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Open Pan Sugar Processing Technology : An Option for Developing Countries

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Sugarcane processing permits a choice, usually between Vacuum and Open Pan technologies. A comparison of the two reveals the superiority of the Vacuum Pan technology in technical and economic efficiency over the Open Pan technology. Despite this superiority, certain conditions inherent in both technologies and in developing countries themselves point to the greater appropriateness of the Open Pan technology than that of the Vacuum Pan in developing countries. Some of these conditions were identified and examined in this paper. Developing countries could benefit more from the open pan technology.

KEYWORDS : Vacuum pan, Open pan, Developing countries, Sugar recovery

INTRODUCTION

Sugar, an energy-giving food, is one of the disaccharide carbohydrates. Apart from its high caloric value and taste which makes it an attractive food, sugar has played an important role as a preservative and as a sweetener for bitter tasting drugs (Wudiri et *al.* 1990). Sugar being consumed directly has come to be one of the most widely produced agro-based products. Sugar is produced mainly from sugarcane (Fry, 1997). Other sources of sugar include sugar beet, sweet sorghum, certain species of palms, various fruits and sugar maple. Among these, sugar beet is primarily a crop of the northern hemisphere and grows best in temperate climates. Sugarcane, on the other-hand grows best in tropical conditions especially at temperatures higher than 21°C and with fairly evenly distributed rainfall of about 1,500 mm per annum (Kaplinsky, 1984). These conditions are obtained in large parts of the developing countries of the world including Nigeria (Lafiagi, 1984). According to Dere (1991), local sugar manufacturing did not start in Nigeria till 1964. Before then the major importer of sugar was the Tate and Lyle, a British company which bought raw sugar from other countries to be refined and exported to Nigeria. Over the years, sugar consumption in Nigeria increased from as low as 50,000 tonnes in the early 60s to about 1,000,000 tonnes in the late 80s (CBN, 1994). This sugar consumption figure does not take into account crude sugar cakes – masarkwaila – made from sugar cane juice that had been in existence from the end of the first world war to date and is widely consumed especially in some Northern states of Nigeria (Misari et *al.* 1998).

The process by which sugarcane is transformed into sugar is considered in this paper as our concern lies with sugar processing technologies in developing countries of the tropics. Two sugar processing technology options are generally available. These are the Vacuum Pan (VP) and the Open Pan (OP). This paper discusses the two available options with a view to identifying the one which is more relevant to developing countries.

PROCESSING TECHNOLOGY

The process of extracting sugar from cane can be classified into six stages (Bush, 1987). However, some variations exist in the types of technologies adopted in each system as shown in Fig . 1.

COMPARISON OF VP AND OP PROCESSES

I. **Crushing** entails the removal of juice from the cane. With the VP technology, this is done without imbibition after cane preparation by multiple roll crushers. In OP, 3-9 roller mills are used with imbibition. Juice extraction and sugar recovery are higher in VP. However, most developing countries like Nigeria still largely employ the OP technology for processing sugar at the cottage level (Anon, 1999).

II. **Clarification** is done with the main aim of

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I. Crushing
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II. Clarification
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III. Boiling
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IV. Crystallization
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V. Centrifuging
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VI. Drying/Packaging

Fig. 1. : Flow chart for sugar extraction from sugarcane

increasing juice pH to a level where losses of sugar through sucrose inversion are minimized. Secondary but also important aims in this stage are removal of insoluble materials and some undesirable dissolved substances from the juice. In VP Technology this is done with liming, sulphitation or carbonation in continuous clarifiers. In OP, usually batch clarification is done in open pans with vegetable bark extracts and manual skimming of the scum. At the National Cereals Research Institute (NCRI) the use of okro bark extract for this process has been perfected (Anon, 1997). Better clarification is, however, achieved with VP than OP as purer juice is obtained with VP.

III. **Boiling** is the most energy consuming stage of sugar extraction. It is done primarily to remove water from the juice. Secondly, this stage achieves elimination of micro-organisms by heat sterilization of the juice and ensures completion of chemical reaction with the clarificant as well as removal of gasses from the juice and better flocculation of scum. In VP technology, boiling is done in multiple effect evaporators and vacuum pans. Here juice is boiled at lower temperatures thus minimizing inversion or sugar loss. In OP technology, juice is boiled in open pan furnaces with little control over sugar losses due to inversion caused by boiling the juice at higher temperatures and for longer periods. The VP technology is energy self sufficient while OP needs additional fuel.

IV. **Crystallization** is the inducement of crystal formation from the massecuite produced after boiling. In VP technology, this process is carried out in evaporative vacuum pan crystallizers with seeding. In OP technology, Crystallization is done by cooling in open tanks or at best in water cooled tanks with or without seeding. VP Technology achieves higher Crystallization due to less sucrose inversion and higher juice purity.

V. **Centrifuging** is done in both VP and OP technologies in high speed centrifuges with steam or water washing device for the purpose of better separation of sugar crystals from the adhering molasses.

VI. **Drying and packaging** are done to preserve the extracted sugar for subsequent usage. In VP technology this is achieved using continuous dryers with automatic bagging or bulk storage. In OP technology drying is done either by sun or rotary dryers and mostly with manual bagging.

ECONOMIC, SOCIAL AND TECHNICAL CONTRASTS BETWEEN VP AND OP

Stewart (1983) put the investment requirement of OP at about 40 percent that required for VP, while the total employment generation of OP is 600 percent that of VP. Comparison of the two basic technologies involves a complex of trade-offs, such as differences in capital and labour intensities, lumpiness of investment, time profiles of costs and returns, relative risks, fuel consumption, product yield and quality; market size and consumer preferences.

In general, it is widely recognised that a VP plant working at optimal capacity will be more technically efficient and more economically optimal than OP. However, there are a number of circumstances which suggest that VP plants cannot always be run at optimal scales. This is associated with countires of the developing world where policies exist to promote a variety of development objectives, which tend to favour the OP technology. Such policies include :

I. Saving of scare foreign exchange

II. Promotion of self-sufficiency in sugar production

III. Encouragement of rural development through rural industrial investment and employment generation

IV. Provision of access to income earning opportunities in rural areas and

V. Improvement of the welfare of rural societies

Three conditions relating to cane supply also favour OP technology in developing countries. These include areas :

(a) where surplus canes from VP mills may be absorbed by OP units

(b) where land available for cane cultivation is insufficient to supply a VP mill and

(c) where a low-cost approach is needed to develop cane cultivation.

Although VP remains more economically efficient as a sugar producing technology, the survival of OP technology seems to provide a wider regional distribution of sugar production. It also offers employment and maintains a more equitable distribution of income. OP is also less likely to encourage monoculture and it stimulates the development of a local sugar engineering industry as its lower technical complexity makes local fabrication feasible (Bush, 1987). Tribe (1987, unpublished report) writing on differential prices and technology selection in India argued that besides saving and labour use there are a number of other factors in favour of OP technology adoption, these are :

I. Hidden over head costs in VP technology adoption for example, the Savannah Sugar Company Ltd. Numan in Adamawa State, Nigeria, had to build a dam and extensive canals to ensure large scale production of cane as well as providing staff housing and transport (Dere, 1991).

II. Utilization of domestic resources as extensively as possible and

III. Low capital base

THE OP EXPERIENCES OF SOME DEVELOPING COUNTRIES

Kenya :

Sugarcane processing using the Open Pan technology was also introduced recently in East Africa where the indigenous source of sweetener was basically honey (Kaplinsky 1984 pp. 78-118). Despite its short period of introduction, it is now a major industry in East Africa because of its associated socio-economic benefits.

A comparison of the VP and OP technology in Kenya favoured the OP technology. The capital cost per workplace of a VP plant is 21 times higher than that of an OP plant. Also a substantial increase in employment (from 4,420 to 25,920) with equivalent sharp reduction in capital costs from K$338 m to K$91 m) was recorded (Kaplinsky 1984). It was also observed that costs for foreign exchange components and infrastructures were higher for VP plants since almost all the components were imported at huge foreign exchange cost unlike the components in OP plants where fabrication of the crushers, crystallizers, sulphtation tanks evaporation systems and driers were done locally. Unlike the VP plants which delay cane processing, the OP plants in Kenya do not, hence recording high recovery rates of nine percent due to prevention of sucrose inversion which usually results from long delay in cane processing. Rural enterprises were also stimulated as investments requiring limited use of land was made possible by the introduction of OP technology (Kaplinsky, 1984).

South Africa :

A successful programme of rural development and upliftment was achieved in South Africa by the establishment of small farmer-producing sugarcane communities for rural sugar production. As such, between 1973 and 1985 alone, there was a 400% increase in cane delivery by small scale farmers in Kwazulu. This opened up formerly inaccessible areas and paved the way for the concomitant development of trading centres, transport systems, medical and educational facilities which are the multiplier effects that accompany any successful rural development (Dewey, 1986).

This can also be done in Nigeria by establishing several OP technologies in all the identified sugarcane producing areas of the country as indicated by Lafiagi (1984). This is so because the three VP plants in existence has turn out less than 10% of Nigeria's annual sugar requirements (Dere, 1991). Development of the country's sugar industry through the OP technologies will be a move in the right direction this will also save the much needed foreign exchange being used on sugar importation. The high costs of VP plants and the attendant risks of their not operating at optimal levels make the OP plants more appropriate for most developing countries. The issue at stake is whether the greater appropriateness of OP technology for operating conditions in developing countries is outweighed by its lower sugar recovery rate. The choice for either technology is however left at the economic discretion of the user.

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