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ORIGINAL ARTICLE

Post-harvest quality and shelf-life of tender coconut

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Abstract Seven to 8 months old (maturity stage) coconuts (*Cocos nucifera* L.) from local tall cultivar ('West Coast Tall') with husk and intact perianth were stored at room temperature (27±2°C) and the minimally processed nuts (60% husk removed) were stored both at room temperature as well as refrigerated conditions (13±2°C) to evaluate the changes in physical and chemical constituents of coconut water during storage. Observations on physiological loss in weight of the stored coconuts, volume and pH of coconut water, total sugars and amino acid, minerals (Na and K) and sensory tests were used to evaluate the quality. The observations were continued till the quality of the nut water deteriorated. It was observed that, to increase the shelf-life of the coconuts the nuts have to be harvested carefully with intact perianth and without any breakage of nuts. The quality of minimally processed nuts deteriorates earlier than non-dehusked nuts during storage.

Keywords Tender coconut · Shelf-life · Minimally processed · Perianth · Total sugars · Amino acid

Introduction

Coconut (*Cocos nucifera* L.) popularly known as "Tree of life", is one of the most useful trees in the world. Tender coconut (7 to 8 months old maturity) is valued both for its sweet water, which is a refreshing drink and the delicious gelatinous meat (kernel). The water of tender coconut, technically the liquid endosperm, is the most nutritious wholesome beverage that nature has provided for people of the tropics and is consumed fresh, largely because, once exposed to air and warm temperatures, it rapidly deteriorates. In addition, sterilizing the water using high temperature and short-time pasteurization destroys some of the nutrients and the entire flavour. Chemical composition and volume of the coconut water change during maturation (Jayalakshmi et al 1986, Shamina and John 2004). The reports of Sudarsana Rao et al (2008) indicate that quality and quantity of coconut water as well as consumer acceptability of tender nut is more after 7 months of maturity.

The bulky nature of the tender coconut and its tendency to undergo biochemical changes and spoilage after harvest are constraints in the popularization and marketing of tender coconut in natural form in areas where coconut is not grown. Although technologies are available for the processing of tender coconut water and matured water into packed soft drinks, consumer preference is for the natural taste of tender coconut. The increasing demand for natural drinks necessitated the urgency of making available, tender coconut water without spoilage and loosing its inherent qualities. It is seen that tender coconut cannot be stored for more than one week at room temperature due to shrinkage and discoloration of skin, fall of perianth and fungal attack on the soft perianth region. Study conducted in Sri Lanka revealed that the quality of tender king coconut could be maintained for few weeks when a whole nut was wrapped with cling film and stored at 14–15°C (Ranasinghe et al 1999). Wijeratnam et al (2006) conducted studies to facilitate low temperature storage and distribution of fresh king coconut, *Cocos nucifera* var. *auranta* and observed that nuts respond best to a dip treatment in wax formulation, when stored at 13.5°C for 28 days while nuts stored at 28±2°C, showed complete deterioration after 7 days. Storage of minimally processed tender coconut under

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refrigerated condition and transportation to distant places is becoming popular. But published reports are not available on the quality aspects of stored tender nuts. In this study the shelf-life of tender coconut was evaluated based on the variation in the quality parameters under different storage conditions.

Materials and methods

Seven months old tender coconuts, harvested from 'West Coast Tall' (WCT), the local tall variety of coconut palm were used for the study. The palms were grown in red sandy loam soil with recommended package of practices (CPCRI 2007). Irrigation was provided through drip during summer months. Care was taken to collect the nuts intact along with perianth ad-pressed to the nuts and to avoid breakage while harvesting.

The intact nuts were stored under room temperature (RT, 27±2°C), under diffused light (75±10 μE $m^{-2}s^{-1}$) and 70±5% RH and the minimally processed nuts (60% husk removed) were stored both under RT (maximum 27±2°C and minimum 17±2°C) as well as refrigerated conditions (13±2°C). Before refrigeration minimally processed nuts were packed in polythene cover of 50 micron thickness. Observations on physiological loss in weight (PLW) of nuts stored (Srivastava and Tandon 1968), volume and pH of the nut water, total sugars (Dubois et al 1956) and amino acids (Ya Pin Lee and Takahashi 1966), Na and K (Jackson 1959) and sensory tests (6 to 8 independent tasters) using 5-point scale (where,1=very good, 2=good, 3=average, 4=below average, 5=poor) were used to evaluate the quality. At each time 3 nuts were randomly selected from the lot for the observation. The observations were continued till the quality deterioration of the nut water was perceptible. Sensory test of the nut water was carried out daily while chemical parameters were estimated based on the taste of the nut water.

Statistical analysis The experimental design was a factorial complete randomized design with storage conditions and quality parameters as factors. The quality parameters were subjected to analysis of variance and significant difference among means were worked out at $p \leq 0.05$ and $p \leq 0.01$ (Panse and Sukhatme 1978).

Results and discussion

Shelf-life and changes in quality parameters of intact tender nuts under room temperature As in other fruit crops viz; water melon (Radulovic et al 2007), strawberry (Singh et al 2008) and ber (Sanjay et al 2008) storage of intact nuts under room temperature (Table 1) clearly showed a gradual increase in PLW (from 2 to 19.6%) and pH during increase in storage period. The nut water was sensorily good only up to fifth day of storage and thereafter a deterioration in taste was observed and got average score of 3. On the 5th day, disintegration of the meat was observed and it continued till the very last day of storage. The nut without the perianth showed spoilage due to fungal attack The nut water also turned yellow and emitted bad odour during the period.

Chemical constituents in tender nut water during storage An increase in sugar content during storage (Table 1) can be attributed to conversion of starch and polysaccharides into

Table 1 Changes in physico-chemical characteristics of tender coconut with husk and nut water during storage in room condition (27±2°C, 70±5% RH)

Coconut Water							
Storage period, day	Physiological loss in weight in nut, %	Volume of water, ml	pH	Total sugars, g/100 ml	Free amino acids, mg/100 ml	Na, mg/100 ml	K, mg/100 ml
1	–	231.7	4.9	3.4	2.0	44.3	325.9
2	2.0	196.7	5.1	3.4	1.8	37.8	291.6
3	3.5	256.7	5.1	4.3	1.6	35.6	297.6
5	6.7	225	5.3	4.7	2.3	39	284.2
6	8.0	273.3	5.1	4.6	2.7	41.2	291.6
7	11.6	230	5.1	4.5	3.2	44	303.6
9	13.9	243.3	5.2	4.3	3.2	39.7	288.7
11	16.5	212	5.2	NE	NE	NE	NE
13	19.6	205	5.4	4.8	2.8	38.8	283.3
C.D:$p \leq 0.05$	4.2*	NS	0.22**	0.32**	0.54**	4.9*	15.3*

*$p \leq 0.05$, ** $p \leq 0.01$, *NS* not significant, *NE* not estimated

Table 2 Changes in quality parameters in intact and infected coconuts

Parameters	Good nut	Infected nut	C.D (p=0.05)
Nut water vol, ml	231.7	211.7	NS
pH	4.9	5.2	NS
Total sugars, g/100 ml	3.5	2.8	0.54*
Free amino acids, mg/100 ml	1.9	3.6	1.1**
Na, mg/100 ml	44.3	41.8	NS
K, mg/100 ml	325.9	274.5	17.6**

* $p \leq 0.05$, ** $p \leq 0.01$, *NS* Not significant

soluble sugars and dehydration of fruits (Hoda et al 2000). Free amino acid content showed a decrease initially and there after an increase (1.6 to 3.2 mg/100 ml). However, by 13th day again the decrease started. An increase in the amino acid in the ripening nut has been reported by Shamina and John (2004). Na and K decreased during storage (12.4% and 13.1%, respectively) (Table 1). Kamala Devi and Velayutham (1978) and Dhamodaran et al (1993) attributed pleasant taste of tender nut to the dissolved salts in the nut water.

Quality of fungus infected nuts As compared to uninfected nuts slight increase in pH of nut water was observed in the fungus infected nuts (Table 2). Reduction in total sugar content (20%) and an increase in the free amino acid content (87%) were also observed in the infected nuts as compared to good nuts. Although slight reduction in Na content was observed in the infected nuts as compared to the good nuts, significant reduction was observed in K content (15.8%) (Table 2).

Storage and changes in quality parameters in minimally processed nuts Nuts were good in appearance during the first four days under RT and 11 days under refrigerated condition although fungal spots were observed by 10th day under refrigerated condition. Deterioration of the taste of nut water (score 3) was observed by 4th day of storage (DOS) under RT and after 8 DOS (score 3) under refrigerated condition (Table 3). Extended shelf-life of coconut under cool condition than ambient condition is also reported by Wijeratnam et al (2006). Disintegration and spoilage of meat was observed under room condition (score 5) on 8th day and by 11th day the nut got spoiled completely and the water became turbid with bad odour. From 11th day onwards fungal growth on the nuts was visible. Beyond 14th day browning of the nuts, disintegration of meat, turbid water with oily tang and fungal growth on the nuts were observed. pH of the nut water fluctuated marginally due to treatments or storage.

Chemical constituents in the nut water of the minimally processed nuts An increase in sugar content was observed on the 8th day and again decreased on the 11th day of storage under RT (Table 3). As compared to the total sugar content of the nuts under RT, 6% lower sugar content was observed in the refrigerated nut. The interaction between storage condition and the storage period was also found to be significant.

Free amino acids in the refrigerated nuts were 60% higher than in RT stored nuts (Table 3). During storage of tender

Table 3 Physico-chemical characteristics of tender coconut water during storage (S) of minimally processed nuts under room and refrigerated (Refrg) conditions (T)

Storage Period, days	Taste, score of nut water		Volume, ml		pH		Total sugars,g/100 ml		Free amino acids, mg/100 ml	
	Room	Refrg	Room	Refrg	Room	Refrg	Room	Refrg	Room	Refrg
1	1	1	247.5	247.5	5.2	5.2	4.6	4.6	2.9	2.9
4	3	2	350	342.5	5.1	5.6	4.2	3.7	3.6	6.6
8	5	3	305	295	5.4	5.5	5.4	4.2	3.8	6.9
11	5	4	260	290	5.2	5.6	4	4.1	3.7	6.2
14		5		285		5.8	4.5	4.2	3.5	5.6
16		5		245		6.1				
17		5		290		6.8				
20		5		260		6.1				
CD	NS		NS		NS		S=0.319**,T=0.225** S×T=0.451**		S=0.938**, T=0.663**, S×T=1.327**	

**$p \leq 0.01$, *NS* not significant

nut the carbohydrates may be broken down to soluble sugars and proteins to amino acids resulting into an increase in soluble sugars and amino acids. Increase in TSS and total sugars during storage have been reported in guava (Mahajan et al 2009).

The disintegration of meat was in the form of flakes in intact nuts while it was slimy in texture with decaying smell in the case of minimally processed nuts. Moreover in the room condition in the intact nuts the water taste was good up to 5 DOS while in the minimally processed nuts it was of average taste by 4 DOS itself. Similarly under refrigeration the nut water taste was below average by 11th DOS while in the intact nut, it was below average only by 13th DOS. This implies that quality of the intact nuts stored under RT is better than the minimally processed nuts. This may be due to insulating effect of husk, which in turn increases the storage-life of tender nuts.

Conclusion

For increasing the shelf-life, the tender coconuts have to be harvested carefully with intact perianth and without any breakage of nuts. The nuts can be stored under room condition and diffused light condition without spoilage of nut water for longer periods. The quality of minimally processed nuts deteriorates earlier than non-dehusked nuts during storage. With respect to the quality of nut water, the increase in total sugar and amino acids due to the disintegration of meat as well as turbidity and colour of the nut water was observed during storage.

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