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Effect of pulsed electric field on physicochemical parameters of membrane processed sugarcane juice

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Abstract
Sugarcane juice is considered as an energetic drink with several nutritional qualities. The deterioration is high in the juice due to the enzyme activity and fermentation occurs. The experiment is performed to observe the changes in the physicochemical parameters of the membrane filtered sugarcane juice after the treatment of pulsed electric field. The pH, TSS, Viscosity, Turbidity was retained the same. The ascorbic acid and reducing sugar content was preserved by the pulsed electric field at different voltages.

Keywords: sugarcane juice; Membrane processed; pulsed electric field

1. Introduction
Sugarcane (*Saccharum officinarum*), a Poaceae family member that is widely cultivated for its beneficial and inexpensive products. Both Southeast Asia and tropical South Asia are native to the species. It grows quickly in tropical and subtropical areas when cultivated in hot, humid weather with plenty of organic matter and well-drained soil (pH 7.5-8.5). In the tropics and subtropics, raw cane is a common consumer good used for both drink and for the treatment of a variety of illnesses. For the reviving sugarcane juice, the young sugarcane culms are ground. With its abundance of organic acids, starch, phosphatides, natural sugars, vitamins, minerals, amino acids, and gums, it is incredibly nourishing (Chauhan *et al*., 2002) [5]. The juice is thought to have cooling properties in addition to helping people recover from cancer, cardiovascular, urinary, and dysuria disorders, as well as bleeding, anuria, dysuria, and jaundice (Chauhan *et al*., 2007) [6]. Fresh Sugarcane Juice has a short shelf life and cannot be kept in a regular refrigerator for longer than 6 hours. The fermentation process is accelerated by high sugar levels and small concentrations of polyphenols and organic acids, which gives the mixture a dark-brown appearance. The juice ferments as a result of the polyphenol oxidase activity, making it unusable for marketing (Bay, 2002) [2]. Due to its low energy consumption and ease of use, UF clarifying and decolonization has recently grown in prominence and is now frequently used in the food industry. Because it produces juice that is more pure, more vibrant, and devoid of starch and acidified materials than regular lime treatment, UF clarification of sugar solution has been shown to be technically superior to that process (Jegatheesan *et al*., 2012) [9]. A recent study looked into UF and coagulation in addition to ultrafiltration for clarification and decolonization of raw brown sugar from the Indian sugar sector. Mineral Carbosep membranes (15-50 kDa) and Polyethersulphone (PES) membranes were used for decolonization (5-100 kDa). It was possible to achieve a colour reduction of about 50% with PES and mineral membranes between 30 and 50 kDa (Gros, 2002) [8]. For inactivating enzymes and harmful bacteria while preserving the sensory and nutritive qualities of fruit and vegetable juices, PEF is an appropriate substitute for heat treatments. Additionally, even at low temperatures between 20 and 40 °C, PEF-pretreatment significantly enhanced diffusion (Elez-Martinez *et al*., 2017) [13]. The use of Pulsed electric field in food processing has getting importance as a non-thermal method to inactivate bacteria and enzymes while retaining the nutritional quality, antioxidant content, and freshness of juices. According to the authors, the PEF treated juices at 30 kV/cm (100 kJ/kg) and warmed to 40 °C to produce the greatest polyphenol oxidase deactivation of 48%. Therefore, when employed without further traditional thermal preservation, PEF processing led to apple juices that had undergone minimum processing (Buckow *et al*., 2013) [3]. Thus, in this study the pulsed electric field at different voltages are used in order to preserve the physicochemical properties of the membrane processed sugarcane juice and the observed changes by the effect of pulsed electric field in the sugarcane juice quality are studied by this experiment.

2. Materials and Methods
2.1 Sugarcane juice collection
The sugarcane juice was collected from shree Krishna juice shop in Thanjavur. The juice was transported using the thermocol box which was fully covered with the ice cold pack and the temperature was maintained around 15 °C.

2.2 Membrane processing
For this study, Tech Inc., Chennai-made membrane separation equipment was used at Centre of Excellence in Non-Thermal, NIFTEM-Thanjavur, and Tamil Nadu. The sugarcane juice was supplied into a feed tank with a 10 litre capacity, where it was permitted to pass through a hollow spiral wound ultra-filter membrane made of Polyethersulphone with 50 kDa pore size at 1 bar pressure. Clarified juice is then collected and placed in sterilized glass vials to undergo pulsed electric field treatment.

2.3 Pulsed electric field treatment
This experiment made use of the pulsed electric field (PEF) processing apparatus at the Centre of Excellence in Non-Thermal, NIFTEM-Thanjavur, Tamil Nadu manufactured by Sureview Instruments, Maharashtra, India. Square wave pulses are produced by the PEF system. The test time was 2.08 minutes for the sample of 500 ml that was held in the liquid food chamber. The investigation was conducted in different pulse modes at field strengths of 15, 25, and 35 kV/cm for pulse widths of 150, and 200 µs.

2.4 Physicochemical properties
The physicochemical parameters are analysed for the membrane processed and pulsed electric field treated sugarcane juice such as pH, TSS, color, viscosity, ascorbic acid and reducing sugar. Wensar's 5-point electronic pH metre and an Atago PAL-1 series hand-held pocket refractometer with a range of 0-53 percent were used to measure the pH and TSS. Sample readings were taken in triplicate, and the average result was taken into consideration. Using a UV-1800 Shimadzu UV-spectrophotometer set to 610 nm, the turbidity of the juice was determined. Using a S00 spindle probe and a Brookfield's DVE digital viscometer with the motor set at 50 rpm, the viscosities of the samples were measured (Nair UK, *et al*., 2019) [1]. Utilizing a titrating approach, the ascorbic acid concentration was determined. First, titrate against the dye (2, 6-diclorophenol indophenol) in 10 ml of 4 percent oxalic acid, and then consume 1 ml of that solution. Then, 10 ml of 4 percent oxalic against the dye and 5 ml of sugarcane juice were combined, and V2 ml of the dye (2, 6-dicloro phenol indophenol) was taken. The appearance of a light pink hue was used as the benchmark. Equation was used to calculate the value. Using the Nelson-Somogyi method, the sample's reducing sugar was determined. The prepared glucose solution was used as the working standard, and the arsenomolybdate reagent and alkaline copper tartrate solution were also prepared in accordance with (Shao & Lin, 2017) for the analysis. The test tubes were then placed in boiling water for 10 minutes while being filled with 30 µl of sugarcane juice, 2 ml of distilled water, and 1 ml of alkaline copper tartrate. 1 ml of the Arsenomolybdate reagent was added once the tubes had cooled, and the absorbance was measured at 620 nm with a UV-1800 Shimadzu UV-spectrophotometer. The proportion of reducing sugars was estimated when the absorbance was compared to the benchmarks.

2.5 Statistical analysis
Five percent confidence level statistical analysis was done to determine the significance of the treatment changes. If $p \leq 0.05$, the null hypothesis is rejected. Consequently, the treatments differed significantly from one another. There was no significant difference between the treatments if the $p \geq 0.05$.

3. Result and discussion
3.1 pH, color, TSS and viscosity
The membrane processed sugar cane juice and the membrane processed PEF treated sugar cane juice was compared and subjected to analysis to observe the changes in the physical properties of the juice. The physical properties such as pH, color, TSS and viscosity of the treated juice were given in the Table 1. On comparing to the membrane treated sugarcane juice (4.54±0.01), the pulsed electric field treatment on the membrane processed sugarcane juice pH was showed that there was no ($p \geq 0.05$) significant changes in the pH of the juice, the highest value was found at the electric field strength of 15 kV/cm for the pulse width of 150 µs was (3.96±0.1).The lowest value was found at the electric field strength of 25 kV/cm for the pulse width of 150 µs was (3.91±0.1). Similarly the study of (Lammerskitten *et al*., 2020) [11] results the same effect at the voltage of 1kV/cm. The TSS of the sugarcane juice was decreased extremely while comparing to membrane processed juice, initially the TSS of the membrane processed juice was observed as (15.4±0.05). There was observed significant reduction in the TSS of the juice, after PEF treatment at the voltage at pulse width of 15 kV/cm and 150 µs was (9.83±0.5). This reduction which may due to the ultrafiltration. According to a study by (Castro-Muñoz *et al*., 2018) [4], ultrafiltration of Xoconostle fruit juice rejected 10.17% of TSS, meaning that filtered juice (TSS = 4.50 Brix) preserved about 89 percent of the initial TSS level of fresh juice (TSS = 5.01 Brix).

3.2 Turbidity and viscosity
The turbidity is highly responsible for the clarity of the juice. From the table 1, the turbidity of the sugarcane juice as remained the same after the pulsed electric treatment. The turbidity was remained as 1.234±0.2%-1.106±0.3% the pulsed electric field at different voltage shows no difference in the values of turbidity thus the physical property was retained. From the observed results thus clarification using UF membrane played major role. Thus, as a result of the clearing process, the amount of suspended and soluble pectin and other suspended particles in fruit juice are reduced. The degree of transparency of the permeate increases after the elimination of suspended compounds and their buildup in the retentate. For instance, the study of (Mirsaeedghazi *et al*., 2010) [12] revealed that, clarification using the membrane in pomegranate juice, results in decrease in the turbidity of about more than 99%. There was no significant changes ($p \geq 0.05$) in the viscosity of the sugarcane juice while compared to the membrane processed sugarcane juice. The viscosity values are observed as 1.41±0.02 Cp -1.42±0.01Cp for the membrane processed pulsed electric field treated sugarcane juice.

Table 1: Physical properties of the membrane processed PEF treated sugar cane juice

PEF Treatment	Pulse width(µs)	pH	TSS	Turbidity (%)	Viscosity (Cp)
15kV/cm	150	3.96±0.1	9.93±0.1	1.212±0.2	1.37±0.05
	200	3.94±0.2	9.83±0.5	1.248±0.2	1.41±0.01
25kV/cm	150	3.91±0.1	9.96±0.2	1.231±0.2	1.42±0.01
	200	3.92±0.1	9.95±0.3	1.230±0.3	1.40±0.02
35 kV/cm	150	3.92±0.1	9.84±0.3	1.122±0.3	1.37±0.03
	200	3.93±0.2	9.91±0.1	1.106±0.3	1.41±0.02
UF treatment		4.54±0.01	15.4±0.05	1.234± 0.2	1.45±0.02

3.3 Reducing sugar content

From the given (Figure 1), there were no observed significant changes in the reducing sugar content on comparing with the membrane processed sugarcane juice. The reducing sugar content was retained as 55% after processing in pulsed electric field of different voltages of 15, 25 and 35 kV/cm for the pulse width of 150 and 200 µs. The PEF thus used to retain the quality of the sugarcane juice.

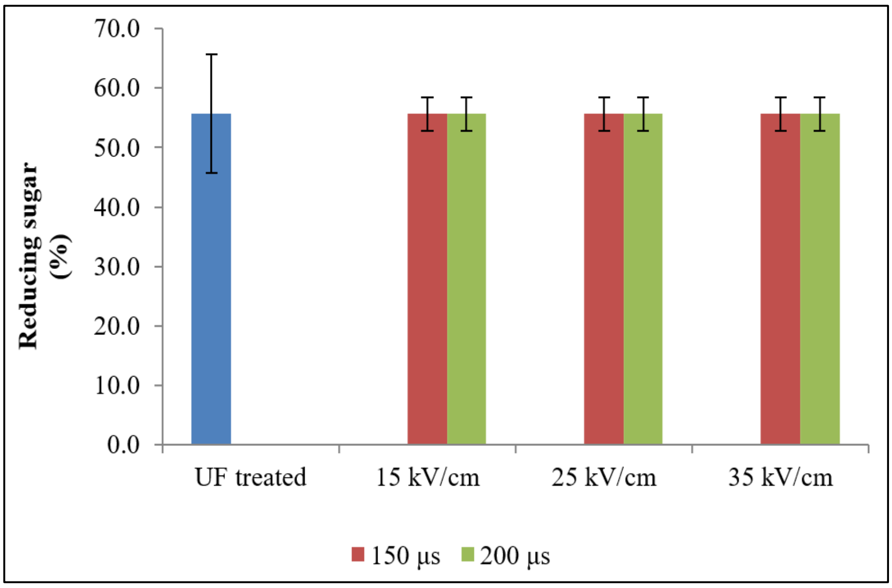

Fig 1: Effect of PEF on reducing sugar of membrane processed sugar cane juice

3.4 Ascorbic acid content

The ascorbic acid content of the sugarcane juice was observed after the pulsed electric field treatment of membrane processed sugarcane juice. There was no observed significant difference in the ascorbic acid content of the sugarcane juice on comparing to the membrane processed juice (Figure 2). At the voltage of 15, 25 and 35 kV/cm for the pulse width of 150 and 200 µs, the values observed was 2.4 ± 0.02 mg/100 g to 2.3 ±0.02 mg/100 g. From the results, it showed that the pulsed electric field remained the ascorbic acid content of the sugarcane juice. Similarly, the results are in coincide with the study by (Koubaa *et al*., 2018) [10] at the voltage of 25 kV/cm for the fruit juices. Thus the overall quality of the sugarcane juice was remained the same after pulsed electric field treatment.

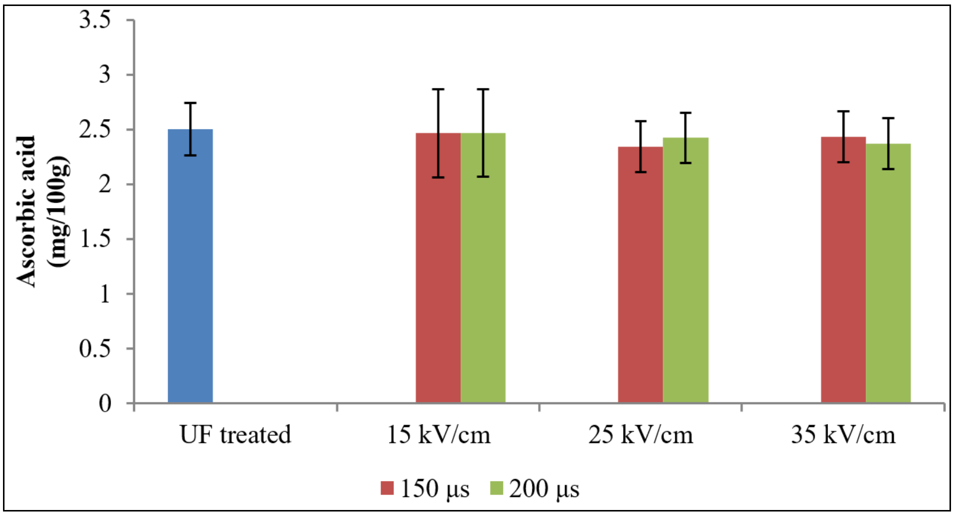

Fig 2: Effect of PEF on ascorbic acid of membrane processed sugar cane juice

4. Conclusion
The aim of this experiment is to analyse the physicochemical changes that occurs due to the effect of PEF in membrane processed sugarcane juice by comparing it to the membrane processed sugarcane juice. There was found to be no significant difference in the juice's pH, TSS, viscosity and turbidity. The ascorbic acid and reducing sugar content was retained the same after the different pulsed electric field treatment. From the results, the PEF has retained the overall physicochemical property of the sugarcane juice and the quality is preserved.

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