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THE ECONOMIC IMPORTANCE OF SUGARCANE : AN IMPERATIVE GRASS OF INDIAN SUB-CONTINENT

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ABSTRACT : Sugarcane is the main source of sugar in India and holds a prominent position as a cash crop. India was the 2nd largest producer of sugar in the world after Brazil in 2014-15. Sugarcane is a renewable, natural agricultural resource because it provides sugar, besides biofuel, fibre, fertilizer and myriad of byproducts/co-products with ecological sustainability. Its juice is used for making white sugar, brown sugar (khandsari) and jiggery (gur). It is one of the main crop of earning foreign exchange. The main byproducts of the sugarcane industry are bagasse and molasses. Bagasse is mainly used as a fuel. It is also used for the production of compressed fiber board, paper, plastics and furfural. Molasses is used in distilleries for the manufacture of ethyl alcohol, butyl alcohol, citric acid etc. Sugarcane press mud has good potential as organic fertilizer. Green tops of cane are a good source of fodder for cattle. Sugar industry in India is next in importance only to the textile industry and provides gainful employment to a large number of people. Warm Countries produce cane sugar whereas regions with cooler climates produce beet sugar. Human being roughly consumes 24kg sugar annually (33 kg in commercial countries). It is mostly considered harmful but it has many health benefits too, and it can be used in fighting with low blood pressure, diabetics and depression.

Key words : *Saccharum officinarum*, Byproducts, Bagasse, Molasses, Sugar pressmud.

INTRODUCTION

Sugarcane, *Saccharum officinarum* L., an old energy source for human beings and, more recently, a replacement of fossil fuel for motor vehicles, was first grown in South East Asia and Western India. Around 327 B.C. it was an important crop in the Indian sub-continent. It was introduced to Egypt around 647 A.D. and about one century later, to Spain (755 A.D.). Sugarcane belong to grass family *Gramineae* (*Poaceae*). The genus *Saccharum* is placed under tribe Andropogonae. This tribe is characteristically found in tropical and sub-tropical regions. The Andropogonae plants are clearly distinguished from other grass species by the presence of paired spikelets, one sessile and one pedicellate borne on a fragile rachis (Burr *et al*, 1957; Mukherjee, 1957). Sugarcane is an important commercial crop of the country occupying around 5.01 million hectares area with an annual cane production of around 350.02 million tones and yield 69838 kg/hectare during 2013-14 (Suman, 2001). India's share in the world production of sugar was 17 percent in 2014-15 (Table 1). The biggest producer and exporter of sugar in the world is Brazil (23% of total production and 50% of total exports in the 2010-11 fiscal year). A significant amount of sugar is also produced in India, China, Thailand and the United States. About 35 million farmers grow and depend on sugarcane for their livelihood and an equal number of agricultural labourers earn their living by working in sugarcane farms. Sugarcane plays a key role in Indian economy by contributing substantially to national agricultural GDP (gross domestic product) by way of contributing excise duty and payment to cane growers. The main product of sugarcane is sucrose, which accumulates in stalk internodes (Kort, 1969-1983; Paturau, 1982; Paturau 984). It extracted and purified in specialized mill factories is used as an important food material in human diet, a raw material in human food industries or is fermented to produce ethanol, a low pollution fuel. Sugarcane products include table sugar, molasse, bagasse and ethanol. Sugarcane as a biofuel crop has much expanded in the last decade, yielding anhydrous ethanol (gasoline additive) and hydrated ethanol by fermentation and distiliation of sugarcane juice and molasses.

Byproducts of sugar industry

Sugar is one of the most valuable products of the plant world obtained from *Saccharum* species. It is used in the manufacture of alcoholic beverages, soft drinks, ice-creams, chocolates, canning industry. The main byproducts of the sugarcane industry (Gunkel *et al*, 2007)

Table 1 : Area, production and yield of Sugarcane during 2013-14 in major producing States of India.

Area-Million Hectares
Production- Million Tonnes
Yield- Kg/Hectare

State	Area	Production	Yield
Uttar Pradesh	2.23	135.16	60665
Maharashtra	0.94	76.55	81702
Karnataka	0.42	35.91	85500
Tamil Nadu	0.33	31.76	97007
Andhra Pradesh	0.19	15.36	80000
Bihar	0.27	13.48	50740
Gujarat	0.17	12.55	72126
Haryana	0.10	7.45	73000
Uttarakhand	0.10	6.43	61846
Punjab	0.09	6.31	70918
Madhya Pradesh	0.07	3.31	46621
West Bengal	0.02	1.71	100294
Assam	0.03	0.97	33414
Odisha	0.01	0.94	65951
Others	0.04	2.14	@
All India	5.01	350.02	69838

Source: Directorate of Economics and Statistics, Department of Agriculture and Cooperation.
Notes: States have been arranged in descending order of percentage share of production during 2013-14.
@ Since area/production is low in individual states, yield rate is not worked out.

are cane tops, bagasse, filter muds and molasses. Molasses, the chief by-product, is the main raw material for alcohol and thus for alcohol-based industries. Excess bagasse is now being used as raw material in the paper industry. Besides, co-generation of power using bagasse as fuel is considered feasible in most sugar mills (Fig. 1). A lot of Sugarcane juice is used for making white sugar, brown sugar (Khandsari), Jaggery (Gur) and ethanol. Byproducts of sugarcane are described as under below-

1. Health Benefits of Sugarcane Juice

India is one of the leading producers of sugar cane in the world and because of that sugarcane juice or *ganne ka ras* as it's known in Hindi is quite a popular drink in India, especially during the harsh summers. However sugar cane juice is not just another sweet juice, and contrary to popular belief it's one of the healthiest drinks out there and list of nutrients in it will definitely put a lot of natural and artificial energy drinks to shame. Sugarcane juice is rich in calcium, chromium, cobalt, copper, magnesium, manganese, phosphorous, potassium and zinc. It also contains iron and vitamins A, C, B1, B2, B3, B5, and B6, along with high concentration of phytonutrients, antioxidants, proteins and soluble fiber. All these nutrients work together to keep our body in a good and healthy shape. Some other benefits of sugarcane juice are as following-

- It gives an instant kick of energy and quenches the thirst. It is good source of glucose which helps to re-hydrates the human body and gives it a boost of energy.
- Even though cane juice tastes very sweet and has high sugar content, it is good for diabetic patients. It contains natural sugar which has low glycemic index that prevents steep rise in blood glucose levels in diabetics, so it can act as a substitute of aerated drinks for them. However people with Type-2 diabetes should consume it in moderation and after consultation with their doctors.
- Sugarcane juice is considered an alkaline forming food because of the high concentration of calcium, magnesium, potassium, iron, and manganese in it. Diseases like cancer cannot survive in an alkaline environment and that's why studies show that it is effective in fighting against cancer, especially prostate and breast cancer.
- As sugar cane juice boosts protein levels in the body, it helps in maintaining the health of the kidney. Taken in a diluted form, with lime juice and coconut water, sugar cane juice helps in reducing the burning sensation which is commonly associated with urinary tract infections, sexually transmitted diseases, kidney stones and prostatitis.

2. Bagasse

Bagasse is used as a fuel in sugar mills. It is also used for paper making and as an ingredient of fiber board. Bagasse is the fibrous residue of the cane stalk left after crushing and extraction of the juice. It consists of fibres, water and relatively small quantities of soluble solids - mostly sugar. The average composition of mill-run bagasse is the following:

Fibre (including ash)	48.0%
Moisture	50.0%
Soluble solids	2.0%

The fibre consists mainly of cellulose (27%), pentosans (30%), lignin (20%) and ash (3%).

The calorific value (CV) of bagasse is given by the formula:

Net CV = 18 309 - 31.1 S - 207.3 W - 196.1 A (expressed in kJ/kg)

Where, S = soluble solids % bagasse

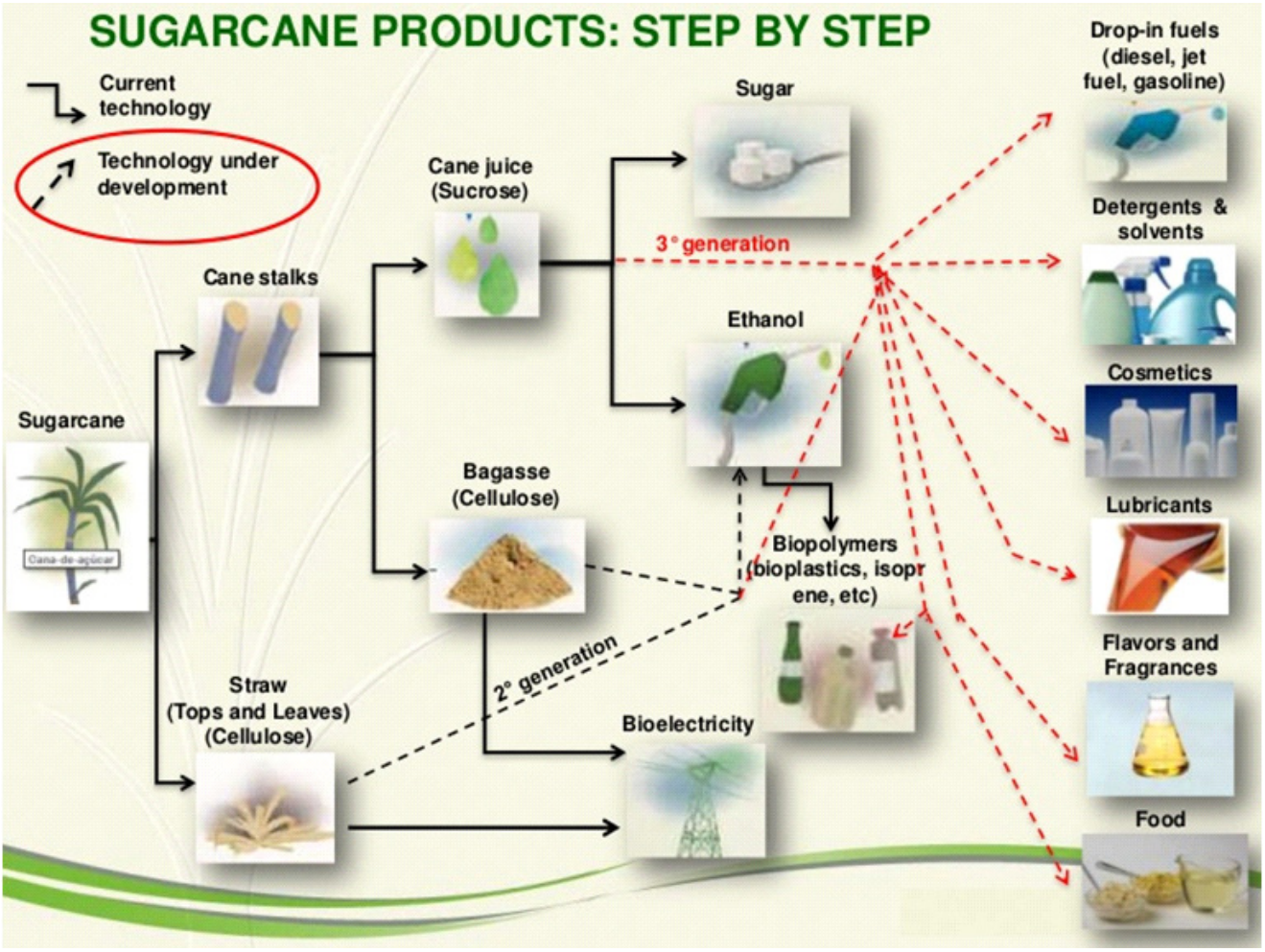

Fig. 1 : Showing adifferent byproducts of the sugarcane industry.

W = moisture % bagasse

A = ash % bagasse

If W = 0, S = 2 and A = 3, then the net CV of bone dry bagasse = 17 659 kJ/kg.

If W = 50, S = 2 and A =1 1/2 then the net CV of mill run bagasse = 7 588 kJ/kg.

Bagasse is used for the generation of steam and power required to operate the sugar factory. A typical factory producing raw sugarcane require, per tonne of cane, about 35 kWh and 450 kg of exhaust steam. Much progress has been achieved lately and, with continuous operation of the pans, crystallizers and centrifuges and an efficient evaporation station, a modern raw sugar factory can now operate with 30 kWh and 300 kg of exhaust steam per tonne of cane. Such a factory can save 50 percent of the bagasse it produces and this bagasse can be used to produce electricity for the grid or saved as raw material for the production of paper, board, furfural, etc.

Main utilization of Bagasse

The major employment of Bagasses are as given below-

a) Electricity

The more straightforward solution is to produce electricity from the bagasse saved via a high pressure boiler and condensing turbo-alternator. This solution has found favour in a number of cane producing countries such a Hawaii, Australia, Reunion and Mauritius and with modern equipment some 450 kWh can now be produced per tonne of mill-run bagasse.

(b) Particle board

The production of particle board from bagasse is a well-proven technology but it has to compete with plywood and fibreboard. Its main difficulty is the high cost of imported synthetic resins which serve as a binder to the bagasse fibres composing the board (Vermas, 1979). Also the board's optimal thickness is about 15 mm and further it cannot be used for outdoor purposes, so

that its main market is limited to inner partitions and furniture.

(c) Paper

Good quality wrapping and magazine paper can be produced with a high percentage of depithed bagasse as raw material (Weyman, M. 1974, Western, A. M. 1979). The availability of a fair size internal market, sufficient surplus bagasse and fair quality industrial water are the usual constraints, apart from the high capital intensity of paper plants and the necessity to handle polluting effluents.

(d) Furfural

Furfural is a colourless, inflammable, volatile, aromatic liquid produced from a number of plant materials containing pentosans - in the case of bagasse, 90 percent being xylan. With acid hydrolysis the xylan yields xylose which subsequently loses 3 water molecules to form furfural. In practice about 25 tonnes of mill-run bagasse are required to produce 1 tonne of furfural. It has many industrial uses, one of them being as a selective solvent for the refining of lubricating oils and another as an intermediate in the production of nylon 6.6 and resins used for moulding powders. Furfural on hydrogenation yields furfuryl alcohol which can produce inexpensive, heat-stable and corrosion-resistant resins. Furfuryl alcohol is also used in the pharmaceutical, fungicide, insecticide and solvent fields.

(e) Methane

Much has been written on the production of methane or biogas and very often sugarcane producers have been under the impression that a good opportunity was being lost in the production of an economic gaseous fuel from their surplus bagasse. Methane (CH_4) and carbon dioxide are the main gaseous products of the anaerobic methane fermentation of waste and cellulosic materials. Theoretically 1 kg of cellulose would produce 415 litres of methane, but in practice the process is less efficient with a complex three-stage reaction operating in cascade and not always easy to manage. Cellulose is, normally, easily digested by bacteria. However when it is combined with lignin, as in bagasse, it is degraded only with great difficulty. Hence a biogas digester in the sugar industry should be planned to operate mainly on distillery stillage or feedlot effluents with a small addition of surplus pith, and not on bagasse as the only or main raw material.

3. Molasses

Molasses is an important by products of sugarcane industry which is used as a livestock feed and for preparation of rum, industrial alcohol (Balch, 1953; Chenu 1977; Kelly, 1977), vinegar, glycerol, lactic acid and mono sodium glutamate. It is also used in cooking and candy making, and sometimes it is used as manure. Molasses is the final effluent obtained in the preparation of sugar by repeated crystallization; it is the residual syrup from which no crystalline sucrose can be obtained by simple means (Prescott and Dunn 1949). The composition of molasses varies also within fairly wide limits but, on average, would be as follows (Table 2):

Table 2 : An average composition of Molasses.

Water	20%
Sucrose	35%
Fructose	9%
Glucose	7%
Other reducing sugars	3%
Other carbohydrates	4%
Nitrogenous compounds	4.5%
Non-nitrogenous acids	5%
Ash	12%
Others	5%

A very large number of products can be derived from molasses are as below -

(a) Rum

(b) Rum is the alcoholic distillate from the fermentation of cane juice, syrup or molasses. It has a characteristic taste and aroma. Its production derives from a simplified, but selective, ethylic fermentation and distillation, a number of esters and higher alcohols or "congeners" being present in the end-product.

(b) Ethyl alcohol (C_2H_5OH)

Ethyl alcohol is amongst the most important fermentation products (Hartemink, 2008) and is derived from three types of raw materials:

i. Sacchrine products - mainly molasses, but also cane juice

ii. Starchy products - mainly maize

iii. Cellulosic products - mainly waste sulphite pulp liquor.

(c) Acetic acid (CH_3COOH)

Acetic acid is a colourless liquid with a characteristic pungent odour and a sharp acid taste. Its density is 1 049 g/l. Vinegar is a condiment made from sugary or starchy materials by alcoholic and subsequent acetous fermentation. It contains at least 4 percent of acetic acid.

(d) Butanol-acetone

Butanol (C_4H_9OH) is the industrial name given to N-butyl alcohol. It is a colourless liquid with a vinous

odour and a density of 810 g/l. It is used, directly or indirectly, in lacquer solvent via its acetate and phtalate salts and also as a plasticizer, hydraulic fluid, and intermediate. The butanol-acetone fermentation is a true anaerobic fermentation brought about by various strains of *Clostridium acetobutlicum*. Maize and molasses are the main raw materials used.

(e) Citric acid

Citric acid is one of the most verstile of the industrial organic acids, finding increasing uses in the food and beverage industries. Since there is no potential threat from any "synthetic" citric acid, the production of fermentation citric acid appears warranted in the larger cane producing countries where molasses is available at a fairly low price, and when the local market for soft drink, confectionery and pharmaceutical preparations is on the increase. Citric acid is usually produced in the monohydrate form ($C_6H_8O_7H_2O$), the crystals of which are colourless and odurless, with a sour taste and readily efflorescent in dry air.

(f) Yeast

Yeasts are complex, protein-rich, living unicellular organisms that have been selected and isolated through research, and two strains are now mainly utilized, namely: *Saccharomyces cerevisiae* to produce baker's yeast and *Torula utilis* to produce feed yeast (Moundlic, J. 1979). Baker's yeast is normally produced from molasses, grains or potatoes. Feed yeast usually utilizes brewer's or distiller's stillage. The assimilation of glucose in the aerobic biosynthesis of yeast can be approximately illustrated by the formula:

$$C_6H_{12}O_6 + NH_3 \text{ — } C_6H_7O_3NH_2 + 3H_2O$$

About 4 kg of molasses would be required to produce 1 kg of active dry baker's yeast (92 percent dry matter). Yeast is used in bread production at about 1 percent by weight of flour. On a dry matter basis, it contains about 44 percent protein.

(g) Monosodium-glutamate ($C_5H_6O_4.NH_2Na.H_2O$)

Monosodium glutamate is an important commercial flavouring intensifier with a world production of about 250 000 tonnes/year. It is currently produced by the aerobic fermentation of molasses but there are also a number of synthetic routes available for its production, especially via acrilonitrile. In the fermentation process which is carried out in well-aerated submerged culture, the bacteria *Micrococus glutamicus* is utilized with molasses as raw material

(h) Industrial alcohol as cooking fuel

Although this utilization will be of little interest to industrialized countries, bearing in mind the very large number of people who still use wood, or wood charcoal, in open ovens to cook their meals, and the critical problem of deforestation in many parts of the world and especially in Africa, consideration must be given to the efficient utilization of ethanol as cooking fuel.

4. Sugarcane Pressmud as a organic fertilizer

Pressmud is a byproduct of sugar industry produced during clarification of sugarcane juice. Crushing of 1 Ton of cane gives 35 to 40Kg of pressmud. It is soft, spongy, amorphous , dark brown material containing sugar, fibres and coagulated colloids including cane, wax, in organic salts and soil particles. It has good potential as organic fertilizer.

CONCLUSION

The large-scale utilization of byproducts of the sugarcane industry, if efficiently implemented, has the dual and important advantage of generating reasonable profits, not only for the sugar producers themselves but also for the national economy at large, as exemplified by cheap electricity, imports replacement, the efficient use of local fuels and forest preservation. Sugar pressmud (SPM) is found to be worthy for maintaining health of plant and soil properties and protects the plant from various soil borne diseases. It has good potential as organic fertilizer. Bagasse a byproduct of both sugar and ethanol production is burned to generate electricity to run the mill and it can also be used for production of biodegradable plastic. India also have diversified into by-products based industries and have invested to put up distilleries, organic chemical plants, paper and board factories as well as co-generation units.

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