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Effect of Pineapple Pomace on the Development of Peanut Bar and their Physicochemical and Nutritional Properties with Consumer Acceptance

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ABSTRACT

The study was conducted to maximally utilize the pineapple pomace for the formulation of peanut bar using jaggery (cane sugar). The study was laid out in complete randomized design (CRD) with 3 replications. Developed pineapple pomace peanut bars were stored in PET boxes for 2 months for observation. The market sample was collected from the local market of Gazipur city to compare with our nut bar. Then the collected sample was stored and analyzed for its color, texture, sensory attributes, nutritional and physicochemical properties. Results revealed that the developed nut bar is a rich source of crude fiber (6.48±0.48 %), crude protein (13.06±0.05 %), vitamin-C (23.28±0.21 mg/100 g) and ß-carotene (16.32±0.03 µg/100 g) than market sample. Nutritional and physicochemical properties of the developed nut bar and the market sample (Badam topi) gradually decreased with the increase of storage periods. An increasing trend of water activity (a_w) is found in the developed and market samples with increasing storage periods. The maximum hardness was found in the market sample as compared to the developed nut bar. A statistically insignificant sensory score was obtained for all the formulated and market samples. The storage studies confirmed that the marketability of the developed nut bar T_3 could be extended 2 months more without any excessive-quality deterioration. These findings may be applied for the manufacturing of pineapple pomace peanut bars with health benefits. These peanut bars can be practically used for the school nutrition programs to uplift the nutritional status of the school-going children.

Keywords: Crude fiber, crude protein, vitamin-C, color, texture, sensory attributes.
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INTRODUCTION

Pineapple is a major fruit in Bangladesh and is cultivated all over the country. It is mainly cultivated in the Modhupur of Tangail district, Sreemongal of Moulvibazar district, Rangamati, Khagrachari and Bandarban of Chattagram Hill Areas of Bangladesh. At present, it is cultivated 15.05 thousand hectares of land with a production of 218.05 thousand metric tons (BBS, 2020). The fruit contains sufficient amount of vitamins A, B and C. Every year the fruit goes to postharvest loss due to a lack of proper processing and preservation techniques.

Food is an elementary requirement of human and may contribute in playing a vital role in making Bangladesh self-sufficient. Bangladesh has achieved a lot in food production but food security and safe food is still a major problem. Globally, various processed products are made from pineapple fruits viz. jam, jelly, leather, cheese, nectar, squash, dried powder, toffee, ice-cream, candy, syrup, juice, concentrated puree, canned fruit segments, ready to serve drinks (Jain and Asati, 2004) but after production of pineapple processed items ther e is a

massive waste generation called pineapple pomace. The drying, storage and shipment of this waste is cost-effective and hence efficient, inexpensive and eco-friendly utilization is becoming more and more necessary. Further, the utilization of the pomace may contribute to minimizing the substantial amount of postharvest losses of pineapple and many health-beneficial effects. Pineapple pomace is a rich source of dietary fiber. Many literature suggest that the dietary fiber can contribute to reducing body weight and different cardiovascular diseases (heart attack, stroke, coronary heart disease, liver injury, cancer, etc.). Therefore, the utilization of this pomace is very crucial for the country. Hence, the present study was undertaken to develop pineapple pomace peanut bar by utilizing pineapple pomace for maximizing the use of pineapple fruits.

MATERIALS AND METHODS

Selection of pineapple

Physiologically matured pineapple fruits (*Emblica officinalis* Gaertn) were procured from the local market of the Gazipur city, Bangladesh and shifted to Postharvest Technology Division, Bangladesh Agricultural Research Institute (BARI), Gazipur, Bangladesh. Then the fruits were sorted out based on pest and disease infestation.

Processing and manufacturing of pineapple pomace peanut bar

Collected fresh fruits were thoroughly washed with fresh tap water. Peels were removed and pulp was collected to extract the juice for the preparation of pineapple jelly and marmalade. The core was used for the preparation of candy (although not the objective of the study). After processing into jelly, marmalade and candy, the fresh pomace (as wastage) was incorporated for the processing (Figure 1) and formulation (Table 1) of pineapple pomace pea-nut bar (Figure 2). The formulated pea-nut bar was packed into high-density polyethylene (HDPE) pouches and finally placed into PET boxes for further proximate, nutritional and storage studies.

Proximate and nutritional composition studies

The proximate and nutritional analysis of crude protein, crude fat, moisture, total sugar, reducing sugar, vitamin-C and ß–carotene content was determined according to the method described by Ranganna (1995).

Color measurement

Pineapple pomace- peanut bar color was assessed with a Chroma Meter (Model CR-400, Minolta Corp. Japan). International Commission on Illumination (CIE) lightness (L*), Chroma (C*) and hue angle (H*) values were documented using D65 illuminates and a 10E standard viewer as an orientation method. The equipment was calibrated on a standard white tile. Then it was assimilated to measure the value of L*, C* and H* and were replicated three times for each treatment.

Texture Analysis

Texture analysis was done based on our previous study Molla et al. (2020) using cross-sectional prove by a Texture Analyzer TA.XT plus (Stable Micro System, Godalming, UK) by back extrusion method. The test mode compression was used to determine the instrument working parameters with test speed at 1mm/s, distance 2.50 cm. The analysis of the data was performed by Texture Exponent Lite version 6.1.14.0 software (Stable Micro System, Godalming, UK) to determine the rupture force and it expressed as g/force.

Sensory evaluation

The sensory attributes were performed using the method of Joshi (2006). It was performed using a 9-point hedonic scale, i.e. 9= Like extremely, 8= like very much, 7= Like moderately, 6= Like slightly, 5= Neither like or dislike, 4= Dislike slightly, 3= Dislike moderately, 2= Dislike very much and 1=Dislike extremely. A panel of judges was formed by the thirty expert members from the BARI inter-divisional Scientists to evaluate their color, flavor, texture, mouth feel, spreadable capacity and overall acceptability. The score obtained by the panelist was analyzed statistically.

Statistical analysis

All data were expressed in duplicate as means ± standard deviation. One-way ANOVA with post-hoc using Turkey Multiple Comparison Test was performed to analyze the data. The connotation was defined at the 95% confidence level. Statistical analysis and data processing was performed using SPSS 17.0 software (IBM INC., New York).

RESULTS AND DISCUSSION

The proximate and nutritional composition of the fresh (on the day of storage) and stored pea-nut bar are shown in Tables 2 and 3.

Crude protein content

Tables 2 and 3 show the physicochemical and nutritional

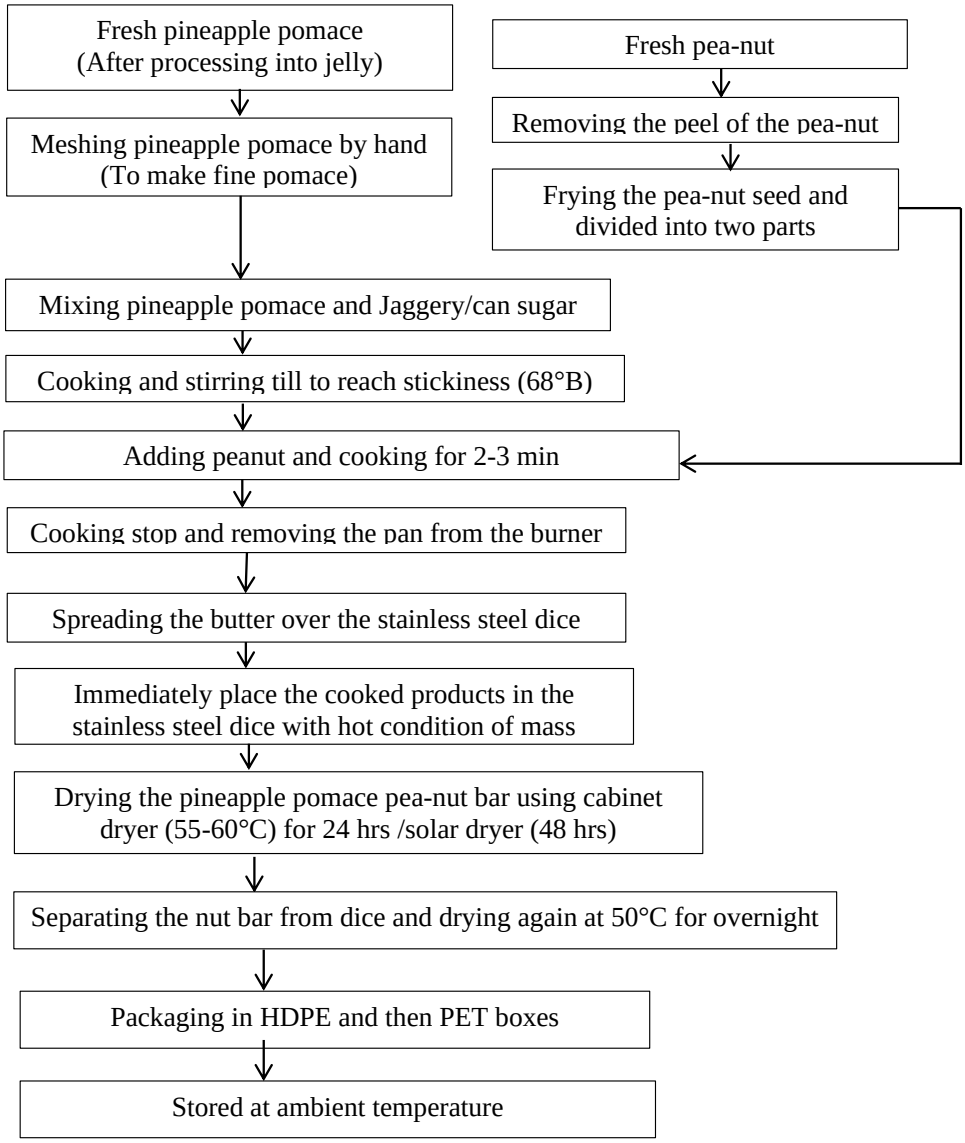

Figure 1: Processing flow chart of pineapple pomace peanut bar.

Table 1: Formulation of peanut bar containing pineapple pomace.

Ingredients	T_1 (g)	T_2 (g)	T_3 (g)	T_4 (g)
Pineapple pomace	250	250	250	-
Peanut	150	150	150	v
Jaggery/cane sugar	200	300	400	v
Puffed rice	10	10	10	v
Ghee/butter	2	2	2	v
Glucose	-	-	-	v
Salt	-	-	-	v
Vegetable oil	-	-	-	v

Sign 'v' indicates ingredients used in market sample whereas the ingredients were reserved secret by the Industry. Sign '-' indicates not used in our treated samples.

composition of the pineapple pomace nut bar on the day of storage and after 2 months of storage. All the treated samples significantly differed. On the day of storage, the protein content of the treated samples ranged from 8.53-13.06 % whereas the collected market sample was 3.18 % (Table 1). But after 2 months of storage, the protein

Figure 2: Processing appearance of pineapple pomace based peanut bar.

Table 2: Proximate and nutritional composition of pineapple pomace pea-nut bar on the day of storage.

	Treatment			
Parameter	**T_1**	**T_2**	**T_3**	**T_4**
Crude protein (%)	8.53±0.03c	10.50±0.05b	13.06±0.05a	3.18±0.13d
Crude fiber (%)	5.05±0.03c	5.56±0.19b	6.48±0.48a	0.98±0.19d
Crude fat (%)	1.83±0.05b	1.83±0.02b	1.41±0.10c	2.11±0.10a
Ash (%)	4.05±0.04b	4.09±0.01b	5.03±0.03a	4.04±0.03b
Moisture content (%)	5.14±0.03a	5.33±0.16a	5.41±0.04a	1.31±0.13b
Carbohydrate (%)	75.40±0.02b	72.69±0.19c	68.61±0.96d	88.18±0.35a
ß-carotene (µg/ 100 g)	15.49±0.02b	16.22±0.03a	16.32±0.03a	12.22±0.28c
Vitamin-C (mg/100 g)	21.18±0.27b	21.76±0.53b	23.28±0.21a	20.11±0.16c
Total sugar (%)	17.21±0.11c	18.28±0.03b	19.22±0.01a	17.25±0.14c
Reducing sugar (%)	9.27±0.03d	10.85±0.05c	12.15±0.03a	11.55±0.17b
Total soluble solid (°B)	6.78±0.03b	6.80±0.03b	8.50±0.03a	4.61±0.10c
Water activity (a_w)	0.73±0.00a	0.74±0.00a	0.74±0.00a	0.45±0.05b
Acidity (%)	0.11±0.02	0.13±0.02	0.12±0.02	0.11±0.02
pH	6.23±0.03	6.46±0.04	6.48±0.31	6.40±0.17
Energy (Cal/g)	3801.10±2.07a	4031.78±3.05a	4037.70±3.50a	3478.30±5.28b

All values are means of triplicate determinations ± SD. Means within columns with different letters a, b, c indicates significant result ($p<0.05$). No letter means no significant difference.

Table 3: Proximate and nutritional composition of pineapple pomace pea-nut bar after 2 months of storage.

	Treatment			
Parameter	**T_1**	**T_2**	**T_3**	**T_4**
Crude protein (%)	5.40±0.06b	5.82±0.03ab	6.35±0.06a	3.01±0.03c
Crude fiber (%)	5.18±0.42b	6.06±0.03b	7.34±0.54a	1.18±0.28c
Crude fat (%)	1.33±0.05b	1.33±0.02b	1.01±0.01c	1.61±0.10a
Ash (%)	4.62±0.04	4.95±0.06	5.54±0.03	4.44±0.07
Moisture content (%)	5.72±0.04a	5.87±0.03a	5.71±0.04a	1.59±0.18b
Carbohydrate (%)	77.75±0.42b	75.97±0.25c	74.05±0.50d	88.39±0.55a
ß-carotene (µg/ 100 g)	7.72±0.02c	8.53±0.03b	9.41±0.04a	7.35±0.29c
Vitamin-C (mg/100 g)	15.88±0.02b	16.21±0.02a	16.23±0.02a	14.91±0.10c
Total sugar (%)	17.51±0.10c	18.59±0.22b	19.81±0.09a	17.85±0.41c
Reducing sugar (%)	8.88±0.10d	10.34±0.15c	11.80±0.20a	11.05±0.04b
Total soluble solid (°B)	7.40±0.03c	8.40±0.03b	9.60±0.05a	5.44±0.04d
Water activity (a_w)	0.83±0.00a	0.82±0.00a	0.82±0.00a	0.53±0.06b
Acidity (%)	0.38±0.02a	0.38±0.02a	0.25±0.04b	0.15±0.01c
pH	5.23±0.23	5.46±0.05	5.40±0.05	5.48±0.31
Energy (Cal/g)	4006.10±1.00a	4044.11±1.00a	4051.27±1.05a	3578.29±5.28b

All values are means of triplicate determinations ± SD. Means within columns with different letters a, b, c, d indicates significant result ($p<0.05$). No letter means no significant difference.

content of the treated samples ranged from 5.40-6.35 % whereas the market sample possessed 3.01 % (Table 3). The results indicate that the protein content decreased with the increase of storage periods. The decrease in protein content may have been affected by tannins reported to form complexes with protein, limiting their availability (Sahore et al., 2007). The results are strongly supported by the findings of Zhang et al. (2017), who

reported that a slight decrease in protein content was found in walnut male florescence's from 1-8 days of storage. The decreased amplitude of protein content might be due to the spontaneity of the proteolytic activity at ambient conditions. Results obtained by this study showed a higher amount of protein content than the results obtained by Aigster et al. (2011), who reported that the protein levels of the cereal nut bar containing pineapple peel flour ranged from 6.31 to 7.08% and 4.47–6.62% respectively. Therefore, the protein content of our formulated pineapple pomace nut bar was satisfactory. This might be attributed to the use of pineapple fresh pomace directly in the jaggery instead of heating. The milling and grinding process was used by the Aigster et al. (2011) as the protein is denatured during heating.

Crude fiber content

Fiber content differentiation was highly significant among the different treatments of the prepared pineapple pomace bar on the day of preparation and after storage (Tables 2 and 3). The fiber values of the treated samples T_1, T_2, T_3 and T_4 were calculated as 5.05 %, 5.56 %, 6.48 % and 0.98 % at the initial day of storage (Table 1) but after 2 months of storage, the values were noted as 5.18%, 6.06%, 7.34 % and 1.18 % respectively. Table 3 indicates that the fiber content was gradually increased with the increase of storage periods. The change in the fiber content during storage for various treatments conforms with the findings of Rokhsana et al. (2007), who reported that fiber content changed non-significantly in legume and vegetable-based soup powder from 0.65-0.70% during storage of 6 months. The lowest fiber content was obtained by the market sample compared to the treated samples. This can be attributed to the market sample been prepared using nut, sugar, salt, vegetable oil, ghee and glucose whereas the treated samples were prepared using pineapple pomace, pea-nut, jaggery, cardamom seed and ghee. Pomace is a byproduct from fruit processing that contains considerable amounts of dietary fiber, bioactive compounds and antioxidants (Larrauri et al., 1997; Figuerola et al., 2005). The synergistic effect of phytochemicals and fiber content present in the prepared nut bar may have the ability to decrease body weight or attenuate weight gain which contributed to several important factors for beneficial effects on the treatment and prevention of obesity and diabetes (Tucker, 2009; Weickert and Pfeiffer, 2008), reduced CVD (Liu, 1999) and decreased incidence of certain types of cancer (Ferguson et al., 2001).

Crude fat content

Different treatments of the pineapple pomace nut bar and the market samples were statistically significant on the day of storage and after 2 months of storage (Tables 2 and 3). On the day of storage, the fat content of the treated sample ranged from 1.41-1.83 % whereas the market sample found 2.11% fat content. After 2 months of storage, the treated samples found 1.01-1.33 % fat content whereas the market sample was 1.61% fat content (Table 3). The results indicate that the market sample possessed a higher amount of fat content than the formulated treated samples. The fat content for both treated and market samples was gradually decreased with the advancement of storage periods. Our results are completely inverse relation with the formulated sesame bars developed by Abbas et al. (2017), who reported that fat content increased from 0.63-0.77 % with the advancement of different storage intervals. The dissimilarity and increased fat content of the developed treated and market samples might be due to conversion of a higher amount of carbohydrate into sugar and later the sugar might be accumulated into fat content by fat adoption and metabolism process.

Ash content

The analysis of variance for ash contents of different treatments of pineapple pomace nut bars on the day of storage and after 2 months of storage showed that the difference in ash contents among different treatments is highly significant (Tables 2 and 3). On the day of storage, the mean values of ash contents for treatments ranged from 4.05 ± 0.04 to 3.43 ± 0.03% whereas the market sample was 4.04±0.03 % (Table 2). But after 2 months of storage, the ash contents of the treated samples ranged from 4.62 ± 0.04 to 5.54 ± 0.03% whereas the market sample was 4.44±0.07 % (Table 3). The results indicate that the lowest ash content was found in the market samples and the highest ash content was found in the treated samples. It is noteworthy that there was a gradual increase in ash contents with increasing storage periods of the formulated pineapple pomace nut bar, due to the increased quantity of crude fiber content in our treated samples as the ash content is directly related to the fibre content of the pineapple pomace nut bars.

Moisture content

The moisture content of the pineapple pomace nut bars was observed to be highly significant among the treatments and market sample. The mean values for moisture content of the treated samples ranged from 5.14 ± 0.03 to 5.41 ± 0.04 % whereas the market sample was 1.31±0.13 % (Table 2) on the day of storage but after 2 months of storage the moisture content of the treated samples ranged from 5.72 ± 0.04 to 5.87 ± 0.03 % whereas the market sample was 1.59±0.18 % (Table 3). After storage, the moisture difference was

significantly high in the treated samples as compared to the market sample. Having the highest moisture content of the treated samples, it was acceptable by the sensory evaluator due to its softness comparatively than the marketable sample. The lowest moisture content obtained by the market sample contributed to achieving more hardness than the treated samples. The variation in moisture content between the treated and market sample might be attributed to the use of different ingredients during formulations. The results also showed that the moisture content gradually increased to 60 days of storage in both treated and market samples. An increase in the moisture of the pomace nut bars was vastly significant, possibly due to absorption of moisture from the surrounding areas, as a result of two main factors i.e. packed in non-airtight polyethylene terephthalate (PET) boxes and polypropylene pouches and exposure to the atmosphere at times. The lowest moisture content in the marketable sample might have contributed to achieving a higher a_w than the treated sample (Tables 2 and 3).

Carbohydrate content

Comparing the total carbohydrate contents among the formulated pomace nut bar and the market sample, there were significant differences ($P< 0.05$) on the day of storage and after 2 months of storage (Tables 2 and 3). On the day of storage, the carbohydrate contents of the formulated samples ranged from 68.31±0.96 to 75.40±0.02 % whereas it was 88.18±0.35 % in the market sample. After 2 months of storage, the ranges of the carbohydrate contents in formulated samples were 74.05±0.50 to 77.85±0.42 % whereas the market sample was 88.39±0.55 % (Tables 2 and 3). Findings from this study were comparable to the results obtained by Souza et al. (2014), the carbohydrate contents obtained in their study ranged between 68.33 and 71.57%. Mendes et al. (2013) reported 61.61% as the carbohydrate content of their cereal bar made with fruit peels and baru. The results from these studies were therefore comparable to the formulated pomace bar having higher carbohydrate contents of their cereal bars. The high contents of carbohydrates found in the formulated samples might be due to the addition of pineapple pomace and jaggery in the formulation of the pomace nut bars. Another possible reason might be the deposition of fat into carbohydrates by fat adoption and metabolism process.

ß-carotene content

β-carotene is the main safe dietary source of vitamin A. The results show that the β-carotene content of the formulated samples ranged from 15.49±0.02 to 16.32±0.03 µg/100 g on the day of storage and after 2 months of storage, the β-carotene content varied from 7.72±0.02 to 9.41±0.04 µg/100 g (Tables 2 and 3). In the case of the market sample, the β-carotene content was 12.22±0.28 µg/100 g on the day of storage but after 2 months of storage, it was 7.35±0.29 µg/100 g (Tables 2 and 3). It can be seen that the β-carotene decreased with the increase of storage periods. The loss of β-carotene might be attributed to the non-oxidative changes (cis-trans isomerization, epoxide formation or heat degradation of tissues) (Aruna et al., 1999) and temperature effect during the cooking process (Molla et al., 2017). Moreover, the formulated pineapple pomace nut bar was a rich source of β-carotene content than the cereal nut bar (market sample).

Vitamin-C content

Vitamin-C content of the treated samples varied significantly higher than the collected market sample (T_4). The highest vitamin-C content observed in the treated samples ranged from 21.18±0.27 to 23.28±0.21 mg/100 g whereas the market sample was 20.11±0.16 mg/100 g on the day of storage (Table 1) but after 2 months of storage, the vitamin-C content of the formulated pomace nut bar was 15.88±0.02 to 16.23 ±0.02 mg/100 g whereas it was 14.91±0.10 mg/100 g for the market sample (Table 2). The results indicate that vitamin-C content decreased with the advancement of storage periods. Among the formulated and market samples, the highest vitamin-C content was recorded in the formulated pineapple pomace nut bar, which might be due to enrich of the nut bar using pineapple pomace as compared to the traditional market sample. The decreased vitamin-C content of the both formulated and market sample may be affected by the cooking temperature and long-term storage at ambient conditions. These results are in agreement with the findings of El Ashwash et al. (1980), who reported that the loss of vitamin C might be due to its oxidation during the long concentration steps at room temperature.

Total sugar

On the day of storage, total sugar content in the treated samples ranged from 17.21±0.11 to 19.22±0.01 % (Table 2) whereas it was 17.25±0.14 % in the market sample. But after 2 months of storage, the total sugar content ranged from 17.51±0.10 to 19.81±0.09 % while the market sample was 17.85±0.41 % (Table 3). It means that total sugar was increased with the increase of storage periods. Among the treated samples, the high sugar content was found in the treated samples than the market sample. It might be the total sugars were positively correlated to acidity as the nutbar was formulated by the fresh pineapple pomace. The positive correlation between total sugars and acidity means pineapple with high sugars generally have more free

organic acids and less hydrogen ion concentration than cereals plants with low sugars (Molla et al., 2017). Here it is noteworthy that the acidity of the formulated pineapple pomace nut bar was higher than the market sample and increased the entire storage periods (Tables 2 and 3).

Reducing sugar

The variation in reducing sugar content on the day of storage and after 2 months of storage for both formulated and market samples were significantly different (Tables 2 and 3). The total reducing sugars decreased during the entire storage period (Table 2). The reduction in sugar content was strongly influenced by the storage time and acidity. The reduction in sugar content may have contributed to achieving the high protein content of the formulated pomace nut bar. These results are supported by the findings of Pallavi et al. (2015).

Total soluble solid (TSS)

Total soluble solids of the formulated pomace peanut bar ranged from 6.78±0.03 to 8.50±0.03°B whereas the market sample was 4.61±0.10°B at on the day of storage but after 2 months of storage the TSS ranged were from 7.40±0.03 to 9.60±0.05°B while the market sample was 5.44±0.04°B, indicate that TSS increased with the advancement of storage periods. The highest TSS was recorded in the formulated samples than the market sample (T_4) on the day of storage and after 2 months of storage (Tables 2 and 3). The increase in TSS might be due to partial hydrolysis of polysaccharides like cellulose, starch and pectic substances into simple substances or due to solidification of pulp constituents during storage (Pandita and Gupta, 2019). Similar results were also reported by Pathak (1988) in aonla jam.

Water activity (a_w)

The water activity (a_w) of the formulated pea-nut bar ranged from 0.73±0.00 to 0.74±0.00 and the market sample was 0.45±0.05 on the day of storage but after storage, it ranged from 0.82±0.00 to 0.83±0.00 in the formulated nut bar whereas it was 0.53±0.06 in the market sample, indicates that the a_w increased with the increasing of storage periods. The highest a_w was recorded in our formulated pomace nut bar than the collected market sample (T_4) and statistically, both the samples (formulated and market sample) were significantly different. The highest a_w in the market sample might be due to lower moisture content (1.31 %) whereas our formulated pomace nut bar possessed moisture content from 5.14-5.41 % (Table 3). It is worth mentioning that this difference may be due to the different formulations and methodologies used for the manufacture of the pineapple pomace nut bar and cereal bars (Aigster et al., 2011).

Acidity

On the day of preparation, the titratable acidity in pineapple pomace pea-nut bar ranged from 0.11±0.02 to 0.13±0.02 % on the day of storage while the market sample was 0.11±0.02 % but after storage, the ranges were from 0.25±0.04 to 0.38±0.02 % whereas it was 0.15±0.01 % in the market sample (Tables 2 and 3), indicates that the acidity was increased with the advancement of storage periods. The highest acidity was recorded in the treated pineapple pomace nut than the market sample. As a reason it is said that the organic acids may be presented in greater quantities in the pineapple, thus conferring a higher acidity to the pomace nut bar. Another reason might be due to the effects of lactic acid bacterium-producing substances.

pH

The values for pH in the formulated pomace nut bar and market sample on the day of storage and after storage are shown in Tables 2 and 3. Statistically insignificant differences in pH values for both market and treated samples were observed which decreased with an increase in storage periods. The addition of pineapple pomace in the nut bar caused a significant decrease in pH values which is an indication of an inverse relationship with acidity of the treated samples. Generally, the pH decreases as the acid increases and vice-versa. The exact relationship differs from sample to sample and it depends on esoteric concepts like 'buffering capacity which will vary for a whole host of reasons. On the other hand, this phenomenon might be possible due to oxidation of acid during storage resulting in lower pH and also as a result of genetically dissimilar fruit varieties, soil texture, soil pH and other nutrients (Islam et al., 2013). These results are in agreement with the findings of Ahmed and Singh (2000).

Energy content

The energy content of the pea-nut bar ranged from 3801.10±2.07 to 4037.70±3.50 cal/g while the market sample was 3478.30±5.28 cal/g (Table 2). After 2 months of storage, the range was 4006.10±1.00 to 4051.27±1.05 cal/g whereas it was 3578.20±5.28 cal/g in the market sample (Table 3). The energy content increased with the increase of storage periods. The highest energy was found in treated sample T_3 whereas the lowest was recorded in the market sample (T_4). The results show that highly significant differences were observed in the calorific value of formulated and market samples with the advancement of storage periods

Table 4: Color changes of pineapple pomace-pea-nut bar on the day of storage and after 2 months of storage.

	Color					
	On the day of preparation			After storage		
Treatment	L*	C*	H*	L*	C*	H*
T_1	30.85±1.46d	21.97±1.42	74.19±5.76	30.52±1.28d	21.54±1.36	73.12±1.87
T_2	37.73±2.04c	28.23±4.60	71.99±1.71	37.20±1.73c	27.30±1.01	71.15±1.67
T_3	48.22±4.00ab	19.03±2.27	74.18±3.48	47.69±1.14ab	18.90±1.24	70.54±0.43
T_4	52.87±2.15a	20.98±3.97	71.54±1.59	52.43±1.17a	20.44±1.08	69.87±0.65

All values are means of triplicate determinations ± SD. Means within columns with different letters a, b, c, d indicates significant result ($p<0.05$). No letter means non-significant difference.

(Tables 2 and 3). An increase in gross energy may be influenced by the storage condition (Gandhi and Taimini, 2009).

Color measurement of the pineapple pomace pea-nut bar

Consumer satisfaction depends on the quality of the product whereas appearance is the greatest and common criteria used to decide the excellence of any materials. Color, size, shape and surface conditions are associated with the appearance of a product. A result obtained from the study shows that on the initial day of storage and after 2 months of storage, lightness (L) value for the treatment T_3 and T_4 recorded higher value than the treated sample T_1 and T_2, which indicates that the treated sample T_1 and T_2 had a little dark color than the treated sample T_3 and market sample T_4. The C value of the treated sample T_1 and T_2 was higher than others, which indicates that the color of the T_1 and T_2 was more saturated than the treated sample T_3 and market sample T_4. At the initial day of storage (0 day), all the treated sample T_1 T_2, T_3 and market sample T_4 showed hue value (h*) of 74.19±5.76, 71.99±1.71, 74.18 ± 3.48 and 71.54±1.59 whereas the value of hue was 73.12±1.87, 71.15±1.67, 70.54 ± 0.43 and 69.87±0.65 after 2 months of storage which indicates that all the sample was in the 0/360° region, confirming that all the pea-nut bar color was red (Table 4).

Sensory evaluation of the pineapple pomace pea-nut bar

The sensory evaluation of the treated samples on the day of storage and after storage was performed based on a 9-point hedonic scale and shown in Tables 5 and 6. Also the score obtained by the panelist in terms of color, flavor, texture, mouth feel, hardness, softness and overall acceptability is shown in Tables 5 and 6. On the day of storage, no significant differences were recorded in terms of color, flavor, softness and overall acceptability (Table 5). The maximum score was obtained by the treated sample T_3 in terms of their mouth feel and hardness than the market and other treated samples. But after storage, the lower mouth feel and hardness score was obtained by the treated sample T_3 as compared to market sample but no other treated samples (Table 6). After storage, no significant differences were found among the treated samples for color, flavor, texture, mouth feel, softness and overall acceptability (Table 6).

Hardness significantly differed whereas the low hardness was found in samples T_1 and T_2 and the highest hardness was noted in treatment T_3 and market sample T_4. The overall acceptability was not significantly differed but the highest score was confirmed by the panelist for the treated sample T_3 and market sample T_4. Data obtained from the results also confirmed that there was an inverse relation between the hardness and softness of the prepared pea-nut bar. None of the expert members of the sensory evaluation like the very hardness and softness of the pea-nut bar.

Texture profile of pineapple pomace pea-nut bar

The hardness of the pea-nut bar depends on the amount of final moisture content and duration of storage. After storage, the values of rupture force (FR) were measured in order to assess the hardness of the treated pea-nut bar on the day of storage (Figure 3) and after storage (Figure 4). The maximum peak was recorded in market sample T_4 both on the day of storage and after storage whereas the treated sample showed the lowest peak. Among the treated sample, T_3 showed maximum hardness than T_1 and T_2. The maximum hardness obtained by the market sample T_4 and our treated sample T_3 (Figure 3) might be due to the presence of lower moisture content than others (Tables 2 and 3).

cThe lower moisture content and high amount of jaggery added in the products might have contributed to achieving hardness with increase in storage periods. Here, it was observed that the hardness of the nut bar was found to be lowest on the day of storage for both the market and treated samples. But the hardness was increased with the increase of storage periods. This can be attributed to the jaggery syrup effect on the nut bar that might have contributed to making a hard bond throughout the storage periods (Figures 3 and 4). However, among the treated samples, the maximum FR was recorded in T_3 with its highest hardness. Hence it was acceptable by the panelist of the sensory evaluator (Table 5).

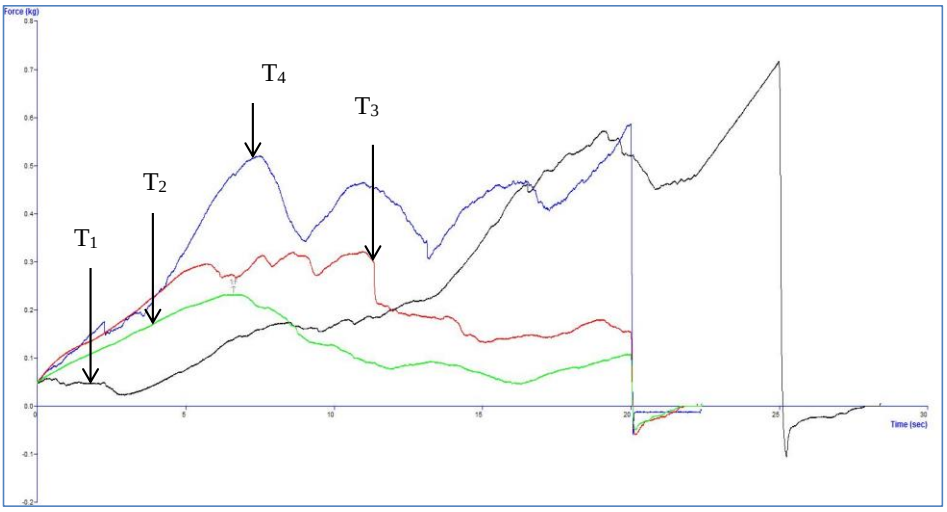

Figure 3: Texture profile of the pineapple pomace-peanut bar on the day of storage.

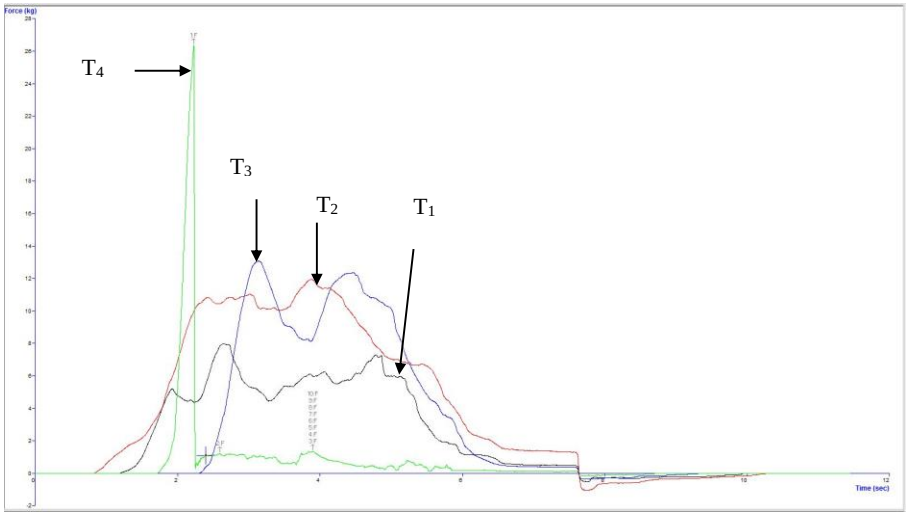

Figure 4: Texture profile of the pineapple pomace-peanut bar after storage.

Table 5: Sensory evaluation of the pineapple pomace pea-nut bar on the day of storage.

	Treatment			
Sensory attributes	**T_1**	**T_2**	**T_3**	**T_4**
Color	7.40±1.26	6.80±0.91	6.90±1.10	6.70±0.67
Flavor	7.00±0.81	6.90±0.99	7.00±0.66	7.10±0.56
Texture	6.30±0.48b	6.50±0.70ab	7.00±0.66ab	7.10±0.56a
Mouth feel	6.50±0.70bc	6.20±0.42c	7.30±0.67a	7.10±0.56ab
Hardness	6.40±0.51c	6.50±0.84bc	7.20±0.42a	7.10±0.31ab
Softness	6.10±0.31	6.40±0.84	6.70±0.82	6.90±0.87
Overall acceptability	6.61±0.36	6.55±0.58	7.01±0.37	7.00±0.29

All values are means of triplicate determinations ± SD. Means within columns with different letters a, b indicates significant result ($p<0.05$). No letter means non-significant difference

CONCLUSION

Findings suggest that the pineapple pomace peanut bar formulated from pineapple pomace is a rich source of crude fiber, crude protein and energy content. Formulation T_3 ((pineapple pomace 250g+ peanut 150 g + cane sugar 400 g+ puffed rice 10 g+ Ghee 2 g) obtained the highest score by the expert's sensory

Table 6: Sensory evaluation of the pineapple pomace pea-nut bar after 2 months of storage.

Sensory attributes	Treatment			
	T_1	T_2	T_3	T_4
Color	6.20±1.22	6.60±1.07	7.20±1.75	7.10±0.75
Flavor	6.60±1.07	7.00±0.66	7.00±0.81	6.90±0.18
Texture	6.30±0.48	6.50±0.71	6.90±0.73	7.00±0.83
Mouth feel	6.20±0.42	6.50±0.71	7.00±0.66	7.10±0.06
Hardness	6.60±0.56b	6.70±1.33b	6.90±0.67ab	7.00±0.07a
Softness	5.90±0.56	6.00±0.24	6.70±0.83	6.00±0.83
Overall acceptability	6.26±0.77	6.39±0.51	6.78±0.38	6.80±0.18

All values are means of triplicate determinations ± SD. Means within columns with different letters a, b indicates significant result ($p<0.05$). No letter means non-significant difference.

evaluation for its color, flavor, texture, mouth feel (taste), softness and less hardness. The marketable life of the developed pea-nut bar could be extended more than 2 months without any quality deterioration. By applying this technology, protein-energy malnutrition can be overcome. In the current scenario, the development of this nutritious bar is a good substitute for other junk foods. The pomace bar has great market potential to boost up energy and maintain performance by providing a high amount of vitamin C, pro-vitamin A (ß-carotene), protein and dietary fiber. Pineapple pomace supplemented bar can be used for the school nutrition programs to uplift the nutritional status of the school-going children.

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REFERENCES

Abbas S, Sharif MK, Shah FH, Ejaz R (2017). Preparation of Sesame Flour Supplemented High Protein and Energy Food Bars. Pakistan Journal of Scientific and Industrial Research Series B: Biol. Sci. 59(1):20-32.

Ahmed MS and Singh S (2000). Studies on extension of storage life of Amrapali mango," Orissa J. Hortic. 28:73–76.

Aigster A, Duncan SE, Conforti FD, Barbeau WE (2011). Physicochemical properties and sensory attributes of resistant starch-supplemented granola bars and cereals. Food Sci. Technol. 44:2159–2165.

Aruna RV, Ramesh B, Kartha VN (1999). Effect of beta-carotene on protein glycosylation in alloxan induced diabetic rats. Indian J. Exp. Biol. 37(4):399-401.

BBS (2020). Yearbook of Agricultural Statistics of Bangladesh. Bangladesh Bureau of Statistics, Statistics and Information Division, Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka, pp. 200-233.

EI Ashwah FA, Abd-EI-Baki NM, Samahy SKEI, Fedul MGEI (1980). Effect of storage on the characteristics of the concentrated orange and lime beverages. Agril. Res. Rev. 58(3): 275-288.

Figuerola F, Hurtado ML, Estevez AM, Chiffelle I, Asenjo F (2005). Fibre concentrates from apple pomace and citrus peel as potential fibre sources for food enrichment. Food Chem. 91:395–401.

Ferguson LR, Chavan RR, Harris PJ (2001). Changing concepts of dietary fiber: Implications for carcinogenesis. Nutr. Cancer 39: 155-169.

Gandhi AP, Taimini V (2009). Organoleptic and nutritional assessment of sesame (*Sesame indicum,* L.) biscuits. As.J.Food Ag-Ind. 2: 87-92.

Islam MK, Khan MZH, Sarkar MAR, Absar N, Sarkar SK (2013). Changes in Acidity, TSS, and Sugar Content at Different Storage Periods of the Postharvest Mango (*Mangifera indica* L.) Influenced by Bavistin DF.Int. J. Food Sci.: 8 pages. Doi: http://dx.doi.org/10.1155/2013/939385

Jain PK, Asati VK (2004). Evaluation of guava cultivars for pulp preparation. J. Food Sci. Technol. 41:684-86.

Joshi VK (2006). Sensory Science: Principles and application in food evaluation. Agrotech Publish Academy, Jaipur (India).

Larrauri JA, Ruperez P, Calixto FS (1997). Pineapple shell as a source of dietary fiber with associated polyphenols. J. Agric. Food Chem. 45:4028–4031.

Liu S, Stampfer MJ, Hu FB, Giovannucci E, Rimm E, Manson JE, Hennekens CH, Willett WC (1999). Whole-grain consumption and risk of coronary heart disease: Results from the Nurses' Health Study. Am. J. Clin. Nutr. 70:412-419.

Mendes NSR, Gomes-Ruffi CR, Lage ME, Becker FS, Melo AAM, Silva FA, Damiani C (2013). Oxidative stability of cereal bars made with fruit peels and baru nuts packaged in different types of packaging. Food Sci.Technol. Camp. 33(4): 730-736.

Molla MM, Rahman E, Khatun A, Islam MF, Uddin MZ, Ulla MA, Saha MG, Miaruddin M (2017). Color retention and extension of shelf life of litchi fruit in response to storage and packaging technique. Am. J. Food Technol. 12(5):322-331.

Molla MM, Sabuz AA, Ferdous GFC, Alam M, Khatun A, Khan MHH, Miaruddin M (2020). Effect of edible coating on quality and marketable life of fresh cut guava fruit. Int. J. Sci. Eng. Appl. Sci. 6(10):1-13.

Pallavi BV, Chetana R, Ravi R, Reddy SY (2015). Moisture sorption curves of fruit and nut cereal bar prepared with sugar and sugar substitutes. J. Food Sci.Technol. 52(3):1663-1669.

Pandita N, Gupta N (2019). Development and evaluation of flavoured ladoo from different cultivars of aonla. Bangladesh J. Bot. 48(4):957-965.

Pathak S (1998). Post-harvest technology of aonla (*Emblica officinalis* Gaertn) fruits. Indian Food Pack. 49(4):43-46.

Ranganna S (1995). Hand Book of Analysis and Quality Control for Fruit and Vegetable Products. Tata McGraw-Hill Publishing Co. Ltd. New Delhi, India, 1995, 1112p.

Rokhsana F, Yeasmin R, Nahar A (2007). Studies on the development and storage stability of legume and vegetable based soup powder. Bangladesh J. Agric. Res. 32: 451-459.

Sahore DA, Nemlin GJ, Kamenan A (2007). Changes in nutritional properties of yam (*Dioscorea spp*), green plantain (*Musa spp*) and cassava (*Manihot esculenta*) during storage. Food Sci. Technol. 47: 81 – 88.

Souza AHP, Gohara AK, Pagamunici LM, Visentainer JV, Souza NE, Matsushita M (2014). Development, characterization and chemometric analysis of gluten-free granolas containing whole flour of pseudo-cereals new cultivars. Acta Sci. Technol. Maringa 36(1):157-163.

Tucker LA, Thomas KS (2009). Increasing total fiber intake reduces risk of weight and fat gains in women. J. Nutr. 139:576-581.

Weickert MO, Pfeiffer AF (2008). Metabolic effects of dietary fiber consumption and prevention of diabetes. J. Nutr.138:439-442.

Zhang W-E, Wang C-L, Shi B-B, Pan X-J (2017). Effect of storage temperature and time on the nutritional quality of walnut male florescences. J. Food Drug Anal. 25: 374-384.