EFFECTS OF DIFFERENT STORAGE CONDITIONS ON PRESERVATION OF COCONUT (*Cocos nucifera*) WATER

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ABSTRACT

To determine proper storage conditions for preservation of green coconut (Cocos nucifera) *water the effects of different temperatures (4, 12, 22 and 28C), time and packing type (with and without polyethylene) on coconuts were investigated for five weeks. A total of 133 dwarf fruits were used. On day 1 (zero time) and on weeks, 2, 3, 4 and 5 of the experiment, the water was taken at random from six wrapped and six unwrapped coconuts for physicochemical (°Brix, total acidity, pH and weight), microbiological and sensory analyses. Treatments were repeated twice for precise data. Statistical differences were determined by the analysis of variance. Our data show that the treatment of choice for a proper storage is: temperature: 12C; packing type: polyethylene; time, four weeks.*

INTRODUCTION

The coconut palm (*Cocos nucfera*) is the most important and widely distributed of cultivated palm-trees (CNPCo). Brazilian production has been estimated in 603.175 million fruits (IBGE 1987); about 75% of this production is used by industries (CEBRAE 1979). More than 100 products are directly or indirectly

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prepared with coconuts; from these the desiccated coconut, copra coconut oil and copra meal cake are the most important for international trade.

The fruit is ovoid in shape and the husk is about the size of a football. It consists of four parts: the husk, shell, meat and water.

The coconut water, technically the liquid endosperm, is approximately 25% by weight of the whole nut, and the amount of coconut water that can be derived from each nut is about 420 mL/nut. This water is a luxury to some, but to others it is a common everyday beverage. It is more palatable about 7 months after the nuts are pollinated, and the total solids are around 5% by weight. The desirable flavor is sweet and slightly astringent, with a pH about 5.6 (Jasper 1979; Pandolina 1983). Its consumption is increasing in a range of 20% per year (CEBRAE 1979), which is attributed to the many healing qualities of the water. Because of the high content of salines and albumin it is said to check cholera, combat intestinal worms and relieve stomach troubles (Jasper 1979). The main sugar fractions of young coconuts are glucose and fructose, while sucrose predominates in mature meat (Pandolina 1983). Minerals, amino acids, vitamins and auximic, or growth promoting properties, are found in the coconut water. Vitamin C ranges from 2.2 to 3.7 mg/100 mL (Jasper 1979; Pandolina 1983; Pinto 1983). Alanine, arginine, cystine and serine values in the proteins are higher than those in cow's milk (Jasper 1979; Dias 1983). Its caloric value is 17.4 kcal/100g (Jasper 1979).

Coconut water is easily absorbed by the human organism and is used in the treatment of dysentery and for infant feeding. During the Second World War it was given orally or intravenously for rehydration of Japanese soldiers. Experiments in Bangkok, Thailand, St. Louis (Jasper 1979), and in Recife (Pinto 1983) have demonstrated the possibilities of using coconut water for feeding patients through the veins; since the water is sterile, only filtration is required before use.

The proper storage of coconuts has been a concern for processors and shippers. Jasper (1979) and Bleinroth (1986) have shown that mature coconuts may be stored at low temperatures (about 2.5C) with relative humidity between 45 and 55% for a period of two years. But too little is known about storage conditions for green coconuts to preserve the coconut water. The purpose of this investigation was, therefore, to determine proper storage conditions for green coconuts to preserve the coconut water.

MATERIALS AND METHODS

Product

Green coconuts of the cultivar dwarf were harvested from a plantation in Pernambuco, Brazil. Picked seven months after nut pollinization. 134 dwarf coconuts were used.

Treatments

The coconuts were weighed and half were wrapped in polythylene (thickness 14 μ and density 1.3 g/cm^3). Equal groups of each were held at controlled temperatures of, 4, 12, 22 and 28C. The relative humidity ranged between 80–85%, except for the samples held at 22C which were kept at 60–65% R.H. Two experiments were performed. In the first, the coconuts were held at temperatures of 4 and 12C for a period of five weeks. In the second, the coconuts were held at temperatures of 4, 12, 22 and 28C for three weeks.

The overall experiment period lasted five weeks. Analyses were started at week 2, because preliminary studies had shown no differences at all from the first week. On day 1 (zero time) and on weeks 2, 3, 4 and 5, six wrapped and six unwrapped coconuts were taken at random and their water analyzed for physicochemical (°Brix, total titratable acidity, pH and weight), microbiological and sensorial data. The complete experiments were repeated to verify precise data.

Physicochemical Analysis

The composition of the coconut water was analyzed in triplicate for all parameters. Total solids and ash determinations followed AOAC (1970) procedure. Total sugars and reducing sugars were determined by the Luff-School method (IFJU 1968). Calcium, phosphorus and chlorine content were determined by precipitation with ammonium molybdate, and by titration with $AgNO_3$, respectively (IFJU 1968). The contents of sodium and potassium were read directly in a flame-photometer digimed NK 2000.

°Brix was measured using a refractomer, Jean Model I-375320. Total acidity was measured by titration, with 0.1N NaOH and phenolfthalein as indicator. A FANEN, Mod. 302, pH meter at 25C was used for pH determination. The weight differences were obtained compared to weight values at zero time. Microbiological analyses (aerobic plate count) (Speck 1976) were performed. Statistical differences were determined by the analysis of variance on factorial designs in a randomized complete block design, where blocks were storage time and variable factors were temperature and type of packing.

Sensory Evaluation

Using 6-point scales (6 = excellent, 1 = very bad), twelve trained judges were asked to evaluate the overall acceptability of the coconut water and the external appearance for green coconuts. At each session, judges were served with a 50 mL white plastic cup (art plast) containing about 25 mL of coconut water, and the green coconuts were exposed on a table for observation. An incomplete-block design was employed, and an analysis of variance on judgments and treatments was conducted for each attribute of each treatment.

RESULTS AND DISCUSSION

Physicochemical Results

The composition of coconut water is shown in Table 1. However, the coconut water is a relatively dilute system with a total solids content of 5% and total sugars of 2.1%. It is a nutritive beverage, furnishing fluid plus potassium chloride, phosphate, calcium and sodium (salt ingredients). Jasper (1979) has cited Child's statement that the coconut water nutritive value is due almost entirely to its sugar content. Therefore, coconut water is suggested as a good drink in cholera cases, stomach troubles and diarrhea because of its composition of inorganic minerals, amino acids and vitamin C (Jasper 1979; Pinto 1983).

The mean values determined for °Brix, total acidity, pH and weight difference in the coconut water stored in green coconuts unwrapped, and wrapped with polyethylene, during five weeks at 4, 12, 22 and 28C are given in Tables 2, 3, 4 and 5. The chemical parameters determined at zero time are used as reference values for coconut water during this work. Microbiological data were discarded because they showed no significant differences, proving one more time that coconut water is sterile. The green coconuts deteriorated; cleavings and water loss were observed at the fourth week when stored at 28C and at the fifth at 22C. The mean values for °Brix decreased little during the time storage. The pH mean values increased together with the decrease of the total acidity mean values for the same period of time. This variation probably may contribute to the flavor-loss of the

TABLE 1.
CHEMICAL COMPOSITION OF COCONUT WATER[a]

Parameters	
Total solids (%)	5.0
Total sugars(%)	2.1
Reducing sugars(%)	1.9
Ash(%)	0.6
Calcicum (mg/%)	59.6
Phosphorus (mg/%)	10.2
Chlorine(%)	0.3
Na (mg/l)	38.0
K (mg/l)	21.4

[a]Each value is the average of three samples determination.

TABLE 2.
MEAN VALUE OF °BRIX DETERMINED IN COCONUT WATER STORED IN GREEN COCONUTS UNWRAPPED AND WRAPPED WITH POLYETHYLENE DURING FIVE WEEKS AT 4, 12, 22 AND 28C

Temperature and packing		Storage time, week				
		Zero time	2nd[c]	3rd[d]	4th[d]	5th[d]
4 C	W[a]	5.75	3.47	5.33	5.07	5.33
	Unw[b]	5.75	5.45	5.53	5.73	5.93
12 C	W	5.75	5.20	5.40	5.27	5.10
	Unw	5.75	5.43	5.27	5.33	5.97
22 C	W	5.75	5.33	5.40	4.47	-
	Unw	5.75	5.32	4.87	5.03	-
28 C	W	5.75	4.87	4.63	-	-
	Unw	5.75	4.85	4.60	-	-

a - Wrapped with polyethylene, b - Unwrapped, c - Mean of six values, d - Mean of three values.

TABLE 3.
MEAN VALUES TOTAL ACIDITY IN MEQ/100G CALCULATED FROM COCONUT WATER STORED IN GREEN COCONUTS UNWRAPPED AND WRAPPED WITH POLYETHLENE DURING FIVE WEEKS AT 4, 12, 22 AND 28C

Temperature and Packing		Storage time, week				
		Zero time[c]	2nd[c]	3rd[d]	4th[d]	5th[d]
4 C	W[a]	1.23	0.94	0.53	0.76	0.48
	Unw[b]	1.23	0.86	0.70	0.63	0.71
12 C	W	1.23	1.09	0.67	0.83	0.76
	Unw	1.23	1.19	0.89	0.93	0.75
22 C	W	1.23	1.25	0.74	0.98	-
	Unw	1.23	1.08	0.77	0.89	-
28 C	W	1.23	0.78	0.64	-	-
	Unw	1.23	0.76	0.52	-	-

a - Wrapped with polyethylene; b - Unwrapped; c - Mean of six values; d - Mean of three values.

TABLE 4.
MEAN VALUES FOR pH DETERMINED IN COCONUT WATER STORED IN GREEN COCONUTS UNWRAPPED AND WRAPPED WITH POLYETHLENE DURING FIVE WEEKS AT 4, 12, 22 AND 28C

Temperature and Packing		Storage time, week				
		Zero time[c]	2nd[c]	3rd[d]	4th[d]	5th[d]
4 C	W[a]	4.70	6.17	6.07	5.43	5.96
	Unw	4.70	6.45	5.80	5.30	5.40
12 C	W	4.70	5.71	5.53	5.24	5.11
	Unw	4.70	4.98	5.28	5.27	5.45
22 C	W	4.70	5.77	5.47	5.03	-
	Unw	4.70	5.47	5.36	4.90	-
28 C	W	4.70	6.20	5.27	-	-
	Unw	4.70	5.93	5.80	-	-

a - Wrapped with polyethylene, b - Unwrapped, c - Mean of six values, d - Mean of three values.

coconut water at the last weeks. Galic acid is the major organic acid found in coconut water, together with shikimic and quinic acid according to Pinto (1983); other studies in coconut water organic acids are scarce. The increase of the weight difference values according to storage time was expected, especially for the unwrapped coconuts, because of the water loss during the storage.

In experiment 1, temperature and time had no significant effects on °Brix (Table 6); packing, however affected ($P < 0.05$) this variable, lowering it. °Brix values were better for unwrapped coconuts regardless of temperature and time. The mean values for total acidity (Table 6) were significantly affected ($P < 0.05$) by two temperatures, 4 and 12C, and time. Regardless of the time and type of packing, 12C was the best temperature for acidity. Packing and time had no significant effect on the mean values for pH (Table 6), but the effects of temperature on pH were highly significant ($P < 0.05$). The temperature of choice was 12C. The mean values for weight difference were significantly affected ($P < 0.05$) by packing and time, although the weight loss of polyethylene-wrapped coconuts was lower. The longer the storage time, the higher the weight loss.

In experiment 2, the mean values for °Brix were not significantly affected by packing, time and temperature until 22C (Table 7). The coefficient of variation was very low (2.9%). The °Brix value, however, was lower at the temperature

TABLE 5.
MEAN VALUES FOR WEIGHT DIFFERENCE (G) DETERMINED FROM GREEN COCONUTS STORED UNWRAPPED AND WRAPPED WITH POLYETHLENE, DURING FIVE WEEKS AT 4, 12, 22 AND 28C

Temperature and Packing		Storage time, week			
		2nd[c]	3rd[d]	4th[d]	5th[d]
4 C	W[a]	17.3	24.3	25.3	29.0
	Unw[b]	112.2	173.0	211.0	260.0
12 C	W	15.3	24.7	43.3	43.0
	Unw	111.2	145.0	202.7	233.3
22 C	W	66.8	59.0	112.0	-
	Unw	223.2	363.0	367.3	-
28 C	W	63.8	103.0	-	-
	Unw	304.8	414.7	-	-

a - Wrapped with polyethylene; b - Unwrapped; c - Mean of six values; d - Mean of three values.

of 28C. The mean values for total acidity (Table 7) were significantly affected ($P < 0.05$) by temperature and time, the best values for total acidity were detected in the samples stored at 12 and 22C for three weeks. Only temperature significantly affected ($P < 0.05$) the mean values for pH (Table 7), the best values being detected when the samples were stored at 4 and 22C. The mean values for weight differences (Table 7) were significantly affected ($P < 0.05$) by temperature, packing and time. Wrapped coconuts stored at 4 and 12C for three weeks showed the best values.

Coconut Water

Coconut water overall acceptance scores were not affected ($P < 0.05$) by the storage system for two weeks. The scores for coconut water acceptability were higher ($P < 0.01$) for coconut water in wrapped coconut at 12 and 22C for three weeks of storage than those at 4C for three weeks. At the fourth week of storage the coconut water overall accceptance scores received higher values ($P < 0.01$) for those stored wrapped at 22C, and those stored unwrapped at 4C, than other storage systems. The acceptability of the coconuts at the fifth week was fair ($P < 0.05$) for both storage systems at 4 and 12C.

TABLE 6.
EFFECT OF STORAGE CONDITIONS ON PHYSICOCHEMICAL PARAMETERS OF COCONUT WATER (EXPERIMENT 1)

Storage conditions		Physicochemical parameters			
		°Brix	Total acidity meq/100g	pH	Weight difference (g)
Temperature, °C	4	5.47a	0.70a	5.82a	106.5a
	12	5.37a	0.89b	5.32b	102.3a
LSD[1] (5%)		0.25	0.35	0.35	33.3
Packing[2]	Unw	5.57a	0.83a	5.32a	181.0b
	W	5.27b	0.76a	5.65a	27.8a
LSD (5%)		2.25	0.10	0.35	33.3
Time, week	2nd	5.39a	0.45c	5.83a	63.9b
	3rd	5.83a	0.54bc	5.67a	91.7ab
	4th	5.35a	0.70a	5.31a	120.6ab
	5rd	5.55a	0.67ab	5.43a	141.3a
LSD (5%)		0.48	0.19	0.69	65.0
CV[3] (%)		4.0	10.7	5.6	28.2

The mean values of the same column followed by similar letter do not differ statistically at a probability level of 5% (Tukey test).
[1]LSD Least significant difference by Tukey's procedure.
[2]Unw Unwrapped; W — Wrapped
[3]CV Coefficient of variation.

Green Coconut

Polyethylene-wrapped green coconuts stored at 4, 12, 22 and 28C for two weeks received higher external appearance scores ($P < 0.01$) than the unwrapped ones stored at the same temperatures and times of storage. The external appearance was scored "good" up to five weeks at 12C ($P < 0.01$) when the green coconuts were wrapped. The polyethylene showed once more that it can protect better the physical characteristics of green coconuts. However, external appearance remained "good" for up to five weeks as 12C wrapped; the coconut water rating was fair.

TABLE 7.
EFFECT OF STORAGE CONDITIONS ON PHYSICOCHEMICAL PARAMETERS OF COCONUT WATER (EXPERIMENT 2)

Storage conditions		Physicochemical Parameters			
		°Brix	Total acidity meq/100g	pH	Weight difference (g)
Temperature, C	4	5.44a	0.75ab	5.37a	81.7a
	12	5.32a	0.96	6.12b	74.0a
	22	5.23a	0.96a	5.37a	178.0b
	28	4.74b	0.67b	6.12b	221.6b
LSD[1] (5%)		0.35	0.21	0.60	86.1
Packing[2]	Unw	5.16a	0.85a	5.63a	230.2b
	W	5.20a	0.82a	5.87a	46.8a
LSD (5%)		0.18	0.11	0.30	43.5
Time, week	2nd	5.24a	0.99a	5.83a	114.3a
	3rd	5.13a	0.86b	5.67a	163.4b
LSD (5%)		0.18	0.11	0.30	43.5
CV[3] (%)		2.91	10.98	4.47	26.51

The mean values of the same column followed by similar letters do not differ statistically at a probability level of 5% (Tukey test)
[1]LSD Least significant difference by Tukey's procedure
[2]Unw Unwrapped; W — Wrapped
[3]CV Coefficient of variation.

Our data lead to the conclusion that polyethylene-wrapped coconuts stored at 12C for 4 weeks were in better condition than those exposed to the other treatments, supporting Bleinroth's finding; that is, that the physicochemical characteristics of coconuts, like almost all tropical fruits, are better preserved at moderate temperatures, 7-12C (Bleinroth 1986).

Our conclusion was based especially on sensory data, since a low coefficient of variation was shown for physicochemical results, except for weight difference. Once more, the importance of sensory analyses to evaluate proper storage conditions for foodstuffs is supported.

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