LETTER TO EDITOR

Indigenous Brown Sugar Processing Technology in Nigeria : Past and On-going Research

A. Gbabo, A.C. Wada and T.O. Akinsanya
National Cereals Research Institute, Badeggi, P.M.B. 8, Bida, Nigeria

The effort to develop brown sugar processing technology in Nigeria was initiated by the Federal Government in 1986 through the Federal Ministry of Industries. The first prototype plant of 2 tons per day cane - crushing capacity was designed, fabricated and tested by the National Cereals Research Institute, Badeggi in 1988. Since then several research activities have been carried out in order to improve the efficiency of the plant and also up-grade its capacity. The basic unit processes are : weighing, crushing, clarification (liming, heating and settling), evaporation, crystallization, centrifugation and drying. Designs of equipment for each of the unit processes were provided by the Institutes engineers. Fabrication materials were procured locally and all the equipment were fabricated through indigenous effort. Test results of the prototype plant using three varieties of Sugarcane BD96-001, BD96-003 and BD96-009 indicated average sugar recovery rate of 6.3-6.5%. The quality of the sugar, compared with existing one at the Nigeria Sugar Company Limited (Nisuco), Bacita was also acceptable.

KEYWORDS : Indigenous, brown sugar, technology, prototype plant, research, sugar recovery.

Sugar is among the most widely consumed food products in the forms of sweetners, blenders and colouring agent. Apart from crude oil, Nigeria has great potential to produce enough sugar that could earn the country a lot of foreign exchange if the resources are properly harnessed (Lafiagi 1984, Wada *et al.*, 2001). At present the three factories using imported technology at Bacita, Numan and Lafiagi produce only about 1% of the national sugar requirement of about 1 million tons annually. The 99% short fall is supplied largely through importation at huge foreign exchange cost to the national economy (Wada *et al.*, 2001).

It is noteworthy that in some third world countries like Cuba, Brazil, Puerto-Rico, and India, the development of sugar processing technology at intermediate level through indigenous effort has reached a tertiary stage (Raphael, 1984). Baron (1975), Guerrin *et al.* (1977) and Garg (1979) stated that the development of these technologies have been attracting enormous socio-economic benefits which have been continually justifying their existence and improvement in these countries.

In Nigeria a study of the traditional sugar processing method indicated that a product referred to as "Masarkwoilla" is processed from sugar cane mostly by rural farmers in several northern states such as Katsina, Kaduna and Niger State (NCRI, 1986). Basically, the product is a conglomerate of sugar crystals and molasses. Tests have shown that it is unhygienic because clarification (purification) is neglected during local processing. Thus the acceptability rating of the product is low (NCRI, 1989).

In order to upgrade the quality standard of the product produced by the small scale rural farmers and argument the production effort of the few giant sugar industries (using adopted technology), a task force was set up by the Federal Government of Nigeria to design, fabricate and commission a prototype brown sugar processing plant. The National Cereals Research Institute, Badeggi was given the national mandate to co-ordinate and ensure the setting up of the plant at its's Headquarters in Badeggi in 1987. In line with this mandate, the prototype brown sugar processing plant having 2 tons per day cane crushing capacity was developed and commissioned in the Institute in 1988. Since then several research work aimed at improving the efficiency of the plant are underway. Thus the objective of this paper is to discuss this technology and highlight the major areas where research works are currently going on.

Author for Correspondence : A.C. Wada
e-mail : acwada@yahoo.com

PROCESSING TECHNOLOGY

The processing technology for the indigenous brown sugar plant is basically comprised of the following eight stages as shown in Fig. 1.

Weighing

The harvested canes from the field are first weighed. This is done in order to be able to determine the overall capacity and efficiency of the plant at the end of processing operations.

Juice extraction

The weighed canes are crushed and pressed in a single operation in order to squeeze out the juice.

Clarification

This is the stage at which the extracted juice is purified. It encompassed liming, heating and settling. This is done in order to prevent inversion of sucrose by micro-organisms and also co-agulate and precipitate impurities such as chlorophyll, polyphenols, wax, gums, albumen and calcium phosphate in form of mud.

Liming entails the addition of predetermined quantity of lime to the juice in a cylindrical tank, while heating involves raising the temperature of the limed juice to 100 °C for 4 h. Settling which is the last stage of the clarification process takes place in a separate system within 24-28 h.

Evaporation

This is a juice concentration process whereby the water fraction of the juice usually constituting 78-83% is removed by applying heat to a battery of rectangular vessels containing the juice at normal atmospheric

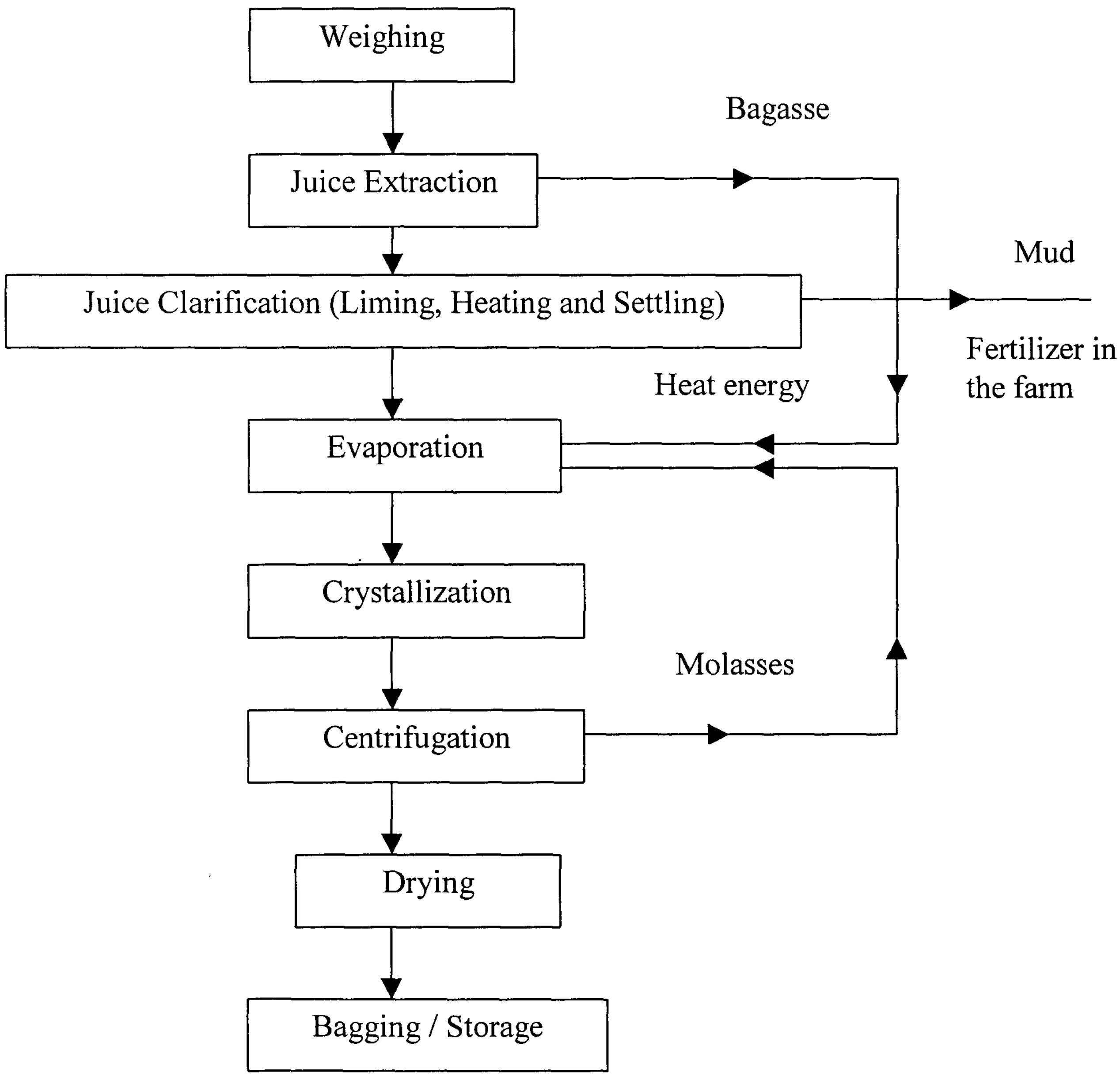

Fig. 1 : Flow Chart of Brown Sugar Processing

temperature and pressure. Usually, the syrup is evacuated with large spoons when the concentration reaches 78-80° brix.

Crystallization

This is the process in which the evaporated juice is cooled in a semi-cylindrical vessel to enhance formation of crystals. The process also prevents aggregation of the formed sugar crystal as a result of the continued motion of the syrup arising from the design of the equipment.

Centrifugation

The crystallized syrup (massercuit) is combination of mollasses and sugar crystals which are separated by centrifugation within 60 seconds. Within this period, the moisture level of the crystal also reduces from about 100% to 40%.

Drying

This is the final moisture removal process that reduces the moisture content of the sugar crystals from 40% (immediately after centrifugation) to 2%. This is done before bagging in order to prevent it from deterioration as a result of the possible growth of micro-organisms.

MACHINES AND EQUIPMENT USED AT BADEGGI

In line with the flow process, the following machines and equipment were designed and fabricated by the National Cereals Research Institute, Badeggi.

Weighing machine

A beam balance capable of weighing 0.2 tons of sugar cane per batch was developed. It is made of a weighing platform, which rests on a spring system. A pointer connected to the spring reads the weight of the cane on a graduated scale.

Cane juice extractor

This consists of three adjustable stainless steel rollers of 0.15 m diameter and 0.3 m long. The rollers were fixed on bearings at the two ends and rest on the framework of the machine. Power is supplied by an 8 hp diesel engine. About two to three canes are fed manually at a time.

Clarification unit

This unit is comprised of the following components:

(1) Liming System : This is made of 0.628 m^3 cylindrical tank constructed with stainless steel sheet. A motorized strirrer was incorporated to ensure thorough mixing of the lime and water while a valve at the bottom of the tank discharges the mixture into the lime/juice-mixing tank with a volumetric capacity of 3.78 m^3. Another motorized stirrer in the lime/juice mixing system mixes the lime solution and the juice. A discharge outlet at the bottom of the tank allows the juice solution to flow out after being mixed thoroughly.

(a) **Heating System :** This is a 3.78 m^3 tank made of stainless sheet with mechanized stirrer. An oil burner with a capacity of 25.0 kw supplies heat energy in the combustion chamber constructed with bricks. Baggase is used as an alternative source of heat energy in the combustion chamber if diesel is not available.

(b) **Settling Tank :** This is also a stainless cylindrical tank of 3.78 m^3 volumetric capacity with graduated taps along the height of the cylinder. Horizontal baffles were incorporated in order to enhance the settling rate and reduce settling time.

Juice evaporation

This is a 'bel-type' open pan (evaporation) system (OPS) which consists of three trapezoidal stainless tanks on a combustion chamber made of bricks having a chimney at the rear. The three tanks are elevated in ascending order and linked with pipes for draining the concentrated juice from one pan to the other. The first tank receives more heat energy because it is nearer the source of heat. Hence when evaporation in the first is completed, the juice in the adjacent ones which gained some heat energy is subsequently drained into the first for evaporation to continue. Each of these open tanks has a volumetric capacity of 0.7 m^3.

Crystallizer

The crystallizer is a 3.5 m^3 cylindrical vessel. Power is mechanically supplied to a stirring arm with the aid of a 5 hp electric motor having speed reduction mechanism. The stirring mechanism rotates at a speed of 1.5 rpm in order to accelerate cooling of the massercuit immediately after evaporation and ensures efficient crystallization process.

Centrifuge

The output capacity of this machine is 640 kg/day. It is mainly made up of a perforated internal rotary basket lined with fine and coarse brass screens and an external solid basket. Power is supplied to the internal basket at 1400 rpm by a 10 hp electric motor.

Dryer

Both platform and rotary dryers were developed to reduce the moisture content of sugar from 0.40 to 0.02 after centrifugal operation. The rotary model with a throughput of 640 kg/day was designed and fabricated in order to eliminate the problems of sugar aggregation, un-even and slow drying associated with the platform dryer. An oil burner of 25 kw capacity supplies heat energy into a drum containing louvres, which rotates at 8.00 rpm. Alternatively an electric heating chamber was incorporated to use electricity as source of heat in urban areas.

Plant's sugar recovery

The plant's sugar recovery rate was evaluated based on the quantity of sugar recovered per given quantity of cane. Data obtained in processing three varieties of sugar cane are shown in Table-1.

PLANT'S PERFORMANCE ASSESSMENT

The result of the plant's sugar recovery rate for the three sugarcane varieties as shown in Table-1 shows slight differences in the quantity of sugar recovered per unit quantity of cane. The maximum sugar recovery rate was 6.5% for BD96-003 while the minimum was 6.3% for BD96-001. The variation in sugar recovery rate might be as a result of the difference in cane varieties with different brix content and delay in liming processes which could enable bacteria to invert the sucrose.

Comparison of the qualitative analysis of the NCRI's (indigenous) brown sugar with the white (bleached) sugar shown in Table-2 indicates that the percent essential nutrients such as calcium, iron and phosphorous are higher for the NCRI (indigenous) brown sugar. The depletion in the essential nutrient content of the white sugar is possibly caused by the bleaching action that is involved in processing white sugar. The value of nitrogen is the same for the indigenous one and NISUCO. The pH of NCRI's brown sugar is the same with that of the white sugar.

PROBLEMS ASSOCIATED WITH THE PLANT

The following problems were observed with the prototype brown sugar processing plant :

(i) Low sugar recovery rate and input capacity of the plant.

(ii) Occasional hooking of canes between rollers of the cane juice extractor hence impeding smooth processing operation.

(iii) Impossibility of the cane juice extractor to extract juice from the local cane which is fatter than the industrial one.

(iv) Long duration and procedures at the clarification stage and loss of juice in the form of mud.

(v) Loss of enormous heat energy during evaporation.

(vi) Formation of minute grains almost of the same size with B or C sugar.

(vii) Difficulty in discharge of massercuit from the crystalizer.

Table - 2 : Comparisons of quality analysis of NCRI (indigenous) brown sugar with NISUCO white sugar

Nutrients (%)	NCRI Brown Sugar (Indigenous)	Nisuco White (Bleaced) Sugar
Ca	0.004	0.1038
Mg	0.0003	0.0093
Mn	0.0005	0.001
Cu	0.0002	0.0004
Zn	Trace	0.0002
Na	Trace	0.002
Fe	0.0025	0.058
P	0.0048	0.0072
N	0.00469	0.938
Moisture	1.2	1.5
pH	6.0	6.0

NCRI (1989)

Table - 1 : Sugar recovery of NCRI plant

Variety	Weight of sugar cane (Wc), kg	Weight of recovered Sugar (Wr), kg	Weight of molasses (Wm), kg (Wac), kg	Average weight of cane Kg	Average weight of recovered sugar (War),	Average sugar recovery rate (Sar), = (War/Wac × 100%)
BD	1,100.3	73.1	30.3			
96-001	1,260.6	75.9	31.6	1158.7	73.0	6.3
	1,115.1	70.0	29.0			
BD	1,300.7	85.5	33.2			
96-003	1,200.2	78.4	28.5	1273.1	82.2	6.5
	1,318.4	82.7	35.8			
BD	1,118.1	72.3	26.2			
96-009	1,210.0	79.1	30.4	1111.5	71.6	6.4
	1,006.5	63.4	29.3			

N.C.R.I. (1990)

ONGOING RESEARCH

The National Cereals Research Institute, Badeggi is currently undertaking some research work aimed at improving the over-all efficiency of the indigenous brown sugar processing technology. This involves re-designing and fabrication of almost all components of the plant after modifying the existing ones. These areas include :

Cane juice extraction

(i) Improvement of the juice extraction rate of the cane juice extractor

(ii) Versatility of the cane juice extractor to process both the local and industrial (exotic) cane varieties.

(iii) Possibility of incorporating a speed reduction system and wider flanges to increase the input capacity of cane and durability of the cane juice extractor.

Evaporation

(i) Modification of the combustion chamber to create a lamiar flow system of the natural air-draft in order to increase the efficiency of the evaporation system.

(ii) Possibility of using less baggasse as source of heat energy to evaporate the juice through the conservation of heat energy within the furnace.

Clarification

(i) Possibility of combining the clarification process with the evaporation process thereby eliminating the three processes of liming, heating and settling.

Crystallization

(i) Reduction of the crystallization period from about 48 hours to 36 hours.

(ii) Provision of easier method of evacuating the massercuit.

Centrifugation

(i) Improvement of the dynamic stability of the centrifuge.

(ii) Improvement in the centrifugal efficiency and output capacity of the machine.

DEVELOPMENT OF CANE VARIETIES

The breeding and agronomy units are working to evolve suitable varieties of both the chewing (local) and exotic varieties to achieve good extraction efficiency.

CONCLUSION

Results obtained in testing the plant were very encouraging as earlier highlighted. The quality of the product itself also meets up acceptable standard. However, since further research works are currently going on to improve the performance of the major components of the plant such as the cane juice extractor, clarification and juice evaporation systems, crystalizer and centrifuge, the plants sugar recovery rate will also improve. The appropriate units are also addressing the variety problem. This is usual with the development of any new technology.

These efforts will definitely lead to the development of an economically viable brown sugar processing technology in Nigeria.

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