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T. Agbor Egbe, A. Brauman, D. Griffon, S. Trèche (éd)

Cassava : Opportunities for the food, feed, and other industries in Africa

Le Manioc : perspectives pour l'alimentation humaine, l'élevage et les industries en Afrique

M. BOKANGA

— Abstract —

The production of cassava in Sub-Saharan Africa has been increasing faster than the production of cereals. Many studies have demonstrated the technical feasibility and the economic advantages of using cassava in partial or total replacement of wheat for breadmaking but the baking industry in non-wheat producing countries has been reluctant to reduce the use of wheat. Targeting the composite and wheatless flour projects to rural and small scale users may prove to be more successful than trying to persuade large mills and bakeries to change their mode of operation. Technologies developed at the International Institute for Tropical Agriculture for making bread and other bakery products from cassava and soybean flour are receiving an enthusiastic response.

The physico-chemical characteristics of cassava starch make it preferable to use starch from other crops for many applications in the food, paper and textile industries.

The ever increasing competition for cereals in the human and livestock industry in most countries of tropical Africa makes it imperative to explore the potentials of cassava as a replacement for maize and wheat in processed feeds. Opportunity cost favors the use of cassava roots as replacement for maize in livestock feeds during the dry season when the price of maize rises considerably. Simple processing techniques profitable for small scale farmers are available for producing acceptable cassava products for the livestock feed industry. Inclusion of cassava leaves in such products improves the nutritive value of animal feed through enhancement of its protein quality, mineral and vitamin contents.

Increasing cassava utilization by the food and feed industries will stimulate cassava production by maintaining a high demand for cassava products.

— Résumé —

La production de manioc en Afrique sub-saharienne a augmenté plus vite que celle des céréales. De nombreuses études ont démontré la faisabilité technique et l'intérêt économique d'utiliser le manioc pour remplacer partiellement ou totalement le blé dans la fabrication du pain, mais les boulangeries industrielles des pays non producteurs de blé sont réticentes à réduire l'utilisation du blé. Encourager des projets ruraux à petite échelle de production de pain utilisant des farines composées sans blé peut s'avérer être plus efficace que d'essayer de persuader les grandes minoteries ou boulangeries de changer leur mode de préparation. Les technologies mises au point à l'Institut International d'Agriculture Tropicale (IITA) pour la préparation de pain et de produits voisins à partir de farines de manioc et de soja reçoivent un accueil enthousiaste.

En raison des propriétés physico-chimiques de son amidon, l'utilisation du manioc dans les industries alimentaires, de la pâte à papier et du textile est préférable à celle de nombreux autres productions végétales.

Dans la plupart des pays d'Afrique Tropicale, la concurrence toujours croissante pour l'utilisation des céréales entre les industries alimentaires pour l'homme et l'animal rend indispensable d'explorer les possibilités de remplacement du maïs et du blé par le manioc dans les aliments préparé pour l'alimentation animale. La comparaison des coûts est favorable à l'utilisation des racines de manioc en remplacement du maïs dans les aliments pour bétail pendant la saison sèche quand le prix du maïs augmente considérablement. Des techniques simples utilisables dans des petites exploitations sont disponibles pour produire des produits dérivés du manioc acceptables pour l'industrie alimentaire du bétail. L'incorporation de feuilles de manioc dans ces produits renforce la valeur nutritionnelle des aliments pour les animaux grâce à l'amélioration de la qualité de leurs protéines et de leur teneurs en minéraux et en vitamines.

L'augmentation de l'utilisation du manioc par les industries alimentaires pour l'homme et l'animal stimulera la production du manioc en maintenant une demande élevée pour les produits qui en sont dérivés.

Introduction

The world production of cassava in 1990 was estimated at about 158 million tons, 46 % of which was produced in Africa (FAO, 1991a). The African production had increased by 12.5 % compared to the 1988 production level. It has been estimated that about 90 % of the cassava produced in Africa is used for human food while the remainder is used largely as animal feed and very little is used in industrial processes (Cock, 1985). Traditional foods processed at home or in small scale cottage operations constitute the principal mode of utilization of cassava. Its use in livestock feeding is largely confined to experimental stations with little adoption by commercial livestock producers, despite the great potential of using cassava in feed formulations as it is done in the European Economic Community where cassava, imported mainly from Thailand, is incorporated in livestock rations at the rate of 10 to 40 % (Phillips, 1983).

If the current increase in cassava production in Africa is not met with an increase in the demand for cassava, it will result in a lowering of the farm gate price for cassava, a disincentive for cassava production. A drop in cassava production will follow, bringing with it a reduction in the farmer's income and welfare. This paper will show that available technological innovations allow the use of cassava in the food, feed and other industries in partial or total substitution of cereals such as maize and wheat whose production is insufficient to meet current demand or which have to be imported using scarce foreign exchange reserves.

1. Cassava and the baking industry

The consumption of bread in Africa has become a well-established habit not only in the city but even in the rural areas. This newly acquired taste for bread can be attributed to the convenience of bread as a food : it requires little or no packaging, and can be kept for several days at room temperature. It may be used as a breakfast food but also as part of other meals where it may be eaten with sauces and stews. The protein content of bread is around 8 % (Lorenz and Kulp, 1991) and, although deficient in the essential amino acid lysine, when consumed along with legume-based foods, it contributes to healthy nutrition.

The major problem with bread consumption in African countries is that wheat needed to make bread cannot be grown in most consuming areas. Ten countries (Nigeria, Zaire, Tanzania, Mozambique, Guinea, Uganda, Madagascar, Angola, Côte d'Ivoire and Cameroon) which produce over 90 % of the African cassava production import annually about 2 million tons of wheat (Table 1). Their local wheat production capacity represents less than 7 % of their wheat imports (FAO, 1991b).

Table 1
Cassava and wheat production and wheat imports in the 10 major cassava-producing countries of Africa.

Country	Cassava production[1] (× 1000 metric tons)	Wheat production[2] (× 1000 metric tons)	Wheat import[2]
Nigeria	20,000	23	1,172
Zaire	18,200	20	200
Tanzania	6,300	76	54
Mozambique	3,700	5	100
Guinea	3,600	0	72
Uganda	3,400	9	12
Madagascar	2,300	0	34
Angola	1,900	n.a.	n.a.
Côte d'Ivoire	1,400	0	208
Cameroon	1,200	1	95
Total	62,000	134	1,947
Africa Total	68,900		

1 Source : FAO, 1992.
2 Source : FAO, 1991b.
n.a. = not available

The idea of substituting part of the wheat with other starchy crops is not new. For over forty years several institutions, including FAO, have carried out research designed to find ways of partially substituting wheat flour with other sources of flour or replacing wheat altogether (Dendy and Trotter, 1988). Although the literature abounds with reports of technological successes, there has been little implementation. In most cases, composite flour programs and other wheat-replacing technologies were targeted to large scale commercial operations. The resistance of the wheat producers was to be expected. Wheat producers could afford to reduce the price of wheat to a level where the substitution technologies would became less profitable than wheat.

In almost all wheat importing countries, large wheat mills were erected and their operations became a good source of income for governments and provided employment to many. The government of those countries were therefore reluctant to see the wheat mills closed down. On a few occasions, however, some governments like Nigeria in 1988 took the bold step of forbidding the importation of wheat. Unfortunately, such decisions are often short-lived. In the case of Nigeria, the ban on wheat importation lasted about four years. It now has been lifted, to the benefit of the wheat producers.

Targeting the small scale user may yield better results. Large amounts of cassava are found daily on the market place in many countries particularly in Central, Eastern and Southern Africa. The increase in cassava production in recent years will drop the farm gate price of cassava if the demand for cassava is not kept high. This demand can be maintained or increased if, in addition to traditional cassava products, new food products possessing the convenience and attraction of modern standards of living can be produced from cassava. They should be relatively easy to make and require only locally available ingredients.

Research done at the International Institute of Tropical Agriculture (IITA) has lead to the production of a nutritious bread and other baked products such as cakes and biscuits using cassava and soybean flour, cassava starch, margarine and eggs. The complete list of ingredients for making the cassava-soy bread is indicated in Table 2. To make cassava-soy bread, all the dry ingredients are mixed in a Kenwood high speed mixer at low speed for 1 minute. The water and whisked egg white is added at this stage, and all the ingredients are mixed at high speed for 10 minutes. The slightly cohesive and viscous batter produced is then deposited into a baking pan and smoothed down with a plastic spatula. The batter is fermented at 30 °C (85-90 % RH) for 60 minutes in a fermentation chamber and is then baked at 200 °C for 30 minutes.

Table 2

The basic cassava bread formula

Ingredient	Amount (g)
Cassava flour	80[a]
Raw or Roasted Soy Flour	20[a]
Dried Yeast	1.5
Salt	1.5
Sugar	6
Oil (Margarine)	10
Water	110
Whisked Egg White	48[b]

a Based on 14 % moisture content

b Based on 12 % dry matter content. The water contained in the egg white is taken into account in the total water added.

The acceptability of cassava bread prepared with the IITA recipe was assessed among middle to high income consumers and in a rural community in Oyo State (Nigeria). The results of the survey are summarized in Table 3. Over 85 % of consumers found the cassava bread good or very good, whether they live in the city (85.5%) or in rural areas (86.2%).

Table 3

Consumer rating of cassava bread (IITA recipe) in an urban and rural locations in Oyo State

Test parameter	Location	% respondent scoring				
		Very good	Good	Fair	Bad	Very bad
Taste	City	25.5	60.7	14.5	0	0
	Village	49.3	44.8	4.5	1.5	0
Texture	City	25.5	58.2	14.5	1.8	0
	Village	38.5	47.7	12.3	1.5	0
Color	City	45.5	34.5	18.2	1.8	0
	Village	60.6	34.8	4.6	0	0
Accepta-bility	City	29.1	56.4	14.5	0	0
	Village	63.1	23.1	13.8	0	0

The question that is often asked is whether any cassava flour could be used to make bread. In 22 cassava varieties screened, there was a strong negative correlation between the diastatic activity of the cassava flours and the specific loaf volumes of the bread. Flours with a relatively high diastatic activity and therefore low maximum paste viscosity produced dense, pudding-like structures, and were therefore not suitable for bread making. It is also generally known (Schwimmer, 1981) that when an excessive amount of alpha-amylase (a component of the diastatic activity) is present in wheat flour, deleterious quality effects are usually observed in the bread. Cassava flour diastatic activity and maximum paste viscosity are therefore being used as screening parameters for cassava improvement with regard to bread making. Among the varieties screened, the improved varieties TMS 4 (2)1425 and TMS 30001, and the local variety Antiota were found to have the best bread making ability.

A study in progress is revealing that the diastatic activity of cassava varieties varies with the age of the plant and other agronomic conditions. The study will determine the optimum growing conditions, time of harvest and the best method of cassava flour preparation to ensure the production of the best quality flour for bread making.

The method of flour preparation is important in determining the quality of the cassava flour for bread making. A hand-operated chipping machine and a manual mill/grinder were developed in response to problems encountered in the production of cassava flour. The chipping machine reduces the tuberous root to about 5 mm diameter chips thus increasing the surface area exposed to air and resulting in a faster drying rate. The production of small size cassava chips results in greater physical damage imparted to cassava roots and a greater reduction in the cyanogenic potential of the flour.

Drying of cassava must be done immediately after harvest to prevent the physiological deterioration of cassava that usually develops a few days after harvest. This deterioration leads to the production of flour of sub-optimal color. Sun-drying is the most prevalent method of drying crops because it is the simplest and most affordable means of drying in rural areas. Artificial drying can be used provided the drying air temperature is maintained below 55 °C and the air is circulated. Sun-drying cassava chips on concrete floor even during the wet season proved to be more efficient than traditional practice of drying chopped or whole tubers. A loading density of 2.5 kg/m2 is optimum during the rainy season but this can be increased to 3.5 kg/m2 during the dry season. Under these conditions, drying can be completed in 8 to 10 h with maximum retention of the bread making quality of cassava chips.

The ingredients and methods for the production of biscuits, cakes and buns with cassava flour or starch and soy bean flour are described in a document that is available on order from IITA. We are currently conducting acceptability surveys in Nigeria. Preliminary results show that these products are much more appreciated than the cassava-soy bread. The responses received from those who have tested the products range from disbelief to admiration. Some of them have gone on to make these products in their homes and, very soon, we expect that there will be commercial exploitation by small scale operators. If this phenomenon is expanded, it is expected that the demand for cassava will be kept high and that eventually cassava would cut into the wheat market share.

2. Prospects for industrial uses of cassava starch

The production and use of cassava starch is an area that could offer the strongest competition not only to maize, wheat, rice and potato. Indeed, cassava flour and starch have unique properties which make them ideal for many applications in the food, textile and paper industries where flour and starch from the other crops have the quasi monopoly.

Cassava starch, because of its high amylopectin content, form clear, fluid, non-gelling pastes with little retrogradation tendency. It has the lowest gelatinization temperature compared to maize, wheat and potato starch ; this means that it consumes less energy during cooking. Drying cassava starch at 70 °C produces short-textured pastes with lowered viscosities which are preferred for pie fillings, cream puddings and the production of baby foods. Dextrins produced from cassava starch can be formulated into better adhesives ideal for uses in gums for envelopes, postage stamps, bottle labeling adhesives, lined cardboard boxes and in binding pigments for the glass fiber industry. There are endless opportunities for chemically modified cassava starch in a market that is currently dominated by modified cereal starches.

All these opportunities depend on the availability of good quality products, the production of which is beyond the means of small scale farmers. Rust-free machinery and clean water are essential and constitute an important investment. The small scale farmer should however have the responsibility to produce high quality cassava chips to reduce the need to transport bulky cassava roots. To avoid the bio-deterioration of cassava roots which start within 2-3 days after harvest, the roots should be dried immediatelyafter harvest to maintain their quality. In Latin America, some development projects are organizing cassava farmers into farmer-managed cooperatives which produce cassava flour and starch for sale to industries. Similar developments in Africa will contribute to raising the income of farmers and establishing truly African industries.

3. Cassava in the livestock feed industry

Animal subsist on a free range with minimal input. Under these conditions, productivity of stock is considerably low due to poor genetic potential and phenotypic factors. Of all the inputs required for satisfactory productivity of livestock in Africa, inadequate feeding constitutes the largest single factor militating against livestock productivity on this continent.

Africa's agricultural system is largely heterogeneous with a predominance of root crops in the farming system. It is therefore imperative to match livestock production with sustainable farming systems if the perennial shortage of feed for livestock will be overcome.

The cereal grains for the bulk of commercial livestock feed as contained in Table 4, constitutes between 40 % and 55 % of compounded rations. Even for ruminants that feed largely on roughage such as herbage, concentrate feeds are required to optimize their productivity. The supply of grains has therefore largely determined the availability of compound livestock feeds. Grains therefore continue to singly determine the course of the livestock industry. This becomes significant when it is realized that there is a traditional keen competition for the available grains between direct human consumption, the feed milling industry and in countries such as Nigeria where there is the newly-added fierce competition from the Breweries, flour mills and some other food industries due to the ban on importation of wheat, malt and barely.

In Nigeria, the feed milling industry estimated requirement for grains is conservatively put at about 400,000 metric tons in 1993. The annual requirement of the brewing industry is estimated at about 600,000 tons of grains while the demand from the flour mills is about 1 million tons.

These requirements could only be met if the current level of maize production is doubled. However, bearing in mind that the growth rate of grain

Table 4
Inclusion rate of feed ingredients in Nigeria Livestock industry.

Feed Ingredients	Inclusion rates (kg/Mt)
Maize	400-500
Sorghum	400-550
Wheat offals	200-300
Maize offals	20-300
Sorghum offals	200-300
Groundnut cake	200-300
Soybean meal	200-300
Palm kernel cake	100-250
Full-fat soya	50-200
Bone meal	35-100
Oyster shell	35-100
Brewers dried grains	5-100
Vitamins	5-10
Minerals	5-10
Fish meal	1-5
Meat meal	1-5
Methionine	1-5
Lysine	1-5
Feed Additives	0-1
Salt	0-0.5

Source : Bello A.O. (1989)

production even in advanced countries is about 6 %, it is doubtful if a better growth rate could be achieved in Nigeria even under the best weather conditions. Therefore, there is an urgent need for the use of other readily available alternatives such as cassava.

Cassava has a prime of place in tropical agriculture. It is undoubtedly the only alternative that can replace a considerable portion of maize in the livestock feed industry. The nutrient composition of cassava tuber and peels are presented in Table 5. It is comparable to maize as a source of energy though its tubers are notoriously deficient in protein. It has been demonstrated that for various livestock species including poultry, cassava tubers can replace all of maize provided adequate supplementation of protein and micronutrients are ensured (Tewe 1975, Oke 1978, Tewe and Egbunike 1992).

Table 5
Proximate composition of cassava storage roots

Constituents	Peel (range %)	Storage root (range %)
Dry matter (%)	29.6 (27.3 — 33.5)	30.8 (13.0 — 43.3)
Crude protein (%)	4.9 (2.8 — 6.5)	2.3 (1.5 — 3.5)
Crude fiber (%)	16.6 (10.0 — 22.0)	3.4 (1.3 — 77.0)
Ether Extract (%)	1.3 (0.5 — 2.2)	1.4 (0.8 — 3.2)
NFE (%)	68.5 (62.5 — 72.9)	88.9 (88.0 — 94.1)
Ash (%)	5.9 (3.5 — 10.4)	2.5 (1.6 — 4.1)

Source : Smith (1992)

The major limitations of using cassava in livestock feeding rest on :
- opportunity cost of its use in the industry as compared to its use in human food ;
- the dustiness of the dried cassava flour which not only limits intake in stock but also constitutes a menace in the milling industry ;
- cost of protein supplementation of cassava based rations ;
- variation in quality of dried products in terms of contaminants, microbial proliferation and cyanide content.

In Nigeria, the seasonal variations in the price of cassava and maize determine the proportions to be included in compound rations. During the dry season of the year (between December and April), the price of maize rises considerably while that of cassava flour drops as the intense solar radiation encourages production of dried cassava flour. Some ingenious medium scale livestock farmers and feed millers substitute between 10-50 % of the compound feed with cassava at the expense maize. The limitations being largely dictated by the price advantage, and the other components which determine the dustiness of the final product - oily components help reduce dustiness of cassava ration. This is quite significant particularly in Nigeria where over 90 % of the commercial livestock feed produced is for poultry. Replacement of 50 % of maize in the dry period of the year can save about 100,000 metric tons of maize for human consumption and other industries.

In order to get rid of the dustiness of cassava, the use of age old traditional technologies can be adopted. In a collaborative study between the IITA and the University of Ibadan, whole cassava roots are washed, grated and fermented for three days. Cassava leaves are also harvested and sun-dried.

The grated roots are pressed on the third day and fried in a certain proportion to the sun-dried leaves. The friable product looks like gari and in addition to its high energy content, it contains about 7 % crude protein. This product can be incorporated into livestock and poultry ration without the attendant dustiness. The heat applied during frying also destroys microbial organisms and the additional protein from the leaves reduces the cost of protein supplementation of the cassava based ration. The product which is currently being used for a layer study also impacts a better egg coloration than a corn based ration due to appreciable carotene content. The peel which is grated with the root also reduces the need for filler materials such as wheat offals or corn bran.

Cassava leaves provide opportunities for reducing the protein deficiency of cassava products. According to Ravindran (1992), cassava leaf yields amounting to as much as 4.60 tons dry matter per hectare can be produced as a by-product at root harvest. The current practice in most industries is to return this valuable feed resource to the soil as a green manure. As shown in Table 6 the nutrient content compares favorably with alfalfa meal. Cassava leaves are good sources of minerals and are also rich in ascorbic acid, vitamin A and contain significant amounts of riboflavin. It is deficient in methionine, possibly marginal in tryptophan but rich in lysine (Eggum 1970, Rogers and Milner 1963). It can therefore serve as a valuable source of protein and vitamin A particularly in layer rations. It should however be noted that levels of inclusion in literature hardly exceeds 5 % (Khajarern and Khajarern, 1985). Our studies which involves frying root and leaves as earlier described can offer a way to increase level of cassava leaf inclusion in livestock rations.

Table 6

Proximate composition and metabolizable energy of cassava leaf meal and alfalfa meal.

Constituents	Cassava leaf meal	Alfalfa Meal
Dry matter (%)	93.0	93.1
Crude protein (%)	21.0 (16.7-39.9)	20.0
Crude fat (%)	3.5 (3.8-10.5)	3.5
Crude fiber (%)	20.0 (4.8-29.6)	20.0
Ash (%)	8.5 (5.7-12.5)	10.5
Metabolizable Energy (kcal/kg)		
For poultry	1.80 (1.56-1.94)	1.63
For swine	2.16	2.03

Source : Ravindran (1992)

Conclusion

The use of cassava in the tropics has largely explored traditional technologies for processing of its roots into human food. The opportunities for inclusion of cassava in industrial food processes, particularly in the baking and starch industries appear tremendous. On the other hand, livestock feeding programs in the tropics involve usage of a very small fraction of cassava. There is the need to explore traditional technologies that can be readily adapted by small scale farmers who largely grow this crop. They can produce wholesome cassava products which will have ready markets with feed millers and livestock farmers who are presently faced with acute problems of energy shortage due to high competition for maize. The incorporation of cassava leaves into livestock ration will also help alleviate the problem of protein deficiency usually associated with consumption of cassava by humans and animals.

Finally, it should be recognized that it is socially and economically advantageous to divert the use of cassava for industrial food and livestock feeds because experiences have confirmed that increase in production of cassava leads to a glut in the cassava market. The price instability that prevails discourages the expansion of cassava cultivation and utilization. The diversion of such excess cassava for human food and animal feeds will guarantee price stability of cassava and encourage sustained cassava production.

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