Capacity Development for Modernizing African Food Systems (MAFS) Working Paper

Food Science and Technology Curricula in Africa: Meeting Africa's New Challenges

By

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The Modernizing African Food Systems (MAFS) Consortium

Modernizing African Food Systems (MAFS) Consortium

Objective: The MAFS Consortium aims to help African agricultural education and training (AET) institutions develop the technical skills and institutional capacity required to modernize African food systems.

MAFS Consortium Members:

- Makerere University
- Michigan State University
- Stellenbosch University
- University of Pretoria

Activities and Outputs: The MAFS Consortium has assembled a technical team from four major agricultural universities to produce a series of empirical background studies that will provide evidence necessary for informing capacity development efforts in African AET institutions. Substantively, the activities center around the following four thematic areas.

Theme 1. Food System Dynamics in Africa and Consequent Skill Requirements in the Private and Public Sectors

Theme 2. Models of AET Engagement with Private and Public Sector Employers

Theme 3. Existing Capacity of African AET: Case studies of African universities with regional footprints

Theme 4. Impact of past AET institution-building efforts in Africa

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ABSTRACT

Africa is changing rapidly. Across the continent, sustained economic growth now averages 4% per annum and by 2030 more than 50% of Africans will live in cities. Africa is now in Nutrition Transition. This transition to an energy dense but nutrient poor diet in conjunction with a sedentary lifestyle threatens an epidemic of so-called Western diseases, cardiovascular disease and type 2 diabetes. Food science and technology (FST) in Africa has a critical role to drive economic development and improve people's diet and health. However, a snapshot survey of FST curricula in African universities revealed that there is insufficient non-degree extension training and nutrition education is very deficient. A four pronged FST strategy is proposed for Africa involving: Advocacy to inform public health officials and food industry executives of the nutrition and health challenges, Reform of university food science and technology curricula, Reform of peri-urban agriculture and horticulture markets, and Technology support of small enterprise food processing entrepreneurs.

Keywords: African universities, Curriculum development, Food Science and Technology, IUFoST, Nutrition Transition, Public health, SME, Urbanization

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1. INTRODUCTION

Africa faces many critical challenges, chief among them raising the quality of its human capital, accelerating economic development and improving its peoples' well-being. Food science and technology (FST) in Africa has a critical role to play in contributing to increased food product manufacturing, improved worker productivity and incomes, and ensuring adequate food supplies, human nutrition and good health.

Africa is changing rapidly, and so are its challenges. Across the continent, sustained economic growth now averages about 4% per annum (Africa Economic Outlook 2012). At the same time, the population continues to grow at roughly 3% per annum and is expected to double to 2 billion people by 2050 (FAO 2009). Even more startling, is the continent's rapid urbanization. As a result, Africa's food consumption patterns will change dramatically over the coming decades. At the same time, evidence strongly suggests that dietary changes and accompanying lifestyle changes are driving a rapid "Nutrition Transition", leading to major health problems, such as an increase in obesity and its associated diseases. FST and nutritional professionals will play a key role in heading off these looming public health problems by developing nutrient-rich, sensorially appealing, low-cost foods, helping to improve people's health and ramping up food and nutritional sciences education at all levels.

This paper strategizes about how food science and technology in Africa needs to develop to meet the challenges of the continent's rapidly changing food systems. Firstly, Africa's changing food systems will be examined with a focus on the markets and the nutritional and human health implication of these changes. Next, the role of food science and technology professionals in this changing environment will be mapped out, examining their current and potential roles across the food sector, from the private food industry (multinationals to small, medium and micro enterprises (SMMEs)), in public health and in shaping the polices of government at all levels. Then, the results of a snapshot survey of current university food science and technology education and training across Africa will be examined in the context of the needs of this broad food sector. The paper concludes with the authors' vision of a strategy for food science and technology curricula to meet Africa's new challenges in food science and nutrition education and training.

2. AFRICA'S CHANGING FOOD SYSTEM

2.1 Changing food markets

Rapid urbanization and growing per capita incomes will trigger major changes in African food systems over the coming decades. With urban population growing at about 3.4% per year (UN Habitat 2012), current projections suggest that Africa will become majority urban by 2030 (Figure 1). The corresponding decline in rural and farm population shares will translate into a rapidly increasing share of marketed food. Although the value added from on-farm food production will roughly triple in Africa over the next forty years, to keep pace with the continent's doubling population and shifting tastes, marketed volumes will increase by a factor of six (Haggblade 2011). As a result, under most plausible future scenarios, the fastest growing segments of Africa's food systems will be in the post-farm segments of the supply chain, i.e. in food processing, distribution and marketing.

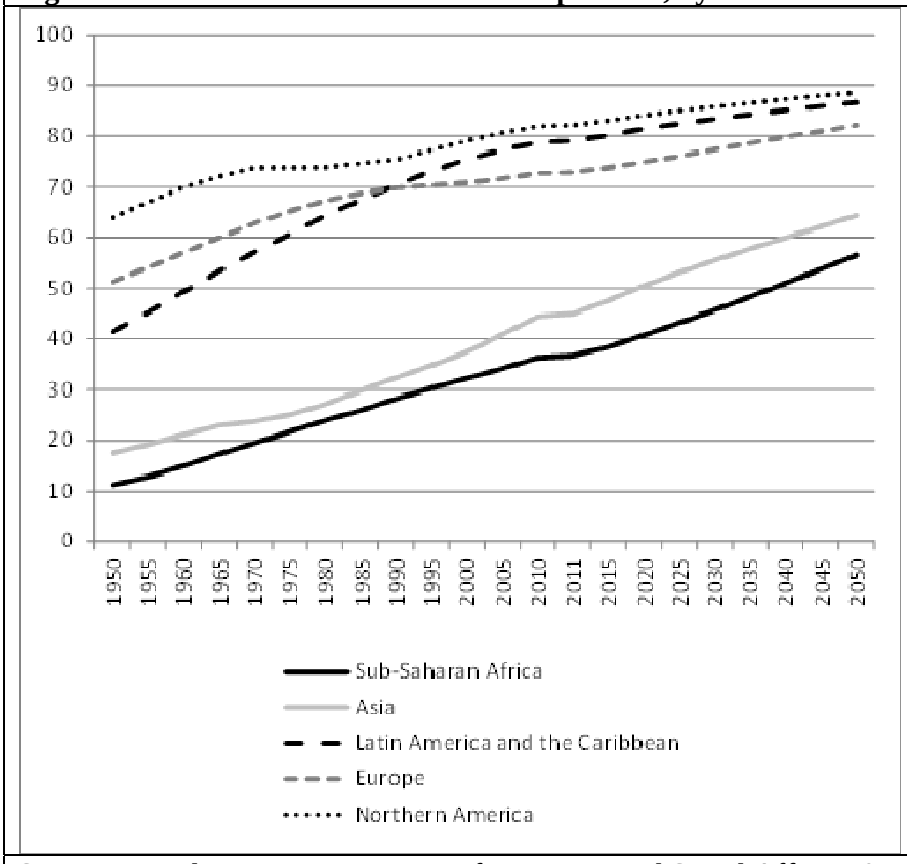
The composition of food consumed will change rapidly as well. Urbanization and growing per capita incomes will translate into greatly increased demand for processed foods, high-

value foods (e.g. dairy, meat and fresh fruits and vegetables), packaged convenience foods and prepared foods. The agribusinesses emerging to meet this growing demand will require food scientists and technologists with expertise in modern food processing and food safety technologies. Markets for cereals, in contrast, will grow more slowly than processed and prepared foods. Increasingly, food grain demand becomes tied to the livestock sector and derivative demand for animal feeds.

Burgeoning urban demand for fresh fruits and vegetables is placing growing pressure on Africa's urban horticulture markets. Unlike processed foods and packaged dry goods, which increasingly rely on supermarket distribution channels, fresh fruit and vegetable markets remain dominated by traditional wet markets (Reardon 2007). Detailed studies from Kenya and Zambia, for example, indicate that traditional retailing through open air markets and street vendors account for over 90% of all fresh produce marketed. Supermarkets, in contrast, handle less than 5% of horticulture retailing (Tschirley et al. 2010).

Yet rapid growth in urban fruit and vegetable markets, coupled with limited investment in wholesale wet market facilities, inadequate town planning, poor zoning, traffic congestion and often deplorable sanitation result in high losses (in the range of 25% to 40%), high prices for consumers and low prices for farmers and traders. Despite the potential nutritional gains from growing purchases of nutrient-rich fresh fruits and vegetables, high prices and poor sanitation remain challenges.

Fig 1: Trends in Urban Share of Total Population, by Continent



Source: United Nations Department of Economic and Social Affairs 2011

This shifting structure of food demand holds two major implications for food science and technology. On the supply side of Africa's growing food markets, agribusiness firms increasingly require employees with technical skills in food biochemistry, food processing, packaging, food safety, storage, logistics and distribution. On the demand side of these growing urban food markets, the widespread shift in consumers' diets holds critical implications for human health and nutrition. As a result, both public and private employers will require employees with technical training in food safety, food standards and nutrition.

2.2 Nutritional implications

All countries in sub-Saharan Africa continue to suffer from unacceptable levels of under-nutrition, particularly among young children in rural areas. In sub-Saharan Africa, some 28% of children under 5 years are moderately or severely underweight (UNICEF 2007). A major cause is unbalanced diets, which are often deficient in micronutrient-rich foods and may also have low bioavailability of essential micronutrients (FAO and ILSI 1997). Africa, today, has also entered the Nutrition Transition. Poplin (2003) describes the Nutrition Transition in terms of the large shifts that have occurred in diet and in physical activity patterns, particularly in the last decades of the twentieth century. The diet of modern societies seems to be converging. It is characterized by high levels of saturated fats, sugar and refined foods, and low levels of fiber. At the same time, there is a change in lifestyles, characterized by lower levels of physical activity. Associated with the change in diet and lifestyle is shift in anthropometric factors (i.e. an increase in average stature, body composition) and changes in disease patterns.

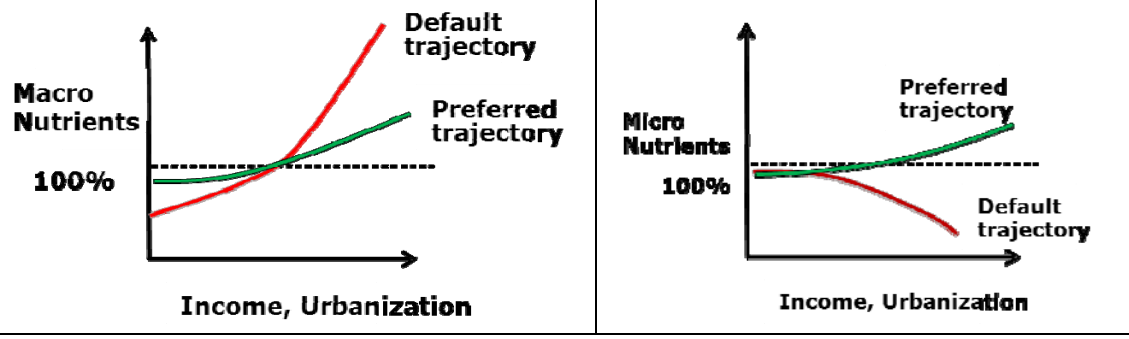
Popkin (2003) further identifies three stages of Nutritional Transition. In Stage 1, food scarcity (and in extreme cases famine) begins to recede as income rises. During Stage 2, changes in diet and activity pattern lead to the emergence of new disease problems and increased disability. Finally, in Stage 3, behavioural change begins to reverse the negative tendencies and make possible a process of successful ageing. South Africa, for example, has advanced far into stage 2 of Nutrition Transition, from a predominantly rural population where people obtain most of their food through their own farming activities to an urban population purchasing its food from supermarkets, fast food outlets and street venders. Other African countries are following closely behind in this transition.

The rapid pace of the Nutrition Transition means that Africa increasingly faces the double burden of simultaneously high rates of under- and over-nutrition. Across Africa, very disturbing health and disease consequences are accompanying this transition. A survey by GlaxoSmithKline in 2010 (Mail & Guardian 2010) revealed that more than 60% of South Africans are overweight. Most worryingly, 17% of children under 9 years are overweight. Even in Tanzania, a low income country, a survey of equal numbers of adult women involved in farming, housework and business, found that 49% were obese (mean BMI 30) and only 4% were chronically energy deficient (mean BMI 17.5) (Mosha 2003). The association of Western non-communicable diseases with urbanization in Africa has been revealed by research findings by the South African Medical Research Council, which showed that 15% of urban people in Africa have high blood pressure compared to 5% of the rural population (Mbewu 2009). The research also revealed that today, in South Africa, some 25% of deaths result from cardiovascular disease, and across Africa the incidence is 11%. The incidence of type 2 diabetes is also increasing rapidly in sub-Saharan Africa. The Diabetes Leadership Forum (2010) predicted that levels will double by 2040. Diabetes South Africa (2012)

estimates that in South Africa 10% of population have diabetes and most are unaware of their condition. Elsewhere in Africa, diabetes is also becoming a major disease. A recent article in the Lancet revealed that in Tanzania, there has been a 3- to 7-fold increase in diabetes in the past 15 years to 6% of urban people (Mbanya et al. 2010).

To avoid these health consequences, it is critical that consumers successfully navigate the Nutrition Transition, which is accompanied by the huge increase in the availability of processed, packaged and prepared foods. This means that traditional diets rich in whole grains and indigenous fruits and vegetables lose ground to a bevy of purchased, packaged, preserved foods based on highly refined flours with high levels of salt, sugar and fat. Figure 2 illustrates what happens to people's macro- and micronutrient intake as populations go through the Nutrition Transition. As indicated, energy-dense but empty calories, in both processed foods and beverages, contribute to growing overweight problems and associated non-communicable disease such as diabetes, heart disease and certain forms of cancer. Africa, the last continent to urbanize, is also the last to face the public health consequences of the resulting Nutrition Transition (Popkin 2003). These trends, likewise, place new and rapidly growing demands on institutions offering scientific training in food science and technology, nutrition and public health.

Figure 2: Influence of urbanization and rising incomes on macro- and micro-nutrient intake in developing countries



Source: BCC Consortium

3. ROLE OF FOOD SCIENCE AND NUTRITION PROFESSIONALS

3.1 Private sector food industry

Food processing firms in Africa, in order to supply growing urban markets and to attain cost-reducing economies of scale, will increasingly need to scale up production from semi-artisanal to industrial levels. In many instances, these increases in scale imply batch sizes several orders of magnitude larger than traditional manual processing. In Southern Africa, the industrialization of sorghum beer (traditional African opaque and cloudy beers) and *mageu* (non-alcoholic fermented cereal porridge gruel) production resulted in scaling up production from 200-liter batches by village women to stainless steel cookers of between 15,000 and 20,000 liters (Haggblade and Holzapfel 1989). In West Africa's industrialization of *gari* (a granulated, pre-cooked convenience food made from toasted cassava) production, emerging food processors have scaled up production from individual, episodic batches of one

to two tons of processed roots to continuously operated industrial plants processing 50 to 60 tons of roots per day (Onyekwere et al. 1989; Nweke et al. 2002).

Another uniquely African example is the development of a lager beer brewing industry based on sorghum, firstly in Nigeria starting 25 years ago (Ilori 1991), and in the past decade in East and Southern Africa (Mackintosh and Higgins 2004) (Figure 3). The success of this development can be seen by the fact that beer production in Nigeria, based on locally grown sorghum, is currently growing at 6% per annum and in 2011 reached 19.5 million hectoliters (Anon 2012), and is now a close second in Africa to South Africa.

Fig 3: Developments in sorghum-based brewing in Africa

a) PLC controlled pneumatic sorghum maltings in Nigeria

b) Lager brewery in Uganda – Each block of fermenters represents an expansion over the past decade (the original brewery fermenters are inside the brewery and still in use)

Source: John Taylor.

In order to improve food and beverage safety, avoid spoilage and to ensure product quality at industrial scales, the African food industry will require increasing numbers of food scientists and technologists. With Africa's many indigenous fermented foods such as *gari*, sorghum beer, *mageu*, *fufu* (cassava or yam porridge), *ogi* (a fermented starchy cereal-based beverage), and fermented dairy products such as amazi – increases in batch sizes will require scientific research into the biochemistry and microbiology of these fermentations in order to identify the microbial cultures driving key fermentations, optimal temperatures and pH and effective protocols for controlling pathogenic micro-organisms and ensuring food safety (Steinkraus 1989, Taylor and Emmambux 2008).

Marketing and logistics become increasingly important as supply chains lengthen. Growth in the post-farm segments of the supply chain results in a growing share of processing, packaging, distribution and marketing in total price paid by African consumers. Consequently, marketing efficiency becomes critical to efficiency of the food system. In Zambia, for example, marketing margins for maize fell by roughly 70% in the decade and a half following liberalization of cereal markets the mid-1990's (Jayne et al. 2010). While increasing farm productivity remains crucial for raising farm incomes, the growing scale of post-farm segments of the supply chain mean that efficiency in food marketing and distribution systems will become increasingly important for moderating consumer food prices. This translates into growing demand for employees with expertise in packaging, food storage, logistics, commodity price hedging and finance. Growing demand for perishable

products such as fresh fruits and vegetables increase demand for expertise in logistics, quality and temperature control, packaging, cold storage management, sanitary controls and monitoring of communicable bacterial diseases (Abbott 1986). Given the increasingly volatile world commodity prices, market forecasting, commodity risk management, market monitoring, storage and regional logistics platforms will all become increasingly important for Africa's food industries.

Food safety, packaging and consumer taste preferences likewise govern food marketability and food safety. As a result, private food processors will increasingly require scientific expertise in food safety, food packing and sensory evaluation techniques. To meet this need, multinational food companies operating in Africa are beginning to set up regional R&D centers where food scientists and technologists develop and adapt food products to meet local requirements. A notable example of this trend is Nestlé's Food R&D Center at Abidjan, Ivory Coast (Nestlé 2010).

Food processing SMMEs are the drivers of job creation. With increasing urbanization, small-scale production of all types of food products is increasing rapidly across Africa. An interesting trend is the development of convenience food products based on traditional local foodstuff, such as pearl millet (Taylor et al. 2010) where three levels of value addition are taking place: simple flour products, value added flours (nutritionally enriched and flavored) and ready-to-eat (RTE) instant porridges and infant foods. Since the small and micro enterprises are invariably run by persons with no technical training in food science and technology, food safety risks are high. Also, processing efficiency and product quality are invariably poor. These factors greatly increase the chance of business failure. Obviously, food scientists and technologists have a critical role to play in providing technology to SMMEs. However, reaching them and making a significant impact is challenging because of the high numbers of SMMEs and small number of food scientists and technologists, and the issue of the SMMEs having little or no money to pay for services of the food professionals.

Franchising is an excellent way of alleviating small enterprise technical and business failure. With urbanization and rising living standards, there is a huge growth in fast food franchises across Africa, particularly from companies based in South Africa. For example, Famous Brands, a South African fast food franchise company opened 18 restaurants in other African countries in the last quarter of 2012 (How We Made in Africa 2012). However, as is well-known, the widely held opinion is that most fast foods from international companies are not healthy (Igumbor and others 2012, Pretoria News 2012). Food scientists and technologists are needed not just to improve technical efficiency, product consistency and food safety standards of fast food franchise enterprises, but importantly to substantially improve the nutritional quality of the products, while at the same time maintain sensory quality.

As food-borne disease (FBD) is of great importance in Africa, food scientists and technologists need to mitigate FBD and deal with pathogens (viruses, bacteria, parasites and prions). This should be given priority in future FST standards especially in setting for animal production food safety.

3.2 Public health, consumer protection and consumer education

Food and nutrition are an integral part of health. Health is not merely absence of diseases but the total well-being of an individual. Future FST activities (and education) in Africa must take cognizance of the new approaches to health. "One Health" is a relatively new approach

to solving complex health related challenges that has generated significant interest and gathered momentum at global, regional and national level. The "One Health" approach, seeks to appropriate total health by ensuring disciplinary, multi-sectorial and systemic approaches to the practice of health service delivery – doing things together, learning together, and shaping the future together in this increasingly "One World, One Health and One Economy". There are multiple and varied disciplinary and professional stakeholders in appropriating One Health including FST, veterinary science, public health, wildlife health, agriculture, nursing, among many others.

Future advocacy roles for FST professionals will be geared towards measures to help curb dietary deficiencies and nutritional disorders as well as labeling of foods, especially genetically modified foods (GMOs), trans-fats, sugars, and other food constituents that are of health concern. FST professionals through their national bodies, affiliated to the International Union of Food Science and Technology (IUFoST) can commission independent scientific statements on contemporary and emerging issues of public interest such as GMOs, the presence of acrylamide in heat processed foods, nanostructured foods and human health, role of antioxidants in human health, trans-fats and cardiovascular diseases, dietary fiber and health, HIV/AIDS and nutrition, and so on, to guide policy directions. Further, the African FST professional bodies affiliated with IUFoST can play an important role of moderating the practices by members not to profiteer at the expense of public safety. Responsible media advertising, for example, can help change peoples' dietary behavior.

At a more basic level, food professionals through private agencies can provide the public with valuable advice about the nutritional composition of foods and what food products should be consumed daily and which in moderation. An example worth emulating in Africa is Vegetables NZ (n.d.) based in New Zealand, which promotes increased vegetable consumption through using a variety of media and activities, even including the early childhood education setting.

Perishable foods likewise require public and private investments in sanitation, food safety urban planning. Africa's urban wholesale markets for horticulture products feature often outmoded infrastructure and inadequate zoning impose consequently heavy losses on farmers, particularly during the rainy season, as well as potential public health risks and high prices for consumers. Pro-active discussions between market traders, city governments, town planners and public health officials are required to anticipate and provide the public zoning and infrastructure required to facilitate continued rapid growth of the sector, particularly in Africa's rapidly growing secondary cities.

Animal health and food safety is dealt with in the related specialization area of veterinary public health. This covers, for example, a number of food science and nutrition areas including: meat hygiene, inspection and technology; milk hygiene and technology; food hygiene and food-borne diseases; food spoilage and preservation; food microbiology; fish hygiene and inspection; egg hygiene; zoonoses and emerging and re-emerging zoonoses; environmental hygiene; water hygiene; inspection of food of animal origin including meat from domestic and wild animals, fish, honey among others. Food scientists and technologists should therefore emphasize the need to strengthen the relationship with the veterinary and other One Health disciplines. They should also contribute to the work of several Codex Committees, including the Codex Committee on Food Import and Export Inspection and Certification Systems (which addresses inter alia the issues of traceability and certification), and the Codex Committee on Milk and Milk Products.

Perhaps sometimes overlooked, is the fact that agriculture and food are among the critical infrastructure susceptible to terrorism. It is advisable that FST professionals, farmers, market vendors, hoteliers, and others selling food to the public be aware of terrorism activities that could impact any portion of the food and nutrition value chain, and relevant competences to address emerging challenges are needed today.

3.3 Role of food science and nutrition professionals in shaping public (government) policies in Africa

As alluded to previously, the future of Africa's food systems will be driven by changes in demographic profiles, structural transformation, income growth (and associated nutritional transitions) and health concerns. Africa, particularly sub-Saharan Africa, is currently the youngest population in the world with 44% of its population below the age of 15 years, majority of which (over 60% on the average) reside in the rural areas (Ashford, 2007). However, by 2030, Africa will have more working-age share of the population predominantly living in urban centers (Kessides 2005). As elsewhere, urbanization in sub-Saharan Africa is strongly associated with increased levels of chronic non-communicable diseases such as obesity, diabetes and cardiovascular disease (Unwin and Alberti 2006).

This unfolding scenario offers immense opportunities for Food Science and Technology to shape the future. As an inherently inter-disciplinary field, FST is uniquely placed to: stimulate value-added food processing, agribusiness and job creation; design food products for convenience to suit urban lifestyles without compromising on health; manage the food-health interphase by ensuring food safety and development of nutritive and health-promoting foods; and facilitate trade in food products by ensuring compliance with agreed standards and safety regulations.

However, the potential contribution of FST to development of African countries has been limited by its persistent misconceptions, especially in public policy circles. In Kenya, for instance, pioneering FST graduates were deployed in the field as home economists and extension officers under the Ministry of Agriculture. The food industry has equally been undiscerning in the capabilities of FST graduates, almost invariably engaging them at best as quality control managers, but mainly as laboratory technicians and managers, while employing chemists as production managers. In many African countries, this gross mismatch of FST skills continues, due to persistent personnel deployment traditions in the industry, inexistent or moribund professional lobby groups, and lack of a clear public perception of FST curricula (Ojijo 2005).

Food science and technology professionals, either as individuals or as body corporate, have the onerous role to help bridge the divide between the seeming public denigration and the true worth of their profession. The food industry in many African countries is still rudimentary. However, agriculture is increasingly seen as the cornerstone for economic growth of African countries, especially through innovations along the value-chains. Within government, food scientists and technologists thus have a key role to play in Ministries of Agriculture, Health, Trade and Industry, and Departments of Standards and Metrology in the general areas of food safety, food quality (including nutritional quality) and food standards. Roles in food safety could include development and enactment of food safety legislation on additives, food toxins and contaminants, microbiological and chemical safety, and GMOs. Also required are the enactment of Codex Alimentarius standards and development of

African Union standards, development of harmonized regional standards, and public health inspection and certification.

Roles in food quality could include development of food product nutrition and health labelling and food fortification. Roles in food standards would include food product classes and grades, food authenticity, facilitation of food import and export (especially removal of unnecessary barriers to regional trade), sanitary and phytosanitary agreements. As mentioned, Africa's growth is creating opportunities for food processing SMMEs and an imperative is to help develop this key sub-sector. An important role for FST professionals in government will be development of an SMME appropriate regulatory framework for food handling, processing and distribution.

Professionals with specific expertise in food science and nutrition have a key role to play in the policy dialogue space with a view to bringing to the attention of governments contemporary food-health and food safety related issues. The interdisciplinary nature of FST endows its professionals with a unique inter-sectorial grasp of technical issues. Thus, FST professionals working in both public and private agencies would potentially be best placed to handle trans-boundary issues of food safety, quality, nutrition and standards that span agriculture, health, and trade and industry sectors. An interesting example in South Africa concerning how food scientists and technologists in the private sector can assist government in ensuring food safety, is FLAG, the Food Legislation Advisory Group. FLAG is a committee of food industry, research and academia food scientists and nutritionals and representatives of the government Department of Health, which advises the government on development of food safety and labeling legislation and regulations appropriate to the rapidly changing food safety, nutrition and health environment.

Together with associated professionals (in nutrition and health), FST professionals must play catalytic roles in helping enact policies on agro-food business, nutrition, food safety, hygiene, and chronic non-communicable diseases. For example, food scientists, nutritionists and pediatric endocrinologists can jointly help in the development of public policy to prevent childhood obesity by giving a robust voice in support of scientific facts that attribute the public health problem to identified dietary proclivities (Friedman and Schwartz 2008).

Food safety crises are an increasingly important issue. Numerous food crises have occurred internationally in recent years (the use of the dye Sudan Red I; the presence of acrylamide in various fried and baked foods; mislabeled or unlabeled genetically modified foods; and the outbreak of variant Creutzfeldt-Jakob disease) originating in both primary agricultural production and in the food manufacturing industries. Public concern at these and other events has led government agencies to implement a variety of legislative actions covering many aspects of the food chain with the expert inputs from food scientists and technologists.

4. SURVEY OF UNIVERSITY FOOD SCIENCE CURRICULA IN AFRICA

4.1 Methodology used for surveying food science and technology curricula in Africa

A short questionnaire (Table 1) was prepared and sent to 28 Food Science or related departments in selected African universities. Seventeen responses were received from 11 counties (Southern Africa – Botswana, Namibia and Botswana; Eastern Africa - Ethiopia, Kenya, Mozambique, Rwanda and Uganda; Middle Africa – Cameroon; Western Africa – Ghana and Nigeria). The questionnaire included questions on the following aspects: specific focus and outcomes of degree programs; important food science skills required for graduates; work experience/experiential training details for degree purposes; national and international collaborative programs and partnerships; adherence to international guidelines for Food Science and Technology degree programs; where graduates are employed; major challenges facing Food Science and Technology educators in Africa.

Table 1: IUFOST Africa Food Science and Technology Education Questionnaire

ITEM	ITEM (continued)
Country	Are there regional guidelines for Food Science and Technology programmes? Yes or No
Name of Institution	Where are your students employed? • Tertiary education institutions • Research institutions • Private industry • Self-employed
Name of Department	Do you have institutional collaborators that contribute to your degree programmes? (please list them)
Name of undergraduate degree programme(s) and duration (e.g. BSc in Food Science or BSc in Food Science and Nutrition – 3 years)	Name of post-graduate degree programme(s) and duration
Is there a specific focus in terms of specialisation or specific outcomes in your degree programmes?	Are your post-graduate degree programmes (i.e. masters and doctoral) research based, taught degrees or a combination thereof?
What skills do you regard to be important for your graduates?	List any specific food security activities in your department
Work experience / experiential training details (if applicable for degree purposes)	Are you involved in formal continuing education activities and please list?
Adherence to either IFT or IUFoST degree programme guidelines (Yes/No)	What is the biggest challenge that you face as Food Science and Technology educators?
Is there a national curriculum for Food Science and Technology and if so under whose jurisdiction?	Any additional comments that you wish to make?

4.2 Curriculum offerings

The majority of universities surveyed offer the equivalent of 4-year BSc Honours level Food Science and/or Technology degrees at undergraduate level (Table 2). Some institutions, notably in Nigeria and Ethiopia offer 5-year programs. The Technical Universities of Technology in South Africa (Tshwane University of Technology, University of Johannesburg and Cape Peninsula University of Technology) offer diploma programs at undergraduate level and technical degrees at post-graduate level. Only four universities surveyed (University of Pretoria, South Africa; University of Ghana, Ghana; Moi University, Kenya and Makerere University, Uganda) offered degree programs in Nutrition or Nutrition and Food Science. The majority of universities surveyed present Master's and Doctoral degree programs. In South Africa, all MSc degrees are research based. The norm for the rest of the countries and institutions surveyed seems to be that there is one year for course work and one year for research-based work. Although the majority of BSc programs in Food Science and/or Technology presented at the universities surveyed adheres to either IFT (US Institute of Food Technologists) or IUFoST degree guidelines, national and in particular regional guidelines / curricula are lacking.

Table 2. Degree offerings at undergraduate and post-graduate level in Food Science and related disciplines at surveyed universities in Africa

Country	Name of Institution	Undergraduate Offerings	Post-graduate Offerings	Work experience/experiential training required for degree purposes	Adherence to IFT/ IUFOST guidelines (Yes/No)	National or regional curricula in Food Science	Regional curricula in Food Science
Eastern Africa							
Ethiopia	Haramaya University: Dept of Food Science and Postharvest Technology	BSc in Food Technology and Process Engineering (5yrs)	MSc in Postharvest Technology MSc in Food Science and Technology MSc in Food Engineering (1 year course work and 1 year research)	6 months internship	Yes	No	No
Kenya	Moi University: Dept of Consumer Science)	BSc Hons Food Science and Nutrition (4 yrs)	None (First undergraduate class graduated in 2011)	90 working days – industrial attachment	Not exactly	No	Yes, with Tanzania and Uganda
Mozambique	Universidade Eduardo Mondlane: Chemical Engineering – Food Technology Division	BSc (Eng) in Chemical Engineering with specialization in Food Technology	MSc with collaboration of Lund and Chalmers Universityies in Sweden (course work and research)	-	-	No	No
Rwanda	Kigali Institute of Science and Technology: Dept of Food Science and Technology	BSc in Food Science and Techonology (4 yrs)	Research based MSc and PhD programmes through research in the process of development	-	Yes	Not sure	Not sure
Uganda	Makarere University Department of Food Technology & Nutrition	BSc Food Science and Technology (4 yrs) BSc Nutrition (3 yrs)	MSc Food Science (2 yrs) MSc Applied Human Nutrition (2 yrs) PhD Food Science (4 yrs) PhD Nutrition (4 yrs) Masters: course work and research PhD: research based	None	Yes	Yes	No

Table 2b (continued)

Country	Name of Institution	Undergraduate Offerings	Post-graduate Offerings	Work experience/experiential training required for degree purposes	Adherence to IFT/ IUFOST guidelines (Yes/No)	National or regional curricula in Food Science	Regional curricula in Food Science
Western Africa							
Ghana	University of Ghana: Dept of Nutrition and Food Science	BSc Nutrition and Food Science (4 yrs) BSc Food Science (4 yrs) BSc Nutrition (4 yrs	M Phil (2 yrs) PhD (3-4 years) Both degrees are a combination of taught courses and research	6 weeks vacation internship	Yes	No	No
Nigeria	Federal University of Agriculture, Abeokuta: Dept of Food Science and Technology	BSc Food Science and Technology (5 yrs)	MSc programmes (2yrs) – taught courses and research): Food Processing and Storage Technology; Food Quality and Assurance; Food Microbiology and Biotechnology; Food Process Engineering Similar programs on doctoral level (3 yrs – research based)	6 months industrial attachment	Yes	Yes	No
Nigeria	University of Agriculture, Makurdi: Dept of Food Science and Technology	BSc in Food Science and Technology (5 yrs with O levels and 4 yrs with A levels)	Masters and doctoral Degrees in Food Science and Technology	6 months industrial attachment	Not sure	Yes	No
Middle Africa							
Cameroon	University of Ngaoundere: Dept of Food Science and Nutrition	None (a post-graduate school)	Professional Masters in Engineering in Agro-Food Process Engineering (3 yrs)	7 months over a period of 3 years of studies	No	No	No

Table 2c (continued)

Country	Name of Institution	Undergraduate Offerings	Post-graduate Offerings	Work experience/experiential training required for degree purposes	Adherence to IFT/ IUFOST guidelines (Yes/No)	National or regional curricula in Food Science	Regional curricula in Food Science
Southern Africa							
Botswana	Botswana College of Agriculture: Dept of Food Science and Technology	BSc in Food Science and Technology (4 yrs) (first intake 2013)	Non-existent at the moment	3 months industrial placement	Not sure	No	No
Namibia	University of Namibia: Dept of Food Science and Technology	BSc (Agric)(Hons) in Food Science and Technology (4 yrs)	None	3 months industrial attachment	No	No	No
South Africa	University of Free State: Department of Microbial, Biochemical and Food Biotechnology	BSc Food Science with either Microbiology, Biochemistry or Chemistry (3 yrs) BSc (Agr0c) Food Science with either Agricultural Economics. Agronomy, Animal Science, Microbiology, Biochemistry or Chemistry (4 yrs)	BSc Hons and BSc (Agric) Hons (1 yr) MSc and MSc (Agric) (minimum3 years) PhD (minimum 2 years) Masters and Doctoral degrees – research based	None	No	No	No
South Africa	University of Johannesburg: Dept of Food Technology	National Diploma in Food Technology (3 yrs) or extended National Diploma in Food Technology (4 yrs) BTech Food Technology (3 + 1 yrs)	MTech (1-2 yrs) DTech (2-4 yrs) Programs research based	1 year industrial training	No	Still follow national curriculum framework as applicable to former Technikons in South Africa do	No
South Africa	Cape Peninsula University of Technology: Dept of Food Technolgy	National Diploma in Food Technology (3 yrs) BTech Food Technology (3 + 1 yrs)	MTech Food Technology (minimum of 2 yrs) Research based	1 year industrial training	Yes		No

Table 2d (continued)

Country	Name of Institution	Undergraduate Offerings	Post-graduate Offerings	Work experience/experiential training required for degree purposes	Adherence to IFT/ IUFOST guidelines (Yes/No)	National or regional curricula in Food Science	Regional curricula in Food Science
South Africa	University of Pretoria: Dept of Food Science	BSc (Agric) Food Science and Technology (4 yrs) BSc Food Science (3 yrs) + BSc (Hons) Food Science (1 yr) BSc Nutrition and Food Science (3 yrs) + BSc (Hons) Nutrition and Food Science (1 yr) (Nutrition and Food Science programs to be replaced in 2014 by 4 yr BSc Nutrition.	MSc (Agric) Food Science (2 yrs) MSc Food Science (2 yrs) MSc Nutrition (2 yrs) PhD Food Science (3 yrs) PhD Nutrition (3 yrs) Masters and doctoral degree programs research based	None	Yes	No	No
South Africa	University of Stellenbosch: Dept of Food Science	BSc Food Science (Food Science with Biochemistry)(4 yrs) BSc Food Science (Food Science with Chemistry)(4 yrs)	MSc Food Science (minimum 1 yr registration) PhD Food Science (minimum 2 yrs registration) DSc Food Science All degrees are research based	8 weeks minimum with at least four weeks at single company	Yes	No	No
South Africa	Tshwane University of Technology: Department of Biotechnology and Food Technology	N Dip Food Technology (3 yr program extended over 4 yrs) B Tech Food Technology – 2 yr part time program	MTech and D Tech degrees are research basd		Yes (IFT) but adapted to qualification structure at TUT	Still follow national curriculum framework as applicable to former Technikons in South Africa	No
South Africa	University of Venda: Department of Food Science and Technology	BSc Food Science and Technology (4 yrs)	MSc course work and mini dissertation (1 yr) MSc by research (1 yr) PhD Agriculture (Food Science and Technology) (3 yrs) – research based	6 months industrial training	Yes	As practised in South Africa	No

- No information provided

Food Science and Technology graduates need a comprehensive skills set (Fig. 4, Table 3). In general, degree programs include fundamental principles of FST – broad base knowledge at the undergraduate level and more specialization at the post-graduate level. Sound knowledge of food science principles (in terms of food chemistry and analyses, food engineering, food processing, food microbiology and safety) is a requirement for most programs. Another element that is important is that graduates have the ability to apply their scientific knowledge to practical situations. Practical hands-on skills and experience are regarded to be important by the majority of universities surveyed. The ability to apply knowledge and theory to practice was emphasized by many of the departments.

Table 3: Description of important skills for Food science and Technology graduates in Africa

Skills or competencies	Description
Sound knowledge and understanding of Food Science and Technology principles	Sound knowledge in basic food science: Food chemistry and analyses, Food microbiology and safety, Food Processing and Engineering
Applied scientific knowledge and practical hands-on skills and experience	Application of basic food science (Applied food sciences - e.g. food product development, food quality assurance, sensory analyses, food research projects)
Soft skills	Computer skills, communication skills, team building, report writing skills, problem solving skills
Entrepreneurial skills	Innovative and creative thinking, willingness to take risks, self-motivated and disciplines, ability to sell ideas to others, competitiveness, ability to network
Research skills	Ability to work independently to solve problems, critical thinking and analytical skills for problem solving
Leadership skills	Take ownership and responsibility and leading by example

Most universities have a specific focus in terms of specialization or have specific outcomes for their degree programs. These are often linked to the perceived needs of their countries. In Nigeria, for example, the Federal University of Agriculture places a special emphasis through research and extension programs on the needs of local food industries in terms of sourcing of raw materials locally and upgrading of traditional food processing technologies. Reduction of food wastages through the use of appropriate food science and technology is also of paramount importance in their programs. At Moi University in Kenya, graduates are expected to develop healthful products to combat nutrition deficiencies and maintain good health in society as part of the degree program. In South Africa, BTech graduates from Tshwane University of Technology are expected to apply and integrate advanced knowledge and skills of Food Technology in the food manufacturing environment. At Haramaya University in Ethiopia, much emphasis is placed on food processing technologies and food

engineering but less coverage are given for nutrition and post-harvest technology. At Makerere University in Uganda, graduates need to be ready and able to address challenges facing the food industry and society at large. In some countries (e.g. Botswana) one of the expectations of their program is that it will develop food entrepreneurs to develop the formal food industry in Botswana.

Well-established Food Science departments with a strong research ethos regard research and statistical skills as well as leadership skills to be important. Future food science and nutrition leaders in Africa must be innovative and creative thinkers, be able to work both independently and in teams and have strong problem solving and analytical skills. Most universities surveyed aim to produce well-rounded graduates equally equipped to enter the private industry or to continue with post-graduate research. Most programs include internships or experiential training in the food industry or private sector, research institutions or regulatory authorities as a degree requirement.

From Table 4, it is evident that the type of employment for graduates from universities surveyed differs substantially. In countries such as South Africa with a well-developed formal food industry, most of the graduates are employed by the public sector. Where the public sector is not as yet well developed, most graduates are employed by government or parastatal organizations.

4.3 Non-degree training and extension work

Of the universities who responded to the questionnaire, less than half present formal non-degree courses and workshops in the FST domain for persons from the wider community.
Examples of non-degree training include:

- University of Ghana: EU/Industry council for Development - Food Safety and Nutrition training project. It offers a nutrition extension and sustainable livelihood short course for industry as part of this project;
- University of Pretoria: CE@UP short courses and workshops (including sensory evaluation workshops, opaque beer brewing certificate course; also part-time honours degree program available for people working in the industry);
- University of Free State: Short courses in Food Processing (1-4 days);
- Federal University of Agriculture - Part-time degree for people working in the industry and a part-time post-graduate Diploma;
- Moi University: They train mature diploma students in preparation to enter their degree programs;
- CPUT - AgriFood Technology Station (ATS) - mandate to assist small and medium enterprises primarily to improve their use of technology.

Table 4. Survey results of where graduates in Food Science related disciplines are employed in Africa

Country	Name of Institution	Private industry	Government/NGO/Others	Research Institutions	Tertiary Education	Self employed
			(% of graduates employed)			
			Eastern Africa			
Ethiopia	Haramaya University	20	57	10	8	2
Kenya	Moi University	40	10	20	30	
Mozambique	Universidade Eduardo Mondlane:	50	10	35	5	
Rwanda	Kigali Institute of Science and Technology:	20	20	15	5	5
Uganda	Makarere University	40	35	10	10	5
			Western Africa			
Ghana	University of Ghana					
	- Undergraduates:	50	45(incl. research institutions)			5
	- Post-graduates:	20	60 (incl. research institutions)			
Nigeria	Federal University of Agriculture, Abeokuta	50		10	30	10
			Middle Africa			
Cameroon	University of Ngaoundere	40	7	18	25	10
			Southern Africa			
Namibia	University of Namibia	80		15	5	
South Africa	University of Free State	80	5	10	5	5
South Africa	University of Johannesburg	85		5	5	5
South Africa	Cape Peninsula University	98	2			
South Africa	University of Pretoria	96		2	2	
South Africa	University of Stellenbosch	90-95		2-3	2-3	2-3
South Africa	Tshwane University of Technology	90		2.5	5	2.5
South Africa	University of Venda:	95		5	5	
Range		20 - 98	5- 60	2- 35	2 - 30	2 - 10

4.4 Challenges perceived by educators

Food Science and Technology educators in Africa face many challenges. Challenges identified in the snap survey include:

- Lack of modern food processing equipment or pilot plant facilities;
- Lack of "state-of-the-art" analytical equipment ;
- Lack of technical support within institutions;
- Inadequate number of academics and support staff to run programs;
- Low student numbers and poor quality of students – Many potential students see other professions to be more attractive than Food Science and Technology;
- Lack of sustainable partnerships in Food Science and Technology research or capacity development in the region.

In the majority of the universities surveyed, laboratories and pilot plant facilities are underequipped for both teaching and research purposes. In most cases, there is a lack of modern food processing equipment and "state-of-the-art" analytical equipment. This is further exacerbated by the lack of technical support within many institutions in terms of human resources but also in terms of consumables. Some universities also appear to lack appropriate teaching and laboratory space, text books and access to food science research journals. In some cases there is also an inadequate number of academic and support staff to run the programs. The quality of incoming students is another concern for some educators.

4.5 Core problems and key opportunities

Given the tight links between the growing prevalence of processed foods and declining health status, solutions to Africa's emerging public health problems will require cross-disciplinary work linking FST, human nutrition and public health. A core problem at present is that very few universities present BSc Nutrition / BSc Food Science and Nutrition programs. Furthermore, there is too little extension work and training (for non-degree purposes) in the area of Food Science and Nutrition.

Another core problem is that collaborative degree programs are almost completely lacking at the national, regional and international levels. Education and Research networks nationally and regionally are required to develop joint collaborative degree and research programs. There is a strong need to create opportunities for food science and nutrition educators and students to interact with other each other, nationally and regionally. Also, food science, food technology and nutrition educators need to engage with multinational companies operating in Africa to support local high-level FST and nutrition education and human resource development.

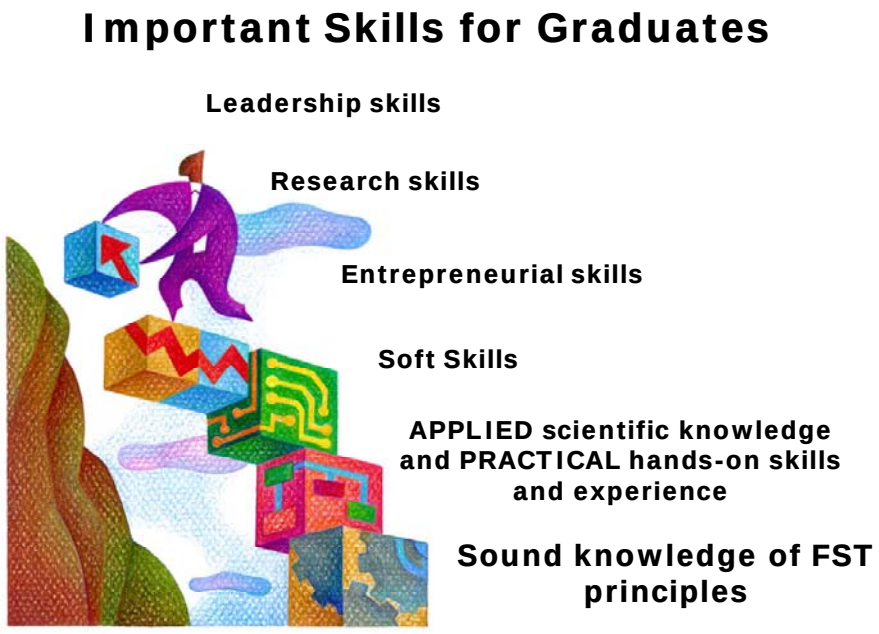
The African FST professional bodies in consultation with other regional stakeholders can help address matters of curriculum development. Graduates in FST and associated courses must be adequately equipped with necessary skills and competences that will enable them to perform future roles. This puts especial premium on the curricula and delivery of course contents in tertiary educational centers as well as promotion of life-long learning. As indicated in Figure 4, future skills sets that will be demanded of FST graduates include both

"hard" - engineering design, product development, agribusiness and entrepreneurship, nanotechnology, food and the environment, sensory and behavioral sciences, chemometrics, nutrigenomics, biotechnology, proteomics and metabolomics) and "soft" - community management, critical and strategic thinking, communication, teambuilding, organizational) skills. Public policies targeting FST curricula would have the following objectives: ensure relevance of FST curricula to national development needs; foster quality in the delivery of FST curricula; foster professional probity in the practice of FST; promote curricula reviews and guidance for such reviews; stimulate foundational or pre-tertiary interest in the food sciences and choice of Food Science as a profession; promote awareness of the role and value of food in society; and foster national accreditation system or other means to assess skills outcomes.

There also need for concerted national and regional activities to promote Food Science as a profession. This will take a spirited effort of all stakeholders involved (educators, industry and government). Post-graduate students are a special case in point; these are the young people that are on the cutting edge of new research and developments. The formal food industry can capitalize much more on this group than is currently the case. There should be a business incentive for graduates from industry to continue with their post-graduate studies.

Innovative approaches should be implemented to utilize scarce resources more effectively. Nationally and even regionally, educators should consider joint purchasing, maintenance and use of expensive equipment by different stakeholders. Equipment suppliers should also be approached for an "equipment on lone" scheme where equipment could be placed in institutions for use by students. This will not only improve the quality of their training but also expose future buyers to a supplier's equipment.

Figure 4. Important skills for Food Science and Technology graduates in Africa



Source: Authors.

5. A STRATEGY FOR ADDRESSING AFRICA'S FOOD SCIENCE AND NUTRITION EDUCATION CHALLENGES

Africa, the world's poorest continent and the last continent to urbanize, is also the last continent to confront the Nutrition Transition. As a result, Africans have a chance to get out ahead of the curve, to learn critical lessons from hard experience elsewhere and apply those lessons to bend the nutritional curve back to a healthier trajectory (Figure 2).

But the nutrition transition appears to be accelerating in many parts of the world, with overweight, obesity and related diseases emerging at lower levels of income and urbanization than historically. Increased globalization of agribusiness supply chains, improved communications and more rapid transmission of western diets may be to blame (Popkin 2003). Consequently, African nutritionists and public health officials will need to move quickly to bend the nutrition curve and moderate the public health costs of emerging overweight and non-communicable diseases.

Africa's Bending the Curve Consortium (BCC) includes a coalition of food scientists, nutritionists and public health professionals dedicated to early, preventative action aimed at improving Africa's long-term nutritional trajectory. BCC partners have identified the four following early action priorities:

5.1 Advocacy

High-level executive education for government public health director generals and food industry CEOs is required to raise awareness about the early arrival and unexpected speed of the Nutrition Transition in Africa, the resulting high prospective costs to human productivity and public health systems, as well as the key lessons emerging from elsewhere about successful mitigation and prevention strategies. A strong parallel is the impact that HIV/AIDS has had on sub-Saharan Africa in terms of the magnitude and severity of health consequences, the population affected - economically productive adults, and the enormous costs of treatment versus prevention.

FST professionals must engage in championing the One Health cause and seek to become leaders in One Health approaches to sustainable health for healthy and productive humans, animals, plants and ecosystems. This new approach will require multidisciplinary research, training and community service so that FST professionals can contribute to the overall goal of reducing local and global health challenges and their socio-economic impacts.

5.2 ***Food science and technology curriculum reform in African universities***

In order to train a new generation of FST professionals capable of taking early and pre-emptive action in bending the curve in Africa's Nutrition Transition, curricular reform must begin now. These efforts will involve curricula that integrate food science and technology, human nutrition and public health as well as educational systems that facilitate internships and applied research programs linking students and faculty to private sector food industry.
Food of animal origin is another priority that requires special attention for FST education, research and training given the growing interface between humans and animals. In response to the demand from consumers worldwide for safe food, FST education should strengthen working together with relevant professionals to reduce food-borne and food-related risks to human health due to hazards arising from animal production.

At the post-graduate level, the development and implementation of joint complementary master's and doctoral programs, nationally and regionally, will not only enhance the quality of food science and nutrition education in Africa but also promote student and academic staff mobility.

Fellows of the International Academy of Food Science and Technology (IAFoST) could assist food science and technology educators in Africa as follows: Providing advice on design and content of curricula; spending serious time at African universities teaching and mentoring; lobbying governments and international funding agencies; and engaging with multinational companies operating in Africa to support local high-level FSTN education and HR development

5.3 *Food industry entrepreneurship*

Africa's rapidly growing demand for processed convenience foods offer significant potential for the promotion of high quality, packaged indigenous foods which cater to local tastes but which most urban food markets fail to deliver under the forces of inertia which, by default, lead to the expansion of low nutritional quality fast foods developed in the West. A pro-active new generation of FST professionals can contribute to the development and marketing of tasty, profitable, inexpensive nutrient-dense packaged foods in Africa, often by building on favored indigenous foods such as pumpkin leaves, cassava leaves, sweet potato leaves and local whole grains. Coupled with agribusiness management and entrepreneurship programs, FST food laboratories, internship programs and competitive grants can translate into food entrepreneurship incubators serving private food industries as well as local consumers.

5.4 *Fresh fruit and vegetable wholesale market reforms*

Parallel increases in urban demand for fresh fruits and vegetables offer similar prospects for raising agribusiness incomes, lowering consumer costs and improving the nutritional quality of urban diets. Early investments in urban planning, zoning, road quality and urban horticulture market infrastructure and management systems could significantly improve the efficiency of urban fresh fruit and vegetable wholesale markets as well as sanitation and public health. By reducing current high losses, improved horticulture markets offer prospects for raising farm incomes, significantly lowering urban consumer prices for fresh fruit and vegetables, and increasing urban consumption of nutrient-dense horticultural products. A focus on Africa's rapidly growing secondary cities offer early opportunities for quick wins.

As an important bridge to transforming agriculture as a business and an engine for economic development, food science, food technology and nutrition professionals need to integrate more in the future with the other stakeholders in the wider agricultural innovation systems, especially in the agricultural commodity value chains and manufacturing and processing end of it.

In conclusion, strong food science and technology professional associations are needed to act as formalized advocacy groups to engage with policy makers on key food science and technology, and nutrition issues based on sound scientific evidence. The professional associations should also advocate for formation of national and regional centers of excellence, e.g. in the form of food research institutes to provide cutting-edge application of

food science and nutrition to address emerging challenges associated with the new African food systems.

REFERENCES

Abbott JC. 1986. *Marketing Improvement in the Developing World: What Happens and What We Have Learned*. FAO Economic and Social Development Series No. 37. Rome: Food and Agriculture Organization.

Africa Economic Outlook: Economic Outlook [Accessed 2012 Nov]. Available from http://www.africaneconomicoutlook.org.

Anon. 2012. SAB opens first greenfield Nigerian plant. *Brew. Distill. Int.* **8**(10):2.

Ashford LS. 2007. Africa's youthful population: Risk or opportunity? Population Reference Bureau, USAID, USA. [accessed 2012 Oct]. Available from http://www.prb.org/pdf07/africayouth.pdf .

Diabetes Leadership Forum. Africa 2010. Diabetes: The hidden pandemic and its impact on sub-Saharan Africa. [accessed 2012 Nov]. Available from http://www.idf.org.

Diabetes South Africa. 2012. [accessed 2012]. Available from http://www.diabetessa.co.za

Food and Agriculture Organization: World Summit on Food Security 2009 [Accessed 2012 Nov]. Available from http://www.fao.org.

Food and Agriculture Organization of the United Nations (FAO) and International Life Sciences Institute (ILSI). 1997. Preventing Micronutrient Malnutrition: A Guide to Food Based Approaches-A Manual for Food Policy Makers and Programme Planners. International Life Sciences Institute. [accessed 2012 Nov]. Available from www.fao.org.docrep/5244E/X5244e00.htm.

Friedman RR, Schwartz MB. 2008. Public policy to prevent childhood obesity, and the role of pediatric endocrinologists. *J Ped. Endocrin. Metabol.* **21**:717–725.

Haggblade S 2011. Modernizing African agribusiness: Reflections for the future. J. Agribusiness Develop. Emerging Econ. 1(1):10-30.

Haggblade S, Holzapfel WH. 1989. Industrialization of Africa's indigenous beer brewing, pages. In: Steinkraus KH, editor, Industrialization of indigenous fermented foods. New York: Marcel Dekker. p 191-284.

How We Made It In Africa. 2012: More than enough potential for restaurants and fast-food in Africa. [accessed 2012 Nov]. Available at http://www.howwemadeitinafrica.co.za.

Igumbor EU, Sanders D, Puoane TR, Tsolekile L, Schwarz C, Purdy C, Swart, R, Duräo S, Hawkes R. 2012. ''Big Food,'' the consumer food environment, health, and the policy response in South Africa. *PLOS Med*. **9**(7): e1001253.

Ilori MO. 1991. The use of sorghum for beer brewing in Nigeria. *Technovation* **11**:27-37.

Jayne TS, Mason N, Myers R, Ferris J, Mather D, Beaver M, Lenski N, Chapoto A, Boughton D. 2010. Patterns and trends in food staples markets in eastern and southern Africa: Toward the identification of priority investments and strategies for developing

markets and promoting smallholder productivity growth, MSU International Development Working Paper No. 104, East Lansing, MI: Michigan State University, Department of Agricultural, Food and Resource Economics.

Kessides C. 2005. The urban transition in sub-Saharan Africa: Implications for economic growth and poverty reduction. Urban Development Unit, The World Bank. [accessed 2012 Nov]. Available from http://www.worldbank.org/afr/wps/wp97.pdf .

Mackintosh I, Higgins B. 2004. The development of a sorghum based lager beer in Uganda: a model of co-operation between industry and government in the development of local ingredients for the production of quality lager beer and consequential benefits for the parties involved. *Aspects Appl. Biol*. **72**:235–245.

Mail & Guardian 2010: South Africans among world's fattest people (accessed 2012 Nov]. Available from http://mg.co.za.

Mbanya JCN, Motala AA, Sobngwi E, Assah FK, Enoru ST. 2010. Diabetes in sub-Saharan Africa. *Lancet* **375**:2244-2266.

Mbewu A. 2009. The burden of cardiovascular disease in sub-Saharan Africa. *SA Heart* **6**:4-10.

Mosha TCE. 2003. Prevalence of obesity and chronic energy deficiency (CED) among females in Morogoro district, Tanzania. *Ecol. Food Nutrit*. **42**:37–67.

Nestlé. 2010. 1st anniversary for Nestlé Research & Development centre in Abidjan [accessed 2012 Nov]. Available from http://www.nestle.com.

Nweke, F. I., Spencer, D. C. and Lynam, J. K. (2002), *The cassava transformation: Africa's best-kept secret*. East Lansing: Michigan State University Press.

Ojijo NKO. 2005. Training, Research & Development: Universities and the Food Value Addition Industries in Kenya. A paper presented at the Value-added Food Exports & Investment Workshop held March 3-4, 2005 at the Grand Regency Hotel, Nairobi. Export Processing Zone Authority (EPZA), Government of Kenya. [Available from http://www.epzakenya.com/news.php?itemno=37Steinkraus KH. 1989. Industrialization of indigenous fermented foods. New York: Marcel Dekker. 439 p.

Onyekwere, O.O., Akinrele, I.A., Koleoso, O.A. and Heys, G. 1989. Industrialization fo Gari Fermentation. Chapter 8 in Keith H. Steinkraus (editor), *Industrialization of Indigenous Fermented Foods*. New York: Marcel Dekker.

Popkin BM. 2003. The Nutrition Transition in the Developing World. Develop. *Policy Rev.* **21**:581-597.

Pretoria News. 2012. Fast and fatty: "Big food" sales bulge in SA. Pretoria News, 2 August 2012.

Steinkraus KH. 1989. Industrialization of Indigenous Fermented Foods. New York: Marcel Dekker.

Taylor JRN, Emmambux MN. 2008. Products containing other speciality grains: sorghum, the millets and pseudocereals. In: Hamaker BR, editor. Technology of functional cereal products. Abington, UK: Woodhead Publishing. p 281-335.

Taylor JRN, Barrion SC, Rooney LW. 2010. Pearl millet – New developments in an ancient food grain. *Cereal Foods World* **55**:16-19.

Tschirley, David, Ayieko, Miltone, Hichaambwa, Munguzwe, Goeb, Joey and Loescher, Wayne. 2010. Modernizing Africa's Fresh Produce Market Chains without Rapid Supermarket Takeover: Towards a Definition of Research and Investment Priorities. MSU International Development Working Paper No. 106. East Lansing, Michigan: Michigan State University.

UN Habitat: The State of African Cities, 2012. [Access 2012 Nov]. Available from http://www.unhabitat.org.

UNICEF: State of the World's Children, 2007. [accessed 2012 Nov]. Available at http://www.unicef.org/sowc07/report/report.php.

United Nations Department of Economic and Social Affairs: The 2010 Revision and World Urbanization [Accessed 2012 Nov]. Available from http://esa.un.org.

Unwin N, Alberti KG. 2006. Chronic non-communicable diseases. Ann. Trop. Med. Parasitol. 100:455-648.

Vegetables NZ. [assessed 2012 Nov]. Available from http://www.vegetables.co.nz.