Value addition of Palmyra palm and studies on the storage life

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Revised: 20 September 2011 / Accepted: 10 October 2011 / Published online: 25 October 2011

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Abstract Palmyra palm (*Borassus flabellifer* L.) belonging to the family Palmae is referred to as tree of life with several uses including food, beverage, fibre, medicinal and timber. Unfortunately, the nutritionally enriched pulp of ripened palm has limited commercial use. Extraction of pulp has been accomplished by using water and heat to ensure maximum pulp recovery. Different recipes were tried for the preparation of two uncommon value added products like palm spread and palm toffee. On the basis of biochemical composition, organoleptic scores, microbial estimation and storage study both under ambient and refrigerated conditions; the suitable recipe was selected with the maximum acceptability. Gradual increase in total soluble solid (TSS), total sugar and reducing sugar while decrease in ascorbic acid, pH, β -carotene and protein content of processed products have been observed irrespective of storage condition. The results obtained from sensory evaluation and microbial status revealed that palm spread and toffee remained acceptable up to 9 months and 8 months, respectively at ambient temperature. The income per rupee investment for these two products was found to be remunerative.

Keywords Palmyra palm · Palm spread and toffee · Organoleptic score · Microbial count

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Introduction

Palmyra palm (*Borassus flabellifer* L.), a multipurpose tree with great utility is believed to be a native of tropical Africa, although it grows extensively in the different parts of India, Sri Lanka and Myanmar and Bangladesh. The genus *Borassus* is one of the most widely distributed member of Palmae, it is extensively grown in tropical dry/wet climate. The three most important economic species are *B. aethiopum* Mart, occurring in Africa, *Borassus flabellifer* L., found in coastal areas of southeast Asia including India, *B. sundaicus* Becc restricted to Indonesia (Davis and Johnson, 1987). In each of these geographic areas *Borassus* palms are of significant value to local populations. It is referred to as tree of life with nearly 800 uses including food, beverage, fibre, medicinal and timber (Arulraj and Augustine 2008). Various by-products like palm sugar and gur (molasses) are also prepared from the juice extracted from tree trunk. The immature soft juicy seed nuts (Tal-Sans) and Neera are very popular in the tropical parts of India as a soft natural drink to protect against hot summer. The soft orange-yellow mesocarp pulp of the ripe fruit is sugary, dense and edible, rich in vitamin A and C. *Borassus* also contains bitter compound called flabelliferins, which are steroidal saponins (Sandhya et al. 2010). Ripe fruit pulp can be processed into soft beverages, jam, toffee, delicious food items and sweets (Das and Das 2003). However, the commercialization of these products is still scanty. As a result, over 60% of the annual fruit yield is being lost due to rot in storage. There exists no standard variety of Palmyra palm in India, although a wide variability is found among the local types. Ali et al. (2010) have examined the nutritional and morphological attributes of ripe palmyra fruit collected from different locations of Cameron and observed significant differences in the physico-chemical properties of various samples. Therefore, an

attempt has been made to prepare value added products like palm spread and palm toffee from the best selected local type on the basis of bio-chemical characteristics and to study on their storage life at ambient and refrigerated condition.

Materials and methods

The ingredients required for the preparation of palm spread and toffee like palmyra fruit, skim milk powder, sugar and small cardamoms were procured from local market. All the chemicals used were purchased from either EMerck, Sigma-Aldrich or Hi-Media sources.

Extraction of pulp from Palmyra palm The well ripened palm was washed, peeled and pulp was extracted manually by rubbing with the traditional Palmyra extractor. Additional water was used (1:1 ratio) to extract the pulp still adhered to the seeds. Heat treatment (70 °C for 10 min) was given to the pulp for maximum pulp recovery as per the method suggested by Roy and Singh (1979) in bael fruit. Then the extract was sieved to remove the fibre and measured the weight of the pulp.

Preparation of palm spread The best recipe (pulp-1 kg; sugar-1 kg; skim milk powder-100 g; small cardamom-4 pcs; citric acid-5 g) for the preparation of palm spread has been standardized to develop the product at desired level of total soluble solid (TSS) and acidity. For the preparation of palm spread, extracted pulp was mixed with other ingredients, heated at low flame with continuous stirring till the TSS reaches 65–68°Brix. Cooked material was removed from heat, filled into broad mouth sterilized bottles, capped, labeled and stored at both room and refrigerated temperature.

Preparation of palm toffee The best recipe (pulp-500 g; sugar-500 g; skim milk powder-200 g; glucose-50 g; maida-50 g; starch-100 g) for the preparation of palm toffee has been standardized as suggested by Diwate et al. (2004) for the preparation of papaya toffee. Palm toffee was prepared by mixing fruit pulp with required ingredients, cooking and stirring the mixture upto 40 min. The end point was determined following drop test in water. The container was removed from heat; the toffee mixture was spread on an aluminium tray that was smeared well with oil/butter, kept overnight in air, cutting into 3 × 1.5 cm size, wrapped with butter paper and stored at room temperature.

Physico-chemical analyses of the products Total soluble solids content of prepared products was measured with the help of digital Hand Refractometer. Acidity was estimated by titrating against standard alkali (N/10 NaOH) solution using phenolphthalein as an indicator and was expressed as

percentage in terms of citric acid (AOAC 1990). Ascorbic acid was determined by the titration method using 2, 6 dichlorophenol indophenol dye solution (Ranganna 2000). Total and reducing sugar was estimated by Fehling's solution (copper reduction) as suggested by Lane and Eynon (1923). The pH was measured by digital pH meter. β -carotene content of spread and toffee was analyzed by using Elico-India made UV–VIS spectrophotometer, model no. SL 159 (Ranganna 2000) after extraction with acetone and in petroleum ether. Protein content was estimated as per the method of Lowry et al. (1951). The above physico-chemical parameters were recorded during ambient (25–37 °C) and refrigerated storage (8–10 °C).

Sensory quality The sensory evaluation was accomplished to determine the overall acceptability on a 5-point hedonic scale by a panel of 10 judges as described by Amerine et al. (1965). The end of storage life of the processed products was determined mostly on the basis of sensory quality (sensory rating 3 and above). *Microbial estimation:* Microbial analyses of the processed products were determined by counting colony forming unit (cfu/g or ml) of yeast and bacteria following the dilution plate technique (10-fold dilution series in cold water). Yeast grown on Yeast extract dextrose medium incubated at 28 °C for 2 days and bacteria grown on nutrient agar medium incubated for 4 days at 34 °C.

Estimation of benefit: cost ratio of standardized products The benefit: cost ratio was calculated after estimation of the cost involved including the operational as well as 10% overhead charges incurred during the preservation of palm spread and toffee.

Statistical analysis The data obtained were subjected to Complete Randomized Design as suggested by Gomez and Gomez (1984). The critical difference (CD) value at 5% level of probability was used for comparing the treatments and to find out the significant difference in between them. Each treatment was replicated for four times.

Results and discussion

Biochemical changes of stored products TSS values of spread increased from 66.90° to 68.30°Brix at the end of ambient storage and 66.90° to 67.50°Brix at the end of refrigerated storage (Table 1) while in toffee, it increased from 68.90° to 69.83°Brix at the end of ambient storage (Table 2). The increase in TSS content indicated that sugar deposited in processed products as polysaccharides, get converted into soluble sugar by various hydrolytic enzymes.

Table 1 Changes in quality parameters of palm spread at room (25–37 °C) and refrigerated storage (8–10 °C) ($n=4$)

Month	TSS (°Brix)		Total sugar (%)		Reducing sugar (%)		Ascorbic acid (mg/100 g)		Acidity (%)		pH		β -Carotene (I.U.)		Protein (%)	
	Room	Low	Room	Low	Room	Low	Room	Low	Room	Low	Room	Low	Room	Low	Room	Low
0	66.9	66.9	28.2	28.2	9.1	9.1	13.4	13.4	0.32	0.32	5.2	5.2	594.2	594.2	2.2	2.2
1	66.9	66.9	30.9	28.2	9.5	9.2	11.8	12.3	0.32	0.32	5.2	5.2	594.2	594.2	2.1	2.2
2	66.9	66.9	32.1	28.5	10.0	9.5	10.5	11.3	0.34	0.32	5.2	5.2	594.2	533.7	1.9	1.9
3	67.0	66.9	34.05	31.7	11.2	10.0	9.1	9.9	0.34	0.32	5.2	5.2	479.9	479.9	1.8	1.7
4	67.1	66.9	36.5	33.5	12.2	10.2	7.9	8.4	0.36	0.29	5.1	5.3	412.8	426.2	1.6	1.7
5	67.2	66.9	38.9	35.9	12.6	10.5	6.7	7.5	0.40	0.29	5.0	5.4	352.3	392.6	1.5	1.5
6	67.4	66.9	43.3	37.7	13.6	10.9	4.6	6.7	0.42	0.28	4.9	5.4	305.2	359.7	1.3	1.5
7	67.5	67.04	46.5	39.5	15.5	10.9	3.2	5.8	0.43	0.27	4.9	5.4	244.8	318.7	1.0	1.5
8	67.6	67.04	48.4	41.6	18.5	11.2	2.0	4.9	0.45	0.25	4.8	5.5	177.6	278.4	0.89	1.2
9	68.3	67.07	50.3	43.7	20.6	11.3	1.1	4.2	0.47	0.24	4.8	5.5	110.3	238.0	0.80	0.9
10	–	67.2	–	45.5	–	11.9	–	3.6	–	0.22	–	5.5	–	191.0	–	0.75
11	–	67.4	–	47.2	–	12.1	–	2.7	–	0.21	–	5.5	–	157.4	–	0.6
12	–	67.5	–	49.3	–	12.7	–	1.7	–	0.20	–	5.6	–	103.6	–	0.5
S.Em ($\pm$)	0.22	0.15	1.34	0.70	0.49	0.18	0.70	0.69	0.02	0.02	0.02	0.02	51.56	61.40	0.038	0.08
CD (0.05)	0.63	0.41	3.81	1.93	1.41	0.49	1.98	1.91	0.06	0.06	0.06	0.06	146.71	170.62	0.109	0.22

Table 2 Changes in quality parameters of palm toffee during room (25–37 °C) storage ($n=4$)

Months	TSS (°Brix)	Total sugar (%)	Reducing sugar (%)	Ascorbic acid (mg/100 g)	Acidity (%)	pH	β -carotene (I.U.)	Protein (%)
0	68.9	39.5	13.0	3.1	0.16	5.7	325.4	2.5
1	68.9	40.1	13.1	2.4	0.16	5.7	291.8	2.4
2	68.9	42.5	13.4	1.9	0.13	5.7	272.6	2.3
3	69.1	44.0	13.9	1.4	0.10	5.7	244.8	2.1
4	69.2	47.2	14.3	0.9	0.08	5.8	217.9	1.9
5	69.3	49.3	15.3	–	–	5.8	199.3	1.8
6	69.5	52.4	16.7	–	–	5.8	189.1	1.6
7	69.7	54.8	18.8	–	–	5.9	164.1	1.3
8	69.8	58.7	22.3	–	–	5.9	130.5	0.89
S.Em ($\pm$)	0.17	1.13	0.35	0.26	0.01	0.07	14.80	0.10
C.D (0.05)	0.48	3.28	1.00	0.82	0.04	0.21	42.62	0.28

Similar finding was reported by Kenghe (2008) while preserving the bael products.

The total sugar as well as reducing sugar content of the processed products also followed the same trend as the case of TSS content. The possible reason behind the increase in total sugar content during storage might be due to the partial hydrolysis of complex carbohydrates. The degree of inversion was found to be more at ambient temperature as compared to refrigerated temperature. Kannan and Thirumaran (2004) also observed the same trend for jamun products.

Ascorbic acid content of palm spread decreased from 13.35 to 1.11 mg/100 g at the end of ambient storage and from 13.35 to 1.66 mg/100 g at the end of refrigerated storage (Table 1). The ascorbic acid content of palm toffee showed similar decreasing trend from 3.06 to 0.87 mg/100 g up to 4 months at ambient storage, after that the value was quite negligible (Table 2). The reduction was due to oxidation of ascorbic acid into dehydro ascorbic acid by oxidase enzyme like ascorbic acid oxidase.

Acidity of palm spread increased from 0.32% to 0.47% at the end of ambient storage while decreased from 0.32% to 0.20% under refrigerated storage (Table 1). It was noted a negligible change up to 4 months at ambient temperature and up to 6 months under refrigeration. However, acidity of toffee declined from 0.16% to 0.08% at ambient temperature up to 4 months (Table 2). The reason behind the increase in acid content and decrease in ascorbic acid content of palm spread during storage might be due to ascorbic acid degradation or hydrolysis of pectin molecules (Cruess, 1958). As the reactions for the above changes were temperature-dependant, the rate of change was variable with (Mir and Nath, 1993). Change in pH is directly related to the acid level. Thus the increase/decrease in acid content as well as the pH level of the processed products showed an opposite trend during entire period of study (Table 1 and 2).

β -carotene content of palm spread decreased from 594.20 I.U. to 110.31 I.U. at the end of ambient storage and from 594.20 I.U. to 103.64 I.U. at the end of refrigerated condition (Table 1). β -carotene content of palm toffee also followed the similar decreasing trend at the end of ambient storage. This was probably because of moisture loss or due to concentration effect of products during storage.

Protein content of palm spread decreased with the increase in storage duration irrespective of storage condition. The protein content of toffee also followed similar decreasing trend at the end of ambient storage (Table 2).

Table 3 Overall acceptability of score of palm spread and palm toffee during room (25–37 °C) and refrigerated storage (8–10 °C) ($n=10$)

Months	Palm spread		Palm toffee
	Room	Low	Room
0	4.9	4.9	4.8
1	4.8	4.8	4.7
2	4.8	4.8	4.6
3	4.6	4.8	4.5
4	4.4	4.7	4.4
5	4.3	4.5	4.1
6	3.9	4.4	3.9
7	3.8	4.3	3.7
8	3.4	4.1	3.3
9	3.1	3.9	–
10	–	3.7	–
11	–	3.4	–
12	–	3.1	–
S. Em ($\pm$)	0.04	0.33	0.04
CD(0.05)	0.12	0.11	0.11

5 = highly acceptable; 4 = fairly acceptable; 3 = acceptable; 2 = least acceptable; 1 = unacceptable

Sensory evaluation Palm spread remained acceptable at room temperature and under refrigeration up to 9 and 12 months, respectively (Table 3). Overall acceptability value of palm spread was found higher in refrigerated products than their ambient stored counterpart. The overall acceptability score of 3.32 for palm toffee was recorded at the end of ambient storage.

Microbial status of processed products during storage The number of yeast and bacterial colonies in palm spread increased from 0.0 to 2.17 and 0.33 to 7.50 $\text{cfu} \times 10^3/\text{g}$, respectively at the end of ambient storage (Fig. 1) while from 0.0 to 4.67 and 0.33 to 10 $\text{cfu} \times 10^3/\text{g}$, yeast and bacterial colonies, respectively at the end of refrigerated storage (Fig. 1). The bacterial population was higher than the yeast as the higher pH level is more favourable for bacterial growth. Bhagirathi et al. (1993) reported the safe

limit of a reconstituted vegetable gravy mix with 8.9×10^3 , 2.5×10^3 , 6.3×10^3 and 2.4×10^3 in order of coliforms, faecal coliforms, yeast and mold, respectively. The average yeast and bacterial count of palm toffee increased linearly from 0.17 to 4.50 cfu/g and from 0.34 to 7.50 cfu/g , respectively at the end of ambient storage (Fig. 2). Similar microbiological evaluation of processed products of minor fruits stored under both ambient and refrigerated conditions was earlier investigated by Monteiro et al. (2005). However, both spread and toffee under the present study showed acceptable limit (ICMSF 1997) with respect to the yeast and bacterial count up to their respective storage period. The presence of microbes up to the above limit is negligible and safe for consumption within the mentioned period at both temperature regimes.

Economic analysis of processed products For the preparation of 1 kg spread, total cost of production was Rs.

Fig. 1 Growth of yeast and bacteria in palm spread during room (25–37 °C) and refrigerated (8–10 °C) temperatures

Fig. 2 Growth of yeast and bacteria in palm toffee during storage at ambient (25–37 °C) temperatures

49.89/-, gross income Rs. 125/- that means net income was Rs. 75.11/-. similarly for 1 kg toffee preparation total cost of production was Rs. 65.04, gross income Rs. 140/-and net income was Rs. 74.96/-. Thus the economic analysis revealed that the income per rupee investment of palm spread was approximately Rs.1.50/- whereas it was only Rs. 1.15/- for palm toffee. Thus, it could be assumed that spread preparation was more profitable than toffee.

Conclusion

The fruit of the Palmyra palm can be classified amongst semi-arid zone resources with important water content and a good sources of sugars, vitamin C, provitamin A, minerals and fibers. Unfortunately a considerable portion is lost due to some factors like shorter shelf life, difficulty in extraction of pulp, presence of bitter principle in some fruits etc. However there is a great possibility of a range of natural products of good nutritional value. The ripe Palmyra palm pulp may be utilized for the preparation of palm spread and toffee which

are not only nutritionally rich and commercially viable but also extremely palatable organoleptically. The storage study indicated that palm spread can easily be stored up to 9 months and 12 months respectively at ambient and refrigerated temperature and palm toffee remains acceptable upto 9 months at room temperature. Within this much storage durations, the products remain safe from microbial point of view.

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