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## CHAPTER XII CASSAVA: Post-harvest Operations

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## 1. Introduction

Cassava (*Manihot esculenta* Crantz) is the fourth supplier of dietary energy in the tropics (after rice, sugar and maize) and the ninth world-wide. Its cultivation and processing provide household food security, income and employment opportunities for 500 million people in Africa, Asia and the Americas. The crop is tolerant of low soil fertility, drought and most pest and diseases with no critical date of harvest. These attributes have made cassava into a crop of primary importance for the food security of farmers living in fragile ecosystems and socially unstable environments. However, in communities having access to markets, cassava can become a source of income and employment for both men and women.

It is estimated that 164 million tons of cassava roots were produced in 1995 (FAOSTAT, 1997). Slightly more than half of that amount was produced in Africa, and the rest in Asia and Latin America. The major producing countries are Nigeria, Brazil, Thailand, D.R. Congo, and Indonesia, which together account for two thirds of the world production ( See Table 1).

Cassava is a staple food in tropical countries and provides more than 10 percent of the daily dietary caloric intake to about 300 million people in 15 African countries and in Paraguay (See Table 2). In the Democratic Republic of Congo, cassava is estimated to provide more than 1000 kcal/day to over 40 million people. However, in Thailand, the third world largest producer, cassava contributes less than 1 percent to the dietary calories: about 90 percent of total production are exported mainly to Europe; the remaining amount is mostly used in industrial applications.

Despite its importance, cassava is mostly grown by small farmers on small plots of land. Urban consumers and factories obtain their cassava from rural areas where it is grown. Cassava is usually processed immediately after it is taken from the ground because it is highly perishable. Spoiling starts within 48 to 72 hours after harvest.

A mature cassava root (hereafter referred to as 'root') may range in length from 15 to 100 cm and weigh 0.5 to 2.5 kg. Circular in cross-section, it is usually fattest at the proximal end and

tapers slightly towards the distal portion. It is connected to the stem by a short woody neck and ends in a tail similar to a regular fibrous root (See Figure 1).

The central pith constitutes the bulk of the root and is primarily a storage parenchyma harbouring a multitude of xylem vessels. A thin layer of cambium mainly responsible for the root expansion surrounds the storage parenchyma whose cells accumulate large starch granules. At the centre of the parenchymal tissue, the primary xylem is organised in a fibrous vascular bundle.

**Table 1. Production of cassava in Africa, Asia and the Americas, and in selected countries in 1995**

		Production (million tons)	Yield (ton/ha)	Area Harvested (thousand ha)
World		165.3	10.1	16,240
Africa		84.4	8.4	9,880
	Nigeria	31.4	10.7	2,940
	Congo, D.R.	18.0	8.3	2,100
	Ghana	6.9	13.3	520
	Tanzania	6.0	10.2	585
	Mozambique	4.2	4.2	986
	Uganda	3.0	7.5	350
	Madagascar	2.4	7.2	336
	Angola	1.7	4.1	410
	Côte d'Ivoire	1.6	5.0	610
	Cameroon	1.3	16.3	80
	Benin	1.1	8.1	141
Asia		48.5	13.3	3,634
	Thailand	18.2	14.0	1,297
	Indonesia	15.4	12.2	1,266
	India	6.0	23.5	255
	China	3.5	15.2	230
	Viet Nam	2.5	8.9	281
	Philippines	2.0	8.7	215
South America		31.4	12.5	2,512
	Brazil	25.5	12.9	1,981
	Paraguay	2.6	14.9	175

	Colombia	1.9	9.7	198
North and Central America (Mexico and the Caribbean)		1.0	5.1	198

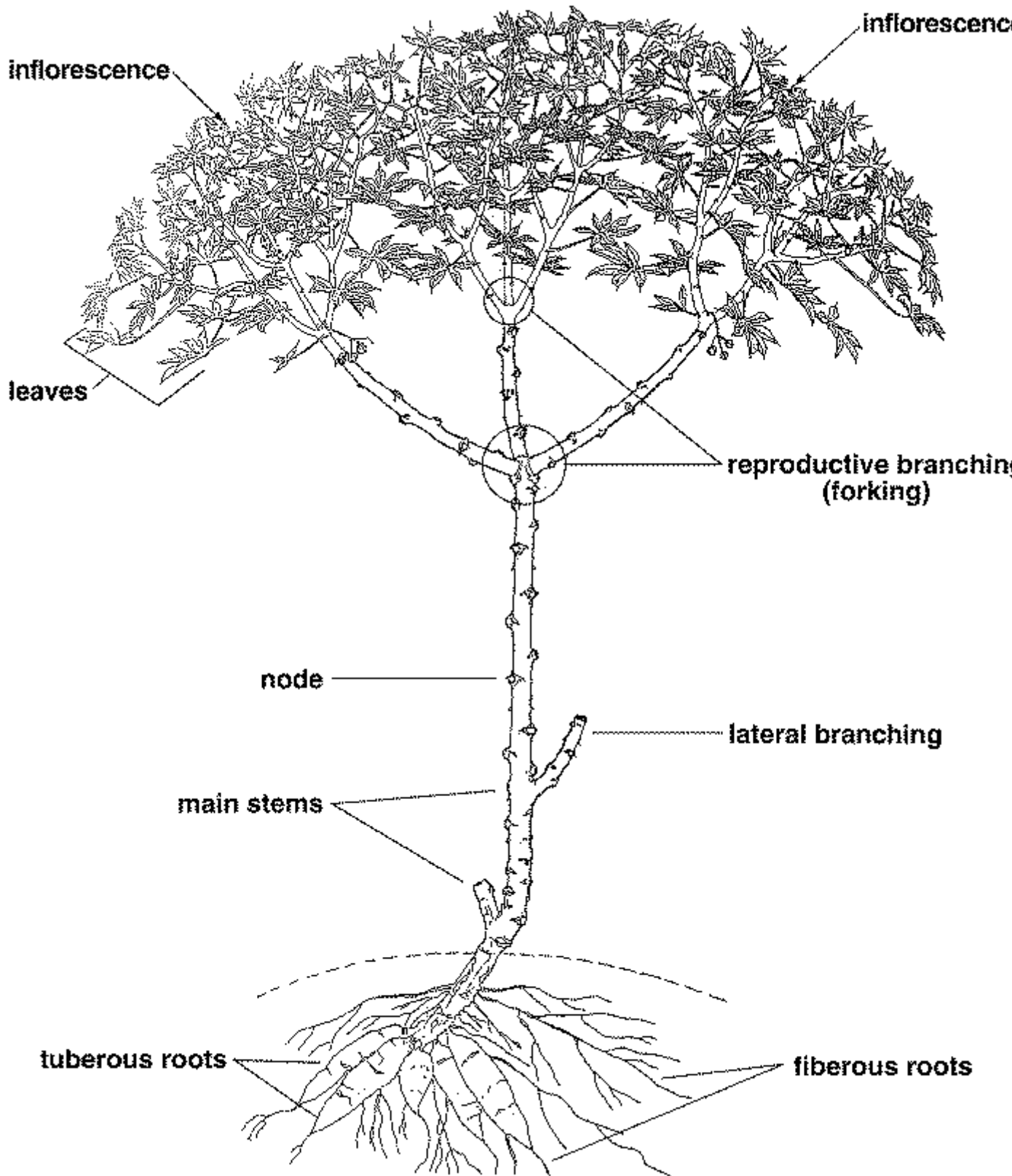
Source: FAOSTAT, 1997

**Table 2. Contribution of cassava to dietary calories in selected countries, 1992-1994**

Country	Amount per person (kcal/day)	Percentage of total dietary energy (%)	Population (million)
Congo D.R.	1099	54.1	41.241
Mozambique	608	36.1	15.121
Congo R.	726	33.2	2.443
Angola	502	28.6	10.279
Ghana	625	26.5	16.450
Central Africa R.	485	24.8	3.156
Tanzania	452	22.0	28.023
Benin	456	19.6	5.087
Madagascar	339	16.5	13.858
Togo	324	15.8	3.886
Nigeria	405	15.6	105.287
Uganda	302	14.0	19.941
Paraguay	329	13.9	4.701
Cameroon	279	12.9	12.526
Côte d'Ivoire	300	12.7	13.319
Gabon	271	11.0	1.248
Burundi	169	9.4	6.027
Guinea	204	8.7	6.308
Chad	108	5.9	6.013
Sierra Leone	107	5.7	4.298
Indonesia	127	4.9	191.676
Kenya	86	4.5	26.388
Brazil	111	4.0	156.483
Vietnam	79	3.4	71.331
Colombia	87	3.3	33.958
Fiji	85	2.8	0.758

Philippines	55	2.3	64.805
Cuba	52	2.1	10.874

*Source: FAO, 1996. Food Balance Sheets, 1992-1994.*



*Figure 1: Diagram of a cassava plant*

A transversal section of the root (See Figure 2) reveals three distinct parts: the peel, the central pith, and the vascular bundle. The peel is usually not considered suitable for human



Moisture	Protein	Fat	Carbohydrates	Fibre	Ash	
Cassava leaf	72.0	7.0 (25.0)	1.0 (3.6)	14.0 (50.0)	4.0 (14.3)	2.0 (7.1)
Amaranth leaf	84.0	4.6 (28.8)	0.2 (1.3)	7.0 (43.8)	1.8 (11.3)	2.9 (18.1)
Soybean	11.0	34.0 (38.2)	18.0 (20.2)	29.0 (32.6)	4.7 (5.3)	5.0 (5.6)
Maize (yellow)	10.0	10.0 (11.1)	4.8 (5.3)	72.0 (80.0)	2.0 (2.2)	1.2 (1.3)

Source: West *et al.*, 1988.

**Table 4. Mineral and vitamin content of 100 g of cassava leaf, amaranth leaf, soybean and yellow maize**

	Ca	Fe	$\beta$ -carotene	Thiamin	Riboflavin	Niacin	Vit. C
	(mg)	(mg)	( $\mu$ g)	(mg)	(mg)	(mg)	(mg)
Cassava leaf	300	7.6	3,000	0.25	0.60	2.4	310
Amaranth leaf	410	8.9	2,300	0.05	0.42	1.2	50
Soybean	185	6.1	28	0.71	0.25	2.0	0
Maize (yellow)	13	4.9	125	0.32	0.12	1.7	4

Source: West *et al.*, 1988.

The nutritional value of fresh foods that are actually consumed after some kind of processing is only indicative of the potential contribution of these foods to the nutrition of the consumer. The composition of prepared foods should be considered for a better evaluation of the quality of these foods. The literature is scant on this aspect, but it has been shown that most processes to which cassava is submitted in the preparation of food products lead to reductions in protein, vitamin and mineral content (Lancaster *et al.*, 1982).

Protein is reduced by 50 to 87 percent in the preparation of foodstuffs from cassava roots in Cameroon, while vitamin C, niacin and thiamine are almost entirely lost (Favier *et al.*, 1971). Riboflavin, on the other hand, has been found in higher quantities in some fermented cassava products than in fresh cassava roots, and it has been suggested that this vitamin may be synthesised during fermentation (Favier *et al.*, 1971; Watson, 1976).

Data on the loss of nutrients during the preparation of cassava leaves are even more rare. Protein is reduced as in the preparation of cassava roots. Vitamin C is reduced by more than half when the leaves are boiled for 10 minutes (Watson, 1976). The remaining concentration

of nutrients does, however, still provide a good contribution to the daily requirements (Lancaster and Brooks, 1983).

Cassava roots should be considered as merely a source of carbohydrates or calories for the diet. Their main advantage is their low cost. Thus, energy requirements can be met at a low cost and a larger proportion of the income can be devoted to other foods and/or needs. This is important on two counts: first, it makes it easier for poor populations for whom cassava is the main staple to afford other items of their diet; and second, it makes much nutritional sense since meeting one's energy requirements has been recognised as a prerequisite for a good utilisation of other elements such as proteins in the diets (FAO/WHO, 1973). It has been recently shown that cassava is a good source of energy and that it interferes very little with the digestion of added protein and fat in weaning diets (Morales and Graham, 1987). A positive effect of cassava on the metabolism of cholesterol in the rat has also been reported (Brydon, 1982). These arguments encourage the utilisation of cassava and call for more research on this crop.

## **1.2 World Trade**

The annual global supply of cassava has increased steadily at a rate of 2.3 percent per year between the 1972-74 and the 1992-94 periods (see Tables 5 and 6) to reach an additional supply of 60 million tons of fresh root equivalent per year. The increase was more pronounced in Africa which averaged a growth rate of 3.4 percent in the same period. Cassava production grew at a rate of 2.6 percent in the 1970s and of 4.2 percent in the 1980s. The main reason for this increase were insufficient alternative food supplies, demographic pressures and failure of other crops during droughts, and in some countries such as Ghana, policies intended to promote cassava and in Nigeria policies to reduce cereal imports. Between 1985 and 1995, cassava production in Ghana and in Nigeria grew at an annual rate of 11.0 percent and 8.4 percent respectively. This rapid increase was due to both expansions in area cultivated and to increases in yields due to the adoption of high-yielding varieties by cassava farmers. Growth rates were more modest in many countries, and were negatives in Mozambique, Tanzania and Uganda.

In Latin America production of cassava declined at a rate of -1.3 percent per year in the 1970s and had a small annual increase (0.2 percent) in the 1980s. This stagnation was mainly caused by a lack of production incentives. In addition, Brazil, which grows 80 percent of the cassava in the region, was hit by a long drought, which reduced yields. However, there is a wide disparity in cassava yields across Brazil: while average yields stand at 4-8 ton/ha in Northeast Brazil, they jump at 20-28 ton/ha in the southern states of Parana and Sao Paulo. In Colombia, cassava production grew at an average annual rate of 1.6 percent per year. Between 1985 and 1995, the annual increase was actually 3.4 percent. This strong performance in a region where cassava production is declining may be related to policies put in place by the Government of Colombia to provide better access to credit and technical assistance by cassava farmers.

Thailand and Indonesia account for the largest share (75 percent) of cassava produced in Asia. In the 1970s, cassava production grew rapidly (5.1 percent annually) due to both yield increase (2.6 percent) and expansion of cultivated land (2.6 percent). This rapid increase in cassava production was due to a growing demand for cassava pellets and starch for export to countries of the European Union. In Thailand, cassava production went from 1.2 million tons in 1960 to about 23 millions tons in 1990. Between 1965 and 1980, production doubled every five years. Like elsewhere cassava is grown, production is primarily in the hands of small

scale producers; but in Thailand, cassava farmers averaged yields exceeding 15 tons per hectare compared to a world average of less than 10 tons per hectare. In the late 1980s and early 1990s, the rate of growth in cassava production has slowed down considerably.

**Table 5. Cassava production, yield and cultivated area per region, 1972-1994.**

Region	<u>Production (million ton)</u>			<u>Yield (ton/ha)</u>			<u>Area harvested (million ha)</u>		
	1972-74	1982-84	1992-94	1972-74	1982-84	1992-94	1972-74	1982-84	1992-94
World	102.2	129.5	162.3	8.2	9.3	9.9	12.4	13.9	16.4
Africa	41.5	54.0	82.1	6.0	7.1	8.2	6.9	7.6	10.0
Americas	32.8	28.9	29.5	12.1	10.8	11.6	2.7	2.7	2.6
Asia	27.8	46.4	50.6	9.8	12.7	13.1	2.8	3.7	3.9

*Source: FAOSTAT, 1997*

**Table 6. Growth rates in cassava production, yield, and area harvested between the periods 1972-1974 and 1982-1984 (indicated as 1973-83) and between the periods 1982-1984 and 1992-1994 (indicated as 1983-93).**

Region	<u>Production ( percent)</u>		<u>Yield ( percent)</u>		<u>Area harvested ( percent)</u>	
	1973-83	1983-93	1973-83	1983-93	1973-83	1983-93
World	2.4	2.3	1.3	0.6	1.1	0.3
Africa	2.6	4.2	1.7	1.4	1.0	2.7
Americas	-1.3	0.2	-1.1	0.7	-0.2	-0.5
Asia	5.1	0.9	2.6	0.3	2.6	0.5

*.Source: FAOSTAT, 1997*

In the late 1980s and early 1990s, the European Union imposed a restrictive quota system. Unable to export all of their production, cassava producers in Thailand have begun looking for alternative markets abroad, but also at home. Strong industry-led economic growth pushed cassava cultivation to marginal lands, leading to a decline in productivity (Henry and Gottret, 1995). In Indonesia, a large proportion of the cassava produced is consumed internally. A strong economy and rising incomes have increased demand for cassava starch. Adoption of high-yielding varieties has contributed to an annual production growth rate of 1.4 percent since the mid-1980s.

### 1.3 Primary product

Wherever cassava is grown, it is primarily used as food. The exception to this rule is Thailand where 90 percent of the cassava produced is exported and the rest is used in industries. In

Africa, close to 90 percent of cassava produced is used as food, with very little used for animal feed and even less for export and industries (See Table 7). Post-harvest losses have been estimated at 9.5 percent. In Asia, over half of the cassava production is used as food. Exports account for 27 percent and come primarily out of Thailand and Indonesia. In Latin America and the Caribbean, cassava is used mainly as food (42 percent) and feed (33 percent). The use of cassava in industry accounts for 10 percent of the production in the Americas, 9 percent in Asia, and 0.1 percent in Africa.

**Table 7. Uses of cassava by continent (in percentage of production)**

Producing region	Food	Feed	Industry	Export	Waste
Africa	88.7	1.4	0.1	0.1	9.5
Asia	55.3	2.9	8.6	26.9	6.3
Americas	42.4	33.4	9.6	0.1	14.0

Source: FAOSTAT, 1997

Cassava has traditionally played an important role as an irreplaceable food security crop in large parts of the developing world. In addition, cassava has increasingly received attention as a low-cost, high quality raw material for both small and large scale manufacturing of a wide range of processed products for growing national markets and for exports.

#### Africa

Almost all cassava grown in Africa is for human consumption; 30 percent is consumed after peeling, cleaning and boiling, while 70 percent is processed into a wide variety of food products including dry chips and flour, cooked pastes, roasted or steamed granules, beverages, etc. Both rural and urban peoples use these products as a basic daily source of dietary energy. The diversity of products is matched by a proliferation of common names for these foods: the same name could refer to different food products (e.g. *foofoo* or *fufu* is a different product in Ghana, Nigeria and Congo), while the same food product can have different names in different locations (e.g. *kwanga* or *chikwanghe* in Congo, *bobolo* or *miondo* in Cameroon refer to a similar product).

The most popular product in West Africa is *gari*, a free-flowing, granular, fermented and gelatinised cassava product. Easy to store and fast to cook, *gari* is a convenient food well suited for a busy urban lifestyle. The processing of cassava into *gari* is labour intensive and requires the use of machinery particularly for the grinding of the roots into a mash. Women are responsible for virtually all cassava processing activities in Africa (Ugwu and Ay, 1992).

Because cassava roots can remain unharvested in the ground for 2 to 3 years, they often play a crucial role during civil unrest when displaced populations return to their farms. This has been seen in Uganda, Rwanda, Burundi, Angola, Mozambique and Liberia. In other countries such as Tanzania and Malawi, cassava has been the only source of food during severe droughts.

Nevertheless, a recent survey has indicated that cassava does not simply play a food security role: an average of 40 percent of cassava per field is planted purposely for sale (Nweke, 1996). Recently, various industries have begun using cassava as low cost commodity to substitute expensive imports of starchy cereals.

Cassava production in Africa has increased steadily in the last thirty years and is the only crop, along with yams, to have kept up with the rate of growth of the population. In Nigeria and in Ghana where the increase in production has been spectacular, the use of cassava by local industries and for export is beginning to expand. Biscuit factories are mixing cassava flour and wheat flour in the production of biscuits, starch is being produced industrially, and one factory has successfully switched from the use of molasses to the use of cassava flour in the production of ethanol. Most of the products are consumed within the countries in which they are produced. However, there is a small but growing export trade in dried cassava chips and other industrial products.

## Americas

In the Americas cassava is slowly evolving from a traditional staple to a market oriented inexpensive raw material for the manufacture of human, livestock and industrial products that have more elastic markets than fresh cassava. Consumption of fresh cassava is decreasing in urban areas, but the demand for fresh cassava remains high in low-income groups. *Farinha*, a typically Brazilian product, remains a traditional favourite. Fermented starch (sour starch, *polvilho azedo*), with its bread-making properties is finding new uses in the food industry and in urban fast-food outlets.

Small-scale cassava chip and drying plants are being built in Colombia, Brazil, Ecuador and Panama. Small and medium scale starch industries are used by resource poor farmers to generate income. There is some evidence that the scale of the starch industry is increasing, particularly in southern Brazil. The production of sour starch (a naturally fermented product that acquires the ability to rise like wheat dough during baking) is also increasing in Colombia and Brazil due to new product applications with growing demand such as snack foods and bakery products (Hershey and Henry, 1997).

## Asia

Since the 1960s, Asian countries, especially Thailand and Indonesia, have grown cassava for processing into value-added export products, offering Asian cassava farmers some stable source of income. Thailand, Asia's largest cassava producer exports nearly 90 percent of its production mainly as chips and to a lesser extent as starch (Maneepun, 1996). In Indonesia, about half of the cassava produced is for local consumption in fresh or dry forms. The rest is used in food and non-food industries or exported as chips. Currently, the cassava industry in these countries is facing shrinking markets for the export of cassava chips and is shifting towards modified starches and other high added-value chemicals. In contrast, the Philippines and Vietnam grow cassava mainly for their domestic market. In the Philippines, cassava is divided almost equally into food, feed and industrial uses. Only 12 percent of the cassava production in Vietnam are consumed as food, mainly as boiled roots. About 60 percent of the production is processed into cassava flour, mainly for the animal feed industry, while the starch industry accounts for 16 percent of the production (Dang Thanh Ha et al., 1996).

China is the fourth largest cassava producer in Asia. In the early 1950s, cassava was mainly used as food; however, in the 1990s industrial uses such as the production of starch and monosodium glutamate constitute the main modes of cassava utilisation (Fang, 1992; Shu-Ren, 1996). Some new industrial products such as ethanol, glucose and fructose are gaining in importance.

## Typical cassava foods

It has already been mentioned that cassava can be boiled and consumed as a vegetable. More often than not, the various processing steps described earlier are combined in differing sequences to produce foods typical to specific areas. Sequences may have similar initial steps and then diverge, resulting in very different end products and, conversely, very different processes can lead to similar products. To complicate the matter further, similar products may have different names, while a common name may be applied to different products. There is a myriad of cassava-based food products found all over the world and it would be impossible to mention all of them here. A general review has been compiled by Lancaster *et al.* (1982). Jones (1959) has reviewed the foods made from cassava in Africa. Several authors have reviewed the different uses of cassava foods in individual countries (Favier *et al.*, 1971; Etejere and Bhat, 1985; Nkiere, 1984).

### *Casabe* or 'cassava' bread

Cassava bread is the main staple in the diet of many people in the Amazon Basin and the Caribbean basin, especially in Guyana, Surinam, and Venezuela. It is prepared by reducing cassava into a pulp and spreading the pulp on a hot clay or stone griddle to make a thin and circular cake toasted on both sides. The cake, which may reach 1 m in diameter, is eaten after dipping pieces of it in a stew. Different types of ingredients such as groundnuts can be added to cassava pulp in the making of the cake. The cakes are usually prepared daily for consumption, but they can be sun-dried for several days in order to withstand several months of storage.

### *Farinha*

Cassava pulp is obtained from fresh roots by grating or crushing. The wet pulp is squeezed to remove the excess of water. Various kinds of devices are used for this purpose. The best known and most sophisticated is called *tipiti*; it is a long cylindrical basket constructed by diagonal weaving so that it can be stretched lengthwise at the same time compressing its content. As the basket is stretched, its diameter decreases, the juice is squeezed out and drips along the basket to be collected below if needed. The de-watered pulp is stirred on a hot griddle, taking care to avoid the formation of lumps. The dry granules obtained, known as *farinha seca* or *farinha de mandioca* can be kept for a long time. In Brazil, *farinha* is usually sprinkled on top of other foods to enhance their texture and taste. *Farinha* is produced in small-scale home factories using family labour, or in small-to-medium scale fully mechanised factories with a daily output of 10 to 50 tons of *farinha*. This product is widely commercialised in Brazil where it comes in two grades depending on the particle size of *farinha* granules: *farinha fina* for a product with very small granules, and *farinha grossa* for a product with larger granules. It should be noted here that, very often, the word *farinha* is translated as 'flour'; however, given the particle size distribution of *farinha*, it should be classified as a granular product rather than as flour. A similar product in Trinidad and Tobago is called *farine*, adding to the confusion since this is the French word for flour.

A different type of product known as *farinha d'agua*, found mainly in Northeast Brazil, is made by first soaking peeled or unpeeled cassava roots and allowing them to ferment for 3 to 8 days, or sometimes even longer. During this time fermentation develops and the roots soften. When the roots are removed from the water, the peel is removed if necessary, and a

pulp is made, de-watered, and dried like for *farinha seca*. The flour produced in this case has different colour, texture and taste.

### *Gari*

*Gari* is the most popular cassava product in West Africa. Its preparation is similar to the Brazilian *farinha*. The differences start at the de-watering step. For making *gari*, the wet pulp is placed in cloth bags or jute sacks and weighted with stones to express the water. This de-watering process can take up to a week, or sometimes longer. During this time, a characteristic sour flavour develops due to fermentation occurring in the cassava pulp. The stone-press technique is progressively being replaced by various types of mechanical presses (screw-press, jack-press, and etc..) which shorten the de-watering time. In the mechanised production of *farinha* in Brazil, powerful hydraulic presses are used to de-water cassava pulp in just a few minutes. When a mechanical press is used in West Africa, the cassava root mash is first left to ferment with no pressure applied on the cassava mash. When the fermentation is estimated complete in the *gari* process, the pulp is removed from the bag, pressed, sieved to remove coarse materials, and roasted on a metal pan to make light and crispy granules. The *gari* so obtained is a granular free-flowing meal, white in colour, or yellow if palm oil has been used.

*Gari* is consumed in a variety of ways (Doku, 1969). Upon adding cold water, the granules swell and soften but retain their individuality; as such, they can be added in a soup or stew. It goes well with cowpea stew. Very hot water can be used to coalesce the individual *gari* granules and form a thick paste. In this form it is called *eba* in Nigeria and can be used just like the cold preparation. Many more variations exist in the utilisation of *gari* as food in West Africa, all mixing the cassava product with other food items to make a complete meal.

### *Fufu*

In Ghana, *fufu* (or *fofoo*) refers to sticky dough prepared from any boiled then pounded starchy food including yam, cocoyam and plantain, as well as cassava. To make *fufu*, cassava roots are first boiled and then pounded in a mortar until a homogenous dough is obtained, which may take about 15 minutes. It is eaten immediately along with a stew made from a variety of meat and vegetables. If left standing, the *fufu* will harden and become unfit for eating.

In Nigeria, *fufu* is the name of a food made from cassava roots soaked for 3 to 5 days, mashed and directly cooked into a dough. However, in Central Africa, *fufu* refers to dough obtained by mixing any type of flour in hot water. One can therefore make cassava *fufu*, corn *fufu*, or sorghum *fufu*. When used alone, however, the term *fufu* refers to the dough made from cassava flour. This flour can be obtained in two ways: sun-drying of fresh cassava whole roots or chips and milling them into flour when dry; or first soaking whole roots in water for 3 to 5 days. Soaking is usually the preferred process if water is in abundance; where water is scarce, cassava flour is made from sun-dried roots. Cassava flour from sun-dried roots is common in East Africa where it is used to make a product similar to the Central African *fufu* but called *ugali*.

### *Kwanga*

*Kwanga* (or *chickwangue*) is a popular fermented cassava product in Central Africa, particularly in the Congo and in Cameroon where it is called *miondo* and *bobolo*. To make it cassava roots fermented by three days of soaking in water are mashed and steamed. The steamed mash is kneaded into smooth dough which is wrapped in leaves and steamed. After steaming, the wrapped cassava is allowed to cool. The product can be consumed warm or cold. Its shelf life is about 3 to 7 days at room temperature if the wrapping is not open. Otherwise it will dry up and become unfit for eating or it will support microbial growth.

#### Cassava leaves

In many tropical countries, cassava leaves constitute a highly prized vegetable. Young tender leaves are usually selected, pounded and boiled for 15 to 30 minutes; various ingredients are then added to taste. In Africa, the highest consumption rates are found in central Africa and in East Africa; however, cassava leaves are widely consumed in several countries of West Africa such as Sierra Leone, Guinea and Liberia. Even though the concentration of cyanogenic glucosides in cassava leaves is 5 to 10 times greater than that of the root parenchyma, there are no reports of toxicity associated with the consumption of cassava leaves. When leaves are processed, their cyanogenic potential is considerably reduced during pounding, and after boiling it is virtually reduced to nil (Bokanga, 1995). A similar phenomenon is observed when cassava roots are ground into a mash, de-watered and heated on a flat hot surface to produce *farinha* in Brazil and *gari* in West Africa. Whereas cassava roots are well recognised as deficient in protein (average 1 percent on fresh weight basis), the leaves contain 7 to 10 percent protein (equivalent to about 30 percent protein on a dry weight basis). The protein content of cassava leaves was determined in 181 varieties and was found to range from 26 to 42 percent (IITA, 1974). Much of this protein is made up of the enzyme linamarase; its activity was found to be about 200 times greater in the leaves than it was in the roots (Bokanga, 1995).

Cassava leaves have a good potential as a source of protein in animal feed. They have the same protein content and the same value as feed as alfalfa, a well-established animal feed in temperate climates. Dried alfalfa foliage is exported to Asia, particularly to Japan, for use as animal feed. In Brazil and in some Asian countries, whole cassava plants (foliage, stems and roots) are shredded and ensiled to make feed for cattle and pigs.

### **1.4 Secondary and derived product**

#### Fermentation

A recent survey of the modes of utilisation of cassava in Africa has revealed that nearly three out of four cassava-based foods encountered in the survey were fermented products (Westby, 1991). Three types of fermentation are generally distinguished: a submerged fermentation, in which cassava roots, whole or in large pieces, are steeped in water for a period of 3 to 5 days; a mash fermentation, in which a mash is obtained by grating or rasping fresh cassava roots, and the mash is left to ferment in a container for several days; and a low-moisture fermentation whereby peeled cassava roots are heaped together and fungal growth is allowed to develop at the surface of the roots.

Nearly all fermentation relies on the fortuitous presence of microbes on the roots and/or in the water, and on the prevailing favourable conditions for the production of the desired product. In some instances, a small amount of a previous batch is kept and used to inoculate the next,

but the fermentation is allowed to follow its natural course with little or no attempt to control it. As a result, the flavour, aroma and texture of the fermented product vary with the season, location, and producer.

The micro-organisms associated with cassava fermentation are mostly lactic acid bacteria (*Lactobacillus plantarum*, *Streptococcus faecium* and *Leuconostoc mesenteroides*) and spore-forming bacteria such as *Bacillus sp.* (Bokanga, 1989; Nwankwo, et al., 1989; Okafor et al., 1984; Ngaba and Lee, 1979; Abe and Lindsay, 1978). Lactic acid bacteria are mainly responsible for the rapid acidification that characterises cassava fermentation. The *Bacillus sp.* seem to be responsible for inducing the retting of cassava root tissues during the submerged fermentation of whole roots. Other micro-organisms, such as *Corynebacterium sp.*, enterobacteriaceae, yeast and moulds have been reported (Akinrele, 1964; Collard and Levi, 1959), but they are usually present in low numbers and their role is not clearly understood.

It is interesting to note that the micro-organisms found in cassava fermentations are similar to those found in milk fermentation. Some of them may possess unique properties that may be of nutritional or industrial importance, e.g. over-secretion of a specific nutrient or chemical, production of bacteriocins, etc. It is therefore essential that the study of indigenous cassava fermentation should receive more attention than it has in the past.

## 1.5 Requirements for export

The amount of cassava exported out of Africa and the Americas is negligible, while it is estimated that 27 percent of the Asian cassava production is exported (See Table 8). Thailand accounts for 90 percent of Asian cassava exports and Indonesia about 9 percent. The largest importer of cassava is the European Union which defines four types of cassava products:

- i. cassava pellets made by compressing flour or starch;
- ii. fresh cassava for human consumption: this category consist of whole and fresh cassava, or peeled and frozen, or sliced in small pieces, packaged in readily marketable form in packages containing less than 28 kg of product;
- iii. dried cassava chips
- iv. starch

The near-totality of traded cassava (99.6 percent) is in the form of cassava chips (See Table 9). Eight countries (Netherlands, Spain, Belgium, Luxembourg, Portugal, Germany, France and Italy) absorb almost all the cassava entering Europe. In the period 1994-1996, the Netherlands alone accounted for 46 percent of the European cassava imports.

The Thai government has defined the standards of cassava chips for export. Two grades can be distinguished:

A *special grade* refers to dried (but not milled) cassava roots, light in colour, without foreign matter and free from unusual odour; it should have a starch and free sugars content of not less than 72 percent by weight and a moisture content of not more than 13 percent by weight. If sand or fibre is present, they should not exceed 2 percent and 4 percent by weight respectively.

A *first grade* is defined like the special grade except that the maximum permissible level for moisture content is 14 percent by weight.

**Table 8. Average annual export of cassava products to the European Union in the period 1994-1996 (in metric tons)**

Producing Region	Fresh	Pellets	Chips	Starch	Total
Africa	159	25	21,031	12	21,227
Americas	3,935	5	33,223	821	37,984
Asia	20,925	1,238	3,766,885	8,447	3,797,696
Total	25,019	1,468	3,821,139	9,281	3,856,907

Source: European Commission for Agriculture, 1997

**Table 9. Average annual imports of cassava products into the European Community in the period 1994-1996 (in metric tons)**

Importing country	Fresh	Pellets	Chips	Starch	Total
Netherlands	1	2,784	1,754,629	1,430	1,758,844
Spain	1,433	0	864,540	7	865,980
Belgium/Luxembourg	7	48	379,629	86	379,770
Portugal	0	1	328,539	23	328,563
Germany	4	3	203,394	1,806	205,207
France	4	293	199,030	3,867	203,194
Italy	2	1	75,745	15	75,763
Ireland	0	0	6,567	0	6,567
United Kingdom	17	1,033	92	1,761	2,903
Denmark	0	0	2,827	10	2,837
Sweden	0	2	0	274	276
Total	1,468	4,165	3,814,992	9,279	3,829,904

Source: European Commission for Agriculture, 1997.