FOOD SCIENCE EDUCATION AND RESEARCH IN SOUTH AFRICA: TOWARDS THE FUTURE

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ABSTRACT

Food Science, as a discipline, forms an integral part of the South African food supply chain. Demands and needs of the developing (rural, poor) consumers are worlds apart from that of developed (affluent, westernised) consumers. The challenges facing food scientists in South Africa are therefore intricate. The South African Food Industry (formal and informal sector) must meet the demands of all our consumers, be profitable to food manufacturers / entrepreneurs and meet dietary guidelines for health maintenance. Relevant food science education and research should play a pivotal role in this regard.

The focus of this inaugural lecture will be to investigate the challenges facing Food Scientists in Southern Africa. Relevant and innovative approaches to education and research in Food Science to effectively serve the South African community are also explored.

1. INTRODUCTION

Food Science is regarded as quite a young profession. From the mid-19th century and onwards, basic sciences (such as chemistry, physics, mathematics and microbiology) had been applied to food in virtually independent compartments. It was only during the 1950's that the knowledge developed in the different sciences was integrated into a coherent, field of study and the discipline of Food Science was born.

Food Science is a multi-disciplinary, applied field of study in which the biological, physical and engineering sciences are used to study the nature of foods, the causes of deterioration, the principles underlying food processing, and the improvement of foods for the consuming public". *Food Technology* is the "application of food science to the selection, preservation, processing, packaging, distribution and use of safe, nutritious, and wholesome foods". In practice the terms "food science" and "food technology" are often used interchangeably (Hartel, 2001).

Food scientists and technologists are involved in scientific and technical aspects of development, manufacturing and distribution of food products to consumers (Karel, 2000).

Throughout the years, Food Science and Technology has contributed significantly to our diverse food supply. Food manufacturers or processors (assisted by Food Scientists and Technologists) have reshaped the composition of our food basket in response to changing consumer needs and technological developments (Manchester, 1997).

The changing consumer demands ten years ago and today are shown in Figure 1.

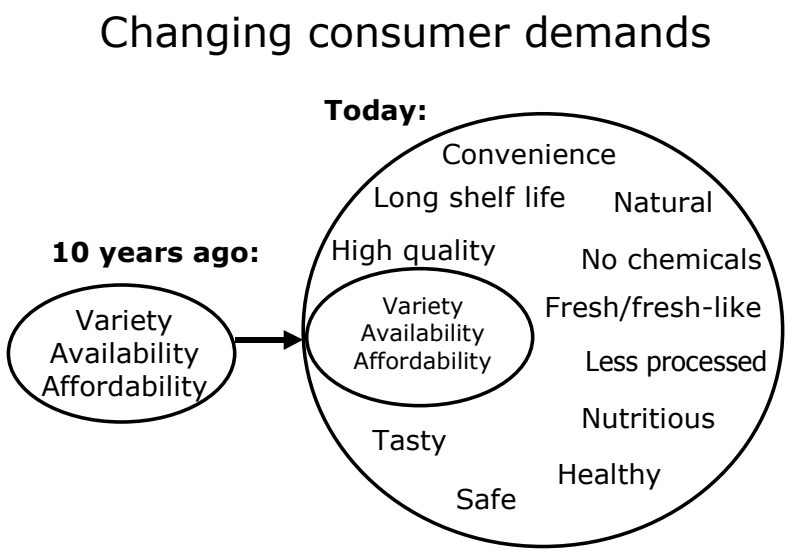

Figure 1 Changing consumer demands ten years ago and today

Table 1 provides selected examples to illustrate some of the contributions that Food Science and Technology has made towards food products currently available on the South African market shelves. It is evident that some of the examples cited attempt to meet more than one of these consumer trends or demands.

NOTE: The following examples were cited in the presentation:

Quality driven food products (frozen oven bake chips: cryogenic freezing – a very rapid freezing method using liquid nitrogen is sometimes used to produce frozen foods of superior quality)

Shelf life driven food products (aseptically packed, low fat, lactose reduced milk – aseptic packaging and processing of foods result in high quality products that are stable at room temperature)

Convenience-driven food products (stir-fry, ready-to-eat sauces)

Table 1 Contributions of Food Science and Technology to the South African food basket in response to changing consumer demands

Consumer demands and trends	Food Science and Technology contributions
Quality driven food products	
Frozen oven chips	Cryogenic freezing
Frozen orange juice concentrates	Concentration techniques and equipment
Shelf life driven food products	
Aseptically processed and packaged milk and fruit juices	Aseptic processing and packaging technologies
Convenience-driven food products:	
Instant coffee	Freeze drying technologies
Instant soups and powders; instant sauces and desserts	Development of custom-made thickeners and stabilisers; application of emulsion technologies
Frozen coated chicken or fish	Development of coating and flavour systems
Fresh- or minimally processed-driven food products	
Microwaveable ready-to-eat refrigerated and frozen foods	Development of microwave-able packaging material and microwave-able stable flavour systems
Refrigerated ready-to eat salads or Fresh-cut vegetables	Modified atmosphere packaging technologies and smart or active packaging films
Nutrition-driven food products:	
Fortified maize meal	Vitamin and mineral supplementation
Fortified bread	fortification of foods without affecting sensory quality
Ready-to-eat breakfast cereals	Extrusion technologies
Health- and diet-driven food products:	Introduction of fat replacers and probiotics
Low and fat fruit yoghurt with live AB cultures	
Culture-driven food products:	
Fermented products: maize and/or milk products; mango atjar	Fermentation technologies
Canned chakalakas	In-container heat sterilisation
Biltong	Modified atmosphere packaging and preservation systems
Safety-driven food products:	
Radurised spices	Ionising irradiation processing technology
Flavour driven food products	
Flavoured potato and maize based snack foods	Deep fat frying technologies; flavour systems

Fresh or minimally processed-driven food products (Modified atmosphere packaging are used to extend the shelf life of fresh and minimally processed fruits and vegetables – a modified atmosphere is created inside the pack which slows down the rate of spoilage)

Nutrition-driven food products (Fortification of bread with added vitamins and minerals; muesli – a whole some breakfast cereal with a variety of grains, seeds and dried fruits)

Health and diet-driven food products (Low fat soft cheeses; Low fat yoghurt with probiotic bacteria, beneficial to gut microflora, rooibos tea beverages rich in polyphenols with anti-oxidant properties)

Culture-driven food products (Biltong and "droë wors"; canned chakalaka)

Flavour-driven food products (Peppadews, a uniquely South African product with a distinct flavour)

2. THE SOUTH AFRICAN FOOD SUPPLY CHAIN

2.1 Role players and stakeholders in SA Food Industry

Figure 2 illustrates the most important role players and stakeholders in the South African food supply chain.

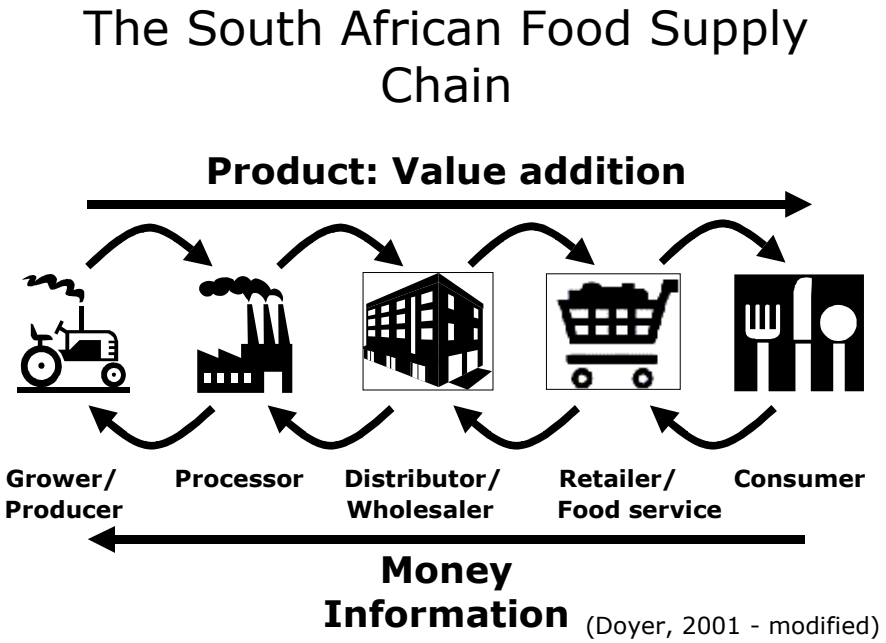

Figure 2 The South African Food Supply Chain

In general, it includes activities related to the production, processing, distribution and consumption of food for domestic and overseas consumers. Various role players and stakeholders can be identified in the food supply chain. The most important role players include the following:

- Growers and producers and their input suppliers;
- Food manufacturers or processors and their suppliers;
- Distributors, wholesalers, traders or agents;
- Retailers and food service providers or caterers; and
- Consumers.

The ***Growers or Producers*** produce raw materials from plant and/or animal origin.

Food processors or manufacturers convert raw unstable agricultural commodities into a variety of more stable, processed food products.

Traditionally the ***food distribution sector*** provides the link between food manufacturers and food retailers or food service providers. The role of wholesalers are probably becoming less important in the formal South African food industry, except for international food commodity traders who are involved in exporting fresh produce to Europe.

Food retailing, service or catering sector needs to provide consumers with the right foods, at the right time, at the right place and at a profit. The division between the traditional definitions of the retail sector (consume food at home) and the food service sector (consume food away from home) is nowadays becoming blurred (Eastham, Ball and Sharples, 2001). This is the fastest growing sector in the food supply chain, with the greatest bargaining power and where the most profit is made.

The sole motivation for the existence of the food supply chain is to satisfy ever-changing ***consumer*** needs. Consumer food trends therefore motivate the actions of all the other role players and stakeholders directly.

It might therefore be more appropriate to refer to a food demand chain rather than to the customary food supply chain.

Important stakeholders in the food demand chain include:

- Input suppliers for growers and producers (suppliers of disease-free, certified seeds, fertilisers, pesticides, animal feeds and machinery)

- Input suppliers of the food processing sector (food packaging, machinery and equipment suppliers; analytical equipment providers; providers of chemicals and test-kits for analyses of foods)
- Consultancy and service providers (e.g. analytical or food testing services)
- Governmental bodies (e.g. funding and legislative or regulatory bodies)
- Research institutions and/or councils (e.g. CSIR and Agricultural Research Council)
- Higher education institutions (Universities and Technikons)

2.2 Food Science and Technology - an integral part of the South African food demand chain

Food Science plays a pivotal role in the food demand chain since food scientists and technologists are involved in technical and scientific matters ranging from raw material selection to consumer related issues.

Many food scientists and technologists are currently employed by the *formal food processing industry* in technical areas such as raw material procurement, production management, product development and quality assurance and management.

Speciality food ingredient companies are increasingly utilising food scientists and technologists in technical marketing and sales or as application specialists.

Some *retailers* employ food scientists and technologists to ensure safety and quality of fresh and processed foods.

Others find employment in *government* in food law enforcement positions where they are responsible for developing and enforcing food legislation in accordance with national and international standards and regulations.

Experienced food scientists and technologists often enter into *food consulting businesses*. Many companies employ food scientists and technologists to provide a range of *services*, e.g. in food analytical services, or training, auditing and monitoring services in terms of quality and safety.

Higher education institutions make use of food scientists and technologists for education and research purposes. Food scientists and technologists employed by Research Institutions and Councils are responsible for food product analyses, development and research as well as technology transfer and trouble-shooting.

Some food scientists find employment in allied industries, such as packaging, chemicals and equipment suppliers.

Another possibility for food science graduates is to start their own food enterprise as an entrepreneur.

It is clear that food scientists and technologists are an integral part of the SA Food Industry. For the purpose of this presentation, the term food industry will be used to include all the role players in the food supply chain with the exception of the consumer (Figure 3)

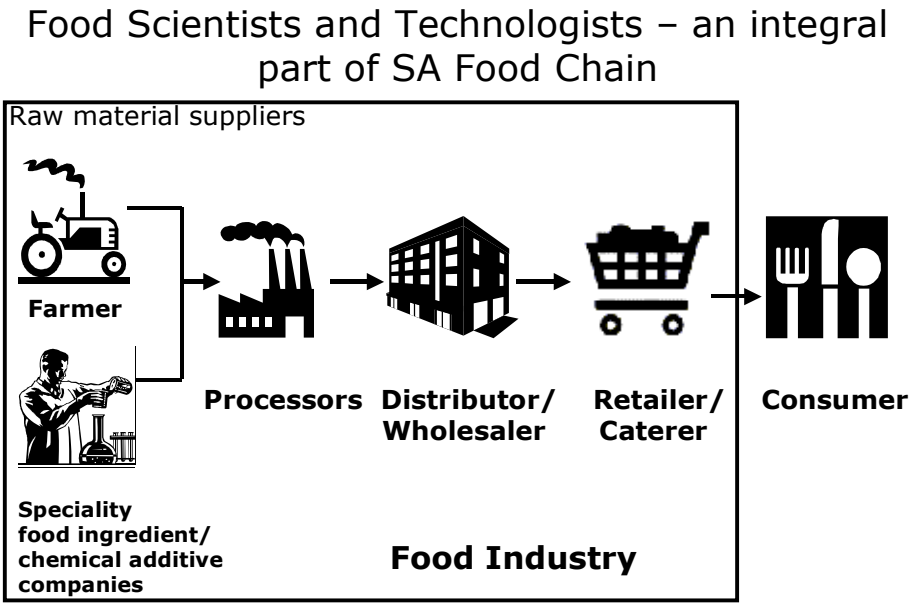

Figure 3 Food Scientists and Technologists – an integral part of the South African Food Chain

One-way of looking at food science education and research at tertiary institutions is to use the analogy of a demand chain. The following diagram (Figure 4) shows an education-research demand chain for Food Science that attempts to meet the needs and requirements of all its role players and stakeholders.

As previously mentioned, consumer needs and demands is the motivating power behind the activities of the Food Industry. For the South African Food Industry to meet food demands of its target markets and consumers, skilled food scientists and appropriate research and development is required. Potential students demand a world-class education (internationally recognised qualification) as well as market related skills. This requires quality inputs from tertiary institutions. Outcome based degree programmes provide potential students with the necessary skills to meet the demands and expectations of industry. Relevant, research (using post-graduate students) provides the Food Industry with research that is innovative, focused and directed towards providing them with a competitive edge.

At this juncture it will be useful to have a closer look at the changing face of the SA Food Industry in order to be in a better position to align food science education and research with industry needs

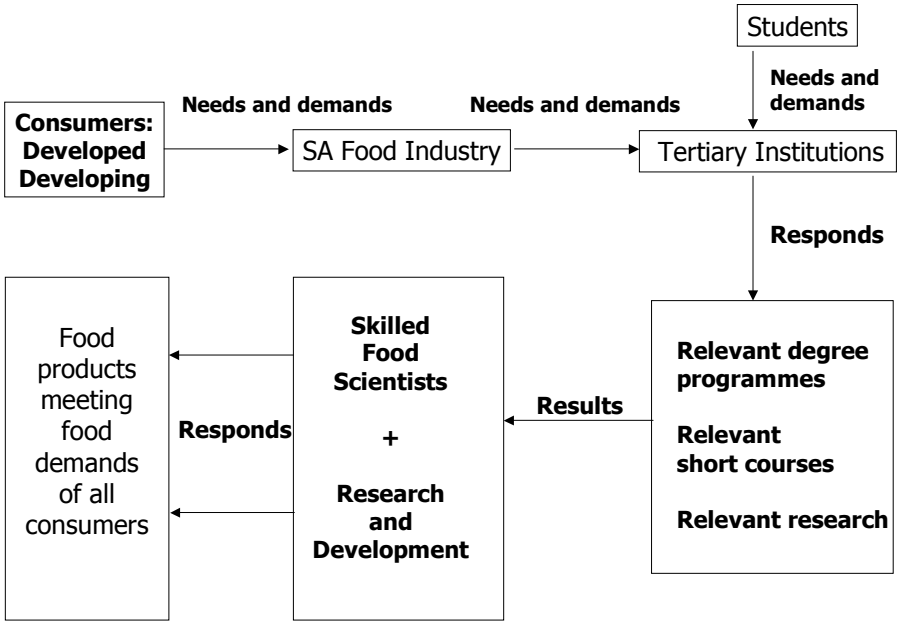

Figure 4: Education-research demand chain for Food Science in South Africa

2.3 The changing face of the South African Food Industry or Supply Chain

Figure 5 shows the changing face of the South African Food Industry. For many decades the food supply chain in South Africa was driven by agricultural production. The focus was on improving agricultural outputs and the consumer food market was characterised by the production of mass, standardised products. However, changes in production no longer drive the market. Instead, new technologies (e.g. biotechnology), new management principles and practices as well as changing consumer needs are shaping the formal food industry (Kinsey, 1999).

Food consumption trends in South Africa, like elsewhere in the world, are towards small, diverse, customised niche markets. The emphasis in an increasingly consumer-driven food market is the provision of "meals to eat" and not "food to cook" (Kinsey, 1997).

Demand, supply and market structure are three closely related factors underlying the changes taking place in the South African food industry.

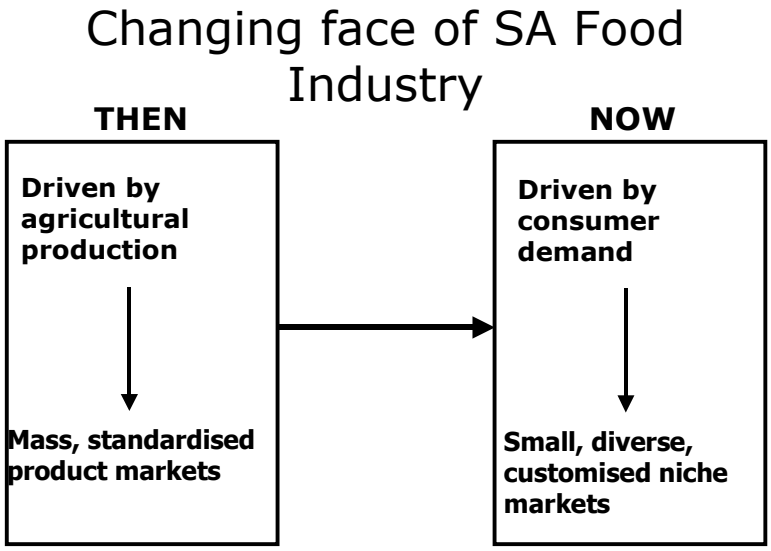

Figure 5 Changing face of South African Food Industry

2.3.1 Demand

Nowadays South Africa consumers are becoming more discerning and selective in terms of the foods that they demand. Changes in the current South African food consumer trends, as elsewhere in the world, are probably due to the following reasons:

- Changes in demographics (e.g. population dynamics, ethnic diversity, household composition, income differences, urbanisation, education levels, labour force participation)(Senauer, Asp and Kinsey, 1991)
- Lifestyle changes (e.g. Meat eaters vs. vegetarians, People on the Go; Health and nutrition conscious, Environmentally conscious)(Senauer, Asp and Kinsey, 1991)
- Availability of new scientific information about food and its relationship to short-term vitality and long-term health (Kinsey, 1997)
- Environmental responsibility and sustainability (Kinsey, 1997)

It is important to emphasise that the demands and needs of the developing (rural, poor) consumers are worlds apart from that of developed (affluent, westernised) consumers.

Developed consumers are demanding natural, healthy, minimally processed foods using milder food processes. Foods have to be safe, convenient and tasty

with extended shelf life but without the use of chemicals. Tailor-made or truly designer foods are required to meet specific demands of specific consumers.

Developing consumer needs and demands could include the availability and accessibility to affordable, shelf stable, convenient, basic foodstuffs. Since these individuals are often malnourished and immuno-compromised, their foods would have to comply with special nutritional requirements.

2.3.2 Supply

New technologies are available to specifically design food products according to consumer specifications. One of the most important technologies now and in future is almost certainly biotechnology, where the genetic material of plants, animals and microorganisms can be modified. Various possibilities exist in food biotechnology: genetically engineered foods with specific functionality; genetically engineered foods with specific chemical composition; genetically engineered food ingredients; rapid sensing techniques for identifying and quantifying microorganisms, contaminants and reaction products in foods before. during and after processing (Spiess, n.d.).

Other emerging food processing technologies that will probably have an effect on the quality and safety of our future food supply include: high-pressure processing, electromagnetic techniques (e.g. ionising irradiation, microwave processing and pulsed electric field treatment). In future, specially developed, smart packaging will contain freshness indicators and safety indicators so that consumers will know whether foods are still fresh or safe to consume.

2.3.3 Market structure

The market structure is becoming more compact with improved and faster flow of information between consumers and producers (Barkema, 1997). This can be attributed principally to two factors. Firstly, globalisation of food markets resulting in more international trade. Today we are looking at a global food supply chain. A possible downside of this development is the fact that large multinational companies are increasingly dominating the global economy (Beer, 2001). It is questionable whether this is always to the advantage of the final end-user of the food product. Secondly, efficiencies of scale, driven by information technology, are leading to vertical integration in all segments of the food supply industry (Kinsey, 1999).

The structure of the South African food supply chain as well as the activities of its role players is rapidly undergoing some changes.

In future, **growers or producers** might move away from simply being suppliers of raw materials from plant and/or animal origin to becoming suppliers of speciality raw materials utilising biotechnology.

Suppliers of **speciality food ingredients and/or chemical additives** to food manufacturers are also expected to genetically modify food ingredients to supply new functional ingredients to food manufacturers to meet new consumer demands. It is envisaged that this sector will develop partnerships in future with pharmaceutical and biotechnology industries. The total reliance of food manufacturers on ingredient or additive suppliers for new product development might also be a reality in years to come. Future alliances, partnerships or collaboration with tertiary institutions and research councils or institutes are also a distinct possibility.

The presence of large multinational **food manufacturing** companies in South African might impact positively on export opportunities elsewhere in the world but the increased reliance on research and development from outside South Africa has some serious drawbacks. Firstly, it could have a decidedly negative effect on those food scientists already employed in research and development or those pursuing a career in this area. Secondly, it is expected that outsourcing in terms of research and development would rather be done to overseas organisations than to local tertiary institutions and research councils or institutions. The challenge to tertiary institutions in South Africa is therefore to produce world-class food scientists able to compete with the best that the world has to offer.

Mergers, acquisitions and buyouts between various food companies (nationally and globally) have been a prominent feature in this sector for a number of years (Manchester, 1997). Some of the recent and pending deals in the South African food and beverage industry include:

- Unbundling agri-poultry business Astral Foods from Tiger Brands (Business day, 4 April 2001)
- Merger of Nampak and Malbak (Business Day, 14 December 2001)
- Nestlé-SA to own all of Dairymaid-Nestlé (50% originally owned by Tiger Brands)(Business Day, 18 January 2002)
- Concessions dominate merger between Unilever division Unifoods and Robertsons Foods (Business Day, 5 April, 2002)
- Pending merger between National Chick (Natchix) by Astral Foods (Business day, 5 April, 2001)
- South African Breweries (SAB) in advanced talks to buy US brewer Miller (beer division of Philip Morris group)(Business Day, Thursday 4 April, 2002)

Food product exports have been strengthened by the weakening of the rand, deregulation of the local and industry as well as by the opening up of international markets to South African products (Erik, 2001).

According to Business Day (13 May 2002), profound changes in South African consumer spending patterns, are forcing many **retailers** and their suppliers to re-think their strategies. Reduced spending power of especially consumers from lower-income groups is attributed to loss of jobs in the formal sector and increased consumer spending on cell phones, national lottery, electrification and home ownership.

Formerly food processors had market power over retailers through national brand marketing. Nowadays, retailers control store shelf space and their use of product sales from scanning data allows them to decide what items to stock. This gives them considerable power over the other role players in the food demand chain, i.e. producers, processors and wholesalers (Senauer, Asp and Kinsey, 1991). It is envisaged that more speciality stores closer to consumers with more "eat as you go" or "meals to go" options as well as home delivery services will dominate in future. Internet shopping will definitely become more prevalent as well as retailers serving niche markets.

3. CHALLENGES FACING FOOD SCIENTISTS IN SOUTHERN AFRICA

It is evident that Food Science and Technology is an integral and essential component of the food supply/demand chain but what are the challenges facing food scientists and how can food science as a discipline best serve sub-Saharan Africa in general and South Africa in particular? Let's deal with the first question first.

A survey using a questionnaire was conducted recently amongst Food Science alumni from the Department of Food Science, University of Pretoria. They were asked, along with other things, what their current and anticipated future challenges are as food scientists in their respective organisations. Their comments were either of a technical, business or "soft issues" nature (Table 2)

The challenges facing food scientists in South Africa are intricate. In general terms, the South African Food Industry (formal and informal sector) must meet the demands of **all** our consumers, be profitable to food manufacturers / entrepreneurs and meet dietary guidelines for health maintenance. Relevant food science education and research should play a pivotal role in this regard.

Table 2 Current and future challenges facing food scientists in the South African Food Industry

Technical issues	Business issues	Soft issues
• Be innovative in terms of new product development • Keep abreast of new technologies • Do research and development to stay technologically ahead of the competition • Be innovative in terms of raw material utilisation • Update legislation in accordance with international standards, reflecting real food-related risks in SA • Have technical know-how to solve problems • Develop new product applications within cost • Improve hygiene and safety • Become more knowledgeable in specialisation area • Enforcement of food labelling requirements • Working effectively with new techniques and technologies	• Understanding changing consumer needs and demands • Understanding consumer dynamics in Africa and develop appropriate products • Manage joint ventures for critical growth • Have unique selling points in technical marketing • Be locally relevant and internationally competitive • Reduce costs by using new technologies appropriately • Find the balance between cost and quality • Manage financial risks (in Africa) • Increase productivity • To do more with less	• Be innovative and creative • Develop sustainable relationships with stakeholders • Collaborate locally with other institutions: create networks and alliances • Improve communication between production and marketing • Project management skills • To interact effectively with clients • Be able to handle stress (high work load)

Now that we have an idea what the challenges are to food scientists in the SA Food Industry, an attempt can be made to answer the second question that was posed, i.e. "How can food science as a discipline best serve sub-Saharan Africa in general and South Africa in particular"?

From a tertiary institution point of view the next logical step is to establish how food science education and research should be shaped and positioned to meet the current and future needs and demands of the industry that it serves.

Before doing so, it is important to briefly mention some of the major changes affecting the Higher Education Sector of South Africa.

4. THE CHANGING FACE OF THE SOUTH AFRICAN HIGHER EDUCATION SECTOR

The South African Higher Education sector is currently experiencing many changes. The legislation governing tertiary education is changing and as a result this sector is at present undergoing significant restructuring as reflected for example in the mergers of some institutions in the sector. Tertiary institutions are further pressurised by budgetary constraints as well as the entrance of international and private institutions (Pistorius, 2001). Local tertiary institutions are therefore forced to compete globally against the best that the world has to offer.

According to Joubert (2002) the critical success factors for Higher Education can be summarised as follows:

Drivers	Outcomes
• Academic innovation	• Market relevance
• Effective governance	• Stakeholder satisfaction
• Quality of teaching	• Human capital formation
• Effective transfer of learning	• Employability of graduates
• Strategic positioning	• Competitiveness
	• Economic sustainability

5. RELEVANT AND INNOVATIVE APPROACHES TO FOOD SCIENCE EDUCATION IN SOUTH AFRICA

5.1 Educating professional food scientists

The following diagram (Figure 6) depicts the various components required to educate professional food scientists.

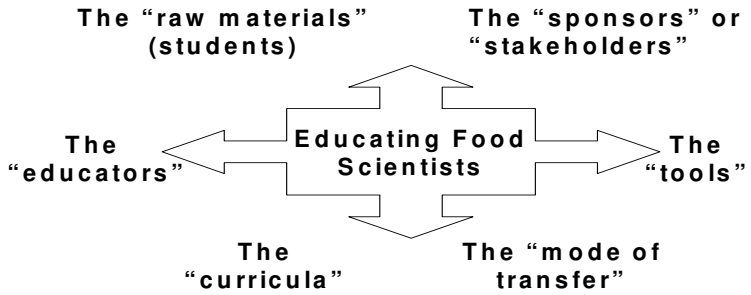

Figure 6 Factors required in educating professional Food Scientists

5.1.1 The students ("raw material") – UP's Innovation Generation

There appears to be a worldwide pattern of declining numbers of students entering the field of food science. School leavers with the appropriate academic abilities rather choose to become doctors, engineers or IT (information technology) specialists than entering into a scientific career. Already it is becoming more difficult to replace retiring key technical people in the food industry. Furthermore, there is a critical shortage of skilled black food scientists in the marketplace. Career opportunities in food science and technology need urgent and serious. Although Food scientists and technologists are represented by SAAFoST (South African Association of Food Science and Technology), and food scientists or technologists can register with the SA Council of Natural Science Professional, it is debatable whether they enjoy the same professional status as that of medical or engineering professionals. Food Science must be promoted as a profession. This will take a concerted effort of all stakeholders involved.

5.1.2 The "sponsors or stakeholders"

One way of attracting suitable candidates is through incentive schemes such as bursaries linked to a suitable position in industry after completion of studies. Active interaction between potential employers and students is essential as well as opportunities for students to gain practical experience through experiential training opportunities.

5.1.3 The "educators"

It goes without saying that any institution wishing to present degree programmes in Food Science at the undergraduate and post-graduate level need to employ an adequate number of dynamic, doctoral food scientists or at the very least have access to these individuals. These individuals need to be scientists of the highest calibre committed and passionate about their chosen careers as educators and researchers. It is advisable to have a team of specialists dealing with the different basic and applied food science subjects required (e.g. specialists in food chemistry, food microbiology, food processing and engineering, food quality and preference).

The involvement of practicing food scientists from the different sectors and sub-sectors of the food industry in study programmes are essential. Students need to apply and incorporate principles of food science and technology in practical, real-world situations problems.

For post-graduate studies, the creation of a southern African network in Food Science and Technology educators from South Africa, SADC and Developed Countries is one way to go. For example, six leading Australian universities with academic programs in food science and technology formed a consortium to jointly present a part-time masters program in food technology.

5.1.4 The "curricula"

Recently, there has been a move away from so-called content-based criteria for undergraduate Food Science programmes towards outcomes-based learning measures.

Tertiary institutions follow different approaches in their undergraduate Food Science programmes; some provide generalist training whereas other provide specialist training. Under certain conditions, it might be more pertinent to have generalist training whereas other job circumstances might benefit more from specialist training. The proviso should rather be that graduates should be equipped with the necessary skills to enable them to be gainfully employed in the food and allied industries and to be able to contribute to the future growth and development of these industries.

In all cases, basic fundamentals in food science should be in place before any specialisation should be done. Sometimes specialisation streams are only provided at a post-graduate level. In our situation specialization should meet the many different challenges facing the community in southern Africa.

Figure 7 illustrates the background courses and core competencies required for a general four-year degree in Food Science. Some institutions are adding "soft skills" and "business skills" to their food science curricula to enable graduates to become job-ready in a relatively short space of time.

In the recent survey mentioned previously, alumni was asked to rate the importance of various competencies or skills in terms of its importance to work successfully as a food scientist in their current position. Between 90 and 100% of alumni gave ratings for the soft skills between 7 and 10 on a scale of 1 to 10 where 1 = not important at all and 10 = extremely important. Of all the business skills rated, alumni indicated that marketing was the most important business skill.

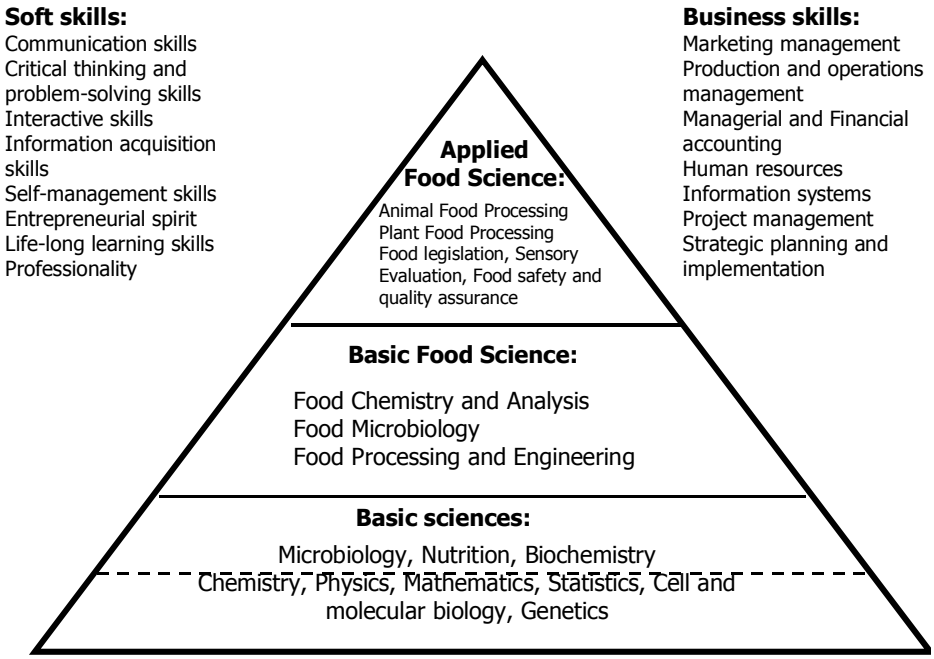

Figure 7 Background courses and core competencies required in Food Science

Anticipated future consumer demands coupled with the changing roles and structures of the stakeholders in the global food industry merits an in-depth look at the current study programmes in food science and related disciplines.

New education and research streams and opportunities are possible when linking and integrating these and other disciplines in multi-disciplinary study programmes. These include the following:

- Food Science combined with other basic disciplines
  - Chemistry, Microbiology, Biology, Nutrition
- Food Science combined with agricultural sciences
  - Food supply chain management
  - Food production and quality
- Food Science and / or Technology combined with management and business

South Africa seems to be lacking behind somewhat in terms of some of the specialisation areas / streams already presented elsewhere.

It is up to Food Scientists to re-launch our role in the food demand chain and also to develop and maintain a high action profile. Food Science is the link between agriculture and food industries and even the link between food industries and medical or pharmaceutical fraternities.

In the coming years the following type of food science graduates will be important to provide relevant skills to the food industries in southern Africa:

- **Graduates in Food Science and Technology: Ensuring the safe and hygienic production of quality processed goods for local and export use**

  Graduates with specialised knowledge in production and manufacturing processes (animal and plant food technologies) as well as in food quality and safety are required by food manufacturers to ensure the safe and hygienic production of food that comply with legal standards and regulations.

  Employment opportunities:

  Technical positions (production, quality assurance) in the food manufacturing sector.

  Those specializing further in business management and marketing would unquestionably be suitable for technical management positions in the food manufacturing sector. Business skills can either be obtained through programmes combining food science with business and economics or though appropriate management developing programmes, or even MBA studies.

- **Graduates specializing in Nutrition and Food Sciences: Champion of the consumer**

  Graduates with specialised knowledge in food manufacturing, product development and nutrition is required to contend with (a) increasing consumer awareness and demands for healthy foods, (b) increasing importance of nutrition in the development and evaluation of food products world-wide and (c) compliance with nutritional labelling and health claims. These graduates can be regarded as the consumer's champion and act as the link between the consumer and other role players in the food industry. Such graduates are likely to find employment in food manufacturing, retailing, food service/catering as well as food legislation sectors.

  Employment opportunities:

  Consumer consultant – to promote understanding of health and nutrition issues as well as new technologies used by the food industry in consumer circles;

  Product developer – to understand consumer needs and behaviour so as to develop appropriate products to meet the ever-changing demands of consumers;

  Communication with media – to inform and educate consumers on food, health and nutrition issues.

- **Graduates specialising in Food Science and Marketing/Business studies: Servicing the food industry**

  Graduates with a sound knowledge of basic food science complimented by business skills are required to market ingredients and services to the food industry

  Employment opportunities:
  Technical sales, marketing as well as management positions in the food and allied industries.

- **Post-harvest technology specialists: Ensuring safety and quality of fresh and minimally processed produce (especially for export purposes)**

  Graduates with a combination of knowledge and skills of the following disciplines: Plant production; Horticulture; Plant Pathology; Plant Physiology; Food Science (i.e. Food microbiology, food processing and engineering, food packaging, food quality and safety assurance); Food Supply Management to serve the growing agro-food industry (fresh and fresh-cut produce for local and international market).

  Employment opportunities:
  Raw material procurement; implementation of quality and safety systems; international commodity trading.

- **Graduates in Food Science and Biotechnology: Scientists for tomorrow's food and fermentation industries**

Graduates with specialised knowledge in basic food science principles and modern molecular biology is required to (a) produce speciality raw materials with improved sensory, nutritional and health-promoting properties; (b) expand opportunities for enzymes developed by genetic engineering in fermentation industries; (c) develop components of sensors to help assess and control microbiological risks in foods.

These graduates are required to fill the gap between traditional food processing technologies and the food processing technologies of the tomorrow where biotechnology will be used extensively.

Employment opportunities:
Production, research and development and analytical services sectors in government and industry should benefit from employing these graduates.

Another type of graduate is essential in southern Africa to address the problems in our developing or rural regions. Rural food entrepreneurs, through the establishment of small and medium size enterprises, can make a positive contribution towards rural development and wealth creation. Figure 8 explains the different skills required by the rural food entrepreneur during his/her studies. These graduates can either manage their own food processing enterprises or assist others in doing so. The government (i.e. Department of Agriculture) should be in a position to utilise these individuals to good effect as project managers or extension officers. The Department of Food Science, University of Pretoria, in collaboration with other departments in the School of Agricultural and Food Sciences and the Post-graduate School for Rural and Agricultural Development is currently presenting a degree programme to address this need. The B Inst Agrar (Food Production and Processing) degree is a 4-year degree, which leads directly to master's study if required.

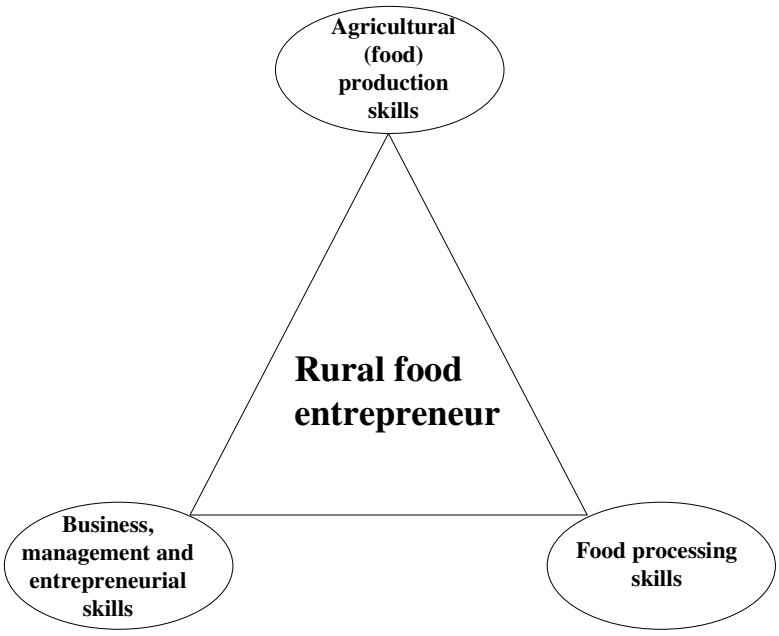

Figure 8 Skills required by rural food entrepreneur during his/her studies

5.1.5 The "tools" (facilities and equipment)

Up-to-date facilities and equipment is required to conduct chemical, engineering, processing, quality and microbiological practicals and exercises. Access to modern pilot plants to demonstrate processing technologies employed by the industry is essential to provide students with hands-on practical experience. Factory visits or at the very least video material depicting food processing

operations are essential to provide students with a realistic idea of the functioning thereof. Access to scientific information using international scientific databases, journals as well as to computer and internet services is essential for any student during his/her studies.

The lack of modern food processing and analytical equipment not only impacts negatively on the quality of educating future food scientists in South Africa, but also on our research excellence. Innovative approaches should be implemented to utilise scarce resources more effectively:

- Joint purchasing, maintenance and use of expensive equipment by different stakeholders;
- Equipment on loan – equipment placed in institutions for use by students will not only improve the quality of their training but also expose future buyers to your company's equipment.

5.1.6 "The mode of transfer"

As mentioned before, there has been a paradigm shift in education from training (imparting knowledge) to outcomes based learning where critical thinking, reasoning and judgments are required. This requires not only a re-think of present courses/modules and their course contents but also the mode of operation. The introduction of new technologies (e.g. telematic teaching), computer presentations by way of data projectors can lull educators in thinking that they are effective in their teaching task. Nothing could be further from the truth. "Talk and chalk" could be more stimulating and effective in nurturing critical thinking than merely imparting knowledge in a high-tech fashion. These are merely "tools" of the trade that can be used to one's advantage and should not be used to replace innovative methodologies to cultivate outcomes based learning.

Decision case-based courses are effective in developing critical thinking and decision-making skills.

Opportunities must be created where students can apply and incorporate the principles of food science and technology in practical, real-world situations and problems. Problem solving abilities and skills are essential to the practicing food scientist: Problem identification, considerations of alternatives, analyses of pro's and con's of alternatives and selection of appropriate action also need to be introduced in a discipline related way. This can be in the form of appropriate case studies or "real industry problems". The lack of critical thinking and team decision-making skills to effectively address complex issues are often criticism voiced against graduates. Exposure to real industry problems as well as the development of problem solving abilities and skills will go a long towards improving this situation.

More practical hands-on experience in the "real-industry environment" is also required. The only way to attain this is through closer liaison with industry during studies, perhaps through internship programmes

The concept of life long learning should be deeply entrenched during their studies to help prepare graduates for the many challenges in store in their future jobs.

5.2 Creating a win-win situation between the different stakeholders in education and research in Food Science and Technology

What type of alliances, networking, collaboration and cooperation between different stakeholders would be most beneficial for food science education and research in South Africa?

To optimise southern Africa's human resources and capabilities in Food Science and Technology a win-win relationship should be formed and nurtured between the following three parties: The student, academia and industry. When post-graduate students and their education are at stake, additional stakeholders (e.g. research councils or institutions) could also be involved. Figure 9 illustrates the potential win-win situation from such an approach.

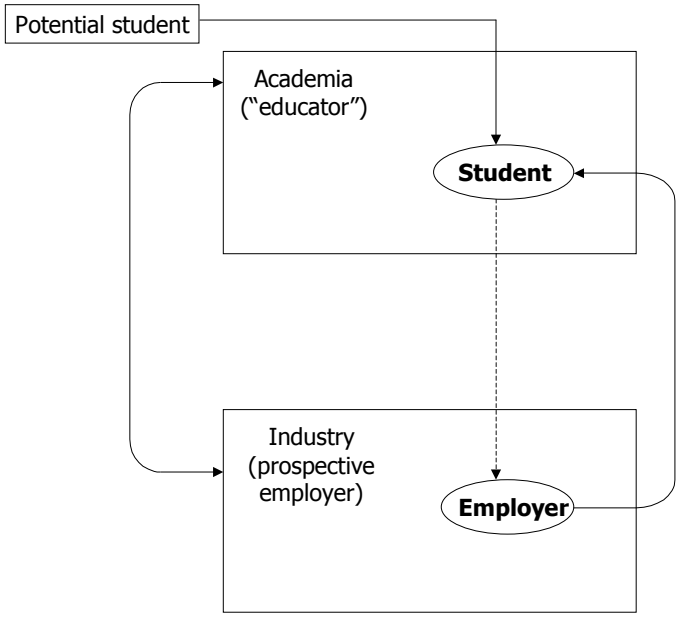

Figure 9 Win-win relationship between student, industry and academia

Relationship 1: Student and academia
Student spends money and time towards an internationally recognized qualification in food science and technology, which will prepare him/her for the workplace. Academia undertakes to provide relevant education and research, which ultimately will be to the benefit of South Africa.

Relationship 2: Student and industry
Industry prepared to sponsor education of student. In return, student has to work for the industry during and after his/her studies. Industry also involved in adding value to the quality of education through involvement.

Relationship 3: Industry and academia
Academia provides industry with skilled food scientists and relevant research and development to meet its needs and demands and to improve its competitiveness in the market. Academia, in consultation with industry, can also provide life-long learning opportunities for employers through continued education (e.g. through short courses). Industry adds value to the quality of education by interacting with students on a formal or informal basis during their studies. Academia, in consultation with industry can also provide life-long learning opportunities for employers through continued education (e.g. through short courses).

6. RELEVANT APPROACHES TO RESEARCH IN SOUTH AFRICA

For many years, education and research in Food Science and Technology in South Africa has focused primarily on the needs and activities of the formal food processing industry. South African Food Manufacturers on their part were attempting to meet the needs of primarily developed (affluent, westernised) consumers. An added incentive for earning foreign exchange by exports has also aligned the industry towards meeting needs of these consumers. However, since 1994 there has been an increasing awareness of the needs and demands of developing (poor, rural) communities.

Quite a serious allegation against the food community worldwide (and also in Southern Africa) is the prevailing malnutrition and even deaths especially among the young and infirm in rural communities. There is a growing concern for people dying from hunger or hunger-related illnesses in developing countries despite food surpluses in developed countries.

South Africa is regarded as the powerhouse of Africa and as scientists (social and natural) we cannot forget the poor and their food problems. As Food Scientists and Technologists I believe we have a social responsibility to enhance food security and alleviate poverty in sub-Saharan Africa. Up to now, we have not really made any difference. Therein lies the challenge.

What research is relevant to South Africa? How should it be carried out, who should be involved and who will fund it? Can South African scientists provide competitive food research at the cutting edge to benefit all South Africans while at the same time making a positive contribution towards protecting and promoting the health and nutritional well being of all our people? How can we be more innovative in food research and development? These are just some of the questions that need to be answered.

Current and anticipated future research needs in South Africa (and elsewhere in the world) include the following (compiled from Anon, 2001; Mermelstein, 2001; Memermelstein, 2002; UP Food Science alumni comments):

- Consumer issues
    - Obtaining better insight into consumer behaviour (Department of Food Science, UP is using sensory evaluation as a tool in one of our research focus areas to understand aspects of products and consumers)
    - Consumer education

- Environmental issues
    - Environmentally friendly packaging systems (UP is one of seven partners in a European Union Research project aimed at developing protein films from waste product from the sorghum processing industry to apply as edible coatings or films to improve quality and extend shelf life of export produce from southern Africa)
    - Better utilisation and recycling of water
    - Waste management
    - Alternative energy sources

- Food safety and quality issues
    - Contaminants in foods
    - Risk Analysis (The Department of Food Science, together with the Department of Consumer Science at UP as well as ARC-Irene are involved in a project where risk assessment is used as a tool to determine the risk profiles for rural foods)Practical implementation of food safety quality systems in processing facilitiesEpidemiological studies relating to food safety as opposed to animal studiesSafety and quality of using natural additives and alternative preservation techniques (Researchers in the Department of Food Science, UP is involved in an international irradiation working group – investigating the use of irradiation to improve the safety and quality of traditional South African foods and meals).
    - Microbiological safety issues in the fresh produce industry
    - Improved raw material utilisation

    - Development of diagnostic tools to address future food safety challenges
    - On-line sensors for food quality and safety
    - New packaging material concepts
    - Constant search for new techniques and technologies to combat changing food safety issues
    - Development of effective, low-cost and enforceable testing procedures for raw materials and products
    - Techniques or tools to determine safety of GMO foods
- New food processing technologies and products issues
    - Natural food preservation technologies (The Department of Food Science has a new research focus area (funded by the National Research Foundation) on the use of natural food preservation technologies. The main research question is to determine whether it is possible to successfully extend the shelf life of selected South African foods through the use of particular natural food preservation technologies including: (1) Biopolymers (protein-, starch- and lipid-based) extracted from South African food crops; (2) Phytochemicals (polyphenols) extracted from South African food crops; (3) Biological food preservation through the use of microbial fermentations, fermentation products (e.g. pediocins) and endogenous systems within foods (e.g. lactoperoxidase system).
    - Processing and commercialisation of traditional or indigenous food products
    - New emerging technologiesSeeking new methods of processing that is specific and applicable to the African contextTransforming bench-scale processes into industrial scale manufacture of foods
    - Quick prototyping
    - Mathematical modelling (predictive)
    - Combination processes (synergy)
    - Validation of non-thermal processes

- Functional foods and health related issues
    - Natural occurring chemicals in food with health benefits / stabilisation of foods (UP is extracting polyphenols from indigenous crops for use as antimicrobials and antioxidants in food systems)
    - Nutritional requirements of people with immunity problems
    - Nutritional claims: have to be scientifically proven
    - Nutrient-gene interaction: research into functional genomicsRapid screening tests that have a particular toxicological event as end-point, e.g. cardiovascular diseases

Research and development activities leading to wealth creation of our nation and to alleviation of poverty and malnutrition are required.

The first type of research leading to wealth creation (Figure 10) should be funded by and carried out, at least in the formal food sector, by industry and its stakeholders. Various funding streams should be utilized for this purpose, e.g. government funding through the various incentive schemes of the Department of Trade and Industry (e.g. innovation fund, sector partnership fund, SPII, THRIP and the competitiveness fund) as well as international funding streams (e.g. European Union.). According to Barnett (2002), government needs to provide the funding for fundamental research aimed to address national priorities. She argues that if industry supports this type of research by being involved as partners and by supplementing the funding, they should be the first to gain from exploiting new technologies arising from this type of research.

The South African Food Industry needs research that is focused and directed towards solutions, which address key business opportunities. Industry needs to exploit new technologies effectively in order to be competitive in the global food industry and earn foreign revenue. It is important for South Africa to be a successful exporter of unique, innovative products or processes.

In South Africa, food manufacturers are relying more and more on the Research and Development Divisions of multinational companies for product research and development. This is forcing tertiary and research institutions to progressively rely on funding from international organizations such as the European Union. There is also a trend to push the burden of research and early development on suppliers in an attempt to keep costs down. Since many speciality food ingredient and chemical additive suppliers operating in South Africa are also part of multinational food groups, the research dilemma from a local tertiary and research institutions perspective still remains.

In future, the challenges to the food industry will probably be too big to handle on one's own – increased outsourcing to specialised organizations and increased alliances with academic institutions and research institutions will be made. Speciality food ingredient and chemical additive suppliers will probably in future develop new partnerships with pharmaceutical and biotechnology industries. It is anticipated that alliances, partnerships or collaboration with academic institutions will also be important. Whether the collaboration will be with local academic institutions remains to be seen. It will be important for local academic institutions to form alliances or partnerships with leading universities and research institutions in the world if it wishes to be part of this process.

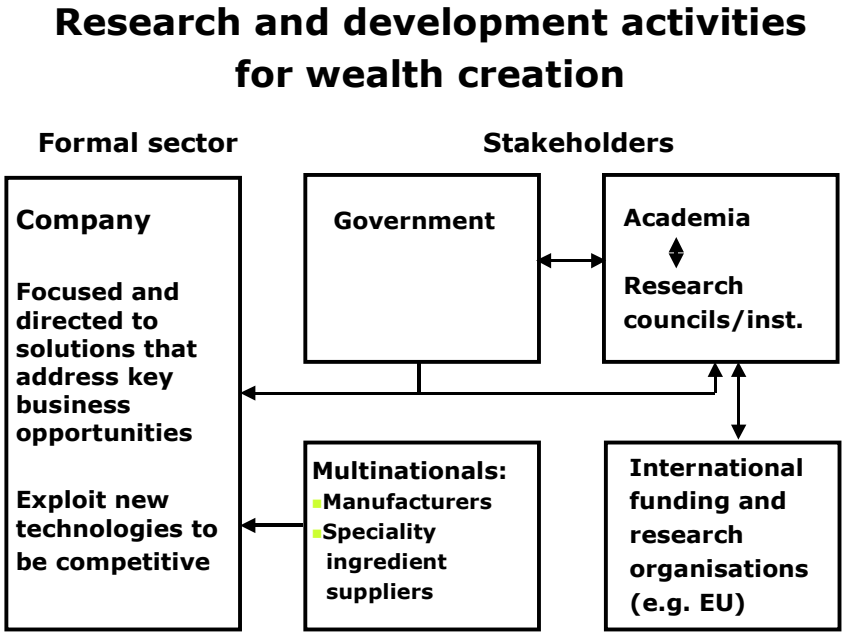

Figure 10 Research and development activities for wealth creation in the formal sector

In the informal sector (Figure 11), endogenous food enterprises need support and research from government and its stakeholders (i.e. academia, research institutions and/or councils) since these entrepreneurs face much more challenges and impediments than those from entrepreneurs operating in the formal food sector (Fennema, 2001). Collaboration and support from international organizations such as United nations through the auspices of some of its agencies (e.g. FAO, WHO , UNESCO) and USAID would also be appropriate.

Simply put, our formal industry needs to become and then maintain its competitiveness whereas new endogenous food enterprises must be developed in the informal sector.

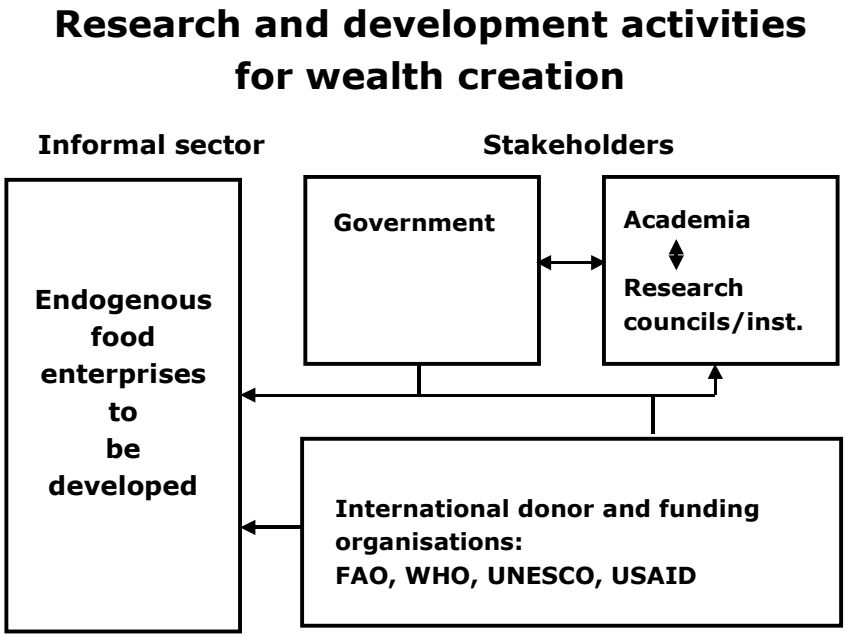

Figure 11 Research and development activities for wealth creation in the informal sector

Research and development for poverty and malnutrition alleviation should be funded by government and supported by academia, industry and research institutions (Figure 12). In terms of the second type of research, government needs to address and solve long-term food problems in southern Africa. A multi-disciplinary approach combining social and natural sciences are required. A concerted effort combining the resources and skills of these scientists from academia, industry, government, research councils and institutes is required if we are serious about solving some of our debilitating socio-economic problems.

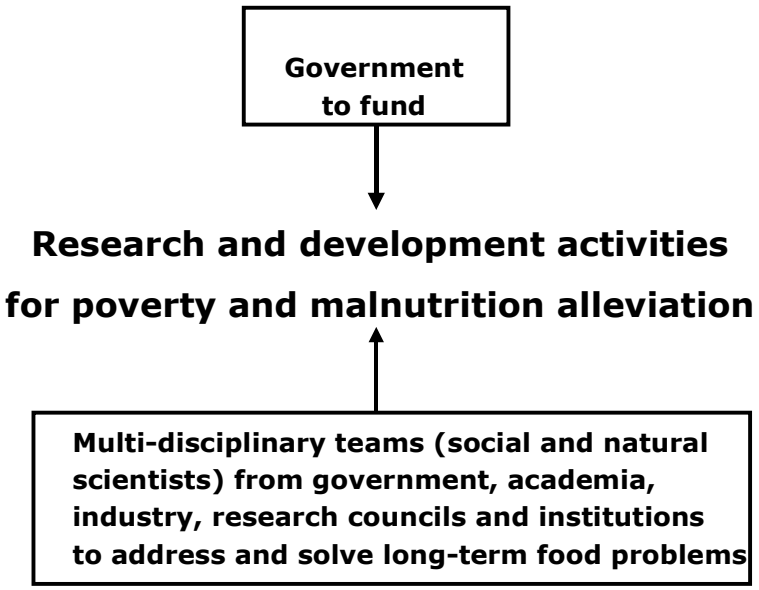

Figure 12 Research and development activities for poverty and malnutrition alleviation

Creating national and international food research networks in Food Science and Technology using multi-disciplinary research teams with complementary skills will be required in future.

How can the Department of Food Science, University of Pretoria best serve the needs of the South African Food Industry in particular and South Africa in general? By becoming your education and research partner.

Food Science, Its Education and Research – our Future!

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