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Effect of Combination Hurdles on Processing and Storage of Tender Coconut Water

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Abstract

Tender coconut is one of the important plantation crops in coastal regions of Puducherry and Tamil Nadu. It is the most nutritious and naturally preserved beverage provided by nature for all age groups of people. Sterile nature of Tender Coconut Water (TCW) is used in intravenous therapy in hospitals during emergency situations. TCW has only 2 hours shelf life, as it gets deteriorated rapidly, once extracted and exposed to air. The present investigation was carried out to study the process and shelf life of TCW using hurdle technology like mild thermal process (85°C for 10 minutes and 90°C for 5 minutes), antimicrobial additives (Sodium benzoate :0.124% to 0.062% & Nisin : 0.0002 %) Head space (1.5 & 2.5 cm) and storage conditions in (Room & Refrigeration). The experimental results showed that two or more combination hurdles effectively restricted enzymatic browning and microbial growth while maintaining quality of TCW during storage. Further storage studies revealed that a decrease in titratable acidity and ascorbic acid, increase in TSS, total sugar content and sensory parameters (flavour & taste) during entire storage periods at room & refrigeration conditions. Therefore, our results indicated that the thermal process of 90°C for 5 minutes, 0.062 per cent of sodium benzoate, 0.0002 per cent of Nisin 1.5 cm head space and both refrigeration and room temperature was best for long storage of fresh TCW around 28 - 180 days followed by other combination hurdles.

Keywords : Tender coconut water (TCW), Shelf life, Hurdle technology, Sensory evolution, Physico-chemical properties

Coconut (*Cocos nucifera* (L.) Arecaceae), is one of the oldest known tropical crops and is known as the 'Tree of Life'. All parts of the coconut palm is used for many purposes by millions of people in the different parts of the world. Coconut water is widely consumed as a fresh beverage usually comes from tender stage of immature coconut fruit and therefore, referred as tender coconut water (Shivashankar *et al.,* 2017).

The tender coconut water (TCW) technically is the liquid endosperm, which is the most nutritious wholesome beverage that the nature has provided. TCW is filled with many healthy natural nutrients including minerals, vitamins and polyphenolic compounds, which can enhance the body's metabolism and immunity. It is naturally fat-free and low in food energy (17.4 calories per 100 g). A suitable pH, high minerals and sugar contents as well as the sterile nature of TCW has made it possible for it to be used even in intravenous therapy in many hospitals during emergency situations (Alexia *et al*., 2011).

At present, many synthetic aerated drinks available are unsafe in-drink/use. Therefore, beverages from natural sources are the only alternative choice for the people. Generally, TCW is consumed as fresh directly. Compared to mature coconuts, it is highly profitable when sold in non-cultivated and non-production regions. But the coconut farmers don't like to sell the tender coconuts due to high transport cost as well as low price in the wholesale market. At present market for tender coconut water is increasing considerably due to awareness about its medicinal, nutritional and sensory properties (Anil Kumar *et al.,* 2017).

Further, TCW inside the fruit is sterile but when it is extracted and exposed to air, it gets spoiled very rapidly by oxidation and microbial contamination as well. Therefore, it should be preserved using appropriate low-cost processing technology. Generally, fruit beverages are predominately preserved by either thermal or non-thermal technique without losing its vital nutrients and natural antioxidants. Compared to non-thermal processing techniques, use of thermal processing is one of the most energy intensive processes used in many food industries. A mild thermal process (pasteurization) performed below 100ºC can extend the shelf life of TCW for several days or for some month by destruction of microorganisms and inactivation of enzymes with minimal changes in the sensory characteristics and nutritive values (Shivashankar *et al.,* 2017). It is an easy, effective and low-cost preservation technique. Therefore, this processing technology, if found successful, can make all time and all region availability of TCW and would ensure better returns to the coconut farmers, entrepreneurs and SHGs. Therefore, in the present study, the objective is to develop appropriate processing technology for preservation of TCW using hurdle technology to produce a shelf stable bottled TCW.

MATERIAL AND METHODS

Tender coconuts with good quality were selected from the College Orchard free from pest or disease for further processing. The selected tender coconuts were disinfected by washing with 25 ppm of chlorine water and manually extracted the tender coconut water, filtered through 2-fold cheese cloth and stored under refrigeration until further processing.

Processing of Tender Coconut Water (TCW)

Fresh tender coconut water was preserved through hurdle technology. In this process 4 combination of hurdles namely mild thermal process, addition of antimicrobial additive, storage temperature and head space were optimized for enhancement of shelf life of fresh tender coconut water upto 6 months. In the first and second treatments, the tender coconut water was pasteurized at 85°C for 10 minutes and 90°C for 5 minutes and the chemical preservatives sodium benzoate (0.124 and 0.062 %) and Nisin (.0002 %) were added. The fresh tender coconut water filtered through muslin cloth was treated as control sample. The control as well as treatments was bottled in pet bottle by leaving 1.5 cm and 2.5 cm head space and stored at ambient and refrigeration conditions. The samples were taken out at every 30 days interval and their physico-chemical, nutrient and sensory

Selection of good quality Tender Coconuts
↓
Washing with 25ppm of chlorine water
↓
Extraction tender coconut water (Manual)
↓
Filtering through 2 fold cheese cloth
↓
Pasteurization
↑
(85°C for 10 minutes and 90°C for 5 minutes
↓
Cooling into below 50°C
↓
Addition of sodium benzoate (0.124 and 0.062 %)
↓
Addition of Nisin (0.0002 %)
↓
Mixing
↓
Bottling (leaving head space 1.5 and 2.5 cm)
↓
Capping
↓
Storage
(Room and Refrigeration conditions)

Fig. 1: Flow chart for processing of tender coconut water

characteristics were determined upto180 days of storage.

Flow chart for the processing of tender coconut water (TCW) is given in Fig. 1 and Fig. 2.

Treatments

T_1: Pasteurization at 85°C for 10 minutes + 0.124 per cent of Sodium benzoate & 0.0002 per cent of Nisin + Head space 1.5 cm under Room and Refrigeration conditions.

T_2: Pasteurization at 90°C for 5 minutes + 0.062 per cent of Sodium benzoate & 0.0002 per cent of Nisin + Head space 2.5 cm under Room and Refrigeration conditions.

T_0: Control (Fresh TCW stored at room and refrigeration conditions without head space)

Physico-Chemical and Nutrient Analysis

The physico-chemical and nutrient parameters of tender coconut water (TCW) was evaluated immediately after preparation and at an interval of 15 days up to 180 days of storage. The pH was determined using pen type digital pH meter (EUTECH Instruments, Mumbai, India) and the acidity was estimated by titrating against 0.1N NaOH solution using phenolphthalein as an indicator and the values expressed as anhydrous citric acid (%). The TSS (°brix) was recorded using hand refractometer. Total sugar (g / 100 ml) and ascorbic acid (mg / 100 ml) were analyzed as per the standards procedures described by Sadasivam and Manickam (2010). The turbidity of the tender coconut water (TCW) was determined by measuring the absorbance at 600nm

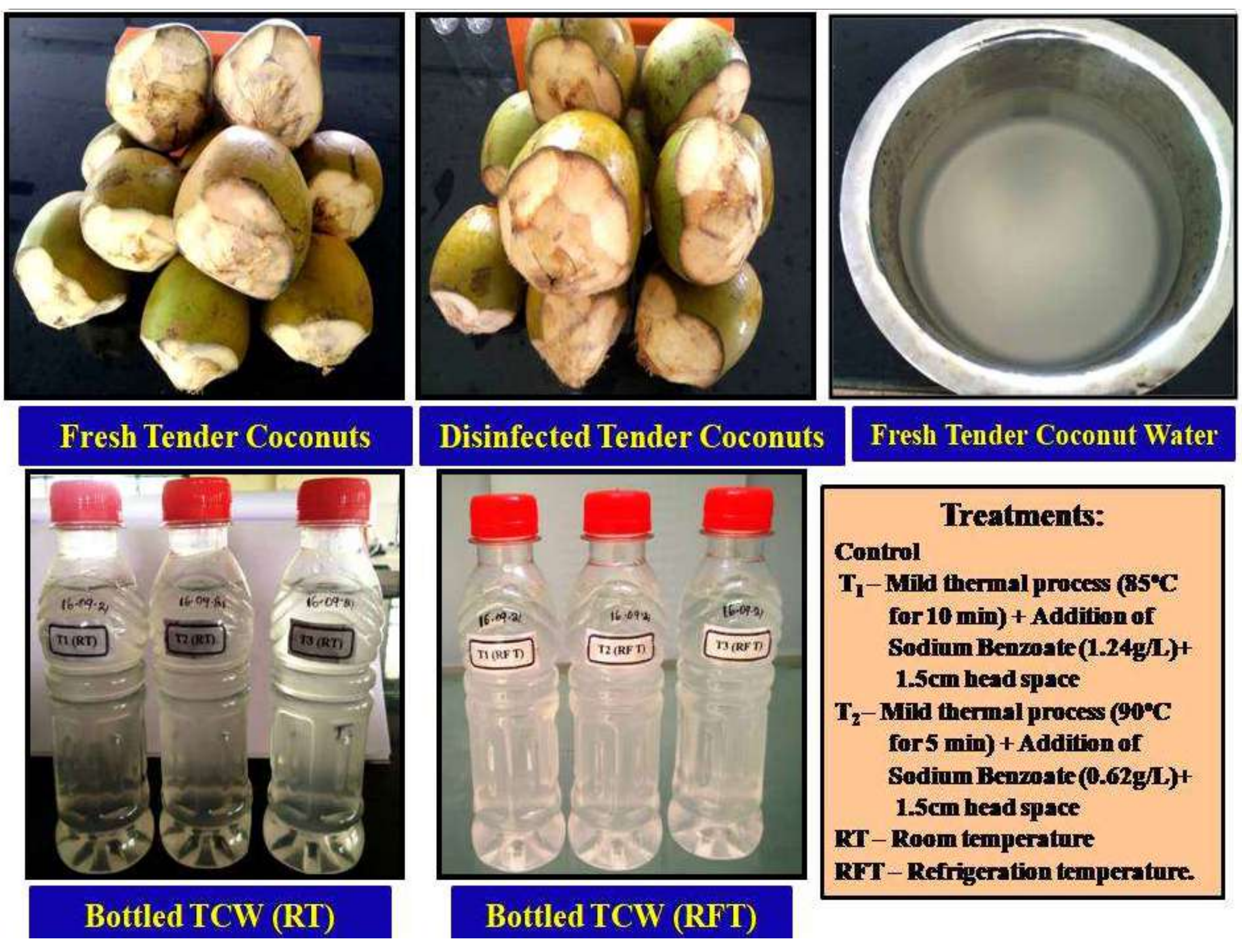

Fig. 2: Processing of tender coconut water (TCW)

using a UV-Visible Double Beam Recording Spectrophotometer (Systronics, India) according to the method described by Candrawinata *et al.* (2012). Distilled water was used as a reference.

Organoleptic Evaluation

The tender coconut water (TCW) was evaluated organoleptically using various quality attributes such as colour, flavour, sweetness, taste and overall acceptability by a panel of ten semi-trained judges using 9 point hedonic scale at regular intervals of 30 days.

Statistical Analysis

The data obtained were subjected to statistical analysis to find out the impact of thermal process, preservative and storage temperature on maximum shelf life with superior sensory quality. Factorial completely randomized design (FCRD) was applied for the analysis of the study as described by Rangaswamy (1995).

RESULTS AND DISCUSSION

Physico-Chemical and Nutrient Parameters

The physico-chemical and nutrient parameters of the tender coconut water were evaluated once in 15 days for a period of 180 days. The initial and final values are taken for discussion.

Total Soluble Solids (TSS) and Total Sugar

The TSS and total sugar content of fresh tender coconut water had 5.2^o brix and 2.12g/100ml. Then the values were slightly increased to 5.8^o brix and 2.18g/100ml in T_1 and 6.0^o brix 2.24g/100ml in T_2 after thermal process. Hence, the pasteurized TCW had initially TSS 5.8^o brix and total sugar 2.18g/100ml in T_1 and 6.0^o brix 2.24g/100ml in T_2. A gradual increase in TSS and total sugar content was observed throughout the storage periods in all treatments (Fig. 3 and 4). Despite, meager changes of TSS and total sugar content were found in both treatments (T_1 and T_2) as well as control samples when stored in refrigeration condition. Whereas, the samples T_1 and T_2 stored at room temperature had only 60 days of shelf life. After 60 days of storage, the colour of T_1 and T_2 had turned into light brown color and also fermented in subsequent storage days. At the same time, the control samples had spoiled within 30 days of storage at room and refrigeration conditions due to formation of gas (CO_2 / N_2) by fermentation. Increasing TSS and total sugar content is mainly due to hydrolysis of polysaccharide like starch and cellulose substance into simpler substances and hydrolysis of non-reducing sugar into reducing sugars. Similar increasing trend in TSS and total sugar content is in line with the findings of Anil kumar *et al.* (2017) in different treatments of tender coconut water during storage. Divate *et al.* (2020) in karonda juice and Kalunkhe *et al.* (2014) in lemon squash observed the same during storage.

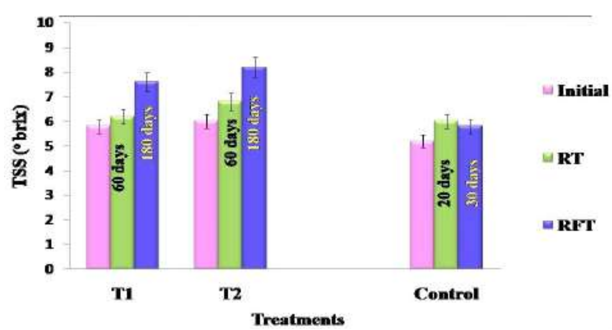

Fig. 3 : Changes in TSS (^{0} brix) content of TCW during storage

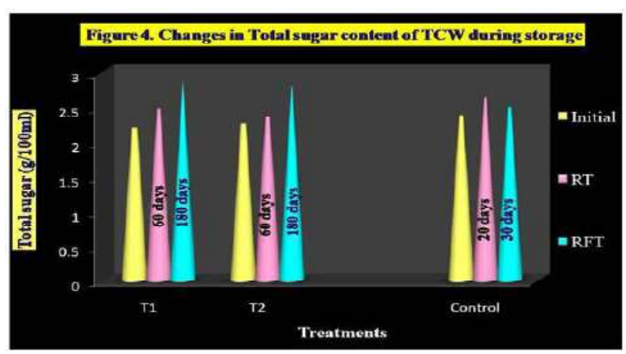

Fig. 4: Changes in total sugar content of TCW during storage

pH and Titratable Acidity

The changes in the titratable acidity and pH of tender coconut water both control and treatments (T_1 and T_2) during storage are presented in Table 1. A significant decrease in pH and increase in titratable acidity was

TABLE 1
Changes in titratable acidity and pH of TCW during storage

Treatments	Titratable acidity (mg/100ml)			pH		
	Initial	RT(60 days)	RFT(180 days)	Initial	RT(60 days)	RFT(180 days)
T_1	0.513	0.522	0.540	4.82	4.26	4.48
T_2	0.520	0.526	0.544	4.90	4.38	4.52
Control	Initial	RT(20 days)	RFT(30 days)	Initial	RT(20 days)	RFT(30 days)
	0.510	0.548	0.536	4.80	4.36	4.56

observed in all treatments during storage. The initial titratable acidity of tender coconut water had (T_1 and T_2) ranged between 0.513 and 0.520 per cent which was gradually increased in between 0.540 and 0.544 per cent at the end of six months storage in refrigeration condition and 0.522 and 0.526 at the end of two months storage in room temperature. The pH of freshly prepared tender coconut water had ranged from 4.82 to 4.90. After six months of storage at refrigeration condition, the pH was decreased to 4.46 in T_1 and 4.52 in T_2. Subsequently, the pH content of samples T_1 and T_2 stored at room temperature was decreased to 4.26 and 4.38. Whereas, the titratable acidity and pH content of control samples had changed from 0.510 to 0.548 and 4.80 to 4.36 within 20 and 30 days of storage at room and refrigeration conditions. Similar observations were also observed by Tiwari *et al.* (2010) in Chinese orange squash, Anil Kumar *et al.* (2017) in different treatments of tender coconut water during storage and Divate *et al.* (2020) in Karonda crush.

Ascorbic Acid

The data on the changes in ascorbic acid content of TCW during storage is presented in Fig. 5. A steady decline in ascorbic acid was observed in all the treatments during storage. The ascorbic acid content of freshly prepared tender coconut water (T_1 and T_2) had 2.2 mg/100ml and 1.98 mg /100 ml which were decreased to 1.42 mg in T_1 and 1.36 mg in T_2 after six-months storage at refrigeration condition and 1.86 mg in T_1 and 1.64mg in T_2 after two months storage at room temperature. This decrease of ascorbic acid might be due to the presence of air at the headspace of pet bottles, which accelerates oxidation process during storage. Beside peroxidase was also responsible for oxidation of ascorbic acid during storage. From the data we could conclude that the highest decrease of ascorbic acid (35 %) was found in T_1 compared to T_2 during storage.

Identical results were observed by Pareek *et al.* (2011) in Nagpur mandarin (*Citrus reticulata* Blanco) juice which was reduced from 31.6 to 22.3 mg / 100 ml after six months storage in ambient temperature, Sindumathi and Amutha (2013) in spiced tender coconut water which was reduced from 1.98 mg to 1.75 mg /100 ml at the end of six months storage at room temperature and Shivsshankar *et al.* (2017) in tender coconut water during storage.

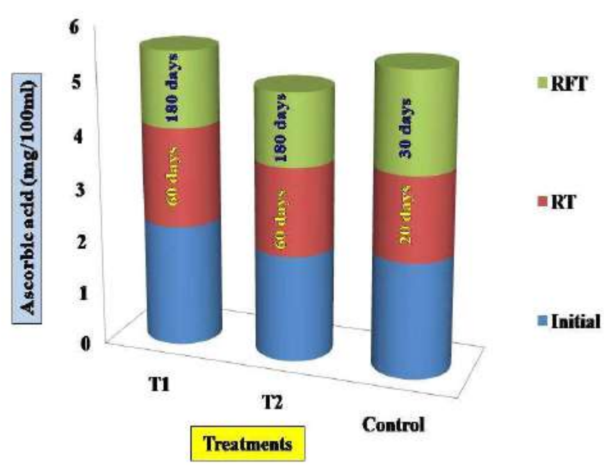

Fig. 5: Changes in ascorbic acid (mg/100ml) content of TCW during storage

Turbidity

The turbidity of the tender coconut water was clearly related to whether the water was cloudy or clarified. Therefore, it directly indicates the unsettled matter or impurities in water suspension, such as colloidal polysaccharide particles in fresh juices. The samples T1 and T2 had much lower levels of turbidity, with values ≤ 0.08 absorbance at 600 nm, than the control samples (Fig. 6). The turbidity of TCW was expressed in terms of optical density (O.D) values. A slight increase in O.D values was observed in both treatments and control samples during storage. The initial O.D value of T1 and T2 had 0.08 and 0.06 which was gradually increased to 0.16 and 0.10 at the end of six months storage in refrigeration temperature and 0.20 and 0.18 at the end of 2 months storage at room temperature. Turbidly in control samples were suddenly increased from 0.07 to 0.14 and 0.28 after 20 and 30 days of storage at room and refrigeration condition. This might be due to the interaction between the chemical compounds which may accelerate by fermentation process during storage. Similar trend was observed by Mohsen *et al*. (2009) in pomegranate juice which was slightly increased from 12.5 NTU to 12.8 NTU at the end of 3 months storage at 4°C.

Organoleptic Evaluation

The changes in the mean sensory qualities (colour and appearance, flavour, taste, consistency and overall acceptability) of tender coconut water (control and treatments) during storage were analyzed using a panel of 10 untrained judges with 9 point hedonic scale. The obtained initial and final scores for each attributes for each treatment are presented in Table 2.

Initially, the control samples had highest sensory scores than treatments, but it was drastically reduced at the end of storage. After two and six months of

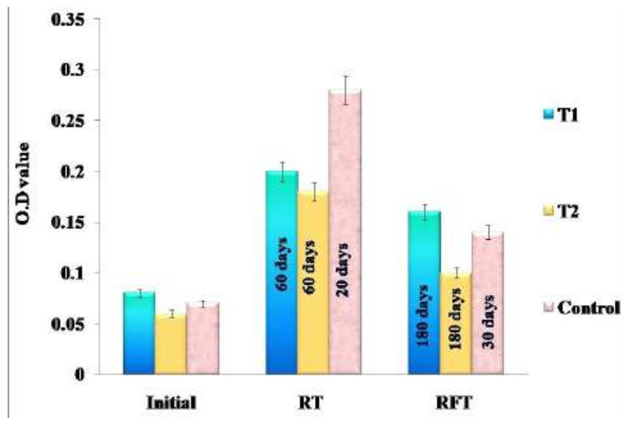

Fig. 6 : Changes in turbidity of TCW during storage

TABLE 2

Organoleptic evaluation of TCW during storage

Sensor parameters	Treatments	Initial	RT(60 days)	RFT(180 days)
Colour & Appearance	T1	9.0	8.0	8.5
	T2	9.0	8.0	8.6
	Control	9.5	7.2 (20 days)	7.8 (30 days)
Flavour	T1	8.5	7.0	7.5
	T2	8.0	7.0	7.2
	Control	9.0	7.0 (20 days)	7.5 (30 days)
Taste	T1	8.2	7.5	8.0
	T2	8.5	7.8	8.0
	Control	9.0	7.0 (20 days)	7.0 (30 days)
Consistency	T1	8.0	7.2	7.5
	T2	8.0	7.5	7.8
	Control	8.5	6.5 (20 days)	6.8 (30 days)

storage, the samples T_1 and T_2 scored highest rating of hedonic scale in terms of colour and appearance (8.0 and 8.5), taste (7.8 and 8.0), flavour (7.0 and 7.5), consistency (7.5 and 7.8) and overall acceptability (7.6 and 7.9).

From this data, there is no major significant difference between the treatments during storage at room and refrigeration conditions. This might be due to thermal process which improved the appearance of TCW by settling down of polysaccharides and addition of chemical preservative which retained taste, flavour and consistency of TCW up to 2 months storage at room temperature and 6 months storage at refrigeration temperature than control samples. Whereas, the control samples had inferior sensory quality at the end of 20 days of storage which might be due to fermentation process.

It can be concluded that the thermal process, concentration of chemical preservative (Sodium benzoate) and storage temperature have a significant impact on extent of the shelf life and quality of TCW. The combination hurdles of mild heat treatment (90°C for 5 minutes), addition of 0.062 per cent of sodium benzoate, refrigerated storage temperature and 1.5 cm head space was the best combination of hurdles for longer storage (180 days) of TCW. Also this combination hurdles could effectively minimize the nutrient loss as well as retained sensory qualities of TCW throughout the storage periods. Among the head space, 1.5 cm was found to be appropriate for long preservation of TCW while maintaining superior sensory qualities by reducing the possibility of oxidization process in between the chemical compounds during storage. Therefore, it is concluded that based on the selected combination hurdles, the mild heat treatment 90°C for 5 minutes, 0.062 per cent of sodium benzoate, refrigeration storage temperature and 1.5 cm head space could be used for commercial preservation of TCW up to 6 months without changing any major quality parameters.

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