Effect of ultrasound treatment on sugars and minerals in tender coconut water

M VIDHYA, N VARADHARAJU and D AMIRTHAM

Department of Food Process Engineering
Agricultural Engineering College and Research Institute
Tamil Nadu Agricultural University, Coimbatore 641003 Tamil Nadu, India
Email for correspondence: vidhyavasagam18@gmail.com

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ABSTRACT

Tender coconut water is a highly perishable drink susceptible to microbial and enzymatic degradation. Preservation by ultrasonic treatment is an innovative technique for liquid food without affecting its organoleptic qualities. The effect of ultrasound (30 kHz, 200 W, 10 and 15 min) on total and reducing sugars and minerals like Ca, K, Mg and P of tender coconut water during storage at 4ºC up to 12 days was studied. Sonication caused significant changes in total sugars, reducing sugars as well as on minerals as compared to untreated samples and during storage. There was a significant increase in reducing sugars, decrease in minerals and no differences for total sugars in storage period. Findings of the present study suggested that ultrasound treatment could improve the nutritional quality of tender coconut water.

Keywords: Tender coconut water; ultrasound; sugars; minerals; preservation

INTRODUCTION

Tender coconut water (TCW) is a clear natural refreshing drink found in tropical regions which is filled with electrolytes and minerals such as potassium, calcium, sodium, phosphorous, iron, copper, sulphur and chlorides (Arditti 2008). The water present inside the fruit is sterile and stable for few days (Yong et al 2009). Once the coconut is opened its biochemical composition, physical appearance and sensory attributes change due to environmental contamination by microorganisms and oxidation caused by enzymes which result in spoilage of tender coconut water (Haseena et al 2010).

Prolonging the shelf-life of tender coconut water without modifying its flavour and nutritious properties remains a technical challenge. Even though thermal processing like pasteurization is being followed to enhance the shelf-life it causes loss of nutritional and sensory characteristics. To overcome these negative effects non-thermal processing was performed by various researchers viz PEF (Kathiravan et al 2014), dense phase CO_2 (Damar et al 2009), UV treatment (Sanganamoni et al 2017, Gautam et al 2017) and membrane filtration (Magalhaes et al 2005). They found that these treatments could retain the natural properties of TCW. Ultrasound is one among non-thermal techniques used to preserve the fruit juices that many researchers studied in detail for apple juice (Abid et al 2014), orange juice (Tiwari et al 2008, 2009), guava juice (Cheng et al 2007), Kasturi lime juice (Bhat et al 2011).

Ultrasound is an emerging technology in the field of food processing and preservation. Ultrasonic waves effectively inactivate the detoreative microorganisms and enzymes based on cavitation principle ie when the sonic waves (20 - 100 kHz) pass into any medium (solid, liquid and gases except vacuum) produce repeated cycles of compression and rarefaction called acoustic cavitation which is the process of formation, growth and collapse of bubbles in liquids. As a result of violent collapse of these vapour bubbles high local temperature (5000 k) and high pressure (1000 atm) are generated that results in high shear rate and strong micro-streaming contributed to enzyme and microbial inactivation (Mason et al 2005, Fonteles et al 2012).

To date no reports are available on the effect of ultrasound on quality of tender coconut water to extend its shelf-life. Hence the study was conducted to evaluate the effect of ultrasound treatment and storage period on sugar concentration and mineral contents of tender coconut water.

MATERIAL and METHODS

Green tender coconuts of variety Aliyar Nagar 1 [ALR (CN) 1] were procured from the TNAU coconut farm and were visually inspected for their size, shape and maturity. Their water was collected in the sterile media bottles once the coconuts were cut opened with a sharp sterilized stainless-steel knife before subjecting to ultrasound treatment. Ultrasound treatment for preserving tender coconut water was performed using laboratory model ultrasound system operated under optimized processing conditions (frequency -30 kHz, power input 200 Watts, treatment time 10 and 15 min). Frequency, power and treatment time were adjusted in the ultrasonic generator (PEI ultrasonic Ltd). A thermocouple was fixed at the center of the chamber for continuously monitoring the temperature change that occured during ultrasound treatment. The actual capacity of treatment chamber was about one litre made up of food grade stainless steel (SS 304) and 500-800 ml tender coconut water was used for sonication. The ultrasonic waves at higher frequency were transmitted to the sample by ultrasonic transmitters or transducers which were fixed over the treatment chamber. These transmitters convert and transmit the electrical energy to vibrational energy which results in cavitational effect for microbial inactivation.

Estimation of total sugars

Total sugars were estimated by following the method described by Ranganna (1995). One ml of the aliquot was pipetted out and five ml of anthrone reagent was added to it. The contents in the test tube were heated for 8 minutes in a boiling water bath; the test tube was cooled rapidly and kept in dark room and the absorbance was measured using spectrophotometer at 620 nm. The glucose content corresponding to the absorbance reading was determined from the standard graph. Thus the quantity of total sugars present in the sample was calculated.

Estimation of reducing sugars

The reducing sugar content of the sample was determined by Nelson-Geer method (Barrett et al 1996). Exactly 1 ml of the aliquot was pipetted out and made to 2 ml using distilled water. One ml of alkaline copper tartarate reagent was added to it and kept in the hot water bath for 10 min. One ml of arsenomolybdic acid reagent was added to it. Volume was made up to 10 ml in all the tubes with distilled water. The absorbance of blue colour was measured using spectrophotometer at 620 nm after 10 minutes. From the standard graph the glucose content corresponding to the absorbance value was determined.

Estimation of minerals

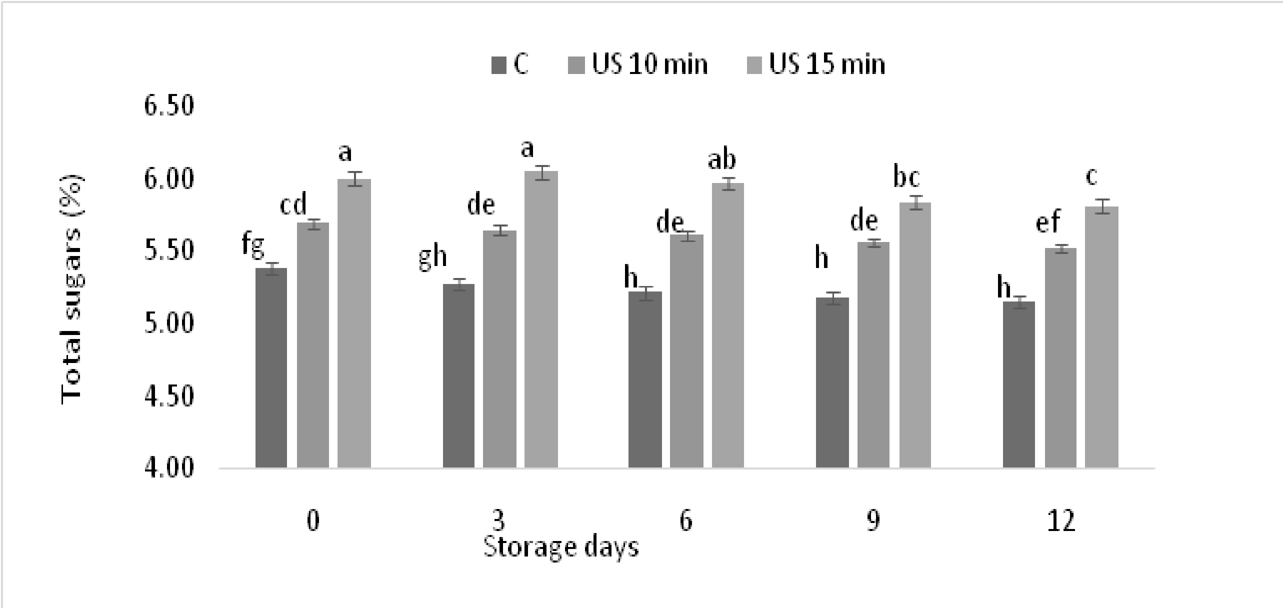
Minerals in the liquid foods are estimated using the atomic absorption sectrophotometer (AAS). Flame atomic absorption technique was used for analysis of minerals (Anon 2000). The minerals such as calcium, potassium, magnesium and phosphorus were determined by comparing the atomic spectroscopic signal for each with that for standard solution of same ion.

Factorial completely randomized design (FCRD) was used to study the effect of ultrasound and storage days on sugars and minerals in tender coconut water and data were analyzed using analysis of variance (ANOVA) using R software.

RESULTS and DISCUSSION

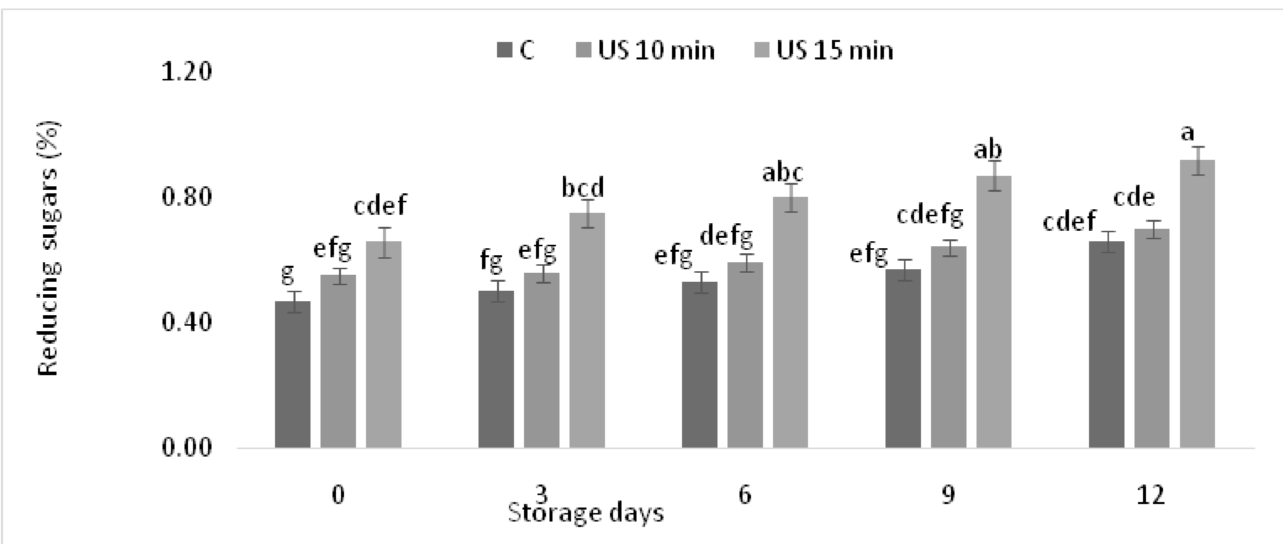
Total and reducing sugars

The results regarding total and reducing sugars are depicted in the Figs 1 and 2. In comparison to the control samples the sonicated tender coconut water resulted in significant increase in total as well as reducing sugar concentration. The total sugar of control sample was 5.38 per cent whereas the ultrasonicated samples had increased level of 5.69 and 6.00 per cent at 10 and 15 min treatment time respectively. Like-wise the reducing sugar level of control was 0.46 per cent whereas for the sonicated samples it was found to be increased to 0.55 and 0.657 per cent at 10 and 15 min treatment time respectively. This might be due to production of positive and negative pressure regions upon cavitation which resulted in disturbing the structure integrity of molecules. Similar results were reported in melon juice (Fonteles et al 2012), carrot juice (Jabbar et al 2014) and apple juice (Abid et al 2014). These changes could be because of cavitational effect which produces strong shear forces and tends to disrupt the cell wall of the molecules thus allowing sugars trapped in the interior of juice particles to permeate to the juice liquid phase (Abid et al 2014, Jabbar et al 2014, Cruz-Cansino et al 2016, Zou and Jiang 2016, Gómez-López



Graphical bars are mean values ± SE (n= 3), bars carrying different letters are significantly different (p <0.05) from each other, C: Control, US 10 min: Ultrasound treatment for 10 minutes, US 15 min: Ultrasound treatment for 15 minutes

Fig 1. Effect of ultrasound on total sugars of tender coconut water between treatment and storage days



Graphical bars are mean values ± SE (n= 3), bars carrying different letters are significantly different (p <0.05) from each other, C: Control, US 10 min: Ultrasound treatment for 10 minutes, US 15 min: Ultrasound treatment for 15 minutes

Fig 2. Effect of ultrasound on reducing sugars of tender coconut water between treatment and storage days

et al 2010). Due to cell disruption ultrasonication improves the extractability of sugars from the molecules (Fernandes et al 2011, Lieu le and Le 2010) and has been applied for extraction processes (Eh and Teoh 2012, Paniwnyk et al 2009, Fonteles et al 2012).

Changes of sugars during storage followed the same trends for both, control and sonicated samples (Figs 1, 2). A significant increase in reducing sugars during storage was observed. This increase could be due to the hydrolysis of polysaccharides like starch,

Table 1. Effect of ultrasound on minerals in tender coconut water between treatment and storage days

Storage	C	US 10 min	US 15 min	C	US 10 min	US 15 min
	Calcium (mg/100 g)			Potassium (mg/100 g)		
0	32.00 ± 1.05[i]	34 ± 1.26[e]	37.00 ± 1.2[a]	225.00 ± 7.4[b]	226.00 ± 8.2[ab]	227.00 ± 7.4[a]
3	32.00 ± 0.90[i]	33.50 ± 1.20[f]	36.50 ± 1.0[b]	211.00 ± 5.9[e]	221.00 ± 4.2[c]	226.50 ± 6.4[a]
6	31.60 ± 1.19[j]	32.80 ± 1.15[h]	35.20 ± 1.3[c]	207.00 ± 7.8[g]	215.00 ± 8.0[d]	220.00 ± 8.2[c]
9	28.40 ± 0.93[l]	29.60 ± 1.25[k]	34.90 ± 1.1[d]	198.00 ± 6.5[i]	209.00 ± 8.5[f]	216.00 ± 7.1[d]
12	27.00 ± 1.01[n]	28.00 ± 1.92[m]	33.10 ± 1.4[g]	190.00 ± 8.0[j]	201.00 ± 8.9[h]	211.00 ± 7.2[e]
	Magnesium (mg/100 g)			Phosphorus (mg/100g)		
0	23.00 ± 0.75[a]	22.50 ± 0.72[b]	21.00 ± 0.69[d]	19.00 ± 0.62[a]	17.10 ± 0.75[e]	15.50 ± 0.51[h]
3	22.50 ± 0.63[b]	21.90 ± 0.43[c]	20.50 ± 0.57[e]	19.10 ± 0.54[a]	17.00 ± 0.64[e]	15.10 ± 0.42[i]
6	21.00 ± 0.79[d]	20.50 ± 0.83[e]	19.70 ± 0.74[f]	18.70 ± 0.70[b]	16.60 ± 0.54[f]	14.50 ± 0.54[j]
9	19.80 ± 0.65[f]	19.00 ± 1.03[h]	18.60 ± 0.61[i]	18.10 ± 0.59[c]	16.10 ± 0.64[g]	14.00 ± 0.46[k]
12	19.50 ± 0.65[g]	18.50 ± 1.08[i]	18.00 ± 0.71[j]	17.40 ± 0.62[d]	16.00 ± 0.70[g]	13.80 ± 0.58[l]

Given values are mean values ± SE (n= 3), Figures carrying different letters are significantly different ($p < 0.05$) from each other, C: Control, US 10 min: Ultrasound treatment for 10 minutes, US 15 min: Ultrasound treatment for 15 minutes

cellulose, pectin etc and conversion into simple sugars (glucose, fructose). There were increased reducing sugars with increased storage time of a cucumber-melon functional drink (Kausar et al 2012). Similarly there were 70 per cent increased reducing sugars during the 6 months of storage of bottled gourd-basil leave juice (Majumdar et al 2011). There were no statistical differences for total sugars between 0 and 12 days of storage. The results on total sugars regarding storage period of tender coconut water are similar to those of Gómez-López et al (2010) in passion fruit juice.

Mineral elements

The changes in the concentrations of mineral elements as a result of ultrasound treatment are shown in Table 1. A significant increase was observed in K and Ca whereas Mg and P decreased significantly in all the ultrasound-treated tender coconut water samples. The samples treated for 15 min displayed the highest value of 227.00 and 37.00 mg/100 g for potassium and calcium respectively as compared to control and sonication at 10 min treatment time. The longer sonication treatment time incites the combination of different structures in the liquid which leads to the forming of new species and reducing ions in the liquid phase (Carvalho et al 1995). A significant increase in Na and K and a significant decrease in Mg and P were also reported in case of sonicated apple juice (Abid et al 2014, Aadil et al 2013). As a result of sonication cellular structure gets damaged that migrates the minerals from cells to solution and also increases the activity of the substances contained in the cells (Sánchez et al 1998).

Changes of minerals (K, Ca, Mg and P) during storage period of 12 days followed the same trend for both control and sonicated samples. There was a significant decrease in all the mineral elements after 6 days of storage period. This might be due to increased growth of microbial population that reduces the availability of mineral elements by utilizing it for their metabolic actions.

CONCLUSION

In the present study ultrasound treatment significantly improved the total sugars, reducing sugars and major minerals like potassium and calcium available in the tender coconut water but there was no improvement in magnesium and phosphorus. Ultrasound is an emerging area and thus lot of research has to be carried out to bring this technology at commercial level. These results suggest that sonication technology may successfully be employed for the processing of tender coconut water with improved safety and quality from consumer's health point of view.

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