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FULL PAPER

Sensorial and physicochemical characterisation of snack bar with gum arabic (*Acacia seyal*) addition

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Abstract

Non-communicable diseases such as diabetes, atherosclerosis, myocardial infarction, and hypertension have rapidly increased. The scenario is due to unhealthy eating habits and unhealthy foods with high fat and oil, and high sugar on the market. A snack bar is one of the most suitable products as ready-to-eat food. It would be an ideal healthy food due to consumer demand for fast-growing natural foods. The application of Gum Arabic to confectionaries (snack bars) in the food industry is still low. Gum Arabic produced by the stem and branches of *Acacia seyal* has an excellent functional value of dietary fibre and the potential as an effective source in the formulation of a high fibre GA snack bar. This study was conducted to evaluate the sensorial and physicochemical characteristics of GA snack bar formulation with different concentrations of Gum Arabic of 10%, 20%, and 30%. Sensory analysis was conducted by using an acceptance test which is a 5-point hedonic scale. The attribute consists of colour, appearance, hardness, crispness, taste, and overall acceptance. For physicochemical properties, the colour, texture (i.e., hardness and crispness), pH, total soluble solid, water activity, moisture, crude protein, crude fat, crude ash, crude fibre, carbohydrate, and calorie determination are included. However, the value of a*, b* and protein were significantly ($p<0.05$) decreased with increasing the Gum Arabic concentrations. Besides, there was a significant difference in all attributes for sensory evaluation except for appearance. In conclusion, the addition of Gum Arabic up to 30% into the GA snack bar caused significantly ($p<0.05$) increased the lightness (L*), texture, total soluble solid, water activity, moisture, crude fat, crude ash, crude fibre, carbohydrate as well as calories.

1. Introduction

Consumer awareness of healthy food consumption and health problems has amplified the demand for functional food (FF) (Shandilya and Sharma, 2017). According to Lau *et al.* (2013), FF is categorized as functional components and ingredients beneficial to health and capable of preventing disease. The FF can promote optimal conditions for human health and prevent the risk of non-communicable diseases such as diabetes, atherosclerosis, myocardial infarction, and hypertension (Granato *et al.*, 2017; Aramesh and Ajoudanifar, 2017). The future of the FF market depends on the acceptance of the consumer. As a result, the FF industry has become a vital part of the food industry due to rising demand. FF is commonly added to the product with an ingredient that provides functionality for human health, such as high in dietary fibre products that have attracted consumer interest (Quigley, 2019).

The best source of high dietary fibre can be found in Gum Arabic (GA), which is well-known as soluble and the safest dietary fibre to consume. GA is recognised as an outstanding source of soluble dietary fibre that easily dissolves in water based on dried, rich, and edible gum characteristics (Hadi *et al.*, 2010; Mohammed, 2015; Mariod, 2018). GA is also classified as a dietary fibre source in the fundamental legislation of the Malaysian food safety program of Food Regulation 1985 of the Twelfth Schedule (Regulation 26). It is widely used in

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the food and non-food sector as well. In the food industry, GA as a food additive and emulsifier has been approved and permitted as a food acting as a stabiliser, thickener, and binding agent according to Food Regulation 1985 (Mortensen *et al*., 2017). GA's viscous and adhesive properties are widely used in gums, sweets, candies, and ice creams (Patel and Goyal, 2015). Therefore, excellent intestinal tolerance and high-dose GA at 10 g daily have been classified and generally recognised as safe (GRAS). GA substance does not cause any adverse effects on consumers (Glover *et al*., 2009). According to the Food and Drug Administration (FDA) (2013), GA is safe to consume and has extended the safe use of GA in the food and beverage industry.

The snack bar was recommended for formulating FF products due to its nutrient compounds such as carbohydrates, fats, vitamins, proteins, minerals, and calories (King, 2006; Ryland *et al*., 2010). Many consumers prefer food with high nutritional content, benefits to health, convenience to consume, and long shelf life (Ramirez *et al*., 2018; Bhakha *et al*., 2019). Previous studies by Aramouni and Abu-Ghoush (2011) reported the use of GA in wheat and soy bars as a coating. Similar to the study of Jan *et al.* (2012), the addition of GA in Nutri bars for lactating women is not the main ingredient but acts as a binder. Thus, a problem and gap have been identified, where most snack bars on the market contain high levels of sodium, fat, and high levels of sugar. It serves as the main ingredient, binder, and sweetener (Pallavi *et al*., 2015; Green *et al*., 2017; Pinto *et al*., 2019). Most of the snack bars in the market were sold with low nutrients. Those snack bars did not consist of healthy ingredients. Therefore, some suggestions and innovations were made to introduce and test soybeans, lentils, and oat as healthy ingredients in the snack bar (Pinto *et al*., 2017; Constantin and Istrati, 2018).

Most products on the market contain GA available in powder form (beverage powder), in juice, and coffee (Idris, 2017). Hence, the formulation of snack bars using GA (*Acacia seyal*) as one of the ingredients has not yet been reported. Apart from that, this study was inspired to formulate and produce GA snack bars that include the determination of sensorial and physicochemical characterisation. The formulation of a promotional GA snack bar is considered beneficial to human health and may be one of the alternatives to be used as a high dietary fibre source in food and beverage applications.

2. Materials and methods

2.1 Material and preparation of Gum Arabic snack bar

The preparation of the GA snack bar was carried out according to Silva *et al*. (2016) with slight modification following the five different ingredients. The ingredient in the formulation of the GA snack bar was prepared based on the different concentrations of GA (i.e., 10%, 20%, and 30%), oat, bubble rice, honey and glucose syrup.

2.2 Preparation of Gum Arabic snack bar

All the ingredients were prepared accordingly. For the first step, the oats and the bubble rice were mixed, then roasted in the pan at 90°C for 60 s before adding a binder to make a whole snack bar. Honey and glucose syrup act as a binder to combine with GA. The binder was made up of honey and glucose syrup combined with GA without heating process before being mixed into oat and bubble rice. The snack bar was placed on the mould for 2 mins until it was set. Subsequently, the mixture was laminated with aluminium foil and left in a chiller for 8 mins at 20°C. The compact snack bar was then cut into rectangular dimensions (9 cm long, 3.5 cm wide, and 1.6 cm thick). Finally, the snack bar was stored at ambient temperature and kept in a dark place until further analysis.

2.3 Sensory acceptability test

Methods were used for sensory analysis, including an affective test and 5 points of the hedonic scale. The GA snack bar was subjected to sensory analysis by sixty untrained panellists among the Universiti Malaysia Terengganu (UMT) students who were randomly selected. The samples were cut into 1 inch of length for each formulation labelled (3 digits number) and prepared based on the permutation number in the master sheet on the presentation tray. The panellist was asked to rate samples according to five sensory attributes, colour, appearance, texture (i.e., hardness and crispness), taste, and overall acceptability by using 5 points of the hedonic scale. The scale value shows 1 referred to extreme dislike while the score ranked 5 referred to extremely like (Shittu and Olaitan, 2014).

2.4 Physicochemical analysis

2.4.1 Physical analysis

The physical analysis consisted of colour, texture (i.e., hardness and crispness), pH, total soluble solids, and water activity. Colour measurement of GA snack bar was carried out using commercial colour meters of Minolta Chroma Meter (Holman *et al*., 2015). Chroma meter (Konica Minolta, Japan) was used to measure samples based on L*, a*, b* values. The L* value indicates lightness. The positive value of a* value is red; negative values of a* are green while the b* value represents yellowness-blueness of the colour. Positive values of b* are yellow; negative values of b* are blue, the yellowness of the sample. The texture was determined using the texture Analyser Machine (TA.XT Plus) Stable Micro Systems Surrey, England. It was used for the analysis of the hardness and the crispness. The preparation of sample total soluble solids was carried out using 5 g bar homogenised with 45 mL of distilled water in a tissue homogeniser (Tecnal Turratec TE-102, Sao Paulo, Brazil) at 22,000 rpm for 1 min at 20°C. The sample was then filtered, and the filtrate was used for further analysis. The pH was measured directly on pH-meter filtrate according to the Association of Official Agricultural Chemists (AOAC, 2010) methods. The total soluble solids (TSS) was also using a refractometer in which the final sample solution was filtered and dropped on the surface of the refractometer (Atago hand refractometer model N-4E, Japan) with automatic temperature adjustment. The result was reported in °Brix as described in AOAC methods (AOAC, 2010). The water activity (a_w) was measured using the AquaLab Water Activity meter (Broomes and Badrie, 2010).

2.4.2 Chemical analysis

The chemical analysis included proximate analysis such as moisture, crude protein, crude fat, crude ash, and crude fibre followed AOAC standard methods (AOAC, 2002). Carbohydrates were determined by difference, subtracting from 100 g of moisture content, crude protein, crude fat, crude ash, crude fibre expressed in %. The calorie value of the sample was calculated using the Bomb Calorimeter (AOAC, 2002). The samples were placed into the sample holder for the combustion process. Then, the fuse wire was placed into the slot, and the fuse wire bent into a U shape. The combustion chamber was sealed with Bomb Cap, and the needle valve was closed on the comb by turning clockwise. The Bomb Charger was attached, and the FILL switch was pressed before The Bomb Charger was removed. After that, the Bomb was placed into the bomb bucket for analysis by filling the bomb bucket with 2000 mL water. The bomb bucket was placed inside the bomb bucket well and closed, followed by pressing START. The heat of combustion was noted to be used in the formula.

2.5 Statistical analysis

The research design used was a completely randomised design (CRD) with a one-way treatment structure. Statistical analysis was carried out using Minitab 19.0 software. Each sample was prepared in three replications. The results were expressed as mean and standard deviation (SD) and analysed by Fisher's Least Significant Difference Test. Data were analysed by one-way ANOVA, which carried out a corresponding confidence level of 95% with a 5% significance level.

3. Results and discussion

3.1 Sensory acceptability of Gum Arabic snack bar

The mean scores for the sensory analysis of snack bars with different GA concentrations are shown in Table 1. The sensory analysis was evaluated to identify the colours, appearance, texture, taste, and overall acceptability.

Table 1 shows the sensory acceptability score of snack bars with different concentrations of Gum Arabic. The highest value of colour acceptance was Formulation 3, and the lowest colour acceptance was exhibited in Formulation 1. The maximum acceptability of the GA snack bar colour may be due to the light yellowish colour that attracts and impresses the acceptance of the panellist. The colour of Formulation 1 and Formulation 2 is the lowest due to the GA ingredient that did not provide colour to the GA snack bar in the different concentrations. According to Patel and Goyal (2015), GA is used in the food industry because it has colourless and odourless properties. The colour changes will appear as other ingredients such as honey is added. According to Agustini *et al*. (2017), a change in GA snack bar colour may associate with the possibility of browning Maillard reaction between GA and honey. A previous study was showed that the yellowish colour of the GA snack bar might be attributed to caramelisation occurring during the roasted.

The addition of GA provided an acceptable hardness texture. Formulation 3 exhibited the highest value for hardness acceptance, while the lowest was found in Formulation 1. Srebernich *et al*. (2016) reported that GA could not produce an effect of hardness on the snack bar. However, it stabilised the texture of the snack bar from the hardening process during the storage period. Apart from that, GA is well known as a higher source of fibre and this was consistent with the findings in Table 2. The hardness in snack bars increased from the higher fibre

Table 1. Sensory acceptability mean (n = 60) of a snack bar with different concentrations of Gum Arabic

GA snack bar	Colour	Texture		Taste	Appearance	Overall acceptance
		Hardness	Crispness			
F1	2.68^{b}	2.85^{b}	2.81^{ab}	2.95^{a}	3.20^{a}	3.03^{b}
F2	2.94^{b}	3.18^{a}	2.91^{a}	3.28^{a}	3.23^{a}	3.21^{a}
F3	3.26^{a}	3.21^{a}	2.25^{b}	2.65^{b}	3.15^{a}	3.81^{a}

Mean values with different superscripts letter in the same column are significantly different (p<0.05). F1: Formulation 1 (10% GA), F2: Formulation 2 (20% GA), F3: Formulation 3 (30% GA).

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content in GA (Dutcosky *et al*., 2006). This study also showed an escalation in the degree of resemblance to the GA snack bar as the hardness increased. A recent study by Puangjinda *et al*. (2016) observed that snack bars containing high in popped rice and honey obtained 3-point scale acceptability on the hardness among most of the pre-school children. Sunyoto *et al*. (2019) added the snack bar with a moderate hardness value was more accepted by the children. Since there is a limitation of sensory acceptability, the study on hardness in the snack bar using GA, for further research is needed.

Formulation 2 showed the highest value of crispness acceptance while the lowest was found in Formulation 3, which the panellist did not favour. Formulation 3 did not reach the level of crunch required by the panellists compared to Formulation 2. The activity of water and moisture influence the crispness level in the snack bar (Hofsetz and Lopes, 2005). The factors play an important role in determining whether the snack bar is crisp and not easy to break. According to Sirohi *et al*. (2002), the consumer prefers a soft-textured snack bar yet still retains its crispness. In line with the result shown in Table 1, Formulation 2 is the best choice and preferred by the panellist. The acceptance by the panellist decreased when the concentration of GA in the snack bar increased. It is due to the changes in the texture of the GA snack bar becoming too crispy. Supported by Srebernich *et al*. (2016), the higher level of GA influenced the characteristic of crispness in cereal bars. Also, it affected the overall quality because of the GA properties, which can affect crispness.

As shown in Table 1, Formulation 2 showed significantly ($p<0.05$) the highest score of taste acceptance. Formulation 2 was the most liked with a score of 3.28, showing the highest acceptance and the best formulation that the panellists liked while Formulation 3 with a score of 2.65 was the lowest and the least accepted. According to Ibrahim *et al*. (2017) and Mohammed (2015), the taste of *Acacia seyal* is tasteless due to its GA characteristics that do not affect the snack bar's taste. Srebenich *et al*. (2016) found that the taste in snack bars was not significantly affected by the addition of GA, inulin, and sorbitol during the sensory assessment. As argued, the sweet taste in the snack bar may not be due to GA, but rather to the sweetness of the honey and glucose syrup. According to Lebedev *et al.* (2010), honey is a natural sweetener extracted from a natural product without chemicals. It acts as a sweetener in food, while glucose syrup is a sugar of natural origin which that prevents crystallisation from occurring in bakery products and acted as a simple carbohydrate (Ahmad, 2010).

For the appearance acceptability, the result of the sensory analysis showed that all the appearance of the GA snack bar was not significantly different. The result of appearance was consistent with the study BeMiller (2019), where the level of liking on GA snack bar may be due to the colourless composition of the GA and the addition of GA, which does not affect the appearance of the snack bar. The snack bar with the addition of GA in the right proportion can increase the panellist preference for the GA snack bar from the overall acceptance analysis. The snack bar with an additional 30% GA (Formulation 3) scored the highest in sensory analysis level. The characteristics of colour and texture (i.e. hardness) may contribute to these results even though the taste and crispness of Formulation 2 are the most preferred of the panels. This can be due to the increased GA concentrations of up to 30% in the snack bar, affecting the character of the snack bar.

3.2 Physical properties of Gum Arabic snack bar

The snack bar physical analysis results with the addition of GA are shown in Table 2, while Table 3 shows the chemical composition of the GA snack bar.

3.2.1 Colour profile of Gum Arabic snack bar

Table 2 shows that the L * value of the formulations was increased with an increasing amount of GA, indicating the influence of GA on the lightness of the snack bar on the colour. The increase in the lightness of the snack bar may be related to the higher addition of the GA. The present study showed that Formulation 3 had a higher L* value of 64.78±0.40 while Formulation 1 had a lower L* value of 57.56± 0.22. The L* value obtained from the current study was similar to the result reported in cereal bars with GA, inulin, and sorbitol, which increased the L* value and had a brightness effect (Srebernich *et al*., 2016). The analysis of the a* value of the three preferred GA snack bars was significantly different ($p<0.05$). The findings showed that Formulation 1 had the highest a* value of 4.29±0.26, which shows the red colour of the snack bar. In contrast, Formulation 3 had the lowest a* value of 2.84±0.29. The a* value in this study was consistent with the recent study by Aramouni and Abu-Ghoush (2011). The a* value decreases when GA is added as a coating for wheat and soy bar snack bars. The increase and reduction of a* value in snack bars could be due to the contribution of anthocyanin pigments (Che Dahri *et al*., 2017; Pramitasari *et al*., 2019). In addition, the baking process, storage condition, temperature, pH and brightness level are also some of the factors affecting the stability of the a* value of the snack bar (Pramitasari *et al*., 2019). As shown in Table 2, Formulation 2 had b* value of 27.88±0.10, while Formulation 3 had b* value of 24.37±0.32. The analysis of the b* value of the three

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Table 2. Physicochemical properties of a snack bar with different percentages of Gum Arabic

GA snack bar	Colour			Texture		pH	Total soluble solids	Water activity
	L*	a*	b*	Hardness	Crispness		(°Brix)	
F1	57.56±0.22[b]	4.29±0.29[a]	25.50±0.32[a]	0.60±0.006[b]	8.06±0.03[b]	4.75±0.01[ab]	2.29±0.02[b]	0.997±0.00[b]
F2	65.14±0.1[a]	4.08±0.12[a]	27.88±0.22[a]	1.05±0.006[a]	8.50±0.23[b]	4.68±0.02[a]	2.46±0.04[b]	1.000±0.00[a]
F3	64.78±0.40[a]	2.84±0.26[b]	24.37±0.10[a]	1.66±0.006[a]	9.51±0.01[a]	4.53±0.02[b]	3.38±0.02[a]	1.000±0.00[a]

Values are presented as mean±SD. Values with different superscripts within the same column are significantly different ($p<0.05$). F1: Formulation 1 (10% GA), F2: Formulation 2 (20% GA), F3: Formulation 3 (30% GA).

Table 3. Chemical composition of a snack bar with different concentration of Gum Arabic

GA snack bar	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Fibre (%)	Carbohydrate (%)	Calories (kcal)
F1	12.73±0.01[b]	4.89±0.04[b]	1.01±0.00[b]	0.57±0.00[ab]	26.76±0.01[b]	50.75±0.002[b]	381.8±2.55[ab]
F2	12.75±0.02[b]	5.32±0.03[ab]	1.36±0.00[b]	1.15±0.00[a]	28.42±0.01[a]	51.76±0.003[ab]	384.7±2.34[b]
F3	12.95±0.02[a]	4.89±0.04[b]	1.97±0.02[a]	1.33±0.03[a]	29.65±0.01[a]	52.78±0.003[a]	392.2±4.98[a]

Values are presented as mean±SD. Values with different superscripts within the same column are significantly different ($p<0.05$). F1: Formulation 1 (10% GA), F2: Formulation 2 (20% GA), F3: Formulation 3 (30% GA).

preferred GA snack bars were not significantly different ($p>0.05$). The addition of GA as a coating to wheat and soy bar increased the value of b* (Aramouni and Abu-Ghoush, 2011). The increase in the value of b* in the GA snack bar may be due to GA's colour properties. *Acacia seyal* itself has contributed to a more yellowish colour (Mohammed, 2015) and attractive appearance.

3.2.2 Hardness

Table 2 shows that the hardness value of the snack bar containing GA had a significantly higher hardness ($p<0.05$). It shows 1.66 g for Formulation 3, higher than the hardness values of 0.60 g and 1.05 g for Formulation 1 and Formulation 2. The hardness value for the three prefered snack bars was significantly different ($p<0.05$). The hardness of the GA snack bar was significantly affected by the addition of the GA to the snack bar. The hardness value obtained from this study was the same as the reported hardness texture in the cereal bars with the addition of GA and inulin (Dutcosky *et al*., 2006). Similarly, the previous study by Srebernich *et al*. (2016) showed that the addition of GA and inulin resulted in increased durability of the cereal bar. It was observed that the GA snack bar formulation had the highest hardness when a high concentration of 30% of GA was added to the formulation from the viscosity of the GA concentration (Dutcosky *et al*., 2006). As supported, the higher viscosity of GA concentration was due to GA's molecular weight, where it was considered a highly branched structure, slightly acidic, complex, globular molecule resulting in its viscosity (Masuelli, 2013; Dutcosky *et al*., 2006). Thus, it can be concluded that if the viscosity of the concentration is increased, the texture of the cereal bars is harder.

3.2.3 Crispness

As shown in Table 2, the crispness value in the three preferred GA snack bars was significantly different ($p<0.05$). The present study showed that Formulation 3 had the highest crispness value of 9.51 g±0.01 while Formulation 1 had the lowest crispness value of 8.06±0.03 g. The result showed that snack bar crispness appeared affected by the addition of GA to the snack bar. It can be concluded that the more GA added to the snack bar, the more snack bar crispness. According to Tunick *et al*. (2013), a_w and moisture content significantly affected the GA snack bar crispness has increased or decreased. When a_w and moisture were reduced, food had become crisp and could not break easily (Hofsetz and Lopes,2005). The consumer prefers a snack bar with a soft texture while at the same time retaining the snack bar crispness (Sirohi *et al*., 2002). According to Tuta and Palazoglu (2017), the rate of heat transfer such as frying, roasted and baking could decrease the moisture content of foods. Since the preparation of the GA snack bar using the roasted method could affect the moisture content of the snack bar, the crispness of the snack bar was increased, respectively.

3.2.4 pH value

The pH value of the snack bar containing GA indicates a gradual decrease when the GA level is increased. The presence of GA in the snack bar has resulted in a significant decrease ($p<0.05$) in pH from 4.75 (Formulation 1) to 4.53. (Formulation 3). Formulation 1 had the highest pH value of 4.75, and Formulation 3 had the lowest pH value of 4.53. However, the pH value for all GA snack bars was included in the category of acidic food. This was attributed to GA (*Acacia seyal*) use in the formulation, commonly reported to be acidic due to the GA composition. The GA properties containing 4-O-methyl-d-glucuronic acid and glucuronic acid GA act as an acid in food with pH of *Acacia seyal* start with 6 to 14

(Aphibanthammakit, 2018; Mariod, 2018; BeMiller, 2019). As shown in Table 2, the pH value obtained from the present study had the highest level. The result reported in the diet cereal bar with the addition of GA and Xanthan gum was less acidic with a pH value of 3.00 (Silva *et al*., 2018). Different behaviour was observed by Silva *et al*. (2016), who reported that it can be regarded as acidic food by adding 20% of jeriva flour into snack bars, even though the pH value was reduced from 6.92 to 6.78. Based on the current outcome, it was shown that the GA snack bar could be classified as an acidic snack bar that can prevent the growth of microorganisms and prolong the shelf life of the snack bar.

3.2.5 Total soluble solid

The TSS results in Table 2 showed that the snack bar containing GA had a significantly higher ($p<0.05$) TSS of 3.38°Bx for Formulation 3. Compared to the TSS value of 2.29°Bx and 2.46°Bx for Formulation 1 and Formulation 2, respectively. The TSS value obtained from this study was lower with the result reported in the dietary cereal bar with the addition of xanthan gum which increased the TSS value by 67.00. In contrast, the addition of GA was 60.00 TSS (Silva *et al*., 2018). The TSS in the snack bar containing GA (*Acacia seyal*) increased gradually by increasing the level of GA used reported by Parnanto *et al*. (2018). The TSS result increased by the GA hydrocolloid structure, consisting of linear and water-soluble polysaccharides acting as a simple sugar. The structure of GA as polysaccharides consisting of D-galactose, L-arabinose, D-glucuronic acid, and L-rhamnose was able to increase the TSS value in the snack bar with different GA concentrations (BeMiller, 2019).

3.2.6 Water activity

As shown in Table 2, the water activity (a_w) of the snack bar containing GA was significantly increased ($p<0.05$) with the addition of GA at a concentration of 10% to 30%. The results showed that Formulation 3 had the highest a_w value of 1.000, whereas Formulation 1 had the lowest a_w value of 0.9997. The present result was contrary to the recent result from Silva *et al*. (2018), which reported the addition of GA and xanthan gum to dietary cereal bars at a lower a_w of 0.60 and 0.57. In a study done by Sarika *et al*. (2019), the a_w in the granola bar was reported to be lower than 0.50. Previous studies reported that a_w of 0.60 was the minimum required for microbiological growth and was classified as having lower moisture content (Erkmen and Bozoglu, 2016). However, all GA snack bars produced in this study were more significant than 0.60, where a_w was greater than 0.90, with a high risk of pathogenic spoilage and microbial proliferation. However, the microbial results of the snack bars (1×10^3 CFU/g) were under the limit proven by the Thai Community Product Standard (TCPS 709/2004). Thus, GA snack bar products are safe to consume, indicating lower potential microbial growth. In the future study is crucial to control the content of the a_w and the proper control of the moisture content due to enormous loss of nutrients to prevent spoilage in food products.

3.3 Chemical composition of GA snack bar

The chemical composition of the snack bar with different concentration of GA is shown in Table 3

3.3.1 Moisture

The moisture content of the GA snack bar was significantly different ($p<0.05$). The increase in the moisture content of the snack bar may be related to the increase in the GA concentration. As shown in Table 3, the moisture content of the snack bar varies from 12.73% to 12.95%, where Formulation 3 was the highest moisture content of 12.95±0.02% and Formulation 1 was the lowest moisture content of 12.73±0.01%. The water content obtained from this study was lower than that reported in the Umbu pulp cereal bar, which is 15.11% to 15.22% (Silva *et al*., 2018). On the other hand, the reported results for cereal bars with pumpkin seed flour of 8.60% to 11.45% (Silva *et al*., 2014) and Omega 3 Enriched Granola bar with 6.46% to 7.35% (Sarika *et al*., 2019) are lower than the present study. The addition of GA at different concentrations increased the moisture value due to a highly branched structure of GA with few hydrocolloids (hydrophilic) groups (BeMiller, 2019). Hydrocolloids are composed of hydrogen bonds bound to water molecules and delayed the moisture loss within 48 hours (Milani and Maleki, 2012; Li and Nie, 2016). According to Aurand (2013), the previous study revealed that the moisture content of flour and cereal products must be below 15% to prevent bacteria from spoiling. Although the moisture content of the GA snack bar is below the limit as mentioned above, it was safe to consume.

3.3.2 Crude protein

The crude protein content in the three preferred GA snack bars was not significantly different ($p>0.05$). The protein content of the snack bar is decreased with more addition of GA because GA has a lower protein content. Table 3 showed that Formulation 2 of the snack bar had the highest protein content of 5.32±0.03%. In contrast, Formulation 1 and Formulation 3 had the lowest protein content of 4.89±0.04%. The protein content obtained from this study was of the same lower level as that reported in dietary cereal bars containing GA, carrageenan, tara, xanthan gum (Silva *et al*., 2018) and cereal bars containing GA inulin and sorbitol (Srebernich *et al*., 2016). It is argued that the protein content may be because the GA composition includes 1.0% of the protein content (Lopez-Torrez *et al*., 2015; Musa *et al*., 2018). Therefore, it is not surprising that applying and adding GA to any food product could result in lower protein content.

3.3.3 Crude fat

Table 3 shows that Formulation 3 had the highest fat content of 1.97±0.02%, while Formulation 1 had the lowest fat content of 1.01±0.00%. Subsequently, the lower fat content of the snack bar can be attributed to the addition of GA for the lower fat composition. The finding revealed on the addition of GA (*Acacia seyal*) to the snack bars produced a lower fat content of 1.5% (Idris, 2017). Mendes *et al*. (2013) found that the fat content in nuts, papayas, and apple cereal bars was 14.55% while the fat content found in Ho *et al.* (2016) was 22.39% in energy bars containing banana, glutinous rice, and coconut milk. As a result, the GA snack bar can be considered to have a lower fat content than previous studies. To claim the snack bar is low in fat and healthy for consumption, food products (snack bars) have complied with several guidelines laid down by the Food and Drug Administration (FDA) (2013). As a rule, the fat content of the snack bar must be <3 g and >30% of the total fat content. It needs to be consistent with a low-fat content that supports the GA snack bar as a healthy snack bar.

3.3.4 Crude ash

The crude ash content in the three preferred GA snack bars was significantly different ($p<0.05$). Formulation 3 had the maximum ash content of 1.33±0.03%, as shown in Table 3, and Formulation 1 had the lowest ash content of 0.57±0.00%. Increasing the GA concentration in the formulation would subsequently increase ash content in the snack bar. The ash content obtained from the present study was lower with the result reported in Granola containing 1.5% with Maize and Coconut bar (Joy *et al*., 2016); however, the current result was higher than the 1.05% result reported for Granola cereal bar (Zamora-Gasga *et al*., 2014). The ash content in the GA snack bar was linked to the mineral content of the ingredients from the formulation. Total ash may be classified as a refined indicator of the mineral content of properties and food (Andualem and Gessesse, 2014). The ash content of this study could be traced back to the GA used, which could be considered the origin of minerals, particularly calcium, magnesium, and iron (Fernandes *et al*., 2010). In addition, the increase in the ash content may be due to the incorporation of GA containing a higher proportion of ash. As a result, the ash content in the snack bar is appropriate. The ash content is still within the GA composition range between 2.0% to 4.0% (Glicksman, 1986; Elamin and Mai, 2019).

3.3.5 Crude fibre

The crude fibre content of the formulated GA snack bar increased with the addition of GA. The fibre content of the three preferred snack bars was significantly different ($p<0.05$). GA contained a higher fibre content, which provides more fibre than other ingredients, resulting in higher fibre content in formulating and developing the GA snack bar. Table 3 shows a Formulation 3 highest ash content of 29.65±0.01%. However, Formulation 1 had the lowest fibre content of 26.76±0.01%. Supported by Agbaje *et al*. (2016), the fibre content in the granola bar was 13.42%. Mendes *et al*. (2013) reported that the fibre content in the Baru Almond and Pulp cereal bars was 18.13%. Compared to previous studies, the GA snack bar may be considered to have a high fibre content that is good to consume. In addition, GA is known as a soluble dietary fibre that contains 80% fibre, has low viscosity, and can absorb and dissolve in water (Yang *et al*., 2017; Mariod, 2018). Soluble fibre can also prevent gastric growth, add food transit time, slow down the digestion process and reduce the absorption of nutrients (Yang *et al*., 2017). GA is, therefore, suitable for use in the formulation of the snack bar. It was a higher source of fibre and classified as a food source of fibre according to Food Regulation 1985.

3.3.6 Carbohydrate content

As shown in Table 3, the present result has shown that GA snack bar carbohydrates ranged from 50.75% to 52.78%. There was a significant difference in the three snack bar preferences ($p<0.05$). Formulation 3 had the highest carbohydrate content of 52.78±0.03%, and Formulation 1 had the lowest carbohydrate content of 50.75±0.02%. The carbohydrate content obtained in this study was in the range as those reported in the energy bar of 56.89% contain banana, glutinous rice, and coconut milk (Ho *et al*., 2016). However, the present study showed a different level. The result was reported in a snack bar with jeriva flour containing the highest carbohydrate content of 77.27% (Silva *et al*., 2016). When comparing with the previous result, it was indicated that the GA snack bar had a lower carbohydrate content compared to other snack bars. As shown in Table 3, the carbohydrate result may have increased due to the biochemical composition of GA in the snack bar (Musa *et al*., 2018; BeMiller, 2019). This was due to the composition of GA as a complex mixture of macromolecules that consisted of D-galactose and L-arabinose, which contributed to the highest proportion of carbohydrates, about 97% (Musa *et al*., 2018; BeMiller, 2019). In addition to GA, the additional ingredients of honey with nutritional value in the GA snack bar also contain the highest carbohydrate content.

3.3.7 Calorie content

The total calorie value for all formulations in Table 3 was significantly different ($p<0.05$). It is interesting to note that the calorie content ranges from 381.8 kcal to 392.2 kcal/100 g. As shown in Table 3, the highest calorie content for Formulation 3 was 392.2 kcal. The lowest calorie content for Formulation 1 was 381.8 kcal. The carbohydrate of GA snack bar contents was close to previous studies by Agbaje *et al*. (2016). The calories in cereal bars containing puffed glutinous rice and Sunnah food ranged from 322.06 Kcal to 379.80 kcal. The calorie content obtained from this study was at the lower level. The result reported in 416.99 kcal (Mendes *et al*., 2013) cereal bars made with fruit peels and Baru nuts and 404 Kcal cashew plum cereal bars (Mourao *et al*., 2009). According to the National Coordinating Committee on Food and Nutrition (NCCFN, 2017), the highest and lowest calorie content in the snack bars is influenced by macronutrients (i.e. proteins, carbohydrates, and fats). Based on the analysis, the micronutrient content of the GA snack bar is lower. Thus, it can be concluded that it can be categorised as a snack bar with a lower calorie content than other snack bars in previous studies.

4. Conclusion

In conclusion, this study exhibited that GA may serve as an excellent ingredient of high dietary fibre to formulate GA snack bar. Formulation 3 was accepted mainly by the panellist with the highest resemblance to the panellist and is suitable for commercialisation. GA snack bar can be a new product containing GA as a snack bar and a healthy ingredient. In conclusion, this product is safe to be consumed as the water activity level is still within a safe range. Thus, the result was showed that GA could be an alternative as an effective source for food industry use and applicable in GA snack bar production.

Conflict of interest

The authors declare no conflict of interest.

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