FINAL REPORT ON THE ASSESSMENT AND COLLATION OF LITERATURE ON ALTERNATIVE UTILISATION OF MAIZE AND MAIZE PRODUCTS – PART 3

by

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1. Executive summary

A study to identify opportunities regarding alternative utilisation of maize was undertaken for the Maize Trust. A broad overview of literature and research, locally and internationally, on maize, maize products and maize processing by-products was undertaken. This led to selection of eight opportunities at different stages of development for which detailed market and patent assessment was undertaken.

Although the information obtained was not detailed enough for an in-depth commercial assessment of the opportunities, some crude scoring and ranking was done. This showed that the most promising opportunities are ethanol from maize, lactic acid and polylactic acid, and cyclodextrins. However, any company that wants to exploit these opportunities needs to look at the synergy with their strategy and resources, and do a detailed techno-economic study to ensure viability.

2. Introduction

During 2004, the South African Maize Forum Liaison Committee extended an invitation to tender for the compilation of results of national and international research projects on alternative utilisation of maize and maize products.

The remit of the tender was to achieve the following:

- Identify opportunities regarding alternative uses for white and yellow maize, maize products and maize processing by-products; while considering prior and current national and international research projects that were or are being conducted on the same;
- Further to this, evaluate and rank these opportunities, with regards to market attractiveness in accordance with the likelihood of commercial success.

3. Methodology and approach

3.1 Proposed approach

CSIR Bio/Chemtek was awarded the tender and proposed the following methodology and approach:

Task 1: Identify categories and product applications for literature procurement and analysis, and further compile product / technology list for workshop purposes. Due to the complex and extensive nature of the proposed study it was proposed that, in consultation with the MFLC, select categories and product applications of maize products/derivatives be identified.

Task 2: Identify key criteria for assessing commercial potential of projects for discussion at workshop.

Task 3: Arrange workshop to communicate and discuss identified opportunities, together with key representative members of the Maize Forum (commercial farmers, emerging farmers, millers, growers etc.), and select opportunities for market and patent assessment. Discuss criteria to be used for assessing commercial potential of opportunities.

Task 4: Procure and analyse market information on selected opportunities.

Task 5: Procure and analyse patents and other intellectual property information on selected opportunities.

Task 6: Analyse data versus criteria and evaluate and score opportunities in terms of commercial success.

Task 7: Prepare report discussing results of literature survey; market assessment; patent evaluation, and opportunities evaluation. Make recommendations versus findings.

3.2 Constraints found with proposed approach

3.2.1 Broad range of study

Task 1 catered for consultation with the MFLC to identify select categories and product applications of maize products/derivatives in order to narrow the focus of the study. However, in a MFLC meeting held in August 2004, the CSIR was requested to conduct a broad study of the research and literature for products from maize and maize processing by-products. This was done and presented in a document entitled “Interim memo on the assessment and collation of literature on alternative utilisation of maize and maize products” (CSIR Report number CSIR/BIO-CHEMTEK/FSTP/MEMO/04/298/B).

The extensive nature of this study meant that less detailed information was found than initially proposed, as the scope was much broader.

3.2.2 Workshop discussions

The aim of the workshop (Task 3), according to the proposed methodology, was to communicate and discuss identified opportunities and to further narrow the focus to selected opportunities. A discussion was also to have been held on the criteria to be used for assessing the commercial potential of the selected opportunities. In the original scope it was envisaged that detailed information for commercial assessment would be obtained as only two to three opportunities would be selected.

However, as the scope was much broader than initially proposed as requested by the MFLC in August 2004, information on all of the maize products was presented at the workshop. While there was some discussion on these and some indication of what not to take further, very little focus was given. Eight opportunities were consequently recommended by the CSIR for market and patent assessment. This meant, therefore that the information obtained was much broader than initially envisaged, but less detailed.

3.2.3 Criteria and commercial assessment

Criteria for assessing the commercial potential of products is typically financial. However, as the number of opportunities that were to be assessed was much broader than initially envisaged, general market and patent information was gathered rather than detailed financial information.

Criteria for the market and patent assessment were proposed at the workshop, and these were broadly followed when the information was obtained. However, information required for scoring and ranking opportunities for commercial assessment was not readily obtained, except for ethanol production.

3.3 Approach adopted

The methodology followed and structure of the report is summarised in Figure 1.

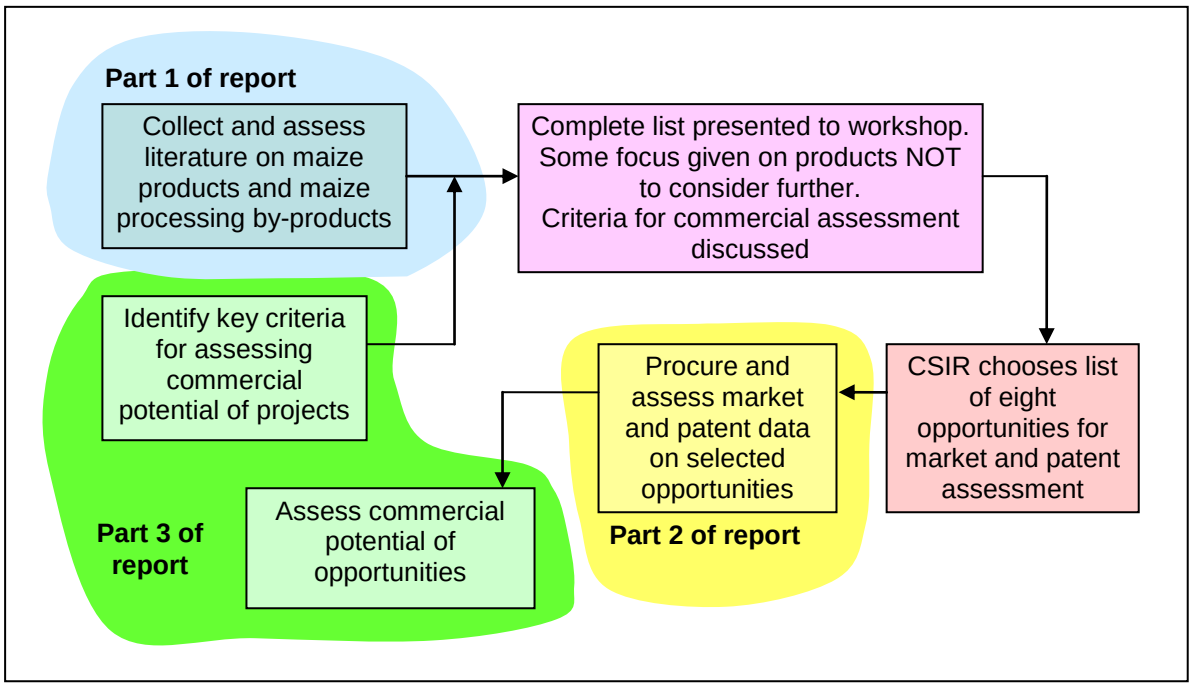

Figure 1: Methodology followed

In Part 1 of this report (blue in Figure 1), a extensive literature study incorporating information from national and international research projects on maize, maize products and maize processing by-products was detailed. In Part 2 of this report (yellow in Figure 1), market and patent opportunities were detailed and analysed for product opportunities discussed at a workshop held on 21 April 2005 (purple in Figure 1). This document is Part 3 of the final report (green in Figure 1) and briefly outlines the criteria identified as relevant for assessing the commercial potential of projects, summarises the analysis from Part 2 of the report, and then presents information relevant for assessing the commercial potential of opportunities.

3.4 Summary of workshop outcomes

The aim of the workshop was to share the information from the literature (Part 1 of the report) with key stakeholders, receive feedback on the data and discuss a way forward. The workshop proceedings are attached in Appendix 1.

Some of the issues raised at the workshop were:

- Using maize stover (e.g. for bioethanol) is not a likely possibility in SA as this is used as animal feed and also to protect the fields during winter. It should thus not be pursued.
- Comments were made that all the data covered is not likely to lead to increased use of maize and that the focus should be on ways to use more maize.
- By-products should be better utilised and add more value to the industry.
- When considering using by-products one must remember and consider that these are currently used primarily as animal feed. What is the implication if other markets are created?
- Ethanol production is very clearly an avenue to be pursued, especially in terms of this project.
- The decision to produce ethanol is not necessarily an economic one; it should also be based on strategic direction and environmental benefits for the long term existence and preservation of natural resources and the environment.
- There was some concern regarding the decision to pursue ethanol. Is this a knee-jerk reaction to existing and potentially increasing surpluses?
- Ethanol may not be an option for small farmers as they cannot achieve the required purity.
- Is maize the cheapest renewable resource for making ethanol? What other materials can be used for ethanol production?

Ethanol from maize, as well as possible new uses for DDGS, were of interest to the industry although some concern was noted. Use of stover has negative implications for farmers and so has been excluded. The other areas are still broad and no guidance was provided in this regard from the workshop participants. The CSIR team then selected a few products for further research and discussed these with Mr Leon du Plessis of the Maize Trust.

4. Criteria for assessing the commercial potential of opportunities

4.1 Search for criteria to use

There are a number of typical stages in new product development as outlined in Table 1[1]. In this study, Exploration, Screening and Business Analysis were proposed to be undertaken followed by scoring and ranking of the opportunities based on commercial potential. Future steps that would be undertaken by private companies include Development, Testing and Commercialisation.

[1] Hart S, Hultink EJ, Tzokas N and Commanduer HR. (2003) Industrial companies' evaluation criteria in new product development gates. J. Prod. Innov. Manag. 20: 22-36

Table 1: Stages in new product development

Stage	Description
Exploration	Search for product ideas
Screening	Weed out impractical ideas Identify ideas that merit more detailed study
Business analysis	Evaluate technical feasibility and market potential
Score and rank opportunities based on commercial potential	
Development	Turning idea on paper into product
Testing	Commercial experiments
Commercialisation	Launch, production and distribution

A search of literature on criteria to screen, evaluate and rank opportunities showed that in most cases evaluation methods are based on synergy with the company's existing resources and markets, although the Exploration stage can be done at an industry level. However, the Screening and Business Analysis stages should be done by a company and not an industry, as synergy with the company's strategy is required and the decision to invest must be made by the company.

In this case, the industry is requesting the evaluation, including scoring and ranking of selected opportunities. Three groups of criteria were found to have aspects that could be used for this type of analysis, where synergy with the company's strategy and resources were not necessarily required:

- Venture capital evaluation criteria[2]
- Common evaluation criteria[3]
- Product evaluation and selection criteria[4]

These are outlined below and final criteria suggested.

4.1.1 Venture capital evaluation criteria

Venture capital firms typically have a screening stage followed by an evaluation stage[5]. The screening stage tries to limit the number of deals that must be evaluated and typically reflects a tendency to limit investments to areas with which the venture capitalists are familiar. For example, the size of the investment, the technology and market sector, the geographic location and the stage of financing required are typically used in the screening stage. In the evaluation stage, during which the proposal is under serious consideration, five basic characteristics of the deal are evaluated:

- *Market attractiveness*: size, growth and accessibility of the market, and the existence of a market need
- *Product differentiation*: a product that is unique, can deter competition through patents and enjoy a high profit margin
- *Managerial capabilities* of the team

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2 Tyebjee TT and Bruno AV. (1984). A model of venture capitalist investment activity. Management Science. 30 (9)

3 Cooper RG and de Brentani U. (1984). Criteria for screening new industrial products. Industrial Marketing Management. 13: 149-156

4 Lin C-T and Chen C-T. (2004). New product Go/No Go evaluation at the front end: a fuzzy linguistic approach. IEEE Transactions on Engineering Management. 51: 197-207

5 Tyebjee TT and Bruno AV. (1984). A model of venture capitalist investment activity. Management Science. 30 (9)

- *Environmental threat resistance*: the extent to which the venture is resistant to uncontrollable pressure from the environment such as obsolescence due to changing technology, sensitivity to economic conditions, or low barriers to entry by competition
- *Cash-out potential*: extent to which the investment can be liquidated.

While the managerial capabilities and cash-out potential are not relevant here, the other characteristics can be used to analyse product opportunities in the maize industry. These are summarised in Table 2.

Table 2: Criteria for analysis of opportunities from venture capital evaluation criteria

Product differentiation	Uniqueness Patentability Profit margins
Market attractiveness	Access to market Market need for product Size of market Growth potential for market
Environmental threat resistance	Protection from competitive entry Resistance to economic cycles Protection from obsolescence Protection from downside risk

4.1.2 Common evaluation criteria

New product screening is the initial decision to commit resources to a new product project. Although it is a critical decision, it is also complex as there is little reliable information on the proposed product's market, costs and nature of the investment required. Screening is thus an investment decision made in the absence of concrete financial data.

In an analysis of 63 firms and 243 managers regularly involved in screening decisions for new products, 86 screening criteria were used which could be summarised in the following factors[6]:

- *Magnitude of product opportunity*
- *Market opportunity*
- *Synergy* of the project with the firm's existing resource base
- *Product strategy* viewed in the light of the firm's overall product strategy.

While the latter two (synergy and product strategy) can only be considered by a specific firm, the first two can be used to analyse product opportunities in the maize industry. These are summarised in Table 3.

Table 3: Criteria for analysis of opportunities from common evaluation criteria

Magnitude of product opportunity	*Product differential advantage*: innovativeness and technology *Financial potential*: high profit and sales potential, high growth market *Probable life*: future development clear and predictable
Market opportunity	*Size of market*: mass market, high volume, geographically broad *Rational market*: customers use objective decision criteria, commercial and not institutional customers *Domestic market*: market is primarily domestic

[6] Cooper RG and de Brentani U. (1984). Criteria for screening new industrial products. Industrial Marketing Management. 13: 149-156

However, the dominant screening criteria used by managers for Go/No Go decisions were found to be:

- Financial potential
- Corporate synergy
- Technological synergy
- Product differential advantage.

While the first two describe the magnitude of the product opportunity itself, the last two are synergy factors. None of the dominant criteria portray the nature of the market at which the new product is aimed. A concern with the dominance of the financial factor is that financial data is typically unreliable at an early stage.

In other research by the same author[7], factors found to be important to new product successes (in contract to factors used by managers during screening) are:

- Product differential advantage
- Project/company resource compatibility
- Market need, growth and size
- Economical advantage of the product to the user.

The market should, therefore, be considered when screening new product opportunities.

4.1.3 Product evaluation and selection criteria

A product Go/No Go decision depends not only on the characteristics of the product, but also on the technological competencies and the competitive environment of the company. Since the situation varies from product to product there is a high probability that no single set of factors reflects all situations and requirements even in the same firm. In addition, evaluators with different functional perspectives bring particular needs and desires into the decision. Table 4 is the result of research undertaken to develop assessment factors that can be used for all new product development decisions.[8]

Table 4: Criteria for analysis of opportunities from common evaluation criteria

Competitive marketing advantages	Market timing Price superiority Marketing competencies Market attractiveness
Superiority	Functional competency Product differentiation
Technological suitability	Design quality Material specialisation Manufacturing compatibility Supply benefit
Risk	Market competitiveness Technological uncertainty Monetary risk

7 Cooper RG. (1981). An empirically derived new product project selection model. IEEE Transactions on Engineering Management. 29: 54-61

8 Lin C-T and Chen C-T. (2004). New product Go/No Go evaluation at the front end: a fuzzy linguistic approach. IEEE Transactions on Engineering Management. 51: 197-207

4.2 Final criteria suggested

The final criteria presented at the workshop are given in Table 5. At the workshop these were discussed and modifications suggested.

Table 5: Data criteria for selected opportunities

	Criteria presented	Criteria chosen at workshop
Product	Probable life Profit margin Patent protection	 Variable cost of production Number of patents Availability and cost of other raw materials required for production
Market	Size Growth Access Cyclicality	Size of market Cyclicality Main players/producers
Risk	Market competitiveness Technological uncertainty Scale of entry required	Competitive products Production technologies Size of plants

4.3 Constraints on criteria chosen

In Part 2 of the report, data for these criteria for the selected opportunities was analysed when it was obtainable. Not all information was available, however, and some of the criteria were found not to be relevant.

4.3.1 Variable cost of production

Except for ethanol, it was not generally possible to get an estimate of the variable cost of production for most products. In many cases, the price can be used as a guide to the variable cost of production. This criterion was therefore modified to include any cost information that was obtainable to give an idea of the potential cost of production.

4.3.2 Number of patents

This criterion will give an indication as to whether there are many patents covering all aspects of the product opportunity and whether the technology would need to be licensed, or whether it could be developed in-house. Although the number of patents in an area can be obtained, it is not always a useful guide to the opportunity, as a comprehensive patent may cut out competition, for example, Cargill's PLA patent. An assessment of the patents, rather than the number is more useful.

4.3.3 Availability and cost of other raw materials required for production

This request was made at the workshop as there was a concern that some products would require raw materials (other than maize and maize products) which would be difficult to obtain. However, no evidence of this was found and this criterion was thus not analysed for the product opportunities.

4.3.4 Size of market

The market size is a measure of whether there is sufficient market "space" for other players to enter. However, more important is the market growth as a decreasing market will lead to price wars and is not attractive for entry.

4.3.5 Cyclicality

In general, cyclicality is governed by economic factors, specifically related to the US and EU economic cycles. There may also be cyclicality related to fashion and trends in the food and beverage market, for example, but little information is available in this regard. This criterion was not analysed for the product opportunities.

4.3.6 Main players/producers

An analysis of the main players/producers can give an indication as to the concentration in the industry, whether the Chinese have entered the market (and usually created cost issues for other players) and whether the technology would be available for licensing for local manufacture.

4.3.7 Competitive products

Competitive products are analysed in order to see whether there are substitutes that may cause market disruptions.

4.3.8 Production technologies

Different production technologies were discussed, with specific regard to the patents found.

4.3.9 Size of plants

Although there are often many sizes of plants that can be constructed for the same product, a "typical" size is given where available.

4.4 Final criteria used for market and patent analysis

The final criteria used for the market and patent analysis of the eight selected opportunities are given in Table 6.

Table 6: Data criteria for selected opportunities

	Final criteria used for assessment
Product	Cost of production or price Patents
Market	Size and growth of market Main players/producers
Risk	Competitive products Production technologies Typical size of plants

4.5 Assessment of commercial potential

While the criteria discussed above are useful to give an understanding of the potential of the selected opportunities, scoring and ranking requires a more detailed analysis. The aim of scoring and ranking of the criteria is to identify the commercial value of a product where the commercial value is typically its Net Present Value (NPV). Sources of commercial value for a product must be determined, and market, competition, manufacturing and technical issues are typically considered.[9]

The most useful information for scoring and ranking selected opportunities for the maize industry are:

- Net Present Value
- Gross added value ($/year)
- Maize consumed (tonnes/year)
- Average added value ($/tonne)
- Estimated development cost

However, there are significant limitations to the amount of this information that can be obtained from the open literature in this regard. Typically, this information is obtained when licensing technology from a vendor or supplier. In addition, NPV and sources of commercial value often depends on country and company specific factors, such as risk, cost of capital, technology base and so on. For example, a new product from the wet milling industry would be rated as a technical challenge for most companies in South Africa, except if African Products were doing the analysis.

Due to the circumstances discussed in this report, it was not possible to find all the required information for commercial assessment for all eight selected opportunities.

5. Summary of analysis of selected opportunities against criteria chosen

The selected opportunities analysed in Part 2 of the report are:

- Lactic acid (LA) and polylactic acid (PLA)
- Plant-made pharmaceuticals (PMPs)
- Food gum from maize fibre
- Cyclodextrins
- Fat replacers
- Inositol
- Herbicide from maize gluten meal
- Ethanol from maize

Table 7 gives a summary of the analysis undertaken in Part 2 of the report.

[9] Menke M. (1994). Improving R&D decisions and execution. Research Technology Management. September-October

Table 7: Summary of selected opportunities

Lactic acid (LA) and polylactic acid (PLA)		
Product	Cost of production or price	• LA as raw material for PLA costs $4.40 to $6.60/kg. • PLA 3 x more expensive than polyethylene. • Ethyl lactate cost dropped to $1.87/kg from $3.30/kg due to improved lactic acid and conversion technology
	Patents	• Area well covered by patents especially PLA but some >10 years
Market	Size and growth of market	• Global LA demand was 168 000 tonnes or $130 million in 2001; volume growth increasing by 5-7% per year • LA market estimated to be $216 million in 2005. • Growth could be 14% if PLA market grows as expected and the lactic acid market could be 1.4 million tonnes ($3 billion/year) • PLA market could be 510 000 tonnes in 2010, 3.6 million tonnes by 2020. • Market for fermented organic acids about $6.04 billion by 2010. • Ethyl lactate potential is 80% of solvent market = 3.6 million tonnes in US • If new technology that reduces cost is available, LA production to increase significantly for use in production of biodegradable polymers
	Main players /producers	• Purac-Cargill (65.8% LA market share in 2004) • Cargill has bulk of PLA market ($10 billion per year)
Risk	Competitive products	• Citric acid and other food acids in food/beverage market
	Production technologies	• Fermentation of sugar and starch feedstocks (including sugar beets and sugar cane), fermentation of lignocellulose (including maize stover); synthetic routes exist
	Typical size of plants	• Galactic (LA) plant of 15 000 tonnes in France • Cargill (PLA) plant 140 000 tonnes/year using 340 000 tonnes of maize; can use lignocellulose feedstocks
Plant-made pharmaceuticals (PMPs)		
Product	Cost of production or price	• Likely to be small - $20 - $30/g compared to mammalian cell production of $200/g • Development costs estimated at $100 million per product with 8 to 10 year time frame.
	Patents	• Emerging field with high current patenting rate
Market	Size and growth of market	• Agricultural biotechnology market estimated to be $5 billion by 2009 if introduced in 2005 • PMPs market estimated to be $2.69 billion by 2009
	Main players /producers	• Maize: Epicyte, Prodigene, Meristem therapeutics, Dow, Monsanto • Other plants: Large-scale biology corporation, Medicago, Ventria bioscience, Planet biotechnology, Biolex
Risk	Competitive products	• Products can be grown in many crops
	Production technologies	• Focus of research is on type of expression system and plant host • Production technology similar to genetic modification of plants
	Typical size of plants	• Unknown • Biopharmaceutical production plant requires investment of $50 million to $500 million in 5 to 6 years. • Less expensive that a 2 x 12,000 litre capacity facility manufacturing therapeutic monoclonal antibody from recombinant CHO cells capable of producing 250 kilograms per year would require an investment of approximately $200 million

Food gum from maize fibre		
Product	Cost of production or price	• Commercial product not yet available
	Patents	• Patents available for wide variety of food gums • ARS and National Starch and Chemical Company have a jointly owned patent for the preparation and purification of maize fibre food gum (Zeagen)
Market	Size and growth of market	• Total market for hydrocolloids was $3 billion in 2001 • Market for gums $600 million in 2001 (90 000 tonnes) • Market for gum rabic $125 million (30 000 tonnes). • Market rising slowly at 1-2% per year; very affected by price changes • Price changes can lead to substitution; food and beverage trends affect demand
	Main players /producers	• CP Kelco, Degussa Texturant Systems, Danisco, Khartoum Gum Arabic Processing, CNI, Ailand & Robert
Risk	Competitive products	• Gum Arabic is the targeted competitor, but starch, pectin, seaweed derivatives, cellulose derivatives, guar gum, gelatine and other food gums are also competitors.
	Production technologies	• Extraction of hemicellulose by alkali treatment • Enzyme steps have been used, as well as steam explosion
	Typical size of plants	• Commercial product not yet available
Cyclodextrins		
Product	Cost of production or price	• Depends on product: likely to be $5/kg for cheapest to $12 000/kg for speciality cyclodextrins
	Patents	• Most patents in application and not manufacture of cyclodextrins, specifically for drug delivery • Proctor and Gamble own most of application patents for household use
Market	Size and growth of market	• Estimated to be $800 million by 2000; 5 000 to 6 000 tonnes per year in 1998. No later information available. • US market growth estimated to be 300% over 5 years • Market for cyclodextrin products is 2 to 3½ times that of cyclodextrin itself
	Main players /producers	• Wacker Chemie, Ensuiko Sugar Refining, Nihon Shikuhin Kako, Roquette Freres, American Maize Products, Algon Chemical Inc, Roquette Corp, Tyron International, UR Industries Inc, Phansthiel Laboratories
Risk	Competitive products	• Polymer-based encapsulation products e.g. starch-based
	Production technologies	• Produced from starch by the action of an enzyme
	Typical size of plants	• 5 000 tonne plant built next to the Cargill wet-milling plant

Fat replacers		
Product	Cost of production or price	• No information available
	Patents	• All areas well covered by patents • Most products branded
Market	Size and growth of market	• $970 million in 2005; 7% growth • US market is $500 million • From 2005 to 2007, protein-based products will increase market share by 4%, carbohydrate-based products will lose 2% of market share and fat-based replacers will lose 3% of market share
	Main players /producers	• Starch-based replacers: Cerestar, National Starch & Chemical and AE Staley
Risk	Competitive products	• Protein-based (egg, milk, soya, whey, wheat proteins) • Carbohydrate-based (starches, gums, cellulose, maltodextrin, polydextrose) • Fat-based replacers
	Production technologies	• Starch is starting point for carbohydrate-based fat replacers • Treatment with enzymes to modify starch
	Typical size of plants	• No information available
Inositol		
Product	Cost of production or price	• No information available
	Patents	• There are a number of patents covering the production of inositol • Emerging area for D-chiro-inositol which has significant medical applications
Market	Size and growth of market	• 12 000 tonnes per annum for B-vitamin group of total vitamins market of 200 000 tonnes • 4.7% growth in B-vitamin group over 4 years from 2001 • Total vitamin market $2.24 billion in 1999; food and beverage market was $480 million in 2005
	Main players /producers	• Roche (now DSM): 40% of vitamin market • BASF: 30% of vitamin market • ADM produces inositol (lecithin/soy-based) • Zhucheng Xingmao Inositol Factory (China): 1 200 tonnes per year
Risk	Competitive products	• Inositol can be produced from other sources
	Production technologies	• Precipitation and hydrolysis of phytin (a phosphorylated form of inositol) from maize steep water • New methods using modified yeasts
	Typical size of plants	• Only information found was a 1 200 tonne per year plant in China

Herbicide from maize gluten meal		
Product	Cost of production or price	• No information available • Development cost can be $150 million per product, but if “natural” can be $10 million
	Patents	• Patents owned by Iowa State University, some from early 1990s
Market	Size and growth of market	• Agrochemical market $31 billion in 1998; herbicides are 49% of market • Biopesticides market estimated to be $167 million in 2004; growth of 10-15% per year
	Main players /producers	• Numerous small players exist that can use maize gluten feed • 20 companies have licensed technology for use as herbicide
Risk	Competitive products	• All chemical and natural herbicides
	Production technologies	• Use of maize gluten meal as is or as hydrolysate • New technology for extraction of active ingredients in research
	Typical size of plants	• By-product of wet milling process • Problem is use as feed competes with use as herbicide
Ethanol from maize		
Product	Cost of production or price	• Estimated production cost (including DDGS credit) is R2.94/litre • Selling price will be similar to the basic fuel price (R3.26/litre on 1 October 2005)
	Patents	• Technology available in open literature; books available to guide manufacturers • Some patents on new production technology
Market	Size and growth of market	• 41 billion litres in 2004 • Growth increasing
	Main players /producers	• US (maize), Brazil (sugarcane) • Mostly farmer cooperatives, maize processors
Risk	Competitive products	• Gasoline, MTBE
	Production technologies	• Fermentation of starch
	Typical size of plants	• Should be > 75 million litres; typically 150 million litres of ethanol from 353 000 tonnes of maize

6. Assessment of commercial potential

As discussed in Section 4.5, information required for assessment of commercial potential is limited and it is thus not possible to score or rank the opportunities based on a detailed knowledge of the potential. However, relevant information on the selected products is presented in Table 8, which can be used to recommend a way forward for the South African maize industry.

Table 8: Information available for assessment of commercial potential

	Maize consumed	Potential added value	Development issues
Lactic acid, polylactic acid	LA consumption small but growing. Cargill plant uses 340 000 tonnes for PLA.	Value added for LA could be >R20 000/tonne	PLA patented – must be licensed. LA technology available to license.
Plant-based pharmaceuticals	Unlikely to be significant unless widespread vaccines put into maize.	Unknown but likely to be high.	Development costs $100 million per product over 8-10 years.
Food gum from maize fibre	Small. Total gum arabic market is 30 000 tonnes.	High. Gums can be >R25 000 per tonne.	Patented – must be licensed.
Cyclodextrins	Unknown but total world maize use likely to be less than 50 000 tonnes. produced from starch.	Could be significant if niche products are made.	Basic technology available. Value-added products and applications covered by patents.
Fat replacers	Small. Many competing products. Produced from starch.	Could be significant if niche products are made.	Well covered by patents so must be licensed. Market penetration costs may be high.
Inositol	Small. By-product of wet milling process.	Unknown. Could be significant for wet miller.	Development costs unlikely to be high. Market penetration costs may be high.
Herbicide from maize gluten meal	Small. By-product of wet milling process.	Unknown. Could be significant for wet miller.	Patented – must be licensed.
Ethanol from maize	Only constraint is local market sales; can consume significant quantities.	If ethanol sold at basic fuel price, then added value is R447/tonne.	No development required. Investment cost only.

Although much of the information in Table 8 is subjective and based on the market and patent assessment rather than information from a licensor, it can be presented in a form that allows some scoring and ranking of opportunities. The following assumptions are required for this analysis:

- A high maize consumption is desirable
- A product that adds significant value to maize is required
- Technology that is available or can be licensed (rather than technology that requires research) is needed.

Table 9 presents the information in Table 8 in a form that allows some crude scoring and ranking of the opportunities.

Table 9: Crude scoring and ranking based on the information presented in Table 8

	Maize consumed 1 = small 2 = growing 3 = high	Potential added value 1 = <R1 000/tonne 2 =- <R10 000/tonne 3 = >R10 000/tonne	Development issues 1 = Research required 2 = Patented 3 = Available	Total
Ethanol from maize	3	1	3	7
Lactic acid, polylactic acid	2	3	2	7
Cyclodextrins	1	3	3	7
Food gum from maize fibre	1	3	2	6
Fat replacers	1	3	2	6
Inositol	1	2	3	6
Plant-based pharmaceuticals	1.5	3	1.5	6
Herbicide from maize gluten meal	1	2	2	5

Ethanol from maize, lactic acid/polylactic acid and cyclodextrins are ranked most highly. In terms of maize consumed, ethanol is likely to consume the most, but the potential added value is lowest for ethanol out of all the products analysed.

7. Conclusions and recommendations

The identification of opportunities regarding alternative utilisation of maize and maize products is a complex task, given the status of maize as one of the most highly processed plant crops in the world. Many countries, with far more resources than South Africa, have intensive research programmes dedicated to adding value to maize, extracting value from maize, splitting maize into its component parts and adding value to maize by-products.

South Africa is in a precarious position as our current maize stocks are too high, which has lowered the maize price to the point where it is bankrupting farmers. There is thus an imperative to use more maize, preferably in value added products, which can increase demand and thus the price. In addition, the move by consumers away from traditional maize food products has meant that maize processors need to find alternative products to maintain profitability. However, a drought could significantly affect maize production which could lead to food insecurity if significant amounts of maize are diverted into other activities.

Against this backdrop, this study has shown that there are some opportunities for alternative utilisation of maize. Crude scoring and ranking of the opportunities has shown that ethanol from maize, lactic acid and polylactic acid, and cyclodextrins hold some promise for maize utilisation. However, scoring and ranking done at a company level may produce different results, for example, if the starting material is already a by-product of a company's current process it will be more attractive. If a company is seeking new opportunities in the pharmaceutical industry, PMPs may be most attractive to them. These opportunities are very different as, for example, ethanol usage will not add significant value to maize, but will use significant quantities. Cyclodextrins may not use significant quantities of maize, but will add significant value.

Alternative utilisation of maize must, however, be informed by the company that wants to take up the opportunity. The eight selected opportunities may not be suitable for some companies, and they should thus look at the first part of the study, which is a broad overview of prior and current research on maize and maize products. There may need to be significant research investment by industry and individual players to make a significant difference to the profitability of the South African maize industry.

Should a company wish to exploit any of the opportunities presented, it is recommended that a detailed techno-economic study be undertaken to ensure viability and synergy with the company's strategy. For example, an economic study of ethanol viability is currently being done by Grain SA to investigate the potential for maize ethanol thoroughly.

Appendix I: Summary of the workshop outcomes

NOTES FROM THE WORKSHOP ON:

COMPILATION OF NATIONAL AND INTERNATIONAL RESEARCH PROJECT RESULTS ON ALTERNATIVE UTILISATION OF MAIZE AND MAIZE PRODUCTS

A workshop on the progress of this project was held on the 10 May 2005, at the Quantum Hall at the CSIR, Pretoria.

1. Background to the project

As the major field crop in South Africa (SA), the production of maize often exceeds the local demand. This creates a need for industry members to identify and diversify into downstream manufacturing opportunities for maize and maize products in order to spread their risk. In addition there is a requirement for new markets for existing upstream maize products.

A project proposal was submitted to the Maize Trust in early 2004 in response to a tender invitation and awarded to CSIR Bio/Chemtek.

The primary objective is to compile a comprehensive document, for the benefit of the SA Maize Industry, on the results of available research and other related projects, both nationally and internationally, regarding the alternative utilisation of white and yellow maize, as well as of the products and by-products that are derived from both white and yellow maize.

In addition, opportunities are to be identified with regard to the possible alternative utilisation of white and yellow maize, maize products and maize processing by-products, as well as an evaluation of these opportunities with regard to market attractiveness.

2. Purpose of the workshop

The Maize Forum Liaison Committee (MFLC) indicated at the onset of the project that the remit of this first phase of the work was to be expansive and should include all possibilities. Currently the project has reached the stage where a considerable amount of information has been assimilated with regard to local and international research. A summary of this information was forwarded to the MFLC in December 2004.

The aim of the workshop was to share this information with key stakeholders, receive feedback on the data and discuss a way forward in terms of narrowing down the scope in order to embark on the next phase of the work, which entails the evaluation of commercial potential and ranking of the opportunities still to be identified. Criteria for this selection process will also be discussed.

3. Workshop programme

09:00 to 09:15	Background to project
09:15 to 09:30	Approach and overview
09:30 to 09:50	Research data: presentation and discussion whole maize
09:50 to 10:10	Research data: presentation and discussion on maize fibre, stover, cobs
10:10 to 10:25	Research data: presentation and discussion maize protein
10:25 to 10:40	Tea
10:40 to 10:55	Research data: presentation and discussion on maize steep liquor
10:55 to 11:10	Research data: presentation and discussion maize germ / oil
11:10 to 11:35	Research data: presentation and discussion on starch
11:35 to 11:55	The possibilities for bioethanol
11:55 to 12:10	Recommendations for selection criteria
12:10 to 12:30	Industry analysis and an integrated growth strategy
12:30 to 13:00	Concluding discussion and wrap up
13:00 to 13:30	Light lunch

4. Workshop comments and notes

General:

- Use of maize stover (e.g. for bioethanol) not a likely possibility in SA as this is used as animal feed and also to protect the fields during winter - thus should not pursue.
- Countries that produce similar maize volumes to SA have been included in the study thus far; additional information should be sourced about countries producing more maize: what are they doing and getting right.
- There was a suggestion to add fructans to the search, as well as the possibility of replacement of starch.
- The Maize Trust to circulate call for proposals on projects concerning dried distillers grain and solubles (the by-product from the dry grind ethanol process).
- Comment/s were made that all the data covered is not likely to lead to increased use of maize and that is where the focus should really be…on ways to use more maize.
- By-products can be better utilised and add more value to the industry.

- When considering using by-products one must remember and consider that these are currently used primarily as animal feed. What is the implication if other markets are created?

Ethanol production:

- Ethanol production very clearly an avenue to be pursued, especially in terms of this project.

- The decision to produce ethanol is not necessarily an economic one, it should also be based on strategic direction and environmental benefits for the long term existence and preservation of natural resources and the environment.

- There was a suggestion to do a competitive analysis between SA and other countries in terms of in terms of ethanol production

- In terms of calculating viability of ethanol product, what portion of the by-product/s value is factored back into the maize price, in other words discounted from the maize price.

- There was some concern regarding the decision to pursue ethanol. Is this a knee-jerk reaction to existing and potentially increasing surpluses (17 million tonnes was estimated as production in the future)?

- How does the import parity price of maize affect the production cost?

- Ethanol may not be an option for small farmers as they cannot achieve the required purity.

- Is maize the cheapest renewable resource for making ethanol? What other materials can be used for ethanol production?

Selection criteria for opportunities:

- Should include raw material availability, as well as availability of intermediates onto criteria list.