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Dhanita Patel
M.Sc. Horticulture (Fruit Science), Department of Fruit Science College of Agriculture IGKV, Raipur, Chhattisgarh, India

HG Sharma
Professor and Head Department of Fruit Science College of Agriculture IGKV, Raipur, Chhattisgarh, India

Vikas Ramteke
ACRIP on Cashew, SGCARS, Jagdalpur, IGKV Raipur Chhattisgarh, India

Romila Xess
M.Sc. Horticulture (Fruit Science), Department of Fruit Science College of Agriculture IGKV, Raipur, Chhattisgarh, India

Corresponding Author:
Dhanita Patel
M.Sc. Horticulture (Fruit Science), Department of Fruit Science College of Agriculture IGKV, Raipur, Chhattisgarh, India

Processing and preservation of green coconut water

Dhanita Patel, HG Sharma, Vikas Ramteke and Romila Xess

Abstract
The experiment was conducted at Horticulture processing laboratory, Department of Fruit Science, College of Agriculture, IGKV, Raipur during the year 2017-18 to study the processing techniques of green coconut water for its preservation. For the study, seven treatments (T_0 = Control, T_1 = Storage at refrigerated temperature, T_2 = Storage below 0 ºC temperature, T_3 = Heating at 60 ºC for 10 minutes, T_4 = Heating at 70 ºC for 10 minutes, T_5 = Heating at 80 ºC for 10 minutes, T_6 = Heating at 90 ºC for 10 minutes, T_7 = Heating at 100 ºC for 10 minutes) were selected. Heating at 100 ºC for 10 minutes of preserved coconut water was stored in glass bottle at room temperature preformed the best quality up to 3 month of storage according to the taste testing panel.

Keywords: Coconut water, processing technique, physico-chemical changes

Introduction
Coconut palm **(***Cocos nucifera* L.**)** also known as "Tree of Heaven" is a tropical fruit plant and belongs to the family Arecaceae (Palmae), which is one of the important members of monocotyledons. It is originated in Central America and Malaysia.

Coconut is an important and outstanding crop as provides a variety of useful by-products and every part of the tree being utilized for some economic purpose. The coconut is cultivated for the nuts from which copra, coconut oil, coconut oil cake and coconut fibre is obtained. These products are used for diverse purposes and are of great commercial importance. The trunk of mature trees are used as timber in house construction. The unopened coconut inflorescences or spadices are tapped to extract the juice which is converted into jaggery, sugar, vinegar and fermented toddy. In certain parts of India, namely Kerala, a large industry employing hundreds of labourers had been built up around the manufacture of coir fibre and coir products, both on a cottage and large industry scale. The coconut shell is largely used as fuel and also for the production of charcoal.

The water inside the tender or green coconut is known as coconut water. It is a refreshing and tasty drink having medicinal properties. It has a great demand especially during the hot season. It is very helpful against dehydration of body tissues due to diarrhoea and vomiting. It acts as antiseptic to urinary track and increases blood circulation.

Materials and methods
The experiment was conducted at Horticulture processing laboratory, Department of Fruit Science, IGKV, Raipur during 2017-2018. Good quality green coconut was collected from local market. Then collected coconut water was taken in a glass beaker and kept in water bath for pasteurization to maintain different levels of temperature according to the treatment. Then treated coconut water was poured into hot, sterilized crown bottles of 200 ml capacity and corked air-tight. The filled bottles were pasteurized in boiling water till the temperature of product reaches 100 ºC. It took about 15 minutes to attain required temperature. The bottles of green coconut water were kept at ambient condition for further studies up to 90 days.

The treatments were as follows:
T_0 = Control (Storage at room temperature)
T_1 = Storage at refrigerated temperature
T_2 = Storage below 0 ºC temperature
T_3 = Heating at 60 ºC for 10 minutes
T_4 = Heating at 70 ºC for 10 minutes
T_5 = Heating at 80 ºC for 10 minutes

T_6 = Heating at 90 ºC for 10 minutes
T_7 = Heating at 100 ºC for 10 minutes

Results and Discussion

The product were analyzed for the changes in their chemical constituents like TSS, pH, titrable acidity, ascorbic acid and sugars during 90 days of storage.

Total soluble solids (°Brix)

A continuous increasing trend was observed in TSS throughout the storage period (Table 1). At the time of preparation, TSS (4.09ºBrix) was found significantly higher with the treatment, heating at 100 °C for 10 minutes (T_7) followed by heating at 90 °C for 10 minutes (T_6). While, minimum TSS content (4.00°Brix) was observed with the treatment, storage at room temperature (T_0). The treatments T_5 and T_4, T_1 and T_0 were found statistically at par. At 30 days of storage, the TSS content (4.09ºBrix) was found to be maximum under the treatment, heating at 100 °C for 10 minutes (T_7) followed by heating at 90 °C for 10 minutes (T_6). While, minimum TSS content (4.01°Brix) was observed with the treatment, storage at room temperature (T_0). The treatments T_3 and T_2 were statistically similar. At 60 days of storage, maximum TSS (4.18°Brix) was recorded with the treatment, heating at 100 °C for 10 minutes (T_7) followed by heating at 90 °C for 10 minutes (T_6). While, minimum TSS content (4.08°Brix) was observed with the treatment, storage at room temperature (T_0). The treatments $T_{5,}$ T_4, and T_3 were found statistically at par. At 90 days of storage, similar trend was observed in TSS.

The increased TSS in green coconut water during storage was probably due to conversion of left over polysaccharides into soluble sugars. In conformity of this, similar results were reported in jamun RTS (Kanan and Thirumaran, 2002; Das, 2009; Gehlot *et al*., 2010) [6, 4, 5], papaya RTS (Saravanan *et al*., 2004) [13], guava beverages (Pandey, 2004) [10] and banana RTS (Yadav *et al*., 2013) [16].

Acidity (%)

The acidity of green coconut water showed an increasing trend with increasing period of storage (Table 1). At the time of preparation (0 days), the maximum acidity (0.17%) was observed with the treatment, heating at 100 °C for 10 minutes (T_7) followed by heating at 90 °C for 10 minutes (T_6). while, minimum acidity (0.05%) was observed with the treatment, storage at room temperature (T_0). At 60 days of storage, higher acidity (0.19%) was found with the treatment, heating at 100 °C for 10 minutes (T_7) followed by heating at 90 °C for 10 minutes (T_6). while, minimum acidity (0.05%) was observed with the treatment, storage at room temperature (T_0). After 90 days of storage, the titrable acidity (0.36%) was found to be higher with the treatment, heating at 100 °C for 10 minutes (T_7) followed by heating at 90 °C for 10 minutes (T_6). while, minimum acidity (0.11%) was observed with the treatment, storage at room temperature (T_0).

The increase in acidity in coconut water during 90 days of storage may be due to formation of organic acids by ascorbic acid degradation as well as progressive decrease in the pectin content. Similar findings were also reported in beverages of sweet orange (Byanna and Gowda, 2012) [2], banana (Yadav *et al*., 2013) [16], and jamun (Khurdiya and Roy, 1985 and Das, 2009) [7, 4].

Ascorbic acid (mg/100ml)

The ascorbic acid content in green coconut water was found decreasing trend with increasing period of storage (0 to 90 days). At the time of preparation (0 day), the maximum ascorbic acid (2.04 mg/100ml) was observed with the treatment, storage at room temperature (T_0) followed by storage below 0ºC (T_2). The minimum ascorbic acid content (1.90 mg/100ml) was recorded with the treatment, heating at 100ºC for 10 minutes (T_7). The treatments T_2 and T_3, T_1 and T_4 were found statistically at par. After 30 days of storage, maximum ascorbic acid (2.03 mg/100ml) was observed with the treatment, storage at room temperature (T_0) followed by heating at 60ºC for 10 minutes (T_3). The minimum ascorbic acid (1.88 mg/100ml) was recorded with the treatment, heating at 100ºC for 10 minutes (T_7). The treatments T_3 and T_2, T_1 and T_4 were found statistically at par. After 60 days of storage, maximum ascorbic acid (2.00 mg/100ml) was observed with the treatment, storage at room temperature (T_0) followed by heating at 60ºC for 10 minutes (T_3). The minimum ascorbic acid (1.85 mg/100ml) was recorded with the treatment, heating at 100ºC for 10 minutes (T_7). The treatments T_4 and T_1 were found at par. After 90 days of storage, maximum ascorbic acid (1.97 mg/100ml) was recorded with the treatment, storage at room temperature (T_0) followed by heating at 60 °C for 10 minutes (T_3). The minimum ascorbic acid (1.82 mg/100ml) was recorded with the treatment, storage at 100 °C for 10 minutes (T_7).

The decrease in ascorbic acid in green coconut water during storage might be due to oxidation or irreversible conversion of L-ascorbic acid into dehydro ascorbic acid in the presence of enzyme ascorbic acid oxidase (ascorbinase) caused by trapped or residual oxygen in the glass bottles. Similar reduction in ascorbic acid content have also been reported by Baramanray *et al.* (1995) [1] in guava nectar, Saravanan *et al.* (2004) [13] in papaya RTS, Das (2009) [4] in jamun products, and by Sharma *et al.* (2009) [14] in guava-jamun RTS.

pH

The pH value in green coconut water was observed a decreasing trend with increasing period of storage (0-90 days). At the time of preparation, maximum pH value (5.68) was observed with the treatment, heating at 100 °C for 10 minutes (T_7) followed by heating at 80 °C for 10 minutes (T_5). while, minimum pH (5.08) was observed with the treatment, storage at room temperature (T_0). At 30 days of storage, maximum pH value (5.64) was recorded under the treatment, heating at 100 °C for 10 minutes (T_7) followed by heating at 80 °C for 10 minutes (T_5). The minimum pH value (5.04) was recorded with the treatment, storage at room temperature (T_0). At 60 days of storage, maximum pH value (5.35) was recorded with the treatment, heating at 100 °C for 10 minutes (T_7) followed by heating at 80 °C for 10 minutes (T_5). The minimum pH value (5.01) was recorded with the treatment, storage at room temperature (T_0). The treatments T_2 and T_1 were found statistically similar. After 90 days of storage, maximum pH value (5.30) was observed with the treatment, heating at 100 °C for 10 minutes (T_7) followed by heating at 80 °C for 10 minutes (T_5). The minimum pH value (4.86) was recorded with the treatment, storage at room temperature (T_0).

The increased acidity and TSS under all the cultivar and recipe treatments during storage had a corresponding decrease in pH. Hence, the reduction in pH could be attributed to simultaneous increase in acidity and TSS of coconut water irrespective of their storage temperature. The present findings are in agreement with those of Krishnaveni *et al.* (2001) [8]

and Byanna and Gowda (2012) [2] in jackfruit and sweet orange RTS, respectively.

Total sugar (%)

The total sugar content in green coconut water showed an increasing trend with increasing period of storage (Table 2). At the time of preparation, the maximum total sugar content (5.89%) was observed with the treatment, heating at 100 °C for 10 minutes (T_7) followed by heating at 90 °C for 10 minutes (T_6). The minimum total sugar content (4.90%) was recorded with the treatment, storage at room temperature (T_0). After 30 days of storage, the maximum total sugar content (5.98%) was observed with the treatment, heating at 100 °C for 10 minutes (T_7) followed by heating at 90 °C for 10 minutes (T_6). The minimum total sugar content (5.00%) was recorded with the treatment, storage at room temperature (T_0). After 60 days of storage, the maximum total sugar content (6.10%) was observed with the treatment, heating at 100 °C for 10 minutes (T_7) followed by heating at 90 °C for 10 minutes (T_6). The minimum total sugar content (5.10%) was recorded with the treatment, storage at room temperature (T_0). At the end (90 days) of storage, the maximum total sugar content (6.19%) was observed with the treatment, heating at 100 °C for 10 minutes (T_7) followed by heating at 90 °C for 10 minutes (T_6). The minimum total sugar content (5.16%) was recorded with the treatment, storage at room temperature (T_0).

Similar findings were reported in jamun juice and beverages (Patil, 2001; Kannan and Thirumaran, 2002; Gehlot *et al*., 2010) [12, 6, 5], Bael beverages (Verma and Gehlot, 2006) [15] and rose apple jamun blended RTS (Patil *et al*., 2014) [11].

Table 1: Changes in TSS (°Brix), acidity (%), ascorbic acid (mg/100ml) and pH in green coconut water during storage.

		TSS (°Brix)				Acidity (%)				Ascorbic acid (mg/100ml				pH			
S. No.	Treatment	0 days	30 days	60 days	90 days	0 days	30 days	60 days	90 days	0 days	30 days	60 days	90 days	0 days	30 days	60 days	90 days
1	T_0	4.00	4.01	4.08	4.11	0.05	0.05	0.07	0.11	2.04	2.03	2.00	1.97	5.08	5.04	5.01	4.86
2	T_1	4.01	4.03	4.09	4.13	0.07	0.08	0.11	0.15	2.00	1.98	1.94	1.90	5.10	5.06	5.03	4.92
3	T_2	4.03	4.05	4.12	4.15	0.08	0.10	0.13	0.17	2.02	2.00	1.96	1.94	5.12	5.08	5.04	5.00
4	T_3	4.04	4.06	4.14	4.18	0.09	0.11	0.15	0.19	2.02	2.01	1.98	1.96	5.15	5.11	5.06	5.02
5	T_4	4.04	4.08	4.15	4.20	0.10	0.12	0.18	0.23	1.99	1.97	1.94	1.88	5.30	5.20	5.10	5.04
6	T_5	4.05	4.10	4.15	4.21	0.12	0.14	0.20	0.25	1.96	1.94	1.91	1.86	5.67	5.62	5.30	5.28
7	T_6	4.07	4.12	4.17	4.22	0.14	0.16	0.24	0.30	1.92	1.90	1.87	1.84	5.64	5.60	5.28	5.25
8	T_7	4.09	4.14	4.18	4.24	0.17	0.19	0.29	0.36	1.90	1.88	1.85	1.82	5.68	5.64	5.35	5.30
	SEm±	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.02	0.01	0.02	0.01	0.01	0.01
	CD at 5%	0.02	0.03	0.02	0.01	0.02	0.01	0.01	0.01	0.04	0.02	0.02	0.01	0.03	0.02	0.03	0.01

Reducing sugar (%)

The reducing sugar content of green coconut water showed an increasing trend with increasing period of storage (Table 2). At the time of preparation, the maximum (4.09%) reducing sugar was observed with the treatment, heating at 100 °C for 10 minutes (T_7) followed by heating at 90 °C for 10 minutes (T_6). The minimum reducing sugar (3.03%) was recorded with the treatment, storage at room temperature (T_0). The treatments T_4 and T_3 were showed statistically similar differences.

At the time of 30 days storage, maximum reducing sugar (4.26%) was observed with the treatment, heating at 100 °C for 10 minutes (T_7) followed by heating at 90 °C for 10 minutes (T_6). The minimum reducing sugar (3.15%) was recorded with the treatment, storage at room temperature (T_0). After 60 days of storage, maximum reducing sugar (4.52%) was recorded with the treatment, heating at 100 °C for 10 minutes (T_7) followed by heating at 90 °C for 10 minutes (T_6). The minimum reducing sugar (3.35%) was recorded with the treatment, storage at room temperature (T_0). After 90 days of storage, maximum reducing sugar (4.98%) was recorded with the treatment, heating at 100 °C for 10 minutes (T_7) followed by heating at 90 °C for 10 minutes (T_6). The minimum reducing sugar (3.70%) was recorded with the treatment, storage at room temperature (T_0).

These results are in close conformity with the report of Patil (2001) [12], who revealed that there was a significant increase in reducing sugars in jamun juice throughout the storage period. The increase in sugars during storage may be due to gradual inversion of non-reducing sugars to the reducing sugars by the hydrolysis process. Chauhan *et al.* (2014) [3] reported that the reducing sugar was increased in a beverage by blending coconut water and lemon juice during six month of storage period.

Non-reducing sugar (%)

The non-reducing sugar in green coconut water showed decreasing trend with increasing period of storage (0-90 days). At the time of preparation, maximum non-reducing sugar (1.60%) was recorded with the treatment, storage at room temperature (T_0) followed by heating at 70 °C for 10 minutes (T_4). whereas, the minimum (0.90%) non-reducing sugar was observed with the treatment, heating at 90 °C for 10 minutes (T_6). The treatments T_1 and T_2 were at par. After 30 days of storage, maximum non-reducing sugar (1.49%) was observed with the treatment, storage at room temperature (T_0) followed by heating at 70 °C for 10 minutes (T_4). while, the minimum content (0.80%) was observed with the treatment, heating at 90 °C for 10 minutes (T_6). The treatments T_1 and T_2 were showed significantly at par differences. After 60 days of storage, maximum non-reducing sugar (1.28%) was recorded with the treatment, storage at room temperature (T_0) followed by heating at 70 °C for 10 minutes (T_4). whereas, the minimum content (0.70%) was observed with the treatment, heating at 90 °C for 10 minutes (T_6). The treatments T_7 and T_3 were at par. After 90 days of storage, maximum non-reducing sugar (1.09%) was recorded with the treatment, storage at room temperature (T_0) followed by heating at 70 °C for 10 minutes (T_4). whereas, the minimum content (0.40%) was observed with the treatment, heating at 90 °C for 10 minutes (T_6).

The increase in reducing sugar as well as total sugar corresponded to the increase in total soluble solids (TSS) and ultimate decrease in non-reducing sugar in both the beverages during storage period. The variation in different fractions of sugar might be due to hydrolysis of polysaccharides like starch, pectin and inversion of non-reducing sugar into reducing sugar, as increase in reducing sugar was correlated with the decrease in non-reducing sugar. The increased level of total sugar was probably due to conversion of starch and pectin into simple sugars. Similar findings were reported by Saravanan *et al.* (2004) [13] in papaya RTS, Mehmood *et al.* (2008) [9] in apple juice and Byanna and Gowda (2012) [2] in sweet orange RTS.

Table 2: Changes in total sugars (%), reducing sugar (%) and non-reducing sugar (%) in green coconut water during storage.

		Total sugars (%)				Reducing sugar (%)				Non-reducing sugar (%)			
S. No.	Treatments	0 Days	30 days	60 days	90 days	0 Days	30 days	60 days	90 days	0 days	30 days	60 days	90 days
1	T_0	4.90	5.00	5.10	5.16	3.03	3.15	3.35	3.70	1.60	1.49	1.28	1.09
2	T_1	4.93	5.02	5.12	5.19	3.08	3.18	3.39	3.78	1.13	1.02	0.88	0.58
3	T_2	5.12	5.22	5.33	5.39	4.00	4.11	4.32	4.64	1.12	1.01	0.86	0.56
4	T_3	5.30	5.42	5.53	5.60	4.02	4.16	4.36	4.69	1.10	0.99	0.78	0.48
5	T_4	5.44	5.54	5.65	5.72	4.02	4.18	4.40	4.75	1.24	1.14	0.94	0.64
6	T_5	5.60	5.70	5.82	5.91	4.04	4.21	4.44	4.80	1.20	1.10	0.90	0.60
7	T_6	5.80	5.91	6.02	6.11	4.08	4.23	4.48	4.91	0.90	0.80	0.70	0.40
8	T_7	5.89	5.98	6.10	6.19	4.09	4.26	4.52	4.98	0.99	0.89	0.79	0.46
	SEm±	0.02	0.02	0.01	0.02	0.02	0.01	0.02	0.01	0.02	0.01	0.02	0.01
	CD at 5%	0.02	0.03	0.02	0.01	0.03	0.02	0.03	0.01	0.02	0.02	0.03	0.01

Conclusion

Considering the above analysis of findings, it was observed that T_7 (heating at 100 ºC for 10 mins) preserved in glass bottle performed the best quality after three months of storage at room temperature. This processed coconut water will be suitable for commercial processing.

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