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Shelf life extension of ambient-stored banana cake using banana powder

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Abstract

Maintaining the quality of bakery products is vital for consumers' health and preference. Since bakery products are intermediate-moisture foods, spoilage by moulds is among the major causes of shelf life reduction. In the present work, the effects of substituting banana purée with banana powder to extend the shelf life of banana cakes were investigated over a ten-day storage period. Three types of banana cake were made using banana purée (control), laboratory-formulated powder (LP), and commercial powder (CP). Results indicated a significant difference in moisture contents and water activities between all treatments in which LP and CP exhibited mould growth at day 9 compared to day 5 in control. For fungal load, LP yielded the lowest CFU by the end of storage period. Although significant differences in texture and appearance were noted between all treatments, untrained sensory panellists scored LP as acceptable. Further works are therefore warranted to assess LP's commercialisation potentials.

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Introduction

Bakery products such as bread, cakes and biscuits are one of the most important staple foods in many countries and cultures (Zhou and Hui, 2014) including Malaysia. They are increasingly becoming famous due to their convenience, affordability, availability and nutritiousness (Azizi *et al.*, 2003), and are being consumed in large quantities daily (Martins *et al.*, 2017). The shift in demographic and socioeconomic also contributes to the increasing demand for bakery products. Bakery products, however, have limited shelf life which is due to several factors such as formulation, packaging, processing and storage condition (Galic *et al.*, 2009).

Among the many types of bakery products, cakes constitute the larger portion in terms of consumption (Azaïs-Braesco *et al.*, 2017). The quality of cakes is generally determined by their volume, firmness, uniform crumb structure and most importantly, their shelf life. All of these criteria depend on the formulation, the stability of fluid batters, baking stage and also aeration of cake batters. Being an intermediate-moisture type of food (15-50% moisture content, 0.60-0.85 water activity), cakes (0.80-0.85 a_w) are highly susceptible to early spoilage by yeasts and moulds (Guynot *et al.*, 2003). Although baking destroys most microorganisms, members of the major food-borne microfungi such as *Aspergillus*, *Fusarium* and *Penicillium* have been isolated from cakes (Lavermicocca *et al.*, 2002; Roussos *et al.*, 2006) which might have been re-introduced during cooling and packaging. Current method of shelf life extension by adding preservative is actually causing a decrease in demand as consumers are reluctant to consume preservatives (Gomez *et al.*, 2007). Controlling the mould growth by manipulating its growth factors is therefore more ideal and favourable that will unlikely impair the sensory quality of the end products.

In controlling the mould growth while at the same time maintaining the sensorial attributes of the cakes, moisture content and by extension, the a_w, are among the important parameters that must always be considered (Hozova *et al.*, 2002). The average shelf life of cake is normally less than seven days and this also highly depends on other environmental factors such as oxygen availability and temperature. Therefore, majority semi-moist cakes are commonly stored in the refrigerator to increase their shelf life.

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Alternatively, cakes' shelf life could also be extended at room temperature by altering the cakes' a_w value (Smith *et al.*, 2004; Saranraj and Geetha, 2012).

In Malaysia, banana cake (or sometimes sold as banana bread) is a common delicacy and can be easily found in the food markets. It is either home-made or manufactured in large scale depending on the size of the shops. Traditionally, smashed ripe bananas of the locally cultivated *pisang emas* (*Musa acuminata* cultivar AA) or *pisang berangan* (*M. acuminata* cultivar AAA) are used. The use of banana in the cakes imparts high content of vitamins B_6 and C, potassium and manganese, and has also been shown to be good for diabetic patients due to its low glycaemic index (<55 GI; Atkinson *et al.*, 2008). Unlike its European or American counterpart, Malaysian banana cake is not prepared with alcohols (e.g., rum, liqueur, brandy, *etc.*). It is therefore more prone to microbial spoilage.

In the present work, laboratory-formulated banana powder (LP; prepared by foam-mat drying), and commercial banana powder (CP; or sometimes sold as banana flour) were used to replace banana purée (control) in making the banana cake. The use of dried fruit powder has been shown to reduce moisture content in order to prolong the shelf life with minimum deterioration (Falade and Okacha, 2010). The objectives of the present work were therefore (i) to investigate the effects of using banana powder on the quality and shelf life extension of banana cake at room temperature, and (ii) to evaluate the consumers' acceptance and perceptions towards the modified banana cake.

Materials and methods

Raw ingredients

Fully ripe bananas (*Musa acuminata* cultivar), commercial banana powder (CP; Secret Barn Sdn. Bhd.) and other baking ingredients were purchased from the food markets around Seri Kembangan, Selangor, Malaysia.

To prepare the banana purée, banana peel was removed from approximately 1 kg fully ripe bananas, and the pulp was homogenised by using a blender (National Blender MX-391N, Malaysia). Next, foaming agent (15% v/v fresh egg white) was added to the banana purée as a stabiliser (Lomakina and Mikova, 2006). The banana purée was divided into two portions; one was used as control ingredient (control) and one was further processed into laboratory-formulated banana powder (LP).

To make the LP, the previously prepared banana purée was whipped with a mixer (KitchenAid, USA) on speed 3 for 5 min to produce banana foam. The banana foam was then transferred onto a mesh tray with 2 mm thickness which was wrapped in aluminum foil and placed in a smoke dryer (Smoke Master SMA-112, JKA Technical Corp., Japan) at 60°C for 24 h (Falade and Okacha, 2010). The dried mat was then removed and pulverised using a blender and sieved (200 mm Ø, 0.5 mm aperture; Endecotts, UK) to obtain uniform-sized powder.

Preparation of banana cakes

Three types of banana cakes using previously prepared purée (control; 160 g; common home-made recipe), LP (80 g) and CP (80 g) were produced by separately adding these raw ingredients with flour (200 g, sugar (140 g), butter (125 g), eggs (3), Ovalette (3 g), vanilla essence (1 g) and baking powder (1 g). The flour composition per 100 g serving is carbohydrate 79 g, protein 10 g and fat 1 g. The amount of banana powders used was as recommended by the manufacturer (CP). The banana powder composition per 100 g serving is carbohydrate 87 g, dietary fibre 8 g, protein 5 g and fat 0.5 g. This mixture was whipped using a mixer (Kenwood mixer KM 283; Japan) on speed 3 for 15 min. Next, adequately whipped cake batter was immediately poured into separate baking trays and oven-baked at 170°C for 50 min. Following baking, all three types of banana cakes were allowed to cool for 2 h and then removed from the trays. The cakes were packed into separate polypropylene containers and stored at room temperature (between 20 to 25°C) for 9 d.

Measurement of water activity and moisture content

Small portion (5 g) of each type of cake was measured for their water activity (a_w) using an Aqua Lab water activity meter (Decagon, USA). For moisture content, 5 g of each type of cake was weighed into a crucible, and dehydrated in an oven for 7 h at 105°C (oven-drying method; Duxbury, 2005). All analyses were conducted in triplicates for each banana cake sample (three batches of purée, LP, CP).

Measurement of fungal load

Yeast and mould counts were determined by spread-plating method. Firstly, 25 g of each banana cake sample (purée, LP, CP) after one day storage at room temperature were weighed and placed in a stomacher bag containing 225 mL sterile 0.1% peptone water and then mixed for 5 min in a stomacher (InterScience, France). This gave a 10^{-1} dilution factor. Next, 1 mL aliquot was serially diluted into 9 mL sterile 0.1% peptone water to obtain 10^{-2} –

Table 1: Moisture contents (MC%) and water activities (a_w) of banana cakes made from different raw ingredients during nine-day storage at room temperature.

Type of cake	Storage time(day)	Moisture content (%)	Water activity (a_w)
Purée		30.79 ± 0.48^{Aa}	0.91 ± 0.01^{Aa}
LP	1	23.08 ± 0.40^{Ba}	0.87 ± 0.00^{Ba}
CP		20.99 ± 0.65^{Ca}	0.85 ± 0.00^{Ca}
Purée		29.19 ± 0.47^{Ab}	0.90 ± 0.01^{Aab}
LP	3	21.12 ± 0.27^{Bb}	0.85 ± 0.01^{Bb}
CP		19.49 ± 0.23^{Cb}	0.84 ± 0.00^{Bb}
Purée		28.71 ± 0.03^{Ab}	0.89 ± 0.01^{Aab}
LP	5	20.78 ± 0.08^{Bbc}	0.85 ± 0.00^{Bb}
CP		19.79 ± 0.35^{Cbc}	0.83 ± 0.00^{Cb}
Purée		28.97 ± 0.75^{Ab}	0.89 ± 0.01^{Aab}
LP	7	20.56 ± 0.25^{Bbc}	0.85 ± 0.00^{Bb}
CP		18.60 ± 0.16^{Ccd}	0.82 ± 0.00^{Cc}
Purée		28.11 ± 0.63^{Ab}	0.88 ± 0.01^{Ab}
LP	9	20.29 ± 0.24^{Bc}	0.85 ± 0.00^{Bb}
CP		18.25 ± 0.26^{Cd}	0.82 ± 0.00^{Cc}

Purée (control); LP (laboratory-formulated banana powder); CP (commercial banana powder). Data are means of triplicate (n = 3) ± SD. Capital letters indicate significant difference ($p \leq 0.05$) between type of cake, and small letters between storage time.

10^{-5} dilution factors. Then, 0.1 mL aliquot from each dilution factor was inoculated onto Potato Dextrose Agar (PDA; Oxoid, UK) supplemented with chloramphenicol. Inoculated plates were incubated for 4 d at 25°C. Following incubation, visible fungal colonies were counted. Plate with colonies < 25 was marked TFTC (too few to count) and plate with colonies > 250 was marked TNTC (too numerous to count). Results were expressed as Colony Forming Unit per gram (CFU/g). All analyses were conducted in triplicates for each banana cake sample (purée, LP, CP). The steps were repeated for day 3, 5, 7 and 9 of storage at room temperature.

Colour analysis

The colour of the banana cakes (top crust) was measured by Minolta Chroma Meter CR-410 (Konica Minolta, Japan). The result was expressed in the CIE L* a* b* colour space, in which L*, a*, b* indicate lightness, redness and yellowness, respectively. The colour measurement was conducted three times for each banana cake sample (purée, LP, CP) at day 1, 3, 5, 7 and 9 of storage at room temperature.

Textural analysis

The texture of the freshly prepared banana cakes and changes during storage were evaluated by measuring the midsection (3 × 3 × 3 cm) of the cakes using a texture analyser (TA.TX*i*; Stable Micro Systems, UK) equipped with a probe P/36R; 36 mm Ø Aluminium Radiused AACC according to texture profile analysis (TPA) procedure. The TPA procedure was carried with a double compression test to penetrate to 50% depth; the speed for pre-test, test, and post-test were 2 mm/s, 1 mm/s, and 5 mm/s respectively; distance: 10 mm; trigger type: auto force; and trigger force: 5 g. The three main textural parameters (hardness, springiness, cohesiveness) were evaluated three times for each banana cake sample (purée, LP, CP) at day 1, 3, 5, 7 and 9 of storage at room temperature.

Sensory evaluation

The hedonic test utilised in the sensory evaluation was used to determine the degree of overall acceptance of the prepared banana cakes. A total of 40 untrained voluntary consumers (aged between 20-28 with a balance ratio between male and female) were recruited among staff and students of the Faculty of Food Science and Technology, UPM, Malaysia. Panellists were asked to sit in individual sensory booths. Three freshly baked samples were coded with a random three-digit number, and were placed on white plates and evaluated for aroma, colour, firmness, taste and overall acceptability. All consumers received a tray containing three different samples of banana cakes (purée, LP, CP), a glass of water and an evaluation sheet. Then, participants were asked to evaluate preference levels for banana cakes using a nine-point hedonic scale with 9 indicating "extremely like", 5 indicating "neither like nor dislike" and 1 indicating "extremely dislike" (Austin and Ram, 1971, Hozova *et al.*, 2002). Participants were advised to rinse their mouth between testing the samples. The cakes were considered acceptable if the participants gave the mean scores for overall acceptance above five.

Statistical analysis

Normally-distributed datasets were analysed using Two-Way Analysis of Variance (ANOVA). To assess significant differences within each banana cake, storage time was selected as the factor. To assess significant differences between types of banana cake, the batch was chosen as the factor. Means were compared by the Tukey test at a significant level of ≤ 0.05 using the statistical software Minitab® version 16 (Minitab Inc.; Pennsylvania, USA).

Results and discussion

Water activities and moisture contents of different banana cakes

Table 1 shows the moisture contents (MC%) and water activities (a_w) for the three types of banana cakes (purée, LP, CP) throughout the nine days of storage at room temperature which clearly indicates significant difference ($p \leq 0.05$) between the different types of cakes. At all storage times evaluated, the control treatment (purée) exhibited significantly high MC% and a_w in comparison to LP (33% and 4.6%) and CP (47% and 7%). This result reflects Phisut's (2012) findings in which powder formed through drying could significantly reduce the MC% and a_w values. In a similar study, Saranraj and Geetha (2012) found that mould spoilage in baked goods could be controlled by maintaining an adequately low a_w. The lowering of a_w is related to the ability of dried powder which has good water-binding properties to lock up any free water that is available. Consequently, the lowering of MC% and a_w could help preserve the food as well as maintain the food quality.

It is also apparent that the longer the storage time, the lower the MC% and a_w albeit not significantly. This finding is similar to that of Secchi *et al.* (2017) who reported that the MC% and a_w of whey cheese cake decreased markedly during storage (60 days) but neither significantly nor drastically. Berry (2012) posited that the MC% in baked goods will reduce over time due to a particular process known as retrogradation, which is highly common in bakery products. This results in moisture loss which causes the crumbs of the baked goods to turn dry and hard. However, the quality of banana cakes in the present work was not significantly compromised as the reduction in MC% (18 – 31%) and a_w (0.82 – 0.91) was not drastic throughout the storage period.

Table 2: Fungal loads (log CFU/g) in banana cakes made from different raw ingredients during nine-day storage at room temperature.

Type of cake	Storage time (day)				
	1	3	5	7	9
Purée	<1^{Ad}	5.029^{Ac}	6.813^{Ab}	7.431^{Aa}	7.462^{Aa}
LP	<1^{Ab}	<1^{Bb}	<1^{Bb}	<1^{Bb}	4.398^{Ba}
CP	<1^{Aa}	<1^{Ba}	<1^{Ba}	<1^{Ba}	<1^{Ca}

Purée (control); LP (laboratory-formulated banana powder); CP (commercial banana powder). Data are means of triplicate (*n* = 3). Capital letters indicate significant difference (p ≤ 0.05) between type of cake, and small letters between storage time. SD values are too small to be included.Um non experat ectorionet quid ute rerenis qui ni volest eaquibe atiisqui sint aut eum conse veligent eos dolor rehenec aecus.

Fungal loads in different banana cakes

Table 2 shows the fungal loads (CFU/g) of the three types of banana cakes (purée, LP, CP) throughout the nine days of storage at room temperature. According to the microbial specification outlined by FDA (2013), the acceptable level of yeast and mould count in baked goods is < 10^2. Going by this specification, LP and CP cakes were considered acceptable for consumption up to day 7 as compared to purée which showed unacceptability in terms of fungal load as early as day 3. Interestingly however, although MC% and a_w of CP were significantly lower than LP as shown in Table 1, LP on the other hand exhibited significantly lower fungal load than CP at the end of storage (day 9). At this point, no possible explanation could be provided as to why the commercial CP yielded higher CFU/g as compared to our laboratory-formulated LP except for doing further chemical analysis to both types of powder in the near future. To our knowledge, the CP used was still within its expiry date. Additionally, microbial count ranging between 10^4 to 10^6 is considered borderline acceptable with count exceeding 10^6 is categorised as unsatisfactory due to health hazard or spoilage potential. This is because of food contaminated with germinated spores can cause disease and thus, not safe to be consumed. By this regulation, purée became unacceptable for consumption by day 5, CP by day 7, and LP remained below the permissible limit throughout the storage period tested (albeit borderline). In terms of visible fungal colonies on the cakes themselves (results unpublished; as opposed to the CFU evaluation by spread-plating onto PDA medium in Table 2), purée exhibited visible fungal colonies at day 5 and became heavily contaminated by yeasts and moulds by day 9 as opposed to both LP and CP which only showed minimal fungal colonies at day 9. This result is more or less in agreement with another study which reported that yeast and mould started to grow on cake kept at room temperature at

Table 3: Colour assessment of banana cakes made from different raw ingredients during nine-day storage at room temperature.

Type of cake	Storage time (day)	Colour assessment		
		L*	a*	b*
Purée	1	57.65 ± 0.29^{Aa}	3.24 ± 0.12^{Ca}	29.54 ± 0.07^{Aa}
LP		48.32 ± 0.16^{Cb}	8.55 ± 0.14^{Ab}	25.39 ± 0.04^{Bb}
CP		49.87 ± 0.03^{Bc}	4.55 ± 0.05^{Bc}	23.46 ± 0.06^{Cc}
Purée	3	57.73 ± 0.26^{Aa}	3.25 ± 0.05^{Ca}	29.51 ± 0.04^{Aa}
LP		48.32 ± 0.07^{Cb}	8.54 ± 0.09^{Ab}	25.46 ± 0.07^{Bb}
CP		49.75 ± 0.22^{Bc}	4.56 ± 0.06^{Bc}	23.49 ± 0.04^{Cc}
Purée	5	57.60 ± 0.15^{Aa}	3.32 ± 0.06^{Ca}	29.52 ± 0.13^{Aa}
LP		48.34 ± 0.09^{Cb}	8.61 ± 0.08^{Ab}	25.37 ± 0.07^{Bb}
CP		49.83 ± 0.07^{Bc}	4.62 ± 0.07^{Bc}	23.51 ± 0.08^{Cc}
Purée	7	–†	–†	–†
LP		48.25 ± 0.09^{Bb}	8.63 ± 0.03^{Ab}	25.44 ± 0.04^{Ab}
CP		49.88 ± 0.06^{Ac}	4.63 ± 0.06^{Bc}	23.48 ± 0.03^{Bc}
Purée	9	–†	–†	–†
LP		48.28 ± 0.10^{Bb}	8.63 ± 0.07^{Ab}	25.46 ± 0.07^{Ab}
CP		49.87 ± 0.08^{Ac}	4.62 ± 0.10^{Bc}	23.49 ± 0.10^{Bc}

†Measurement discontinued on account of heavy contamination by moulds

L* (lightness), a* (redness), b* (yellowness). Purée (control); LP (laboratory-formulated banana powder); CP (commercial banana powder). Data are means of triplicate (n = 3) ± SD. Capital letters indicate significant difference ($p \leq 0.05$) between type of cake, and small letters between storage time.

day 10 (Khaki *et al.*, 2012). From the consumers' perspective, any visible growth (*e.g.*, fungal cotton-like colonies, bacterial slime layers) on the food is sufficient to render it unacceptable for human consumption. Therefore, in this regard, LP and CP have evidently exemplified longer shelf life as compared to purée. It is also noteworthy that the high fungal load observed in purée corresponded well with the fact that it was the moistest (highest MC% and a_w) of all the three types of cakes analysed.

Another factor that should be seriously considered in shelf life extension is hygiene. Good hygiene practice (GHP) is crucial in order to prevent cross contamination. The contamination would normally occur during cooling process following baking and also during handling of the cake. In the present work however, hygiene practice was not assessed.

Colour assessment of different banana cakes

The colour data are expressed by L* (lightness), a* (redness), and b* (yellowness) values. As shown in Table 3, the result indicates that there was a significant difference ($p \leq 0.05$) between the three types of banana cake in terms of L*, a* and b* values. For L*, LP yielded the lowest values throughout the storage period which might possibly due to the formation of brown pigment during foam mat drying (Karabulut *et al.*, 2007). This was followed by CP and purée. For a*, LP yielded the highest values throughout the storage period which might be due to chemical changes from the heat applied during Maillard and caramelisation reactions, (Mehmet and Halis, 2008) and milling after foam mat drying. For b*, a slight reduction of yellowness was observed in both LP and CP as compared to control which might also be due to the powder drying. In terms of length of the storage time, no significant difference was observed in the L*, a*, and b* values as the samples progressed to day 9. This in turn might suggest that the loss of moisture had minimal effects on the colour. This result is similar to a previous study which reported no significant difference in the colour of different batches of cheesecake throughout a 60-day storage period (Secchi *et al.*, 2017). Overall, the loss of the moisture throughout the storage period did not affect the cake's colour. However, different formulations between the banana cakes which reduced the MC% and a_w had significant impact on colour parameters.

Textural analysis of different banana cakes

Table 4 shows the results for textural analysis for all the three types of banana cakes. The three textural parameters assessed were hardness, springiness and cohesiveness. Significant difference was observed between purée and both LP and CP powders on all parameters tested.

In term of hardness, purée was found to be significantly softer as compared to LP and CP which might be due to purée's higher MC%. This is parallel to the suggestion made by Rockland and Nishi

Table 4: Textural assessment of banana cakes made from different raw ingredients during nine-day storage at room temperature.

Type of cake	Storage time (day)	Textural assessment		
		Hardness	Springiness	Cohesiveness
Purée	1	889.75 ± 27.38^{Bb}	0.83 ± 0.01^{Aa}	0.58 ± 0.00^{Ab}
LP		961.79 ± 9.39^{Ad}	0.79 ± 0.00^{Ba}	0.55 ± 0.01^{Ba}
CP		963.88 ± 37.22^{Ac}	0.79 ± 0.00^{Ba}	0.55 ± 0.00^{Bd}
Purée	3	922.93 ± 22.32^{Bab}	0.82 ± 0.00^{Aa}	0.58 ± 0.00^{Ab}
LP		985.85 ± 15.98^{Acd}	0.78 ± 0.00^{Ba}	0.55 ± 0.01^{Bb}
CP		1023.97 ± 24.82^{Ac}	0.77 ± 0.00^{Bb}	0.55 ± 0.00^{Bcd}
Purée	5	944.42 ± 10.85^{Ba}	0.82 ± 0.01^{Aa}	0.59 ± 0.00^{Aa}
LP		1014.36 ± 17.80^{Abc}	0.76 ± 0.01^{Bb}	0.57 ± 0.01^{Abb}
CP		1102.33 ± 16.29^{Ab}	0.77 ± 0.01^{Bb}	0.57 ± 0.02^{Abc}
Purée	7	–†	–†	–†
LP		1040.07 ± 24.50^{Bb}	0.75 ± 0.00^{Ac}	0.57 ± 0.01^{Ab}
CP		1275.76 ± 13.89^{Aa}	0.76 ± 0.00^{Ab}	0.58 ± 0.00^{Ab}
Purée	9	–†	–†	–†
LP		1136.37 ± 21.40^{Ba}	0.74 ± 0.00^{Ac}	0.63 ± 0.03^{Ab}
CP		1288.59 ± 23.04^{Aa}	0.76 ± 0.01^{Ab}	0.65 ± 0.01^{Aa}

†Measurement discontinued on account of heavy contamination by moulds

Purée (control); LP (laboratory-formulated banana powder); CP (commercial banana powder). Data are means of triplicate (n = 3) ± SD. Capital letters indicate significant difference ($p \leq 0.05$) between type of cake, and small letters between storage time.

(1980) that the texture becomes juicier, moist, tender and chewy when the food has high MC% and a_w. In term of springiness, LP and CP were found to be significantly less springy as compared to the tender control. This is true as the cake becomes harder, the less springy it would be as evidenced in LP and CP which exhibited lower values of springiness. Similar trend was observed for cohesiveness which strongly suggests that banana cake made using purée (with high MC%) attained greater springiness and cohesiveness as compared to both LP and CP.

Throughout the storage time, all samples of banana cakes exhibited textural changes in which the banana cakes became harder, less springy and more cohesive. As discussed earlier, this might be due to retrogradation. Similar result was obtained in a previous study related to prolonged storage of par-baked cakes (Mehmet and Halis, 2008) which demonstrated that longer storage period resulted in a decrease in MC% and caused more brittle-like texture. Overall, all textural parameters assessed were correlated with each other, with the changes in one parameter affected the other. This textural determination is essential as it could well describe the effects on consumers' sensory and perception.

Sensory evaluation of different banana cakes

Sensory analysis was conducted on the three types of freshly baked banana cakes based on five attributes which included aroma, colour, firmness, taste and overall acceptability, as presented in Table 5. Significant differences were noted between all types of banana cakes in which purée scored the highest followed by LP and CP. This finding is similar to a research by Ratti (2001) who postulated that using dried powder instead of fresh fruit mash might affect the colour, texture and also biochemical reactions such as loss of aromatic compounds as well as nutritional values. Lower scores of the modified banana cakes could also be influenced by the overall perception of the consumers which was ascribed by the modified cakes' appearance and the sensation of their textures. Referring to colour assessment, consumers would often have their own default perception of what a banana cake should look like which closely resembles the natural banana colour. However, due to the drying of banana powder, the modified banana cakes appeared in a slightly pale looking colour that did not well describe or reflect the natural sight or taste of banana. Additionally, the sensation of tasting the modified cakes could also have influenced the sensory scores. Similarly, most fruits have their own distinct moist taste that distinguishes them from other fruits. Reducing the moisture might consequently render the cake to be slightly dry and brittle which could have influenced the panellists to prefer the control cake over the modified cakes. Nevertheless, based on the result for overall acceptability, panellists were still able to accept the modification made on the banana cakes (scores > 5; Austin and Ram, 1971).

Table 5: Sensory evaluation of banana cakes made from different raw ingredients using a nine-point hedonic scale with 9 indicating "extremely like" and 1 indicating "extremely dislike".

Sensorial attribute	Type of cake		
	Purée	LP	CP
Aroma	7.50 ± 1.69^a	6.05 ± 1.62^b	6.18 ± 1.60^b
Colour	7.40 ± 1.55^a	5.40 ± 1.03^c	6.13 ± 1.42^b
Firmness	7.43 ± 1.24^a	6.40 ± 0.87^b	6.03 ± 1.39^b
Taste	7.60 ± 1.35^a	6.60 ± 0.90^b	6.03 ± 1.29^b
Overall Acceptability	7.90 ± 1.10^a	6.45 ± 1.26^b	6.38 ± 1.23^b

Purée (control); LP (laboratory-formulated banana powder); CP (commercial banana powder). Data are means of scores from 40 panellists (n = 40) ± SD. Small letters indicate significant difference ($p \leq 0.05$) between type of cake.

Conclusions

In the present work, the modification of banana cake by using banana powder as a replacement of banana purée resulted in the extension of the product's shelf life from four days to nine days during storage at room temperature. The extension of the shelf life came from incorporating banana powder which reduced MC% and a_w of the resulting cakes and subsequently delayed mould growth. However, this modification slightly affected the textural parameters (hardness, springiness, cohesiveness) and the colour of the banana cake which in turn affected the perception and sensory scores by the panellists. Nevertheless, the panellists still deemed the sensory attributes as unimpaired and acceptable. Future works are therefore warranted such as combining this with other hurdle and packaging technology that could further delay microbial growth without impairing the quality and sensory of the end product.

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