

EVALUATION OF FREEZE-CONCENTRATED SUGAR-CANE JUICE

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ABSTRACT

Sugar-cane juice with total soluble solid (TSS) of ~ 15 °brix was extracted from blanched sugar-cane stalks. The juice was then used for the production of a double strength (~ 30 °brix) sugar-cane juice using a freeze-concentration process. The freeze-concentrated juice was lower in pH and color values, and higher in chlorophyll content and non-enzymic browning (NEB) index as compared to the fresh juice, however its microbial content was similar to the fresh juice. A sensory evaluation performed on the samples indicated that fresh sugar-cane juice had higher hedonic scores in sweetness, flavor, color and overall acceptability as compared to that of freeze-concentrated juice. The sensory scores of concentrated juice however improved upon reconstitution with mineral water. Reconstituted juice with TSS of 15 and 20 °brix had the highest hedonic scores for the flavor, sweetness, color and overall acceptability attributes. During storage studies, the TSS and pH values of freeze-concentrated juice stored at 10 and 25 °C decreased considerably with storage times, and the decrease was more pronounced in the juice stored at 25 °C. The TSS and pH values however were almost unchanged at storage temperatures of -18 and 4 °C. The color values and NEB index of all juice were not affected by the storage temperatures used. The possibility of concentrating sugar-cane juice through freeze-concentration or membrane processing is suggested.

Keywords: Freeze-concentration; fresh sugar-cane juice; reconstitution

Introduction

Fresh sugar-cane juice is a popular thirst-quenching drink in many South East Asian countries due probably to its typical cane's flavor and sweetness. The main problem associated with fresh sugar-cane juice is its short shelf life and heat sensitivity of its flavor. Therefore the drink is mostly sold-fresh by the roadsides and small eateries. This contributes to the variation in the total solid content (TSS) of the fresh juice and may give rise to differences in flavor and other sensory attributes.

The difficulty in preserving sugar-cane juice stems from the nature of the juice itself. Being a non-fruit, the pH of the juice is normally above 5.0 (Yusof *et al*, 2000), a condition that favors microbial growth. In addition, the high sugar content of the juice makes it vulnerable to sugar degradation if heated at high temperatures such as during the processes of pasteurization, evaporation and drying. Therefore, most of the attempts to preserve the sugar-cane juice have been focusing on the use of refrigeration, heat treatment and preservatives (Bhupinder *et al* 1991; Yusof *et al*, 2000). The uses of heat treatment and preservatives however, have not been commercially applied since these could have an effect on the sensory attributes of the juice. The use of low temperatures or chilling has been the most preferred method in maintaining the quality of sugar-cane juice (Yusof *et al*, 2000; Bhupinder *et al*, 1991) even though this may not be practical for many small scale sugar-cane juice vendors.

The high sugar content of ~ 15 - 18 % (Tee *et al* 1997; Yusof *et al* 2000) of the juice means that sugar cane juice can potentially be developed into a natural energy drink. Alternatively, the sugar composition of the juice can also be modified in order to obtain the so called "functional sugar-cane juice"; a juice that is high in fructose-oligosaccharides and low in sucrose (Easa, 2000). The content of chlorophyll in the juice is also quite substantial (~ 1 mg/100 ml) (Yusof *et al*, 2000). This is important since chlorophyll has been suggested as one of the promising anticancer ingredients (Lin, 1999). However, the authenticity of sugar-cane juice and its impact on health will be more appreciated if the juice can be properly preserved using a user-friendly technology that is accessible by the small operators.

During consumption of the fresh juice, it is typical for consumers to add ice cubes in order to achieve the cool and freshness sensation. In many road sides and night-market practices, freshly extracted juice is cooled by mixing it with a quantity of crushed ice and left to stand for several hours. This dilution of flavor and sweetness can reduce the authenticity of the juice as a tropical drink. The authors were not successful in finding any reference of attempts to standardize the flavor of sugar-cane juice by controlling the total solid content of the juice or by drying the juice to a powder form.

Therefore the objective of this study is to evaluate the use of a freeze-concentration process to produce concentrated sugar-cane juice and a range of suitable storage temperatures for maintaining the juice quality. Freeze-concentration is beneficial in conditions where heat is damaging to product quality (Despande *et al*, 1982; Braddock and Marcy, 1985). By controlling the freezing process, the total solid content (TSS) of ingredients occurring within the fresh juice can be substantially increased without the use of excessive heat such as that applied during evaporation. The concentrated juice with standardized TSS can be used by consumer in accordance to their preference.

Materials and methods

Canes were cut into uniform lengths about 0.4 m long (after removing the nodes and outer skin from the cane). They were then washed with plain water to remove any dirt or foreign particles from the cane surfaces. Canes were then blanched at 80 °C for 15 min

using a steaming cabinet (MSM-2001, Malaysia). After rinsing, a three-roller power crusher (Mindong Electric, model CH-316, Taiwan) was used to extract the juice.

Extracted juice was filled into polypropylene plastic casings (30.5 cm x 21 cm) that was then sealed and subjected to a rapid chilling treatment to -18 °C using an air blast freezer (Irinex, Italy). The juice was then transferred into a domestic freezer (Sharp, Malaysia) and stored for 24 h after which the hardening and completion of ice formation occurred. At this stage separation of ice and unfrozen phase consisted mainly of concentrated sugar-cane juice were evidenced. A small opening was made at one end of the plastic casing to allow the flow of the concentrated juice into a volumetric flask.

Freeze-concentrated juice was compared against fresh juice for physicochemical properties (pH, total soluble solid or TSS, colour and chlorophyll), sensory attributes (Hedonic ratings) and storage stability at -18, 4, 10 and 25 °C. Analysis of colour, TSS and chlorophyll were performed according to the methods of Yusof *et al* (2000). NEB index analysis was performed according to the method of Butchelli and Robinson (1994).

Estimation of relative viscosity

Juice was filtered through a 40 µ filter to separate the pulp and the viscosity of the juice measured using a graduated burette (50 ml, 1 mm orifice). Time required for 40 ml freeze-concentrated juice to run out at 3-4 °C was measured and expressed relative to time found for fresh juice.

Sensory evaluation and reconstitution studies

To standardize the temperature of samples for sensory evaluation, freshly prepared samples were kept in paper cups and stored at 4 °C for 4 h before serving. Sensory evaluation of the juice was carried out by 10 panelists. The panelists rated the samples for color, aroma, sweetness, aftertaste, flavor and overall acceptability using a hedonic scale of 1-9 (1=dislike very much, 9=like very much). In the reconstitution studies, freeze-concentrated juice was reconstituted with a commercial mineral water to a TSS range of 15 to 25 °Brix and sensory evaluation performed.

Results and discussion

Freeze-concentration process was employed during the production of a double strength sugar cane juice (~ 30 °Brix). 2 kg of cane stalk yielded approximately 2 L of fresh juice that was used during the freeze-concentration process to yield approximately 500 ml of concentrated juice. Freeze-concentrated juice had lower pH, color values but higher chlorophyll content, relative viscosity and non-enzymic browning (NEB) index as compared to the fresh juice. It can thus be suggested that the freeze-concentrated juice was higher in organic acid content, darker in color and may have had a higher level of water soluble materials (Table 1). The change in the colour values of the freeze-concentrated juice could have been due the combined effect of an increase in chlorophyll content and occurrence of non-enzymic browning during stalk-blanching. The increased negative of a* value may be due to the rise in chlorophyll content.

The freeze-concentrated juice also differed in the sensory attributes as compared to the fresh juice (Fig. 1). Even though the TSS of fresh juice was half that of freeze-concentrated juice, the scores in flavor, sweetness, aftertaste and overall acceptability were higher than the freeze-concentrated juice. No difference in the score of color and aroma was detected between the two juices. This suggests that the freeze concentration process had changed some of the sensory values of the fresh juice.

Analysis	Fresh sugar-cane juice	Freeze-concentrated sugar cane juice
TSS (°brix)	15.0	30.0
pH	5.1	4.8
NEB index	0.121	0.254
Relative viscosity	1.0	1.1
Color	97.8	93.7
Chroma/saturation	9.0	16.2
a*	-0.40	-0.70
Chlorophyll (mg/10 ml)	0.11	0.20

Table 1. Comparison of the average values of some physicochemical properties of fresh (15 °brix) and freeze-concentrated sugar-cane juice (30 °brix).

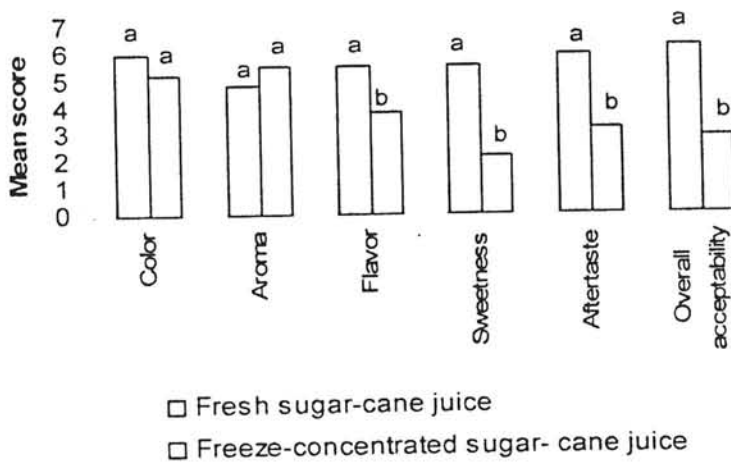


Fig. 1 Comparison of mean sensory attributes of fresh sugar-cane with freeze-concentrated juice. Means of each attribute with different letter are significantly difference ($p < 0.05$).

To see the effect of TSS on the sensory attributes of freeze-concentrated juice, the juice was reconstituted with a commercial mineral water. Diluted juice with a range of TSS between 15 to 25 °Brix were obtained and these were subjected to sensory evaluation (Table 2).

Sensory attributes	Final TSS after dilution			
	15 °brix	20 °brix	25 °brix	30 °brix (original)
Color	5.7 _a ±1.50	6.5 _a ±1.36	6.3 _a ±1.99	6.0 _a =2.17
Aroma	5.3 _a ±1.68	6.3 _a ±1.16	5.6 _a ±1.92	5.7 _a =2.06
Sweetness	6.4 _b ±1.55	6.2 _b ±1.70	4.1 _a ±2.45	3.8 _a =2.21
Flavor	6.5 _c ±1.06	5.9 _{bc} ±1.39	4.9 _{ab} ±2.9	3.9 _a =2.15
"Aftertaste"	6.7 _b ±1.39	6.1 _b ±1.19	3.9 _a ±1.94	3.7 _a =1.95
Overall acceptability	6.9 _b ±1.51	5.8 _b ±1.47	4.3 _a ±2.23	3.9 _a =2.43

Table 2. Sensory attributes of freeze-concentrated sugar cane juice after diluting with mineral water. Means in the same row with different subscript are significantly difference ($p < 0.05$).

The scores for color and aroma were not affected by reconstitution of the concentrated juice with water. However, the scores for sweetness, flavor, aftertaste and overall acceptability improved with dilution. The most acceptable TSS of the diluted freeze-concentrated juice was juices with 15 and 20 °Brix. These TSS were similar to that of a freshly extracted juice (Table 1). Thus it was possible to reconstitute freeze-concentrated sugar cane juice with water to achieve a similar freshness level of the fresh juice. As many consumers prefer drinking sugar-cane juice with ice cubes, the dilution of the freeze-concentrated juice with ice can be expected to yield similar sensory sensation of a fresh juice. The fresh juice may also be formulated to a level of TSS that helps maintain the authenticity of the juice.

During storage of freeze-concentrated juice at -18, 4, 10 and 25 °C, the TSS and pH values of juice stored at 10 and 25 °C decreased considerably with storage time (Fig. 2), and these effect was most pronounced in the juice that was stored at 25 °C. Since a high storage temperature is known to promote microbial infestation of sugar-cane juice (Bhupinder *et al.* 1991) and caused a subsequent drop in pH, this result has been expected. The slight decrease in TSS with storage was due to the loss of sucrose that was consumed by microbes (Yusof *et al.* 2000). The TSS and pH values of juice stored at -18 and 4 °C however remained almost unchanged throughout storage indicating the suitability of these storage temperatures for the juice preservation. It is also possible to suggest the incorporation of preservatives such as potassium metabisulphite (Bhupinder *et al.* 1991) to improve the keeping quality of the freeze-concentrated juice.

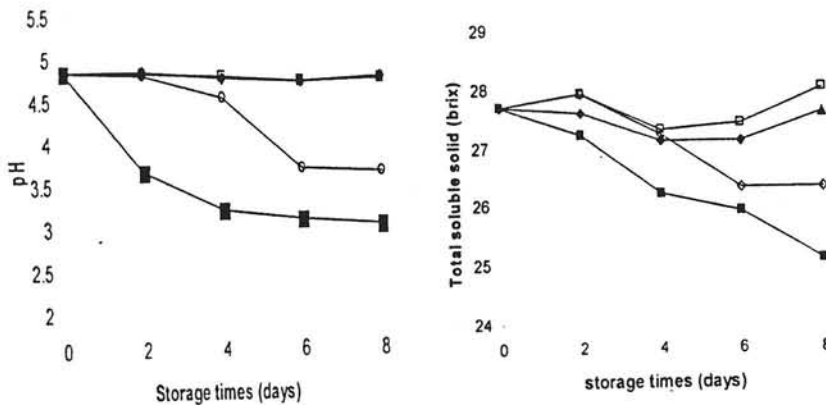


Fig. 2 Changes in pH and total soluble solid (TSS) of freeze-concentrated sugar-cane juice (30 °brix) during storage at -18 (□), 4 (◆), 10 (○) and 25 °C (■) as a function of storage times

Conclusion

The significance of this paper is clear. The potential of producing concentrated sugar cane juice is suggested. However the application of commercial freeze-concentration or membrane processing equipments may result in better yields.

Despite differing in the acceptability of sensory attributes, the freeze-concentrated juice was similar to the fresh juice in terms of changes occurring during storage. The freeze-concentrated sugar cane juice can be reconstituted with water (or diluted with ice cubes) to yield the freshness value similar to the fresh sugar-cane juice.

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