

Original Research Article

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Microbial and Sensory Quality Evaluation of Membrane Processed Sugarcane Juice

Samreen¹, Ch.V.V. Satyanarayana², L. Edukondalu¹ and M. Sandhya³

¹College of Agricultural Engineering, Bapatla, India

²College of Food Science and Technology, Bapatla, India

³College of Home Science, Guntur, India

*Corresponding author

ABSTRACT

Sugarcane juice is commonly used as a delicious drink in both urban and rural areas. Sugarcane juice is spoiled quickly due to the presence of simple sugars. Preservation of sugarcane juice was examined to reduce the spoilage and to increase the shelf life by membrane processing. A study was carried out to preserve sugarcane juice by membrane processing and compared with the untreated juice. The results revealed that good quality sugarcane juice of variety CO380 with satisfactory storage stability at refrigeration could be prepared by microfiltration and pasteurization of sugarcane juice with addition of flocculant. The permeate flux of microfiltered and pasteurized sugarcane juice with addition of flocculant decreased from 9.14 to 6.53 L/h m². Microbial analysis indicated by yeast count, mould count and total plate count revealed that preheated and pasteurized juice and microfiltered and pasteurized juice with addition of PAC and without addition of PAC are relatively better. Sensory evaluation indicated that the microfiltered and pasteurized juice with addition of PAC followed by only thermal treated juice scored highest rating on hedonic scale by panelists in terms of appearance (8.0), flavour (8.16) and overall acceptability (8.0). The colour values generally decreased in all the treatments. Overall based on microbiological and sensory data, it could be concluded that thermal treatment and flocculant added, microfiltered, pasteurized treatments are better in that order, the former being the best. The study suggests that membrane filtration in combination with thermal treatment results in good quality bottled sugarcane juice.

Keywords

Membrane processing, Microfiltration, Ultrafiltration, Poly Aluminium Chloride, Permeate flux, Microbial analysis, Sensory analysis.

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Introduction

Sugarcane (*Saccharum officinarum* L.) is an important industrial crop cultivated in tropical and subtropical regions of the world. India is the world second largest producer of sugarcane next to Brazil. Sugarcane has been used as a sweetener for millennia and today refined sugar is used in copious quantities to supplement the natural sugar found in fruits and vegetables. A part of sugarcane juice is consumed as inexpensive and pleasing beverages in India. It possesses therapeutic

value. Sugarcane juice is commonly used as a delicious drink in both urban and rural areas. Sugarcane juice of 100 ml provides 40 Kcal of energy, 10 mg of iron and 6 µg of carotene. Sugarcane juice is rich in enzymes and has many medicinal properties. It contains water (75%-85%), reducing sugar (0.3-3.0%) and non-reducing sugar (10-21%). Sugarcane juice is a great preventive and healing source for sore throat, cold and flu. Even the diabetic can enjoy this sweet drink without worrying

about calories. It hydrates the body quickly when exposed to prolonged heat and physical activity. It is an excellent substitute for aerated drinks and colas; it refreshes and energizes the body (Ashish *et al.*, 2012). Due to its commercial importance, it is envisaged that sugarcane juice production can become a profitable business provided efforts are made to preserve its fresh quality during storage (Krishnakumar *et al.*, 2013).

In general sugarcane juice is spoiled quickly due to the presence of simple sugars. Soon after the harvest of sugarcane, endogenous invertase enzyme is activated and acts as a cause of deterioration. These enzymes lead to inversion of sucrose and affect the quality of sugar. The polyphenol oxidase is the major enzyme involved in the discoloration of sugarcane juice which can be improved by heat inactivation of enzyme. The sugarcane juice can be introduced as delicious beverage by preventing the spoilage of juice with appropriate preservation method. One of the processes used to enable the commercialization of sugar cane juice is the clarification which can be achieved through two methods, one the conventional filtration method and the other membrane separation method.

The membrane separation processes such as Microfiltration (MF), Ultrafiltration (UF), Nanofiltration (NF) and Reverse osmosis (RO) are promising novel alternative non-thermal and non-chemical methods that are relatively less energy intensive and retain heat labile components. MF and UF offer excellent potential in food industry for clarification and pasteurization to replace conventional techniques. MF is the separation process with membranes similar to classical filtration to retain material that are larger than pore size and permeate as the desired product. UF can be used to produce further clarified juice and also free of microbes as they are larger than molecular weight cutoff of most UF

membranes. Therefore, both UF and MF can potentially replace thermal processing and give better quality juice with good sensory attributes. These processes have several advantages such as energy efficiency, selectivity, simplicity of operation, and reduced consumption of chemicals. Therefore, an attempt was made to explore a non-thermal or combination of thermal and membrane filtration process to produce high quality bottled sugarcane juice. Studies were conducted using fresh sugarcane juice with the objective to explore the possibility of replacing preheating operation in thermal treatment using microfiltration and to develop a process technology for preservation of sugarcane juice by membrane processing.

Materials and Methods

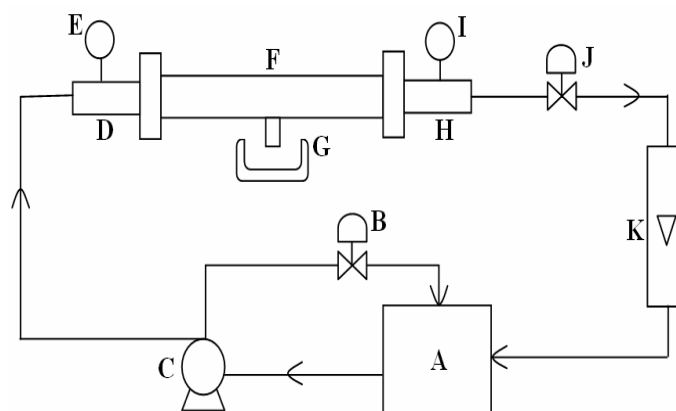
The raw materials i.e. Sugarcane CO380 variety was obtained from a local farmer of Thoreddu village, East Godavari district, Andhra Pradesh. Sodium Benzoate, Poly Aluminium Chloride (PAC), bottles of 250 ml capacity were procured from the market. Sugarcane stems with good quality and without any pest or disease infestation were selected and peeled for juice extraction. Sugarcane juice crusher, Hot air oven, autoclave, Hollow Fibre Membrane Setup (Model HFM-01, IIT Kharagpur), Crown corking machine, Hunterlab color flex meter (M/S. Hunterlab, Reston, VA, USA, and Model CFLX-45).

The colour was expressed as Chroma value (Lo *et al.*, 2007). It can be measured by $\text{Chroma} = (a^{*2} + b^{*2})^{1/2}$. The presence of microorganisms in the processed sugar cane juice was determined by performing Total Plate Count methods (to enumerate the growth of coliforms and other bacteria), mould count (to enumerate the growth of fungi) and yeast count (to enumerate the growth of yeast).

Sugarcane juice was extracted by power operated two horizontal roller type juice extractor and filtered through the muslin cloth to remove the extraneous matter. The juice formulation was done by the addition of ginger extract and lemon extract to sugarcane juice in proper concentration as stated below and the samples were refrigerated. The prepared mixture of ginger extract, lemon

juice and sugarcane juice was filtered through muslin cloth and is subsequently used as a raw material for processing. This mixture is referred as sugarcane juice here after. Flocculation was done for T₂ treatment prior to microfiltration shown in table 1. Membrane processing was carried out in hollow fiber membrane module setup shown in figure 1.

Fig.1 Schematic diagram of the hollow fiber membrane module setup



Where,

A: Feed Tank, B: Bypass Valve, C: Booster Pump, D: Short piece, E: Upstream Pressure gauge (0 – 4.21kg/cm²(60 psi)), F: Hollow Fiber Module, G: Permeate Collector, H: Short Piece, I: Downstream Pressure Gauge (0 – 4.21kg/cm²(60 psi)), J: Pressure valve (Needle type), K: Rotameter (0 – 50 lph).

The permeate flux was calculated as

$$J^* = (1/A) * (dv/dt)$$

Where J* = permeate flux (L /h m²)

A = area of the membrane (m²)

dv = volume of flow rate (L)

dt = time of flow rate (h)

The different treatments which were given to the sugarcane juice are explained in table 1.

Results and Discussion

Changes in microbiological quality of stored sugarcane juice

There was no yeast count found initially in pasteurized, microfiltered pasteurized and PAC added microfiltered pasteurized juices. Then it increased to 1 x 10⁶ CFU / 10 ml in storage. This may be due to thermal treatment and addition of preservative sodium benzoate. In treatments T₄ and T₅ the yeast count was observed to be 2 x 10⁶ CFU / 10 ml. In treatment T₆ higher colonies were observed (Table 2). Chauhan *et al.* (2002) also reported similar microbial changes in pasteurized stored sugarcane juice.

The mould count indicated no growth in all treated samples and in Sample T₆ it was 1 x 10⁶ CFU / 10 ml and increased to 3 x 10⁶

CFU/10 ml on 12th, 16th and 20th days. The mould count for treatments T₁, T₂, T₃ was 1 x 10⁶ CFU / 10 ml and remained same upon storage also. In treatments T₄ and T₅ it was observed to be 1 x 10⁶ CFU / 10 ml and 2 x 10⁶ CFU / 10 ml respectively. However, it increased to 2 x 10⁶ CFU / 10 ml on 12th, 16th and 20th days (Table 3). Similar observations were made by Chauhan *et al.*, (2002).

The total plate count (TPC) was observed to be more in treatment T₆ upon storage. TPC was observed to be less for samples T₁ and T₂. Initially there no growth then increased from 1 x 10⁶ CFU / 10 ml on 12th day to 2 x 10⁶ CFU / 10 ml on 20th day. The treatment T₃ had standard count of 1 x 10⁶ CFU / 10 ml on 0th day to 3 x 10⁶ CFU / 10 ml on 20th day. The treatment T₄ had TPC of 2 x 10⁶ CFU / 10 ml on 0th day to 4 x 10⁶ CFU / 10 ml on

20th day. The treatment T₅ had TPC of 2 x 10⁶ CFU / 10 ml on 0th day to 4 x 10⁶ CFU / 10 ml on 20th day (Table 4). Chauhan *et al.*, (2002) reported similar observations during storage of juice.

Sensory Evaluation of sugarcane juice samples

Sensory evaluation of treatments was carried out for consumer acceptance and preference using 10 untrained panelists selected at random. Appearance, flavour, overall acceptability of the samples were rated using a 9-point Hedonic scale where 9 and 1 represent like extremely and dislike extremely respectively. Sensory evaluation was carried out at ambient conditions in a comfortable and quiet area without disturbance under fluorescent lighting. Water was supplied to cleanse palate between samples.

Table.1 Different treatments given in sugarcane juice processing

Treatment code	Treatment	Method	MEMBRANE	PRESSURE
T ₁	Preheated and pasteurised juice	Juice was preheated at 50°C, 10 min and pasteurised at 80°C, 5 min and sodium benzoate was added	—	—
T ₂	Microfiltered and pasteurised juice	Juice was Microfiltered and pasteurised at 80°C, 5 min	0.2µm(PAN)	1.05 kg/cm ² (15 psi)
T ₃	Microfiltered and pasteurised juice with addition of PAC	Addition of PAC before MF to juice, microfiltered and pasteurised at 80°C, 5 min	0.2µm(PAN)	1.05 kg/cm ² (15 psi)
T ₄	Ultrafiltration of microfiltered juice permeate at 2.10 kg/cm ² (30 psi)	Ultrafiltration of microfiltered permeate juice, non-thermal, no preservative was added	MF-0.2µm(PAN) UF-70kDa(PS)	MF-1.05 kg/cm ² (15 psi) UF-2.10 kg/cm ² (30 psi)
T ₅	Ultrafiltration of microfiltered juice permeate at 3.16 kg/cm ² (45 psi)	Ultrafiltration of microfiltered permeate juice, non-thermal, no preservative was added	MF-0.2µm(PAN) UF-70kDa(PS)	MF-1.05 kg/cm ² (15 psi) UF-3.16 kg/cm ² (45 psi)
T ₆	Control	no treatment was given	-	-

PAN : Poly Acrylo Nitrite

PS : Polysulphone

Table.2 Yeast count of different treatments of sugarcane juice during storage

Storage period, days	Yeast count (x 10 ⁶ CFU / 10 ml of sample)					
	T ₁	T ₂	T ₃	T ₄	T ₅	T ₆
0	-	-	-	2	2	3
4	1	1	1	2	2	3
8	1	1	1	2	2	3
12	1	1	1	2	2	3
16	1	1	1	2	2	3
20	1	1	1	2	2	3

T₁ – thermal treatment (pre-treatment 50°C,10min) +pasteurization at 80°C, 5min+preservative; T₂- microfiltration [0.2µm, 1.05 kg/cm²(15 psi)]+pasteurization at 80°C, 5min+preservative; T₃- PAC+ microfiltration [0.2µm,1.05 kg/cm²(15 psi)] +pasteurization at 80°C, 5min+preservative; T₄- microfiltration [0.2µm,1.05 kg/cm²(15 psi)] +ultrafiltration [70 kDa, 2.10 kg/cm² (30 psi)]; T₅- microfiltration [0.2µm, 1.05 kg/cm²(15 psi)] + ultrafiltration [70 kDa, 3.16 kg/cm²(45 psi)]; T₆- control

Table.3 Mould count of different treatments of sugarcane juice during storage

Storage period, Days	Mould count (x 10 ⁶ CFU / 10 ml of sample)					
	T ₁	T ₂	T ₃	T ₄	T ₅	T ₆
0	-	-	-	-	-	1
4	1	1	1	1	2	2
8	1	1	1	1	2	2
12	1	1	1	2	2	3
16	1	1	1	2	2	3
20	1	1	1	2	2	3

T₁ – thermal treatment (pre-treatment 50°C,10min) +pasteurization at 80°C, 5min+preservative; T₂- microfiltration [0.2µm, 1.05 kg/cm²(15 psi)]+pasteurization at 80°C, 5min+preservative; T₃- PAC+ microfiltration [0.2µm,1.05 kg/cm²(15 psi)] +pasteurization at 80°C, 5min+preservative; T₄- microfiltration [0.2µm,1.05 kg/cm²(15 psi)] +ultrafiltration [70 kDa, 2.10 kg/cm²(30 psi)]; T₅- microfiltration [0.2µm, 1.05 kg/cm²(15 psi)] +ultrafiltration [70 kDa, 3.16 kg/cm²(45 psi)]; T₆- control

Table.4 Total plate count of different treatments of sugarcane juice during storage

Storage period, days	Total plate count (x 10 ⁶ CFU / 10 ml of sample)					
	T ₁	T ₂	T ₃	T ₄	T ₅	T ₆
0	-	-	1	2	2	3
4	-	-	1	2	2	3
8	-	-	2	2	2	3
12	1	1	2	4	2	4
16	1	1	3	4	3	4
20	1	2	3	4	4	5

T₁ – thermal treatment (pre-treatment 50°C,10min) +pasteurization at 80°C, 5min+preservative; T₂- microfiltration [0.2µm, 1.05 kg/cm²(15 psi)]+pasteurization at 80°C, 5min+preservative; T₃- PAC+ microfiltration [0.2µm,1.05 kg/cm²(15 psi)] +pasteurization at 80°C, 5min+preservative; T₄- microfiltration [0.2µm,1.05 kg/cm²(15 psi)] +ultrafiltration [70 kDa, 2.10 kg/cm²(30 psi)]; T₅- microfiltration [0.2µm, 1.05 kg/cm²(15 psi)] +ultrafiltration [70 kDa, 3.16 kg/cm²(45 psi)]; T₆- control

Fig.2 Appearance values of different treatments of sugarcane juice during storage

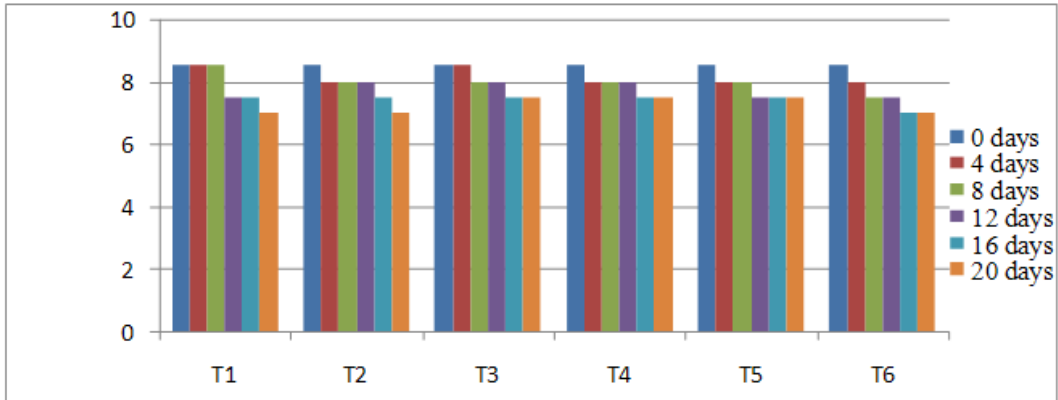


Fig.3 Flavour values of different samples of sugarcane juice during storage

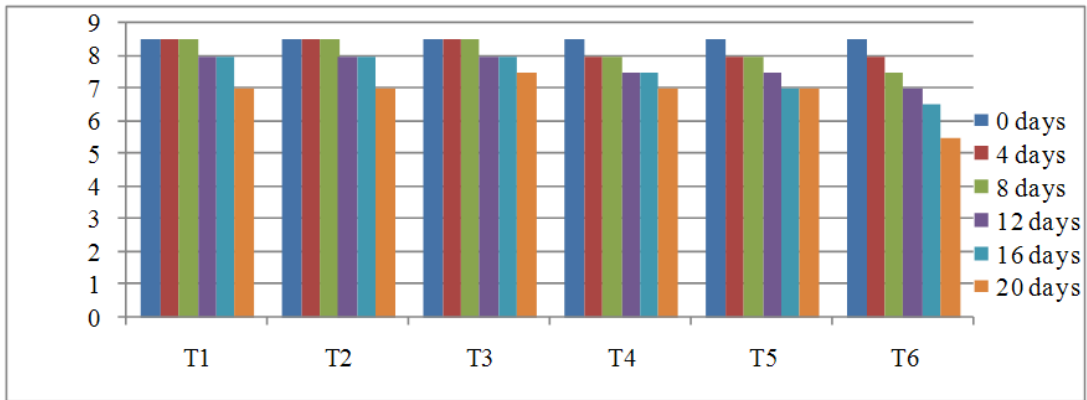
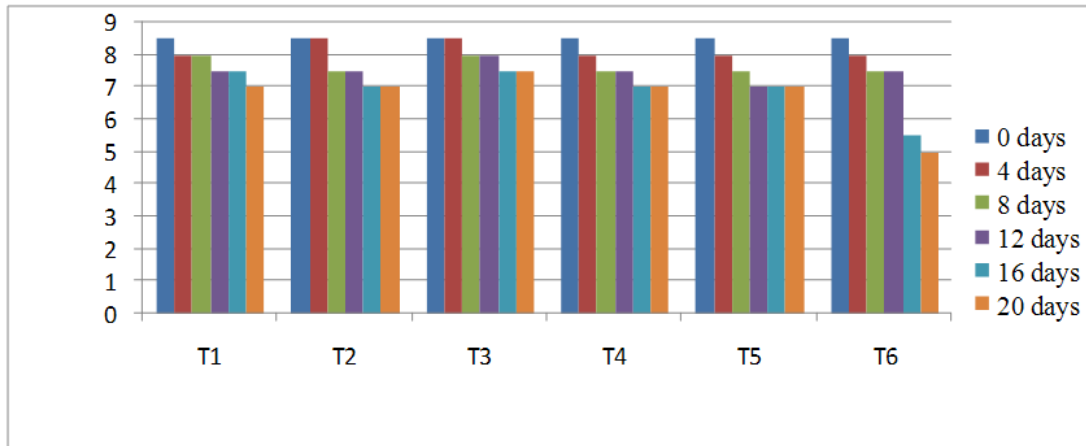


Fig.4 Overall acceptability values of different treatments of sugarcane juice during storage



The sugarcane juice samples which were membrane filtered and thermally processed and evaluated by panelists. Appearance rating has been compiled (Fig. 2). The treatment T₃, PAC added, microfiltration of sugarcane juice using 0.2µm pore size, at pressure 15 psi scored highest rating on hedonic scale than other treatments.

Similarly the evaluated data assessed by panel of experts for establishing flavour rating was also compiled (Fig. 3). The treatment T₃, PAC added, microfiltered and pasteurized scored highest rating on hedonic scale than other samples.

Similarly the evaluated data assessed by panelists for establishing overall acceptability rating has been compiled (Fig. 4). The treatment T₃, PAC added, microfiltered and pasteurized scored highest rating on hedonic scale than other treatments. Overall based on the experimental data, it can be concluded that among all the treatments T₁ and T₃ exhibited good physico-chemical, microbiological and sensory properties for the processed sugarcane juice upon storage. The data indicated that membrane filtration in combination with thermal processing is an alternative to existing thermal processing as the quality attributes are relatively better.

In conclusion, the results revealed that good quality sugarcane juice of variety CO380 with satisfactory storage stability at refrigeration could be prepared by microfiltration and pasteurization of sugarcane juice with addition of flocculant. The permeate flux of microfiltered and pasteurized sugarcane juice with addition of flocculant decreased from 9.14 to 6.53 L/h m² with time. The colour values generally decreased in all the treatments. In microbial analysis, Yeast, Mould and Total Plate Count were observed to be less in microfiltered and pasteurised with and without addition of PAC treatments.

Sensory evaluation indicated that the microfiltered and pasteurized juice with addition of PAC followed by only thermal treated juice scored highest rating on hedonic scale by panelists in terms of appearance (8.0), flavour (8.16) and overall acceptability (8.0). It can be concluded that membrane processing of sugarcane juice is one of the alternate methods in combination with thermal processing for producing quality juice.

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