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A review of post-harvest activities for cassava in Tanzania

Mlingi N.V. and Ndunguru G.T.
Tanzania Food and Nutrition Centre, P.O. Box 977, Dar es Salaam Tanzania

Abstract. Post-harvest problems affecting cassava in Tanzania are high losses during marketing of fresh cassava and rudimentary processing technology. A needs assessment study identified reduction in income from post harvest losses as a major problem facing stakeholders involved in production and marketing of fresh cassava roots from rural areas to urban markets. The most suitable intervention identified to address the problem of fresh cassava root storage was adoption of the modified low-cost fresh cassava root storage technology originally developed by the Centro Internacional de Agricultura Tropical (CIAT) in Columbia and Natural Resources Institute (NRI) of U.K. The technology was tested in several villages in Coast region and two urban markets in Dar es Salaam, after which a flexible dissemination strategy was developed and applied to other villages between 1996 and 1998. Processing of cassava and other root crops into more storable forms offers an opportunity to overcome perishability of the fresh produce. Processing of cassava also provides a means of adding value to the crop. Cassava processing methods in Tanzania are varied especially in the four main cassava growing zones. The products obtained are always moulded, contaminated with sand and may contain high levels of cyanogens. This is because cassava processing methods are simple and do not result in tissue disintegration but leaves behind high levels of cyanogens in intact peeled whole or split roots. The most suitable processing method adopted in these zones since 1996 is chipping or grating of fresh cassava roots before obtaining flour. The flour is an intermediate product for various bakery, industrial and pharmaceutical products. Efforts to disseminate the technology were initiated and some villages in eastern and lake zones were involved.

Introduction

Cassava is a basic staple for hundreds of millions of people in the tropical and sub-tropical belts as well as being a feedstock for numerous industrial applications, including food, feed and starch (IFAD/FAO, 2001). It is a source of food security not because it can be grown on less productive land but because it is a source of income for producers. It is predicted that cassava will spur rural industrial development and raise incomes for producers, processors and traders in the near future. Cassava contributes to the food security status of the producing and consuming households. Urbanization in cassava-producing countries represents an opportunity for producers to produce cassava for a larger consuming population. This means that cassava markets for fresh roots and processed products can grow if the products are convenient and are in a more desirable form. Cassava products include flour, animal feeds, alcohol, starches for sizing paper and textiles, sweeteners, prepared foods and biodegradable products. The products are derived from a number of forms of cassava ranging from fresh leaves and roots to modified cassava starch.

Post-harvest handling of cassava begins the moment it is harvested. It ranges from simple uprooting/ lifting of the roots from the ground, ferrying them to the house for immediate consumption after cooking or subjected to sophisticated preparatory methods of processing into high quality food products. Processing of cassava and other root crops into more storable forms offers an opportunity to overcome perishability of the fresh produce resulting into safe, palatable and storable products (Lancaster *et al.*, 1982). It provides a means of adding value to the crop. For fresh cassava, processing is a means of stabilizing them to improve storage, increase shelf life and provide income generation opportunities especially for women in the rural areas (CPHP, 2000). Processing simplifies transportation of cassava products to the urban markets due to reduced water content and waste materials of the fresh roots.

Cassava processing and post harvest handling in Tanzania is still rudimentary. The methods employed are simple ones and are not efficient in removing cyanogens to safe levels (Mlingi, 1995). The processing methods can be categorized into:

i) Direct sun drying of peeled roots or root pieces for some days on platforms, roof tops or on some rocks in the field to obtain a product called *makopa*. This is the popular method practised in most cassava growing areas.
ii) Soaking in water for several days. During this period the roots undergo fermentation by submerging peeled or unpeeled roots. Subsequently, the product is sun dried.
iii) Heaping involves air or solid-state fermentation of peeled roots/ root pieces for some days.

Products obtained by the above mentioned methods are later pounded or milled into flour for making stiff porridge (*ugali*). The *makopa* product can alternatively be soaked in water and boiled in which oil, salt, tomatoes and onions are added and consumed. *Makopa* or the flour is used for brewing purposes in some communities.

Post-harvest research activities on cassava in Tanzania. National efforts to improve cassava post harvest handling started actively in early 1980s (Msabaha *et al.*, 1986; Shao *et al.*, 1988). Targets put forward on cassava post harvest by various research institutions in Tanzania are:

- Improvement of local processing and storage facilities for cassava,
- Conducting surveys on consumer demands for cassava,
- Establishing the effects of cyanogen residues in processed cassava products and
- Conducting socio-economic evaluations of improved cassava processing and storage.

Several activities were undertaken to achieve some of the above targets. Notable outputs from such activities were documentation of existing traditional cassava processing methods, determination of cyanogen levels in cassava products and health effects associated with consumption of insufficiently processed cassava (Mlingi, 1995). In all these activities no attention was given to handling of fresh cassava roots and their marketing.

From the 1990's attention on cassava post harvest research focused on four major areas namely:

i) Storage and extension of shelf-life of fresh cassava roots,
ii) Cassava product diversification in rural and urban areas,
iii) Improvement of cassava processing methods by introduction of cassava processing equipment such as graters, chippers, presses, etc.
iv) Identification of post harvest storage pests and diseases of cassava.

Low-cost fresh cassava root storage technology. A needs assessment study carried out in Dar es Salaam identified that reduction in income from post-harvest losses was a major problem facing stakeholders involved in marketing of fresh cassava roots from rural to urban markets (Ndunguru *et al.*, 1994). This was because of the perishability of cassava roots. The most suitable intervention identified to address the problem of the fresh cassava root storage was adoption of the modified low-cost fresh cassava root storage technology originally developed by the Centro Internacional de Agricultura Tropica (CIAT) in Columbia and Natural Resources Institute (NRI) of U.K. They developed a simple conservation strategy based on cassava root storage in polypropylene bags combined with water or chemical treatment to control secondary microbial (fungal) rotting. Storage of up to one month was achieved and this permitted the provision of fresh, high quality product to consumers.

The original CIAT/NRI technology involved harvesting and selecting high quality, relatively undamaged roots from low cyanide cassava varieties. The roots are washed or cleaned and then dipped or sprayed with a fungicide, thiabendazole which is widely used as a post-harvest treatment for banana and potato. The drained roots are then placed in polypropylene bags that are sealed. The respiration of the roots within the bag causes the relative humidity (RH) of the enclosed atmosphere to rise. The high RH in combination with a temporary holding of the bagged roots at high temperature causes root curing which promotes an extension of shelf life of the roots (CIAT, 1989).

The technology adopted in Tanzania was validated in Ghana by NRI in collaboration with the Ministry of Agriculture and Food to test its suitability in Ghana. In Tanzania it was tested in several villages in Coast region and two urban markets in Dar es Salaam by TFNC and NRI, after which a flexible dissemination strategy was developed and applied to other villages. In a case study carried out at the same time, it was shown that successful adoption of the technology would improve the quality of cassava reaching the urban consumers and contribute to poverty alleviation by improving the income generating potential of marketing of fresh cassava.

The technology involves a series of steps which link together to create optimal conditions for storage of cassava roots under field conditions. The steps include:

- Harvesting of cassava roots carefully with roots intact on the stem,
- Removing roots from the stem taking care to avoid wounding the roots,
- Separating damaged and undamaged roots,
- Using a sharp knife to make smooth cuts in damaged surfaces and allowing cut surfaces to dry before dipping roots in water,
- Pouring water into a large container and dipping roots in the water for about one minute,
- Putting wet roots into sacks,
- Tying sacks with string,
- Placing sacks on a platform of logs in the shade,
- Wrapping sacks with plastic sheets or sheets made from old sacks sewn together.

Dipping sound roots in water and maintaining them at high humidity for several days in the shade was shown to extend the shelf life of fresh cassava roots for seven to ten days without the necessity of using the fungicide (Ndunguru *et al.*, 1998). Before adoption of this technology, three storage trials were conducted to demonstrate the feasibility and potential of the cassava storage technology. One was on-station at TFNC to demonstrate the ability of high humidity and fungicide (thiabendazole) treatments to prolong the storage of fresh cassava roots for periods of one to two weeks, respectively. Later with the local wholesale agents, two further market-based demonstrations were carried out to show the effectiveness of different elements of the storage technology. A five-day investigation highlighted the contribution of shade to minimising the rate of cassava deterioration. Finally cassava traders were introduced to the concept of creating a cassava clamp using polypropylene sheets to conserve sacks of cassava in the open market.

Validation exercises demonstrated that low cost fresh cassava root storage technology has the technical and economic potential to alleviate post-harvest losses associated with marketing of fresh cassava and improve the incomes of those involved in the cassava marketing system (Ndunguru *et al*., 1998). This was shown in an economic study which demonstrated that as a consequence of using the technology, profits could be increased by as much as 16% for certain participants in the marketing chain (Mashamba, 1997). Key stakeholders were genuinely interested in adoption of the technology and were willing to cooperate and spend their own funds to promote the uptake of the technology.

Processing of high quality cassava flour. Adoption of low-cost fresh cassava root storage technology made it possible getting fresh roots to the urban consumers. The technology could also assure urban processors a good supply of fresh roots suitable for processing into high quality cassava flour for bakery and industrial purposes. This is because the increase in population and the trend in urbanization make it necessary to diversify cassava products and to maintain their appeal to consumers. Efforts to partially substitute wheat flour with indigenous crops such as cassava and yams have been made to minimize the expensive wheat imports. Studies done at the International Institute of Tropical Agriculture, Ibadan Nigeria and Katholieke Universiteit Leuven, Belgium demonstrated the possibility of baking bread with cassava flour using the same ingredients used in baking the conventional wheat bread. A method for producing high quality cassava flour suitable for baking was developed and this was adopted in Tanzania in 1993.

The method involves peeling the roots, washing and chipping in a manually operated chipper and sun drying on a black plastic mat. The loading density recommended is 2 kg/m^2 while the temperature at the mat surface could vary from 26.8 to 49.1^oC and the drying time range from 4 to 8 hours. The dried chips are milled and sieved through a 25 mm mesh size sieve. The flour obtained has moisture content of 8 – 12% and should be stored in air tight containers. With this kind of flour, a proportion of 20% cassava flour could be added to 80% wheat flour to make composite breads indistinguishable from 100% wheat breads (Omoaka, 1993).

The first training of baking cassava bread and other products such as biscuits, bread buns, cakes, chinchin, cookies, doughnuts and croquettes was conducted at TFNC where a number of staff were involved. The trained staff alternatively trained 15 women groups in Dar es Salaam and Coast region who in turn trained other women in their areas. All the baked products were subjected to sensory evaluation at various stages of product development. The degree of liking or disliking of the products by a cross-section of people from a wide range of income groups showed that cassava cake was most preferred, probably because of its sweet taste while the cassava starch bread was highly preferred. Comments from the taste panelists indicated that cassava-soy bread could be preferred when used with stews and sauces just like any other starchy staple food.

Cassava flour product diversification for income generation. In needs assessment studies in Lake zone (Thro, 1994; Rwiza *et al.*, 1995; Ndunguru *et al.*, 1998) women processors and market vendors expressed interest in increasing the range of cassava products. In collaboration with TFNC and ARI – Ukiriguru Mwanza, the Natural Resources Institute addressed this request under a Regional Technology Transfer Project on non-grain starch staples funded by the Department for International Development (DFID) of U.K. Various products such as doughnuts, chin-chin, croquettes, cakes and biscuits were prepared and tested for acceptability. This was carried out hand in hand with training of 75 individuals beside 138 trainers of others who were supported by Client Oriented Research (COR, 1998) programme for Lake zone and Southern Africa Root crops Research Network (SARRNET). Follow up activities on dissemination and uptake showed that there was demand for three products especially cassava doughnuts, chin-chin and cakes which warranted a dissemination phase during which several workshops were organized (Kapinga *et al.*,1998). To ensure sustainability of the diversification of cassava products, the dissemination package in Lake zone focused mainly on women, community groups and farmer research groups. The wide dissemination phase in the zone advocated networking and collaboration with other stakeholders especially NGOs, rural community based organizations, government projects and international agencies. About 509 women representing 82 community groups were trained to serve as trainers for others. In the follow up of technology transfer it was learnt that at least every one person trained, passed the knowledge to eight more people.

Technology and equipment for processing high quality cassava chips/flour. Technological package on the diversified use of cassava flour through product development went along with improved techniques on processing of high quality cassava flour. Chipping equipment address the constraint of drying during cassava processing (Van Oirschot *et al.*, 2001). The chipping equipment are either manually operated or motorized. Manual chippers on an average cost US $ 125 while motorised chippers cost around US $ 500. The manual chipper can on an average chip 69 kg/hour while the motorised one can chip 500kg/hour. The manual chippers were validated and many improvements made. These included stable structure, effective blades, adjustable blades to minimise gaps between blade and the feeder (Ngendello *et al.*, 2001).

In Lake zone different types of hand-operated chippers, graters and presses had earlier on been tested with farmers but were rejected because they were laborious. Other improved models by IITA/ESARC in Kampala Uganda were introduced and tested by 250 farmers in four districts. The equipment was highly accepted by farmers especially community groups. The quality of cassava flour obtained by these machines was compared to that processed by traditional methods. The cassava flour obtained was sold at Tshs. 250 compared to the price of Tshs. 80 – 90 normally paid for traditionally processed cassava flour. Farmers indicated the need to acquire the cassava processing equipment through credit systems (COR, 1998).

In Southern Tanzania, studies on rapid processing of cassava from bitter varieties were carried out by TFNC in collaboration with Natural Resources Institute of U.K. The technology was introduced in four pilot villages in Masasi and Newala districts using manually operated graters. On-station cassava processing trial to compare the efficiency of cyanogens removal in the traditional rapid processing by pounding roots and grating showed that two options were suitable. One option was grating of cassava followed by incubation for three hours (resting the grated mash in the shade) followed by wasting roasted. The second was grating, followed by fermentation over night and then sun drying or roasting. These two options could reduce the level of cyanogens in fresh cassava from an average of 562 $\pm$ 300 mg HCN equivalent/kg dry weight to 3.9±7.4 and 5.3 ± 4.9mg HCN equiv/kg dry weight respectively. The cassava flour obtained by these methods was very safe and acceptable for human consumption and marketing. Note that the permitted level of cyanogens in cassava flour proposed by FAO/WHO in 1991 is 10 mg HCN equiv/kg dry weight.

Pilot processing of high quality cassava flour for biscuit production. Pilot processing of high quality cassava flour for biscuit production in Dar es Salaam was carried out by TFNC in collaboration with SARRNET office in Dar es Salaam and the Root and Tuber programme of Sugar Research Institute Kibaha. The proportion of 20% cassava flour substituted with 80% wheat flour produced biscuits, which were acceptable to the consumers. The study identified five private bakeries namely Salim Modern Bakery, Souza Plast, New Bakery, Taj-Mahal Confectionery and Thakur which produced biscuits. They were ready to accept substituting wheat flour with cassava if quality cassava flour was made available and technical know how was at hand (Mlingi *et al.*, 1999). Souza Plast bakery was involved in the trial production of cassava biscuits. Similarly the bakeries declared that if significant economic benefits were realized by substituting wheat flour with cassava flour they would adopt the technology. Farmers in the villages surrounding Dar es Salaam were ready to process high quality cassava flour for sale to the bakeries instead of selling fresh cassava roots to the city. Cost benefits calculated on the basis of wheat flour requirement in Tanzania in 1998 showed that the country could save an equivalent of US $ 1.2 million annually by substituting wheat flour with 20% cassava flour.

Creating markets for small-scale cassava farmers through rural agro-processing of high quality cassava chips/flour. In order to expand production, utilisation and commercialisation of cassava in Tanzania, the SARRNET in collaboration with the National Root and Tuber Programme and TFNC adopted a "linking to markets" approach (Sicco *et al.*, 2003). This approach included:

- Identifying and exploring of new markets for flour, feed, starch and other industrial applications with private partners,
- Identification of viable production areas and partners (peri-urban versus rural) and providing improved production and processing technologies through pilot demonstration sites to rural farmers and link them with identified markets,
- Scaling up assistance of support partners such as NGOs, micro-credit facilitators, traders and development of public-private sector partnerships.

The strategies were also to cater for the need of processing high quality cassava flour to meet the urban demand. For Dar es Salaam city the aim was to guarantee constant supply of high quality cassava flour to feed the bakeries. In responding to this requirement, SARRNET with the collaborating partners decided to set up pilot cassava processing sites in Rufiji district near Dar es Salaam which supplies the bulk of fresh cassava to the city markets. A similar processing site was suggested for Tanga municipality, a town north of Dar es Salaam to supply high quality cassava flour to the consumers in Tanga.

A pilot processing demonstration site was set up at Bungu. In this area, an active farmer group was identified and supplied with a processing equipment. Group members were trained on how to operate the equipment and how to process high quality cassava chips. Some farmers visited potential markets and flour millers in Dar es Salaam. The success of this group sparked off formation of several other groups.

The demand for high quality cassava chips/flour was increased after introduction of a handy 5-kg cassava flour bag which was tested and positively accepted by various sales outlets. The demand resulted in SARRNET supporting the three more farmer groups with processing equipment. At the same time the Rufiji District Council provided small loans to new farmer groups to meet the operational costs. The venture for processing high quality cassava flour looked promising since farmers were getting higher incomes from cassava through reduced transport costs than selling fresh cassava roots.

The sustainability of the farmer/ processing groups will however depend on their access to loans. There is therefore a need to link them to micro-credit facilities so that they can continue with their businesses.

Conclusions

The technologies reported here were introduced to only three main cassava growing zones of Tanzania. Although promising, preliminary observations show that diffusion and adoption of the technologies is slow. The task ahead therefore is to devise better ways and strategies for improving the rate of dissemination. This will involve developing cassava products into widely traded commodities so that the market is guaranteed.

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