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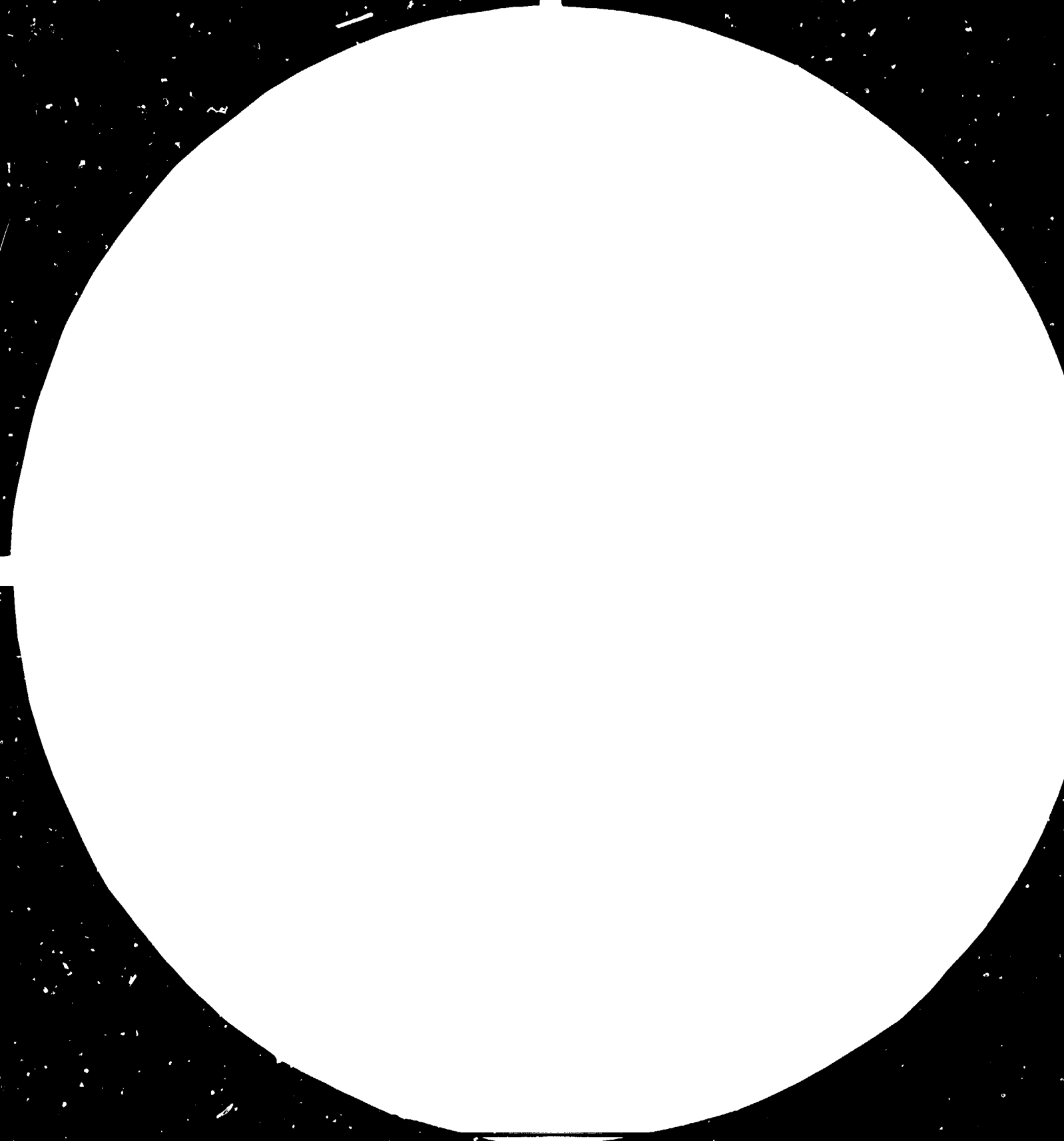
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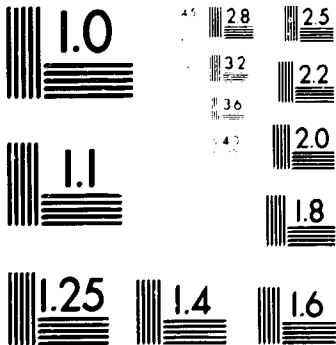
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THE ROLE OF FACULTIES OF AGRICULTURE  
IN  
THE DEVELOPMENT OF  
THE FOOD PROCESSING INDUSTRIES \*

by

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1444

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## I. INTRODUCTION

1. On 5 December 1980, the U.N. General Assembly, at the 83rd plenary meeting of its 35th session, passed a resolution proclaiming the 1980's as the Industrial Development Decade for Africa.<sup>1/</sup>
2. That important proclamation was the culmination of various events which led member states of the Organization of African Unity to adopt in April 1980 the Lagos Plan of Action for the Economic Development of Africa which originally brought the concept of the Decade into being "for the purpose of focusing greater attention and evoking greater political commitment and financial and technical support, at the national, regional and international levels for the industrialization of Africa".<sup>2/</sup>
3. In its resolution, the General Assembly called upon the United Nations Industrial Development Organization (UNIDO), the Economic Commission for Africa (ECA) and the Organization of African Unity (OAU), to formulate proposals to implement the programme for the Industrial Development Decade for Africa and to monitor its progress. A committee was set up by the three secretariats to co-ordinate activities relating to the implementation of joint programmes and projects, and its first task was to prepare proposals for the formulation and implementation of a programme of action for the Decade along the lines set out in the Lagos Plan of Action.
4. After a joint meeting in March 1981, at which an agreement was reached on the fundamental principles contained in the Lagos Plan of Action and on its translation into an operational programme, work proceeded on the preparation of proposals for the formulation and implementation of a programme for the Decade. The proposals were presented to an Intergovernmental Meeting of Experts on the Programme of the Industrial Development Decade for Africa, and to the Sixth Conference of African Ministers of Industry, held in October and November 1981 respectively, in the form of four major working papers entitled as follows:
  - i) Framework for the Formulation and Implementation of the Decade Programme;
  - ii) Guidelines for the Formulation of Strategies for Major Industrial Subsectors and Areas;

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<sup>1/</sup> U.N. General Assembly resolution 35/66. Industrial Development Co-operation - 83rd Plenary Meeting, 5 December 1980

<sup>2/</sup> Organization of African Unity - Lagos Plan of Action for the Economic Development of Africa. 1980 - 2000. International Institute for Labour Studies, Geneva, Switzerland, 1981.

- iii) Modalities for the Implementation of the Decade Programme; and
- iv) Monitoring and Reporting on the Implementation of the Decade Programme;

After due consideration by the expert group meeting and the ministerial conference the four papers were amended to reflect the findings of both gatherings which adopted the proposals put forward therein. The four papers now constitute the major chapters of a document entitled "A Programme for the Industrial Development Decade for Africa"<sup>3/</sup> which will be henceforth referred to in this paper as the Programme.

5. In responding to the concern expressed in the Lagos Plan of Action over the deteriorating food situation in Africa, the Programme recognizes that the subject of "Food Security" involves enormous problems; problems far surpassing the narrow sphere of increased agricultural production or the accumulation of grain reserves. They go to the very core of the prevailing agro-food systems in Africa, and touch upon many weighty questions.

6. One of those questions is how to re-orient African agriculture towards national food needs rather than towards exports of raw, or partially processed, materials to advanced economies. Is it better to grow cash crops for export to earn foreign currency which is hardly sufficient to import enough food for the population, or should cash crops be replaced by indigenous food crops?

7. Another question is why the industrialized countries do not suffer from a shortage of food, while countries with agriculture as the predominant sector of their economic structure seem to have a chronic food problem? In other words, could industrialization per se solve the problem of food shortages or would increased agriculture production simply eliminate it.

8. Looking at the economies of the developed countries, it becomes apparent that neither agriculture nor industry could have proceeded very far without parallel and balanced development of the other. Growth of agricultural output has usually been a critical determinant of the rate at which industrialization has proceeded. On the other hand, agricultural output and productivity in those countries could never have reached the present high levels without sufficient industrial support for agriculture and ample manufacturing facilities to process agricultural output.

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<sup>3/</sup> UNITED NATIONS, New York, 1982. UNIDO, ID/287. A. Programme for the Industrial Development Decade For Africa. Prepared jointly by ECA, OAU, and UNIDO.

9. The complementary interrelations between agriculture and industry are, therefore, essential for achieving self-sufficiency in food, and can only be fostered in developing countries within the national development plans. This is especially true in Africa where agricultural development was by and large originally dictated by the requirements of colonial powers, and does not seem to have significantly changed since colonialism had run its course.

10. As a minimum requirement, a national development plan should include a chapter on food development as a coherent whole, listing the various projects, reforms and measures to be undertaken in the various fields - nutrition policies, agriculture, industry, marketing, exports and imports (agricultural inputs, food processing industry, domestic marketing, transportation, financial and other investments, etc.) - in order to attain the food objective. This should lead the political and planning authorities to take an overall view of the adequacy of the measures to be adopted and the institutions to be provided.<sup>4/</sup>

The World Food Council has taken the lead within the U.N. System in recommending national food strategies as the means for food self-sufficiency and the eradication of hunger in developing countries.<sup>5/</sup> A food strategy has been defined as an ongoing process based on a picture and a plan:

A picture of a country's present food situation - needs, supply, potential for increasing food production (including land and its distribution), storage, processing, transport, distribution and marketing facilities, legislative and administrative policies and machinery affecting food, availability of inputs (including seeds and fertilizers), infrastructure (including irrigation networks and roads), technology, research, training and manpower in the food sector, and the ability to meet food emergencies.

A plan to improve the picture - so that enough food of sufficient nutritional value reaches all the people in a country.

As each picture differs so does each plan, for no two countries have exactly the same problems, same needs, same economic philosophy.

But every plan contains the policies to reach the goals, the projects to carry out the policies, the technical and financial resource requirements of each project, how many of these resources can be supplied in the country, and how many will have to be provided externally.

In this way, the strategy is also a prospectus for international development assistance agencies and donor countries.

Briefly, a national food strategy shows, in food terms, where a country is, where it wants to go and how much it will cost to get there, and at the same time, provides the vehicle to make the trip.

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<sup>4/</sup> First Global Study on the Food Processing Industry. UNIDO, ID/WG.345/3/Rev. 1 September 1981.

<sup>5/</sup> United Nations World Food Council. National Food Strategies, Overcoming Hunger Country by Country. 1982.



At the time of writing this paper, 23 African countries have endorsed more integrated national food planning, and a national Food Policy or Strategy has already been developed in Kenya<sup>6/</sup> and Mali<sup>7/</sup> in which food processing has been given due consideration.

11. It is quite clear from the above that the food processing industries have a vital function within any national plans aiming at food self-sufficiency and security. They increase the quantity and quality of food through reduction of waste, preservation of perishable products, and utilization of by-products for animal husbandary, and in this way satisfy a larger final demand for food from a given unit of land and other resources. This is of particular value in the current world food situation.<sup>8/</sup>

12. According to the Programme<sup>3/</sup> "Developing food industries in African countries will improve food supplies and reduce imports. It will contribute to increased self-reliance by reducing food losses, adding value to the raw materials, increasing export earnings, raising employment levels and improving incomes. It will further ensure better market opportunities, stimulate production and rural development, reduce urban migration, improve nutrition standards both qualitatively and quantitatively, increase opportunities for investment in agriculture and processing industries, and stimulate the development of allied sectors of the economy".

13. In spite of wide variations in the pattern of development in African countries it does appear that food processing industries possess certain characteristics which make them especially suitable for all developing countries. These include:

- a) High labour intensity;
- b) Many employment linkages;
- c) Modest capital and skill requirements;
- d) Prospects for rural development; and
- e) Prospects for export - led growth

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<sup>6/</sup> Republic of Kenya. Sessional Paper No. 4 of 1981 on National Food Policy

<sup>7/</sup> Republic of Mali. International Conference of Donors for the Recovery and Development of Mali. Bamako, 11 - 16 December 1982. The Food Strategy of Mali (condensed edition)

<sup>8/</sup> Aref, M. M. - The Role of Agro-Industries in the Industrialization of Developing Countries. UNIDO/IOD. 1. March 1976.

They can thus perform an important function in stimulating production, productivity and diversification in the agricultural sector and can be strategic elements in the process of development. Many of these resource-based industries have proved to be pioneer industries in several developing countries, as they were in industrialized countries several generations ago.<sup>8/</sup> Food processing accounts for up to 60% of the value added in all African industrial manufacturing, but, unfortunately, the choice of product lines for local processing is often based on external demand which sometimes encourages the local production of non-indigenous crops. Most other processed foods are for consumption by a high-income urban élite rather than the mass of the population.<sup>3/</sup>

14. In aiming at the priority goal of food self-sufficiency, the Programme recognizes that, "the food production-processing-marketing system represents an integrated and inter-dependent relationship since no area can be developed in isolation. Viable food industries depend on steady supplies of raw materials of suitable quality, plus a steady demand for the final products. The inter-dependence inherent in this food 'system' means that several government ministries, agencies and other bodies are involved, with the result that the system is sometimes not efficiently organized".<sup>3/</sup>

15. The concept of the integrated approach to the food-processing industry was one of the two basic issues examined by UNIDO's First Consultation on the Food Processing Industry.<sup>9/</sup> Many participants at that consultation felt that the planning, evaluation, implementation, and co-ordination at the national level of all phases of the integrated food-processing chain were essential and that among the many factors which needed to be considered along that chain were such matters as the extent and quality of land, land tenure, water resource management, crop-production practices, appropriate varieties of plant and animal types, fisheries resources, technology and technology transfer, including the negotiation of technology agreements, and training at all levels and in particular at the intermediate or technician level.

16. Most of those factors are within the functions of Faculties of Agriculture, and UNIDO is most grateful to the Secretariat of the Association of Faculties of Agriculture in Africa (AFAA) for this opportunity to help break the barriers which traditionally existed between industry and agriculture, and to present some ideas on how Faculties of Agriculture in African Universities can contribute to the development of the food-processing industries as part of an overall solution for the food security question.

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<sup>9/</sup> UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION. First Consultation on the Food-Processing Industry. The Hague, Netherlands, 9 - 13 November 1981. Report. ID/278.

17. It must be stressed that the food security question is not only a matter of socio-economic development, but seems to be moving since 1975 to the realm of political contention. It has been disquieting to read that, "The deployment of American food power is the focus of a serious policy debate now under way in Washington".<sup>10/</sup> That debate was apparently a result of a research report which concluded that world grain shortages, "could give the United States a measure of power it had never had before - possibly an economic and political dominance greater than that of the immediate post-World War II years".<sup>11/</sup> Such pronouncements, though unofficial, must not be overlooked by developing countries suffering from food deficits.

## II. FOOD TECHNOLOGY EDUCATION AND FACULTIES OF AGRICULTURE

18. Up to the early years of the 20th Century, the agronomists, horticulturists, physiologists, zoologists, chemists and micro-biologists in university departments or government laboratories, were involved in solving problems of storing, processing, packaging, transporting, and marketing of foods. Gradually, however, the importance of food technology as a separate discipline became recognized and acquired an independent organizational identity. Food-processing specialists were joined together in university departments designated as food technology, food science, food science and technology, food industries, etc. The subject matter itself became to be defined as "the application of science and engineering to the production, processing, storage, packaging, distribution and utilization of foods".<sup>12/</sup>

19. The development of food technology as an applied science in its own right was pioneered in the U.S.A. where there were already 5 departments of food technology in American universities by 1930.<sup>13/</sup> By 1973, the number had grown to 32 distinct departments within which teaching was exclusively in the field of food science, food technology or food engineering. In addition, there were 13 programmes where instruction in food subjects was offered in more than one department and administered by an interdepartmental committee, and 5 graduate programmes where only advanced degrees were offered.<sup>14/</sup>

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<sup>10/</sup> U.S. Food Power. Ultimate Weapon in World Politics? Business Week. December 15, 1975. pp; 54 - 60

<sup>11/</sup> Weinstein, Henry. CIA Study Says Food Crisis Could Increase U.S. Power International Herald Tribune, 18 March, 1975.

<sup>12/</sup> Tape, N.W., and Sabry, Z.I. The Marriage of Food Technology and Nutrition. World Review of Nutrition and Dietetics, 10: 1 - 12 (1969)

<sup>13/</sup> Schultz, H.W. Educating our Food Scientists and Technologists. Food Technology 18 : 1795 - 1798 (1964)

20. Departments of "Food Technology" in the U.S.A. have been almost invariably established within the faculty, college or school of agriculture whenever one existed in the university or educational institution. This implantation has also been the habitual course when "Food Technology" education was introduced in other countries such as Egypt<sup>15/</sup>, India<sup>16/</sup>, the Netherlands<sup>17/</sup>, Lebanon<sup>14/</sup> and Canada<sup>12/</sup>.

21. In Africa as a whole, "Food Technology" education seems to have been lagging behind as indicated by two studies conducted by the AFAA and entitled "AFAA Comparative Study for Higher Agricultural Education in Africa (1980)" and "Who's Who in Higher Agricultural Education in Africa (1982)". The studies show that about 86% of all "Food Technology" personnel in African faculties of agriculture were concentrated in the five countries of North Africa while African countries south of the Sahara had only 14%. More than 50% of all African countries had no "Food Technology" personnel in their faculties of agriculture.

22. In view of the priority accorded the food processing industries in both the Lagos Plan of Action<sup>2/</sup> and the Programme<sup>3/</sup>, it seems incumbent on the faculties of agriculture in Africa to increase their capabilities for the education and training of technical personnel in "Food Technology" at all skill levels.

23. The inclusion of this type of instruction in the curricula of faculties of agriculture is neither haphazard nor fatuous.

Familiarity with the production techniques of the raw materials to be used for processing, their genetic characteristics and general physiology is essential knowledge for food industry personnel in view of the perishability of living matter. In addition, most of the basic courses necessary for the formation of "Food Technologists" are either already available at faculties of agriculture or could be furnished by existing staff. It is a simple matter, for example, for an agricultural microbiologist to teach a course in food microbiology. The originality of a "Food Technology" curriculum is only the food-oriented courses which would require a small faculty of about four.

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- <sup>14/</sup> Anon. Directory of Courses and Professional Organizations in Food Science and Technology. International Union of Food Science and Technology. (1973)
- <sup>15/</sup> Shehata, A.M. El-Tabey and Aref, M. Training Food Technologists at the University of Alexandria. Food Technology. 10(11), 28 and 30, 1956.
- <sup>16/</sup> Subramanyan V., Bhatia, D.S. and Swaminathan, M. India, in Food Technology the World Over. The AVI Publishing Company. Inc. Westport, Conn., 1963
- <sup>17/</sup> Kraal, A., and Leniger, H.A. The Netherlands, Ibid.
- <sup>18/</sup> Tansawa, A.U. Executive Secretary of AFAA. Private Communication, June 1980.

24. An example of an undergraduate curriculum in "Food Technology" in an African developing country (Egypt) has been reported by Shehata and Aref in 1956,<sup>15/</sup> and is presented in Table 1. The courses given in the first year are attended by all students who enroll in the Faculty of Agriculture, University of Alexandria. Although the "Food Technology" curriculum starts in the second year, most of the courses given in that year are still of a general nature and are designed to familiarize the students with the new materials they will handle.

TABLE 1  
Undergraduate Curriculum in Food Technology  
Faculty of Agriculture, University of Alexandria, Egypt

First Semester	No. of Units	Second Semester	No. of Units
First Year <sup>a</sup>			
General Botany 1A	4	General Botany 1B	4
Chemistry 1A	5	Chemistry 1B	3
Economics 1A	3	Economics 1B	3
Geology	3	Physics	3
Analytical Geometry	2	Calculus	2
		Zoology	5
	<u>17</u>		<u>20</u>
Second Year			
Agronomy 1A	3	Agronomy 1B	3
Agricultural Economics	3	Organic Chemistry	5
Bacteriology	4	Horticulture	4
Entomology	4	Truck Crops	4
Dairy Science	4	Animal Breeding	3
	<u>18</u>		<u>19</u>
Third Year			
Plant Physiology	3	Food Analysis	5
Biochemistry	4	Canning	4
Principles of Food Preservation	5	Freezing and Dehydrating	4
Food Microbiology	4	Dairy Products	4
Ice Cream and Concentrated Milk	4	Dairy Microbiology	3
	<u>3</u>		<u>3</u>
	<u>19</u>		<u>20</u>
Fourth Year			
Nutrition	3	Food Control	3
Industrial Fermentations	4	Packing and Storage of Fruits	2
Farm Crop Industries	4	Food Engineering	3
Dairy Chemistry	3	Colloidal Chemistry	4
Marketing of Agricultural Products	3	Special Problems in Food Technology	2
	<u>3</u>		<u>2</u>
	<u>17</u>		<u>14</u>

a) The academic year includes two semesters of 14 weeks each: 1 UNIT equals one class hour or 2 laboratory hours per week per semester.

In the third and fourth years, the courses are all designed for the "Food Technology" student except a few such as plant physiology, biochemistry, and colloidal chemistry, which are open to students from other disciplines. The technological courses include visits to food plants in and near Alexandria. Guided tours furnish a kind of practical laboratory experience, and the students have to submit detailed reports on what they have observed. During the two weeks vacation between semesters, the students of the fourth year are taken on an educational tour throughout the country, visiting the important agricultural and industrial establishments. An excellent perspective on the food economy - from point of origin to consumption - is thereby attained. In the final semester, a special problem is assigned to each student. This is intended as training for research to overcome anticipated technical difficulties and the problems likely to be encountered in future jobs. Each student has to submit an extensive analytical report on his problem - stating his own observations, conclusions, and solutions. To accommodate this important feature of his training, the number of units taken by the student in the last semester is reduced.

25. Minimum standards for undergraduate education in Food Science and Technology in the U.S.A. were adopted by the Council of the American Institute of Food Technologists in 1966<sup>19/</sup> and are reproduced below:

- i) FOOD CHEMISTRY. One semester (4 credits) Lecture and Laboratory. The basic composition, structure and properties of food and the chemistry of changes occurring during processing and utilization. Prerequisites should be two years of chemistry, including organic.
- ii) FOOD ANALYSIS. One semester (4 credits) Lecture and Laboratory. A study of the principles, methods and techniques necessary for quantitative physical and chemical analysis of food and food products. The analyses will be related to the standards and regulations for food processing. Prerequisites should be two years of chemistry including organic, plus food chemistry.
- iii) FOOD MICROBIOLOGY. One semester (4 credits) Lecture and Laboratory. Relationship of habitat to occurrence of micro-organisms of foods: effect of environment on growth of various microorganisms in food; microbiology of food spoilage and food manufacture; physical, chemical and biological destruction of microorganisms in foods; microbiological examination of foodstuffs; and public health and sanitation bacteriology. Prerequisites would normally include two years of chemistry (including organic), one semester of general biology, and one semester of general microbiology.
- iv) FOOD ENGINEERING. Two or three semesters (8 or 9 credits). Lecture and Laboratory. Engineering concepts and unit operations applied to food processing. Engineering principles include mechanics, fluid mechanics, transfer and rate processes, and process control instrumentation. Unit operations to include fluid flow, heat transfer, evaporation, drying, extraction, distillation,

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<sup>19/</sup> Anon., IFT Council Adopts Undergraduate Curriculum Minimum Standards. Food Technology. 40: 1567 - 1569 (1966)

filtration, mixing, and materials handling. Prerequisites should be one year of mathematics beyond college algebra and trigonometry.

- v) FOOD PROCESSING. Two semesters (8 credits) Lecture and Laboratory. General characteristics of raw food materials; harvesting, assembling and receiving raw materials; methods of food preservation; processing objectives including factors influencing food acceptability and preferences; packaging; and water, waste disposal and sanitation.

26. Since there had been confusion in terminology with respect to Food Technology versus Food Science, the same Council recommended that the term "Food Technologist" be used to describe those with a B.S. Degree and the term "Food Scientist" be reserved primarily for those who acquire an M.S. or Ph.D. Degree. The primary difference between the two being that the food technologist is concerned with the acquisition of knowledge and its professional application, while the food scientist acquires additional knowledge and skills that will enable him to develop new knowledge of a more basic nature. In other words, the additional preparation of the food scientist is concerned with developing research competence.

27. In 1969, the Education Committee of the same Council made recommendations on subject matter outlines for the food-oriented courses proposed in the minimum standards, including an outline for an additional course entitled "Introductory Food Science". This latter course was found to be taught by many departments of "Food Technology" in the U.S.A.<sup>20/</sup> The subject matter outlines are presented in Annex A.

28. Facilities required for food technology education include in addition to class room laboratories and library holdings, an adequate pilot plant to teach principles of unit operations and unit processes involved in the subject matter. Such pilot plants are relatively expensive and represent one constraint to the introduction of that type of education.

29. Another constraint is that a food technology department once established may well be able to meet the manpower requirements of a small developing country within a few years. It is usually much simpler to produce qualified personnel than to create job opportunities to accommodate them.

30. To overcome those two constraints it might be well-advised to introduce this type of education as a "programme" within the faculties of agriculture with administrative responsibility shared by three or four existing departments. An adequate pilot plant and a minimum food technology faculty of two would be attached to one of those departments, say, the department of horticulture.

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<sup>20/</sup> Anon. Recommendations on Subject Matter Outlines for Food Oriented Courses Proposed in the Minimum Standards for Undergraduate Education in Food Science and Technology. Food Technology. 23 : 307 - 311 (1969)

Such a "programme" could then be instituted or discontinued at will according to national manpower needs. During its operation, the food technology faculty could be supplemented by visiting professors. When discontinued, the permanent food technology faculty would be charged with additional research activities, extension services, advisory functions and other duties as will be explained in the following chapters.

31. It is perhaps appropriate to mention here that advice on the introduction of food science and technology education to faculties of agriculture may be obtained from the International Union of Food Science and Technology (IUFOST). This Union was launched at the International Congress of Food Science and Technology which was held in Washington, D.C., U.S.A., in 1970, with 20 nations in the founding membership. By 1979, there were 42 member nations, including two African countries, Kenya and Nigeria<sup>21/</sup>. According to its constitution, the chief aims of IUFOST are:

- International co-operation among working food scientists and technologists;
- Support of international progress in basic and applied food science;
- Advancement of technology in the preservation, processing and distribution of foods;
- Stimulation of education and training in food science and technology.

It is also worth mentioning that the First African Conference of Food Science and Technology was convened in Cairo, Egypt, in November 1983, under the auspices of the Egyptian Society of Food Science and Technology, the Egyptian Ministry of Agriculture and Food Security, the Egyptian Academy of Scientific Research and Technology, and the Association for the Advancement of Agricultural Sciences in Africa (Addis Ababa).

32. In addition to the basic role of educating and training professional food technologists which faculties of agriculture could attain by adopting food technology curricula or programmes, there are other important training activities which could also be carried out by faculties having such a discipline. There is need in most developing countries, for example, to upgrade the technical knowledge of existing food industry personnel engaged in actual factory operations. Short courses of two to three weeks duration in such subjects as food plant sanitation, simple quality control, basic food testing methodology, proper storage of raw materials and grading of finished products are only a few examples of this type of training.

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<sup>21/</sup> Kefford, J.E. IUFOST. The International Union, A Force for Progress. Food Technology. 23: June 1979.



Another type of training which could go a long way towards food self-sufficiency involves teaching rural women simple food preservation techniques such as sun drying of fruits and vegetables, vinegar making, preparation of salted and pickled products, cottage or pot cheese and fermented milks. Still another type of training would be specialized short courses for owners/managers of small-scale food processing enterprises producing special food preparations such as sausages, jams, jellies and marmalades, relishes, mustard, horse-radish and other condiments with the aim of improving the quality of their production and bringing it up to a satisfactory standard of uniformity, thus promoting their chances of joining up in a co-operative operation.

33. The role of national co-operatives in the development of the food processing industry has been described by Aref<sup>22/</sup> at the International Conference on "The Potential for Co-operative Food Processing in Developing Countries" which was convened in Ottawa, Canada, in August 1983. Faculties of agriculture have traditionally been the seat of education of agriculture co-operatives and could play a significant role in promoting the integration of the production-processing-marketing system of agro-food materials through agricultural co-operatives.

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<sup>22/</sup> Aref, M. M. Integration in the Food Processing Industry and the Role of Co-operatives in its Promotion through International Collaboration. UNIDO/PC. 69. 25 July 1983.

III. FOOD RESEARCH AND FACULTIES OF AGRICULTURE.

34. The research needed to support an expanding food industry should be a joint endeavour by food manufacturers, governments, universities, and private laboratories<sup>23/</sup>. This is especially true in the case of a nascent food industry as unfortunately found in most developing countries and particularly in Africa.

35. Estimates of food scientists' employment in the U.S.A. show that about 80% of the total number are employed by industry, 12.5% by universities, about 4% by government and about 3.5% by research institutes, while the corresponding figures for developing countries are 20%, 30%, 20% and 30%<sup>24/</sup>. These latter figures are admittedly "guesstimates", but they seem to indicate that the responsibility for food research lies much more with the universities in developing countries than is the case in the industrialized world. This is also implied with respect to African Faculties of Agriculture<sup>18/</sup>.

36. It would, therefore, appear reasonable to assume that in addition to the basic function of training food technologists at food technology departments in faculties of agriculture, such departments would be the backbone of needed food research in most countries in Africa.

37. The Lagos Plan of Action for the Economic Development of Africa<sup>2/</sup> as well as the Programme<sup>3/</sup> identified certain priority areas for food research activities in the Continent. These will be included in the following paragraphs of this chapter along with other topics of importance to several African countries. Most of the problems to be touched upon are concerned with the post-harvest aspects of foods, and some of them have undoubtedly been tackled by existing institutions in Africa.

38. Post-harvest lossess of crops due to insects, rodents and microorganisms are known to be substantial even in the most technologically advanced countries. Mayer<sup>25/</sup> stated that the loss is known to be close to 10 percent for the U.S. wheat crop and is probably higher for other crops, and that in some tropical countries the loss could run as high as 40%.

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<sup>23/</sup> Marion, W.W. Needs and Capabilities in Food Research in Academia. Report of the IFT Committee on Research Needs. Food Technology. January 1982. pp 89-91.

<sup>24/</sup> Bourne, M.C.- Graduate Education Needs for Students from Less Developed Countries. Food Technology. January 1980, pp. 50-55.

<sup>25/</sup> Mayer, Jean. The Dimensions of Human Hunger. Scientific American, 235: (3), pp. 40-49, September 1976.

Marion<sup>23/</sup> reported that 20% of all food produced for human consumption is lost annually in the U.S., representing a multi-billion dollar loss. In Africa losses and wastage of no less than 35% of fresh food products occur during their transportation either in bulk or in artisanal packages<sup>3/</sup>; and dried fish losses due to Dermestes spp. were found to be over 50%<sup>26/</sup>.

39. There is, therefore, urgent need to initiate programmes of research to identify, control, and reduce the major losses in food materials which occur in the food pipeline between harvesting/slaughtering/landing and consumption. This research should be oriented to the development of economical approaches to reducing food losses in all parts of the food delivery system including the home. Such reduction could result not only in food being made available to a greater number of people but also to significant savings in energy and other resources used for its production.

40. Closely associated with research on food losses is food-packaging research. It is essential in this connection to survey the main food-packaging and related materials imported, or locally produced by African countries and to study alternative or complementary types of packaging materials for their replacement or improvement. It must be mentioned here that Africa as a continent has in hand all the raw materials needed to produce all types of packaging material, i.e., wooden boxes, crates, cases, barrels, wrapping paper, cardboard containers, glass containers, tinsplate and aluminum cans, aluminum foil, boxes and drums, plastic containers, bags and film. A Pan-African packaging industry to meet industrialization needs, including the food processing industry, is certainly not beyond reach.

41. A major area of food research in which faculties of agriculture could play a role of vital importance is food composition, for unless the actual constituents of local prepared foods are known, calculation of the habitual diet and the introduction of complementary food to combat malnutrition cannot be satisfactorily put into practice. There has been already a most useful effort in that direction<sup>27/</sup>, but urgent need still exists to fill certain gaps which have been shown by that effort. The thrust of food composition research should be not only the accumulation of analytical data but also the unification of methodology and terminology. Action by the Association of Faculties of

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<sup>26/</sup> Aref, M. Timbely, A. and Dajet, J. Fish and Fish - Processing in the Republic of Mali. III. On the Dermestes Beetle, Alexandria Journal of Agricultural Research, XII. (1), 52-60, 1964

<sup>27/</sup> Anon. - Food Composition Table for Use in Africa. Food and Agriculture Organization of the United Nations and U.S. Department of Health, Education and Welfare, 1968.

Agriculture in Africa in collaboration with relevant African regional institutions seems to be called for in this connection.

42. Another area of food research related to food composition concerns the utilization of vegetable oils and fats in African countries. It has been reported by Mosh<sup>28/</sup> that developing African countries imported 538.4 thousand metric tons of vegetable oils (valued at U.S. \$ 407 million) in 1979 and 700.1 metric tons (valued at U.S.\$445.1 million) in 1981. Oilseeds exports, including copra and palm nuts and kernels, from the same group of countries for the same period amounted to 728.7 thousand metric tons (valued at U.S. \$139.1 million) and 595.0 thousand metric tons (valued at U.S.\$80.8 million) respectively.

Noting that the main imports, i.e., over 330 thousand metric tons, for each year, were from an oilseed not widely grown in Africa, namely the soya-bean, many questions come to mind. Firstly, whether the importation of soya-bean oil is under concessionary or gratuitous conditions which meet the immediate requirements but do not enhance the long-term desire for food self-sufficiency. Secondly, whether soyabean oil is more suitable for certain usages than locally-produced oils, in which case research should be undertaken to modify the local oils taking advantage of available technology<sup>29/</sup>. Thirdly, whether the importation of oil is basically due to lack of raw material, local processing capabilities, know-how, or organizational deficiencies. Such information would be crucial to the proper development of this important sector of the food-processing industry, especially when remedial actions are taken or identified.

43. In addition to "classical" research on vegetable oils and fats, it would seem that attention should also be paid to the development of non-conventional sources of vegetable oil which abound, or could be beneficially expanded, in Africa. Such a source is Balanites aegyptiaca<sup>30/</sup> whose kernel contains roughly 50% of edible oil with high stability against auto-oxidation, and up to 30% of crude protein with a satisfactory amino acid profile and which can be used for human consumption or animal feed after simple debittering. The

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<sup>28/</sup> Mosh<sup>a</sup>, A.C. - Vegetable Oils and Fats Industries in Developing African Countries: Constraints and Promotion of Integrated Development. UNIDO ID/WG. 404/2. September, 1983. Expert Group meeting on Measures and Forms in Promoting Integrated Development of the Vegetable Oils and Fats Industry within the Food-Processing Industry. Alexandria, Egypt, 24 - 27 October 1983

<sup>29/</sup> Anon - Draft World-Wide Study on the Vegetable Oils and Fats Industry: 1975-2000. UNIDO/ICIS.46, September 1977. pp. 110-132.

<sup>30/</sup> Abu-Al-Futuh, I.M. - Balanites aegyptiaca. An Unutilized Raw Material Potential Ready for Agro-Industrial Exploitation. UNIDO/IO.494. April 1983.

Balanites tree is known locally as Heglig, Musongolee, Mutete, Loba or Logba, To, Echomai, Shashoba, and Sarongo and is indigenous to Sudan, Gambia, Chad, Nigeria, Tanzania, Upper Volta, Northern Guinea, Ivory Coast, Senegal, Kenya and Uganda. A primary survey carried out in the Sudan in 1979 indicates that about 72,000 acres in the Blue Nile Province are covered with trees at an average density of fifteen mature trees per acre, amounting to over one million trees in that province alone, with an estimated one hundred thousand tons of Balanites fruit per year. It is believed, however, that the total wild resources of the fruit in the Sudan exceed four hundred thousand tons per year. No information is available on the production of the Balanites tree in other African countries, but once its industrial potential is assured through research it will be warranted to include it in organized plantations within an overall policy to combat desertification.

44. Another important area of food research which has been traditionally the responsibility of faculties of agriculture in many countries concerns fruits and vegetables. In view of the proximity of many African countries to Europe and the oil-producing Arab countries, as well as the existing ties between most African countries and the European Economic Community through the Lomé Convention, and between 20 African countries and the Islamic World through membership in the Islamic Development Bank, there seem to be great possibilities for the establishment of a large fruit and vegetable industry in Africa dealing with both fresh produce and processed products. But to establish such an industry there would be need to assure supplies of raw material of sufficient quantities and required quality standards.

Research would be needed to identify suitable varieties of fruits and vegetables with characteristics corresponding to the end use. Growing of fruit and vegetable plantations would have to be supported and supervised. Harvesting, transportation, storage, packing, processing, and all other aspects of the production-to-market system would have to be critically reviewed to detect the most pressing problem areas and work out research projects for appropriate solutions. It may also be necessary in certain cases to introduce new strains, varieties or species from outside the country for the improvement of local production.

45. Although both the Lagos Plan of Action<sup>2/</sup> and the Programme<sup>3/</sup> have included meat processing in the sub-sectors of the food-processing industries to be given attention during the Decade, it is very difficult for several reasons to specify research topics which should be given priority by African faculties of agriculture at large. In the first place, commercial beef production

as practiced in the developed countries constitutes very inefficient utilization of food grains. It has been reported<sup>31/</sup> that the average steer in the U.S.A. consumes 21 pounds of protein in feed to produce one pound of protein in the meat. The rest of the protein becomes inaccessible to humans, since the animal uses it to produce energy and to make inedible parts of its body such as hair and hooves or excretes it in manure. Similar figures have been reported by Berg<sup>32/</sup> and by Aylward and Jul<sup>33/</sup>. Secondly, livestock availability in African countries in relation to population is extremely varied. Ethiopia, for example, with an estimated population of 29 million people in 1976, had 26 million heads of cattle, 23 million sheep and 17 million goats, while Nigeria, with an estimated population of 65 million people in the same year, had 11.3 million heads of cattle, 7.9 million sheep and 23 million goats.<sup>34/</sup> Obviously meat research in support of a meat processing industry in either country would have a certain bias different from that in the other.

Thirdly, even if meat production and processing is substantially increased in Africa, it is another question whether this meat will be available for domestic consumption or whether the majority of the African populations can afford it. A case in point has been presented by Berg<sup>32/</sup> with respect to increased meat production in Central America as shown in Table 2.

TABLE 2  
Production and Consumption of Beef  
in Central America, 1961-65 and 1970

Country	Production (000 tons)		Production change %	Per capita Consumption Kgs.		Consumption Change %
	Av. 1961-65	1970		Av. 1961-65	1970	
Costa Rica	21.4	41.1	+ 92	12.3	9.1	- 26
El Salvador	21.0	20.0	- 5	7.7	5.9	- 23
Guatemala	41.0	57.4	+ 40	8.2	7.7	- 6
Honduras	16.7	29.6	+ 77	5.5	5.0	- 9
Panama	24.7	32.0	+ 30	20.9	21.8	+ 4
Nicaragua	32.2	56.4	+ 75	12.3	12.7	+ 3
Mexico	475.0	605.3	+ 27	10.9	10.9	0

<sup>31/</sup> Lappé, F.M., and Collins, J. - Food First. Houghton Mifflin, Boston U.S.A. - 1977

<sup>32/</sup> Berg, Alan- The Nutrition Factor. The Brookings Institution, 1973

<sup>33/</sup> Aylward, Francis, and Jul, Mogens - Protein and Nutrition Policy in Low Income Countries - Charles Knight and Co. Ltd. London and Tonbridge U.K. 1975.

<sup>34/</sup> Anon. The World in Figures. 2nd Edition. The Economist Newspaper Ltd. London, England. 1978.

It can be seen that substantial increases in meat production did not result in corresponding increases in domestic consumption but rather in a relative or absolute decline. Obviously those increases were destined for exports to foreign markets and did not contribute to improved nutrition of the local populations.

46. It would, therefore, seem appropriate to suggest that topics for meat processing research will have to be determined on a country to country basis taking into account livestock production patterns, food habits, rate of urbanization and family income. Serious consideration should be given to the fact that the meat processing industry is the main precursor of the leather industry and that hide and skin improvement, through establishment of mechanized and un-mechanized abattoirs and supervision of slaughtering practices at the village and family levels, is acutely needed in most African countries<sup>35/</sup>.

47. Milk and dairy products utilization in Africa seems to be susceptible to the same constraints facing the meat production and processing industry, and specific research activities will have to be developed on a country or even a district level.

48. Parallel to the research to be developed on meat and dairy processing, it is necessary to pay attention to the animal feed industry. While a certain amount of animal feed is imported into Africa, greater amounts (principally oil cake) are exported<sup>3/</sup>. To be able to utilize different processing by-products in animal feed formulations it is essential to know their composition and feed value and this has been traditionally carried out within faculties of agriculture.

49. Further to the above examples of conventional research some of which have been, or are being, undoubtedly carried out by several faculties of agriculture in Africa, there are a few topics which have not been traditionally of much concern to food researchers. One such topic is the quantity and quality of available supplies of water, an essential component in food processing operations<sup>33/</sup>. Research on water quality, water purification, softening, recirculation and conservation would be essential especially in those countries not endowed with adequate supplies. It is to be noted in this connection that the U.N. General Assembly, concerned about availability of safe water supplies in most developing countries, even for drinking and sanitation purposes, has declared the 1980's as the "International Drinking Water Supply and Sanitation Decade."<sup>36/</sup>

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<sup>35/</sup> Anon. Draft World Wide Study of the Leather and Leather Products Industry 1975 - 200. UNIDO/ICID.45 September 1977

<sup>36/</sup> Anon. Drinking Water Decade. U.N. Chronicle. XX: (3):39-40, 1983

50. Another topic of importance in several African countries is food safety. There seems to be need for a systematic evaluation of African foods with regard to contaminants, microorganisms, microbial toxicants and processing - and cooking-hazards. It is to be recalled that aflatoxins, for example, were not discovered until the early 1960's and only accidentally as a result of the death of large numbers of turkey poults on English farms<sup>37/</sup>. Subsequently, they were associated with incidence of liver cancer in regions of the Sahara<sup>38/</sup>, and in Uganda<sup>39/</sup>, where 40% of Ugandan foods, when screened for the presence of aflatoxins, contained measurable quantities.

A recent paper by Obeta<sup>40/</sup> identified the bacteria associated with the production of Ugba, an important and cheap source of protein, which is produced by the Ibo in Nigeria through the fermentation of the seeds of the African oil bean tree. Another recent paper by Achinewhu<sup>41/</sup> on the same food showed the presence of the toxic alkaloid paucine as well as of saponins in the bean and recommended further research to study possible adverse effects on the consumers of Ugba.

51. A most important area of research which must be adopted by faculties of agriculture in Africa is the new field of recombinant DNA or genetic engineering. The techniques of this biotechnology seem to offer nearly unlimited opportunity to provide inexpensive solutions to Africa's growing shortages of food and energy<sup>42/</sup>. It seems possible, for example, to manipulate the genes of free-living nitrogen fixing bacteria to cause them to adhere to the roots of important crops which absorb fixed nitrogen from the soil. In principle, the concentration of fixed nitrogen should be increased in the immediate neighbourhood of the roots thus increasing crop yields without resort to chemical fertilizers. In the area of food processing, genetic engineering could make a much larger range of enzymes available on a larger scale at reduced cost. Series of these enzymes could then be used

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<sup>37/</sup> Goldblatt, L.A. (Ed.) - Aflatoxins, Academic Press, New York, U.S.A. 1969.

<sup>38/</sup> Oettle, A.G. Cancer in Africa, Especially in Regions of the Sahara. J. Nat. Cancer Inst. 33: 383-439, 1964.

<sup>39/</sup> Alpert, M.E., Hutt, M.S.R., and Davidson, C.S.- Hepatoma in Uganda. Lancet 1: 1265-1267, 1968

<sup>40/</sup> Obeta, J.A.N. - A Note on the Micro-organisms Associated with the Fermentation of seeds of the African oil Bean Tree (Pentaclethra macrophylla). Journal of Applied Microbiology, 54:(3):433-435., 1983

<sup>41/</sup> Achinewhu, S.C. - The Protein Quality of African Oil Bean (Pentaclethra Macrophylla). Abstract of paper presented at the First African Conference of Food Science and Technology - 14 - 17 November 1983

<sup>42/</sup> McConnell, David - Improved Agricultural and Food Products Through Genetic Engineering and Biotechnology - UNIDO. ID/WG. 382/2/Add.5. High Level Meeting on the Establishment of the International Centre for Genetic Engineering and Biotechnology, Belgrade, Yugoslavia, 13 - 17 December 1982.



to convert cellulose to glucose, using grass, seaweed, algae, straw and other plant wastes such as sunflower and cotton residues as the basic feedstock. The glucose could either be used directly if needed, or could be converted to biofuel. UNIDO has been promoting the establishment of an International Centre for Genetic Engineering and Biotechnology (ICGEB) to strengthen the technological capabilities of developing countries in this new area of research. In a recent ministerial level plenipotentiary meeting on the establishment of the ICGEB<sup>43/</sup> the statutes of the Centre were adopted but no final agreement on its location was reached. At the time of preparing this report, the following countries have signed the statutes: Afghanistan, Algeria, Argentina, Bolivia, Bulgaria, Chile, China, Congo, Cuba, Ecuador, Egypt, Greece, India, Indonesia, Italy, Kuwait, Mauritania, Mexico, Nigeria, Spain, Sudan, Thailand, Trinidad and Tobago, Venezuela, Yugoslavia, and Zaire.

52. Food irradiation which had been censured in the late 1960's <sup>44/</sup> has been recently given a fresh lease of life<sup>45/</sup>, and could be very useful for many African countries. Research on inhibition of sprouting of onions during storage, and control of insect infestation in stored food products such as rice, pulses, cocoa beans, dried fish, dates, spices and condiments should be carried out where irradiation facilities are available. Such facilities should also be installed whenever possible because of their additional value of reducing the microbial load of many food products with or without the application of heat and their effect in improving the keeping quality of certain fruits by delaying ripening.

53. The suggestion that research in such sophisticated areas as genetic engineering or food irradiation would be both feasible and useful for African countries may cause concern at some quarters more in favour of appropriate or intermediate technology. The remaining paragraphs of this chapter will, therefore, be devoted to various views on this subject with particular reference to food processing.

54. Definitions of "Appropriate Technology" in general have ranged from the

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<sup>43/</sup> Ministerial- Level Plenipotentiary Meeting on the Establishment of the International Centre for Genetic Engineering and Biotechnology, Madrid, Spain, 7 - 13 September 1983. Report. UNIDIO, ID/WG 397/9. November 1983.

<sup>44/</sup> Tape, N.W. - Is Irradiation Dead? Canadian Food Industries, 39:(12): 30-32, 1968.

<sup>45/</sup> Anon. - Wholesomeness of Irradiated Foods. Technical Report Series 659. World Health Organisation, Geneva, Switzerland, 1981.

intolerant to the impossible. Coates<sup>46/</sup>, Assistant Director of the Federal Office of Technology Assessment (U.S.A.) does not agree that appropriate technology "AT" is needed and was quoted as saying that the AT movement in the U.S.A. is, "An intellectually empty haven for disenchanting middle class youth who are seeking a playground for their hobbies....Small May Be Beautiful, but the various solar houses and compost toilets built by appropriate technologists are ugly and unattractive. To expect that the American public would prefer them to the products of our large-scale, centralized technical system flies in the face of everything we know about people."

At the other end of the scale, Garg<sup>47/</sup> defined AT in a way that sets unattainable goals saying that it can be defined as "a technology which can carry out production on the smallest possible scale and yet can produce the same quality product at a competitive price compared with that of large scale industry." While this is a very desirable state, it is not possible to visualize how all the benefits of both large and small scale production can be attained in a single operation without any of the disadvantages of either.

55. Between those two extremes there are more reasonable definitions of AT. Tranet<sup>48/</sup>, for example, issued the following statement: "Key characteristics of appropriate technologies are that they are low cost, easily maintained, use local materials, protect the environment, are resource conserving, fit into established cultural patterns and increase the well being and the dignity of mankind".

The volunteers for International Development<sup>49/</sup> were reported to have said, "Appropriate technology has the following characteristics: 1) It fills a real need expressed directly by the recipient and beneficiary of the technology. 2) It increases production. 3) It is labour intensive rather than capital intensive. 4) It makes maximum use of local available materials, resources and skills. 5) It is compatible with local traditions and customs."

56/ With respect to food "technology", Bourne<sup>50/</sup> makes a distinction between appropriate and intermediate food technology. In his view, appropriate food

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46/ Coates, J.F. (Quoted by Boffey, P.M.) News and Comment. Science 195-966, 1977

47/ Garg, M.K. Problems of developing appropriate technology in India. Appropriate technology. 1(1): 16, 1974.

48/ TRANET. Transnational Network For Appropriate/Alternative Technologies. An Invitation to Join TRANET, Alexandria, Virginia, U.S.A. 1976. Unpublished Communication.

49/ Anon. Vita Views. 4(2):1, 1975. Volunteers for International Development.

50/ Bourne, M.C. What is Appropriate/Intermediate Food Technology. Food Technology April, 1978. pp. 78 - 80.

technology is the best technology for a given market after taking into account the constraints on that particular market area such as scale of operation, cost and availability of capital, labour and raw materials, family incomes, infrastructure, social structure, climate, and other factors that have a bearing on the success of the operation. It considers the complete food production - processing - marketing system and optimizes the total system rather than just the technical components in it.

He considers intermediate food technology as a sub-heading under appropriate food technology, and that it is a technology that is smaller in scale, less demanding of capital, and needs more labour than the typical high capacity technology of the industrialized countries. It is not static but continues to grow in size and sophistication.

57. A viewpoint from Africa is well presented by Caurie<sup>51/</sup> (Food Research Institute, Accra, Ghana), who refers to Adaptive Food Technology which has been defined in the literature to mean the modification by scaling down of existing large sophisticated machines and processes to smaller, cheaper and simpler products and methods. It is his opinion that this definition looks at the problem from the top downwards, but in the case of developing countries, the problem has to be additionally viewed from the bottom upwards. In other words, the modification should also involve the scaling upwards or upgrading of existing simple traditional machines and processes to more sophisticated machines and processes to improve production efficiency.

He also suggests that instead of talking separately of Appropriate, Adaptive or Intermediate Food Technology, we should talk more of Appropriate Intermediate Food Technology (AIFT) which should be defined as the application of modern science and engineering ideas to upgrade traditional or simplify sophisticated food processes and machines in a way compatible with the educational, economic, cultural and social needs of developing countries. Caurie then goes on to consider the question as to which economic sector AIFT is more suited for application - the traditional (non-modern) or the urban(modern) sector? Since AIFT springs basically from the need to increase employment in rural areas and decrease income disparities, it will seem that it should be limited to the traditional or rural sector. Yet the economic growth of a country cannot be based on small scale rural economic activities alone. In addition, since one of the merits of AIFT is its value in saving scarce foreign exchange resources by substituting local materials and ingenuity, the modern sector may also benefit from exposure to it. So in order to

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<sup>51/</sup> Caurie, Matthew. Appropriate/Intermediate Food Technology. How Not To Do It: A View From the Third World. Food Technology, April 1978. pp. 37-38.

avoid competition between the two sectors in the application of AIFT it may be necessary to delineate specific areas of activity where either sector may be given priority. Rural AIFT, for example, could concentrate on improvements in simple food processing methods and equipment such as vegetable preservation and processing of food grains. Urban AIFT, on the other hand, could simplify modern technology, redesign tradition technology, or introduce new technologies in such areas as sugar and oil refining.

58. Another type of research which needs to be undertaken in most developing countries concerns the marketing of food staples in both the rural and urban areas. It has been reported by Meissner<sup>52/</sup> that the "supermarkets" of the industrialized countries can serve only mid- and high- income groups in the developing countries, while the rest of the population will have to use the traditional marketing system. Food marketing research should thus be aimed at improving rural assembly centres and municipal retail markets, regulating ambulatory vendors, and the establishment of grades and standards.

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<sup>52/</sup> Meissner, F. Food Marketing Technology For Developing Countries. *Agribusiness Worldwide*. August/September. 1980, pp. 1 - 8.

IV. SERVICES TO THE FOOD PROCESSING INDUSTRIES.

58. In addition to the role of faculties of agriculture in food technology education and research, it is to be expected that in many African countries the same faculties will have to answer for other related activities for many years to come.

59. One of these activities will be support services at different levels to the existing small-scale food processing industries which, by and large, do not possess the equipment or know-how to carry out routine laboratory tests for the purpose of conforming to existing food regulations; or may not have access to sources of technical information they require; or may lack knowledge of routine quality control measures to improve their performance. A possible constraint to this type of services is that universities do not generally have a mechanism to cater to requests from industry or budgetary allocations to respond to them at no cost. It might be necessary in many countries to give serious attention to this constraint in order to strengthen university linkages with industry.

60. One way to reinforce those linkages in many countries in Africa would be the creation of an Agro-industrial Development Consultancy Service at the faculty of agriculture. Drawing on members of the faculty of agriculture, as well as on other university experts, and utilizing many of the students as appropriate, the Consultancy Service could cover a wide range of disciplines allowing it to carry out a variety of activities for government and the private sector. Activities could include feasibility studies, market studies, product and equipment tests, chemical and microbiological analyses, energy and water conservation research, fruit and vegetables variety evaluations, and a host of other consultancy services only limited by the available expertise. Such a service could be established with a minimum expenditure since the most expensive components, i.e. manpower and basic laboratories, are available. It would not only act as an additional resource for government and industry, but would also provide significant benefit to both staff and students by keeping them in tune with the problems and opportunities of the market, and ensuring that students develop skills applicable to government and industry needs.

The consultancy service could be established with an initial grant from government and would eventually charge fees for its services to meet expenses. A management board, including government and industry representatives, would be appointed to help shape the consultancy service's overall direction, to ensure that all activities fall within its stated mandate and to determine that all funds are used according to established

criteria.

61. An example of consultancy services in African universities is the Technology Consultancy Centre at the University of Science and Technology, Kumasi, Ghana, which was started in 1972<sup>53/</sup>. The purpose of the Centre is to make available to the public the technical and scientific expertise of the university, and to promote the industrial development of Ghana. Run by a staff of only seven professionals in the fields of engineering, agriculture and industrial art, the Centre draws on thirty to forty members of the university faculty for planning and executing its projects and for consultancies; and employs more than fifty technical staff in production units on the campus. Its work falls into three broad categories: technical and commercial advice to industry and government; development and testing of new products; and the commercial operation of production units on the campus, sales from which account for nearly half of the Centre's total income.

Although not devoted solely to agro-industries, the Centre has advised over the past few years on the manufacture of sugar, tonic drinks, and jams; has carried out chemical analysis on alcohol, glue and cassava starch; and has developed a new technique for the production of animal feed stuffs from brewers' spent grain.

62. Other examples in Africa include the Food Research and Development Institute at the Faculty of Agriculture, El-Minia University, Egypt, which carries out feasibility studies and implements projects in the areas of vegetable oils, cereal technology and food storage; and the Industrial Research and Consultancy Unit at the University of Nairobi, Kenya<sup>54/</sup>.

63. The utilization of university staff in creating consultancy services to serve government and industry has been also practiced in the industrialized countries and several examples have been cited such as the consultancy service at the National College of Agricultural Engineering at Silsoe, Bedford, England; the one at the California State University, at Fresno, California, U.S.A.<sup>55/</sup>; the one at the University of Guelph, at Guelph, Ontario, Canada<sup>56/</sup>, and the one at Ryerson Polytechnical Institute

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<sup>53/</sup> McRobie, George, Small Is Possible. Harper and Row. New York, U.S.A., 1981.

<sup>54/</sup> Anon. Directory of Industrial and Technological Research Institutes in Africa. UNIDO:IS. 299. March, 1982.

<sup>55/</sup> Anon. Agribusiness Consulting Firms. An International List. Agribusiness Worldwide. July, 1982, pp. 14-32.

<sup>56/</sup> Howell, D.G. Centre for International Programmes. University of Guelph, Guelph, Ontario, Canada. Private Communications, 1983.

in Toronto which has become one of the largest in Canada.<sup>57/</sup>

64. Another area where faculties of agriculture in Africa would have to take the lead is that of industrial extension work related to the food processing industry, and similar to the agricultural extension work already common in some universities. Such work may include the identification and solution, to the extent possible, of problems associated with the production of processed foods; adaptation of new or modified products and processes to the needs of local industries and markets; acquainting industry personnel with relevant developments and improvements; and the publications of manuals on pertinent topics such as preparation and use of quality control charts, food plant sanitation, sensory evaluation or simple laboratory control tests. For effective industrial extension work in many developing countries it might be necessary for the food technology department at the faculty of agriculture to also become the centre of information about who is doing what, where and how in the food processing industries sector, at least in that part of the country where the department is located.

65. It is quite clear from the above that faculties of agriculture in African universities could be instrumental in the development of an institutional infrastructure for the industrial technology of food processing through four principal functional areas, namely training, research, consultancy services and extension work. Since the food processing industry with its broad applications is an essential part of any integrated food production-processing-marketing system aimed at food self-sufficiency, it is most important to call upon African faculties of agriculture to discharge those principal functions, and to provide them with the funds and facilities required for their pursuit.

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<sup>57/</sup> Anon.- College sets up centre for Industrial Research. Canada Weekly 11:(28), July 1983.

V. PROSPECTIVE FUNCTIONS FOR AFRICAN FACULTIES OF AGRICULTURE

66. What has been dealt with so far may be considered as the conventional role of the faculties of agriculture, in Africa and elsewhere, in the long-term development of the food processing industries. But the food situation is much worse in Africa than in other parts of the world, and this imposes greater responsibilities on African faculties of agriculture.

67. It would seem necessary, for example, that faculties of agriculture in Africa are given more say in the co-ordination of research activities at other faculties of the university, in order that the total research effort of the latter be more oriented towards solving the roster of problems besetting the food production - processing- marketing systems in Africa.

Upgrading traditional food processes, for instance, or the simplification of sophisticated food processes and machines to suit conditions prevailing in some African countries, may require inputs from faculties of engineering. Similarly, market studies for processed foods may well be carried out as co-ordinated projects by faculties of agriculture and faculties of commerce, and nutritional aspects of food processing may involve inputs from faculties of medicine.

The main idea is to fully mobilize the total expertise available at the university to combat food shortages and losses. An additional benefit would be the orientation of university research to the solution of existing problems related to actual national needs. It had been the writer's observation in Egypt that many university scientists who had acquired their Ph. D.'s in industrialized countries continued to carry out in-depth studies in narrow areas of no practical bearing on immediate needs in order to produce research papers suitable for publication in international journals. Parpia<sup>58/</sup> noted the same trend in India and discouraged it during his term as Director of the Central Food Technological Research Institute at Mysore, orienting the research effort of the Institute to the solution of problems troubling the food processing industry in India.

68. It would also seem necessary to involve staff of the African faculties of agriculture in governmental advisory committees dealing with food matters, as well as in governmental delegations to international meetings devoted to the world food problems. In addition to making available to those committees and delegations the technical knowledge of the faculties, which would help make their decisions and resolutions more precise in many cases, that involve-

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<sup>58/</sup> Parpia, H.A.B. U.N. University, Tokyo, Japan. Private information on several occasions.



ment would enhance faculties' appreciation of the significance of their work with respect to the food problem in their own countries.

69. Another function which has been assumed by some faculties of agriculture in Africa is the establishment of national professional societies of food science and technology which sponsor annual meetings featuring technical papers and serving as fora for exchange of information, sharing of knowledge, and reunion of peers. Such a function should be fostered wherever possible and the professional societies should include food scientists and technologists from university, industry and government.

Ultimately, the national professional societies could form an All-African Food Science and Technology Union which could co-ordinate subject matter training, research, and other activities for the benefit of all countries.

70. Last, but not least in importance, faculties of agriculture in most African countries should be given a leading role in the development of a national conservation strategy for the protection of the natural environment, especially with respect to matters related to food production and processing. It has been reported, for example, that around one fishing centre in the Sahel region of Africa the drying of some 40,000 tons of fish consumes 130,000 tons of wood every year, with the result that deforestation extends as far away as 100 km.<sup>59/</sup> Similarly, fuel wood has become so scarce in the Gambia that gathering it takes 360 woman days per family. Other drastic effects of population growth and its destructive influence on national resources, while desperately seeking food and shelter, have been described in the same reference, along with a framework for national and subnational conservation strategies. Faculties of agriculture in most countries of Africa would seem to be the only institutions capable of developing conservation strategies commensurate with development needs, and to come up with measures to meet the short term requirements of the growing populations and break the vicious circle by which poverty causes ecological degradation.

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<sup>59/</sup> World Conservation Strategy. International Union for Conservation of Nature and Natural Resources (IUCN), United Nations Environmental Programme, and the World Wildlife Fund. 1980.

ANNEX A

Subject Matter Outlines for Food Oriented Courses.

I. - FOOD CHEMISTRY

a.) Preamble:

This course must emphasize those aspects of chemistry that exist uniquely in food. It should provide knowledge that can be put to effective use in present-day work as well as in creating the advances of the future.

The rapid pace of progress in biological science and technology should be reflected in the guidelines and goals for food science and technology. Increasing numbers of students will be attracted to this field if the goals are high and the excitement and challenges of the profession are demonstrated.

The course outline presented below is basic to future open-ended achievement by graduates of baccalaureate degree programs in food science and technology. Some of the subjects included might equally well be presented within other "core" courses.

Prerequisites for the course should be 1 year each of Organic Chemistry and of Biochemistry, and Physical Chemistry also is desirable as a prerequisite.

The Table lists only lecture material. Experiments and projects that illustrate principles inherent in the topic discussed should be considered. If the contents of the Food Analysis course can be coordinated with that of Food Chemistry, some laboratory work might be shifted to Food Analysis.

b.) Course Outline:

Introduction: Definition of Food Chemistry; Relationship to other applied fields of chemistry (biochemistry, pharmaceutical and clinical chemistry);

Historical Aspects and Importance.

Water and Ice: Chemical and physical properties; Influence on properties of foods

Carbohydrates: Types and content in foods; Locus in raw material; Brief review of structure and reactions; Sweetness and structure.

Specific Carbohydrates: Starch: occurrence and types; particulate structure; characteristics for processing; modified starches - Pectin: occurrence and uses - Other Polysaccharides: Gums; cellulose; hemicellulose.

Lipids: Brief review of structure and reactions of glycerides and phospholipids; Lipid content in food systems; Functional properties of lipids; Nutritive value and essential fatty acids; Glycolipids.

Fat and Oil Technology and Changes: Production of edible lipids; hydrogenation; interesterification; Effects of processing and cooking; Decomposition; Types of rancidity (hydrolytic; oxidative - theory and use of antioxidants - and ketone).

Proteins and Amino Acids: Brief review of structure and functions; Protein content in food systems; Essential amino acids; Lipoproteins.

Processing and Proteins and Amino Acids: Degradation of proteins, or hydrolysis of proteins, effects on functional properties and food quality; Tests for protein degradation; Effects of processing on essential amino acids; Supplementation or fortifying; Non-enzymatic browning.

Plant Pigments: Chemical structure, location, classification, occurrence; Mechanism of degradation.

Biological Food Systems: Distribution and organization of chemical constituents.

Muscle Tissue: Gross anatomy and microstructure; Chemical composition; Cell structure; Effects of ante-mortem conditions and post-mortem changes (glycolysis); Relationship of texture to structure and composition; Changes through processing (curing, smoking, dehydration, freezing) and storage (packaging).

Plant Tissue: Gross anatomy and microstructure; Chemical composition of leaves, stems, buds, seeds, etc.; Cell structure; Texture and structure, turgidity; Changes through processing and storage (respiration, sugar-starch equilibria, etc.).

Special Systems: Milk, eggs and other special systems, chemical composition, structure, and changes in processing and storage.

Vitamins: Stability during processing and storage.

Enzymes: Deterioration reactions of enzymes naturally present in foods (enzymatic browning, lipolysis, proteolysis, oxidation/reduction) and useful reactions such as tenderizing, flavor development; Use of added enzymes in food processing.

Food Solutions/Dispersions: Physicochemical concepts of solutions, sols and suspensions; gels; emulsions; foams; and disrupted tissue systems such as fruit or vegetable juices and purees, bakery products, meat products, etc.

Flavor and Texture: Relation to chemical composition, structure and processing.

Food Additives: Use to modify physical and chemical properties of foods.

## II. - FOOD ANALYSIS

### a.) Preamble:

Depth of comprehension should be provided through instruction in fundamental principles rather than in the methodology of analysis of specific commodities.

A proper balance should be maintained between classical and more sophisticated recent method of analysis. Both kinds should be taught whenever appropriate along with an indication of precision, accuracy, sensitivity, advantages and disadvantages of each. The preferred method and the legal method might well be indicated.

The Task Force on Food Analysis presents in the course outline following what it considers to be an optimum coverage of the subject area. The Task Force recognizes the rapid advances being made in analytical instrumentation which may render obsolescent some of the approaches now recommended.

Prerequisites for the course should be 1 year of General Chemistry, and one term of Quantitative Analysis, Organic Chemistry, Food Chemistry, and an appreciation of Biochemistry.

b.) Course Outline:

- Lecture Material -

Introduction: Review of chemical calculations.

Data: Recording, interpretation, presentation.

Sampling: Tools, frequency, representative technique, preparation for analysis.

Separation techniques: Extraction, precipitation, filtration, distillation, dialysis, electrophoresis, chromatography (gas, paper, thin layer, ion-exchange, gel permeation), and centrifugation.

Physical Measurements: Weighing, density, polarimetry, refractometry, rheology (viscosity, deformation, flow) and texture, spectrophotometry (nephelometry, flame photometry, atomic absorption spectrophotometry, spectrofluorimetry, reflectance), colorimetry (CIE, Hunter, Munsell), conductivity methods, spectrometry (NMR, electron spin resonance, mass), and polarography.

Chemical Techniques: Titrations (acid-base, chelation), redox potentials, other electrometric (ion and gas sensitive).

Biochemical Techniques: Enzyme assays, bioassays, micro-biological and physiological assay techniques.

- Applications -

Note: The following tabulation is for lecture material. An asterisk(\*) following any item means that laboratory exercises relating to that item are recommended.

In both lecture and laboratory work, qualitative and quantitative aspects should be stressed that illustrate principles of analysis.

Proximate Analysis: Moisture\* (Karl Fischer, vacuum oven, xylene distillation, conductivity, IR, NMR, moisture balance); Ashing\* (dry and wet; physical, chemical and microbiological assay of individual metals); Crude Fiber\* (acid/base extraction, alcohol insoluble solids\*); Crude protein\* (Macro/Micro Kjeldahl, dye binding, biuret, Lowry, absorbance 280/260 nm); Lipid (either soluble extract\* Mojonnier; Babcock and modifications); Carbohydrates\*.

Lipid Analysis: Iodine No., saponification No., melting point, refractive index\*; Oxidative and hydrolytic rancidity measurements and stability determination; Composition (gas chromatography, thin-layer chromatography); Identification and adulteration (qualitative tests).

Carbohydrate Analysis: Determination of pectin and of starch; Reducing sugar methods, Enzymatic assay, Polarimetry\* and Composition (gas chromatography\* paper chromatography\*).

Protein Analysis: Isolation, Biological activity; Amino acid composition (paper chromatography, ion-exchange chromatography).

Enzyme Analysis: Determination\* and as index of proper blanching or pasteurization.

Color/Pigment Analysis: Coal tar dyes (detection, separation, identification); Pigments\* Tannins.

Vitamin Assays: Microbiological, chemical, physical\* bioassay, physiological (serological).

Flavor Analysis: Components of flavor.

Additives/Contaminants: Detection, separation, identification of preservatives; pesticides, toxins (incl. mycotoxins) and antibiotics.

Note: The following techniques may not fall uniquely into the province of Food Analysis, but they are important to the overall training of a food technologist: Sizing of particles; Grading; Sensory evaluation; Testing of packaging materials; Detection of filth; Mold counting; Standards of Identity; and Surface tension.

Experimental: Conductivity; Surface tension; Microscopic examination; Bioassays; Microbiological assays; Physiological (immunology) techniques; Consistency and texture; Spectrophotometry; Polarography; Density.

### III. FOOD MICROBIOLOGY

#### a.) Preamble

Several assumptions were made in developing a suggested outline for a course in Food Microbiology: 1. Students taking the course will have completed a comprehensive course in General Microbiology. 2. Laboratory experiments will be included, but will be chosen by the instructor to illustrate best those concepts he feels particularly competent and equipped to present.

While the suggested outline (below) was developed with considerable thought being given to the sequence of the subjects included, it is not sacrosanct. The major consideration was to include the most important topics that should be studied in this fascinating field of microbial ecology involving human food.

#### b.) Course Outline:

Introduction: Ecological aspects; food composition and microbial flora; Microbial interactions; Food preservation need and methods; Food as vectors of microbial pathogens.

Microorganisms: Morphology, Culture, Physiology, Activities in Food - Pseudomonadaceae, Achromobacteriaceae (vinegar manufacture, psychrophiles); Enterobacteriaceae (coliforms and fecal streptococci as indices of sanitation); Brevibacteriaceae, Lactobacillaceae, Propionibacteriaceae (starter cultures, bacteriophage of starters); Micrococcaceae (thermoduric bacteria); Bacillaceae (sporulation/germination, industrial fermentations with bacilli and clostridia, thermophiles); Yeasts (spoilage, beer, alcohol and bread making, food yeast); Molds (Spoilage, organic acid and cheese making, source of enzymes); Viruses and rickettsia.

Food Poisoning: microbial toxins; microbial spoilage; food-borne infections; food poisoning incl. botulism; mycotoxins.

Control of Microbial Populations in Foods: "Normal" populations on plant/animal foods; Asepsis in food production/processing (human sanitation, equipment, air and water); Control of microbial growth through temperature, pH, water activity, gaseous environment, additives).

Inactivation or Removal: Purposes (preservation, public health, remove competitors for starters); Resistance to stresses (inherent, environment during microbial growth, storage and inactivation treatment) Detection of survivors (death vs. injury); Bactericidal treatments (chemical, gaseous, irradiation, heat); Removal by centrifugation or filtration (membrane).

Thermal Process Evaluation: pasteurization or sterilization factors to be evaluated; Model canning flow sheet; Process evaluation; Rationale for

basic treatments and adaptations; Order of microbial death; Survivor and lethality curves.

Microorganisms and Their Properties Utilized in Processing: Streptococcus, lactobacillus, pediococcus, leuconostoc; Propionibacterium; Acetobacter, Brevibacterium; Yeasts; Fungi; -Starter cultures: stock, intermediate, bulk, concentrates; Malfunctions; Evaluation of activity; -Food conversions: milk products; cucumbers, soybeans, cabbage; tea, coffee, cocoa; sausages; alcoholic beverages, bread, vinegar; -Food materials from microorganisms: enzymes; fats; vitamins; Microorganisms as complete food.

Microbiological Examination: Food sampling; Enumeration by total and selective (differential) counts; Quality tests; Standardization of methodology.

Foods and Public Health: Food-borne infections (salmonellosis, dysentery, enteropathogens, viruses and rickettsia); Microbial toxins (staphylococcus, botulism, Clostridium perfringens, Bacillus cereus, mycotoxins); Detection of pathogens and toxins (epidemiological and laboratory procedures); Chemical residues.

Standards for Foods: Bases (health, shelf-life, labeling, esthetics); Development (measurability; enforceability; economic validity); Inspection methodology; Control agencies.

#### IV. FOOD ENGINEERING

##### a.) Preamble:

The objective of Food Engineering courses is to introduce a limited number of engineering fundamentals. The student interested in in-depth aspects of food engineering would be expected to elect a course sequence in engineering independently of the courses discussed here.

The proposed outline (that appears below) contains material for a full year's work, preferably the junior year. The first course covers thermodynamics, fluid flow and heat transfer. The second course covers evaporation, refrigeration, psychrometry, drying, distillation, and optional topics.

Prerequisites for the first course in Food Engineering are 1 year of Calculus and 1 year of physics. It is recommended that Physical Chemistry be taken concurrently with Food Engineering.

Effective instruction in Food Engineering cannot be carried out without some parallel laboratory work. Therefore, a list of experiments, which might serve as a basis for a laboratory text, is included in the outline.

##### b.) Course Outline:

###### First Course (1/2 Year)

- Lecture Material -

Units/Dimensions: Consistency of dimensions; mass-force concept.

Thermodynamics: First Law (closed and steady-state systems); Material balance; Energy balance; Thermodynamic properties of materials (steam, refrigerants);

Fluid Flow: Mechanical energy equation (Bernoulli); Laminar and turbulent flow; Reynolds number, Friction factors; Flow measurement; Newtonian and

non-Newtonian liquids; Compressible fluids.

Heat Transfer: Conduction, steady and unsteady state (series and parallel); thermal conductivity; heat capacity, diffusivity, Gurney-Lurie charts; thermal processing/process engineering; Convection, coefficients (film, overall, and analysis of selected systems); Radiation (fundamental equation; emissivity-qualitative aspects); Heat exchangers (counterflow, parallel flow, significance of log-mean temperature differences).

- Laboratory Experiments -

Measurement: pressure/vacuum; temperature; liquid flow; gas flow; heat transfer by radiation.

Characteristics - of pumps; fans, blowers, compressors; vacuum pumps.

Heat Transfer: Heat exchangers (evaluation of overall heat transfer coefficient; comparison of different types of exchangers)

Optional Exercises: Heat transfer in transient conduction; Energy transfer, e.g. by dielectric devices and radiofrequency ovens.

Second Course (1/2 Year)

- Lecture Material -

Evaporation: Mass and energy balance; Rate calculations; Principles of operation.

Refrigeration: Thermodynamics of compression cycle; Principles of operation; Liquefied gases as contact refrigerants.

Psychrometry: Properties of air-water mixtures; Psychrometric charts; Examples (other than drying).

Dehydration: Drying during constant and falling rate periods; Mass transfer coefficients, diffusion mechanisms; Principles of operation of dryers.

Distillation: Equilibrium; Batch and continuous distillations; Equilibrium flash distillation; McCabe-Thiele diagrams (optional).

Control: Principles of instrumentation and process control.

- Laboratory Experiments -

Evaporation.

Refrigeration.

Psychrometric Measurements.

Drying: Rate studies; Evaluation of continuous process.

Instrumentation and Control.

- Appendix -

The following topics are optional Lecture Material. An asterisk (\*) designates those topics for which laboratory experiments may be included at the discretion of the instructor.

Size Reduction \*

Separations \* : Filtration; Mechanical; Density; Membrane processes; Extraction\*  
Leaching; Ion exchange; Adsorption.

Materials Handling: Including mixing, Homogenization\*.

Electrical\*: Circuits, power, motors.

Cost Analysis.

## V. FOOD PROCESSING

### a.) Preamble:

The two Food Processing courses for which outlines have been developed (see below) should bring together the total body of knowledge related to food processing in a meaningful and integrated way. They should provide opportunities for application of the principles of food science in problem-solving situations.

As a minimum, the subject matter may be treated conveniently as two separate courses, Preservation Technology and Case Studies. Both courses may be extended to two quarters or semesters.

The technology of food preservation is important to all processing industries. Subjects related to preservation are a logical group to include in one course or course sequence.

Other material related to Food Processing may be treated by case study approach. Objectives of this approach are: 1. To provide experience in applying principles to solving problems of the type encountered by a professional food technologist; 2. To introduce flexibility in adapting the broad scope of subject matter to specific objectives of different universities, and to career interests of individual students; and 3. To improve competence in developing new areas of food information, individually and by team work.

Recommended prerequisites for Preservation Technology are Food Chemistry, Food Engineering and Food Microbiology; for Case Studies they are Senior standing and consent of instructor.

By judicious selection of problems and by challenging direction, the treatment can provide an excellent opportunity to "round out" the education of the food technologist.

### b.) Course Outline:

#### First Course - Preservation Technology

Objectives: Provide integrated understanding of basic disciplines in relation to preservation of foods.

Introduction/Review: Causes of spoilage (Microorganisms, enzymes, oxygen, moisture, insects).

Refrigeration: Chemical, physical, biological changes; Heat load; Atmospheric requirements; Spoilage problems.

Freezing: Methods and equipment; Crystal formation control; Storage problems.

Pasteurization: Methods (heat, filtration, centrifugation, radiation, chemical); Equipment, Storage problems.

Heat Sterilization: Suitable products, containers (types, product demands, closure); Blanching; Exhausting; Sterilizer design and operation (non-agitating,



agitating, continuous flow, HTST vs. conventional); Thermal processing (review thermal destruction; Heat penetration; Process calculation); Storage problems.

Dehydration: Methods and equipment; Enzymatic and other changes during processing; Packaging; Storage problems.

Other Methods: Fermentation (acid, alcohol); Control of osmotic pressure (sugar, salt); Radiation (insect control); sprout inhibition; Smoking.

Note: Minimum suggested class time is 3 lecture periods and 1 laboratory period per week.

#### Second Course - Case Studies

Objectives: Provide experience in developing information and applying it to decision-making in food industry situations. Intended for students preparing for technical or management positions in the food industry.

Course Organization: Subjects of study are selected by the class with the guidance of the instructor. Emphasis is to be on subjects not covered in depth elsewhere in the Food Science and Technology curriculum, for example, packaging, quality control, consumer acceptance testing, sanitation, waste disposal, plant layout, cost estimating and analysis, and others.

Approach: The case studies approach is used to give the student deep specialized insight and to develop problem-solving ability.

Note: Scheduled class periods should include lectures by instructors and by invited guest lecturers from industry and public agencies; reports by students; discussion periods; and visits to food processing plants.

#### VI. INTRODUCTORY FOOD SCIENCE

##### a.) Preamble:

Students should learn that the growing, processing and or fabricating and packaging of food is one of the wonders of modern civilization and a tribute to the food industry and to its heartbeat, the food scientist. Food must be understood as a complex chemical material over which man can exercise control. Such control is possible only when the food scientist has a thorough knowledge of the basic sciences and of the composition of foods.

The course should employ modern teaching techniques, including demonstrations and experiments by instructor and/or students, discussion panels and groups, team teaching, slides, films, etc. If the instructor uses imagination in organizing class material, the course can be meaningful as well as popular.

The course outline below gives a recommended breakdown of subject matter and the percentage of course time that might be allocated to each subject. More flexibility may be gained with several 2-hour periods per week.

##### b.) Course Outline:

###### Food and Man (10% of total course)

Early History: Decline of hunting and gathering food; Development of agriculture and other fields.

Geographical Aspects: Food production, processing and consumption in the world and the nation.

Human Nutrition: Requirements; Sociological aspects such as religious and cultural prejudices, and habits and trends.

Development of an Industry: The recent roles of: Science and engineering; food scientists and technologists; government; universities; chemical, equipment and container companies; professional, technical and trade organizations; and publications.

Marketing Developments:

Standard of Living: World and national impact

Challenges and Opportunities.

Food Acceptance (8%)

Acceptability Factors: Bases in: Religious, ethnic background, and "fads" Quality, uniformity, appeal, nutrition, and convenience; Cost; Supply; and Packaging.

Sensory Properties: Perception of color, odor, taste, texture, etc.; Consumer evaluation.

Food Quality (10%)

Definitions: for consumer; industry; government

Criteria: Wholesomeness including health hazards; Esthetic factors.

Obligations of Industry: to consumer; to farmer

Obligations of Government: to consumer; to farmer; to food and related industries.

Laws and Regulations: Federal, state and local: Development and philosophy; Standards, labeling and advertising. Additives, residues and toxicants; Plant inspection and environmental sanitation.

Raw Materials (20%)

Types: Fruit, vegetable, meat and poultry, seafood, milk, grain, etc.; Genetics and physiology.

Availability

Nutritional Value

Composition: Significance of: water, acids, proteins, enzymes, lipids, carbohydrates, pigments, minerals, vitamins, etc.

Microorganisms: Significance; Classification; Man's control and utilization.

Food Preservation (20%)

Objectives: Prevent deterioration; Protect quality and nutritive value; Provide safe food; Provide variety and convenience.

Historical Aspects

Basic Methods: Drying and/or concentration; Chemical; Fermentation; Refrigeration and freezing; Heat treatment; Ionizing radiations; and Packaging.

Food Processing (20%)

Raw Materials: Harvesting and handling; Unit operations.

Processing and Formulating: Prepared and synthetic foods.

Processed Foods: Packaging, stability and nutritive value.

Public Health Factors: Water and air supply; Environmental sanitation; Waste disposal.

The Future (8%)

World Food Problems: Population increase ; Food supply and marketing;  
Nutrition; Political and social factors.

Science and Technology: Processing; New raw materials; Food toxicants;  
Water supplies; Waste disposal; New food trends.

Careers and Opportunities (4%)

The Profession: Food science and technology.

Roles of Food Professionals: In food industry and supplier companies; in  
government jobs; in universities; in marketing organizations; in professional,  
technical and trade organizations; in publication work.

