African Journal of Biotechnology Vol. 7 (22), pp. 4172-4180, 19 November, 2008
Available online at http://www.academicjournals.org/AJB
ISSN 1684–5315 © 2008 Academic Journals

Full Length Research Paper

Farmers' perceptions of practices and constraints in cassava (*Manihot esculenta* Crantz) chips production in rural Cameroon

G. Essono[1]*, M. Ayodele[2], J. Foko[+], A. Akoa[1], J. Gockowski[2], Z. Ambang[1], J.M. Bell[1], and Ndongo Bekolo[1]

[1]Department of Plant Biology, the University of Yaoundé I, P.M.B. 812, Yaoundé, Cameroon.
[2]International Institute of Tropical Agriculture (IITA), Lamburn, Carolyn House, 26 Dingwall Road, Croydon CR9 3EE, UK.

Accepted 6 October, 2008

A survey aimed at collecting information on practices and constraints in the production of cassava (*Manihot esculenta* Crantz) chips, a transformed cassava product obtained through fermentation and drying of its fresh roots was carried out in 45 villages located in three geographical regions (Yaoundé, Mbalmayo, and Ebolowa) of the humid forest zone of Cameroon. A structured questionnaire to interview farmers was employed. Out of 225 farmers sampled, 212 (94%) relying on chips as food and source of income were women. Overall, 51% of all farmers marketed chips locally. Three distinct forms of chips such as broken pulp (62%), balls (25%), and pellets (13%) were cited as being locally produced by farmers. These were obtained either through air fermentation (cassava pellets), or submerged fermentation (broken pulps and balls), using starters or fermenting agents (31% of responses) or without using them (69%). Chips were mainly home-stored in jute and or/plastic bags (43% of responses), open or closed containers (36%), or on devices hanging over the fireplace (21% of responses) for as long as 180 days. Dark spots or discolouration occurring as a result of chips damage were reported by the majority of respondents (82%) as frequent on cassava chips. These were related to insufficient drying (42%), the use of infected cassava roots by plant pathogenic microbes from the fields (12%), or too long drying of chips under sun light (11% of responses). To avoid dark spots and/or discolouration, 112 farmers out of a total of 185 who were aware about chips damage, practiced sun-drying, and 21% of this total dried their chips over the fireplace to control chips damage. Pests and diseases problems (47% of responses), mainly related to the incidence of *Stictococcus vayssierei* Richard (Homoptera: Stictococcidae) and lack of market (26%) were cited by farmers as the most important constraints in cassava chips production. From the results obtained, this study outlined that the potential utilization of cassava and its derived products for industrial purposes is not yet exploited in the locations investigated. Additionally, the study also raised concerns about the safety and hygiene associated with traditionally processed and stored cassava chips in the investigated areas.

Key words: Survey, production practices, pests and diseases, lack of the market, safety and hygiene.

INTRODUCTION

Cassava (*Manihot esculenta* Crantz, Euphorbiaceae) ranks first among root and tuber crops cultivated in Cameroon (Anonymous, 2006a). Recent data from the Cameroonian Ministry of Agriculture and Rural Development report that in all five agro ecological zones of Cameroon, cassava forms the most important part of many cropping systems and occurs in a wide array of marketing channels (Anonymous, 2006b), thus constituting an important food security and income generating crop for several households. Both cassava leaves and roots are consumed (Kehinde, 2006; Aduni et al., 2005;

*Corresponding author. E-mail: germainessono@yahoo.fr.

[+]Prof. Foko died in a road accident in December 2004 while on his way to preside over a PhD thesis defence jury in the University of Buea, Cameroon.

Cock, 1985). Leaves provide an important protein intake (Khampa and Wanapat, 2006; Ayodeji, 2005; Cock, 1985) whereas roots are a cheap source of carbohydrates (Nwokoro et al., 2005; Cock, 1985). However, one of the main constraints related to fresh roots of cassava is their poor shelf life. After harvest, cassava roots cannot be stored longer than three or four days due to post-harvest physiological deterioration (Hahn, 1993, 1989). Another drawback associated with cassava is its potential toxicity: depending on cultivars, edible organs of cassava (leaves or roots) may contain large amounts of the cyanogenic glucoside linamarin, along with additional small quantities of a similar compound referred to as lautostralin (Bokanga, 1996; Bradbury et al., 1991). Both substances are highly toxic and negatively impact the health of animals and human upon consumption of cassava. In attempting to simultaneously increase shelf life of fresh roots and avoid dietary cyanide exposure due to the above-mentioned glucoside compounds, fresh roots are often processed into variable stable and durable products such as gari, chikwangue, cassava chips and other dried products (Zhou and Nzingamasobo, 2006; Kobawila et al., 2005; Osho and Dashiell, 2002; Hahn, 1993). In this respect, cassava processing could be related to the necessity of having permanent food reserves and also to remove toxic cyanide glucosides contained in its edible organs before its consumption. Apart from overcoming the perishability and toxicity of the crop, transformation has also been shown to enhance the nutritional standard, along with adding substantial economic value to cassava (Laswai et al., 2006; Khampa and Wanapat, 2006; Solomon and Sudip Khumar, 2004).

Among the derived cassava products identified in Sub-Saharan Africa, cassava chips are the most commonly encountered (Anonymous, 1992). Additionally, recent and past research reports suggest that cassava chips form the bulk of cassava based-foods in several cassava consuming populations (Zhou and Nzigamasobo, 2006; Grizotto and De Menezes, 2002; Anonymous, 1992). These are the derived products of fresh roots of cassava, obtained after fermentation, drying, and usually followed by their subsequent storage (Hahn, 1993; 1989). In many cassava growing communities, chips are used as foods, feeds, and may serve as raw material to manufacture starch, and alcoholic drinks (Kehinde, 2006; Favier, 1977). Cassava chips' production is therefore likely to be of great importance to farmers in several communities where the crop forms the staple. Research results suggest that there may exist differences in cassava chip production processes not only between individual farmers, but also between similar and/or different ecological zones (Grizotto and De Menezes, 2002; Anabolu et al., 2001; Hahn, 1989). This indicates that the production of this food commodity may have local or regional preferences.

Based on these assumptions, the present study hypothesizes that: despite increasing interest in cassava processing research, there is still limited knowledge about practices implemented by farmers. Similarly, there is also scanty understanding of the main constraints the farmers could face while carrying out this activity. Such an understanding is important for stimulating appropriate collaboration between farmers and scientists helpful to further provide the necessary assistance to farmers, for the production of safe cassava based-products for local and international markets.

In these respects, this paper sheds light on conditions and factors of cassava transformation processes following a survey based-study carried out in households located in 45 villages of Southern Cameroon. It helps to understand the rationale of transforming cassava into chips, and to assess the main constraints related to this activity in different socio-economic environments as well as the measures undertaken by the farmers to overcome them.

MATERIALS AND METHODS

Study area

Three geographical areas (Figure 1) of equal surface area importance and including Ebolowa, Mbalmayo and Yaoundé, referred to as blocks and located within the humid forest zone of Cameroon were defined based on the benchmark concept (Anonymous, 1989b). This concept is linked to the idea that there is a range of geographical and socio-economic characteristics which can affect the habits and behaviour of people in a given setting. In this respect, the most important criteria used to demark areas inside the benchmark include: geographical and ecological distribution of the main local crops, human population densities, accessibility to major or nearest cities (data not shown). It was thus assumed that, climatic differences may influence growth, production techniques, biological factors and processing methods associated with the cassava crop. Accessibility criteria to major towns may also be important factors influencing the degree of commercialization of derived cassava products. Population densities may likewise change the pattern of resource uses such as labor allocation, and crop choices. All these may affect cassava processing technology systems as well as the frequency of consumption of cassava and derived products by the local population.

The Ebolowa block stretches from the southern boundary of Cameroon to Gabon and Equatorial Guinea, within latitudes 2°20'N to 3°5'N and longitudes 11°00'E to 11°24'E, and covers 5150 km². The annual rainfall averages 1876 mm. The average relative humidity is 83.4% and the annual mean temperature is 24.4°C.

The Mbalmayo block extends from latitudes 3°16'N to 3°37'N and longitudes 11°6'E to 11°47'E, covering 5120 km². The annual rainfall averages 1624 mm, and the annual mean temperature is 23°C. The mean relative humidity is 79%.

The Yaoundé block lies within latitudes 3°45'N to 4°26'N and longitudes 11°14'E to 11°35'E, and covers an area of 5200 km². The block has an annual mean temperature of 22.2°C, a relative humidity of 77% and an annual rainfall of 1654 mm.

Within each of the three blocks forming the benchmark, and based on the criteria of selection mentioned-above, 15 villages were identified following a macro level characterization study previously carried out by the International Institute of Tropical Agriculture (11). Accordingly, a total of 45 villages formed the basis of this study.

Survey

From January to April 1998, surveys were undertaken across the 45

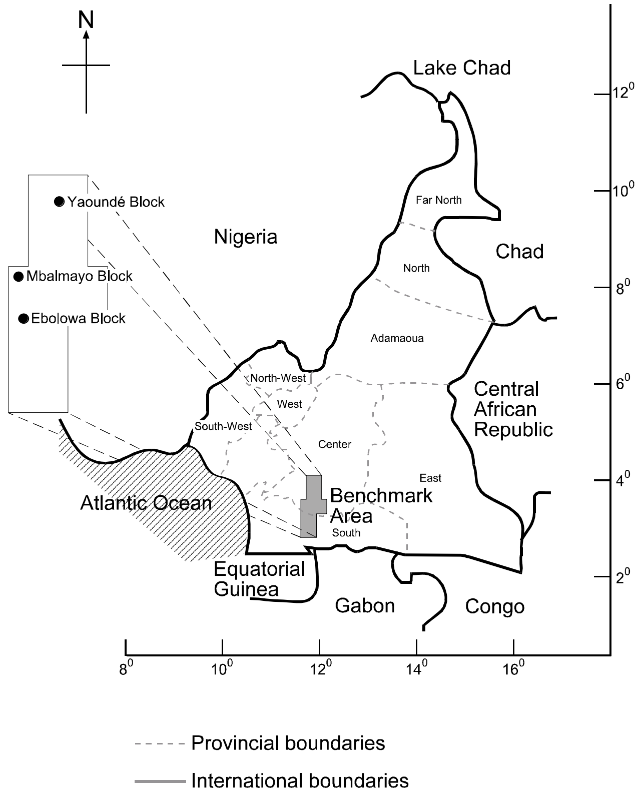

Figure 1. Location of the benchmark within Cameroon.

villages of the benchmark at household level to collect production practices and constraints related information from farmers in cassava chips production. A structured questionnaire to interview farmers within households in each village was drawn up based on previous COSCA (Collaborative Study on Cassava in Africa) projects' recommendations (Anonymous, 1989a). Information on the questionnaire included: processing methods, form of chips produced as well as the handling techniques implemented by farmers. After this information was obtained, farmers were questioned on the end use of chips (family consumption, marketing, and other uses), their awareness of stored chips' contamination as well as means used to avoid it. The major constraints associated with chips production were also addressed.

To carry out interviews, 2 villages were visited each day: the first one, early in the morning before the farmers left for their fields, and the second one in the afternoon after they had returned from the field works. In each visited village, 5 households were randomly selected along a transect cutting across the village. Eligible households were those hosting people who had been residing in the village for the past 12 months, with farming activities. Within each household, the head of the family or the spouse, or any other appropriate person involved in cassava cultivation and/or transformation was interviewed. A total of 225 farmers were thus submitted to interviews that were conducted in the main local languages (Ewondo, Bassa, Bafia, Boulou, Ntoumou or Eton) spoken in the areas investigated, using interpreters where needed.

Questionnaire analysis

Two types of questions were included in the questionnaire. Fixed choice questions were those for which the respondents had to choose one item among several alternatives, or questions for which the expected response was "YES" or "NO". Open-ended questions were those which allowed the informants to express their opinion.

Answers were coded numerically. For fixed choice questions, positive and negative answers were coded "1" and "0", respectively. For open-ended questions, the various responses were recorded, checked, and grouped into similar categories. After that, they were given additional code numbers. Codified data were processed using a spread sheet program (Excel 5.1/97). Results were expressed as percentages of responses obtained from farmers.

RESULTS

Personal characteristics of farmers and rationale for producing cassava chips

Cassava chips production was carried out by people who did mainly farming (89% of respondents) and only little trading (11%). Ninety four percent of the farmers interviewed were women of various age groups; processing experience and education levels (Table 1).

In all the locations investigated, cassava chips were produced mainly for home consumption and/or commercial purposes. The use of cassava chips for the production of local beverages (alcoholic drinks) and doughnuts was noted as an important feature in the Ebolowa block where over 41% of the farmers reported to produce chips for that purpose compared to 21% in Mbalmayo and about 15% in Yaoundé. No industrial uses of the chips such as gums or starch manufacturing was mentioned by any of the farmers sampled (Table 1). An important observation associated with the present results is connected to the fact that, chips were not especially used as feeds, but occasionally used as such by farmers raising cattle or farm animals.

Processing practices associated with the production of cassava chips

Two processing methods leading to three forms of cassava chips were identified during the survey. The first, carried out by 13% of the respondents, consisted of peeling, washing cassava roots in water and cutting them, before drying (Table 2). The resulting products which are rectangular pieces of cassava of about 1 cm wide and 2 to 3 cm long are referred to as pellets in this paper. In the second method, cassava roots are peeled soaked in water for three to four days, before being dried. One hundred and ninety-six out of 225 farmers interviewed representing over 87% of the total, cited this method as their way of producing cassava chips. The types of chips that resulted from this technique were either small pieces of cassava of 1 to 2 cm diameter and referred to as dried broken pulp, or circular cassava balls with a diameter more often greater than 10 cm. On the average, balls were more predominant in Ebolowa compared to Yaoundé and Mbalmayo locations (Table 2).

Table 1. Personal characteristics for 225 farmers and rationale for producing cassava chips in southern Cameroon.

Item	Yao block		Mba block		Ebo block		Total	
	#	%	#	%	#	%	#	%
	75	100	75	100	75	100	225	100
Gender								
male	4	5.3	4	5.3	5	6.7	13	5.8
female	71	94.7	71	94.7	70	93.3	212	94.2
Age (years)								
<30	22	29.3	13	17.13	15	20	50	22.2
30-50	33	44	40	53.4	37	49.3	110	48.9
>50	20	26.7	22	29.3	23	30.7	65	28.9
average age	39.50[1]	(19.5)	42.4	(19.3)	43.5	(21.6)	41.8	(20.1)
Education								
<6 yrs 1ary edu	42	56	41	54.7	38	50.7	121	53.8
6 yrs 1ary edu	22	29.3	19	25.3	17	22.7	58	25.8
6 yrs 2ndary edu	11	14.7	14	18.7	18	24.0	43	19.10
higher edu	0	0	1	1.3	2	2.6	3	1.3
average edu	1.59	(0.74)	1.68	(0.87)	1.79	(0.95)	1.68	(0.85)
Experience (years)								
1-5	16	21.3	18	24	17	22.7	51	22.7
6-10	18	24	14	18.7	10	13.3	42	18.7
11-20	20	26.7	19	25.3	23	30.7	62	27.5
>20	21	28	24	32	25	33.3	70	31.1
average experience	16.45	(12.18)	17.83	(12.54)	17.69	(12.01)	17.32	(12.24)
Main occupation								
Agriculture	61	81.3	71	94.7	69	92	201	89.3
Non agriculture	14	18.7	4	5.3	6	8	24	10.7
Rationale for cassava chips production								
	# of farmers	**%**	**# of farmers**	**%**	**# of farmers**	**%**	**#of farmers**	**%**
Food and Feed	54	72.0	71	94.7	47	62.7		
Sales in nearest	37	49.3	23	30.7	12	16.0	61	27.1
cities	55	73.3	38	50.7	21	28.0	146	64.9
Locale sales	11	14.7	16	21.3	31	41.3	18	8
Alcohol and doughs								

#: Number of farmers; %: Percentage of farmers; Yrs: Years; 1ary: primary; 2ndary: secondary; Edu: education; Yao: Yaoundé; Mba: Mbalmayo; Ebo: Ebolowa.1: Figures in parentheses are standard deviations from the average.

The use of ferments by 31% of the respondents was noted as an important feature in cassava processing. Ferments were of common use in Yaoundé and were cited by 42 out of 75 informants of this block against 14 in Ebolowa, 13 in Mbalmayo. According to the farmers, these were essential in speeding up the softening process of cassava roots after soaking in water. Ferments used to this effect mostly consisted of cassava flour that were poured on water containing peeled cassava roots.

Farmers when asked the main criteria for preferences in size or form of cassava chips they produced gave a variety of reasons ranging from market purposes, imitation of neighbors, ease of drying, good visual appearance, good taste, tradition and multi-purpose uses (Table 2). While none of these criteria was dominant, it could be stated that besides locations, economic considerations as illustrated by market purposes might have determined preferences in forms.

The drying process was reported to be achieved either under sun on roof tops, on concrete floors, on raised platforms in the village, on rocks in the farm, or above the fire place indoors for periods extending from one to seven days depending on the weather or the form of chips produced. Generally, cassava balls were dried for at least four days over the fireplace indoors on constructed devices hanging above fire, whereas the drying of pellets and dried broken pulp could be achieved from 1 to four days under sunlight depending on its intensity (Table 2).

Table 2. Processing practices associated with cassava chips' production in Southern Cameroon.

Item	Yao block		Mba block		Ebo block		Total	
	# of farmers	%	# of farmers	%	# of farmers	%	# of farmers	%
Processing methods								
Proc1	12	16	10	13.3	7	9.3	29	12.9
Proc2	21	28	51	68	55	73.3	127	56.4
Proc3	42	56	14	18.7	13	17.3	69	30.7
Forms of chips								
balls	5	6.7	8	13.3	44	58.7	57	25.3
Pellets	12	16	10	10.7	7	9.3	29	12.9
Dried broken pulp	58	77.3	57	76	24	32	139	61.8
Reasons of preference								
Rp1	27	36	19	25.3	21	28	67	29.8
Rp2	10	13.3	13	17.3	5	6.7	28	12.4
Rp3	2	2.7	4	5.3	0	0.0	6	2.7
Rp4	13	17.3	9	12.0	9	12.0	31	13.8
Rp5	6	8.0	10	13.3	17	22.7	33	14.7
Rp6	4	5.3	7	9.3	15	20.0	26	11.5
Rp7	5	6.7	7	9.3	3	4.0	15	6.7
Rp8	8	10.7	6	8.0	5	6.7	19	8.4
Drying facilities								
Df1	19	25.3	13	17.3	10	13.3	42	18.7
Df2	6	8.0	37	49.3	5	6.7	48	21.3
Df3	23	30.7	8	10.7	5	6.7	36	16.0
Df4	22	29.3	12	16.0	11	14.6	45	20.0
Df5	8	10.7	6	8.0	40	53.3	54	24.0
Drying duration								
1 day drying	35	46	33	44.3	11	14.7	79	35.1
2 to 3 days drying	32	43	34	45.3	22	29.3	88	39.1
4 to 7 days drying	8	10.7	8	10.7	42	56.0	58	25.8

Yao: Yaoundé; Mba: Mbalmayo; Ebo/Ebolowa. Rp1: market purposes; Rp2: ease of drying; Rp3: ease of processing; Rp4: good visual appearance Rp5: tradition; Rp6: multi-purpose uses; Rp7: good taste; Rp8: imitation of neighbors Df1: drying under sunlight on roof tops in the village; Df2: drying under sunlight on rocks in the farm; Df3: drying under sunlight on concrete floors in the village; Df4: Drying under sunlight on raised platforms in the village; Df5: drying over the fire place indoors; Proc1: processing by peeling cassava roots, cutting and washing them before drying; Proc2: processing by peeling, washing and soaking cassava roots in water for 3 to 4 days before drying
Proc3: processing by peeling, washing and soaking cassava roots in water with fermenting agents for 2 to 3 days before drying.

Storage practices associated with the production of cassava chips

For a number of reasons such as permanent availability and market purposes, all the respondents reported storing cassava chips. Farmers reported storage useful mainly as a mean for a permanent food reserve. In addition, farmers frequently stored for further sales when either prices were better, or they were in need of cash.

Storage generally took place indoors. Jute bags were the most common storage facility and adopted by 53% of the farmers in Yaoundé, 40% in Mbalmayo, whereas 16% of the farmers in Ebolowa reported storing their chips in the same way. Some farmers adopted a storage system in which plastic bags were inserted inside jute bags so as to prevent insects and mites from damaging chips.

Storage of cassava chips in plastic or aluminium containers was also common in all locations. Mbalmayo zone had the highest percentage of farmers who used containers as a storage system (35% of the farmers), compared to Ebolowa and Yaoundé. A few farmers preferred storage in closed containers so as to prevent dirty or extraneous materials such as insects and/or mites and their defects from infesting their chips. Another storage option was storage over the fire place. This method was mostly applied to balls. It was of common usage in Ebolowa zone with the largest percentage of the farmers (32%) storing their chips this way.

Qualitative aspects associated with stored cassava chips

One of the survey objectives also was to assess changes

Table 3. Percent[1] of interviewed farmers that identified damages on cassava chips in storage and the preventive actions taken in southern Cameroon.

Block	Identified causes (%)								Preventive actions (%)		
	Insufficient drying	Inadequate storage	Infected roots from fields	long drying of chips under sun	Long storage of roots before processing	Smoke effect	Improper processing	Insects	Sun-drying	No action	Smoking
Yao	44	10.7	16	9.3	8	2.7	4	13	69.3	22.7	8
Mba	36	13.3	9.3	17.3	10.7	2.7	2.7	8	69.3	20	10.7
Ebo	46.7	8	9.3	6.7	10.7	10.1	0	8	44	13.3	44
Mean %	**42.2**	**10.7**	**11.5**	**11.1**	**9.8**	**5.2**	**2.2**	**9.7**	**60.9**	**18.7**	**20.9**

Legend: Yao: Yaoundé; Mba: Mbalmayo; Ebo: Ebolowa; 1 = Data computed from a set of 68 informants in Yaoundé, 59 in Mbalmayo, and 58 informants in Ebolowa who reported to be aware of dark spots on stored chips.

in quality of cassava chips while in storage. Overall, alterations on stored cassava chips were reported by 82% of the respondents whereas 18% did not. Table 3 shows the percentage of interviewed farmers who reported damages of their chips and the preventive actions taken. Insufficient drying, inadequate storage, long drying under sunlight of cassava chips and the presence of insects and mites in the stored chips were more often cited. The use of infected cassava roots by plant pathogenic microbes from the field, prolonged storage of roots before processing, and improper processing methods were also reported. Most of these factors probably originate from processing practices, with only one originating however from the field (use of infected roots).

Forty-two percent of the farmers overall reported that insufficiently dried cassava chips were highly susceptible to damage and to discoloration when stored. A second group of farmers representing 12% of respondents believed that dark spots often observed on stored cassava chips could originate from diseased or infected cassava roots from the fields. Typically, pathological damages were reported by farmers to be apparent on cassava roots and the affected roots were often discarded at harvest. However, even after sorting, some farmers reported that quiescent infections could lead to subsequent development of these pathogens during the processing process.

Likewise, 11% of the farmers in the benchmark reported that a wide range of discoloration observed on stored cassava chips are caused by excessive drying under sunlight. According to them, exposure of cassava chips to excessive sunlight for a prolonged period could result in sunburn of the chips, thus leading to browning.

Farmers also reported feeding by a diverse array of insects and mites as a cause of undesirable alterations often associated with cassava chips' appearance. Insects' damages were apparent by holes they created on chips (Table 3).

Preventive measures used by farmers to avoid damages of stored cassava chips

Among the remedies used to cope with alterations of stored cassava chips, sun re-drying was used as a preventive measure by the majority of farmers. This method was reported by 61% of the informants overall. A second category of farmers reported to keep their chips dried over the fire place as a preventive measure against insect damages and dark spots. This measure was more widespread in Ebolowa by 44% of farmers (Table 3). Inno location did farmers report using chemical treatments as a preventive or corrective action against damages caused on cassava chips by insects or mites.

Production constraints

When questioned on the problems they faced in chips production, the farmers highlighted pests and diseases, lack of market, tedious nature of chips processing, inadequate cassava roots, high costs of labor, lack of labor, inadequate credit, and decrease in soil fertility as the main constraints associated with this activity. Most of these constraints were connected with either the conditions of their fields (pests and diseases or decrease in soil fertility) from where cassava was harvested, or market and processing outlets.

When asked to rank what they perceived as the most important constraints, pests and diseases

Table 4. Constraints in cassava chips production in southern Cameroon.

Constraints	Yaoundé		Mbalmayo		Ebolowa		Total	
	# of farmers	%	# of farmers	%	# of farmers	%	# of farmers	%
Pests and disease	29	38.7	38	50.7	36	48.0	103	45.8
Processing is tedious	19	25.3	9	12.0	11	14.7	39	17.3
Lack of the market	16	21.3	20	26.7	22	29.3	58	25.8
Low yields	7	9.3	4	5.3	2	2.7	13	5.8
High costs of labour	1	1.3	0	0.0	0	0.0	1	0.4
Inadequate roots	2	2.7	3	4.0	4	5.3	9	4.0
Inadequate credit	1	1.3	1	1.3	0	0.0	2	0.9
Total	**75**	**100**	**75**	**100**	**75**	**100**	**225**	**100**

were ranked as the main problem facing almost 47% of the respondents in the benchmark. Farmers were of the view that no chips could be produced if cassava plants could not yield adequate roots as a result of pests and diseases attacks in their fields. Farmers from all the locations visited frequently reported root rots, yields of tiny roots, wilting of stems or other plant parts as adverse effects of pests and diseases. However, the common pests well known to farmers as cited by 71% of them overall were small insects often found in association with red ants on cassava roots. These small insects locally called either Kop in Yaoundé and Mbalmayo blocks or Zamgola in Mbalmayo and Ebolowa blocks, and scientifically referred to as the “cassava root mealybug” (*Stictococcus vayssierei* Richard) (Homoptera: Stictococcidae), were reported to be seen feeding on stems or roots of cassava mostly during the dry season.

The second most important constraint highlighted by 26.7% of the farmers in the benchmark was related to market constraints. Market related constraints were reflected in the form of the lack of a reliable market in which farmers could sell their produce. Market constraints were also connected with the absence of good road infrastructures in some locations, resulting in high costs of transportation with subsequent poor returns on sales of their produce (Table 4).

DISCUSSION

Results of these surveys have shown that the production of cassava chips is widespread and mainly carried out by women in the investigated areas. With regards to processing, the practices locally associated with the production of chips involved one form of fermentation or the other. These practices are believed to improve the palatability of cassava roots and to reduce their potential toxicity after processing (Ayodeji, 2005; Essers, 1995; Oyewole and Odunfa; 1992). Previously, Hahn (1993) and Blanshard et al. (1994) raised concerns on the hygiene and safety associated with chips resulting from such processes, arguing that fermentation practices always enhance an abundant mould growth among which toxigenic fungi during the soaking step of chips production.

The fact that more than 80% of interviewed farmers reported spots on stored cassava chips implies that an important quantity of this food commodity could be of poor quality after storage and when sold and/or consumed. In this study, several factors were identified as causes of low quality of stored cassava chips, but it was apparent from farmers’ responses that their insufficient drying was the most important factor accounting for their spoilage.

Although the respondents were able to predict damages occurring in stored cassava chips, preventive measures to avoid such damages were somewhat limited and mostly consisted of their re-drying under sun. Accordingly, and even when insects and mites were cited by some farmers as causes of chips spoilage, none among the farmers who gave this reason, reported using chemicals to control adverse effects of insects and mites on cassava chips. This lack of interest in the use of chemicals by farmers may have different explanations. Firstly, this may be due to the hazardous nature of chemicals as the farmers stated. Farmers were of the view that chemicals should be avoided in food products intended for human consumption. A second reason may be related to the fact that cassava is cultivated and processed into chips in the investigated areas mainly by subsistence farmers who have low income and therefore lack money to purchase agricultural inputs such as pesticides.

During surveys, farmers highlighted eight different types of constraints associated with the production of cassava chips, but pests and diseases, although not directly involved in the processing activity, represented the most important constraint, as a result of their connection with cassava availability and supply for subsequent chips production. In the three locations surveyed, only the cassava root scale *Stictococcus vayssierei* Richard (Homoptera: *Stictococcidae*) called Kop or Zamgola depending on locations, was viewed by the farmers as the most serious pest problem of the field. This may imply that losses due to microbial diseases might be very limited or more likely, that the losses or symptoms observed on cassava in the fields were not properly diagnosed by farmers. During the course of this work and under farmers' requests, some fields were visited and surveyed for pests and diseases occurrence (data not shown). From personal observations, several types of damages and symptoms were observed but there was no evidence that these were due to a single organism attack.

The high level of importance attached to pests in their fields seems to be a common feature of rural farmers. In similar investigations dealing with surveys on pests and diseases associated with rice-based systems, Litsinger et al. (1982) also reported that farmers in the Phillipines raised concerns about health problems associated with rice in their fields, but had a poor classification of their causal agents and tended to cite only those pests they could see. In this respect, this raises the question as whether the incidence of *S. vayssierei*, which is reportedly important (Lema et al., 2004; Ngeve, 2003; Anonymous, 1995) and easy to observe, was not exaggerated when compared to diseases which are somewhat difficult to diagnose.

From the results of the present study, several observations can be made. The first one acknowledges the importance of cassava chips in the diet and income generation of farmers in the households sampled. This observation is in line with previous outcomes obtained by Nweke (1998), when he conducted a research on cassava food systems in several sub-Sahara African countries. Additionally, although the use of chips in the production of local alcoholic drinks could be viewed as an important feature in cassava transformation, the study indicates that there were few cases of the use of cassava in industry related processes such as gum making and starch manufacturing from cassava, suggesting that the potential industrial utilization of this food crop and its derived products is not yet fully exploited in the investigated areas. The third remark is related to the differences reported in the wide array of practices used in the production of cassava chips. Some of the methods employed by the farmers, for example, the use of ferments, although reported helpful by some farmers in some particular stages of the cassava transformation process, are likely to bring about contamination of chips by microbes that are harmful to the health of consumers. This suggests that a study related to the safety of stored cassava chips is necessary in view of assessing the extent to which this food commodity may be contaminated by toxigenic microbes (bacteria and/or fungi), taking into account the production practices implemented and storage facilities used by individual farmers in the investigated areas. In all respects, however, the most important observation that can be drawn from the present study is related to farmers' statements about the constraints they faced in cassava chips production. Their perception of pest and diseases as the main constraint related to this activity is suggestive that cassava may not be a disease tolerant crop as commonly reported in some studies (Onyeka et al., 2005; Msikita et al., 2000; Cock, 1985).

ACKNOWLEDGEMENTS

The authors are grateful to the African Union commission (AU) through the African Center for research and Phytosanitary training (ACRPT) for having funded the academic part of this research. The Plant Health Management Division (PHMD) of the International Institute of Tropical Agriculture (IITA) provided financial and logistic support to the first author during surveys. The contributions of Drs. Peter Neuenschwander, Manuel Tamò, and Ousmane Coulibaly were very important and acknowledged with many thanks in this respect.

REFERENCES

Aduni UA, Ajayi OA, Bokanga M, Dixon BM (2005). The use of cassava leaves as food in Africa. Ecol. Food Nutr. 44(6): 423-435.

Anabolu AO, Oluwole OSA, Bokanga M, Rosling H (2001). Ecological variation of intake of cassava food and dietary cyanide load in Nigerian communities. Pub. Health Nutr. 4(4): 871-876.

Anonymous (1989a). COSCA (Collaborative Study on Cassava in Africa), 1989. Nweke FI, Lynam J (eds.). Status of data on cassava in major producing countries in Africa. COSCA working paper N° 3.

Anonymous (1989b). COSCA (Collaborative Study on Cassava in Africa). Carter SE, Jones PG (eds.). Site selection procedure, COSCA working paper N° 19.

Anonymous (1992). COSCA (Collaborative Study on Cassava in Africa). Ugwu BU, Ay P. (eds.). Seasonality of cassava processing in Africa and tests of hypothesis. COSCA working paper No 6: 23.

Anonymous (1995). Plant Health Management Division (PHMD). Annual report, p. 181.

Anonymous (1996). EPHTA (Ecoregional Program for Humid and Tropical Africa) 1996. IITA dans les villages: quelques données de l'enquête agricole dans les villages de recherche, p. 11.

Anonymous (2006a). Programme National de Développement des Racines et Tubercules (PNDRT), 2006. Rapport Annuel d'activités 2005, p. 118.

Anonymous (2006b). Ministère de l'Agriculture et du Développement Rural (MINADER). Division des enquêtes agro-économiques et des statistiques agricoles (DEASA). Rapport annuel d'activités pour la campagne agricole 2005. 217pp.

Ayodeji OF (2005). Nutrient composition and processing effects on cassava leaf (*Manihot esculenta*, Crantz) antinutrients. Pak. J. Nutr. 4(1): 37-42.

Blanshard AFJ, Dahnya MT, Poulter NH, Taylor AJ (1994). Quality of cassava foods in Sierra Leone. J. Sci. Food Agric. 64(4): 425-432.

Bokanga M (1996). Biotechnology and cassava processing in Africa. IITA Res. 12: 14-18.

Bradbury JH, Egan SV, Lynch MJ (1991). Rapid screening assay of cyanid content in cssava using acid hydrolysis of cyanogenic glucosides. J. Sci. Food Agric. 55(2): 277-290.

Cock JH (1985), Cassava. New potential for a neglected crop. Westview Press, Boulder, Colorado and London. (Praeger FA ed.), p. 191.

Essers S (1995). Removal of cyanogens from cassava roots: Studies on domestic sun-drying and solid-substrate fermentation. PhD thesis Agricultural University of Wagenigen. 131 pp.

Favier JC (1977). Valeur alimentaire de deux aliments de base africains: le manioc et le sorgho. Travaux et documents de l'ORSTOM, Paris, France. 122 pp.

Grizotto R, De Menezes HC (2002). Effect of cooking in the crispness of cassava chips. J. Food Sci. 67(3): 1219-1223.

Hahn SK (1993). Méthodes traditionnelles de transformation et d'utilisation du manioc en Afrique. Guide de recherche de l'IITA (41) : 45.

Hahn SK (1989). An overview of African traditional cassava processing and utilization. Outlook Agric. 18(3): 110-118.

Kehinde AT (2006). Utilization potentials of cassava in Nigeria: The domestic and Industrial Products. Food Rev. Int. 22(1): 29-42.

Khampa S, Wanapat M (2006). Supplementation levels of concentrates containing high levels of cassava chip on rumen ecology and microbial protein synthesis in cattle. Pak. J. Nutr. 5(6): 501-506.

Kobawila SC, Louembe D, Keleke S, Hounhouigan J, Gamba C (2005). Reduction of the cyanide content during fermentation of cassava roots and leaves to ptoduce kikedi and Ntoba mbodi, two food products from Congo. Afr. J. Biotechnol. 4(7): 689-696.

Laswai HS, Silayo VCK, Mpagalile JJ, Balegu WR, John J (2006). Improvement and popularization of diversified cassava products for income generation and food security: A case study of Kibabu. Afr. J. Food Agric. Nutr. Dev. 6(1): 1-15.

Lema KM, Tata-Hangy K, Bediaka M (2004). Management of African root and tuber scale using improving cassava genotypes and mineral fertilizers. Afr. Crop Sci. J. 12(3): 217-222.

Litsinger JA, Canapi B, Alviola A (1982). Farmers perceptions and control of rice pests in Solana, Cagayan valley, a pre-green revolution area of the phillipines. Philippines Entomol. 5: 373-383.

Msikita W, Braima J, Nnodu E, Legg J, Wydra K, Ogbe F (2000). Disease control in cassava farms : IPM field guide for extension agents. International Institute of Tropical Agriculture (ed.), Wordmithes Printers, Lagos, Nigeria, p. 15.

Ngeve JM (2003). The cassava mealybug (*Stictococcus vayssierei* Richard) (Homoptera: Stictococcidae): a threat to cassava production and utilization in Cameroon. Int. J. Pest Manage. 49(4): 327-333.

Nweke FI (1998). The role root crops in poverty alleviation in Africa. Root crops and Poverty alleviation. In: Proceedings of the 6th triennal symposium of the International Society for tropical root crops, Africa branch. 102-110.

Nwokoro SO, Vaikosen SE, Bamgbose AM (2005). Nutrient composition of cassava offals and cassava sievates collected from locations in Edo state, Nigeria. Pak. J. Nutr. 4(4): 262-264.

Onyeka TJ, Dixon AGO, Ekpo EJA (2005). Identification of levels of resistance to cassava root rot disease (*Botryodiplodia theobromae*) in African landraces and improved germplasm using *in vitro* inoculation method. Euphytica. 145(3): 281-288.

Osho SM, Dashiell KE (2002). The processing and acceptability of a fortified cassava based product (gari) with soybean. Discov. Innov. 14(3): 186-191.

Oyewole OB, Odunfa SA (1992). Extracellular enzyme activities during cassava transformation for “fufu” production. World J. Microbiol. Biotechnol. 8(1): 71-72.

Solomon A, Sudip KR (2004). Effect of dry cassava chip storage on yield and functional properties of extracted starch. Starch. 56(6): 232-240.

Zhou HM, Nzigamasabo A (2006). Traditional Cassava Foods in Burundi - A Review. Food Rev. Int. 22(1): 1-27.