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Spoilage of sugarcane juice a problem in sugarcane industry

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ABSTRACT : Sugarcane juice deterioration in the factory storage pile, or during factory milling processes, has become a topic of major concern in recent years, where mechanical harvesting of billeted sugar cane has increased dramatically. Sucrose destruction reactions in cane deterioration include chemical (acid) and enzymic inversion reactions, and those from microbial activity, and can be influenced by sugarcane health and environmental conditions. Sugar technologists (Eggleston *et al.*, 2001a and b; Lionnet, 1996; Morel du Boil, 1995) have reported a variety of sugarcane deterioration products to confirm cane deterioration and delay (cut-to-crush time), which have been used to predict and control processing problems at the factory. Such deterioration products have included high invert concentrations, microbial (yeast, bacteria, and fungi) contamination (e.g. ethanol and lactic acid concentrations) and polysaccharides. In addition, the consumption of sugarcane itself as sugarcane juice is very popular because it is considered a refreshing and energizing drink, which is sold in restaurants, supermarkets, trailers, and kiosks. This drink is also quite common in other countries, such as Malaysia (Qudsieh *et al*., 2002), India (Shinde *et al*., 2010) and Cuba (Alonso Pippo *et al*., 2007). However, processing and marketing of sugarcane juice is limited by its rapid deterioration (Prasad and Nath, 2002; Yusof *et al.*, 2000).Aim of this review paper was to discuss different technology to stabilize sugarcane juice.

KEY WORDS : Spoilage of sugarcane juice, Deterioration, Presentation of sugar cane juice

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Sugarcane (*Saccharum officinarum*), is a giant grass belonging to the family Graminae. Mythological texts of India dating back over 3000 years ago, mention the name of sugarcane and its products. The Sanskrit word 'SARKARA' from which the word 'SACCHARUM' seems to have been derived, also indicates the antiquity knowledge of sugarcane in India (Lakshmikantham, 1983).

The sugarcane plant is composed of four principal parts, the leaf, the stalk, the root system and the flower. The stalk is approximately cylindrical and is composed of number of section or internodes (King *et al*., 1965). The sugar content of cane is dissolved in juice contained in millions of plant cells each one of which must be ruptured for the juice to be expressed (Mathur, 1975).

Sugarcane juice is a type of drink commonly found in Southeast Asia, South Asia, Latin America, and also in other countries where sugarcane is grown commercially. Sugarcane juice is a very popular drink in India but still it is rarely available commercially in packaged form.

Development of effective treatments or procedures to keep the fresh quality of sugarcane juice would allow it to be more widely marketed, and would enhance its quality and safety as well. Considerable efforts have been aimed at stabilizing the juice quality during processing and distribution.

Production of sugarcane in India:

Sugarcane (*Saccharum officinarum*) is one of the most important agro-industrial crops in our country. The total production of sugarcane in India has been increased from 342.382 M tonnes during 2010-11 to 361.037 tonnes during 2011-12.In India maximum cane area is to be found in Uttar Pradesh among the different states of the country. In 2010-11, sugarcane was planted in 4.98 million hectares across the country, of which 1 million hectares was in Maharashtra and over 2 million hectares in Uttar Pradesh, official estimates show. Uttar Pradesh and Maharashtra are the two largest sugarcane producing states in the country, accounting for more than 80 per cent of the annual crop production.

In 2009-10, the total production of sugarcane in the country was around 292 million tonnes, producing about 63.50

% of white sugar and 26.60 % gur and khandsari. (Anonymous, 2011) whereas in 2010-11 the total production of sugarcane was around 340 million tonnes, producing nearly 70.70 million tonnes white sugar and 17.40 million tonnes gur and khandsari. India stands second among other sugarcane growing countries, contributing nearly 20.40% area and 18.60% production. About 50-60% of the cane produced is utilized for production of jaggery (gur) and open pan sugar- khandsari (Pattnayak and Misra, 2004). With cane continuing to be profitable, farmers in India are devoting more land to the crop. Most of the cane for the 2011-12 crushing season has already been planted, the area under cane cultivation at 5.061 million ha, up 4.1% from 4.863 million a year ago. The area under the crop in the top sugarcane producing state of Uttar Pradesh (UP) is likely to rise about 10% in 2011-12 due to the increase in cane procurement prices and regular and timely payments to farmers by mills. The acreage is estimated to increase by about 200,000 ha to 2.3 million in 2011-12. In UP, most of cane planting takes place between February and May and the rest in September-October (Agriculture Ministry, 2011-12).

This is a popular drink in India especially in states such as Gujarat, Maharashtra, Andhra Pradesh, Tamil Nadu, Punjab, Haryana, Himachal Pradesh, Rajasthan and Uttar Pradesh. It is known as "Oosacha Ras" or "Ganneka Ras" in Maharashtra in Marathi and Hindi accordingly ('Ras' translates to 'juice', whereas the former in both terms, 'Oos' and 'Ganna' translate to 'Sugar cane'). It is called Roh in eastern Punjab. People usually like this drink in the summer months. Some other additives are added to the fresh juice like lemon, ginger, mint, and ice. "Oosacha Ras" vendors are common place all year round in the city of Mumbai, Maharashtra. People also can find this drink along the roads sides in Punjab from mid March to the last of October. Most of the vendors do prepare fresh juice quickly on demand.

Deterioration of sugarcane juice source and indicator:

Dextran polysaccharide (formed mainly by leuconostoc bacteria) has often been reported as a cane deterioration indicator, and is responsible for many of the numerous negative impacts that cane deterioration has on factory processing, mostly associated with the rise in viscosity from this polysaccharide. Oligosaccharides are also products of cane deterioration (Eggleston *et al*., 2001; Morel du boil, 1995; Ravelo *et al.*, 1995) and are responsible for crystal deformation problems (Morel du boil, 1991). Ravelo *et al.* (1991) reported that the formation of total oligosaccharides was greater than the formation of dextran and ethanol in cane subjected to delays and is, therefore, a more sensitive indicator of cane deterioration. A number of cane deterioration products including high invert sugars, polysaccharides (e.g. Dextran) and microbial contamination (e.g., ethanol and lactic acid formation) have been reported to predict and control processing problems at the factory (Solomon *et al.*, 2006, Eggleston *et al.*, 200 l, Lionnet, 1996, Morel du boil, 1995), but not all deterioration products effect factory processing. Polysaccharide producing soil borne bacteria such as *Leuconostoc* spp. From cane field enters inside the cane through cut ends or damaged sites and thrives at the expense of stored sucrose, further reduces quality of milled juice. The *Leuconostoc* bacteria have the ability to synthesize alpha-glucan polysaccharide (dextran) from sucrose through an extracellular enzyme called dextan sucrose as shown below.

$$\text{Sucrose} + H_2O \xrightarrow[\textit{Leuconostoc}\text{ spp}]{\text{Dextransucrasc}} \text{ID (Glucose).} + \text{Fructose}$$
$$\text{Dextran}$$

Nutrition aspects of sugarcane juice:

Sugarcane juice is very useful in scanty urination. It keeps the urinary flow clear and helps kidneys to perform their functions properly. Sugar is valued highly by common people.

It also contains iron and vitamins A, C, B1, B2, B3, B5, and B6, plus a high concentration of phytonutrients (including chlorophyll), antioxidants, proteins, soluble fibre and numerous other health supportive compounds. Working synergistically, these nutrients provide a supremely health-promoting food which has been studied for its role in fighting cancer, stabilizing blood sugar levels in diabetics, assisting in weight loss, reducing fevers, clearing the kidneys, preventing tooth decay, and a host of other health benefits. It is also valuable in burning micturition due to high acidity, gonorrhea, enlarged prostrate and cystitis. Sugarcane juice is a fattening food. It is thus an effective remedy for thinness. Rapid gain in weight can be achieved by its regular use (Karthikeyan and Samipillai, 2010).Sugarcane juice has been used in the Ayurveda and Unani systems of medicine in India, since time immemorial.Sugarcane extract has displayed a wide range of biological effects including immunostimulation (El-Abasy *et al*., 2002), anti-thrombosis activity, anti-inflammatory activity, vaccine adjuvant, modulation of acetylcholine release (Barocci *et al*., 1999) and anti-stress effects. Sugarcane juice has broad biological effects in raising innate immunity to infections (Lo *et al*., 2005).

The works in this field of study carried out by different renowned workers are summarized as follows:

Changes in quality of sugar-cane juice upon delayed extraction and storage:

Yusof *et al*. (1999) studied the quality of sugar-cane juice extracted from stored canes, as well as changes in quality of fresh juice stored at different temperatures. Cane stems were stored at 10.1^0 C, 85±88% relative humidity (RH) and 27.1^0 C, 55±85% RH, while fresh juice was stored at 5.1^0 C, 61±84% RH and 27.1^0 C, 55±85% RH. The physicochemical parameters evaluated were juice yield, juice colour, total soluble solids, sugar content (sucrose, fructose, glucose), titratable acidity, pH, chlorophyll content and sensory evaluation for colour and flavour. Viscosity and total microbial count on stored cane juice were also determined. Results showed that low temperature storage (10^0 C) of canes was able to maintain the quality of juice for up to 9 days while low temperature storage (5^0 C) of juice could last for only 4 days. During storage, sucrose contents decreased while fructose, glucose and titratable acidity increased in both types of samples. The colour changes in juice extracted from stored canes was inconspicuous until day 9. Deterioration of cane stored at 27.1^0 C occurred faster than that stored at 10.1^0 C. Fresh sugar-cane juice became spoiled after 4 days when stored at 5.1^0 C and 1 day when stored at 27.1^0 C. Microbial count, especially lactic acid bacteria count, increase during storage of cane juice.

Effect of maturity on chlorophyll, tannin, color and polyphenol oxidase (PPO) activity of sugarcane juice :

Hanan *et al.* (2001) determined the effect of sugarcane maturation on the contents of chlorophyll, tannin, and polyphenol oxidase (PPO) activity and on color change of sugarcane juice. The maturation period of the cane studied was between 3 and 10 months after planting. Different parts of the cane, namely, the top, middle, and bottom portions, were analyzed. Results obtained indicated that there were significant ($P < 0.01$) decreases in total chlorophyll a and b and tannin contents during maturity followed by slower rates of decrease of both parameters at the end of maturity stages. There were no significant differences ($P > 0.05$) in chlorophyll and tannin contents between the middle and bottom portions. On the other hand, the top portion of the stem had a significantly ($P < 0.01$) lower concentration of chlorophyll and a significantly ($P < 0.01$) higher content of tannin. PPO activity of sugarcane juice was determined using chlorogenic acid as a substrate. There was a highly significant difference ($P < 0.01$) in PPO activity of cane juice during maturity. PPO activity was high at the early development stage, decreased during maturation, and then remained relatively constant at the end of maturity.

Maintaining the quality of sugarcane juice with balanching and ascorbic acid :

Lin Chun Mao *et al*. (2007) observed that blanching of stems before squeezing reduced the juice yield by about 5%. Both blanching of stems and addition of ascorbic acid influenced all parameters determined. Both treatments had significant effects on preventing color change, delaying the increase of reducing sugar, titratable acidity, viscosity and total microbial count, reducing PPO and SNI activities. Freshly extracted, unpasteurised sugarcane juice could be kept at 10^0 C for 5 days. Beyond that, the quality deteriorated as indicating browning, increased titratable acidity and viscosity. The combination of blanching of sugarcane stems and addition of ascorbic acid would produce the best quality of sugarcane juice.

Weerachet Jittanit *et al*. (2010) reported that microwave heating for 5 min by frequency 2,450 MHz at 850W and the blanching sugarcane in hot water at 80°C for 5 min could inactivate the peroxidise enzymes at the comparable level.

Effect of pretreatments on physico-chemical characteristics of sugarcane juice:

Karmakar *et al*. (2011) reported that sugarcane juice beverage samples were prepared by pasteurizing the juice at different temperatures. Pasteurization was done in eight conical flasks which contain 100 ml of sugarcane juice per flask at different temperatures *viz*., 80, 85, 90, 95^0 C for 2 min. Samples of sugarcane juice were stored at 25 and 4^0 C in pasteurized glass bottles and analyzed vitamin C and microbiological attributes at every 2 days interval for 25 days. sample heated at 90^0 C for 5 min and stored at 4^0 C, the desired properties remain intact for a longer time. After studying all the parameters of the sugarcane juice in each of the above mentioned conditions this juice is biologically safe after pasteurization and the food value is more or less same. An acceptable quality beverage of sugarcane juice with satisfactory storage stability for 25 days at 4^0 C could be prepared.

Optimization of process and physico-chemical properties of ready-to-serve (RTS) beverage of cane juice with curd:

Singh *et al*. (2012) used cane juice from sugarcane variety in this study having 18.3–19.5 ^{0}Brix total soluble solid (TSS), 0.13–0.18 % acidity, 6.05–6.16 mg/100 g ascorbic acid, 59.14–63.18 % sucrose, 5.1–5.4 pH and 4.36–5.43 % reducing sugar. The proportions of sugarcane juice with curd in the RTS beverage was optimized using various cane juice to curd proportions. Sugarcane juice with curd was preserved and packed in 200 ml glass bottles and kept for different storage periods (0, 5, 15 and 20 days). Beverages prepared from 4:1 proportion of juice and curd were found superior after 15 days of storage.

Preservation of sugarcane juice using hurdle technology:

Sneh Sankhla *et al*. 2011 observed that sugarcane juice was subjected following treatments *viz*. pasteurization at 80^0 C for 10 min, chemical treatments (KMS @ 150 ppm and citric acid @ 0.05%); pasteurization at 80^0 C for 10 min, chemical treatments (KMS @ 150 ppm and citric acid @ 0.05%) and sterilization at 80^0 C for 20 min. All the samples were packed in glass bottles, polyethylene tetrapthelate (PET) bottles and low density polyethylene pouches (LDPE) and then irradiated at 0.25, 0.5 and 1.0 kGy and stored for 90 days at room and low temperature. Non-irradiated samples were taken as control. On treatment moisture content, ascorbic acid, viable bacterial count and viable yeast and mold count were decreased significantly (P =0.05) where as no significant effect was observed on reducing and total sugars in cane juice. Among the three packaging material used glass and PET was found to be at par in increasing the shelf life of sugarcane juice in comparison to LDPE pouches.

Shelf life extension of sugarcane juice using preservatives and gamma radiation processing:

Mishra *et al*. (2011) analysed that a combination of gamma radiation (5 kGy) with permitted preservatives and low temperature storage (10^0C) could preserve raw sugarcane juice for more than a month. The preservatives used were citric acid (0.3%), sodium benzoate (0.015%), potassium sorbate (0.025%), and sucrose (10%). The treatment helped in extending the shelf life to 15 days at ambient temperature (26 ± 2^0C) and 35 days at 10^0C. The microbial load was found to be below detectable limit within this period. The biochemical like phenolics and flavonoids were not found to be affected by addition of these preservatives. The antioxidant activities including free radical scavenging activity, nitrite scavenging activity, and reducing power were also not significantly affected. The sensory evaluation scores showed that the juice with this combination treatment was highly acceptable.

Azra Yasmin *et al*. (2010) reported that sugar cane juice was preserved naturally *i.e.* no traditional chemical additives were added during the production process. Sugarcane Juice was pasteurized just after extraction and its pH was maintained at 4.3 by the addition of citric acid. Pasteurized juice was filled hot in sterilized glass bottles and was stored at room temperature for four months. Physiochemical, microbial and sensory evaluation of the sugar cane juice samples were carried out after fifteen days interval. The developed product was attractive in color, flavor and refreshing with uniform consistency. Bottled juice samples were merely accepted up to a storage period of 120 days.

Naturally preserved sugarcane juice:

Krishnakumar *et al*. (2013) determined the quality of sugarcane juice extracted from stored canes, as well as changes in quality of fresh juice stored at different temperatures. Cane stems were stored at 10 and 30^0C, while the fresh juice was stored at 5 and 30^0C. The parameters studied were juice yield, total soluble solids, total sugar content, titratable acidity, pH, viscosity, total microbial count and sensory evaluation for colour and flavor. Results showed that low temperature storage (10^0C) of canes was able to maintain the quality of juice for 10 days, while low temperature storage (5^0C) of juice could last for only 4 days. Spoilage of cane stored at 30^0C occurred faster than that stored at 10^0C. Fresh sugarcane juice became spoil within a day when stored at 30^0C. Microbial count (bacteria, yeast, fungi) especially lactic acid bacteria count increased, during storage of cane juice.

Conclusion:

Hygiene standards are usually not maintained during the transport of sugarcanes from field to the point of extraction and preparation of juice. Further the juice is consumed unpasteurised therefore, it is possible that the sugarcane juice is contaminated and pose health hazards. Main objective of this review work is to provide hygienic sugarcane juice to peoples and encourage the industrialists to start sugarcane juice production on commercial scale. In order to make the availability of cane juice during off season as a soft drink juice was preserved by different techniques and these techniques also play major role in overcome the problem of increased sugarcane juice viscosity and subsequent loss in recoverable sugars.

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