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Fabrication and testing of a pulveriser for starch extraction from cassava in Malawi

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ABSTRACT

Objective: A pulverizer for extracting starch from cassava was fabricated and tested at Masinda Cassava Starch Cooperative Society in Malawi.

Methodology and results: The pulveriser was fabricated locally mainly of mild steel. The pulveriser was cylindrical drum shaped measuring 900 millimetres long, 900 millimetres high and with a diameter of 300 millimetres. Inside the pulveriser, there was a shaft (40 mm long) with twelve rotating spines of 40mm wide, 4mm thick and 140mm long. The pulveriser was coupled to a 3.5horse power petrol engine with a speed of 750 revolutions per minute (rpm). The driver pulley had a diameter of 75mm while the driven pulley had a diameter of 150mm. The cost of the pulveriser was USD 462 including the engine. When tested, the pulveriser significantly ($P<0.05$) increased starch extraction from cassava to 21% as compared to grating only yields 18% of starch. The cost benefit ratio was 0.74.

Conclusion and application of findings: The pulveriser increases the starch extraction efficiency from cassava and it is economically viable to operate. However, it is more suitable for individual medium scale processors or small scale processors under a cooperative or an association due to the relatively high cost of installing, which is over US$ 400.

Key words: Cassava, starch extraction, pulverizer

INTRODUCTION

Cassava is the most important root crop in Malawi, being grown across the country and supporting more than 30% of the people along the central and northern shore areas of Lake Malawi and the Shire highlands. Cassava is becoming an important cash crop for smallholder farmers, middlemen as well as traders in various markets, and also increasingly becoming an important industrial crop (Sauti *et al.*, 1994, Benesi *et al.*, 2001a; Benesi, 2002; Benesi *et al.*, 2004).

One of the products of key economic value to farmers as well as industries is cassava starch. Industries in Malawi import starch, dextrins and cassava substitutes from Zimbabwe, South Africa, the Netherlands, United Kingdom and Tanzania, mostly prepared from maize, potato and wheat (NSO, 1994-1999; Fungulani & Maseko, 2001; Itaye, 2001; Munthali, 2001; Masumbu, 2002). Use of cassava starch has high potential for growth, both for industrial purposes and for human consumption. The unique properties of cassava starch, e.g. higher binding ability than corn starch, lower gelatinization temperatures (55 to 70◦C) than corn starch thus allowing foods like sausages to be cooked for a short time when the cassava starch is used, and lower protein than corn starch. These properties suggest that cassava starch could be used for special markets such as adhesives, baby foods, non-allergenic products and food for hospitalized persons (Moorthy, 1994; Thomas & Atwell, 1999; Masumbu, 2002).

During year 2004 the International Institute of Tropical Agriculture / Southern Africa Root crops Research Network (IITA/SARRNET) received funding for three years through the International Centre for Tropical Agriculture (CIAT) from United States Agency for International Development (USAID) Washington to establish two rural pilot cassava starch processing centers in Tanzania and Malawi. The objective was to improve the livelihoods of rural farmers through expansion of the range of uses of cassava starch for income generation. Although functioning starch extraction plants were established in both countries, a problem was encountered due to low starch extraction level, averaging 18%, compared to 25% realised in other cassava starch extracting operations.

Increasing the starch extraction rate at both extraction plants (in Malawi and Tanzania) would increase gross profit margins and improve the livelihoods of members. The introduction of a pulveriser into the starch production process at the Masinda Cassava Starch Cooperative Society in Malawi (MCSCS) was identified as a possible means of improving the starch extraction rate. This paper describes the equipment and the process followed, and the results obtained.

MATERIALS AND METHODS

Description of the pulveriser and its operations: The Pulveriser was drum shaped measuring 900 millimetres long, 900 millimetres high and with a diameter of 300 millimetres. Inside the pulveriser, there was a shaft (40mm diameter) with twelve rotating spines of 40mm wide, 4mm thick and 140mm long. The pulveriser was made of mild steel while the stand was made of 40mm*40mm*4mm angle iron. The pulveriser was driven by a 3.5 horsepower petrol engine at a speed of 750 revolutions per minute (rpm). The driver pulley had a diameter of 75 mm while the driven pulley had a diameter of 150mm.

The pulveriser operates by further crushing cassava root pulp after it has been run through the cassava grater. The crushing of cassava root breaks down cell walls, allowing the separation of the starch granules from the biomass. The greater the degree of crushing and breaking down of cell walls, the greater the amount of starch that can be collected from a fixed quantity of cassava root. The pulveriser consists of an engine-powered turbine that transforms cassava pulp mixed with water into fine slurry.

Experimental method and data collection: Raw cassava root was grated using the cassava grater. Quantity of grated cassava pulp was then run through the pulveriser with an equal volume of water (Batch A) while another batch of grated cassava pulp was set aside (Batch B). The grated pulp was run through the pulveriser with water in quantities of approximately 8 kg each. The pulveriser was run for sixty seconds with each 8 kg batch.

The pulverised volume (A), as well as the control (B) was then sieved with water through a cloth into separate 50 L buckets for 15 minutes, ensuring that the final volume of starchy water in the buckets was approximately equal. The starchy water in both buckets was allowed to settle for two hours, after which the water was drained from the buckets and the starch that had collected at the bottom of the buckets was allowed to dry. Starch from both buckets was then collected and measured using a weighing scale. Thus, two treatments were compared, i.e. grating (T1-control) and grating and pulverizing (T2), each with ten replications.

Data analysis: The data were analysed using t-test

RESULTS AND DISCUSSION

The results of the experiments are summarized in Tables 1 and 2. The results in tables 1 and 2 show that a significant improvement ($P<0.005$) in starch extraction from cassava was realised when the pulveriser was used. The average starch mass measurements indicate that a pulveriser increased starch extraction by 16.9%. There was a cost benefit ratio of 0.74, which shows that when a pulveriser is used, there are more benefits obtained than the costs incurred. With the cost of the pulveriser being more than US$400, individual small scale processors may not afford it, unless they operate under Cooperatives or Association. Therefore, it is proposed that the pulveriser should be owned by either individual medium scale processors or small scale processors under cooperatives or associations.

One of the problems with cooperatives and associations is that there is no sense of ownership hence it is difficult to take care of the equipment unless the processors are well organised and trained in group dynamics. The pulveriser is easy to operate and the spare parts and raw materials are locally available in Malawi. The raw materials which it requires are mild steel flat sheets and angle iron bars while the spare parts are bearings, bolts and nuts, shafts, carburettors, spark plugs, pistons, rings, filters, high tension leads, and camshaft. There are a lot of local artisans who can be trained by IITA engineer in Malawi on how to fabricate the pulveriser. The pulveriser needs simple maintenance like changing of oil, filters, spark plugs and tightening of bolts which small processors can easily do.

IITA engineer has already trained the processors on how to operate and maintain the pulveriser. There is a need to make sure that the pulveriser is fabricated from metal that does not corrode like stainless steel or aluminum because the pulveriser crushes the wet cassava pulp or fresh cassava.

The efficiency resulting from the use of pulveriser can lead to a reduction of cassava available for consumption, which could create food insecurity in the cassava growing areas. This calls for the intervention of cassava breeders and agronomists. The cassava breeders need to develop varieties that are better in both yields and starch content. Different superior varieties should be developed for different end uses. The agronomists should teach farmers about good crop management practices for cassava in order to improve the current average cassava yield which stands at 18 tones per hectare in Malawi.

In Malawi the standards for non-edible starch have already been developed by the Malawi Bureau of standards (MBS). What is required now is to develop standards for edible starch. The starch markets are also already available such that processors have already been linked to the markets and these markets created through the carrying out of industrial tests which have shown that cassava starch is superior to corn starch, e.g it has higher binding ability than corn starch which the industries are used to. Currently, the demand for starch in Malawi is not being met due to low starch production. The popularization of the pulveriser amongst the Cassava starch processors will increase starch production in the country.

Table 1: Comparison of starch extraction from cassava in Malawi by grating (method 1) and grating and pulverizing (method 2). (The starch was extracted form 8 kilogrammes of fresh cassava)

TREATMENT	Mass of starch (kilogrammes)	STANDARD ERROR (se)	PR>0.05	t
T1 (B)- Grating only (Control)	1.38	0.04	0.0025	4.00
	1.50			
	1.58			
	1.63			
	1.37			
Mean	1.42			
	1.48			
T2 (A)-Grating pulverising	1.63	0.04	0.0025	
	1.75			
	1.83			
	1.88			
	1.62			
Mean	1.67			
	1.73			

Table 2: Economic analyses of starch extraction from cassava using a pulveriser in Malawi.

Item	Units
Cost of the Pulveriser	US$462
Life span of the pulveriser	5 years
Cost of using a pulveriser per day assuming liner depreciation	US $1.27
Fuel consumption	0.9 litres/ ton of cassava
Extra power rating	3.5 horse power
Starch conversion ration increase	0.18 to 0.21
Increases in starch productivity (%) per tone of cassava	16.9%
Increases in starch productivity per tone of cassava	30 kg
Increase in starch productivity per day (four tonnes of cassava crashed per day)	120kg
Total fuel use per day	3.6 litres
Fuel cost for additional starch increase	US$54.77
Cost for pulveriser operator per day	US$4.11
Total additional cost including depreciation	US$60.15
Total revenue from starch production increase	US$81.71
Cost benefit ratio (C/B)	**0.74**

CONCLUSION

The results of this study provide evidence that the mechanical pulveriser is more efficient than manual grating alone for extracting cassava starch. The starch mass that is produced is significantly improved when the pulveriser is used compared to the current starch extraction rate of 18%, a 16.9% shows that starch extraction rates can potentially be as high as 21%. However, this is still less than 25% because 25% starch extraction is only achieved under laboratory and conditions. Therefore, there is a need to promote the use of the pulveriser in order to increase starch extraction rate from cassava as it is also economically viable.

REFERENCES

Benesi IRM, 2002. Native evaluation and analysis of genetic distance using AFLP of elite cassava (*Manihot esculenta* Crantz) genotypes from Malawi. MSc Thesis in Plant Breeding, University of the Free state, Bloemfontein, South Africa.

Benesi IRM, Moyo CC, Mkumbira J, Chipungu FP, Mtukuso A P. and Mahungu NM, 2001a. Cassava research and production to enhance commercialization in Malawi. In: Mahungu, N.M., J.W. Banda and C. Mataya (eds). *Cassava commercialization for economic development in Malawi. Proceedings of the Symposium held at Kwacha International Conference Centre,* Blantyre, Malawi, 21-23 May 2001: 78-86.

Benesi IRM, Labuschagne MT, Dixon AGO, Mahungu NM, 2004. Genotype x Environment interaction effects on native cassava starch quality and potential for starch in the commercial sector. African Crop Science Journal 12: 205-216.

Fungulani T. and Maseko, 2001. Utilization of cassava starch in textile industry. In: Mahungu, N.M., J.W. Banda and C. Mataya (eds.). C*assava commercialization for economic development in Malawi. Proceedings of the symposium held at Kwacha International Conference Centre,* Blantyre, Malawi, 21-23 May 2001: 98-99.

Itaye S, 2001. The use of starch in the production of corrugated cartons. In: Mahungu, N.M., J.W. Banda and C. Mataya (eds.) *Cassava commercialization for economic development in Malawi. Proceedings of the symposium held at Kwacha Intenrational conference Centre*, Blantyre, Malawi, 21-23 May 2001.105-107.

Masumbu FFF, 2002. Production of cold -setting adhesives using starch and dextrins from cassava (*Manihot esculenta* Cranz). Msc thesis in applied Chemistry, University of Malawi, Zomba, Malawi.

Moorthy, 1994. Tuber Crops Starches. Central Tuber Crops Research Institute. Technical Bulletin

Series: 18. pp.40. St Josephs Press, Cotton Hill, Thiruwanathapuram, Kerala, India.

Munthali HM, 2001. The use of starch in manufacturing batteries. In: Mahungu, N.M., J.W. Banda and C. Mataya (eds.). *Cassava commercialization for economic development in Malawi. Proceedings of the symposium held at Kwacha International Conference Centre*, Blantyre, Malawi, 21-23 May 2001. 122pp.

National Statistical Office (NSO), 1994-1999. *Bill of entry of starches, Dextrins and other Modified Starches*. Zomba, Malawi.

Sauti RFN, Khonje EMH, Thaulo G, Chibambo M, Bulla GM, 1994. *The importance of cassava and production constraints in Malawi*. In: Akoroda, M.O. (ed). *Root crops for food security in Africa. Proceedings of the fifth triennial symposium of the international Society for tropical Root crops*-Africa branch (ISTRC-AB). 22-28 November, 1992, Kampala, Uganda: 93-96.

Thomas DJ. and Atwell WA, 1999. *Starches: Practical guides for the food industry*. Eagan Press Hand Book Series. St Paul, Minnesota, USA.94.pp.