Nutritional implications of projects giving high priority to the production of staples of low nutritive quality: The Case for Cassava (Manihot esculenta, Crantz) in the Humid Tropics of West Africa

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INTRODUCTION

Cassava (Manihot esculenta, Crantz) is emerging as a dominant staple of primary or secondary importance in many developing countries of the humid and sub-humid tropics in Africa and elsewhere. Since it can withstand drought, it is sometimes a nutritionally strategic famine reserve crop in areas of unreliable rainfall. This paper reviews reasons for the spread of, and increasing interest in, cassava, the possible cyanide toxicity associated with it, the nutritional problems of cassava dependency, and the need for consideration of the total food/nutrition system in the planning of interventions to ensure balanced diets or attainment of acceptable nutritional status in cassava-dependent cultures. It also emphasizes the need to ensure that cassava, which is not usually fed to young children in tropical Africa, does not replace the traditional cereal-based and more protein-rich weaning foods.

CASSAVA AS A MAJOR STAPLE IN THE WORLD AND IN WEST AFRICA IN PARTICULAR

Cassava (Manihot escutenta, Crantz), variously designated as manioc, yucca, or tapioca, is native to South America and southern and western Mexico. It was one of the first crops to be domesticated, and there is archaeological evidence that it was grown in Peru 4,000 years ago and in Mexico 2,000 years ago. Cassava is adapted to the zone within latitudes 30 north and south of the equator, at elevations of not more than 2,000 m above sea level, in temperatures ranging from 18 to 25 C, to rainfall of 50 to 5,000 mm annually, and to poor soils with a pH from 4 to 9.0 (1 - 3). Within the cassava belt are located most of the developing countries of the world. They account for only 13 per cent of the world's GDP, but have 47 per cent of the world's population and 46 per cent of the arable land.

From Mid and South America, cassava spread to other parts of the world in post-Columbian times and was introduced into the West Coast of Africa and Zaire in the late sixteenth century, probably in slave ships. It was introduced into East Africa (Madagascar and Zanzibar) via Réunion by the end of the eighteenth century, and by 1800 it had reached India. It was widely grown in Africa and Southeast Asia by the 1850s.

Importance of Cassava

Cassava is a major subsistence staple, with an annual world production estimated at over 100 million tons in 1972. This made cassava the sixth major source of staple foods in the world, amounting to 57 per cent of the tropical root and tuber production in 1972 (4,5). Cassava supplies 38.6 per cent of the caloric requirements in Africa, 11.7 per cent in Latin America, and 6.7 per cent in the Far East (3). In 1970, it was estimated that about 200 million people relied upon cassava for most of their calorie requirements. However, the number of people relying on cassava for satisfying 50 per cent or more of their calorie requirements amounted to 420 million in 1972 (3).

Although cassava is of New World origin, 40 per cent of the current world production takes place in Africa. According to FAO (6), Brazil accounts for 30 million tons annually, Zaire 10.5 million, Indonesia 10.5 million, and Nigeria 7.5 million tons. Other major producing countries that make up the bulk of the world's market supplies of cassava products are Thailand, Madagascar, Indonesia, and Benin.

In the humid and sub-humid areas of tropical Africa, cassava is either a primary staple or a secondary co-staple. About 80 per cent of Africa's cassava production, equivalent to 42 million tons in 1972, was produced in West Africa. Nigeria's production of cassava in 1977 was 10.6 million tons on 1.1 million ha. Cassava comprised about 25 per cent of all food crops consumed in Nigeria in 1968 (7). Cassava is not only used in many food preparations for human consumption, but is of importance in industries (starch, textiles, fuel, confectionery, etc.), and in animal feeds. A list of cassava products for these purposes is given in table 1.

TABLE 1. Cassava Products for Human Consumption, Livestock Feed, and Industrial Use

Major uses	Products
Human consumption	Raw cassava
	Boiled cassava
	Cooked cassava slices
	Fried cassava slices
	Cassava flakes
	Fermented cassava
	Cassava flour
	Macaroni
	Fufu
	Gaplek
	Composite flour, bread
	Tapioca
	Gari
	Cassaripo or tucupa
	Cassava rice
Livestock feed	Cassava pellets
	Cassava meal
	Cassava chips
	Cassava slices (fresh or boiled)
	Cassava peels
	Cassava-leaf meal
	Broken roots
	Cassava silage

Industrial products	Starch
	Alcohol
	Glucose
	Acetone
	Dextrins
	Glues and pastes
	Binders
	Stabilizer
	Bodying agent (caramel)
	Fillers
	Dusting agent (chewing gum)
	Single-cell protein

Reasons for the Rapid Spread of Cassava

The reasons for the rapid spread of cassava and why it is often the preferred crop in parts of West Africa include the following.

a. It adapts to poor soils on which most other crops fail.
b. It resists drought, except at planting time, and it resists locust damage, making it a good famine crop.
c. Cassava is very easily propagated by stem cuttings that, unlike the case with yams, are not used for food.
d. Cassava is a relatively high yielder and an excellent source of calories. It can produce more carbohydrate per unit area than is provided by other staples. According to DeVries (8), its potential yield may reach 75 tons/ha and up to 250,000 calories/ha/day.
e. Cassava is relatively inexpensive to produce and (i) requires very little weeding when planted in optimal plant populations; (ii) has no critical planting date, provided there is enough moisture at planting; and (iii) its roots can be left stored in the ground and harvested when required.

Despite these obvious advantages, cassava remained for some time a neglected crop in agricultural research and development activities to an extent not commensurate with its importance as food. However, some developments within the past 15 years have enhanced interest in the crop and research priority has been given to research on its improvement, increased production, and utilization.

First, the International Society for Tropical Root and Tuber Crops was founded in 1967 to encourage research, increased production, and utilization and exchange of information on tropical root and tuber crops, including cassava, yams, sweet potatoes, and aroids. Second, among the International Agricultural Research Networks are two institutes (International Centre for Tropical Agriculture - IITA- in Nigeria, and the International Centre for Tropical Agriculture- CIAT- in Colombia) that have programmes giving high priority to research on the improvement, production systems, storage, and utilization of cassava, and other related training.

Cassava in Tropical Africa

Since its introduction into West Africa in the sixteenth century, cassava has spread rapidly to various parts of Africa, where it is grown alone in sequence or in different inter-cropping systems with other staples Cassava is now an important staple in southern Nigeria, parts of Ghana, the Ivory Coast, Sierra Leone, Liberia, Guinea, Senegal, the United Republic of Cameroon, Gabon, Zaire, the Central African Republic, Madagascar, Tanzania, Uganda, the southern Sudan, Angola, Mozambique, and Kenya (fig. 1) (9). In countries such as Sierra Leone and Zaire, cassava leaves are popular leaf vegetables. A more detailed account of the importance and production of cassava in tropical Africa is presented in Jones (10).

FIG. 1. Areas of Cassava Production in Tropical Africa (Adapted from ref. 9)

NUTRITIONAL VALUE OF CASSAVA

Cassava is a starchy staple whose roots are very rich in carbohydrates, a major source of energy. In fact, the cassava plant is the highest producer of carbohydrates among crop plants with perhaps the exception of sugarcane. It has been reported that cassava can produce 250 x 10^3 calories/ha/day compared to 176 x 10^3 for rice, 110 x 10^3 for wheat, 200 x 10^3 for maize, and 114 x 10^3 for sorghum (3,11 - 13). The chemical composition of cassava varies in different parts of the plant, and according to variety, location, age, method of analysis, and environmental conditions (table 2).

Although cassava roots are rich in calories, they are grossly deficient in proteins, fat, and some of the minerals and vitamins. Consequently, cassava is of lower nutritional value than are cereals, legumes, and even some other root and tuber crops such as yams (table 3; 14,15). The cassava root contains carbohydrates, 64 to 72 per cent of which is made up of starch, mainly in the form of amylose and amylopectin. About 17 per cent sucrose is found in sweet varieties, and small quantities of fructose and dextrose have been reported (14). The lipid content of cassava is only 0.5 per cent. Cassava is poor in proteins (1 to 2 per cent), and the aminoacid profile of the cassava root is very low in some essential amino acids, particularly lysine, methionine, and tryptophan. The peel of cassava roots contains slightly more protein than is found in the flesh. Therefore, peeling results in loss of part of the valuable protein component of the root. However, fermentation of the roots results in protein enrichment by a factor of some 6 to 8 (14). Cassava is reasonably rich in calcium and vitamin C, but the thiamine, riboflavin, and niacin contents are not as high. Large proportions of these nutrients have been reported to be lost during processing. All of this should be taken into account in cassava-processing in order to retain as much as possible of these nutrients.

Cassava leaves are much richer in proteins than the roots are. Although the leaves contain far less methionine than the roots, the levels of all other essential amino acids exceed the FAO's recommended reference protein intake. For this reason, cassava-leaf protein is claimed to be superior to soybean protein. Supplementation of Cassava products such as leaf-meal with methionine or any other of the nutrients it lacks serves to improve its biological value significantly and has been widely practiced in industry for the processing of food for human consumption and animal feeds (16).

TABLE 2. Average Chemical Composition of Cassava on a Per Cent Dry Matter Basis

	Dry matter %	Crude protein %	True protein %	EE %	Crude fibre %	NFE %	Total ash %	Silica-free ash %
Bitter cassava								
root unpeeled	31.94	2.71	1.68	0.53	3.09	91.01	2.66	2.41
root peeled	28.50	2.58	2.58	0.46	0.43	94.12	2.41	2.29
peel only	27.94	4.29	4.59	1.18	20.97	66.63	5.93	4.60
Sweet cassava								
unpeeled	31.94	2.38	1.30	0.65	1.95	92.13	2.89	2.73
peel only	28.50	1.66	1.66	0.65	1.60	90.86	5.23	4.96
Sweet cassava	27.94	5.61	2.37	1.39	10.31	78.25	4.44	3.83
Cassava leaves	25.60	14.69	13.76	8.39	15.63	45.22	16.07	7.87
Gari	86.47	1.20	1.02	0.38	2.31	94.03	2.08	0.92

Source: V.A. Oyenaga, personal communication.

TABLE 3. Average Nutrient Composition (per 100 gm Edible Portion) of Cassava Compared to That of Some Staple Food Crops Found in West Africa

	Unit	Potatoes	Sweet potatoes	Fresh cassava	Yams	Taro	Maize
Food energy	calories	82	117	146	105	104	363
Water	gms	78	70	62.5	72.4	72.5	12
Carbohydrate	gms	18.9	27.3	34.7	24.1	24.2	71
Protein	gms	2.0	1.3	1.2	2.4	1.9	10.0
Fat	gms	0.1	0.4	0.3	0.2	0.2	4.5
Calcium	mgs	8	34	33	22	23	12
Iron	mgs	0.7	1.0	0.7	0.8	1.1	2.5
Vitamin A	I.U.	tr	500	tr	tr	tr	tr
Thiamine, B1	mgs	0.10	0.10	0.06	0.09	0.15	0.35
Riboflavin, B2	mgs	0.03	0.05	0.03	0.03	0.03	0.13
Niacin	mgs	1.4	0.6	0.06	0.5	0.9	2.0
Vitamin C	mgs	10	23	36	10	5	0

Source: Refs. 14 and 15.

TABLE 4. Concentration of Cyanogenic Glucosides in Tissues of Sweet and Bitter Cultivars of Cassava (M. esculenta)

Cultivar	Tissue	Cyanogenic glucosides (mg HCN/kg fresh wt. tissue)
Sweet	Seeds	0.00
(3 varieties)	Seedlings	
	(10-day-old)	285.00
	Leaves (mature)	468.00
	Roots	126.50
	Tubers	462.00
Bitter	Seeds	7.50
(3 varieties)	Seedlings	
	(10-day-old)	245.00
	Leaves (mature)	310.00
	Roots	185.00
	Tubers	395.00

Source: Ref. 13.

CYANIDE CONTENT AND TOXICITY OF CASSAVA

Cassava contains cyanogenic glucosides in the form of linamarin (93 per cent), and to much less extent, lotaustralin (7 per cent). The amount of cyanogenic glucosides varies with the part of the plant, its age, variety, and environmental conditions such as soil, moisture, temperature, etc. (table 4) (13). Certain varieties of Cassava have long been designated as sweet or bitter, purportedly in relation to their cyanogenic glucoside content. The sweet varieties are supposed to be much lower in HCN content than the bitter varieties. However, results of chemical analysis of various parts of the cassava plant at different stages of development indicate that, at times, no significant differences exist between comparable parts of sweet and bitter varieties. Nartey (13) observed that the phelloderm of sweet varieties may contain cyanogenic glucoside, while the fleshy cortex may contain none. Also, the seeds of sweet varieties contain no HCN, though seeds of bitter ones do.

Cassava Toxicity and Nutritional Problems Associated with a High Cassava Diet

Circumstantial evidence, epidemiological studies, and laboratory studies with experimental animals have linked Cassava consumption with certain pathological conditions and diseases such as tropical ataxic neuropathy and endemic goitre (13, 17 - 24). Only a brief review of the problem will be presented here.

Cassava-eating American Indians have known of toxic properties in the roots for centuries. This led to the development of methods for detoxification. Consumption of cassava and other foodstuffs high in cyanide can cause acute cyanide poisoning and death in man and other animals. Coursey (23) has suggested the following as a rough guide to cyanide toxicity:

1. Innocuous: less than 50 mg HCN/kg of fresh, peeled root

2. Moderately poisonous: 50 - 100 mg HCN/kg of fresh, peeled root

3. Dangerously poisonous: over 100 mg HCN/kg fresh, peeled root

He also observed that, in relation to organoleptic quality, sweet-cassava products usually contain 40 to 130 ppm cyanide, non-bitter ones 30 to 180 ppm, bitter 80 to 412.5 ppm, and very bitter 280 to 490 ppm of cyanide. It is interesting to note the overlap in cyanide content among different bitter varieties of cassava.

Consumption of cassava products containing non-toxic levels of cyanide over long periods of time results in chronic cyanide toxicity and associated pathological conditions. Osuntokun (21) reported the occurrence of tropical ataxic neuropathy (TAN) consisting of lesions of the skin, mucous membranes, optic and auditory nerves, spinal cord, and peripheral nerves. Patients exhibited myelopathy, bilateral optic atrophy, bilateral hearing loss, and polyneuropathy. About 35 per cent of the patients had stomato-glossitis and motor-neurone disease, Parkinson's disease, cerebellar degeneration; psychosis and dementia were also found to be associated with the disease.

It was concluded that, although the pathological conditions in Nigerian cases of tropical ataxic neuropathy are similar to those observed elsewhere, it is not justifiable to assume that these represent clinical variants of the same disease, since, when a diet is poor, multiple nutritional deficiencies usually occur together, although one single factor may exercise overriding influence in association with others that combine to produce the final picture. TAN was observed by Osuntokun (21) to be prevalent in areas of intense cultivation of cassava, high frequency of cassava consumption, and high thiocyanate levels. The disease was rare among 1- to 10-year olds, and, although it tended to run in some families, there was no evidence to indicate it was genetically inherited. In one village, the average incidence was 3 per cent, but was 8 per cent among those 50 to 60 years old.

Goitre was observed to be 2 to 5 per cent higher among patients with TAN. Osuntokun (21) observed that certain local cassava preparations such as purupuru may contain 50 mg of cyanide per 3 kg of product compared to a lethal dose of 60 mg. Cyanide contents of other local Nigerian cassava preparations such as gari or eba and purupuru were found to be higher than in other food items in areas where TAN occurs. Similar cases have been reported in Tanzania.

Ekpechi (22) reported marked variation in incidence of endemic goitre from village to village, but no inverse relationship was observed between iodine content of drinking water and incidence of goitre. In the village of Eha Amufu, visible goitre was present in 38.2 per cent of the population, though drinking-water iodine content was 2.75 ± 0.04 mg/litre, compared to Nsukka village, where goitre incidence was 9.3 per cent and drinking-water iodine content was 0.86 ± 0.09 mg/litre. A survey revealed a high correlation between intake of dry, smoked, unfermented cassava and goitre incidence. A subsequent laboratory animal experiment in which rats were fed dry, unfermented cassava indicated that the diet had adverse effects on thyroid function- an action comparable to that of thion-amide goitrogen. Delange et al. (17) also reported endemic goitre on Idjwi Island in Lake Kivu that was not related to iodine deficiency alone. Experiments with laboratory animals confirmed that cassava in the diet interfered with iodine uptake by the thyroid.

Other conditions that may result from cassava dependency include kwashiorkor among children following weaning because of an imbalance of protein relative to calorie intake, An incidence of between 2 and 9 per cent of cases of kwashiorkor among children one to four years old has been reported by Sai in Ghana. Mere reduction of the amount of cassava consumed will only serve to aggravate the situation, since seasonal short-falls in available food supplies often reduce intake to only 70 to 80 per cent of the recommended calorie intake in parts of Nigeria and Ghana. Because there is heavy reliance on cheap, starchy staples as sources of energy, there is need in the food system for increasing the amounts of protein-rich foods such as legumes and animal proteins (meat, fish, eggs, milk, etc.).

The major problem with feeding protein-rich foods in the rural areas is that the amount available depends on incomes, and even when incomes are high, nutritional ignorance and certain food habits make it difficult for adequate nutritional status to be attained. Thus, although meat in soups used to make fufu constitutes a protein enrichment measure in the diet, local customs that deny meat to children and certain family members may result in protein malnutrition. As emphasized below, it must be recognized that there is a need to adopt a systems approach in understanding the role of the farming system in the interaction between the food/nutrition status in the population as a basis for designing effective interventions.

FOOD/NUTRITION SYSTEM OF A CASSAVA-DEPENDENT CULTURE IN SOUTHERN NIGERIA

Historical Background

According to Flores (25), climate, soil, geographical location, and cultural factors play a major role in determining to what extent a population maintains the same food consumption pattern for generations. Moreover, changes in economic status, increasing education, and the advent of technology or industrialization modify food patterns. It should also be borne in mind that dietary habits are based on foods regularly grown, raised, or gathered in the region where any group of people lives. The prevailing food patterns may later be supplemented or modified by foods imported from elsewhere, as indicated by Clark (26), who goes on to emphasize that man is an opportunist in his choice of food. These observations are very pertinent in considering the complex food/nutrition system of the cassava-dependent cultures of southern Nigeria.

Historically, the original food patterns in southern Nigeria were based on the indigenous white Guinea yam (Dioscorea rotundata) supplemented with other minor yams (D. cayenensis, D. dumetorum, and D. bulbifera). The yam culture evolved after many centuries of experimentation, culminating in the domestication of yams some three to four thousand years ago. Several methods of yam preparation were developed that rendered the yam suitable for eating alone or with supplementary food items. These methods include roasting, boiling, frying, and pounding. The complexity of yam preparation and the number of complementary food items involved in yam preparations depend on whether a meal is to be eaten as a snack or as the main meal of the day. The extent to which a given yam species contains toxic principles is also reflected in the method of preparation, especially with respect to how it is cooked and for how long. Other characteristics of the different yams also determine whether they are suitable for pounding. Moreover, the occasion for which a meal is being prepared, and the socio-economic status of the people cooking or eating the yam, influence the method and elaborateness of the preparations.

Thus, yams to be eaten as snacks are usually roasted alone or boiled and eaten with as few complementary items as necessary. These items may consist of salt, palm oil, and/or pepper. When a main meal is prepared, or if there is to be a celebration, pounded yam is the traditional dish. It usually involves different kinds of soups consisting of water, salt, and oil, leafy vegetables, some ground seeds or nuts that are usually rich in protein, and animal products in the form of meat or fish. When starchy yams are eaten with soup, the overall nutritional quality is greatly improved by the complementary food items that are sources of proteins, vitamins, fats, and minerals. Some of the condiments used help to improve the flavour and also add variety to minimize monotony.

With the introduction of Asian crops (bananas, plantains, cocoyam [Colocasia spp.], water yam, mangoes, etc.}, in about the eleventh century A.D., and subsequently American crops (maize, cocoyam [Xanthosoma spp.], cassava, sweet potato, groundnuts, etc.) in post-Columbian times, the people of southern Nigeria appear to have readily adopted the new crops and grafted them into the existing farming systems where they were suited to the humid tropics and derived Savannah zones. It would also appear that those most often adopted were the most easily prepared for eating, and in much the same manner as indigenous yams were cooked. Thus bananas, plantains, cocoyams, and cassava were usually roasted, boiled, or pounded and eaten with soup as were the local yams. The same methods used for preparation of yam snacks and main meals were used for the exotic starch staples. For more complete meals, the new foods were pounded into fufu alone, or sometimes mixed with yams.

Fig. 2. Seasonal Variation in Calorie Intake of Cassava and Yam at Uboma, Imo State, 1963/64

Cassava seems initially to have been adopted with caution because of its toxicity. Even in recent times, within living memory, there have been old men in southern Nigeria who would not eat cassava. But as methods of processing and detoxifying cassava were copied from South America, the use of cassava as a staple spread far and wide in tropical Africa. The various advantages that the cassava crop has over the indigenous yams and other staples enhanced its rapid adoption. Consequently, yam lost its dominance to cassava in southern Nigeria, even though it is the preferred crop.

In Nigeria, cassava leaves never became popular as vegetables as they did in Zaire and Sierra Leone, since the nontoxic indigenous vegetables eaten in combination with yams still remained dominant. Cassava also made inroads into the rice-based cultures west of the Bandama River and attained a status second only to rice in Sierra Leone and Liberia. Cassava accounts for 41.5 per cent of the food consumed in Ogun, Oyo, and Ondo States Former Western State), as compared to 53 per cent in Bendel State (Midwest) and 45 per cent in Anambra and Imo States (East Central). Correspondingly, all starchy staples comprised 79, 69, and 79.5 per cent, respectively, of the diet compared to corresponding figures of 7, 2.8, and 1.8 per cent for cereals.

Yam still remains an important crop as a co-staple, but its availability is more seasonal than that of cassava, which is of nutritionally strategic importance during February to July, the hungry season after cassava has been planted (fig. 2). Thus, cassava and yams interact with each other and with other constituents of the diet in a very complex manner. It is also interesting to note that cereals play a relatively more important role in the diets of the people of Ogun, Oyo, and Ondo States because a larger proportion of the area is almost Savannah or derived savannah compared to the land in Bendel, Anambra, and Imo States.

Characteristics of Cassava Dependency

Since cassava supplies the bulk of the energy intake in southern Nigeria as compared to other staples, there are several cassava-based food preparations for different periods of the day and various occasions. Cassava-based snacks include cassava products such as gari or cassava flakes sometimes eaten alone, but usually with a nut (e.g., coconut) or, as in the case of gari, with water or milk and sugar (table 5). The gari may, however, contain palm oil, which is used for colour and to enrich it with fat and vitamins during processing. The nutritional quality of the snack is relatively low because of the low protein content of both the cassava and the complementary foods eaten with it, except where dried fish is chewed with the cassava product.

TABLE 5. Cassava Products and Complementary Food Items Used in Cassava-Based Snacks

Cassava products	**Complementary food items**
Boiled, sliced cassava	Palm kernel
	Coconut
Dry cassava flakes	Palm kernel
	Coconut
	Groundnut
	Palm oil
	Lye (from palm bunch ash)
	Stock fish
	Oil-bean slices
Kpokpogari	Pal kernel
	Coconut
	Groundnut
	Palm oil
	Fish
Gari	Sugar
	Palm kernel
	Coconut
	Palm oil
	Fish
	Milk

For main meals, cassava fufu made from gari, fermented cassava, cassava flour, or just boiled cassava, forms the bulk of the meal. It may sometimes be blended with other starchy staples such as yams (table 6). The fufu is eaten with soup that contains three main groups of food items. First, there are various seeds and nuts that are usually ground up and used to thicken the soup, either by themselves or in a mixture of some starchy staples or okra (table 6). These are high in protein, fats, and other nutrients. Second, there are leafy and fruit vegetables such as African spinach and okra that are sources of minerals, vitamins, and fibre. Their nutritional value may depend on the method of preparation, age, and other factors. There are also animal products that may come from terrestrial animals (livestock or bush meat) and/or aquatics like fish and crayfish. There are miscellaneous items such as water, salt, condiments, and oil that are common ingredients used in soup preparation. The kind of animal product used in the soup usually depends on social status or income, and the occasion for which the meal is prepared. The fufu and the soup together constitute a meal of high nutritive value. Since the soup is rich in sulfur amino acids, the toxicity of any cyanide in the cassava product used for fufu may be minimized by the detoxifying effects of the sulfur amino acids in the animal products.

Cassava products are generally not very income- or price-elastic except to the extent that increased income may result in shifts toward yams or semovita (27). Cassava itself is not very price-elastic because it is one of the least expensive of the starchy staples available. This is why cassava products such as gari are very popular with the low-income groups in urban areas. Moreover, almost every farmer can afford to grow cassava.

As for the soup and the ingredients used in making it, the whole soup may be regarded to some extent as income-inelastic, because in order to eat a main cassava meal, everyone (rich or poor) must make some soup whose ingredients have varying income elasticities. Among the ingredients used in the soup, whether egusi, crayfish, fish, or meat, the kind and amount used depend on income and socioeconomic status. The subsistence farmer in rural areas must therefore produce some surpluses to sell so he can obtain money with which to buy some of the ingredients required to balance his diet. His farming systems must be efficient and diversified enough to satisfy subsistence needs as well as the need for some ready cash. Nutrition education is also important because farmers do not always readily eat what they produce, even when the body requires it. In this regard, efforts to attain increased cassava production through breeding high-yielding and adapted cassava varieties that are resistant to pests and diseases may ensure that the farmer produces the surplus required by the urban population. This constitutes a ready source of money needed by the farmer to purchase all the complementary foods necessary for maintenance of adequate nutritional status.

TABLE 6. Cassava Products and Complementary Starchy Staples and Soup Ingredients Combined in Meals of Cassava-Dependent Peoples in West Africa

	Non-cassava food items and ingredients		
Cassava products	**Starch staples used in fufu**	**Soup ingredients**	
		Leafy Vegetables	Nuts, Seeds, Oils
Fermented cassava	Yam	African spinach (Amaranthus sp.)	Groundnut (Arachis sp.)
Cassava flour	Cocoyam	Indian spinach (Basella spp.)	Melon (Colocynthis vulgaris,
Starch	Banana	Water leaf (Talinum triangulare)	Cucumeropsis vulgaris,

Gari and farina	Plantain	Bitter leaf (Vernonia amydalina)	Lagenaria siceraria)
	Maize (flour)	Celosia argentia	Cottonseed
	Rice (flour)	Jute (Corchorus olitorus)	Agbono (Irvingia spp.)
	Wheat (semolina)	Okra (Abelmochus esculenta)	Afzelia africana
		Bobmax and Ceiba spp.	Castor bean (Ricinus sp.)
		Gnetum spp.	Locust bean (Pankia
		Ipomoea spp.	clappertoniana)
		Pterocarpus spp.	Detarium spp.
		Pennisetum purpureum	Dioclea spp.
		Vitex spp.	Mucuna sloanei
		Myrianthus arborea	Brachystegia spp.
		Ceratotheca sesamoides	Palm oil and fruit
		Hibiscus cannabinus	
		Hibiscus sabdariffa	Miscellaneous Items
		Onion (Allium spp.)	Okra (Abelmochus sp.)
		Pepper (Piper gruneense)	Capsicum spp.
			Tomato (Lycopersicum sp.)
		Animal products	Cocoyam (Colocasia spp.)
		Meat (including bush meat)	Yam (Dioscorea spp.)
		Fish	Mushroom
		Snails	Salt
		Periwinkles	
		Crayfish and other aquatics	

OPPORTUNITIES FOR INTERVENTION TO IMPROVE THE NUTRITIVE VALUE OF CASSAVA

Production

There are opportunities for improvement of the nutritive value of Cassava in direct Cassava improvement and production programmer. In the latter, various methods of breeding can be used to improve the protein content, overall nutritive value of roots and leaves, and reduction of cyanogenic glucoside content. Improved and more efficient crop combinations, and sequences involving relay and other intercropping systems, offer much greater opportunity for the production of a range of co-staples and complementary crops of higher nutritive value than pure crops grown sequentially, a practice fraught with risks for small farmers.

Processing

The toxicity of Cassava roots has resulted in the development of several methods of processing that minimize the danger of cyanide poisoning (table 7). For most root and tuber crops, processing could be used to produce a range of enriched, convenient foods that not only increase nutritive quality, but also increase their elasticity of demand among urban masses and higher income groups. It is the increased mobility in our urban population that has resulted in increasing demand for gari, which is a more convenient food than fermented cassava.

TABLE 7. A Tentative Classification of Traditional Cassava Processing

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I. No special detoxification techniques applied

1.1 Totally unprocessed (i.e., eaten raw)

1.2 Simple cooking techniques only (as used for non-toxic starchy staples)

1.21 Boiling, stewing, etc.
1.22 Roasting, baking
1.23 Frying

1.3 Sun-drying

1.31 Sun-drying without subsequent processing
1.32 Sun-drying with subsequent processing

1.321, etc. Different types of milling, grinding, etc.

1.4 Kiln or hot-air drying (Subdivide as for 1.3)

II. Special detoxification techniques applied

2.1 Detoxification by solution

2.11 Soaking of whole roots or large pieces

2.111 Soaking in static water
2.112 Soaking in running water
2.113 Soaking in salt water

2.12 Soaking after comminution (Subdivide as for 2.11)

2.13 Boiling

2.131 Simple boiling
2.132 Repeated boiling, in changes of water

2.14 Wet extraction processes for starch

2.141 Starch extraction without subsequent gelatinization
2.142 Starch extraction with subsequent gelatinization

2.2 Detoxification by fermentation

2.21 Spontaneous fermentation

2.211 Fermentation followed only by washing
2.212 Fermentation followed by washing and heat treatment

2.2121 Roasting
2.2122 Steaming
2.2123 Drying in hot air

2.22 Fermentation with use of inoculum from earlier preparations (Subdivide as 2.21)

Source: Ref. 11

Marketing

Where there are adequate marketing facilities, suitable pricing arrangements, and effective farmers' organizations that can handle marketing, smallholders derive maximum incentive from farming. They are not left at the mercy of middlemen who have to perform certain functions that increase their returns from collection, distribution, and marketing at the expense of the farmer. Wholesale and retail markets are necessary for ensuring availability of foods where consumers require them.

Home Preparation and Consumption

Nutritional training is necessary to ensure that everyone recognizes the need for a balanced diet, and that losses in food quality and wastage are minimized. Knowledge of nutrition is also necessary for the elimination of superstition that may constitute a stumbling block to achievement of nutritional well-being. With good nutritional training, it is not enough to achieve a balanced diet and ensure that foods are well prepared; there is also the need to make sure that there is sufficient food of good quality properly distributed among all the individuals in different parts of the country, and within each household, according to need. It is as important to eliminate undernutrition as it is to avoid consuming more than is required.

Storage and Transportation

Storage and transportation activities are necessary to facilitate processing, distribution, and provision of food to everyone in any part of the country and throughout the year. The occurrence of mycotoxins in mouldy food constitutes a health hazard that should be avoided by proper handling and preservation. Adequate measures should be taken to minimize losses in transit and storage while maintaining quality.

CASSAVA AND SOIL FERTILITY

The cassava plant has often been label led a soil-depleting crop, but it does not remove nutrients from the soil more than do any of the common tropical crops such as sugarcane, orange trees, or maize, especially considering the high yield of the cassava plant and the fact that it is usually harvested one year or more after planting. Although it removes large quantities of potassium from the soil, the amount compares favourably with that taken out by other roots crops, sugarcane, tomatoes, and Bermuda grass grown for forage.

It should, however, be borne in mind that cassava is adapted to marginal or even impoverished soils. It is also a common practice to grow cassava last in the rotation before fallow. Consequently, the depleted condition of soils on which cassava is often grown in traditional agriculture is the result of nutrient uptake by crops other than cassava, except where several cassava crops are involved. Recent studies also indicate that cassava is associated with mycorrhiza and is able to extract phosphates from soil in which they exist in a fixed, usually unavailable form. This may partly explain the cassava plant's ability to thrive on poor soils where other crops fail.

SUMMARY

Cassava has attained the status of either dominant staple or co-staple in certain parts of the world where it contributes more than 50 per cent of the energy requirements of a bulk of the population.

The nutritional hazards of cassava dependency require careful attention. It is necessary to adopt a systems approach and study the whole, often complex, food/nutrition system so as to understand it and arrive at a more realistic appraisal of the problems of cassava-dependence

However, increasing dependence on cassava may result in gradually increasing quantities of its products being fed to young children. Replacement of more protein-rich weaning foods by cassava products should be avoided in order to safeguard young children from cassava toxicity and protein deficiency.

Increased production of cassava as part of a food system should also involve the production of complementary foods to be consumed with cassava. Alternatively, the strategy should involve farming systems that ensure enough increases in cassava production to allow the resulting profit to be used to purchase all of the food that the farmer needs.

A systems approach to the study of a cassava-dependent culture reveals many intervention opportunities in production, harvesting, processing, storage, marketing, home preparation, and transportation that can significantly minimize nutritional hazards while holding high potential for improving human welfare.

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