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Formulation and Senso-chemical Evaluation of Palmyrah Palm (*Borassus flabellifer* L.) Based Value-added Products

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Abstract

Palmyrah palm (*Borassus flabellifer* L.), a member of the Arecaceae family, is a tree with a variety of uses, including food, beverage, fiber, medicinal, and timber. Unfortunately, commercial applications for the nutritionally rich pulp of ripened palm are limited. The current study was conducted to develop a technology for the preparation of a value-added products from palm and to evaluate them in terms of chemical composition, sensory properties, and microbial quality during refrigerated storage. This study resulted in the creation of a palm toffee product with optimal levels of ingredients such as palm pulp, sugar, fat, cream, glucose, and skimmed milk powder. Three palm-based toffees were selected based on the analysis and they were compared with a control sample. The results of the physicochemical analysis revealed that fresh toffees had an average moisture content of 9.79%, ash content of 3.5-6.15%, fat content of 8.20-29.70g, titrable acidity of 0.27-0.49%, total sugars of 78.26-79.66%, reducing sugar of 46.12-49.90%, and ascorbic acid content of 5.330-3.553 mg/100g, *ß*–Carotene of 20-133 mg/100g. Na, Mg, K, Ca, Zn, and Fe were identified as abundant minerals in prepared toffees. On a 9-point hedonic scale, the mean color, taste, flavor, texture and overall acceptability score for selected three toffees were 6.9-7.8, 6.6-8.4, 7.0-8.1, 7.1-8.0, and 7.2-8.4, respectively. According to the storage study, reducing sugars and total sugars increased with the increase in storage period, while moisture content, ascorbic acid, and total acidity decreased. The toffee is a contribution to the value-added food product development from a traditional fruit in Bangladesh.

Keywords: palmyrah palm, palm toffee, calorific value, sensory assessment, microbial studies

Highlights:

- Value added food products from indigenous fruit was prepared
- Nutritional quality of the processed products was assessed
- Produts were preserved at room temperature and storage potential was evaluated

1. Introduction

Palmyrah palm (*Borassus flabellifer* L.) is a dioecious plant found in Bangladesh, India, Sri Lanka, Malaysia, and the Philippines (Morton, 1988). The fruit pulp of Borassus flabellifer has been used in traditional dishes, and the sap has been used as a diabetic sweetener (Gummadi et al., 2016). Palmyrah pulp is nutritionally important and there is a scope of value addition as it is an under explored fruit (Rao et al., 2021). The sugary, dense, and edible orange-yellow mesocarp pulp of ripe fruit is rich in vitamins and minerals. Bitter flabelliferrins, which are steroidal saponins, are also found in Borassus (Sandhya and Kalaiselvam, 2020). Soft drinks, jam, toffee, delectable foods, and sweets can all be made from fruit pulp (Jaya and Das, 2003). The processing and commercialization of these products, however, are still in their early stages.

Palmyrah palm, also known as “taal” in Bangladesh. Additionally, it is known as the "tree of life," and it has a wide range of applications, including food, beverage, fiber, medicine, and timber (Peter, 2008). It is easily cultivated and can be found growing in the wild, agricultural fields, and on rare occasions, wastelands. For centuries, the palmyrah palm has been used traditionally to produce fresh juice (sweet toddy), fermented drinks (toddy, wine, and arak), syrup (honey), brown sugar (jaggery), and refined sugar (Somasekharan Nair Rajam et al., 2020). However, processed food made from palm pulp is not commercially available.

Nilugin and Mahendran (2010) researched to create a ready-to-serve beverage from palmyrah pulp at various concentrations. Golly et al. (2017) on the other hand investigated the alternative uses of palmyrah palm. Vengaiah et al. (2013) conducted a study on jaggery derived from the palmyrah palm. In Bangladesh, there has been limited research aiming at value-added food products made from palmyrah pulp, although there are huge opportunities to work in this direction. Due to the lack of a proper preservation/storage system, a large number of fruits is wasted. Concentrate or puree could be a potential solution to preserve the pulp during the harvesting season and to prepare food products during the off-season.

Toffees are a popular and widely accepted confectionery product that is enjoyed as a quick energy snack by people of all ages. Toffees can be used to promote the consumption and utilization of such fruits, which have a low market demand and a relatively short shelf life. The goals of this study were to preserve palmyrah pulp as a concentrate, to standardize the procedure for preparation of good quality toffee from palmyrah pulp, sensory evaluation and proximate analysis of palm toffee, and to monitor the microbial load in toffee over a three-month storage period.

2. Method

The research was carried out at the Department of Agro-Processing, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU). The mineral content of the sample was determined at the Soil Science Division, Bangladesh Agricultural Research Institute, Gazipur. Evenly ripened palmyrah pulp, sugar, fat, skim milk powder (SMP), butter, cream, flour, and glucose were all purchased from the local market.

2.1 Extraction of Pulp

Fruits were washed thoroughly with tap water to remove any surface dirt and/or macroflora. Then fruit was peeled, and the pulp was manually extracted following the conventional method. Water was used to efficiently extract the pulp. The extract was then sieved to remove the fibers.

2.2 Toffee Formulation

Seven different combinations of pulp and sugar, as well as other additives for standardization of toffee recipe, were investigated as shown in Table 1. The major ingredients of the toffee were palm and sugar and some other additives include glucose, cream, butter, and skim milk powder (SMP).

Table 1. Treatments of toffee with different formulations

Treatment	Palmyrah palm pulp + Sugar	Glucose(g)	SMP (g)	Milk cream (g)	Butter(g)
T0	0 g + 200 g	30	40	10	30
T1	100 g + 100 g (1:1)	30	40	10	30
T2	100 g + 150 g (1:1.5)	30	40	10	30
T3	100 g + 175 g (1:1.75)	30	40	10	30
T4	100 g + 200 g (1:2)	30	40	10	30
*T5	100 g + 200 g (1:2)	30	40	10	30
T6	50 g palmyrah pulp +50 g mango pulp) + 100 g Sugar (1:2)	30	40	10	30

*****This product contains 10 g flour.

2.3 Preparation of Toffee

The process of making toffee requires driving off moisture by the boiling of ingredients until the mix is stiff enough to be pulled into a shape that holds and has a glossy surface. After heating, the resulting mixture needs to pour into a shallow tray and be allowed to cool to form a slab. The brown color and smoky taste of the toffee indicate the caramelization of the sugars.

The homogenized pulps were taken into a stainless-steel container and mixed well. Other ingredients such as sugar, butter, SMP, flour, milk cream as per the treatment were mixed into a pulp and placed in an electric heater. The mixture was heated till the TSS of content reached 80 °Brix. Salt was added, mixed, and heated till the TSS of content reached 82-83 °Brix.

The hot mass was transferred in to a stainless-steel plate which was already smeared with oil and the product was spread into a thin sheet of 1 to 2 cm thickness and allowed to cool and set for 2-3 h, and then the solid sheet was cut into cubes of 1.5 to 2.5 cm (Parpia, 1967) with a stainless-steel knife. The detailed flow sheet for the preparation of toffee is shown in Figure 1.

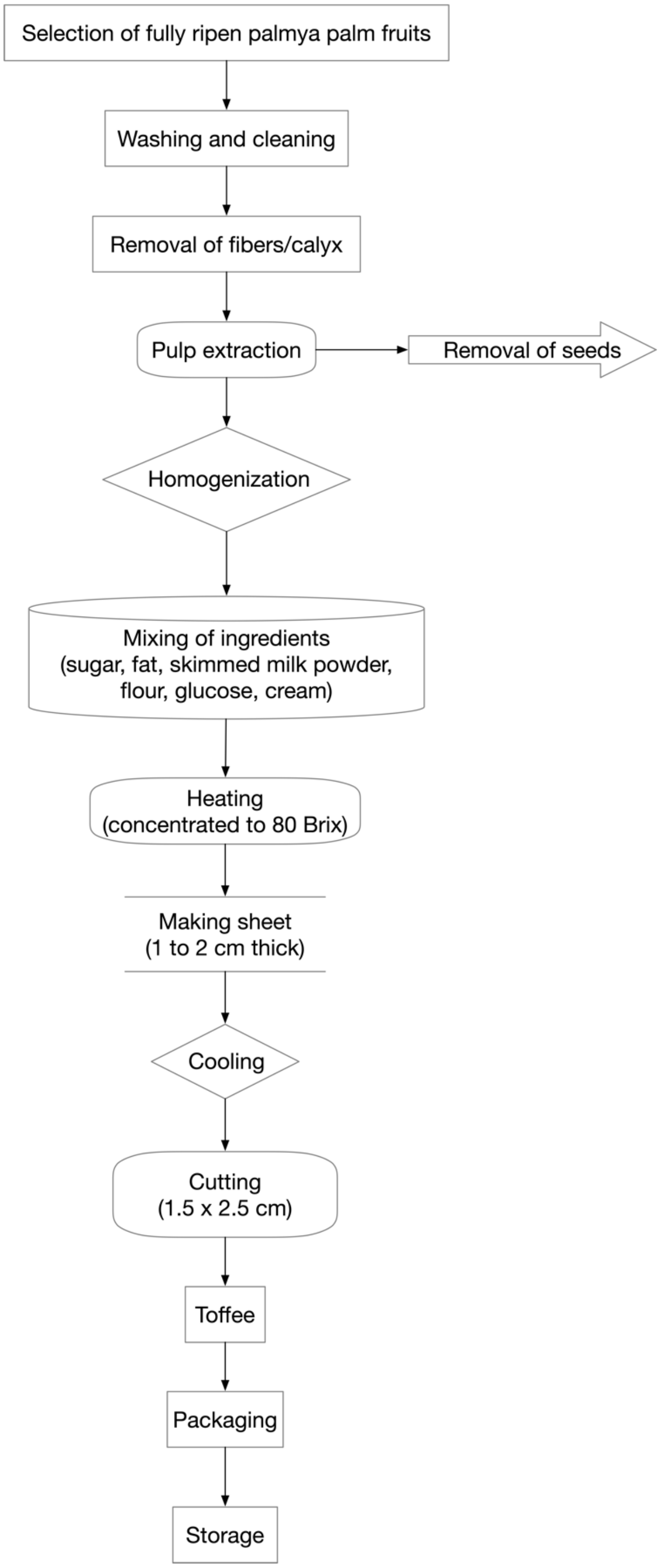

Figure 1. Flowsheet for preparation of palmyrah palm toffee

2.4 Acceptability of the Product

The descriptive sensory evaluation was carried out according to "generic sensory descriptive analysis" shown by Cao *et al.* (2019) with little modification. The total procedure consisted of three steps, namely 1) panel selection, 2) sample preparation, and 3) evaluation. The panel consisted of 10 panelists included 5 women (age 25-50 years) who had more than two years of experience in sensory evaluation. Before running the panel test, the panelists were gone through two training sessions. The panelists were agreed to use a hedonic rating for color, flavor, taste, texture, and overall acceptability of the products, from 9 to 1 (9 = Like extremely, 8 = Like very much, 7 = Like moderately, 6 = Like slightly, 5 = Neither like nor a dislike, 4 = Dislike slightly, 3 = Dislike moderately, 2 = Dislike very much and 1 = Dislike extremely). The samples were evaluated in triplicate according to a complete randomized block design. The sensory evaluation was performed in the sensory evaluation room in the department of Agro-Processing, BSMRAU, by maintaining international standards (Eggert and Zook, 1986).

2.5 Physicochemical Analysis of the Product

The prepared toffees were analyzed for moisture content, ash content and fat content, total sugars and reducing sugars, titrable acidity, and ascorbic acid contents, minerals content and calorific value (Sharmin *et al.*, 2021). All analyses were carried out maintaining Standard Official Methods of Analysis (Feldsine *et al.*, 2002).

2.6 Microbiological Analysis

The plate count was used for estimating the number of viable microorganisms in a given sample that is capable of growing in a specified medium. Microbial plate count was carried out according to the method shown by Cao *et al.* (2020b). The number of visible colonies in the medium is equal to the number of micro-organisms which is always expressed as the number of viable microorganisms per milliliter of a single strength sample. When the number exceeds 300 per ml, the sample was serially diluted.

2.7 Statistical Analysis

Analysis of variance (ANOVA) tests was applied to identify differences between the different samples. Duncan's multiple range test (DMRT) at $p<0.05$ was applied for multiple comparisons of the mean values. All analysis was carried out using R software (version 3.4.4, R Development Core Team, 2018).

3. Results and Discussion

3.1 Sensory Evaluation of the Prepared Toffees

The sensory evaluation values for color, flavor, texture, taste, overall acceptability have been presented in Table 2. The color preference of the control sample was significantly different from those of the treated one. The sample T_6 was better than others in terms of color preference and it secured the highest score (7.8). Results also revealed that sample T_4 and T_6 were the most acceptable than other samples. The results also showed that samples T_4 and T6 were equally acceptable in terms of flavor preference. The textural quality of the different toffees was significantly different. The highest score was 8 for T_6, which can be termed as "Like Very Much", and the lowest score was 4.9 for T_5 which represents "Dislike". No significant differences between T_1, T_2 and T_3 were found for the taste values. Similar to other parameters, T_6 had the highest score in taste of 8.4. The overall acceptability varied significantly among the treatments. T_6 was highly accepted by the sensory panelists with significantly different among all the sample followed by T_3 and T_4. The results clearly indicate that three toffees (T_3, T_4, and T_6) get preferences above control one. Therefore, these three toffees were selected for further analyses and compared with control one (T_0).

Table 2. Sensory evaluation of prepared palm toffees

Sample	Color	Taste	Flavor	Texture	Overall Acceptability
T_0	6.6^{bc}	7.5^{b}	6.5^{bc}	6.9^{b}	6.6^{c}
T_1	5.4^{d}	6.3^{c}	5^{d}	5.5^{c}	5.4^{d}
T_2	5.8^{cd}	6.6^{c}	5.7^{cd}	5.3^{c}	5.4^{d}
T_3	6.9^{b}	6.6^{c}	7^{b}	7.1^{b}	7.2^{bc}
T_4	7^{ab}	7.4^{b}	7.3^{ab}	7.2^{ab}	7.3^{b}
T_5	5.4^{d}	5.5^{d}	5.2^{d}	4.9^{c}	5.6^{d}
T_6	7.8^{a}	8.4^{a}	8.1^{a}	8^{a}	8.4^{a}
p-value	0.01	0.01	0.01	0.01	0.01

Note: Different letters in the same column represent a significant difference.

3.2 Changes in the Physicochemical Composition of Toffees during Storage

3.2.1 Moisture Content

The results moisture content, ash content, and dry matter content has been shown in Table 3. From Table 3, it can be seen that the moisture content decreased with the increase in storage time. The moisture content of toffees decreased from 10.13 to 9.34% for T0, 10.34 to 9.21% for T3, 9.31 to 8.46% for T4, and 9.37 to 8.66 % for T6 during the storage period of 0 to 60 days. The highest decrease in moisture content was found to be 1.13% for T3 and the lowest decrease in moisture content was found to be 0.71% for T6 (Table 3). All Toffees were constituted of near about 10% of water. The higher amount of protein and starch content might be responsible for the higher moisture retention. The decrease in moisture content during storage was reported 0.43% in mango fruit toffees (Kerawala and Siddappa, 1963), 1.21% for banana toffee (Avelar et al., 2014), 0.69% for sapota toffee (Nalage et al., 2014), 0.75% for guava toffee (Chavan et al., 2015), 1.04% for fig toffee (Kohinkar et al., 2014), 3.23% for tamarind and mango blended toffee (Kiranmi et al., 2018), 2.81% for aonla toffee (Norzom et al., 2018).

Table 3. Moisture, ash, and dry matter content of palmyrah palm toffee

Attribute	Sample	% content at different storage period		
		0 day	30 days	60 days
Moisture	T_0	10.13	9.38	9.34
	T_3	10.34	9.35	9.21
	T_4	9.37	8.65	8.46
	T_6	9.37	8.84	8.66
Ash	T_0	3.5	3.52	3.55
	T_3	5.17	5.24	5.29
	T_4	8.53	8.55	8.59
	T_6	6.12	6.18	6.19
Dry matter	T_0	86.37	87.1	87.2
	T_3	84.51	85.41	85.5
	T_4	82.16	82.8	82.95
	T_6	84.51	84.66	85.15

3.2.2 Ash Content

The results showed that the percentage of ash increased with the increase in storage time (Table 3). Ash in the different samples was found as (3.5 to 3.55%), (5.17 to 5.29%), (8.53 to 8.59%) and (6.12 to 6.19 %) for T0, T3, T4, and T6, respectively between 0 and 60 days. The results also show that the ash content slightly increased with storage and with the decrease in moisture content. Since SMP contains around 8% ash content, therefore, toffees were higher in ash content. A similar increasing trend in ash percentage has been found in different Mango toffees (Vijaya Bhaskar Reddy, 2004).

3.2.3 Dry Matter Content

The results showed that the dry matter content increased with the increase in storage time (Table 3). Dry matter content in the different samples was found to be (86.37-87.2%), (84.49-85.5%), (82.16-82.95%), and (84.51 - 85.15 %) for T0, T3, T4, and T6, respectively between 0 and 60 days.

3.2.4 Mineral Contents

Figure 2, and 3 presents the mineral contents (Na, k, Ca, Mg) and (Fe and Zn) of toffees, respectively. Results show that the calcium content in toffees is higher than other minerals in all treatments. Most of the mineral was higher in T4 contains Na (0.189%), K (0.289%), Ca (0.251%), Mg (0.347%) which were made with both palm and sugar with 1:2 ratio. Na and Ca content were 0.176% and 0.234% in T3 which were much higher compared to other samples. Mg content was higher in T4 and T6 which are respectively 0.347% and 0.196%. These values are in accordance with the reference value Ca 0.22 %, Mg 0.13%, K 0.11% Na 0.15% in Palmyrah palm (Atchley, 1984).

From Figure 3, it can be found that Fe content was higher in T6 (23.88 ppm) and lower in T0 (18.53 ppm). On the other hand, Zn content is higher in T6 (9.42 ppm). Lower Zn was found in T0 (18.53 ppm). All of the values are mostly similar with reference value Fe 10.35 ppm Zn 5.38 ppm in palmyrah pulp (Atchley, 1984). The increase in Fe and Zn content might be due to the addition of SMP, cream, and butter.

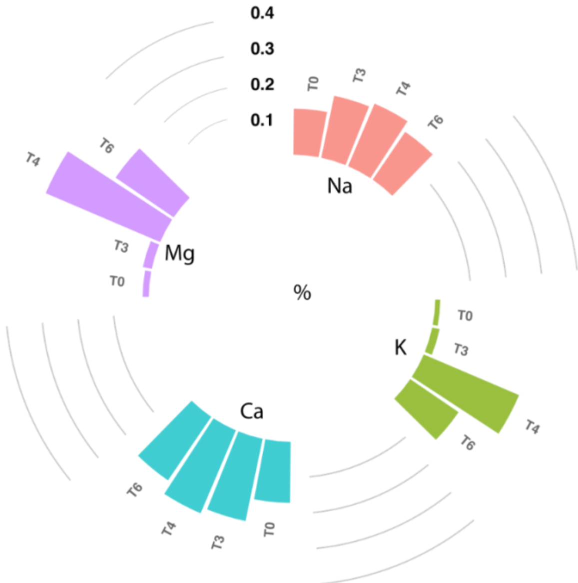

Figure 2. Mineral content (Na, k, Ca, Mg) of the different Toffees

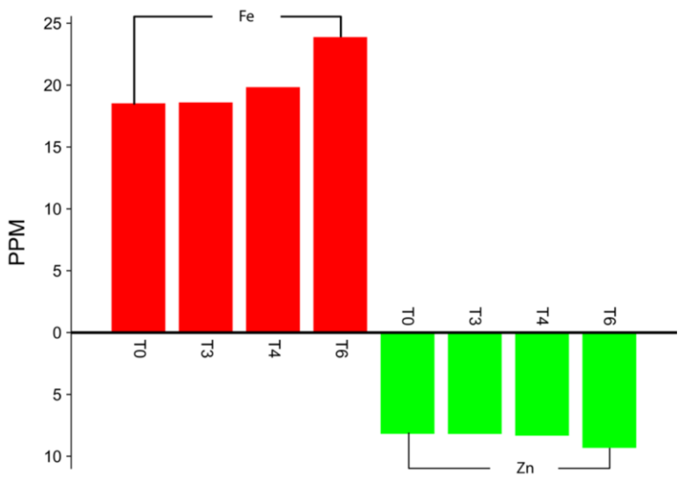

Figure 3. Mineral content (Fe and Zn) of the different toffees

3.2.5 Total Sugar

The results of changing total sugar (%) during storage concerning treatment T0, T3, T4, and T6 has presented in Table 4. The mean values of total sugar (%) of four toffees increased from 78.87 to 79.83% at refrigerated storage conditions. There was a substantial increase in the total sugar of toffees in different treatments. The increase in total sugar of toffees might be due to a decrease in moisture content, conversion of polysaccharides to sugars, and oxidation during the storage period.

At refrigerated temperature, treatment T6 showed a maximum increase in total sugar from 78.63 to 80.23%, followed by 78.61 to 79.53% for treatment T3. There was an increase in total sugar percentage during the storage period of toffees. Similar results in increase in the total sugar content during the storage period were reported in sapota toffee from 82.25 to 82.55 % (Arsul, 1999), papaya toffee from 83.75 to 84.00 % (Attri et al., 2014), guava toffee from 82.25 to 82.56 % (Chavan et al., 2015), banana toffee from 82.25 to 82.55 % (Avelar et al., 2014), fig toffee from 83.13 to 83.92 % (Kohinkar et al., 2014) aonla toffee from 84.44 to 85.46 % (Nalage et al., 2014).

Table 4. Chemical properties of toffee at different days of storage

Attributes	Sample	% content at different storage period		
		0 day	30 days	60 days
Total sugar	T0	78.26	78.56	78.86
	T3	78.63	78.92	79.53
	T4	79.66	79.98	80.12
	T6	78.63	79.85	80.23
Reducing sugar	T0	46.12	47.8	48.26
	T3	48.54	49.11	50.71
	T4	49.02	50.2	51.23
	T6	49.9	50.81	51.98
Titrable acidity (%)	T0	0.36	0.35	0.27
	T3	0.42	0.36	0.29
	T4	0.46	0.41	0.36
	T6	0.49	0.47	0.4
Ascorbic acid (mg/100g)	T0	5.33	4.13	2.84
	T3	5.46	3.92	2.61
	T4	5.29	3.9	2.57
	T6	4.91	3.47	2.15

3.2.6 Reducing Sugars

The results of changing in reducing sugar content of toffee during storage at refrigerated conditions with respect to treatment T1, T2, T3, and T4 has been presented in Table 4. There was a substantial increase in the reducing sugar content of toffees during storage. The maximum increase was 48.83 to 51.98% for treatment T6, followed by treatment T4 (48.35 to 51.23%), treatment T3 (46.91 to 50.71%), and treatment T0 (45.05 to 48.26%). The increase in reducing sugars content in palmyrah palm toffee is due to loss in moisture in the storage conditions. An increase in reducing sugars might be due to the hydrolysis of sugar. This might have resulted in the degradation of disaccharides to monosaccharides. The findings in the present investigation are in accordance with those of Kohinkar et al. (2014) in the case of fig toffees that showed a gradual increase in reducing sugars from 38.69 to 39.34 percent over 60 days of storage. The increase in reducing sugars content from 46.40 to 46.77 percent during 90 days of storage was reported in guava toffee by Kohinkar et al. (2014).

3.2.7 Titrable Acidity

The results on changes in percent of acidity of palm toffee during storage for treatments T0, T3, T4, and T6 has presented in Table 4. There was a decreasing trend in the percent acidity of toffee at storage conditions. At refrigerated conditions the acidity percent decreased merely in treatment T6, 0.49 to 0.40 percent followed by treatment T4, 0.46 to 0.36 percent, treatment T3, 0.42 to 0.29, and T0, 0.36 to 0.27 percent. The rate of decrease in percent acidity was faster in the refrigerated storage. The decrease in acidity content was reported in fig toffee from 0.246 to 0.226 percent (Kohinkar et al., 2014), tamarind-mango blended toffee from 2.60 to 2.02 percent (Kerawala and Siddappa, 1963), banana toffee from 0.191 to 0.172 percent (Avelar et al., 2014), papaya toffee from 0.34 to 0.32 percent (Attri et al., 2014), aonla and ginger mixed toffee from 0.420 to 0.400 percent (Nalage et al., 2014) and guava and strawberry mixed toffee from 0.30 to 0.26 (Chavan et al., 2015).

3.2.8 Ascorbic Acid Content

The data for the changes in ascorbic acid has given in Table 4. Substantial differences were observed among the treatments during storage. Among the treatments, T3 had the highest value (5.330 mg) and T6 had the lowest value (4.910 mg). A decreasing trend was observed from day zero (5.460 mg) to day 60 (2.150 mg). The decrease in ascorbic acid content in T0, T3, T4, T6 was 2.38, 3.11, 9.52, and 10.07 percent respectively.

The decrease was variable as ascorbic acid was sensitive to heat and light. The better retention of ascorbic acid might be due to the amount of SMP which helped in the retention of ascorbic acid. Dhumal et al. (1996) reported that the incorporation of skim milk powder caused an increase in the ascorbic acid content of the custard apple toffees.

3.2.9 β-carotene Content

β-carotene, fat, and calory content contents of toffee have been presented in Table 5. Results show that the β-carotene content was much higher in T3, lower carotene content was found in T0 followed by T3 (143.26mg/100g) and T4 (20.52m/100g). It was noticeable that *β*-Carotene content was lower where palm was not used and the source of *β*-carotene in T0 was butter (Çakmakçi et al. 2018) that was used to prepare toffees as a principal ingredient as palm contains a higher amount of *β*-carotene content (53.5mg/100g). The research value is as per reference value (Atchley, 1984).

3.2.10 Fat Content

It can be found from Table 5 that the fat content was much higher in T0 which was prepared with milk and butter, lower fat content was found in T3 (8.20g) followed by T4 (12.26g) and T6 (13.52g). It was noticeable that fat content was lower where palm was used as a principal ingredient as palm contain a lower amount of fat content (0.8 g). The research value was in accordance with the reference value (Atchley, 1984).

Table 5. Beta carotene, fat, and calory content of toffee

Sample	*β*-carotene (mg/100g)	Fat content (g)	Calory (k.cal/100g)
T0	20.23	29.67	422.93
T3	143.7	8.2	545.11
T4	91.6	12.26	481.54
T6	132.2	13.52	489.52

3.2.11 Calorific Value

From Table 5, it is observable that all the toffees had higher energy values. Among them, the highest calorific value was found in T3 and it was 545.11 k.cal/100g. Followed by T6 (489.52 k.cal/100g), T4 (481.54 k.cal/100g) and T0 (457.93 k.cal/100g). A higher amount of calorific value was found in the toffee which was prepared by Palmyrah palm with a 1:1 ratio, followed by one made with Palmyrah palm (1:1.75 ratios). It indicates that toffee with a higher pulp ratio contains higher calories.

It was reported that banana toffees had a calorific value of 413 k.cal/100g (Avelar et al., 2014), papaya toffee contains 252 to 325 k.cal/100g (Attri et al., 2014), aonla and ginger mixed toffee contain 325 to 421 k.cal/100g (Nalage et al., 2014). The results obtained in the present investigation are in agreement with the previous study.

3.2.12 Effect of Storage on Microbial Growth

At the initial period there was no growth observed but after one month storage period treatment T3 and T4 showed standard plate counts as 4 x 104, 3 x 104 (CFU/g) respectively. In T0 and T6 bacterial growth were as 1x 104 CFU/g and 2 x 104 CFU/g respectively. The microbial growth observed in treatment T3 and T4 was due to the content of fruits, much lower sugar content, and higher moisture content in ambient temperature. After 2 months storage period treatment T0, T3, T4, T6, and concentrated pulp showed standard plate count for refrigerated temperature were 14 x 104, 15 x 104, 16 x 104, 8 x 104, and 17 x 104 CFU/g respectively.

The results indicated that the standard plate counts were directly proportional to the moisture content in toffee. The acceptability of the product by the panel members after 2 months of storage confirms that the minimum changes which might have occurred due to microbes were within safe limits (<5 x 105 CFU/g) for human consumption (azi et al., 2018). At present, there are no standard limits of a safe level of microbes to compare with prepared palmyrah palm toffees.

Aruna et al. (2000) reported that the papaya toffees stored at room temperature showed 3 x 102 CFU/g bacterial growth. The standard plate count of fig toffee was reported from 11 x 103 to 23 x 103 CFU/g (Khandekar et al., 2005). In the case of tamarind toffee, the standard plate count was reported from 35 x 103 to 56 x 103 CFU/g (Kiranmai et al., 2018). In the case of aonla and ginger toffee the standard plate count was reported from 9 x 105 to 5 x 105 CFU/g (Nalage et al., 2014) and in the case of guava and strawberry mixed toffee the standard plate count reported from 7 x 105 to 5 x 105 CFU/g (Chavan et al., 2015).

4. Conclusion

Value-added food product development from indigenous fruits provides a means for ensuring nutrient supply round the year. The study presented the development of fruit toffee from ripe palmyrah palm pulp. The formulation and preparation of palmyrah palm toffee has been described in details. The toffees prepared were evaluated for their sensory as well as nutritional parameters. Based upon results, the main experiment was planned and conducted using optimum levels of ingredients per kg palmyrah pulp. The results revealed that toffees had an average moisture content of 9.79%, ash content of 3.5-6.15%, fat content of 8.20-29.70 g, titrable acidity of 0.27-0.49%, total sugars of 78.26-79.66%, reducing sugar of 46.12-49.90%, and ascorbic acid content of 5.330-3.553 mg/100g, ß–Carotene of 20-133 mg/100g. Toffee containing ingredient of raw pulp and sugar (1:2), glucose 30 gm, skimmed milk powder 40 gm, cream 10 gm, and Butter 30 gm outperformed over other combinations in terms of organoleptic properties and storage period. The toffee prepared in this study is a contribution to the value-added food product development from a traditional fruit in Bangladesh.

Author contributions

Conceptualization and experiment design, Md. Ahiduzzaman (M.A.); conducting experiment, Md. Mehedi Hasan (M.M.H.); data analysis, M.A., M.M.H and Md. Nahidul Islam (M.N.I.); draft preparation, M.M.H. and M.N.I.; review and editing, M.A. and M.N.I.; supervision, M.A., Md. Amdadul Haque (M.A.H.), and Md. Mofazzal Hossain (M.M.H.); project administration, M.A.; funding acquisition, M.A. All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

Authors declare no conflicts of interest.

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