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High quality cassava flour, promising raw material for bread, biscuit and pastry industries: lessons from a pilot study in Madagascar

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Abstract

Cassava is the second most important staple crop in Madagascar after rice, in term of production volume and area cultivated. Traditional cassava processing techniques are rudimentary and provide insignificant market opportunities to the smallholder cassava farmers. On the other hand, market survey showed that the high price of wheat flour in the retail market high, 0.9 to 1.08 US$ per kg, and bakers desired a substitute raw material. The potential market demand for High Quality Cassava Flour (HQCF) by local bakeries, a biscuit factory, and the caterers in Antananarivo was about 9,400 tons a year. A project to vertically integrate the cassava sector through the processing and supply of HQCF to bakers was implemented in Madagascar from 2003 to 2007. The HQCF technology was introduced at pilot-scale to farmers in Ambatomanoina locality of Madagascar. The technology introduction was accompanied with training of farmers in all aspects of business enterprise management. The pilot farmers produced 24.3 tons of high quality cassava flour a month from the first year. Annual cost of production for HQCF was estimated at US$ 17,328. Profitability analysis revealed profit about US$ 18,783.

Keywords: Cassava, high quality cassava flour, profitability index, French bread, biscuit, pastries.

Introduction

The cassava is the second most important staple crop after the rice in Madagascar. Annual production and area harvested are 2.4million tons and 357,370 ha per year respectively while the total value of cassava produced in 2007 was about US$173 million (FAO, 2009). In the past, cassava was a neglected crop considered as food for poor. During the last 15 years, the attention of Malagasy government was draw to the importance of through the research and development work on cassava by the regional networks such as the East African Root and Tubers Network (EARRNET) and Postharvest and Marketing Research Network for Eastern and Central Africa (FOODNET). Political support for the development of cassava has therefore been strong and national taskforce was formed to further popularize cassava production and utilization in Madagascar (UPDR, 2008). In line with government objectives of increasing the utilization of cassava, a pilot test was carried out in Madagascar with a group of smallholder farmers, processors and a biscuit factory from 2004 to 2007 to evaluate the technical and economic feasibility of the high quality cassava flour technology (HQCF) developed in 1995 by the International Institute of Tropical Agriculture (Abass et al, 1998, 2009). A market led approach was used to establish link between smallholder cassava farmers, new generation of cassava processors in Ambato-manoina village using the new processing technology and machinery, end-users of the HQCF and marketers who are based in Antananarivo, the capital of Madagascar. The lessons from the pilot activities were used by the national project implementation agencies for policy advocacy, strengthening of the cassava sector through supports to all categories of stakeholders along the cassava value chain, dissemination of results and out-scaling. This paper reports the organization of the pilot activities, results obtained and the lessons learned during the pilot testing.

Methodology for pilot plant set-up

The technology for production and use of HQCF was new to Madagascar. There were no processors of HQCF, and bakers had no knowledge of use of HQCF for baking. A step-wise approach was adopted for the establishment of the pilot operation in a village near Antananarivo to ensure market access by the smallholder processors since more than 92% of total wheat imported is utilized for baking bread and biscuits, and for making pastries and the largest number of bread bakers, caterers and the main biscuit factory in Madagascar are located in Antananarivo. The steps include an analysis of the cassava value chain and the market. Information from the analyses was used for the strategy formation. The strategy formulation involved *i*) sensitization of smallholder farmers on the need to develop their capacity to process the highly perishable cassava into an easy to store commodity that meets the quality and quantity requirements of end-users, *ii*) importance of and group formation, *iii*) sensitization of potential end users and market formation, *iv*) partnership building for pilot system set-up, *v*) training of farmers, processors and end-users, *vi*) marketing strategy development and market linkage, vii) fostering of relationships between processors and end-users. The lessons from the pilot activities were used by the national project implementation agencies for policy advocacy, strengthening of the cassava sector through supports to all categories of stakeholders along the cassava value chain, dissemination of results and out-scaling.

Analysis of the cassava value chain, market analysis

A study by Mbwika (2000) to gain an understanding of what was the status of the cassava industry in Madagascar in order to identify the technological and policy environment in which the sub-sector operates, information gaps and constraints in the sub-sector, opportunities for immediate investment and research programming found that cassava is grown all over Madagascar. It is the main staple food in the Southern parts. About 70% of cassava produced in Madagascar is consumed directly at home by the smallholder producers, 16% is marketed, and 11.5 % is used as food reserve and 3% as animal feeds. Previous studies showed that during the colonial days, cassava was a cash crop mainly grown as a plantation crop and processed into cassava chips, which were exported to Europe for manufacture of animal feeds. Cassava is now a smallholder crop intercropped with beans and considered a poor man's food crop. Cassava mosaic disease, lack of clean planting material, poor agronomic practices, limited processing technologies and lack of market have been identified as major constraints of cassava in Madagascar leading to a decline in total production. Marketing of cassava is largely unorganized. The limited processing technologies and labor intensiveness at the home/ cottage level contributes to the limited market access after the collapse of export oriented processing plants. The main stakeholders in the cassava sector were identified as farmers, household processors and traders of dried chips, flour, crisps and starch.

Secondary stakeholders include; NGOs, researchers, extension agents, root-crop networks, donor agencies and policy makers. However, links between these stakeholders, particularly between producers and potential users of cassava based products such as the livestock feed industry, pharmaceutical industry, and flour millers were not established. Cassava has a relatively higher potential to feel the food supply gap in Madagascar due to its high food yield. Although cassava occupies only about a third of the area occupied by rice, its production is more than half of rice. The predominant processing of cassava in Madagascar is through sun-drying of the peeled or unpeeled roots and milling to flour which is sold in local markets by retail traders and used for preparation of different dishes and products. Processed products of cassava compete in market with products from cereals but lowering costs of production is a key factor in enhancing their competitiveness. The virulent form of cassava mosaic disease is devastating cassava production in Madagascar. However, there were only two agencies involved in the multiplication of planting materials in few locations in Madagascar. These were Care International in collaboration with FOFIFA and in Mid-West by PMMO. The major challenge in the promotion of high-yielding technologies for cassava is the lack of market to absorb excess production. At the same time, a number of industries expressed interest in use of cassava in their production processes. However, the level of potential demand for cassava products in the industry and the consumer perception of use of cassava in industrial products were not established as was done in Uganda, Nigeria and Ghana where the quality of cassava raw materials and consistency of supply have been established to be constraints in the industrial use of cassava starch and flour (Abass et al 1998; Graffham, *et al*., 1999). Research into appropriate processing technologies for increasing the quality of cassava products and their shelf life have been requested in Madagascar (Mbwika, 2000). Policy measures that give recognition to cassava as both a food crop and commercial crop were identified as a way to increase market for cassava. These was to encourage food processing industry such as flour millers and confectionery manufacturers to get involved in the use of cassava products, sale in supermarkets and in retail outlets in ready to cook/eat forms.

Previous attempts to link farmers with potential markets were not successful, the potential market demand for cassava, the quality and the type of products needed by each market segment were not established. The negative image of cassava among some social groups as a poor man's food contributes to its poor acceptance as a suitable raw material by some end-users. The problem is further compounded by the poor policy support and lack of public awareness on the importance of cassava. There were also concerns about nutritional value of cassava and the potential negative health effects cassava foods could cause due to residual cyanide if not properly prepared. The bulkiness of cassava and poor road and transport infrastructure hinders marketing efficiency. Processing technologies that minimize the processing time and reduce the bulkiness of cassava are needed to increase utilization and improve marketing efficiency, particularly if the technologies would increase the range of cassava products, enabling consumers to have a wide range of choices.

Strategy formation and pilot operation

Sensitization of smallholder farmers, group formation, and partnership building for pilot system set-up

Ambatomanoina village was selected to establish the pilot activity because of the nearness to Antananarivo; it is located northeast of Antananarivo, has the highest number of smallholder farmers and is the largest cassava producing village around Antananarivo. Annual cassava production in Ambatomanoina village is up to 44,000 tons annually. A group of twenty resource poor farmers, Cooperative Aintsoa, was selected at Antananarivo village for the pilot testing of HQCF technology. The farmers were sensitized on the potential benefits of processing cassava into novel products for use by a diverse range of end-users. Partnerships were formed with national and international institutions, NGOs, etc to establish the pilot processing plants. The Ministry of Agriculture leased a building to the farmers' group to be used as processing center. The building, 180 m^2, was designed and renovated to have an office (3.8 x 3.8 m^2), peeling and processing area (150 m^2) including a washing basin (0.5 m^3); and a store (6.0 x 4 m^2). A deep well was dug by Rano Fisotro Fidiovana (RFF). Processing machines, a grater, press, and mill were installed and the maintenance was handled by Ecole Supérieure Polytechnique of Antananarivo. An extension office from the Ministry of Agriculture was responsible for coordination of most of the activities

Training of farmers and processors

The twenty (20) members of Cooperative Aintsoa were trained on high quality cassava flour processing, quality assurance and hygiene as described by Onabolu *et al* (1998) and Dziedzoave et al (2006). Pilot operation for processing fresh cassava to HQCF was initiated by helping processors to get used to the manufacturing process including the use and cleaning of processing equipments, training to optimize processing operation targeting the installed capacity of 20 tons HQCF per month (Figures 1 & 2). Selected members of the group were trained on food factory management, covering bookkeeping, how to maintain the machines, yield calculations, raw material handling, factory cleaning/hygiene, personal hygiene, etc. The pilot farmers were also trained on basic principles of business management, market identification, entrepreneurial skills, leadership, business ethics, business planning, marketing, record keeping, costing and pricing. In order to increase product quality, the group was also trained on product quality, grading, and food standards. The book on "Methods for Assessing Quality Characteristics of Non-Grain Starch Staples" (Bainbridge, et al 1996)" was made available by the Natural Resource Institute and used for setting up quality control measure for HQCF at the pilot centre.

Figures 1 and 2: Small-scale processing of HQCF

Ensuring consistent supply of fresh cassava

The East Africa Root-crop Research Network (EARRNET) and the pilot group in collaboration with the extension service of Ambatomanoina established a cassava multiplication site. Sixty (60) new IITA clones were planted on a farm owned by the corporative group near the pilot center with the objectives of selecting the most adapted variety for Ambatomanoina and appropriate for HQCF processing. Ambatondrazaka, one of the IITA cultivars adapted to Madagascar was one of the disease tolerant clones multiplied on the farmers' field. At evaluation, nine clones gave higher yields compared to the local land races and have more tolerance to diseases. The clones were TMS 40160 P6-1, TMS 85/00066, TMS 84776, TMS 81/00110, TMS 91934, and TMS 31/01635. The selected clones were replanted on the farm to serve as both a source of planting materials for more individual farmers and a model for commercial planting material production in order to solve the problem of lack of planting materials.

Sensitization of potential end users, training and market formation

In order to increase market opportunity for HQCF, bread bakers needed to be convinced about suitability of HQCF for bread baking with the hope that demand for the products would thereby be created. Three trials on bread baking with cassava flour (15% of substitution) and training of bakers on how to use HQCF were carried out with a local bakery called Boulangerie d'Avaradrano with the participation of members of Association des Boulangers Professionnels (bakers association). Loaves of bread baked were used to determine the perception of bread baker on the use of HQCF.

Marketing strategy development and market linkage through fostering of relationships between processors and end-users

Meetings were organized between farmers, processors and potential end-users. The meeting enabled the farmers' group (Cooperative Aintsoa) and the end-users, Biscuiterie JB and Association des Boulangers Professionnels, to discuss all issues relating to cassava flour production, quality, supply, prices and payment systems. Bread and biscuit bakeries were willing to accept the HQCF as a raw material because the high price of wheat flour while the government pegged the price of loaf of bread at about US$ 0.1. Consequently, bread bakers have reduced loaf volume to the disappointment of consumers, which resulted to low demand. As a marketing strategy, the price of HQCF was set at maximum of 75% of the price of hard wheat flour used for bread baking. The farmers' group was of the opinion that members would be comfortable if they were able to sell HQCF at about 1,000 Ar (US$0.5) which is 62.5% of the price of bread flour 1,600 Ar (US$0.8). The collaborating biscuit factory, BISCUITERIE JB, had use wheat flour for biscuit baking wafer manufacture. 1-2 t of wheat flour (8-10% protein, 9% gluten) was used daily for wafers while 8-10 t/day of soft wheat flour was used for biscuits. Baking tests were done with the biscuit factory to determine potential inclusion rates. Test results showed that wheat could be substituted with cassava in the two product lines up to 25%. Hence the company planed to use 2-4 t HQCF in wafers and 10 t in biscuits per month.

Profitability analysis of small scale processing of cassava to HQCF

In order to fully evaluate the economic viability of the pilot operations, data collection at the pilot processing center, from farmers supplying fresh cassava to the plant and traders around the pilot area was undertaken by the Département Industries Agricoles et Alimentaires of l'Ecole Supérieure des Sciences Agronomiques d'Antananarivo. The techniques used for the economic feasibility study has been described by Abass *et al* (2009).

Results and lessons learned

The estimated potential market in Antananarivo was about 9,400 tons a year (Anonym, 2006). Bread bakers and biscuit factories are the main users of wheat flour. In fact, the Institut National des Statistiques showed that the average consumption of French bread by Malagasy was 50 g per day (INSTAT, 2007). Therefore substitution of wheat with HQCF would add value to cassava, to create jobs and to save foreign exchange for Madagascar.

The small-scale HQCF processing technology was easily adaptable by the pilot farmers. The production capacity of the processors grew from 1 ton fresh root (250kg flour) daily during the first month to 8 - 10 tons per day before end of first year. The characteristics of the high quality cassava flour produced by the pilot farmers/processors include 160 μ particle size, 10-15% moisture and less than 10ppm cyanogens.

Profitability analysis of the pilot operation shows that the total capital investment was US$ 5,680 which includes steelyard, cassava grater, press machine, flour milling machine, water supply system, renovation, etc. The total investment for 10 years periods which includes the maintenance and an interest (10% p.a) was US $ 11, 928 (Table 1).

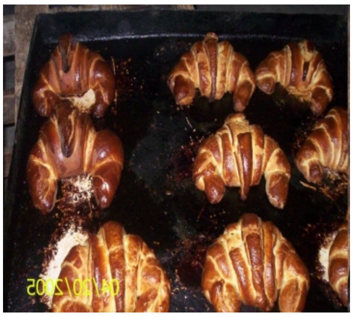
Table 1: Profitability and return to labour for intermediate processing, for 10 years with 250 tons of high quality cassava flour per year.

	Cost US $
Initial investment	
Equipment	1,680
Grating	780
Dewatering	900
Building and store	4,000
Total investment for 10 year period	5,680
Maintenance	568
Interest (10 years 10 % p.a)	5,680
Grand Total investment 10 year period	11,928
Annual cost of production	
Fixed cost, depreciation, interest per year	1,193
Labour cost	0.361
Raw material procurement	11,111
Diesel	1,165
Water	0.116
Bags	1,111
Interest on bank overdraft (19% p.a)	2,748
Annual cost production	17,328
Cost of delivery (cost/ton)	5,555
Cost delivery	22,883
Sales price, marked based	41,666
Profit/loss, incl. labour	18,783

The fixed cost, the depreciation and the interest per year were US$ 1,193; the labour cost was evaluated about US$ 0.361. The raw material procurement was estimated about US$ 11,111; while the others costs (fuel, water and bags) were assessed about US$ 3,913. The annual profit in taking account loss and labour was US$ 18,783 (Table 1).

Perception of bread bakers on use of cassava

The trials of utilization of HQCF as substitute for wheat flour in French bread and biscuit baking and wafers production showed encouraging results. Twenty three (23) bakers were involved in the bake tests. Loaves of bread were made at one of the members' bakery (Boulangerie d'Avaradrano) using 10% HQCF in wheat flour (Figures 4, 5 and 6). A taste panel made up of the bakers was constituted to evaluate the cassava-wheat bread samples: 13.04% of the bakers scored the loaves very pleasant, 52.15% pleasant, 26.08% pleasant enough, and 9.73% no comment.



Figures 4, 5 and 6: French breads, pastry products and biscuits made with HQCF substitution

For biscuits, previous study by Ranaivoson (2000) showed that while 100% HQCF biscuit made with addition of ginger, sugar, powder milk, and vegetal butter was not acceptable to Malagasy tasters, the biscuit was acceptable to foreign tasters (5%). During the current industrial test, biscuits baked with 25% and 50% HQCF and wafers made with 10% HQCF were acceptable to the taste panel (Figure 7). Shortly after the industrial testing, the biscuit factory and bread bakers in Antananarivo began to order for 10-15 t HQCF per month from the pilot farmers. Eight bakeries in Antananarivo have requested for up to 425 tons HQCF per year while pastries makers in Antananarivo might require even more.

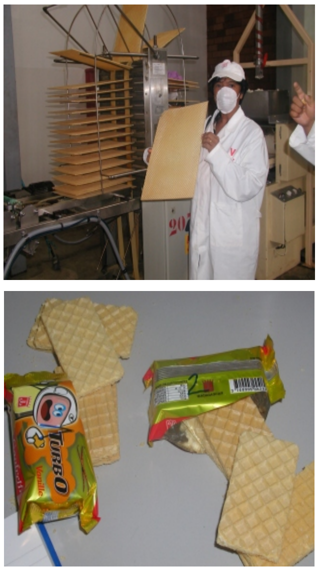


Figure 7: Wafers made with 10% HQCF substitution

Challenges

Although well made HQCF was acceptable for bread, biscuit and wafers manufacture, the quality of HQCF was found to be negatively affected by the sun-drying technique. Inadequate sun-energy led to insufficient drying while the HQCF is also contaminated by wind and honey bees, which were found to always invade wet cassava grits during drying. Microbial analysis of a batch of cassava flour produced in Dec 2004 and kept till March 2005 showed that the flour had high loads of microbes. HACCP was carried out to determine sources of contamination, the water source and drying were found to be responsible. On the basis of this experience, the biscuit/wafer factory insisted that a new system of drying must the used to ensure that the microbial load of the HQCF to be supplied to the company would remain low.

Information dissemination andout-scaling

Although few challenges were encountered in the implementation of the pilot activities on HQCF in Madagascar, the activities were successful (http://www.common-fund.org/ Projects?Project_id=3; http://www.common-fund.org/News?news_id=84).

Several policy makers (Senators, Deputies, Mayors, Special Delegation President) were sensitised about the potential of cassava as income generator for farmers through processing and supply of HQCF to the baking industry. Training on cassava processing and products development was requested by many policy makers for more groups of processors and end-users across Madagascar. Project experience was shared in different scientific meetings, through newspapers articles, radio program of the extension radio service of the Ministry of Agriculture, and discussions with the private sector. Handbills, posters and a short video titled: The high quality cassava flour of Ambatomanoina were also made and distributed widely. The development of standard for HQCF was identified as critical to improve the image of cassava with end users and to ensure acceptance by the bread bakeries and biscuit factories. In order to further enhance the confidence of end-users to adopt HQCF, collaboration was established with the Bureau de Normes des Madagascar to develop standards for HQCF. Other national institutions and projects, such as the MCA-Madagascar have identified and assisted more cooperative groups to utilize HQCF in biscuit baking, in pastries and mayonnaise production.

Conclusion and Recommendation

The HQCF is a promising raw material for bread bakers, food factories and pastry makers in Madagascar. Majority of poor rural farmers can benefit from a national adoption of HQCF as import substitute for imported raw materials like wheat, starch, etc. On the basis of 10 % import substitution for wheat only, the HQCF could save Madagascar about US$ 5.4 million annually from foreign exchange expenditure. However, such benefits can only be derived with a systematic development of cassava production in Madagascar. Yields are low and the HQCF processing machinery still not known common. The targeted policy and investments to develop the cassava sector through the use of HQCF in the baking industry will benefit the population.

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Development and production of fermented flour from sweet potato (*Ipomea batatas L*) as a potential food security product

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Abstract
Yellow fleshed sweet potato (*Ipomea batatas L*) obtained from a local market in Nigeria was processed into fermented flour via the processes of washing and peeling, chipping (4-5mm thick), soaking in water for 0-96hrs, draining, dewatering, drying at 70^{0}C for 8hrs in a tray drier and milling into flour (= 250 micron). During the fermentation period, the microbial profile in the fermenting chips as well as the pH changes was monitored. The proximate analysis of the raw potato and the fermented flour were also determined as well as the pasting properties of the fermented flour proximate composition showed that the crude protein and starch content of the sweet potato flour were higher than in the raw sweet potato which were 4.27% and 34.56% respectively for crude protein and starch content in the fermented flour and 1.86% and 23.47% in corresponding sweet potato crops. However, the fat, crude fibre and ash content were significantly lower than in the raw sweet potato crops which were 0.21%, 0.06 and 1.78% respectively for fat, crude fibre and ash content in the flour with a corresponding value of 0.5% fat, 0.73% crude fibre and 2.52% ash in the raw sweet potato. The microbial profile in the fermenting sweet potato revealed that lactic acid bacteria were the predominant fermenting organisms apart from yeast and mould. Also, the pH in the mash reduced as the fermenting days increased while the microbial increased as the fermentation days increased. Pasting properties of the flour also showed that the peak viscousity was attained at 278.67 RVA with pasting temperature of 80.35^{0}C, pasting time of 5minutes, final viscousity of 391.58 RVA and breakdown