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The Search for an Effective Cassava Peeler

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Abstract: *Nigeria is widely acclaimed as the largest producer of cassava in the world, thus when Nigeria succeeds in cassava production or processing it would be a global success. The federal government in Nigeria opened up the market and challenges of cassava production, processing and export in 2004, since then there has been the need to improve the concept and methods of production/processing of cassava. One of the major challenges of cassava processing is peeling. To this end, the International Institute of Tropical Agriculture (IITA) Ibadan, Nigeria and The Federal University of Technology Akure (FUTA) initiated a technical collaboration to develop an effective cassava peeler. The collaboration was in conjunction with some private fabricators A&H Nig. Ltd in Iwo and Fataroy Nigeria Limited, Ibadan, Nigeria. Several efforts, meetings and technical sessions resulted in the design and fabrication of improved automated cassava peeling machines. This study presents the features, prospects, performance evaluation and limitations of the various models of cassava peeling machines. Results show appreciable improvement in the design and performance of the cassava peeling machines. The peel retained on the tubers with each model of the cassava peeler was influenced by peeler speed. Minimum peel retention were 5.7%, 6%, 11%, 0% and 0% respectively, for A&H, FUTA, Fataroy, Hand Fed Model and manual method. The capacity of the machines is between 0.25 and 1 ton/h.*

Keywords: *Search, effective cassava peeling machine*

1. Introduction

Cassava (Manihot esculenta Crantz) is fast becoming a wonder crop due to its potential uses in several agro and agro-allied industries. The large demand for cassava from China has changed the status of the crop from poor man's food into an export commodity, which compares favourably with crude oil in terms of foreign revenue. There is an ever-increasing global demand for cassava chips and pellets particularly from China and Brazil. Cassava starch is an ingredient in the manufacture of dyes, drugs, chemicals, and carpets and in coagulation of rubber latex (Odigboh, 1983). Since 1990, Nigeria has surpassed Brazil as the world's leading producer of cassava with an estimated annual production of 26 million tonnes from an estimated area of 1.7 million hectares of land (FAO, 1991). Other major producers of cassava are Zaire, Thailand, Indonesia, China, India, Malaysia, Malawi, Togo and Tanzania. Cassava processing thus deserves serious attention in order to meet the local and international demand for cassava products. Cassava roots develop radially around the base of the plant forming five to ten tubers per plant.

In this study, an appraisal of the recent models of cassava peeling machines in Nigeria is presented with a view to determining the way forward in the desperate search for an effective world-class cassava-peeling machine.

2. Literature Review

Adetan et al. (2003) reported that the tubers constitute the main storage region. Tubers are white or cream in colour and are surrounded by a thin cambium layer. Covering the cambium layer is the tuber peel, which consists of a corky periderm on the outside and cortex on the inside. The outer periderm may be thick and rough or thin and smooth with surfaces varying considerably in colour from pink to grey (Igbeka, 1984). Asoegwu (1981) studied some breaking characteristics of cassava roots when subjected to bending loads. The loading rate and root diameter were reported to have significant effects on the breaking strength, breaking energy and breaking deformation of the roots (Onwueme, 1978;

Ohwovoriole et al., 1988). Recent studies (Olukunle and Adesina, 2004; Olukunle, 2005; Olukunle et al., 2005) reported the various efforts at developing an effective peeler in China, Brazil and Nigeria.

The review conducted jointly by IITA and FUTA in 2005 revealed that cassava peeling is still largely done manually. This is in agreement with Adetan et al. (2003) who also characterised some properties of cassava tubers as a scientific basis for the development of a cassava peeler. The results of their study showed that weight of peel in the roots (p) ranged from 10.6% to 21.5%; the root surface taper angle (ar) ranged from 0° to 22°; the root peel thickness (t) ranged from 1.20 to 4.15mm; the root diameter (d) ranged from 18.8 to 88.5mm; and the root peel penetration force per unit length of knife-edge (F) ranged from 0.54 to 2.30 N/mm. Nweke (2004) discussed the urgent need for an effective cassava peeler and concluded that if any cassava harvesting or peeling machine designed for smallholders can be identified anywhere in the world it should be urgently put to on-farm test in Africa with a view to adapt, fabricate, and diffuse it to farmers if confirmed suitable in the on-farm testing.

Several researchers (e.g., Odigboh, 1983; Igbeka, 1984, 1985; Ezekwe, 1979) made appreciable attempts on the properties of cassava as well as in the design of cassava handling and processing equipment. Cassava and sweet potato are the most important root crops in the developing world, with a combined total annual production of around 300 million tones (Azan-Ali et al., 2003). However, cassava processing and in particular, cassava peeling has been identified as energy sapping and labour intensive. Several efforts have been made to develop effective cassava peeling machines in China, Brazil and in some parts of Africa (Odigboh, 1976, 1979; Sherrif et al., 1995; Olukunle, 2005).

At the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria, the integrated cassava project initiated a search for an effective cassava peeler in 2005 in conjunction with the Federal University of Technology, Akure (FUTA), which started a conscious and desperate search for effective cassava peeling machines in July, 2004. This effort resulted in the production of commercial models of the single and double gang hand fed cassava-peeling machines (see Figures 1a and 1b).

However, the machines require manual feeding and could only peel 2 to 5 tons of cassava per day depending on the variety, maturity, size of the tuber and the skill of the operator (Olukunle et al. 2005). Three models (i.e., A, B and C) of a self-fed cassava-peeling machine have also been developed in FUTA. Model A (see Figure 2) was first demonstrated in IITA and was also posted on the web in 2005. These models represented notable improvement on the hand fed models. Major advantages include elimination of manual intervention during the peeling process, overall reduction in drudgery and also increase in capacity.

Figure 1(a). Double gang cassava peeling machine

Figure 1(b). Single gang cassava peeling machine

Figure 2. Self-fed cassava peeling machine

However, peeling efficiency is generally less than 80% and losses are more than 8%. The capacity of the machine is also less than the requirement of medium to large-scale industrialists. Fataroy and A&H local fabricators also make remarkable appearance at the cassava peeler search fair organised by the Integrated

Cassava project in IITA.

3. Materials and Methods

The crew from FUTA and IITA made several visits to research institutes, agencies and countries in order to obtain first hand information on the global trend in cassava peeling mechanisation. These include, Raw Materials Research and Development council, Abuja, Nigeria; National Agency for Science and Engineering Infrastructure, (Nassenni) Abuja, Nigeria, China, Brazil and Germany. An appraisal of previous models of self-fed cassava peeling machines from FUTA, Fataroy and A&H was done in order to determine the strengths and weaknesses of these designs. Particular attention was placed on the global trend in the development of cassava /tuber peeling machine. The three models were subjected to rigorous improvements. Major areas of improvement include, increase in the length of the peeling brush from 30cm to 60cm and automatic adjuster for a range of cassava tuber sizes in the FUTA model, aesthetics and feed rate in Fataroy and A&H models and peeling efficiency in the three models. The machines were tested under various crop, machine and operational conditions. The results of the performance evaluation were compared with manual methods. The results of the project were intended to serve as a basis for the commercial production and utilisation of cassava peeling machines.

4. Machine Description

The double action/self fed cassava peeling machine (see Figure 3) consists of two conveyors arranged in parallel, two rotating brushes, 60cm long mounted at 90° on the auger conveyors, tuber inlets and outlets, tuber monitor, a protective hood, frame and transmission system. The machine impacts rotary/linear motion on the tuber, which also makes contact with the peeling brush and thus provides the required peeling effect on the tubers. Tubers were fed into the two inlets at the same time and the machine effects simultaneous peeling of the tubers.

Figure 3. Double action self-fed cassava peeling machine

The resident time is governed by the auger speed and the slippage provided by the combined action of the auger and the brush on the tuber. Higher slippage is also obtainable with this design through the tuber monitor fitted with soft elastic rubberised material. Auger speed and brush speed have been synchronised from previous designs such that a predetermined speed ratio between the auger and the brush is obtained by throttling the engine. Incorporating stainless steel (or galvanised steel) components preserves the food value of cassava. The double action peeler thus aids enhanced machine capacity at minimum cost. The development of this machine and its advantages underscores the need for continuous research in the desperate search for a world-class cassava-peeling machine.

In the design of Model C, the tuber monitor provides the same clearance for tubers across the length of the peeling chamber. However, it is possible to adjust the clearance in this design to obtain a tapering chamber. The inlet and outlet clearance could be varied. This is exceptionally useful because the size of cassava tuber subjected to peeling in the chamber would continuously decrease at a decreasing rate unless the relationship between the inlet and outlet clearance is synchronised.

Fataroy and A&H models were similar in length and general orientation except that A&H model consists of two rollers with a spring loaded attachment to monitor variations in tuber sizes. The peeling roller in A&H is fitted with a 3mm thick flat bar neatly wound round the roller to form a continuous auger. The peeling efficiency of this model largely depends on the speed of the auger, the efficacy of the spring-loaded device and the number of tubers in the chamber per unit time. Fataroy model is shorter in overall length compared to A&H model. The machine speed and hence the machine capacity is however higher than A&H model. FUTA model provides a dual tuber path for enhanced machine capacity. A quantity of 20 Kg of cassava was fed into the machines and the tubers passing through the machines were peeled. The time taken to process the tubers was recorded. The peel retained on the tubers was manually peeled and weighed. Peeling efficiency and % retention was thus determined for each model.

5. Results and Discussion

The modifications introduced into these designs are commendable; each producing desired effects on the peeling process. The increase in brush length and hence the resident time of tubers within the peeling chamber influenced the peeling process remarkably. In the FUTA model, the peeling brush was increased in length from 300 mm to 600 mm. This permitted more contact with the brush as the tuber moved through the peeling chamber. Soft-elastic material on the tuber monitor introduces higher slippage, which is required to increase the resident time of tubers in the peeling chamber. Thus, the outer layer was completely removed in one pass of the tubers through the peeling chamber. This represents an appreciable improvement on the previous designs.

Tubers were presented in the range of 20 to 25 cm long during the peeling process; this was done to reduce/eliminate pronounced bends commonly found in cassava tubers. The three categories into which the tubers were divided also aided faster peeling process since the tuber monitor could be adjusted only thrice, each time to handle a specific range of size of cassava tubers. It is important to note that tubers less than 10 cm long would be poorly handled during the peeling process with this model. It is advisable to ensure that tuber length is beyond 10 cm during trimming.

In the Fataroy model, the abrasive component, which was similar to the abrasive plate for grating cassava, was initially employed. The latter has been replaced with an auger fitted with helical flights. Further work has also been done on the relative speed of the auger and the peeling roller. A&H has also improved the aesthetics, the feeding system and has attempted to optimise auger speed relative to peeling roller. A&H also studied the effect of pre-treatment on the peeling process. Losses and retention was highest in the Fataroy model than values obtain in FUTA and A&H models.

The peel retained on the tubers with each model of the cassava peeler was influenced by peeler speed (i.e., a combination of Auger and brush speed). Figure 4 shows that the records of minimum peel retention were 5.7%, 6%, 11%, 0% and 0% for A&H, FUTA, Fataroy hand-fed model and manual method, respectively. Determinants of choice of peeler type or peeling method include cost, labour requirement, capacity, time, losses, food quality and end product.

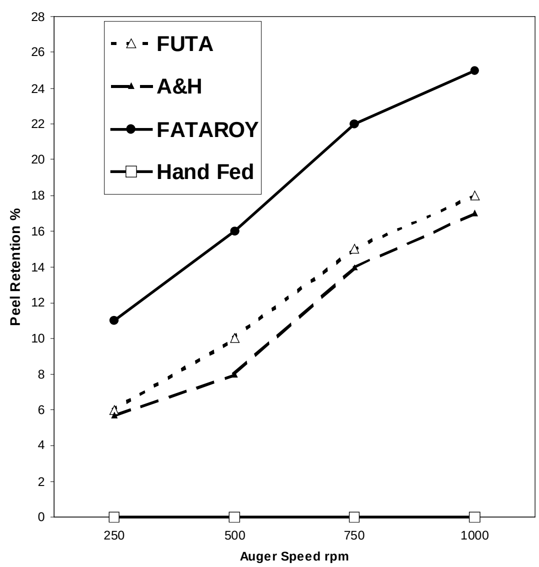

Figure 4. Effect of auger speed on peel retention

Results show that the three automatic peelers are ideal for starch production, where peel retention in the range of 5.7 to 16% would not affect the process. However, for high-grade cassava flour and Garri, peel retention affects product quality in terms of colour and taste. The less peel retained, the whiter the end product. Tuber losses in the three models were between 0.5 and 9.4 %, 0.25 and 1.84 in the hand fed and 0.05 and 1.0 for manual peeling (see Figures 5 and 6).

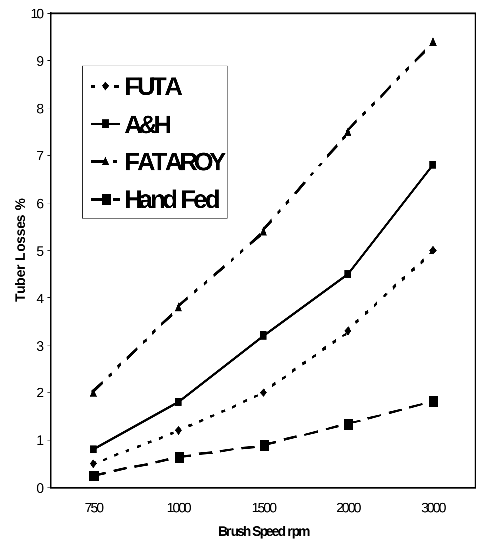

Figure 5. Effect of brush speed on tuber losses at 250 rpm auger speed

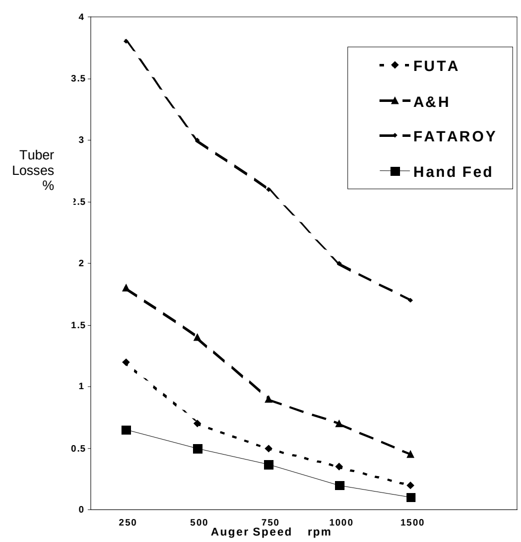

Figure 6. Effect of auger speed on tuber losses at 1,000 rpm brush speed

Brush speed influenced tuber losses considerably, at 250 rpm auger speed, tuber losses increase with increase in brush speed, hence brush speed is directly related to tuber losses but auger speed is inversely related to tuber losses. Lower auger speeds imply higher resident time in the peeling chamber which produced higher peeling efficiency with lower tuber losses (see Figure 4). However, lower auger speeds produced higher tuber losses (see Figure 6). The capacities of the self-fed cassava peelers are 1, 0.5, 0.6, 0.8 ton/h, for Double Action FUTA Model, FUTA models A, B and C, A&H and Fataroy, respectively. The capacity of FUTA hand fed model was 0.25 ton/h compared to 0.025 ton/h for manual peeling.

6. Conclusion

The International Institute of Tropical Agriculture (IITA) Ibadan, Nigeria and The Federal University of Technology Akure (FUTA) initiated a technical collaboration to develop an effective cassava peeler. The collaboration was in conjunction with some private fabricators in Iwo and Ibadan, Nigeria. Several efforts, meetings and technical sessions resulted in the design and fabrication of some improved automated cassava peeling machines.

Results show appreciable improvement in the design and performance of the cassava peeling machines. The peel retained on the tubers with each model of the cassava peeler was influenced by peeler speed (combination of Auger and brush speed). Minimum peel retention were 5.7%, 6%, 11%, 0% and 0%, respectively for A&H; FUTA; Fataroy; hand-fed model and manual method). The capacity of the machines is between 0.25 and 1 ton/h.

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