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Technological Transitions: Technical Upgrading of Indigenous Food Technologies in Africa

EXECUTIVE SUMMARY

As a result of high population growth in sub-Saharan Africa, it is estimated that 20 million more people would need to be fed every year. In 1995 sub-Saharan Africa had the lowest daily per capita calorie supply indicating an acute state of food insecurity in the region. Food production is far outpaced by the high population growth.

This paper highlights the importance of food processing and preservation as an essential component of national strategic plans for food security. Features of indigenous technologies are discussed. Experiences in upgrading indigenous technologies for food processing in Africa as well as examples of current best practices are given.

Recommendations for the development of the sub-sector are given. These include government policies on creating an enabling environment for building the capacities of stakeholders and on provision of incentives to promote growth in the sub-sector.

1. INTRODUCTION

1.1. Population and Food Security in Africa

African governments agree that population matters are an integral part of the socio-economic development process and should be accorded high priority in the allocation of financial resources.

Sub-Saharan Africa's population trends are unique in the developing world. It is the only region where fertility rates (average number of children per women) have remained virtually unchanged for more than a quarter of a century. A study of 1990 and 1995 statistics show that in Latin America the fertility rate has fallen from 6 to 2.8. In sub-Saharan Africa the rate has moved from 6.7 to 6.0 which is the highest among all regions. With an average population growth rate of 2.9 from 1970-95 (Table 1) Africa's population is expected to double by the year 2020. Africa has no option but to pursue

population policies which ensure a balance between population growth and socio-economic development. Secretary-general of the Organization of African Unity, Salim A. Salim, estimated that Africa's high population growth rate means feeding an additional 20 million people per year as well as provide them with other basic needs.

Sub-Saharan Africa is the only region in the world where food production per capita has declined during the past three decades (FAO, 1999). Hunger is the most immediate symptom of under-development of the continent's agricultural sector. Estimates of the chronically undernourished population of the world suggest that two in every 5 persons in the sub-Saharan Africa is chronically malnourished. FAO and WHO data show improvements of the nutritional situation in Asia and Latin America from 1980 to 1990 but a deterioration in sub-Saharan Africa (Table 2). In Africa, drought, other natural disasters, civil conflicts, political instability, inefficient production practices which adversely affect the environment, soil erosion leading to loss of top soil and poor soil fertility have contributed significantly to hunger and poor nutritional status. Sub-Saharan Africa had the lowest daily per capita calorie supply in 1995 (Latham, 1997).

The relationship between environmental degradation and the decline in agricultural production is too often not brought into focus in the formulation of agricultural development strategies. Environmental degradation is evident in all parts of the region and be seen in the semi-arid western and eastern Africa, the high rainfall areas such as Zambia, the Democratic Republic of Congo and the West African coastal areas. Desertification, the conversion of once arable soil to desert can be seen across equatorial Africa from the extreme end of West Africa to the 'Horn' of Africa.

1.2 Staple Crops of Africa

Important among staple food crops in Africa are:

- root and tuber crops such as cassava, yam, cocoyam, and sweet potatoes;

- cereals such as the coarse grains namely maize, sorghum and millet as well as rice;
- oil seeds such as oil palm, groundnut, sheanut, sunflower seed, copra and sesame;
- fruits including plantain, banana, mango, orange;
- vegetables such as aubergine, tomatoes, okra, onion, chilli pepper;
- grain legumes such as various types of beans (including soy beans) and peas;
- various types of meat and fish from both marine and freshwater sources

Tables 3 and 4 show world production levels of some of these crops.

1.3 Cassava: The Security Crop

Africa is the leading cassava producer with an estimated total production of 88.1 million tones about 50% of total world output in 1998 (Table 4).

Increase in cassava production of about 2 percent per year in Africa have been largely due to fabourable climatic conditions as well as government policies aimed at promoting cassava cultivation.

According to FAO, countries such as Angola, Ghana, Nigeria, Tanzania and Uganda had substantial increases in cassava production in 1997/98. This is attributed in part to national programmes which have brought new growing areas under intensive cassava cultivation using new high-yield varieties with high starch content.

Seventy percent of cassava that is produced in Africa is used for human consumption while in Asia, Latin America and the Caribbean only 35 to 40 percent of cassava production is used as food for humans.

The development of cassava as a major crop in African countries is primarily one way to mitigate food insecurity by having a diverse production system which includes cereals (Table 3), roots and tubers and legumes.

Comparatively, cassava grows well in poor soils and can be harvested all year round thus helping to reduce food insecurity during seasonal food shortages.

TABLE - 1 SOME REGIONAL AGGREGATES OF HUMAN DEVELOPMENT INDICATORS

	Sub Saharan Africa	South East Asia and Pacific	Latin America and the Caribbean	All Developing Countries	Eastern Europe and CIS	Industrial Countries	World
Human Dev. Index							
Life Expectancy (Years)	50.6	64.7	69.2	62.2	68.1	74.2	63.6
Adult Literacy Rate	56.9	87.3	86.7	70.4	98.5	98.6	77.6
Real GDP per capita	1,407	3,852	5,982	3,068	4,109	16,337	5,990
Human Dev. Index	0.386	0.683	0.831	0.586	0.756	0.911	0.772
Food Security							
Daily per capital calories supply (1995)	2,237	2,533	2,781	2,572	2,882	3,157	2,702
Daily per capita supply of protein total (grams)	52	60	72	65	88	99	73
Food Production per capita index (1980=100)	99	127	111	139	-	103	132
Growing Urbanization							
Urban Population (as% of total) 1995	32	33	73	37	66	74	45
Urban Population Annual Growth Rate (1970-95)	5	4	3	4	2	1	3
Population Trends							
Population Growth Rate (1970-95)	2.9	2.1	2.1	2.1	0.7	0.7	1.7
Population Doubling Date	2020	2038	2039	2037	-	2223	2046
Total Fertility Rate	6.0	3.0	2.8	3.2	1.8	1.7	2.9
Estimated Population (Million-1995)	543.4	489.9	471.5	4,394.0	400.8	1,233.1	5627.1

Source: UNDP Human Development Report 1998

TABLE - 2 PREVALENCE OF CHRONIC UNDER NUTRITION IN DEVELOPING REGIONS

Region	Percent of Population			Number (Millions)		
	1969-1971	1979-1981	1990-1992	1969-1971	1979-1981	1990-1992
Latin America and the Caribbean	18	13	14	51	46	61
Near East and North Africa	25	10	10	44	24	32
Sub-Saharan Africa	36	39	41	96	140	204
East and South East Asia	41	27	16	468	371	262
South Asia	33	33	22	233	297	250
Continental Africa	34	33	34	116	148	211
Developing Regions	35	27	20	893	878	809

Source: Lathan, MC (1997), Human Nutrition in the Developing World

TABLE - 3 WORLD CEREAL PRODUCTION – ESTIMATES FOR 1998 – MILLION TONNES

	Wheat			Course Grains			Rice (Paddy)			Total Cereals		
	1996	1997	1998	1996	1997	1998	1996	1997	1998	1996	1997	1998
World	589.5	613.9	596.4	920.8	904.9	906.1	571.2	577.2	560.2	2081.5	2096.0	2062.6
Asia	229.4	249.9	241.7	226.3	193.6	216.6	522.7	526.8	512.1	978.4	970.3	970.4
Africa	22.7	15.3	19.3	88.4	76.2	83.9	15.5	17.0	15.8	126.6	108.5	118.9
North Africa	16.6	10.0	14.0	13.5	9.1	10.7	5.0	5.5	4.5	35.1	24.6	29.2
Sub-Saharan Africa	6.1	5.4	5.3	74.9	67.2	73.1	10.5	11.5	11.3	91.5	84.0	89.7
Central America	3.4	3.7	3.3	29.4	28.2	28.6	2.2	2.2	2.1	35.0	34.1	33.9
South America	22.1	20.1	15.6	54.5	63.7	63.8	18.2	17.7	16.4	94.8	101.5	95.7
North America	91.8	91.8	93.8	294.6	285.9	298.5	7.8	8.3	8.5	394.4	386.0	400.9
Europe	128.5	132.1	139.2	160.2	175.8	162.7	2.7	2.7	2.7	291.5	310.6	304.6
CIS	67.6	81.2	62.1	55.7	70.8	43.0	1.2	1.1	1.3	124.5	153.0	106.4
	24.0	19.7	21.3	11.7	10.7	9.1	1.0	1.4	1.4	36.7	31.9	31.8

Source: FAO, Food Outlook (1999)

TABLE - 4 WORLD CASSAVA PRODUCTION (IN FRESH ROOTS)

	Million Tonnes		
	1996	**1997**	**1998 (Prelim)**
World	165.4	166.2	161.6
Africa	84.7	86.5	88.1
Congo Dem. Rep.	16.8	16.8	16.5
Ghana	7.1	7.1	7.6
Madagascar	2.4	2.4	2.4
Mozambique	4.7	5.3	5.0
Nigeria	31.4	32.1	32.7
Tanzania	6.0	5.7	6.2
Uganda	2.2	2.3	2.6
Asia	48.8	47.5	45.0
China	3.6	3.6	3.4
India	6.0	6.0	4.8
Indonesia	17.0	15.1	16.1
Philippines	1.9	2.0	1.9
Thailand	17.4	18.1	16.0
Viet Nam	2.1	2.0	2.0
Latin America and Caribbean	31.6	32.0	28.4
Brazil	24.6	24.3	20.4
Colombia	1.8	1.8	1.8
Paraguay	2.6	3.2	3.3

Source: FAO

2. ECONOMIC SIGNIFICANCE OF INDIGENOUS FOOD PROCESSING IN SUB-SAHARAN AFRICA

Food processing industries contribute considerably to African national economies. In Africa, food processing accounts for 40 percent of the value-added by all manufacturing industries. These activities which are mostly small or informal enterprises are a major source of rural employment. They create jobs and income for about 60 percent of the Sub-Saharan African labour force, most of whom are women. These small-scale food processing industries are mostly rural-based. They supply local markets with low-cost consumer goods, add value to Africa's produce, contribute to its economic growth through diversification, contribute to import substitution, and to foreign exchange earnings (as non-traditional export products) and increase the technical and management skills of the rural population.

Agriculture is a seasonal activity. Local processing at village level offers employment to many as an important off-farm income-generating activity. Some estimates indicate that in the case of perishable commodities such as fruits, vegetables and fish, as much as 50 percent of production may deteriorate and may be lost due to complete lack of/or inadequate facilities for appropriate storage. This is particularly so in the harvest period when producers may not be able to store all the harvest. The major thrust of African government strategies and agricultural research and development programmes has been to increase yields rather than make optimum use of what is already available. Food processing helps to preserve food, reduce post-harvest losses and to extend the availability of food products over a longer period. In this way, the hunger gap is reduced between the harvest period and the lean period when prices of food shoot up and put many people at nutritional risk.

From above, it is obvious that the promotion and improvement of food processing and preservation, at all levels of operation, should be an essential component of national strategic plans for food security. This should be an integral part of agricultural development efforts which aim at achieving national food security. Until now, most interventions have concentrated on post-harvest technologies with emphasis on on-farm and off-farm storage of

agricultural produce. In addition to this, governments and development agencies have realized that they need to invest in micro and small-scale food processing to upgrade technologies and assist them to grow into market-oriented enterprises. Such food enterprises would help facilitate increased demand for agricultural produce and thereby expand the market and incomes of farmers.

Through indigenous food processing operations:

- Components of some crops which are more useful for nourishing the body are extracted. The extraction of sugar from sugarcane is a typical example of this.

- Toxic components in some raw materials are broken down to make the food free from the toxic factors and safe for human consumption. For example, a cyanide-containing glycoside is found in fresh cassava tubers. This compound which can produce extremely toxic hydrogen cyanide is present in cassava tubers at varying levels depending on the variety. Various studies have shown that the toxic glycoside of cassava is reduced to safer levels during traditional processing. In West Africa, cassava processing into 'gari' involves grating of the peeled tuber which breaks up the internal cells into a mash and release enzymes in the tuber which in turn breaks down the cyanogenic glycoside complex. This results in the release of hydrogen cyanide, a gaseous compound which escapes form the product. Further release of the gaseous toxin occurs during the fermentation and subsequent roasting stages.

- Food crops, fishery and livestock products are transformed into a form with desired organoleptic qualities such as taste and texture. The conversion of various types of cereals into different types of stiff porridges and flat breads which serve as staple dishes in various parts of Africa such as the conversion of millet into 'couscous', a rice-like product in Senegal; the flat bread 'kisra' prepared from fermented sorghum dough in the Sudan; 'kenkey' a steamed dumpling-like dish prepared from fermented maize dough in Ghana; 'ogi' a stiff porridge

made from fermented maize in Nigeri, 'injera' a spongy flat bread made from fermented teff dough in Ethiopia are examples.

- Through indigenous food processing, certain food crops in a very complex indigestible form are transformed into simpler digestible forms. Complex, indigestible carbohydrates, such as oligosaccharides and complex protein forms are broken down into simpler digestible forms when locust beans are boiled and fermented into 'dawadawa', a natural flavour enhancer and condiment popularly used in the semiarid zones of West Africa. In their unfermented state, locust beans are not used as food.

3. CHARACTERISTICS OF INDIGENOUS FOOD PROCESSING OPERATIONS

In most parts of sub-Saharan Africa, indigenous food processing operations are predominantly managed by women. Various studies have shown that such women have little or no education. In spite of this, there exists a wealth of indigenous knowledge of the crops, fishery and livestock products that they handle and the technologies they use to process these raw materials. Such technologies are carefully selected on the basis of the set of conditions under which they operate, namely the social, economic, political, technological and ecological environment.

Indigenous technologies are dependent on local agricultural produce and can therefore be found mostly in the rural areas in close proximity to the source raw materials. In operations that handle perishable commodities, this is advantageous in terms of having ready access to the raw material before deterioration sets in. Transportation costs are sometimes eliminated when the processing operation is located within the production area.

Markets for indigenous products are usually in the local areas where processing is done. However, products with longer shelf-life such as vegetable oil and rice, find their way to local urban and export markets through itinerant marketing agents.

Indigenous food technologies are micro/small/medium-scale in capacity, ranging from household level operations to small/medium commercial operations. Operations are mostly manual with high labour requirement. Family labour, made up of children and relatives, is usually used. Labour productivity is low as a result of inappropriate management of manpower. In rare cases where labour is fairly well managed, efficient use of manpower is achieved in terms of unit output per labour requirement.

Indigenous food technologies are generally rudimentary, easy to operate and low-cost. They usually give inconsistent product quality. The yield or output per unit weight of raw material is generally low. They are associated with drudgery with other attendant health hazards such as exposure of operators to smoke heat and toxic gaseous emissions from certain product, e.g. roasting stage of gari production.

Energy use is very wasteful as a result of application of inefficient heating appliances. Very often stoves are made of three stones with openings that allow most of the heat from burning fires to escape. Fule-wood requirement per batch is very high. This contributes to extensive degradation of the environment through indiscriminate exploitation of forestry products.

Inappropriate disposal of liquid waste or effluent contributes to contamination of water bodies. In operations with high water requirement for processing, the indigenous food processing activity may be located near a water body. Under such a condition contribution to the contamination of such a water body which may serve as an important source of water for other communities down stream occurs.

Some operations are carried out under very unhygienic conditions especially in remote areas without adequate supply of water. This results in the contamination of finished precuts, sometimes with disease-causing organisms.

4. EARLIER EXPERIENCES IN TECHNOLOGY TRANSFER

In view of the significant role that food processing plays in promoting the social and economic well-being of Africa's population, several interventions have focused on introduction of equipment/machinery primarily to alleviate the drudgery associated with indigenous food processing operations. Activities that have sought to upgrade indigenous food processing in Africa have focused on mechanization of traditional processes:

- technology for cereal processing: cereal grain milling, sorghum hulling and rice milling (Whitby 1985, UNIFEM 1988, MacGarry 1990, Visser 1993);
- processing of cassava (Bruinsma *et al.* 1985, Adamu 1989, Hain 1989, UNIFEM 1989, SPORE 1991, Kwatia 1991);
- processing oil seeds such as sheanuts, sunflower seeds, oil palm, copra, groundnut (Corbett 1981, UNIFEM 1987, Hyman 1991, Ndanema 1990, Wallace Bruce 1991, Anon, 1993, Iikkaraca and Appleton 1994);
- Fish Processing and Preservation (Kagan 1969, Maembe 1982, Brownwell 1983, UNIFEM 1988, Nerquaye-Tetteh 1999).

Results of project evaluation of some of these interventions have shown that in most of these technology transfer projects which failed, due consideration was not given to the need to ensure that improved machinery or techniques were fully integrated into the production systems of the users. Management of the introduced technology as an integral part of the whole production process was not well planned.

Differences of the class, race, ethnicity, religion and gender also rendered experiences of the technical experts completely different from those of the target group who were mostly among the rural poor in Africa. Production systems in which target groups operate are complex and need to be well understood in order to guide technical experts to make informed choices of appropriate technical solutions. In these earlier interventions, the target groups' priorities and objectives were often at variance with those of the technical experts. (Andah and Schoemaker 1996, Iikkaracan and Appleton,

1994). Labour patterns in rural Africa were not taken into consideration in fixing times of operation of these facilities, most of which operated as service mills. Little or no provision was made for the maintenance and sustainable management of these facilities.

5. UPGRADING OF INDIGENOUS TECHNOLOGY

All aspects of food must be understood scientifically to facilitate its control. Such scientific understanding of the different food crops forms the basis for developing and applying suitable or appropriate processing and preservation procedures which minimize loss of nutrients, make products safe for human consumption and prevent its spoilage. To be able to predict the post-harvest behaviour of any food commodity and to identify which food preservation principles should be applied, it is essential to have knowledge on its physiology, physical and chemical composition.

Scientific investigations into indigenous food processing helps to provide useful information on physical, biochemical, nutritional, microbiological and organoleptic changes that the raw material undergoes while being transformed into the finished product. With this knowledge, critical stages that relate to product quality and consumer preference as well as parameters for controlling these stages are identified and used to determine conditions under which the processes could be optimized.

The objective of upgrading an indigenous system should be to achieve a process control system, a sanitary and hygiene system as well as a system for achieving technical efficiency in terms of time, energy, labour and material use while focusing on improved product quality. An improved indigenous technology is the result of the combination of modern technological practices and traditional food processing practices. The traditional character of the final product may be maintained, modified and changed depending on the target market for the final product.

Upgrading of indigenous technology helps to diversify the type of products that could be derived from food commodities through the

development of new or novel food products. New product development also helps to substitute existing ingredients with more cost-effective and readily available ones. This may lead to import substitution and foreign-exchange savings.

It also helps to respond to new values, changing habits and tastes of consumers. Increasing rate of urbanization and a trend for men and women to work some distance away from home is leading to consumer demand for 'convenience', ready-to-eat foods. Demand for such time-saving foods is on the increase in the region and other parts of the world. With high and increasing levels of literacy in the developed and developing worlds respectively, coupled with abundance of information on food-related health issues, consumer knowledge on healthy eating habits is growing at a fast rate. Consumer preferences are therefore shifting in favour of natural foods with little or no chemical additives and preservatives. Processed foods from various parts of Africa are responding to this demand.

6. CASE STUDY 1: EXPERIENCES ON THE DEVELOPMENT OF TCHORKOR FISH SMOKER (NERQUAYE-TETTEH, 1999)

In Ghana fish constitutes 70 percent of total animal protein intake. The high moisture content of fish makes it highly perishable especially in the high ambient temperatures of the tropics where spoilage is estimated to set in within 12-20 hours of harvesting depending on the species and the method of catch.

Traditional methods that are used for the processing and preservation of fish include smoking, drying, salting, frying and fermentation (Okraku-Offei 1970; Nerquaye-Tetteh, 1989). In Ghana, more fish is consumed in the smoked form.

To overcome the shortcomings associated with the traditional methods of smoking, different models of improved ovens were developed in various parts of Africa (Anon, 1971, Maembe 1982 and Wood and Tariq 1990)

These earlier 'improved ovens' were found too expensive and therefore unaffordable, had a lot of inconveniences associated with their operation, had higher labour requirement without adequate returns on additional labour input, were technically inefficient with uneven heat and smoke distribution as well as poor product quality.

6.1 Participatory Needs Assessment

To initiate the development of an improved fish smoking oven, a study was conducted at the national level to assess available methods and equipment in use for the smoking of fish, the types of products, the people involved in fish smoking in Ghana, and the marketing of the products. A number of problems were identified through visits, observation and interactive discussions with fish smokers. Problems associated with the use of existing ovens were identified and prioritized during these visits.

Designs of traditional ovens that were identified in the study include the cylindrical mud oven, the cylindrical metal or oil drum oven, the rectangular mud oven and the rectangular or square metal oven.

Problems associated with existing ovens which were identified using the national survey were (Kagan 1969):

1. The ovens need constant attention to control the fire and to turn the fish.
2. Smokers suffer discomfort from the heat and smoke from the oven.
3. Loss of heat from the oven is high, resulting in poor fuel conservation. Fuelwood requirement for smoking a batch is therefore high.
4. There is uneven heat and smoke distribution.

5. The construction material, especially the metallic ones, has a short durability due to corrosion from contact with sea water.
6. The design of the ovens left the fish exposed to attacks from household animals and other spoilage agents in the atmosphere.
7. The finished product, smoked fish, has inconsistent quality. Physical losses were sometimes incurred as a result of charring of the fish.

Next, a fishing village near Accra called Chorkor where fish smoking is a major economic activity was selected as a pilot study area. Together with the fish smokers, an already existing smoking oven which had the potential to alleviate problems associated with the activity, the rectangular mud oven, was selected for improvement.

Using information from smokers, the Chorkor Smoker was designed and constructed at the pilot site. The oven has a combustion chamber where heat and smoke are generated using fuelwood and a smoking unit made up of a set of 5-15 trays each with wire mesh at the bottom and a wooden frame. Construction material originally selected for the combustion chamber is mud which is readily available in Ghana.

6.2 Feed Back

The fish smokers on whose premises the prototype smoker was located, gave the following feed-back to the team of scientists, after they had used the smoker for a few months:

1. The tedium and discomfort associated with the use of traditional ovens was reduced.
2. The volume of fish that could be smoked at a time with the same number of labour, was increased four fold.
3. Heat and smoke circulation in the smoking chamber made up of the stacked trays was improved. This contributed to more efficient use of fuelwood and reduction in processing period by 60 percent.

4. A better quality smoked fish in terms of uniformity of colour, the physical state of the fish and taste properties was obtained.

The Chorkor smoker reduces to a significantly low level most of the problems associated with traditional ovens and with some improved ones.

To facilitate the use of the technology within the community, so as to satisfy other fish smokers who had expressed the desire to have access to the technology, Freedom From Hunger Campaign provided funding from 1969 to 1971.

6.3 Techno-Economic Analysis

A techno-economic study conducted on the Chorkor smoker in comparison with other improved ovens and existing traditional ovens, found the Chorkor smoker superior in terms of cost, capacity, ease of operation, product quality, fuel efficiency and labour productivity (Stroud, 1986).

6.4 Training and Extension

In the extension of this technology, a multidisciplinary approach, which required inter-institutional collaboration, was adopted in addition to the use of participatory approach among stakeholders involved in the extension work and with various target groups who have benefited from this technology.

Capacity building through training of extension agents was the main strategy used to diffuse the technology into the fishery sector under a training programme which targeted key extension agents in the fishery sector, 204 extensionists from public and Non-governmental Organizations (NGOs) in 12 African countries have been given training on the Chorkor Smoking Technology at the Food Research Institute, Ghana. Participants were from Ghana, Nigeria, Sierra Leone, The Gambia, Cameroon, Kenya, Tanzania, Uganda, Zambia, Ethiopia, Eritrea and Lesotho. To facilitate the training, tools such as an illustrated manual on the construction of the oven was prepared with support

from UNICEF as well as a video cassette on "Improved Fish Smoking in the Tropics" with support from FAO.

6.5 Field Demonstration

Field Demonstration of the technology formed an important feature in the training of extension agents. Pilot villages were selected where some progressive fish smokers were identified as partners. In each pilot village the premises of a few selected fish smokers were used to conduct demonstrations of the construction and use of the smoker. As part of the training activities, local artisans in the pilot demonstration villages were also taught how to construct and maintain the smoking oven.

A number of projects with women as the target group and poverty alleviation as their theme has selected this technology and transferred it to several communities. These have included projects that were implemented in Ghana and in other African countries with funding from UNICEF, ILO, UNDP, UNESCO, FAO and the Netherlands Government. They have helped in the spread of this technology to all parts of Ghana and other African countries where smoked fish is important in the diet.

6.6 Flexibility of the Technology

Flexibility of the technology allows processors and local artisans to adapt it to suit local conditions. The capacity of the smoking oven can be doubled or halved depending on the volume of fish that is available.

The use of other materials for the construction of the combustion chamber have been observed in some fish smoking communities. These include burnt bricks and refractive bricks. These materials are readily available in places where they are used by fish smokers with higher economic status and bigger markets. The use of other sources of fuel such as LP gas is being explored in on-going projects of the Food Research Institute, Ghana. The objective is to make the technology more environmentally friendly by reducing

dependence on woodfuel as a source of energy for heating the combustion chamber.

6.7 Market Approach

Results of impact assessment studies conducted in project pilot demonstration villages have shown that it is important to integrate transfer of technology with enterprise development concerns. Upgrading of the technology used by an enterprise requires investment in the improved technology. Willingness of entrepreneurs to invest in improved technology should be influenced by market expectations and external consumer demands.

To improve the performance of rural based micro-scale enterprises engaged in food processing, the use of appropriate technology as an instrument for employment creation and income-generation should have a business approach. Characteristics of products with potential for sale on external markets should be identified and these should influence the choice of technology. Product quality and type should match demand of consumers on external markets, such as urban and foreign markets.

6.8 Access to Credit

To enhance access to credit facilities, fish smokers in some pilot communities were assisted to constitute themselves into groups. Appropriate training on group management, record keeping, management of loans, leadership skills and business planning was given to the groups. With this done, groups were linked to savings and credit schemes in rural banks. Pre-financing of some fish smokers by exporters is also assisting in attracting working capital to cope with increased production.

6.9 Specific Impact

1. In most parts of Ghana and other parts of Africa where the Chorkor Fish Smoking Technology has been adopted, markets for smoked fish have expanded beyond national borders.

2. Production cost in fish smoking has reduced as a result of the efficiency of the technology and resource requirements.
3. Smoked fish has a higher market value.
4. Incomes of fish smokers have increased by at least 30 percent.

7. CASE STUDY 2: MECHANISATION OF SHEA-BUTTER EXTRACTION (Wallace-Bruce, 1991, in UNIFEM, 1994)

This case study illustrates participatory technology development approach where technologists listen to, work together with, and build on the knowledge of women in developing an efficient technology.

Shea butter is widely used in Ghana as the only traditional cooking oil, which is also used as an ointment and cosmetic. It is also exported to industrialized countries where butter is used as a substitute for cocoa butter, and in the pharmaceutical and cosmetic industries. The shea-nut tree (Butyrosperum parkii) grows wild in the savanna regions of Western and Central Africa in a belt about 5000km long and 600km wide, stretching from Gambia to Southern Sudan. Women in these areas use variations of a traditional extraction technology, which achieves a very high oil extraction rate. In Ghana, women from the Dagomba tribe in the Northern Region are said to have the most advanced traditional technology, which provides an efficient extraction rate of around eighty-three per cent to produce shea butter of high quality. The process is nevertheless very time-consuming and labour-intensive. The collection of the shea fruits and their processing into butter is exclusively a woman's job in Northern Ghana and one of the main sources of income for women.

7.1 The Traditional Process

The traditional process of shea butter production involves the following stages: collection of fruits; boiling of fruits to remove the flesh; drying of fruits; shelling of nuts; drying and storage of kernels. When processing has to be done the stored nuts are used. The kernels are crushed and roasted, ground into a paste which is then kneaded by hand with addition of water to separate the fat

to the top. The fatty component is removed by scooping with hand, into a separate container, clarified and crystallized. Kneading is the most crucial step which determines the yield of the final product. Its successful execution depends on the recognition of changes in appearance, colour, viscosity and temperature of the kneaded mass, possible only for the well-trained and experienced eye to see.

In the clarification and crystallization phase, the washed cream is heated in a big pot. The clear oil that is formed is collected with a ladle into a smaller pot. Scum floating on top of the oil is discarded. The clarified oil is poured into clean, enameled basins and left to cool overnight. In the morning, the oil starts to crystallize or solidify, sometimes after seeding with a small lump of shea butter from a previous batch. The mass is stirred at hourly intervals with a wooden spoon until the oil has been transformed into a warm, thick but fluid state. The shea butter is then transferred into calabashes. This is covered with a piece of cloth and stored until it is taken to the market.

7.2 Modifications to the Traditional Processing Technology

The first attempt at the mechanization of the shea butter production process came from the women themselves. They adapted the corn mill, which was introduced to Ghana thirty-two years ago at the time of independence, for the grinding of roasted shea nuts. The crushing, removing of kernels and kneading activities were still done by hand. The second attempt, supported by the National Council of Women in Development (NCWD), was the introduction of the Mali oil extractor to the Dagomba women who abandoned it after a few trials. They felt that this extractor did not give them enough fat as compared to the traditional method. The quality of the final product was found inferior to the fat from traditional processors.

The NCWD, this time together with two international development agencies, intervened using a different approach. This time, instead of attempting to import a machine designed elsewhere, like the Mali Oil Extractor, they employed a local engineering enterprise to produce machines to substitute

the traditional manual processes. Machines to mill, crack and crush the nuts were developed and proved acceptable, but the kneading machine was abandoned by most women after a few trials. These women were not consulted over the design of this machine. The next attempt to produce a kneading machine was based on full co-operation with the women shea butter producers. The extension workers from a local technology centre acted as communicators between the engineers and the women producers. The project team initially studied in depth the traditional method of production, particularly the kneading stage, in the village. Initial traits with the women shea butter producers had shown that the traditional extraction method had an efficiency of around eighty-three per cent yield which compared favourably with present day industrial technology. This convinced the project team further that the traditional technology, which the women had developed over centuries through trial and error, was an efficient one that produced high quality and higher yield of butter. Further improvements were needed to make the process less time- and energy-consuming for women.

The traditional method of kneading involves dipping the hand into the paste and stirring vigorously. While stirring with the hand, women can tell what to do next by the temperature and feel of the mass on their hand. When the paste is thick and difficult to stir, hot water needs to be added. When the paste is slippery, it means that the fat is melting, so cold water needs to be added. The addition of hot or cold water at particular times is an important component of the production process, which determines the quality of the final product and the efficiency of the extraction rate.

When the project staff had gone into the village and worked with the women, they learned that the first kneading machine had been rejected because it simply stirred rather than kneaded. Acting as communicators between the women producers and the technologists, the project staff recommended the contracted engineer to design a more efficient baffle-impeller arrangement in the kneader along the guidelines provided by the women.

The best results obtained from the nine trials to establish the best possible performance of kneading machine gave an extraction rate slightly lower than the manual process but a reduction of about sixty-six per cent in the working time. There are still some shortcomings of the kneading machine, but the established dialogue between the women and the designers, where the latter are instructed by the former, is expected to lead eventually to an acceptable kneading machine.

7.3 Two Technologists with Different Attitudes, Two Rates of Success

Throughout the course of several attempts at the mechanization of shea butter production under different schemes, the producers in pilot villages have been exposed to different technologists using different methodologies, and achieving different rates of success with oil extraction. Women producers in one of the pilot villages tell the following story to illustrate how the attitude of an outsider can make all the difference in women's willingness to co-operate, and consequently the success of the project:

> "First, the technologist from town X arrived to study our traditional method of shea butter production and explore the potential for achieving better efficiency rates. As we were going through the various stages, he would time the processes such as kneading, when to add water, and so on, look at his watch, tell us to stop, or to continue on without listening to whether we thought it as the right time to do these things. The few times we tried to express our opinions, he would not hear them. So eventually, we just gave up, and got on with what he instructed us just for his own satisfaction. We knew that the amount of oil extracted at the end was going to be low because he was making us do all sorts of wrong things".

"After a few months, a second technologist came into the village. The way he worked with us was very different from the first one. At every stage of production, he would enquire why we were doing things the way we were, and really listen. Once we felt that he had an ear to lend us, we started to listen to him as well. Eventually we got a much larger amount of oil from that trial. So if you want to get your message across to the people who are involved in such work, it is simple: just tell them to listen!"

8. BEST PRACTICES – NEEDS ASSESSMENT

8.1 Indigenous Knowledge

The conventional approach to collection of information uses questionnaire surveys to penetrate quantitative data which is analyzed statistically. Experience has shown that valuable information which cannot be accommodated in the questionnaire is usually unprocessed and ignored (Nabasa *et al.*, 1995).

Much of earlier development strategies which used surveys were based on top-down approach in which experts considered themselves to have superior knowledge and therefore went to target groups with questionnaires which presumed that the technical experts already had answers to the target groups' problems. The failure of most development efforts has prompted rethinking and reorientation of the process of development. In a recent expert consultation on technology assessment and transfer for sustainable development, food security and poverty alleviation in sub-Saharan Africa, held in Accra, one of the important conclusions stressed the need for participatory approach to ensure that vital local knowledge is recognized and tapped in development. Local people should be recognized as managers knowledgeable about local resources, the environment and their operations. Consensus building through group participatory approach should be adopted as the strategy for assisting with development (FAO, 1998). Indigenous knowledge provides a conceptual framework through which people understand their physical world and on which they base their choices.

Analysis of case studies of community development projects showed that a common characteristic responsible for their success was that the projects identified and met peoples' perceived needs. The integration of needs and wants analysis with development work represents a challenge for selection and application of appropriate technology, as does the use of traditional or indigenous knowledge (Chambers, 1988). Indigenous knowledge is seen as having the effect of complementing science-based knowledge in finding solutions to development problems.

8.2 Participatory Approach: Needs Assessment and Technology Development

Experience from successful Research and Development organizations shows that there has to be constant forward and backward flow of information between key players in the process of technology development so as to achieve a balance between 'science-push and demand-pull'. There is need for close interaction between all persons concerned with decision making in technology development, extension and diffusion (Andah and Shoemaker, 1994). A participatory approach that requires the active involvement of all stakeholders, with the target group at the centre, facilitates the selection of appropriate choices and contributes to eventual success of the project.

8.3 Tools in Participatory Needs Assessment

Recent strategies which have adopted a more participatory approach use a set of techniques individually or in different combinations depending on the situation being assessed. Among techniques used are:

1. Semi-structured interviews;
2. Visits and informal discussions;
3. Direct observations of target group engaged in target activity;
4. Group discussions;
5. Community level fora;
6. Stakeholders meetings; and
7. Participatory Rural Appraisal which combines some of the different techniques mentioned earlier and also reviews existing general socio-economic and production information and literature on target group and its environment (Nabasa et al, 1995).

8.4 Gender Analysis

It has also been demonstrated world-wide that lack of participatory approach contributed to absence of gender analysis in the planning of earlier

developmental projects. Gender analysis is defined as a systematic effort, through the use of suitable techniques, to understand, document qualitative and quantitative information on the separate roles and responsibilities of men and women, and how they interrelate in a given social, political, economic and ecological environment. Gender analysis helps:

1. To dis-aggregate data and statistics which form the basis for formulating and implementation of development programmes;
2. To assess the appropriateness of technologies, technical information and messages to men and/or women;
3. To predict the impact of project incentives on the distribution of benefits to men and women;
4. To link the projects expected impact to possible changes in the role and status of women; and
5. To ensure the establishment of reliable feedback mechanisms from both men and women (Andah and Schoemaker, 1994).

The involvement of stakeholders creates a sense of ownership of the planned project which in turn provides the basis for commitment to the project and its activities. It also gives them the opportunity to contribute to planning and implementation of projects. It allows the scientists and engineers to combine their knowledge and methods with those of the other stakeholders.

9. BEST PRACTICES IN APPROPRIATE TECHNOLOGY DEVELOPMENT

From the results of participatory needs assessment and the prioritized needs, alternative technological designs are assessed and choices made on the basis of target groups socio-economic and bio-physical environment.

9.1 Factors for the Success of Technology Design and Transfer

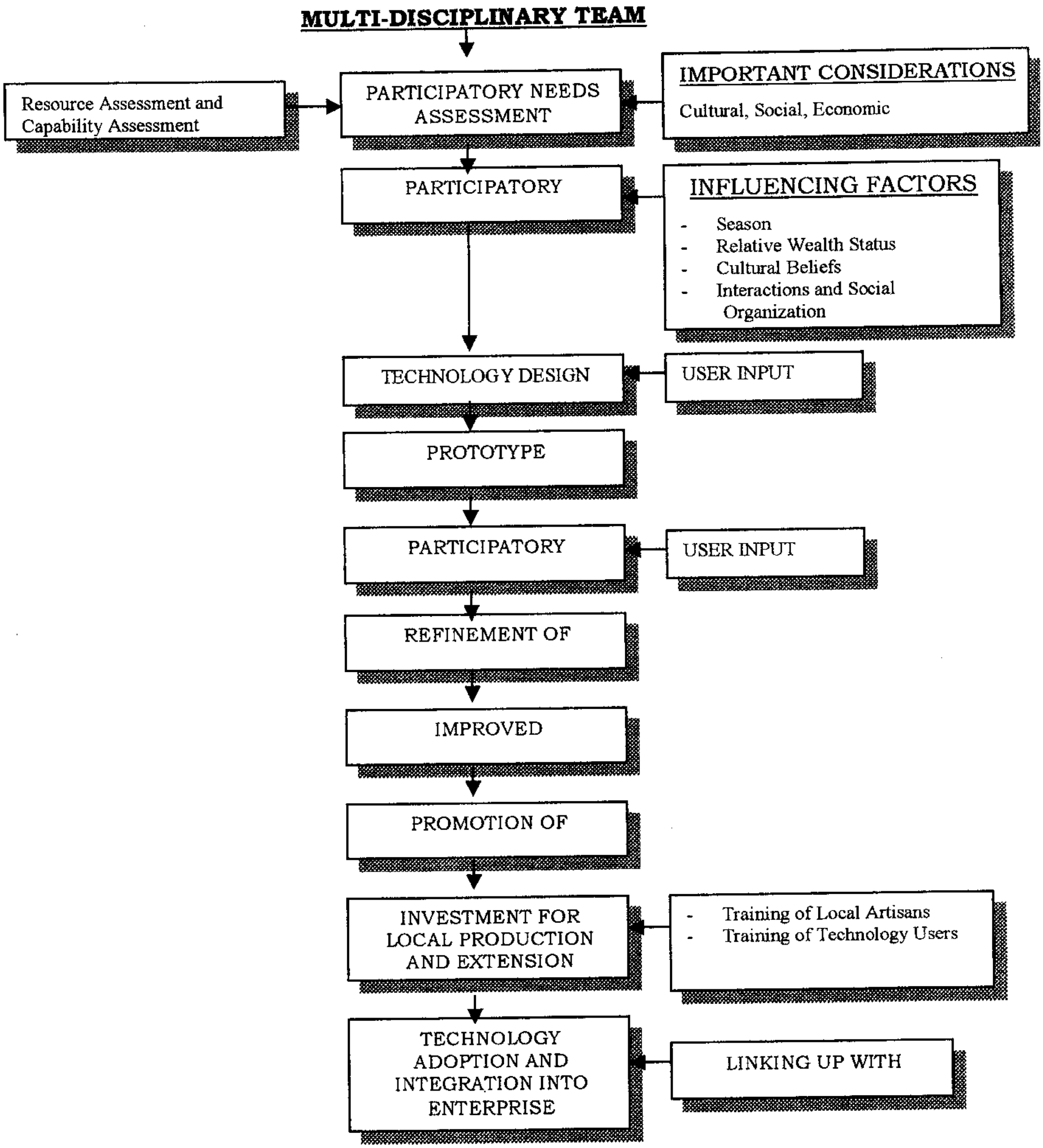
1. An approach which is adapted to local conditions, conforms to local norms and uses familiar labour patterns is preferred.
2. Technical knowledge of the characteristics of the food raw material to be processed helps to design suitable equipment for its processing. In the

development of a mechanical dehuller for locust beans in Ghana, the engineers had to work closely with food scientists on the project, to identify the physical and chemical characteristic of the beans. Taking into consideration the very hard and thick seed coat, the conformation of the seeds, as well as other characteristics, an appropriate machinery was developed.

3. The use of locally available raw materials, coupled with local skills for the design and fabrication of equipment and machinery have proved to be essential for sustainability (Andah and Schoemaker, 1994).
4. Capacities of technologies should match resource base. Experiences in Africa and other developing countries in which there have been mis-match of limited resources and excess capacities of technologies have resulted in low capacity utilization and poor returns on investment. A capacity which can be managed effectively in terms of appropriateness of input requirements is desirable.
5. The possibility of the use of alternative sources of renewable energy makes a technology flexible for easy adaptability to different locations. Heating appliances in most rural based, micro scale food processing operations are inefficient in energy conservation. Best practices promote the use of energy-efficient technologies that use less resources and create less environmental degradation.
6. Upgraded technology should result in increased productivity to reduce labour and costs through faster production and lower production cost.
7. For micro-scale rural operations, preference is for simple, affordable technologies that are easy to handle, repair and maintain locally (Olorunipa, 1993).
8. Some past experiences in technology transfer that aimed at alleviating the drudgery associated with small-scale food processing operations failed, because the technologies were not technically efficient. There were records of technologies with high input requirements, low yields or outputs and poorer quality food products in comparison with existing technologies that they sought to upgrade. In addition, some of these technologies contributed to very serious environmental degradation.

9. The socio-economic feasibility of a technology coupled with the technical feasibility are the two key indicators that dictate whether it is worthwhile to use a technology or not. It should be noted that these two analysis need to be carried out under the local conditions where the technology is to be used to ensure applicability of the results.

FRAMEWORK FOR DEVELOPMENT OF APPROPRIATE FOOD PROCESSING TECHNOLOGY



10. RECOMMENDATIONS

Policies

1. Governments should provide adequate funding for research into indigenous (traditional, rural) food technology so as to provide information on scientific principles upon which improvements could be made for upgrading of technologies.

2. There is need for African governments to formulate development policies and strategies to create enabling environment that focuses on enhancing technology-led, market-oriented enterprise development of micro and small-scale food processing operations. Such policies should provide incentives which should include exemptions from payment of duty on imported equipment and machinery, tax holidays, low interest rates on loans through special savings and credit schemes and strengthening of support institutions to provide effective assistance to the sub sector.

Technology identification and selection

3. An effective mechanism should be established to assist micro and small-scale entrepreneurs to have access to sustainable technologies that would facilitate the upgrading of traditional food processing in Africa.

   3.1. Information on relevant technology products that are available locally and elsewhere should be accessed and/or compiled. Such information should include uses of the technology, technical specifications, summaries of cost-benefit analysis, and sources of the technology to guide entrepreneurs to make informed choices.

   3.2. There needs to be a vigorous promotion of benefits to be derived from the application of sustainable technologies and dissemination of information on available technologies to users and potential users. Strategies for technology promotion must recognize the need for introducing market-oriented approach with emphasis on improving

competitiveness, product quality and presentation as well as increased productivity to assist rural processors to penetrate new markets.

3.3. Support should be provided in the identification, selection, installation, operation and maintenance of sustainable technologies.

4. Financing

Access to adequate financing for the procurement, operation and maintenance of selected sustainable technologies should be improved through the establishment of innovative savings and credit schemes tailored to suit the needs of the small-scale operators.

5. Capacity Building

5.1. Knowledge, skills and expertise within S&T institutions and technology consulting firms in the region need to be strengthened in terms of clients' needs assessment, selection of appropriate technologies and assistance in technology management. Contact with technology suppliers is weak. This will require training, industrial attachments, study tours and other forms of exposure to build capacity in provision of technical support to clients.

5.2. Local expertise should be developed for capital goods manufacture. The skills of local equipment manufacturers should be strengthened. In Africa, a number of artisans are engaged in the production of tools and machinery. These artisans who are mostly in the informal sector, as well as equipment manufacturers in the formal sector need to be trained to upgrade the quality of their products which are of sub-standard and inconsistent in quality in most cases. Facilities for the design and fabrication of capital goods should be improved in the private sector.

5.3. Intensive training of operators of indigenous technologies needs to be done as part of efforts to upgrade such technologies. Practitioners are

lacking in technology management, entrepreneurial practices and business management. Training programmes which integrate technology acquisition with enterprise development need to be promoted to upgrade indigenous food processing to improve their viability and sustainability.

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