, $ 1,3/kg)		78.780	157.560	236.340	236.340	236.340	236.340	236.340	236.340	236.340
2.3.6	Drinking water costs ($)		45.450	90.900	136.350	136.350	136.350	136.350	136.350	136.350	136.350
2.3.7	Cooling water costs ($)		22.725	45.450	68.175	68.175	68.175	68.175	68.175	68.175	68.175
	Electricity price ($/kwh)		0,035	0,036	0,036	0,037	0,038	0,039	0,039	0,040	0,041
2.3.8	Electricy costs ($)		907.894	1.852.104	2.833.719	2.890.393	2.948.201	3.007.165	3.067.308	3.128.655	3.191.228
2.4	Labour										
	Labour number white collar/1000 tons		3	3	3	3	3	3	3	3	3
	Labour number blue collar/1000 tons		5	5	5	5	5	5	5	5	5
	Labour costs blue collar ($/unit/year)		6.000	6.120	6.242	6.367	6.495	6.624	6.757	6.892	7.030
	Labour costs white collar ($/unit/year)		12.000	12.240	12.485	12.734	12.989	13.249	13.514	13.784	14.060
	Total labour costs ($)		399.960	815.918	1.248.355	1.273.322	1.298.789	1.324.764	1.351.260	1.378.285	1.405.851
2.5	Other Costs (Admin & Sales)		21.205	43.894	68.144	70.527	72.994	75.547	78.189	80.924	83.754
2.6	Total costs ($)	49.000.000	5.873.386	11.505.125	17.280.459	17.505.005	17.735.482	17.972.053	18.214.885	18.464.148	18.720.020
3	**Cash flow and IRR**										
3.1	Cash flow ($)	-49.000.000	1.195.089	3.126.247	5.434.179	6.004.067	6.595.816	7.210.239	7.848.173	8.510.490	9.198.092
3.2	Cumulative cash flow ($)	-49.000.000	-47.804.911	-44.678.664	-39.244.485	-33.240.419	-26.644.602	-19.434.364	-11.586.191	-3.075.701	6.122.391
3.3	IRR	2%									

The overview shows that with a calculated Internal Rate of Return of 2%, bio-ethanol production based on straw is not economical.

Overview 93: Cash flow Development for a Bio-Ethanol Plant based on Rice Straw (20.000 tons, basic model)



There is a multitude of factors which influence its economics out of which investments costs, straw price, enzyme costs, energy costs and the conversion ratio from straw to ethanol are the most important ones. Changing each individual factor can contribute to an improvement but for a robust economics more that one of these factors must be improved:

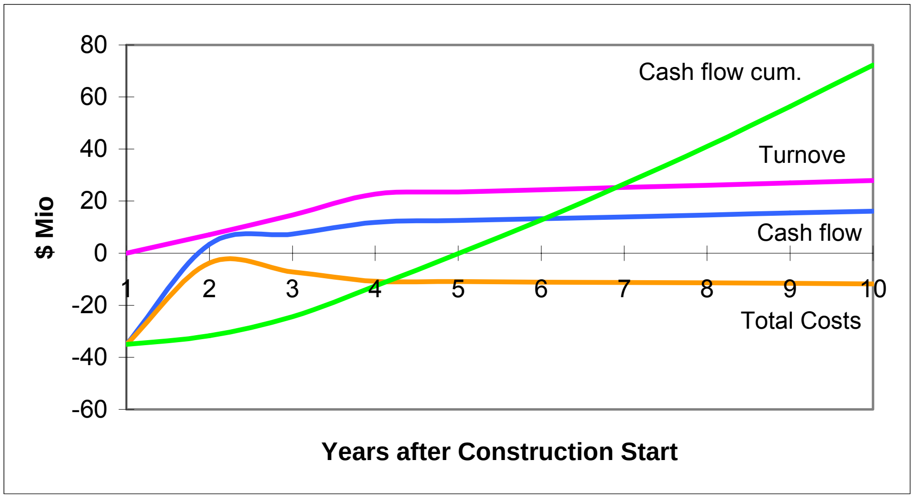
- Reducing specific investment costs to $ 1.750 per ton of ethanol increases the IRR to 8%.
- Lowering enzyme costs to $ 0,25 per litre ethanol increases the IRR to 7%.
- Increasing the content of useable fermentables in the straw to 40% increases the IRR to 6%.
- Full energy recycling also increases the IRR to 6%.

If all these factors are combined, the Internal Rate of Return will be higher than 20% and under these conditions an ethanol factory based on rice straw can be considered for an investment. The payback period is in the range of five years and not too far away from a standard molasses based ethanol plant.

Overview 94: Cash flow for a Bio-Ethanol Plant based on Rice Straw with 20.000 Tons Annual Capacity (optimised system)

No	Parameter/Year	1	2	3	4	5	6	7	8	9	10
1	**Turnover Parameter**										
1.1	Production (t)	0	6.060	12.120	18.180	18.180	18.180	18.180	18.180	18.180	18.180
1.2	Selling Price ($/kg)	1,13	1,16	1,21	1,25	1,29	1,34	1,38	1,43	1,48	1,53
1.3	Turnover EOH ($)	0	7.056.113	14.606.153	22.676.052	23.469.714	24.291.154	25.141.345	26.021.292	26.932.037	27.874.658
	Residue Value ($/ton)	100	102	104	106	108	110	113	115	117	120
	Turnver protein residue ($)	0	12.362	25.219	38.586	39.357	40.144	40.947	41.766	42.602	43.454
	Total turnover ($)	0	7.068.475	14.631.372	22.714.638	23.509.071	24.331.299	25.182.292	26.063.058	26.974.638	27.918.112
2	**Cost Parameter**										
2.1	Investment Costs ($)	35.000.000									
2.2	Maintenance Costs ($)		280.000	280.000	280.000	280.000	280.000	280.000	280.000	280.000	280.000
2.3	Raw materials and utilities										
	Fermentables in straw (%)		40	40	40	40	40	40	40	40	40
	Conversion rate to alcohol (%)		45	45	45	45	45	45	45	45	45
	Straw quantity (t)		33.667	67.333	101.000	101.000	101.000	101.000	101.000	101.000	101.000
	Straw price ($/t)		30	31	32	33	34	35	36	37	38
2.3.1	Straw costs ($)		1.010.000	2.080.600	3.214.527	3.310.963	3.410.292	3.512.600	3.617.978	3.726.518	3.838.313
2.3.2	H2SO4 (33 kg/t of straw)		288.860	583.497	875.246	875.246	875.246	875.246	875.246	875.246	875.246
2.3.3	Enzymes ($ 0,26/l ethanol)		1.133.220	2.266.440	3.399.660	3.399.660	3.399.660	3.399.660	3.399.660	3.399.660	3.399.660
2.3.4	Other nutrients ($)		20.200	41.612	64.291	66.219	68.206	70.252	72.360	74.530	76.766
2.3.5	Yeast ($)		78.780	157.560	236.340	236.340	236.340	236.340	236.340	236.340	236.340
2.3.6	Denaturant (1%, $ 1,3/kg)		78.780	157.560	236.340	236.340	236.340	236.340	236.340	236.340	236.340
2.3.7	Drinking water costs ($)		45.450	90.900	136.350	136.350	136.350	136.350	136.350	136.350	136.350
2.3.8	Cooling water costs ($)		22.725	45.450	68.175	68.175	68.175	68.175	68.175	68.175	68.175
	Electricity price ($/kwh)		0,035	0,036	0,036	0,037	0,038	0,039	0,039	0,040	0,041
2.3.9	Electricy costs ($)		389.097	793.759	1.214.451	1.238.740	1.263.515	1.288.785	1.314.561	1.340.852	1.367.669
2.4	Labour										
	Labour number white collar/1000 tons		3	3	3	3	3	3	3	3	3
	Labour number blue collar/1000 tons		5	5	5	5	5	5	5	5	5
	Labour costs blue collar ($/unit/year)		6.000	6.120	6.242	6.367	6.495	6.624	6.757	6.892	7.030
	Labour costs white collar ($/unit/year)		12.000	12.240	12.485	12.734	12.989	13.249	13.514	13.784	14.060
	Total labour costs ($)		399.960	815.918	1.248.355	1.273.322	1.298.789	1.324.764	1.351.260	1.378.285	1.405.851
2.5	Total costs ($)	35.000.000	3.747.072	7.313.296	10.973.734	11.121.355	11.272.912	11.428.513	11.588.269	11.752.296	11.920.710
3	**Cash flow and IRR**										
3.1	Cash flow ($)	-35.000.000	3.321.402	7.318.076	11.740.903	12.387.716	13.058.387	13.753.779	14.474.788	15.222.342	15.997.402
3.2	Cumulative cash flow ($)	-35.000.000	-31.678.598	-24.360.522	-12.619.618	-231.902	12.826.485	26.580.264	41.055.052	56.277.395	72.274.796
3.3	IRR	24%									

Overview 95: Cash flow Development for a Bio-Ethanol Plant based on Rice Straw (20.000 tons, optimised system)



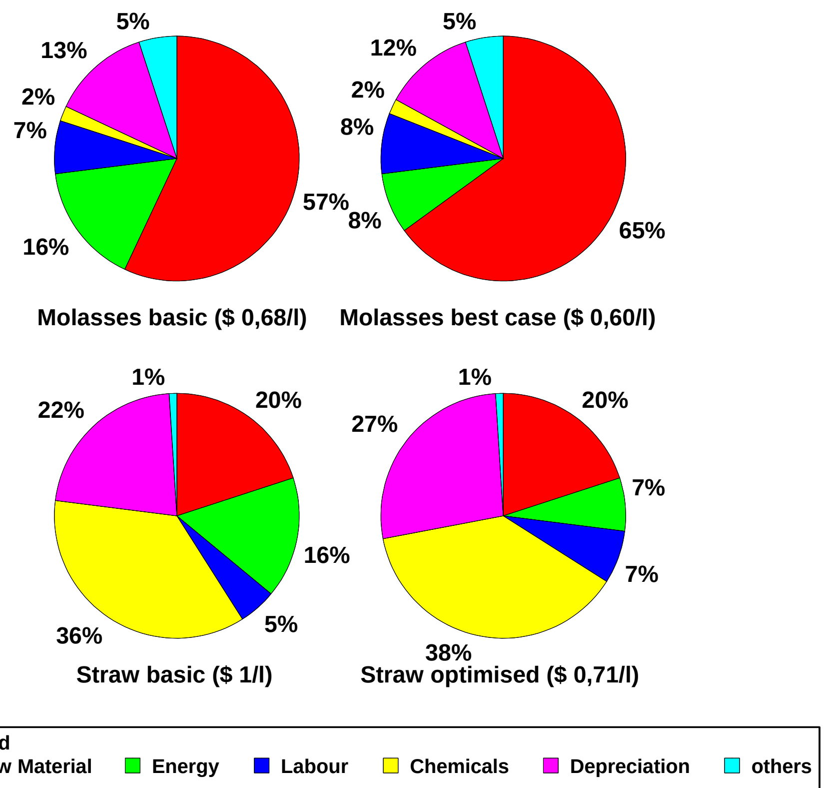
4.5.3.3.5 Comparison of Ethanol Production Costs

As the technical description and the economic calculations for the various ethanol processes showed, production costs allow in some cases a high economic return.

In the case of molasses total production costs are estimated to be in the range of $ 0,6-0,7/l of ethanol and in the case of rice straw between $ 0,7-1/l.

Even the straw process results in manufacturing costs which are not too far from molasses. As the sensitivity analysis for the straw based process shows, comparable costs of production can be obtained under optimised conditions, which require only a moderate additional R&D input.

Overview 96: Structure and Comparison of Ethanol Production Costs by Type of Raw Material



4.5.3.3.6 Macroeconomic Considerations

Although the basic outline of fermenting ethanol based on straw does under non-optimised conditions not result in a highly attractive economics, the process as such is appealing from a macroeconomic perspective.

The technology is not only at the forefront of international science and research but also represents one of the few possibilities to manufacture a chemical product in Egypt, which is strongly demanded, for which the raw material base is largely available and which is not much used for other purposes. Developing a commercial and economically feasible ethanol process based on straw would therefore not only support the development of economic growth in the high-tech sector but provides Egypt with the possibility to achieve a leading position in the international engineering market. Egypt's technology export of ethanol plants, which so far is based on molasses processes, can be expanded and future oriented.

Overview 97: Macroeconomic Assessment of a Bio-Ethanol Plant based on Rice Straw in Egypt

Parameter	Appraisal
Support to sustainable GDP growth	Bio-ethanol will be highly demanded in future in Egypt but also in other countries such the EU. Prices are expected to rise. The sustainability of a plant is currently not given but upon optimising and mastering a straw based ethanol process, an IRR of more than 20% can be expected for a 20.000 tons plant.
Fostering the manufacturing sector	Bio-ethanol production based on straw is at the forefront of international technology development. A successful straw process would not only contribute to a substantiation of the chemical sector but at the same time propel Egypt's engineering industry to the top of technology leaders in the ethanol manufacturing sector and open opportunities for exporting high-tech know-how.
Improvements of balance of trade	Bio-ethanol can be used for both, domestic consumption and for exports. In the case exporting is preferred, a straw based plant under optimised conditions will contribute with about $ 25 Mio to the export value. Presumably of higher relevance is the potential for exporting know-how, which can reach $ 20-30 Mio per plant.
Employment of academic staff and stimulation of applied R&D	A straw plant employs 160 staff directly but straw collection will require several hundred farmers and village based labour. A straw based technology therefore can contribute massively to the employment in rural areas and reduce migration. Having researched and developed an internationally competitive straw process will entail the continuous employment of academic and engineering staff in the case technology export is achieved.
Usage of low wages	Labour costs for a straw based ethanol plant do not play a major role with 7% of the total as other cost items are of much higher importance.
High energy efficiency and low energy costs	A straw plant is energy intensive and profits substantially from low energy costs. High energy efficiency is obtained as an agricultural waste is used. In total process costs, energy keeps a share of 16%, which is higher for other fermentations.
Usage of locally available raw materials and refrain from imported resources	The plant is based on rice straw, one of the few locally available raw materials for fermentation. Rice straw is abundantly availability and its usage does not restrict any other application. It is therefore the raw material of choice for any kind of fermentation development.
Usage of existing biotechnology know-how	Know-how in ethanol production exists in Egypt and therefore the fermentation part can be built on available engineering technology. The pre-treatment of straw is new for Egypt and a technology transfer is needed.
Technology transfer	Know-how transfer for the basic fermentation step is not needed to a large extent. However, in the setting up of the pre-treatment part an intensive cooperation with an international partner and/or the domestic development of engineering know-how based on external advice is required. Due to the strategic importance of ethanol manufacturing but even more of using rice straw as a raw material, the engagement of the Egyptian Government in setting up a pilot plant and presumably later in a commercial plant is recommended.
Cluster effect	Setting up a state-of-the-art ethanol factory based on rice straw can strongly support Egypt's engineering sector and foster export possibilities for such know-how. This applies not only for the developing world but also for Western and advanced Asian countries, which all look for possibilities to use cellulosic raw materials for fermentation.

4.5.3.3.7 Recommendations for Investment and R&D Policy

In order to develop an ethanol process based on straw to economic feasibility, a limited R&D and piloting program is recommended. As ethanol fermentation as such is known in Egypt, R&D and piloting efforts refer mainly to the pre-treatment of straw. As overview 94 shows, a straw based process will be economical when the following parameters can be met:

- Conversion rate of straw to ethanol: >> 20%.
- Costs of straw: < \$50/ton supplied.
- Total energy costs: < 10% of total costs.
- Enzyme costs < 30% of total costs.
- Investment costs: < \$ 2.000/ton of ethanol capacity.
- Maintenance and repairs: < 0,6% of investment.

It is trusted that costs of straw can be controlled under Egyptian conditions and the engineering sector is able to design plants which meet the investment and maintenance parameters. Also energy costs can be minimised by applying recycling technologies for the straw waste such as gasification.

The true challenges of the straw process are

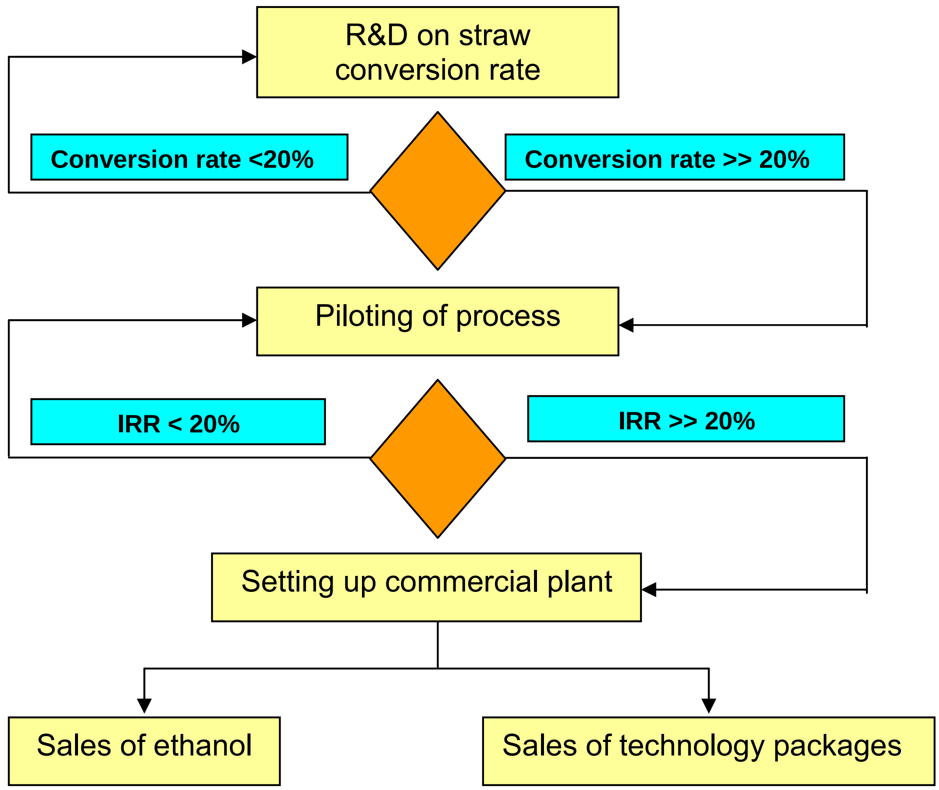
- increasing the conversion rates of straw to fermentable sugars and
- reducing enzyme costs.

Both parameters are interrelated and it is ultimately the identification of procedures and micro-organisms/enzyme systems allowing the utilisation of not only C6- but also C5-sugars. Academic research in microbiology is advanced in Egypt and finding procedures under which a higher part of carbohydrates in straw can be converted, should become a priority topic, which potentially can also connects academia and industry successfully and thus fulfilling one of the demands for applied research.

Not withstanding of this proposals for domestic research, an intensive cooperation with an enzyme manufacturer, active in the field of cellulases and xylanases, is strongly recommended. The partner might be NOVOZYME, who currently claims to have a lead in enzyme technology. However, also other companies in North America, Europe and Asia are active in that area and it will depend on testing results of various commercially available enzyme cocktails with which company cooperation might be most promising. Enzyme screening can start with standard feed enzymes, developed for better digesting cellulosic compounds in wheat and barley. Such enzymes (e.g. available from GNC in Canada) are very cheap and might be competitive for straw processing even when increased dosages are needed.

Consequently the setting up of an economically feasible straw based ethanol production requires the interfacing of R&D, piloting and production according to the model given in overview 96.

Overview 98: **R&D and Piloting Procedures for optimising a Bio-Ethanol Process based on Rice Straw**



4.5.3.3.8 Log-Frame for setting up a bio-Ethanol Plant based on Rice Straw (20.000 tons)

	Intervention Logic	Objectively Verifiable Indicators	Assumptions
Overall Objective	Sustainable growth of Egypt's economy is supported by fostering the industrial sector with investments in manufacturing of higher valued biotech products	A set of key macro-economic criteria is positively influenced	Egypt remains politically and socially stable, continues reforming the economy and stays investor friendly
Project Objective	An innovative bio-ethanol plant based on rice straw is set-up and economically operated	An innovative bio-ethanol plant based on rice straw with a production of not less than 18.000 tons per year operates at an IRR of not less than 25% over 10 years	Governmental and private bodies in Egypt as well as international technology owners cooperate efficiently.
Result 1	Proposal and concept are approved by relevant ministries and official bodies	Key ministries and governmental institutions include the setting up of a straw-based bio-ethanol factory as one of the targets over the next five years	Key ministries find proposal of setting-up an innovative rice straw-based bio-ethanol factory attractive and strategically important enough to include it in political frame
Result 2	Suitable R&D scheme for the pre-treatment of rice straw is set-up and leads to desired results	The conversion of rice straw to ethanol can be increased to more than 20%	Suitable R&D institute in Egypt can be identified and limited funding ensured.
Result 3	The pre-treatment of rice straw is piloted and leads to the desired results	Pilot trials lead to the conclusion that a commercial plant can be operated successfully with respect to technical feasibility and economic sustainability.	Suitable engineering company can be identified and funding for a pilot plant can be ensured.
Result 4	The results of a feasibility study considering the optimised pre-treatment of rice straw justify investments in a commercial plant	Techno-economic scenarios and pressure testing of key parameters show robust economics even under adverse frame-work conditions.	Basic assumptions with respect to availability and pricing of resources remain valid over longer periods of time.
Result 5	Suitable investment scheme for a rice straw based ethanol plant is identified and implemented	A suitable investment scheme, involving governmental and/or private bodies is announced and published.	Official and/or local private investors recognise the micro- and macroeconomic potential of a straw-based ethanol process.
Result 6	Plant is constructed within 12 months and successfully started up	A innovative straw-based bio-ethanol plant comes on stream not later than 2010 and operates according to business plan	Bureaucracy in Egypt does not restrict advancements in planning, construction and operation of the plant; markets for bio-ethanol develop as envisaged

4.5.4 Other Chemical Processes

The review of the international competitiveness of fermentation derived products also identified acetic acid as a possible candidate for Egypt. During the discussion with IMC also baker's yeast was recommended as a product to be analysed. A closer look however reveals that neither acetic acid nor baker's yeast can be recommended as investment targets:

4.5.4.1 Acetic Acid

In the standard process based on fermentation, acetic acid production starts with ethanol. Ethanol is converted by fermentation to diluted acetic acid, which is then distilled again to obtain the anhydrous form. The ethanol process calculation showed that in the best case cost of productions are in the range of $ 0,6/l. Acetic acid anhydrous is dumped into the market currently by Chinese manufacturers at $ 0,7/l. It is obvious that this small increment between acetic acid and ethanol does not allow a second fermentation and distillation on economic grounds. In the case however, acetic acid reaches a longer lasting price high of $ 2/l, as it was already the case temporarily in the past years, a second look is justified. Also technologies are explored which directly convert cellulosic materials to acetic acid. Such technology might also be worthwhile to explore in more detail, although that is considered to be outside of the scope of this work.

4.5.4.2 Baker's Yeast

Baker's yeast is used in Egypt for the preparation of baguette-type bread, for cakes and for home consumption. Existing baker's yeast factories supply the local market to a large extent and imports over the last years never exceeded 500 tons per year. On a global scale the baker's yeast market is strongly concentrated by five companies Lesaffre, ABF, Gilde, Lallemand and Pakmaya. Their combined global share is 80%. The concentration process took place in the last years and is based on the economics of baker's yeast production.

The conversion process from e.g. molasses to yeast is approx. 1:1 for yeast with 27% dry matter. Considering the molasses price of $ 110/ton and a yeast price of $ 300-400/ton[191], a decent profitability can only be obtained when plants are sufficient large. According to Gilde, break even is reached at an annual output of 10-15.000 tons of yeast with 27% dry matter. Considering the low import of yeast to Egypt and estimating domestic production at not more than a few thousand tons, an investment in a large-scale yeast factory can not be justified for both – microeconomic and macroeconomic reasons:

[191] Yeast at the retail store is substantially more expensive and shows prices of $ 1000/ton. The ex-factory price for crude yeast is derived as follows: Margin of retailer: 30%, transport and logistics incl. cooling from factory to retailer: 15-20%, packaging: 10%, value of discarded yeast, due to limited shelf life: 5%.

- It is unrealistic to assume that a yeast plant with such high capacity can find a sufficiently large market in Egypt, in the region and even on a more global scale. Marketing and sales efforts would be enormous and costly.
- A plant with such a high capacity would automatically destroy the small and medium sized existing baker's yeast factories, which can not be the objective of an investment program aiming at supporting the development of the industrial sector.

In consequence both projects are not considered further

5 Veterinary Vaccines in Egypt

Under the scope of the study of "Egypt's Industry Development Strategy, White Biotechnology, A Roadmap for Efficient Implementation and Economic Success" the pharmaceutical biotechnology sector was studied also.

Apparently, there is no commercial pharmaceutical biotechnology industry in Egypt today. The analyts heard comments that entrepreneurial endeavours have been made in the past to establish a commercial recombinant insulin production facility in Egypt, with the help of foreign investors. However, up to date, there are no such facilities in Egypt.

Pharmaceutical biotechnology, today, can be classified by the scientific methods and toolboxes applied[1]. Subsegments of R&D and industrial production have been defined in various other studies. Accordingly, following commercial sections and product segments can be used to classify pharmaceutical biotech products today: Arrays (incl. DNA microarrays), Bioassays, Biomarkers, Biomembrane, Biomimetics, Biosensors, Biotags, Biothreat Detection, Blood, Bone Marrow, Cardiology, Cell and Tissue markers, cell-based Gene Therapy, Dermatology, Designer Macromolecules, Diagnostics and Analytics, Drugs and Drug delivery, Stem Cells, Endocrinology, Envrironmental monitoring, Enzyme assays, Fluidics, Food safety and Production, Gastroenterology, Genetic assays, Growth and differentiation factors, Gynecology, Imaging, Immunology (incl Human and Animal Vaccines), Instrumentation and Informatics.

However, except vaccines for animals, none of these fields is currently represented by commercial production activitiy in Egypt. Veterinary vaccines is are produced in Egypt (for poultry, cattle, goat and and other agricultural animal).

The following analysis undertakes to briefly analyse the current situation of animal vaccine, globally and in Egypt, striving to outline prerequesties for further development of private investment into this sector in Egypt.

5.1 Introduction

Animal and poultry are playing an important role in the development of agricultural economy as sources of meat, dairy and eggs. Healthy animals produce high quality food. Disease is a concern because it can cause suffering in animals and create large economic losses. It has been estimated that the population of livestock (annually) in Egypt are 800.000.000 chicken, 4.369.000 head of cattle, 3.845.000 head of buffalo, 5.043.000 sheep, 3.879.000 goat, 1.265.000 horse and 130.000 camel (Table 1).

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1 Report on Innovation and Competetiveness in European Biotechnology, European Comission 2002 [1]

Table Number of animal's heads (2006)

Species		Number of animals Total (1000 heads)	Production indicators		
			Milk (kg/head/yr)	Growth gain (g/day)	Ava Weight (kg)
Sheep		5,043	150	150	40
Goat		3,879	200	100	30
Beef	Local	2,709	1,059	500	300
	Improved	1,502	1,735	750	400
	Imported	158	6,000	1,000	500
Water buffalo		3,845	1,629	750	500
Camel		130	1,500	500	500
Horses		1,265			
Chicken		775,499		35-40	1.5-1.75
Chicken –egg imported species		18,529		150-250 egg	
Chicken – egg- local species		10,660		150 egg	
Rabbit		985		15-20	2-3
Fish		3,504			

Sources: National Animal Feeding Program, Animal Production Research Inst, Agricultural Research Center, Giza

Animals suffer from a range of infectious diseases. As veterinary medicine has advanced, prevention of disease has become a priority as healthy food comes from healthy animals. One of the best means of preventing disease is by creating immunity in the animal. This is usually achieved by vaccination. Vaccination protects hundreds of millions of animals worldwide from disease and possibly death.

5.2 Diseases and Vaccination

Diseases are caused by microorganisms such as bacteria or viruses. Like all living things, the cells of such microorganisms are made up of strands of genetic materials called DNA - except the RNA viruses - their genetic material is RNA. Inside the DNA are genes which act like libraries of hereditary information. Every gene is responsible for producing a particular type of protein. Each protein has a particular role to play. Disease-causing organisms are made up of 50-1000 proteins. These proteins are involved in stimulating protection from disease and are called "antigens". Different diseases can be recognized by the unique shape and structure of their antigens. The antigen's job is to alert the animal's immune system that a disease has invaded its body.

When the immune system recognizes the antigens it prepares antibodies to combat that specific disease. A vaccine works by introducing disease-signaling proteins to the immune system so that antibodies can be produced without the animal actually getting the disease.

The principle of vaccination has been established for over 200 years. Since those early days, enormous strides have been made in the development of vaccines which have helped to prevent and in some cases eliminate many diseases in humans, farm animals and the pet animals.

The diseased animals often require treatment with medicines which will be effective in some diseases and not effective in the others. So vaccination significantly helps reduce the amount of pharmaceuticals used in the treatment of animals.

Animal vaccines are a cost effective method to prevent animal diseases, to increase the efficiency of food production, and to increase the availability of high quality protein for human consumption.

Veterinary vaccines may contain live or inactivated organisms and can be divided into different categories based on the type of the antigen used as active ingredient, e.g. virus, bacteria, protozoa, parasite or toxoids.

The live attenuated vaccine has usually been developed by serial passages of the virus in animals, embryonated eggs or cell cultures. For its efficacy this type of vaccine depends on the replication of the vaccine microorganism in the vaccinee and therefore elicits an immune response by production of the appropriate antibodies Attenuated vaccines are particularly effective in providing long-term protection, because they are a more powerful stimulus to the immune system. They are also more versatile in their rout of administration.

The inactivated or (killed) vaccines are usually manufactured by producing large amounts of the organism, which are then concentrated, purified and subsequently inactivated by chemical and / or physical means. In general, the safety of these vaccines is greater than that of life attenuated vaccine, but provides a relatively short period of immunity. Killed vaccines are usually combined with an adjuvant such as aluminum hydroxide gel or oil.

Vaccination can be applied by different routes: through drinking water, baits, air-spray, eye inoculation, intranasal, orally or using the more classical injection.

Achieving initial immunity may require more than one injection. Once established, this can be boosted by subsequent vaccination, as required. Modern vaccine research and technology means that some vaccines can actively protect against a variety of diseases, in a single product. These are called multivalent vaccines and using these reduces the number of injections, broadens disease protection - and helps reduce costs to the farmer.

5.3 Biotechnology and vaccines

Traditional vaccine technology has its limitations; almost all vaccines consist of either inactivated or attenuated strains of the pathogen. For this scientists have turned their attention towards the molecular vaccines e.g. subunit, synthetic peptide, live vector, DNA, and edible vaccines.

Biotechnology can provide vaccines for diseases which can not be controlled by conventional vaccine technology and create more specific, better defined products. Biotechnological tools are able to identify the protective antigen and the genes encoding protective antigens. In some bacteria identifying the genes' coding for toxins production and expressing them by recombinant means is very important, many bacterial genes have been expressed in E. coli or other Gram-negative microorganism (eukaryotic system) and tested experimentally as potential vaccines.

A number of important veterinary vaccines have been investigated using different eukaryotic expression system. The most common is the use of mammalian viruses such as Capri pox, herbs, adenovirus, for expression of the desired protein.

For poultry vaccine; a recombinant fowl pox, canary pox and baculovirus were used for expressing different genes of Newcastle, IBD, influenza, have been implemented.

Whether for disease prevention or treatment, the veterinarian, the animal owner and the public all have a right to expect that the research, development should bring to market of reliably animal medicines based on the triple standards of quality, safety and efficacy.

5.4 Diseases controlled by vaccines

Not all animals need every vaccine. Some, like clostridial disease prevention, are basically routine. The vaccination program chosen for farm animals depends on the management system, the location of the farm and the history of the herd or flock (and whether or not a disease is likely to be encountered). Most farm animals are young, and these animals are often more susceptible to infection. So, for example, calves often need to be protected by vaccination against respiratory disease.

Cattle diseases: blackleg, tetanus, 'husk' (lungworm disease), pasteurellosis, leptospirosis, salmonella, E.coli, enteritis, mastitis, ringworm, rotavirus, infectious bovine rhinotrachietis (IBR), respiratory syncytial virus, BVD, PI3, coronavirus, foot and mouth disease, rift vally fever.

Sheep and goats disease: Clostridial diseases (8 different species including tetanus), pasteurellosis, ovine abortion (chlamydiosis and toxoplasmosis), louping ill, footrot, contagious pustular dermatitis (orf), sheep pox, rift vally fever.

Poultry diseases: avian encephalomyelitis, avian infectious bronchitis, avian infectious bursal disease, avian reovirus, chicken anaemia virus, duck virus enteritis, egg drop syndrome (1976), erysipelas, infectious laryngotracheitis, Marek's disease, Newcastle disease, pasteurellosis, post-natal colibacillosis, salmonellosis, avian coccidiosis, swollen head syndrome, turkey haemorrhagic enteritis, turkey rhinotracheitis.

Fish Enteric red mouth disease, furunculosis, vibriosis (vibrio anguillarum, vibrio salmonicida and Vibrio viscosus (now named moratella viscos)

5.5 Global vaccine industry

The Veterinary vaccines accounted for 14.4% of the total world market for veterinary animal health and nutrition products. The vaccines sector has grown. This can be attributed to the development of technologically advanced new vaccines and of vaccines against diseases not previously covered. In particular, biotechnology offers significant potential for new product development.

Internationally, there has been significant consolidation in the biological sectors over the last few years, following a series of high-level mergers and acquisitions in the animal health industry. These have not only led to a change of leadership in the global veterinary vaccine market but also to increased market shares amongst the major players. The industry is organized by International Federation for Animal Health (IFAH) Geneva, Switzerland. The top three vaccine manufacturers hold 45% of the biological market between them. Furthermore, the leading eight companies account for nearly three quarters of the market, with the remainder being supplied by companies with national or regional interests, or multinationals with comparatively small interest in biologicals.

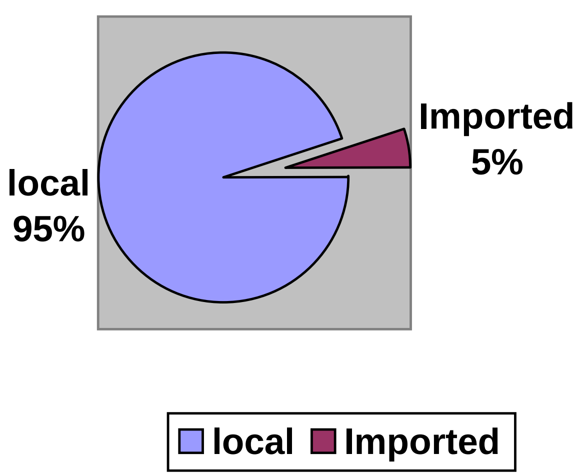
5.6 Veterinary Vaccines' Demand and availability in Egypt

Egyptian National markets are very diverse in terms of the major species that are targets for vaccine use. Consumer demand for the end product (i.e. livestock meat), the intensity of the production system, and the importance of the companion animal sector are influential in market sizes and trends.

5.7 Animal Vaccines Market Orientation

Clearly, Egypt is an importer of red meat. However, farm and domestic animals' vaccination have traditionally always been under the direct control of the government through General Agency for Veterinary Services, Ministry Agriculture and land Reclamation (established by a Presidential Decree 187/1984). The Agency is providing and monitoring vaccination programs for all animals and keeping strategic quality stock of all sort of animal vaccines to be used during emergency outbreak, e.g. Foot and Mouth Disease (FMD). The vaccines available through the Agency are highly subsidized in order to prevent epidemics which might affect the volume and the quality of livestock (no violation for WTO regulations). The Agency depends on government facilities to produce 95% of the animals vaccines needed for their vaccination national programs as shown in details in table (2) and fig (1) of 2006 market data. The heavy subsidiary regimes for the animal vaccines had and continue to prevent any new private investment in that industry. On the other hand, serious upgrading program is recommended to improve the government owned production units.

Fig (1)Animal Vaccines Market Orientation
(excl. Poultry)



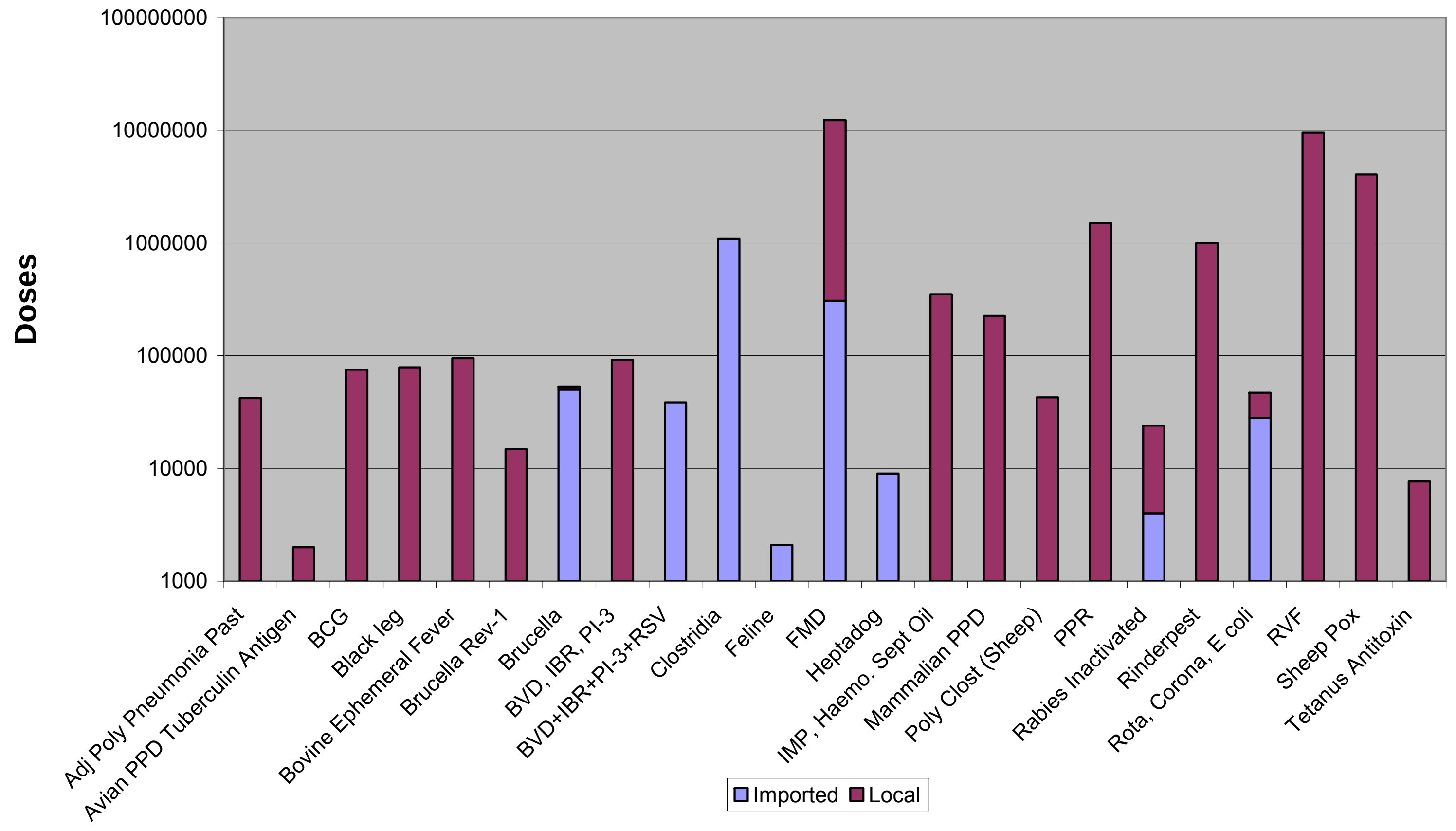
These production facilities are affiliated with Agricultural Research Center and is located East of Cairo in an area used to call Abasia Desert. The facilities setup and capabilities will be discussed later in this report.

The local production depends on isolation and identification of local strains of pathogens which known to be more adapted to environment surrounding the infected animals. Biological preparations using local strains are known to be more effective in protecting animals.. A type cultures collection is not available for strains long term storage and identification which is vital resources for that industry.

Table Animal Vaccines (excl poultry) Demand for Egyptian Market (2006) in Doses

Vaccines	Imported	Local
Adj Poly Pneumonia Past	0	42,000
Avian PPD Tuberculin Antigen	0	2,000
BCG	0	75,000
Black leg	0	79,000
Bovine Ephemeral Fever	0	95,000
Brucella Rev-1	0	14,850
Brucella	50,000	3,410
BVD, IBR, PI-3	0	92,000
BVD+IBR+PI-3+RSV	38,580	0
Clostridia	1,097,000	0
Feline	2,100	0
FMD	307,405	12,001,800
Heptadog	9,000	0
IMP, Haemo. Sept Oil	0	350,250
Mammalian PPD	0	225,000
Poly Clost (Sheep)	0	42,600
PPR	0	1,500,000
Rabies Inactivated	4,010	20,000
Rinderpest	0	1,000,000
Rota, Corona, E coli	28,100	19,000
RVF	0	9,500,000
Sheep Pox	0	4,050,000
Tetanus Antitoxin	0	7,675
Total	1,536,625	29,120,385

Fig (2) Animal Vaccines-Market Orientation 2006



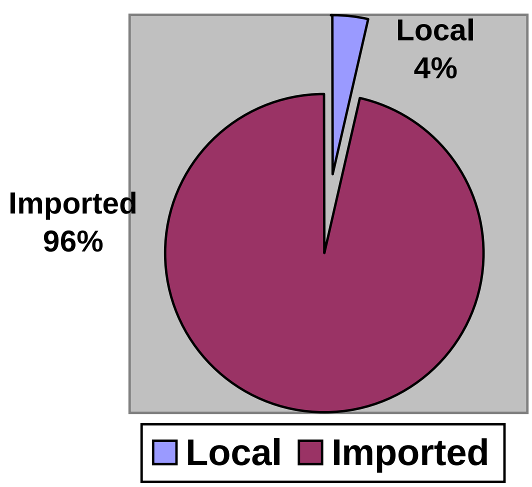
5.8 Poultry Vaccination in Egypt

Egypt poultry industry has allocated about 36 billion Egyptian pounds ($6 billion) in investment and employing between 2.5-3 million people. Poultry account of about 45-50% of the animal protein consumption.

The poultry industry is regulated through some relevant Ministerial decrees and organized through an Association for Poultry Producers. The industry has expanded in the last few years to the extent that covers the needs of poultry meat and eggs. The numbers of broiler farms of the private sector have reached about 17.000 farms with production more them 800.000.000 broiler chicks per annum.

The mass expansion of poultry industry encourages many of the private enterprises as well as the government sector to import different breeds of poultry from different parts of the world. , Egypt used to import 180 million one-day old chicks and 500.000 million fowl annually This importation of poultry has the risk of introducing of different diseases such as IB, ILT, AE,

Fig (3) Poultry vaccines Demand 2006

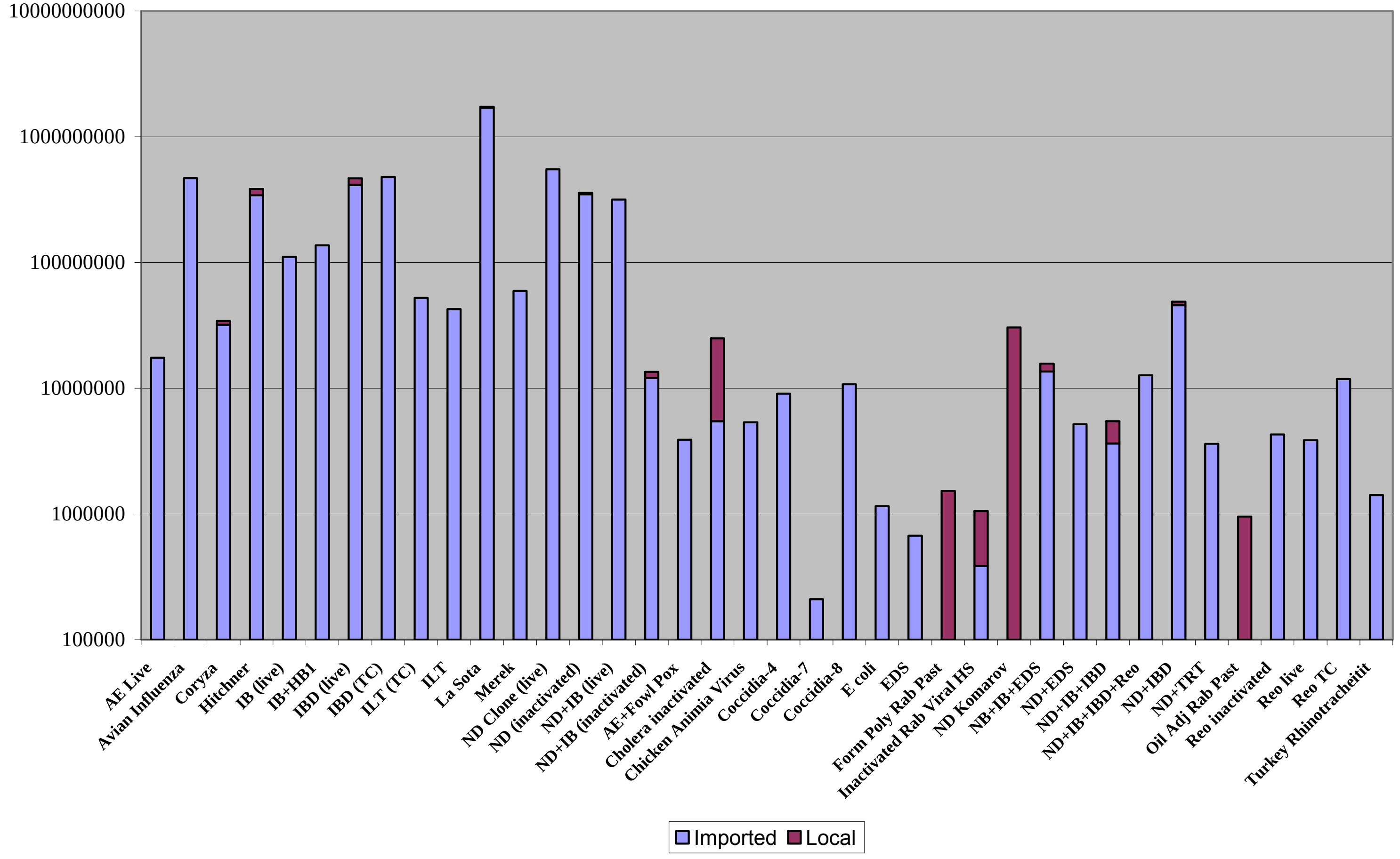


Marek's etc (for details see tables 1-3) which can cause great economical losses in the industry without mass vaccinations with potent poultry vaccines doses (vaccination programs). In contrast of animal vaccines, small portion of poultry vaccines are locally produced and a great bulk are imported as shown in fig (3) and with more details in fig (4) and table (6). The imported poultry vaccines cost about $700-800 million annually

Table: Poultry Vaccines Market in Egypt (Doses)

	Year 2003	Year 2004	Year 2005	Year 2006
AE Live	10,540,000	27,130,000	16,160,000	17,470,000
Avian Influenza				469,635,000
Coryza	19,41800	33,033,000	43637000	34,124,000
Hitchner	691,100000	702,783,000	1,011,442,000	394,190,000
IB (live)	142,100000	392,525,000	189,620,000	110,830,000
IB+HB1	197,580000	295,840,000	219,110,000	136,750,000
IBD (live)	938,000,000	1,739,940,000	2,059,193,000	467,358,000
IBD (TC)	3,200,000	4,671,000	5,178,000	477,215,000
ILT (TC)				52,150,000
ILT	40,000,000	25,945,000	77,415,000	42,530,000
La Sota	1,277,000,000	2,604,550,000	3,220,624,000	1,726,998,000
Merek	242,600,000	232735000	341,736,000	59,347,000
ND Clone (live)	758,100,000	525,815,000	956,855,000	552,485,000
ND (inactivated)	234,297,700	415,442,000	667,802,000	357,810,000
ND+IB (live)	248,750,000	150,235,000	456,950,000	316,190,000
ND+IB (inactivated)	66,900,000	10,978,000	15,648,000	13,472,000
AE+Fowl Pox	36,500,000	56,932,000	134,250,000	3,899,000
Cholera inactivated	29,325,000	31,810,000	36,626,000	24,960,000
Chicken Animia Virus	6,910,000	3,350,000	4,269,000	5,360,000
Coccidia-4	3,828,000	26,930,000	12,190,000	9,050,000
Coccidia-7			210,000	210,000
Coccidia-8			13,460,000	10,730,000
E coli	300,000	1,368,000	1,080,000	1,152,000
EDS	900,000	350,000	700,000	670,000
Form Poly Rab Past	595,000	1,510,500	1,592,500	1,530,000
Inactivated Rab Viral HS		267,000	420,290	1,000,000
ND Komarov			259,00,000	30,450,000
NB+IB+EDS	81,810,000	13,896,000	18,811,000	15,659,000
ND+EDS	5,564,000	3,257,000	8,629,000	5,172,000
ND+IB+IBD	57,673,000	2,608,000	2,330,000	5,470,000
ND+IB+IBD+Reo	6,532,500	8,455,000	8,973,000	12,698,000
ND+IBD	553,800,000	31738000	47502000	48,860,000
ND+TRT	10,764,000	2,520,000	5,436,000	3,612,000
Oil Adj Rab Past	480,000	774,000	600,000	951,000
Reo inactivated	53,500,000	14,968,000	9,910,000	4,282,000
Reo live		17,140,000	13,830,000	3,850,000
Reo TC				11,820,000
Turkey Rhinotracheitit	16,200,000	5,850,000	1,770,000	1,410,000

FIG (4) Poultry Vaccines-Market Orientation 2006



5.9 Vaccines Production in Egypt

There are two main facilities for vaccines production in Egypt – **none of them is privately owned**. One is dedicated for human vaccines (VACSERA) and affiliated with Ministry of Health and the other is dedicated for animal and poultry vaccines and biological preparations (VSVRI) and affiliated with Ministry Agriculture and Land Reclamation.

Beside those production facilities there are numerous importing firms working as agents for multinationals and are able to fill the gap between animal and poultry vaccines demand and local supply through importation. The market is regulated by international standards to insure the safety, efficacy and quality. The animal and poultry vaccines are all monitored through a governmental Central Lab for Monitoring Veterinary Vaccines and Biological Preparations. The lab use state of the art protocols to test the efficacy, safety and the quality of all vaccines before entering into the market. It is of key importance to keep the existing facilities at state of the art technically and finance them well.

Foreign or even Egyptian investors may benefit from market opportunity for setting up a production facility from scratch.

The Veterinary Serum and Vaccine Research Institute (VSVRI)

VSVRI is a certified local production facility for veterinary vaccines. The institute is the oldest and largest veterinary research, R&D, and production institutes in Africa and the Middle East.

It was establishes in 1903 on an area of about 23 hectares in the Abbesses district, East of Cairo. It used to be affiliated with the Ministry of Health until 1914 when it became part of Veterinary Medicine Department, of Ministry of Agriculture. The responsibility of the institute was limited to produce antiserum for protecting cattle against Rinderpest (cattle plague). In 1928 vaccines for hemorrhagic septicemia, fowl plague, and fowl cholera were prepared for the first time.

In 1934, Rinderpest vaccine was produced. New vaccine such as Newcastle vaccine for poultry, Rinderpest tissue culture, Foot and mouth disease, and Rift Valley fever Vaccines were produced in 1948, 1963, 1973 and 1978 respectively.

The institute became an independent institute, affiliated with the Agricultural Research center (ARC) in 1983.

VSVRI is organized into 14 departments. Thirteen departments for vaccine R&D and one genetic Engineering department besides the Computer unit, conference room, library, Animal care unit, unit for breeding of small laboratory animals, lyphilization unit (freeze drier unit) condemnation unit and veterinary biological products sales unit.

The overall goal of the institute is to:

1. Conduct researches associated with the improvement of bacterial and viral veterinary vaccines, diagnostic products and antisera to immunize farm animals, poultry and pet animals against outbreaks of infectious diseases endemic in Egypt or against diseases introduced through importation of animals.
2. Use of new technology and molecular Biology tools to improve the veterinary vaccines and diagnostic reagents to obtain high potent vaccine and rapid, sensitive diagnostic reagent.
3. Increase the production of poultry and animal vaccine to satisfy the need.
4. Conducting training program in different vaccines techniques(development, formulation, and QC),

The Vaccines Production Facilities at VSVRI:

As mentioned before the VSVRI has 13 viral & bacterial vaccine production departments. Each unit is dedicated to produce special vaccines depending on the type of caused agent (table 7).

The Poultry viral vaccine unit produce about 19 products with capacity covers only 3% of the poultry vaccine local market .

The unit is equipped with:

1. Incubator (5) for SPF egg with a total capacity of 12500 egg and 4 new incubators with a total capacity of 35000 egg, The SPF eggs consider the main material for poultry vaccine preparation
2. 2 lyophilized machine with capacity of 7200vial/run and can work twice a week (14400 vial/week).
3. Filling machine with capacity 7000 vial /hr
4. Labeling machine with capacity 10000 vial /hr
5. 4 laminar air flow .

The VSVRI has large animal isolation facility with capacity:

1. 100 head of cattle , 50 sheep, and 20 horses.
2. Laboratory animal production farm (mice and rat)with production capacity 2000 mice./month

Table Vaccines produced from different units at VSVRI

Production Department	**Vaccines**
Poultry viral vaccines	new castle (HB1), new castle (komarov), new castle (LaSota), new castle clone(live) , Inactivated new castle, new castle + Infectious Bronchitis, ND+IBD, ND+ IB (Inactivated), HB1+IB, ND+IB +IBD, ND+IB+EDS, Infectious Bronchitis (live), Infectious Bursal Disease (D78, Infectious Bursal Disease(Bursa), Reo strain (1133), Duck Plaque, Duck virus Hepatitis, Pigeon Paramyxo, Inactivated Rabbit D.vaccine
Pox vaccine	Fowl Pox, Pigeon Pox, Sheep Pox (TC), Camel Pox (TC),
Rinderpest Vaccine	Rinderpest (TC)& PPR (TC)
Rift Valley Fever	RVF (Inactivated&attenuated)
Foot and Mouth Disease	FMD (Inactivated Monovalent&Bivalent O&A)
Rinderpest like Vaccine	BVD,IBR,PI-3, BVD,IBR,PI-3,RSV, Pneumo-3
Pet animal	Distemper, Feline, Rabies Inactivated, Parvo &BEF.
African Horse Sickens	African horse sickness
Anaerobic Vaccines	Infectious coryza-oil adj, Blackleg and gas gangrene Bivalent, Lamb Dysentery and Pulpy Kidney, Black Disease, Poly Valeant Clostridia for sheep
Aerobic Bacterial	Fowl Cholera- oil adj. Polyvalent, Rabbit past eurellosis-oil adj. polyvalent, Rabbit pasleurellosis Formalized. Polyvalent, Haemorrhagic septicemia oil adj for cattle, Haemorrhagic septicemia oil adj for sheep
Bacterial Diagnostic Products	Avian ,Bovine &mammalian P.P.D Tuberculin, Mammalian BCG
Bacterial Sera and Antigens	Brucella Rev-1, Brucella (st 19), Tube agglutinative Brucella antigen, Buffer Acidified plate, Brucella Antigen Rose Bengal, Brucella Antigen Rivanol, Brucella Antigen Rivanol solution, Milk Ring Test Brucella Antigen, Anti- Tetanic serum
Parasitic	Theileria annulata attenuated tissue culture&Inactivated Spirochetosis

.

5.10 Future Trends in Veterinary Vaccines Demand in Egypt

Fig (5) depicts the demand for various poultry vaccines (from 2003-2006) and Tab(3) shows the demand for various animal vaccines for the same period (2003-2006). Some of these vaccinations are required by industry as a routine program for preventive reason other are required as a reaction to out break as in the case of Avian Influenza. Private investment should be encouraged to take the lead in the future of this industry. New technology in target antigens' (receptor) identification and immune-protein synthesis using molecular biology tools, etc. According to the diseases profile of both animals and poultry in Egypt, it is expected that the following diseases (vaccines) will continue to lead the veterinary vaccines market for at least 10 years:

5.10.1 Avian Influenza (AI) vaccines demand in commercial birds

Outbreaks of avian influenza during the late 2005 in the poultry industry have caused devastating economic losses. A successful vaccination campaign is highly recommended by using a high quality vaccines complying with OIE standards. With the expansion plan of the industry the expected market size will grow to be around 900-1000 billion flocks per year. The market for AI vaccine will be 800-900 billion doses per year.

For production of AI vaccine locally, an appropriate infrastructure need to be available and permitted for such activities to ensure the rapid and safe delivery of vacancies, monitoring of vaccinated flocks, and control of poultry market. The recommended requirement specifically for AI vaccines are:

a- Operation facility with a biosafety level of p3 which will be suitable for work with infectious agents AI virus which may cause serious or potentially lethal diseases as a result of exposure by the inhalation route. These operation facilities are characterized by having double door entry, particular attention is given to air movement. Air moves from area of lesser contamination to areas of higher contamination, such as from the corridor into the laboratory. Air movement is also single pass; exhaust air is not re-circulated to other rooms.

b- Permission from General Organization of Veterinary Services in Egypt to import the virus strain which will be compatible with the virus isolated from Egypt.

5.10.2 Marek's Disease (Visceral Leukosis)

Merek's disease is a lympho proliferative disease of chicken characterized by presence of lymphoid tumors of a yellow/white color in various organs e.g. liver, spleen, kidneys, ovary, lungs, heart, muscles, scialie and bronchial nerves. Chicks up to one week of age are more susceptible than older ones. The Merek AL vaccine is effective in the prevention of Merek's disease. It is administered to one-day old chickens while the birds are in the hatchery.

The current market demand for Merek vaccine is 60 million doses per year. All are imported. With the expansion plan of the industry the expected market size will grow to be around 90-100 million doses per year.

5.10.3 Avian Encephalomylitis (AE)

Avian Encephalomyltis (AE) disease can cause devastating egg production drop in laying hens. In breeders, the AE virus can be passed to offspring resulting in neurological disorders and mortality. When AE causes neurological lesions, it may be described as "Crazy Chick Disease". AE or AE + fowl pox vaccines are imported with an estimation of 22 million doses have been certified for selling during 2006. No local production. The expected demand will be expanded to 28-29 million doses up to year 2012.

5.10.4 Newcastle disease

Newcastle disease is a highly contagious viral infection causing a respiratory nervous disorder in several species of poultry including chickens and turkeys. The most severe virus strain is called viscerotropic velogenic Newcastle disease (VVND). A milder form of the disease is called mesogenic Newcastle disease. Vaccination is a recommended method in all vaccination programs for prevention of the Newcastle disease. The current (2006) market for all Newcastle vaccines' combinations and formulations is 1314 billion doses of those only 10 million doses are locally produced (0.7%)

5.10.5 Clostridial Disease Vaccines

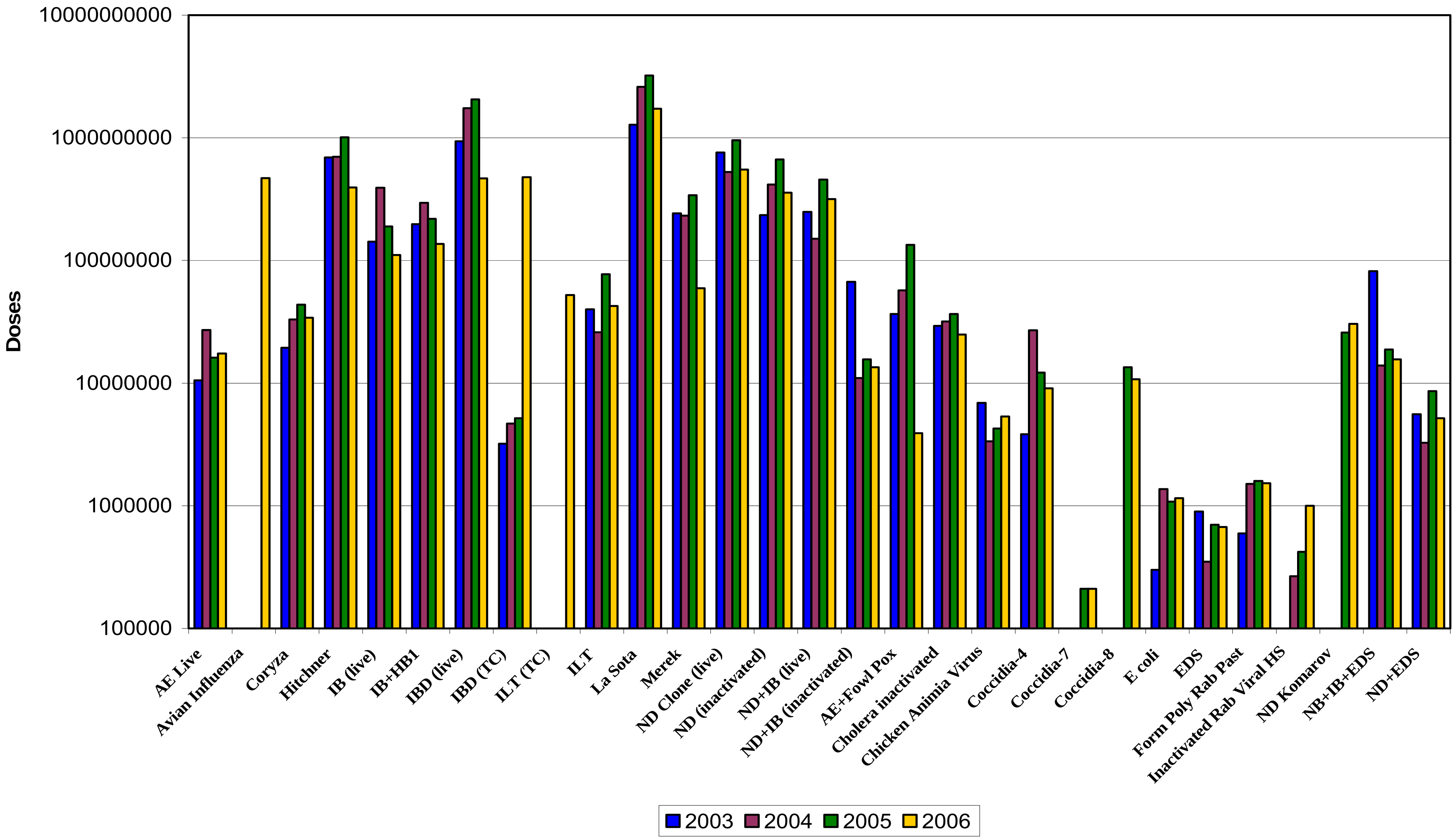
Clostridial diseases go by many names depending on the specific bacteria causing the disease, or the clinical signs associated with it. Black leg, enlerolaxenin and letanus are all clostridial diseases. The diseases progress rapidly and sudden death is often the first and only sign of disease. In the case of letanus, signs include muscle spasms, rigid limbs, extreme sensitivity to touch and sound, and death within 3-10 days. Clostridial perfringens type A causes blood clots in the intestines, leading to enlarge and/or obstructed bowels, and in calves causes quick onset of abdominal distension with pain, bloat, depression, and feed refusal. Clostridial perfringens type C and D cause severe abdominal pain, diarrhea, depression and convulsions. According to the last market data released by the Central Lab Monitoring Vet Vaccines and Biological Preparation of 2006, one million doses are released to the market up by 15% from the previous year. None is produced locally.

5.10.6 Brucella Vaccine

Brucellosis is a worldwide zoonosis transmittable to humanscausing acute febrile which may progress to a more chronic form. The disease is affecting various domestic wild life species and resulting from infection with Gram negative bacteria belonging to the genus Brucells. The transmission of the disease is done through ingestion, direct contact via skin abrasions and mucous membrane, inhalation, risk factors includes contact with infected tissues, blood, urine, vaginal discharge, aborted fetuses, ingestion of raw milk, or cheese from infected animals.

The vaccine that has been most widely used to prevent bovine brucellosis is B. abortus strain 19. Rev. 1 vaccine is alive attenuated B. melitensis strain derived from a virulent B. melitensis, it stimulates protection against infection with B. melitenses in sheep and goats and protects rams against infection with B. ovis

Fig (5) Poultry Vaccines Market Development 2003-2006



5.11 Boosting of veterinary vaccines production in Egypt

To support the local animal and poultry industries; veterinary vaccines have to be available strategically and on demand in order to protect the investment capitals and to secure safe and quality sources of both red and white meat for local market and for exporting. Under all conditions and according to experts in the industry, veterinary biological preparations produced through utilization of local forms of the disease causative agents, have showed more efficacy than imported forms. All are depends of using of advance technology, proper production facilities and trained staff. Veterinary vaccines local market is account for $1-1.2 billion per year. The market share of the chicken vaccines' sector is about 70-80%. The market share of the local production facilities are 80% of the animal vaccines and only 3% of the poultry vaccines.

5.12 The legal environment of veterinary vaccines industry in Egypt:

There are extremely stringent requirements for product registration set down in Egyptian law. If these requirements are not met, a vaccine will not be allowed on the market. Careful monitoring and reviewing of products and disease patterns ensure that once on the market, vaccines remain safe and effective. There are very strict quality control processes to guarantee the safety and efficacy of each dose of vaccine.

In Egypt the Central Laboratory for Evaluation of Veterinary Biologics (certified facilities for ISO) is responsible for the evaluation of all local and imported vaccines. By law, all veterinary vaccines should be permitted by this lab for safety and potency before marketing.

Production facilities would be certified, according to GMP from the General Agency for Veterinary Services. There is no law or regulations which could have any restrictions for private investments in the veterinary vaccines production, marketing and sales.

Please refer to the following laws and decrees for further info

- Law 53/1966 Agriculture law
- Law 187/1984 Establishment of General Authority for Veterinary Services.
- Law 96/1998 Establishment of General Association for Poultry Producers
- Ministerial Decree 1563/1993 For Poultry vaccines
- Ministerial Decree 37/1981 for Importing of Veterinary Vaccines
- Ministerial Decree 11/1983 for Monitoring of imported Veterinary vaccines
- Ministerial Decree 348/1988 for Animal Vaccines prices

Vaccines and biological preparations industry is a dynamic short call business. The out break of any disease can happen in a matter of weeks – a month as a maximum (the out break of Avian Influenza is a good model). Access to data, information and predications within the poultry and animal industry is then crucial to make the right vaccines available at the right time with the right efficacy and to protect private investment. The culture of government agencies to make such data and information available to private request still lacks behind – as a matter of fact. The analysts see possibilities to improve the section – maybe in cooperation within policy makers.

Poultry Industry shows almost 100% private sector investment and a tendency to attract further private investment. In order to secure the positive development of this industry the establishment of independent production facilities for veterinary health products (vaccines and biological preparations) seems desirable. For preparation of a investment paln following key figures need to be adreessed and analyzed in detail:

The actual market data about the real volume of poultry production and its geographic distribution (registered and non-registered poultry farms) in Egypt. Such data will help business investors determine the capacity and the list of veterinary products need to be traced.

The actual data regarding diseases pattern facing the industry and the existence of intelligence prediction system to monitor the epidemiological trends of each disease. The information will be helpful for vaccines industry to prepare products R&D and production time table.

The production of vaccines depends on the availability of core agents represented by type culture and reference strains of microorganisms isolated and identified according to industry standards. Importing or licensing type culture strains costs large investment in both licensing fee and intellectual property royalty.

With the diversity and the complexity of production standard (GMP) for each product, high caliber trained technical staff as well as sources of technical and logistic information are vital to support the success of that industry. The General Association for Poultry Producers should be a co-investor with the government in that area.

5.13 Modernization of Veterinary vaccines production national facilities

5.13.1 Vision

Introduction of private-based veterinary vaccines industry in Egypt to serve national and regional markets

5.13.2 Mission

Make available state of the art veterinary vaccines production and monitoring facilities able to provide the national and the regional Animal and Poultry industries with safe and high potent veterinary vaccines with reasonable cost to enhance the competitive advantage of the local industry.

5.13.3 Goals

Start a monitoring, data collection and clearance house program for veterinary vaccines industry to make available in timely based critical data and information needed for production strategy. The program need support from government, animal and poultry industries.

Upgrade the excited production national facilities to level BSL2, BSL3 and P3 to serve as sources of technical, and staff supports for the local private industry.

Establish a resource industry based-culture bank to be used to provide local industry with reliable certified, well identified, high potent and pure strains. The Bank also will work as a reference for strain verifications.

Certified the current production facilities according to ISO standard and GMP of the industry,

Provide the technical and the non-technical staff with the proper skills for technology and business development, service providing and QC and assurance.

5.13.4 List of recommended equipment for upgrading both production and monitoring facilities at ARC:

- Two lyophelization of live attenuated vaccines with capacity of 30000vial /process each
- Automated filling machine of 2-50mm (filling-partial stoppering- capsulation) capacity of minimum 1800vial /hr
- Semi automatic filling machine suitable for filling glass or plastic bottles 50-550 ml capacity.
- Semi automatic capping machine suitable for capping 100, 300 and 500 ml
- Continuous flow cooling centrifuge.
- High speed cooling centrifuges with rotor for 6 cups 500 ml each
- Biosafety cabinets for working with pathogenic viruses and bacteria.
- Pilot fermenters of about 300-500 liter for anaerobic pathogenic bacteria sterilizable in situ..
- Automated sequencer.(for upgrading genetic engineering department)
- Real time PCR. .(for upgrading genetic engineering department

This study allows for analysis of costs and benefits of vaccine industry as well as to calculate the net value that will lead to the vaccine developement ,which will creat incentives for industry to increase investment in research and development.

6 International Product Listings

Below (Tables 2-4) are complete lists of Poultry Products available internationally. This Product Guide is intended for international use, and contains information on veterinary pharmaceutical and biological products that are sold in several different countries and areas. Many of the products in this Guide may be marketed under different trade names and pursuant to different regulatory approvals.

6.1 Live Poultry Vaccines

AE + Pox	live vaccine against Avian Encephalomyelitis and Fowl Pox in chickens and turkeys
AE 1143	live vaccine against Avian Encephalomyelitis in chickens and turkeys
CAV P4	live attenuated vaccine against Chicken Anaemia Virus
COX ATM	live vaccine against field infection caused by strains of *Eimeria acervulina, Eimeria tenella and Eimeria maxima*.
Duck Plague	live vaccine against Duck Plague
Gumboro Broiler	live vaccine for the immunization of chickens against Infectious Bronchitis serotype 4-91 and related serotypes.
Gumboro D78	live freeze-dried vaccine against Infectious Bursal Disease (IBD). Containing at least log$^{4.0}$ TCID$_{50}$ per bird dose it is indicated for active immunisation of chickens against Gumboro (IBD) disease.
Gumboro 228E	live freeze-dried vaccine against Infectious Bursal Disease (IBD). Containing at least log$^{2.0}$ EID$_{50}$ per bird dose it is indicated for active immunisation of chickens against Gumboro (IBD) disease
IB Ma5	live vaccine against Infectious Bronchitis seortype Massachusetts (strain Ma5) in poultry
IB D1466	vaccine against Infectious Bronchitis serotype D212 (strain D1466) in poultry
IB D274	live vaccine against Infectious Bronchitis serotype D207 (strain D274) in poultry
IB H120	live vaccine against Infectious Bronchitis seortype Massachusetts (strain H120) in poultry
IB 4/91	live vaccine for the immunization of chickens against Infectious Bronchitis serotype 4-91 and related serotypes
IB Ma5	live vaccine for the immunization of healthy chickens against disease caused by the Massachusetts type (Ma5) or serologically related types of Infectious Bronchitis Virus
ILT	live vaccine against Infectious Laryngotracheitis in poultry
Ma5 + Clone 30	live vaccine against Infectious Bronchitis serotype Massachusetts (strain Ma5) and Newcastle Disease in chickens
Marexine CA126 + SB1	live vaccine for the active immunization of chickens against Marekâ€™s Disease
Marexine CA126	live vaccine for the active immunization of chickens against Marekâ€™s Disease.
Marexine-89/03	live vaccine against Marekâ€™s disease and Infectious

	Bursal Disease in chickens.
Ma5 + Hitchner	live vaccine for the immunization of healthy chickens against disease caused by the Massachusetts type or serologically related types of Infectious Bronchitis Virus, and Newcastle Disease
MG 6/85	live freeze-dried vaccine for the active immunization of chickens to reduce clinical signs of infection with *Mycoplasma gallisepticum*.
ND C2	live vaccine for active immunisation of chickens to reduce clinical signs and mortality caused by Newcastle disease virus.
ND Clone 30	live vaccine against Newcastle Disease in chickens
ND Hitchner	live vaccine against Newcastle Disease in chickens
ND LaSota	live vaccine against Newcastle Disease in chickens
Ovo-Diphtherin	live vaccine against pox in chickens and turkeys
Paramyxo P201	an inactivated vaccine against Paramyxovirus Disease in pigeons
Pigeon Pox	live, freeze-dried vaccine against Pox in pigeons
Reo + IB + G + ND	a combined inactivated vaccine against Reovirus infections, Infectious Bronchitis (Massachusetts type), Infectious Bursal Disease and Newcastle Disease
Reo 1133	a mild vaccine against Reovirus infections in chickens
Reo 2177	a live vaccine against Reovirus infections in chickens
Rhino CV	live vaccine stimulating active immunity against Avian Pneumovirus infections in chickens.
Rismavac + CA126	a live vaccine for the active immunization of chickens against Marekâ€™s Disease
RTV 8544	live vaccine for the active immunization of chickens against Avian Rhinotracheitis caused by Avian Rhinotracheitis virus infections
SG 9R	indicated for the vaccination of layer type chickens against *S. Enteritidis* and *S. Gallinarum*
TRT	live vaccine against Turkey Rhinotracheitis in turkeys

Source: http://www.thepoultrysite.com/focus/intervet/1833/intervet-poultry-products-nobilis-vaccines

6.2 Inactivated Poultry Vaccines

Corvac	inactivated vaccine for the immunisation of chickens against infectious Coryza. The vaccine contains inactivated bacteria of serotypes A, B and C of *Haemophilus paragallinarum*, the causative agents of infectious Coryza.
Corvac-4	inactivated vaccine for the immunization of chickens against infectious Coryza, caused by the bacterium Haemophilus paragallinarum
COR4+IB+ND+EDS	inactivated vaccine for the immunization of chickens against Infectious Bronchitis, Newcastle Disease, Egg Drop Syndrome and infectious Coryza, caused by the bacterium *Haemophilus paragallinarum*
Coryza	inactivated vaccine for the immunisation of chickens against infectious Coryza. The vaccine contains inactivated bacteria of serotypes A, B and C of *Haemophilus paragallinarum*, the causative agents of infectious Coryza.
EDS	inactivated vaccine for the immunisation of chickens against Egg Drop Syndrome â€™76.
E. coli inac	vaccine for the passive immunization of broiler chickens against colibacillosis by vaccination of broiler breeders
Erysipelas	inactivated vaccine against Erysipelas in Turkeys
G + ND	inactivated combined vaccine for the immunisation of chickens against Gumboro Disease (Infectious Bursal Disease) and Newcastle Disease
G + ND + EDS	an inactivated combined vaccine for the immunisation of chickens against Gumboro Disease (Infectious Bursal Disease), Newcastle Disease and Egg Drop Syndrome â€™76.
Gumboro inac	an inactivated vaccine for the immunisation of chickens against Gumboro Disease (Infectious Bursal Disease).
IB3+G+ND	inactivated combined vaccine for the immunisation of chickens against Infectious Bronchitis (serotype Massachusetts, D207/ strain D274, D212/ stain D1466 and related strains), Gumboro Disease (Infectious Bursal Disease) and Newcastle Disease.
IB3+ND	inactivated combined vaccine for the immunisation of chickens against Infectious Bronchitis (serotype Massachusetts, D207/ strain D274, D212/ strain D1466 and related strains) and Newcastle Disease
IB multi+G+ND	inactivated combined vaccine for the immunisation of chickens against Infectious Bronchitis (serotype Massachusetts and D207/ strain D274 and related strains), Gumboro Disease (Infectious Bursal Disease) and Newcastle Disease
IB multi + ND	inactivated combined vaccine for the immunisation of

	chickens against Infectious Bronchitis (serotype Massachusetts and D207/ strain D274 and related strains and Newcastle Disease.
IB multi + ND	inactivated combined vaccine for the immunisation of chickens against Infectious Bronchitis (serotype Massachusetts and D207/ strain D274 and related strains), Newcastle Disease and Egg Drop Syndrome â€™76.
IB + G + ND	inactivated combined vaccine for the immunisation of chickens against Infectious Bronchitis (serotype Massachusetts), Gumboro Disease (Infectious Bursal Disease) and Newcastle Disease
IB + G + ND	inactivated combined vaccine for the immunisation of chickens against infectious Bronchitis (serotype Massachusetts) and Newcastle Disease
IB + ND + EDS	inactivated combined vaccine for the immunisation of chickens against Infectious Bronchitis (serotype Massachusetts), Newcastle Disease and Egg Drop Syndrome
MG inac	inactivated vaccine against Mycoplasma gallisepticum
ND + EDS	inactivated combined vaccine for the immunisation of chickens against Newcastle Disease and Egg Drop Syndrome
ND Broiler	inactivated combined vaccine for the immunisation of chickens against Newcastle Disease and Egg Drop Syndrome
Newcavac	live vaccine against Newcastle Disease in chickens
OR inac	1x107 cells of an inactivated whole cell suspension of *Ornithobcterium rhinotracheale* serotype A strain B3263/91
Paramyxo	inactivated vaccine against Paramyxovirus Disease in pigeons
Reo + IB + G + ND	combined inactivated vaccine against Reovirus infections, Infectious Bronchitis (Massachusetts type), Infectious Bursal Disease and Newcastle Disease
Reo inac	an inactivated vaccine for the immunisation of chickens against Reovirus infections
RT + IB multi + G + ND	combined inactivated vaccine for the active immunization of chickens against Infectious Bronchitis (serotype Massachusetts and D207 (strain D274 and related strains)) and against Newcastle Disease, Infectious Bursal Disease and Avian Rhinotracheitis
RT+IBmulti+ND+EDS	combined inactivated vaccine for the active immunization of chickens against Avian Pneumovirus, Infectious Bronchitis (serotype Massachusetts and D207 (strain D274 and related strains)), Newcastle Disease and Egg Drop Syndrome.

RT + ND	combined inactivated vaccine for the active immunization of chickens against Newcastle Disease and Avian Rhinotracheitis
RT inac	Inactivated vaccine against Avian Rhinotracheitis caused by Avian Pneumovirus in chickens
Salenvac	indicated for the vaccination of breeders and laying type chickens against *S. enteritidis* infections
Salenvac T	indicated for the vaccination of breeder and layer type chickens against *S. Enteritidis* and *S. Typhimurium*.
TRT + ND	combined inactivated vaccine for the active immunization of turkeys against Newcastle Disease and Turkey Rhinotracheitis (caused by an Avian Pneumovirus).
TRT inac	inactivated vaccine for the active immunization of turkeys against Turkey Rhinotracheitis (caused by an Avian Pneumovirus).

Source: http://www.thepoultrysite.com/focus/intervet/1833/intervet-poultry-products-nobilis-vaccines

6.3 Diagnostics

MG Antigen	used for the detection of a *Mycoplasma gallisepticum* infection in chicken or turkeys
MS Antigen	used for the detection of a Mycoplasma synoviae infection in chicken or turkeys
MM Antigen	for the detection of Mycoplasma meleagridis infection in turkeys

Source: http://www.thepoultrysite.com/focus/intervet/1833/intervet-poultry-products-nobilis-vaccines

END OF REPORT