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FULL PAPER

Nutritional compositions, physicochemical properties, and sensory attributes of green banana flour-based snack bar incorporated with konjac glucomannan

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Abstract

The objective of this study was to determine the nutritional composition, physicochemical properties, and sensory acceptability of snack bars prepared by using green banana flour (20% based on the total weight of rolled oats) and konjac glucomannan (KGM). Various levels of KGM (0.5%, 1.0%, 1.5%, and 2.0%) were incorporated to the snack bar sample formulation to prepare samples of SBKGM0.5, SBKGM1.0, SBKGM1.5, and SBKGM2.0, respectively. Results showed that the incorporation of KGM at increasing levels for snack bar production had significantly ($p<0.05$) increased the moisture, ash, crude fibre, total carbohydrate, and mineral contents but decreased the crude protein and crude fat contents, as well as calorie values. As for textural properties, the hardness value was significantly increased ($p<0.05$) with an increased level of added KGM. For overall acceptability by panellists, the addition of KGM up to a maximum of 1.5% to the formulation of green banana-flour based snack bar was recorded as the most suitable for snack bar preparation. These findings could be a useful platform in developing a green banana flour-based snack bar with property improvement, especially in the nutrition and physical aspects.

1. Introduction

Today, consumers eat snacks not only to satisfy their hunger but also to search for snacks that can supply essential body nutrients (Herawati *et al.*, 2019). Because of the growing consumers demand convenient, natural, and healthy foods, different types of fruit, such as marolo (Silva *et al.*, 2014), passion fruit (Wahane and Talib, 2015), and kiwi (Guine and Seabra, 2017) are used to produce snack bars.

Banana, which is widely planted in tropical and subtropical regions, is globally recognised as a highly consumed fruit (Gomes *et al.*, 2016). In 2016, the world's banana production was 113,000,000 metric tons, whereby approximately 35,000,000 metric tons were plantains (FAO, 2017). Green banana is gaining interest due to its nutritional content which contains a significantly high proportion of antioxidant properties, vitamins, and minerals. Green banana also contains indigestible compounds, such as dietary fiber, resistant starch at indigestible fraction which may be beneficial for intestinal health (Alkarkhi *et al.*, 2011). Large quantities of green banana rejection are usually from the low-grade fruit, those that deteriorate during transportation, and bananas with short shelf life (Ng *et al.*, 2014). Therefore, a better strategy to solve the rejected green bananas problem is worth pursuing processing these by-products into more useful products, such as flour prior to transforming it into various innovative products to encourage banana consumption and thus contribute to benefits for human health.

Konjac glucomannan (KGM) is a high molecular weight polysaccharide obtained through the tuber of Amorphophallus konjac plant extraction (Zheng *et al.*, 2019). KGM consists of many water-soluble polysaccharides with chemical structures of β-1,4-linked D-glucose and D-mannose residues (Behera and Ray, 2016). KGM provides diverse functional properties, such as gelling, thickening, stabilising, foaming, and textural enhancing properties by controlling the water molecule mobility (Rosell *et al.*, 2001). It is widely applied in the food industry due to its strong synergistic effects in viscosity, gel strength, elasticity, and stability in boiling water. Moreover, KGM is also widely used as a binder, bioadhesives, thickener or gelling agent in the food industry for the improvement of food texture (Takigami, 2000).

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In our preliminary study, a low glycemic index (GI) (<55) snack bars were developed using green banana flour (GBF) (Ho et al., 2018). However, the developed snack bar has weak texture properties, *i.e* agglutination. Agglutination is an important characteristic in determining the ability of particles of ingredients to adhere or glue or bind together. Weak agglutination of the food texture is not a desirable characteristic in food products due to easily breaking into small fragments or granular. The problem becomes worse during product selection by consumers whereby they tend to feel and touch the product by pressing the packaging before purchasing. Studies on the use of KGM and green banana flour in the production of snack bars for the improvement of textural and nutritional quality, respectively are limited. The development of snack bars incorporated with green banana flour and KGM can be an alternative method to produce highly nutritious ready-to-eat snacks. In this study, the effects of konjac glucomannan on nutritional compositions, physicochemical properties, and sensory attributes of green banana flour-based snack bars incorporated with KGM were investigated.

2. Materials and methods

2.1 Preparation of green banana flour

Unripe green bananas, without yellow or brown spots, were used to produce green banana flour (GBF). The preparation procedure for GBF was according to the method by Dahri *et al.* (2017).

2.2 Preparation of snack bar

Snack bars were prepared according to the method by Dahri *et al.* (2017), with modification on the addition of KGM into the snack bars. Ingredients such as toasted rolled oats (24 g), GBF (6 g), skimmed milk powder (20 g), goji berry (20 g), pumpkin seeds (10 g), sorbitol (20 mL), and KGM (0.5%, 1.0%, 1.5%, or 2.0%) were used to formulate the snack bars. Different percentages of KGM were added to the formulation to prepare SBKGM0.5, SBKGM1.0, SBKGM1.5, and SBKGM2.0, respectively. A snack bar without the incorporation of KGM served as the control, i.e., KGM0. All ingredients were mixed by using a blender (Waring Commercial Blender, 7011HS, Osaka, Japan) until a uniform mixture was obtained. The mixture was shaped into cuboids (3×9×0.8 cm) prior to drying at 40°C for 3 hrs.

2.3 Determination of proximate composition

The proximate composition of all prepared snack bars was determined according to the official method by AOAC (1990). Oven drying (AOAC Official Method 977.11), Kjeldahl (AOAC Official Method 955.04), Soxhlet (AOAC Official Method 960.39), dry ashing (AOAC Official Method 923.03) and gravimetric methods (AOAC Official Method 991.43) were used to analyze the moisture, crude protein, crude fat, ash and crude fibre contents, respectively.

2.4 Total carbohydrate and energy estimation

The total carbohydrate content was estimated by difference [total carbohydrate (% wet basis) = 100% –% (moisture + ash + crude protein + crude fat)]. The sample energy was calculated by multiplying with the factor values; 1 g of crude protein or carbohydrate provides 4 kcal of energy and 1 g of crude fat provides 9 kcal of energy) (Nielsen, 1998).

2.5 Water activity (a_w) determination

The a_w of the snack bars was measured by using an Aqualab Series 4 water activity meter (Aqualab dew point water activity meter 4TE), at 25°C. A total of 2 g of snack bars were placed on plastic cells and allowed to equilibrate within the headspace of the sealed chamber. The water activity of samples was recorded when an equilibrium of the snack bars was achieved.

2.6 Total soluble solid determination

Approximately, 1 g of powdered snack bar was added into 10 mL distilled water and stirred for 10 mins to obtain a slurry. Then, the total soluble solids of the slurry was determined by using a hand-held digital refractometer (Atago, 2383 MASTER-20M, Tokyo, Japan). The result was expressed in ºBrix.

2.7 Total sugar determination

The total sugar of snack bars was determined based on phenol-sulphuric acid with a phenol concentration of 2% (Chow and Landhausser, 2004). A standard mixture of glucose, fructose, and galactose was used. The absorbance of the prepared standard and samples was measured at 490 nm by using a UV-1280 UV-VIS spectrophotometer.

2.8 Vitamin C analysis

Vitamin C in the snack bar was determined through the redox titration method by using iodine. A total of 10 g of sample was suspended in 20 mL of distilled water and the mixture was stirred well. Then, the mixture was filtered by using a muslin cloth. 1 mL of the starch indicator was added to the filtrate or extracted solution. The solution was titrated with 0.005 mol/L iodine solution until the solution turned blue.

2.9 Mineral content determination

The essential minerals of snack bars, such as magnesium (Mg), iron (Fe), copper, (Cu), phosphorus (P), zinc (Zn), potassium (K), sodium (Na), and calcium (Ca) were determined by using Thermo Scientific iCAP 7000 Plus Series Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) (Thermo Fisher Scientific, Massachusetts, USA).

2.10 Texture profile analysis (TPA)

The snack bar texture was analyzed by using double-arm texture analyzer TA-XT Plus model. The texture characteristics, such as hardness, fracturability, adhesiveness, cohesiveness, gumminess, and snack bar chewiness, were determined. The texture analyzer was fitted with a three-point bending rig probe. The snack bar was cut into sizes of 3×9×0.8 cm and placed at the middle of the texture analyzer, then was compressed by two deformation cycles. The snack bar was compressed up to 40% of its height on the first cycle and moved to the second test cycle.

2.11 Sensory evaluation

Sensory evaluation of snack bars was conducted by using a seven-point hedonic scale. A total of 65 panellists who comprised staff and students from University Sultan Zainal Abidin (UniSZA), Besut Campus were invited for the evaluation. This test was performed in the Sensory Analysis Laboratory at the Faculty of Bioresources and Food Industry, UniSZA, whereby the panellists were provided with individual booths. Each panellist received five types of sample (size: 1×3×0.8 cm per piece) labelled with a three-digit code, a sensory evaluation form, a pencil, and plain water to rinse their mouth before the start of each test sample. Panellists were asked to score on a scale from 1 to 7 (Watts *et al.*, 1989).

2.12 Statistical analysis

All obtained data were reported as mean ± standard deviation (triplicate samples). The data were subjected to analysis of variance (one-way ANOVA) by using Statistical Social Sciences Version 14.0 software (SPSS Inc., Chicago, IL, USA) to obtain the mean values. The significant differences between mean values were analyzed by the Turkey Test at $p<0.05$ level.

3. Results and discussion

3.1 Proximate composition of snack bars

The effects of increasing levels (0% to 2.0%) of konjac glucomannan (KGM) on the proximate compositions of snack bars are presented in Table 1. The moisture obtained from the snack bars showed a significant increase with the increasing levels of KGM, the highest (13.18%) was for snack bars with 2% KGM (SBKGM2.0). The moisture value (11.22–13.18%) of snack bars obtained in this study was relatively close to those found by Mridula *et al.* (2013) for energy bars prepared with different percentages of flaxseed (0–20%) in addition to cereals and pulses with varying percentages of sweeteners (45–55%).

In general, the KGM level in the green banana flour-based snack bar did not affect the ash content (3.74–3.90%), whereby the incorporation of KGM into the snack bar formulation had slightly increased the ash content. However, it was insignificant. Generally, ash content gives a rough idea about the mineral content of a product (Dahri *et al.*, 2017). In this present study, it was revealed that KGM could increase the snack bar ash content. Dhari *et al.* (2017) reported that the increase in green banana flour amount (5-20%) in snack bars preparation led to the gradual increase in ash contents (3.54-3.66%). Furthermore, Dotto *et al.* (2019) reported that green banana flour has a high content of ash (ranging from 0.66 to 1.45%), indicating high mineral concentration. Therefore, it can be concluded that the ash content of the snack bars made of green banana flour with or without the addition of KGM (SBKGM0, SBKGM0.5, SBKGM1.0, SBKGM1.5, and SBKGM2.0)

Table 1. Proximate composition of snack bars

Proximate Composition	Type of Snack Bar[1]				
	SBKGM0	SBKGM0.5	SBKGM1.0	SBKGM1.5	SBKGM2.0
Moisture	$11.22±0.05^{e}$	$11.58±0.05^{d}$	$12.09±0.01^{c}$	$12.44±0.07^{b}$	$13.18±0.02^{a}$
Ash	$3.74±0.05^{a}$	$3.76±0.06^{a}$	$3.81±0.06^{a}$	$3.88±0.03^{a}$	$3.90±0.10^{a}$
Crude Protein	$16.59±0.06^{a}$	$16.41±0.05^{ab}$	$16.33±0.03^{b}$	$16.03±0.13^{c}$	$15.77±0.03^{d}$
Crude Fat	$7.27±0.05^{a}$	$6.92±0.03^{b}$	$6.52±0.06^{c}$	$5.82±0.16^{d}$	$5.25±0.08^{e}$
Crude Fibre	$3.65±0.13^{e}$	$4.27±0.10^{d}$	$5.69±0.13^{c}$	$6.23±0.08^{b}$	$6.88±0.11^{a}$
Total carbohydrate	$61.17±0.06^{b}$	$61.19±0.10^{b}$	$61.30±0.04^{b}$	$61.82±0.19^{a}$	$61.99±0.11^{a}$
Energy	$376.49±0.47^{a}$	$372.68±0.38^{b}$	$369.19±0.49^{c}$	$363.83±0.93^{d}$	$358.29±0.26^{e}$

Values are presented as mean ± standard deviation (n = 3). Values with different superscript letters within the row are significantly different ($P<0.05$).

[1]SBKGM0 (control), SBKGM0.5, SBKGM1.0, SBKGM1.5, and SBKGM2.0 represent snack bars added with Konjac Glucomannan at 0, 0.5, 1.0, 1.5, and 2.0% level, respectively.

was contributed dominantly by green banana flour.

The crude protein content showed a decreasing trend with increasing KGM levels in the prepared snack bars (16.41–15.77% for SBKGM0.5–SBKGM2.0). The results of crude protein obtained from the present study were higher than those reported by Sun-Waterhouse *et al.* (2010), wherein it ranged from 1.07 to 2.74% of crude protein for fruit-based functional snack bars. The crude fat content of snacks incorporated with different KGM levels showed a decreasing trend with increasing KGM levels; from 6.92% to 5.25% for SBKGM0.5 to SBKGM2.0. The control sample (SBKGM0) had the highest value of crude fat content, which was 7.27%. The results obtained in the present study was in agreement with a study by Li *et al.* (2014), whereby the addition of KGM in mayonnaise resulted in gradually decreased crude fat content of the end products, which ranged from 77.27% to 28.46%. Therefore, the higher the percentage of KGM used, the lower the value of crude fat content of snack bars.

The crude fibre content of KGM added snack bars were in the range of 4.27% to 6.88%, which was significantly higher ($p<0.05$) than the control snack bar (3.65%). This could be attributed to KGM as the source of soluble dietary fibre (Fang and Wu, 2004). Based on the previous study, the crude fibre content of green banana flour-based snack bars, fruit-based nutritious snack bars, and energy snack bars was ranged from 2.22% to 2.78% (Dahri *et al.*, 2017), 2.45% to 4.12% (Silva *et al.*, 2014) and 1.16% (Ho *et al.*, 2016), respectively. In addition, according to Shah *et al.* (2015), KGM was found to be a highly viscous soluble fibre, which was shown to reduce fasting and postprandial glycemia, and cardiovascular risk factors. In addition, green banana flour was reported to contain crude fibre ranging from 0.92% to 2.79% (Anggraeni and Saputra, 2018; Dotto *et al.*, 2019) which plays a central role in human nutrition. Kaczmarczyk *et al.* (2012) mentioned that the presence of dietary fibre in food is of great interest in health, as many studies had linked their roles in reducing the risks of some diseases, such as obesity, heart problems, diabetes, and colon cancer.

Table 1 shows that the addition of KGM into a snack bar formulation of up to 1% level did not affect the total carbohydrate content. However, the addition of beyond 1% of KGM had significantly increased the total carbohydrate content (61.82–61.99%). The results obtained from the present study showed a slightly higher value of total carbohydrate content as compared to Dahri *et al.* (2017), who reported that the total carbohydrate contents obtained in their study for green banana flour snack bar ranged between 56.49% and 61.07%. The increase in the total carbohydrate content of the snack bar could be due to the high accumulation of starch content in KGM. Chua *et al.* (2010) reported that the dormant commercial konjac contained 10–30% (w/w) of starch. The starch content in KGM contributed to the total carbohydrate content of snack bars. In addition, the energy content of snack bars that contained different KGM levels was found to decrease as the KGM level increased, which ranged from 376.49 kcal/100 g to 358.29 kcal/100 g. With regard to energy contents, the control sample, without the addition of KGM, was significantly higher ($p<0.05$) than the snack bar with the addition of KGM. In the present study, results obtained showed a similar trend to that reported by Dahri et al. (2017) for fruit bars that ranged between 322.06-379.80 kcal/100 g.

3.2 Water activity, total soluble solids, total sugar, and vitamin C of the snack bars

The physicochemical properties of snack bar samples are presented in Table 2. The water activity values of the snack bars were in the range of 0.55– 0.64. The water activity of snack bars was significantly increased ($p<0.05$) with the incorporation of KGM at 1% to 2% levels (0.61-0.64) to the snack bars. According to Loveday *et al.* (2009), the minimum water activity value required for microbiological growth was 0.6. This indicated that all the snack bars, except for the snack bar incorporated with 2% KGM had a low risk of microbial proliferation and pathogenic spoilage. The current water activity value obtained was in agreement with the previous study reported by Dahri *et al.* (2017). A previously reported study showed that the water activity of snack bars made of green banana flour (0.50-0.52) was significantly lower than that of snack bars without green banana flour (0.54). Therefore, long shelf life is expected for the control sample (i.e., SBKGM0), but a slightly shorter shelf life for snack bars that contain KGM.

Total soluble solids (TSS) in the snack bars, with or without KGM, were in the range of 3.67–4.70°Bx (Table 2). The control sample showed the lowest TSS value, which was 3.67°Bx, whereas the sample with 2% of KGM addition had the highest TSS value, which was 4.70°Brix. TTS in snack bars that contained KGM had gradually increased with increasing KGM levels. According to Chua *et al.* (2010), KGM has abundant carbohydrate compositions which contribute to higher total soluble solids. Ho *et al.* (2012) revealed that glucose, sucrose, and fructose were correlated with the starch content that contributed to the soluble sugar in TSS. Therefore, the addition of KGM in snack bars had increased the total soluble solids.

The control snack bar (i.e., SBKGM0) contained

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Table 2. Physicochemical properties of snack bars

Formulation[1]	Water Activity (a_w)	Total Soluble Solid (°Bx)	Total Sugar (% w/v)	Vitamin C (mg/100 g)
SBKGM 0	0.55±0.01[c]	3.67±0.15[c]	39.14±0.63[d]	30.53±3.09[a]
SBKGM 0.5	0.57±0.01[c]	4.10±0.10[b]	41.59±0.56[c]	30.82±2.33[a]
SBKGM 1.0	0.61±0.01[b]	4.40±0.17[ab]	42.57±0.49[bc]	31.71±2.64[a]
SBKGM 1.5	0.62±0.01[b]	4.60±0.17[a]	44.03±0.58[ab]	31.12±3.97[a]
SBKGM 2.0	0.64±0.01[a]	4.70±0.17[a]	45.24±0.88[a]	30.82±0.88[a]

Values are presented as mean ± standard deviation (n = 3). Values with different superscript letters within the column are significantly different (P<0.05).
[1]SBKGM0 (control), SBKGM0.5, SBKGM1.0, SBKGM1.5, and SBKGM2.0 represent snack bars added with konjac glucomannan at 0, 0.5, 1.0, 1.5, and 2.0% level, respectively.

39.14% of total sugars, which was significantly lower (p<0.05) than snack bars with KGM (41.59%, 42.57%, 44.03% and 45.24% for SBKGM0.5, SBKGM1.0, SBKGM1.5, and SBKGM2.0, respectively). The results of total sugars were in line with the results of the total soluble solid (Table 2). The slight increase in total sugar content in snack bars with KGM was derived from the raw KGM material, which contained a small amount of carbohydrate. According to Xiao *et al.* (2018), starch content in unripe banana fruits is completely hydrolysed to simple sugars (i.e., glucose, sucrose, and fructose) during ripening, which then accumulates as soluble sugars making the fruits sweeter. However, green banana fruit (unripe) used in this present study indicate that the transformation of starch to simple sugars is yet to occur. Hence the total sugars content in all the prepared snack bars was associated with the simple sugars of the other ingredients that are present in the formulation.

There was an insignificant difference (p>0.05) in vitamin C content among all prepared snack bars. The addition of KGM in the production of snack bars did not affect the vitamin C content (30.82%, 31.71%, 31.12%, and 30.82% for SBKGM0.5, SBKGM1.0, SBKGM1.5 and SBKGM2.0, respectively). Generally, goji berry in the snack bars gives a rough idea about the vitamin C of a product (Donno *et al.*, 2015). According to Donno *et al.* (2015), goji berry has a vitamin C content of 48.94 mg/100 g, which was considered high. Vitamin C is a potent antioxidant that acts effectively in the extinction of free radicals to prevent premature ageing (Rosell, 2007). The antioxidant effects of vitamin C were demonstrated in many in vitro assays and the role of antioxidants in different human diseases, such as atherosclerosis and cancer, is also known. Although the direct relationship between protective or prevention effects of vitamin C and disease incidence was not demonstrated, optimal dosing was critical for intervention studies, whereby food sources of vitamin C were required (Silva *et al.*, 2014).

3.3 Mineral content of the snack bars

Macro-elements and micro-elements are essential for the daily human diet due to their involvement in neural conduction and muscle contraction (Ho *et al.*, 2012). The mineral content of snack bar samples is presented in Table 3. In general, snack bars added with KGM showed a significantly higher amount of potassium (K), sodium (Na), calcium (Ca), phosphorus (P), magnesium (Mg), copper (Cu), iron (Fe), and zinc (Zn) than the control sample. The increase in minerals was derived from the raw KGM material, which had abundant inorganic elements, including Ca, Fe, Mg Mn, P, K, Na, Tin (Ti), and Zn (Chua *et al.*, 2010). Minerals cannot be synthesized by the human body and should be supplied from food, and thus, the developed snack bars incorporated with KGM can be considered as viable alternatives for mineral intake.

Potassium was recorded to be the most dominant element in all the snack bars studied with the mean value ranging from 964.21 mg/100 g to 1271.11 mg/100 g. The mean value of minerals in snack bars is in accordance with the results of Dotto *et al.* (2019) whereby, the authors revealed that potassium (410 mg/100 g) was the major element present in all 15 varieties of unripe banana studied. In addition, Abbas *et al.* (2009) also reported that green banana flour has a high content of potassium (679.71–699.56 mg/100 g). This indicates that green banana flour used in this current study had a high concentration of potassium which contributed to the significant higher content in all the green banana flour-based snack bars. However, the snack bar with KGM showed significantly higher potassium (983.08–1271.77 mg/100 g) than the control bar (964.21 mg/100 g). Potassium is a beneficial element for those suffering from hypertension and excessive excretion of potassium through body fluids (D'Elia *et al.*, 2011), especially athletes.

Snack bars with added KGM exhibited higher sodium (228.20–333.23 mg/100 g) contents than the control bar (163.90 mg/100 g). These results were in line

Table 3. Mineral content of snack bars

Formulation[1]	Mineral (mg/100 g)							
	K	Na	Ca	P	Mg	Cu	Fe	Zn
SBKGM 0	964.21 ± 45.17^{c}	163.90 ± 57.40^{b}	30.34 ± 7.93^{c}	521.23 ± 13.37^{b}	78.92 ± 4.25^{b}	4.47 ± 0.23^{c}	3.46 ± 0.10^{a}	1.71 ± 0.39^{a}
SBKGM 0.5	983.08 ± 53.98^{c}	228.20 ± 49.21^{ab}	47.38 ± 2.19^{b}	558.57 ± 6.10^{ab}	81.85 ± 1.03^{ab}	5.53 ± 0.47^{bc}	3.49 ± 0.47^{a}	1.77 ± 0.24^{a}
SBKGM 1.0	1131.28 ± 58.01^{b}	232.67 ± 56.12^{ab}	50.13 ± 4.29^{ab}	579.77 ± 32.15^{a}	83.67 ± 2.24^{ab}	6.73 ± 0.29^{ab}	3.66 ± 0.21^{a}	2.23 ± 0.30^{a}
SBKGM 1.5	1190.69 ± 32.45^{ab}	255.70 ± 42.99^{ab}	52.86 ± 8.82^{ab}	590.13 ± 16.98^{a}	85.31 ± 1.10^{a}	7.00 ± 0.44^{ab}	3.75 ± 0.09^{a}	2.28 ± 0.45^{a}
SBKGM 2.0	1271.77 ± 19.22^{a}	333.23 ± 32.47^{a}	66.30 ± 4.67^{a}	605.17 ± 25.65^{a}	86.47 ± 0.88^{a}	8.57 ± 1.43^{a}	3.96 ± 0.08^{a}	2.48 ± 0.20^{a}

Values are presented as mean ± standard deviation (n = 3). Values with different superscript letters within the column are significantly different ($P<0.05$).
[1]SBKGM0 (control), SBKGM0.5, SBKGM1.0, SBKGM1.5, and SBKGM2.0 represent snack bars added with konjac glucomannan at 0, 0.5, 1.0, 1.5, and 2.0% level, respectively.

Table 4. Texture profile of snack bars

Attributes	Types of snack bar				
	SBKGM0	SBKGM0.5	SBKGM1.0	SBKGM1.5	SBKGM2.0
Hardness (g)	6.39 ± 0.31^{e}	7.00 ± 0.12^{d}	7.51 ± 0.19^{c}	8.03 ± 0.13^{b}	8.46 ± 0.05^{a}
Fracturability (g)	5.37 ± 0.84^{a}	6.16 ± 0.23^{a}	6.24 ± 0.04^{a}	6.42 ± 0.50^{a}	6.94 ± 0.93^{a}
Cohesiveness (g)	0.02 ± 0.004^{a}	0.03 ± 0.01^{a}	0.05 ± 0.05^{a}	0.04 ± 0.02^{a}	0.06 ± 0.03^{a}
Gumminess (g)	0.16 ± 0.03^{a}	0.24 ± 0.04^{a}	0.29 ± 0.13^{a}	0.37 ± 0.37^{a}	0.49 ± 0.27^{a}
Adhesiveness (g/s)	-2.39 ± 0.95^{d}	-5.20 ± 1.76^{cd}	-10.23 ± 1.57^{bc}	-12.80 ± 2.14^{b}	-20.25 ± 4.26^{a}
Chewiness (g/s)	0.09 ± 0.04^{b}	0.11 ± 0.03^{b}	0.13 ± 0.07^{b}	0.17 ± 0.13^{b}	0.26 ± 0.16^{a}

Values are presented as mean ± standard deviation (n = 3). Values with different superscript letters within the row are significantly different ($P<0.05$).
[1]SBKGM0 (control), SBKGM0.5, SBKGM1.0, SBKGM1.5, and SBKGM2.0 represent snack bars added with konjac glucomannan at 0, 0.5, 1.0, 1.5, and 2.0% level, respectively.

Table 5. Mean score for sensory acceptability of snack bars

Attributes	Types of snack bar				
	SBKGM0	SBKGM0.5	SBKGM1.0	SBKGM1.5	SBKGM2.0
Hardness	3.65 ± 1.25^{c}	4.77 ± 0.97^{a}	5.23 ± 0.99^{a}	4.55 ± 1.26^{ab}	3.87 ± 1.43^{bc}
Fracturability	3.65 ± 1.17^{c}	4.71 ± 1.27^{ab}	5.35 ± 1.14^{a}	4.77 ± 1.06^{ab}	4.03 ± 1.45^{bc}
Adhesiveness	4.65 ± 1.40^{ab}	5.26 ± 1.46^{a}	5.03 ± 1.08^{a}	4.81 ± 1.01^{a}	3.87 ± 0.92^{b}
Cohesiveness	3.71 ± 1.22^{b}	4.61 ± 1.26^{ab}	5.10 ± 1.11^{a}	4.74 ± 1.15^{a}	5.03 ± 1.70^{a}
Gumminess	4.35 ± 1.56^{a}	4.87 ± 0.96^{a}	5.23 ± 0.88^{a}	4.68 ± 1.11^{a}	4.55 ± 1.57^{a}
Chewiness	3.87 ± 1.63^{b}	4.61 ± 0.80^{ab}	5.42 ± 1.06^{a}	5.39 ± 1.26^{a}	3.97 ± 1.68^{b}
Overall Acceptability	3.58 ± 1.57^{c}	4.58 ± 1.15^{ab}	5.23 ± 0.88^{a}	4.84 ± 1.07^{ab}	4.16 ± 1.42^{bc}

Values are presented as mean ± standard deviation (n = 3). Values with different superscript letters within the row are significantly different ($P<0.05$).
[1]SBKGM0 (control), SBKGM0.5, SBKGM1.0, SBKGM1.5, and SBKGM2.0 represent snack bars added with konjac glucomannan at 0, 0.5, 1.0, 1.5, and 2.0% level, respectively.

with a study by Triki *et al.* (2013) who found that sausage added with konjac gels contained a higher amount of sodium than sausage without konjac gel, which was in the range of 760–833 mg/100 g. Moreover, the variation of calcium content (30.34–66.30 mg/100 g) in different formulations of snack bars could be explained by the proportion of konjac materials used in each case. According to Bhat *et al.* (2010), calcium supplemented from plant sources can be beneficial to patients who are allergic to or intolerant to animal-based source foods, including dairy products or it may be useful to vegetarians. Furthermore, calcium is also essential for strengthening bones and teeth. Therefore, the fortification of foods with KGM allows the addition of minerals to some foods that have low calcium and potassium contents.

In the case of trace elements (micro-elements), the Fe, Cu, and Zn contents were low. Iron, which is an essential element for animals and plants, ranged from 3.46 mg/100 g to 3.96 mg/100 g in snack bars, copper ranged from 4.47–8.57 mg/100 g, and zinc (1.71–2.48 mg/100 g).

3.4 Texture profile analysis of snack bars

Table 4 shows the texture profile of snack bars with or without added KGM. The hardness of a snack bar was found to be significantly affected by the KGM levels. Results showed that hardness increased (7.00 g–8.46 g) with increased KGM levels (0.5–2.0%). A higher hardness value indicated that the snack bar required a higher force for breaking. This might be due to the comparatively higher binding of ingredients in bars containing KGM, which resulted in higher hardness than the control sample (without KGM). KGM was able to increase the gel-forming, and fibre network; hence, improving the gel strength and elasticity of the end product (Zhou *et al.*, 2013). These present results were in accordance with a study by Tobin *et al.* (2012), whereby the incorporation of KGM at 11% level with whey protein showed a higher hardness value than the control (without KGM) due to the higher gel strength and compactness. However, for the control snack bar without KGM (SBKGM0), the sample showed a significant ($p<0.05$) lowest hardness value (6.39 g). The results obtained from this study could be explained by the fact that the compactness of the bars has resulted from the presence of fibre components (Table 1) which reduce the level of some of the compounds responsible for leaving empty spaces in snack bars. Hence, a higher force is required to compress the snack bar that contains a high amount of fibre (Garcia *et al.*, 2012). Besides, green banana flour has a lower bulk density than KGM, which might also influence the hardness of the end products.

Fracturability, cohesiveness, and gumminess were not affected by the KGM levels in green banana flour-based snack bars. Fracturability is defined as the ability of the force to break food into pieces, which represents the breakability of food when bitten (Paula and Conti-Silva, 2014). There was no statistically significant difference ($p>0.05$) found among all prepared snack bars for fracturability attributes. The obtained fracturability values for snack bars ranged from 5.37 g (the control) to 6.94 g (SBKGM2.0). Moreover, a similar trend was observed for cohesiveness; no significant difference ($p>0.05$) among all prepared snack bars.

Cohesiveness is defined as a work area during the second compression divided over work area at first compression (Chaiya and Pungsawatmanit, 2011). It represents the ability of food structure to withstand deformation between the teeth before it breaks (Noroul-Asyikeen *et al.*, 2018). The cohesiveness value ranges from 0.02 g to 0.06 g because the formulation increased in KGM from 0% to 2.0%. According to Impaprasert *et al.* (2016), the addition of KGM promoted the viscosity of the solution/mixture, and thus increased the cohesiveness of the product. However, the present results showed no significant difference among all prepared samples for cohesiveness. This may be attributed to a lower integral of KGM percentage used to incorporate with the snack bar was not sufficient to produce significant results. In addition, the results of gumminess also showed no significant difference ($p>0.05$) for all prepared snack bars. These results showed that force was required to break down all the snack bars into a 'ready to swallow' state were similar (Dahri *et al.*, 2017).

Furthermore, results for adhesiveness showed a significant difference ($p<0.05$) between control snack bar and snack bar added with KGM at/beyond 1.0% (i.e., SBKGM1.5 and SBKGM2.0), whereby SBKGM2.0 demonstrated the lowest significant ($p<0.05$) adhesiveness value (-20.25 g/s). This was because KGM had gelling properties that affected the adhesiveness of snack bars. KGM also had the ability to quickly hydrate and reduce free water when it was added in higher percentages (Zhou *et al.*, 2013). The hygroscopic properties of KGM with viscous texture caused the product to become more adhesive. According to Zhou *et al.* (2013), for making noodles an increase in KGM at a level from 0% to 5% resulted in decreased adhesiveness values from -29.55% to -168.73%.

In addition, a significant decrease ($p<0.05$) was found in chewiness value for SBKGM2.0. The present results were in accordance with the reports by Srebernich *et al.* (2016), whereby the application of gums in cereal bar preparation caused an increase in product chewiness.

This indicated that snack bars with higher KGM were harder to bite/chew. Zhou *et al.* (2013) mentioned that the properties of KGM provided binding to the ingredients, and thus increased KGM percentage also improved the stickiness of the products.

3.5 Sensory evaluation of snack bars

The mean scores of sensory attributes for snack bars are presented in Table 5. The mean scores for the hardness attribute showed a significant difference ($p<0.05$) among all prepared snack bars. SBKGM1.0 received the highest score (5.23) for the hardness attribute, whereas the lowest acceptability score (3.65) was found for the control snack bar. This was probably due to the absence of KGM in the control formulation which exhibited low compactness and crumbly texture and was not preferred by the panellist. According to Takigami (2000), KGM forms highly viscous solutions when dissolved in water and serves as an agent for thickening, gelling, and texturing. These are important criteria in providing a firm texture to the product and enhancing its palatability. KGM was used as polysaccharides that act as a functional replacement for gel network to improve the hardness of snack bar, but the sensory of hardness was subjective to the panellist acceptance.

Furthermore, the sensory score for the attribute of fracturability was observed to be the highest in SBKGM1.0 (5.35). This indicated that the panellists' slightly like' the fracturability attribute for SBKGM1.0 as compared to the control snack (3.65). This was due to the absence of KGM (SBKGM0) in the control sample which caused the texture to fall apart without upholding the bar, and thus it was not prefered by the panellists. According to Bezerra *et al.* (2013), green banana flour contains 7.15 g/100 g of insoluble dietary fibre and 1.34 g/100 g of soluble dietary fibre. This filament-like fibrous structure probably is an insoluble dietary fibre that could disturb the structure matrix and reduce the binding ability of the starch granules (Aravind *et al.*, 2012) in the snack bar. Then, causing the snack bar too easy to break into pieces and fall apart. Besides, the mean scores for adhesiveness were significantly ($p<0.05$) the lowest for SBKGM2.0 (3.87). SBKGM2.0 snack bar received the lowest sensory score due to the sticky characteristic of bars which were not preferred by the panellists since the product was very sticky to teeth during chewing. Milani and Maleki (2012) reported that the addition of gums in snack bar production had increased the adhesiveness of the product. It showed that the addition of KGM in food processing can also result in the increased absolute value of the adhesiveness, and thus increase the hardness value of the snack bar. Since the snack bar tends to become very sticky with the addition of KGM2.0, the panellist preferred the sample least.

For cohesiveness, the higher mean sensory scores were 4.61, 5.10, 4.74, and 5.03 for SBKGM0.5, SBKGM1.0, SBKGM1.5, and SBKGM2.0, respectively, as compared to the observed value for the control bar (3.71). On the other hand, no significant difference ($p<0.05$) was observed among the evaluated snack bars for the gumminess attribute (4.35–5.23). These results revealed that the addition of KGM at different levels did not affect the gumminess acceptability of consumers. This suggested that KGM added to the snack bar possessed a similar force required to differentiate each snack bar sample.

The mean score of chewiness for SBKGM1.0 and SBKGM1.5 snack bars was significantly ($p<0.05$) higher than the other produced snack bars. However, the mean score of chewiness was significantly decreased when the addition of KGM was at a higher level (i.e., 2%) in the snack bar (SBKGM2.0). This was associated with the increase in texture hardness, whereby more energy was required to chew and break the food, which was not preferred by the panellists. According to Parn *et al.* (2015), products that can easily be chewed because of their low cohesiveness could increase the acceptability of consumer towards products.

For overall acceptability, green banana flour-based snack bar incorporated with konjac glucomannan up to 1.5% (i.e., SBKGM0.5, SBKGM1.0, and SBKGM1.5) received a significantly higher mean score (4.58, 5.23, and 4.84, respectively) than the control snack bar; SBKGM0 (3.58). Therefore, the addition of KGM up to a maximum of 1.5% to the formulation of the snack bar was recorded as the most suitable for snack bar preparation. Therefore, this combination of KGM at a 1.5% level could be considered as the optimum level for incorporating in the green banana flour-based snack bar preparation.

4. Conclusion

In conclusion, snack bars incorporated with KGM at levels of 0.5-2.0% influence the proximate composition, physicochemical properties and sensory preferences from the consumer aspects. The incorporation of KGM in snack bars had improved the nutritional quality. Different levels of KGM brought significant variation in the texture profile attributes. From the sensory acceptability results, green banana flour-based snack bar with the addition of KGM up to 1.5% level (i.e., SBKGM0.5, SBKGM1.0, and SBKGM1.5) had the highest mean scores for overall acceptability. Therefore, the incorporation of KGM at a 1% level to the formulation of a green banana flour-based snack bar is feasible and could offer various types of healthy snack bars for consumers.

Conflict of interest

The authors declare no conflict of interest.

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