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Formulation and Physicochemical Properties of Meatless Floss

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Abstract: Meat is perishable food susceptible to chemical deterioration and microbial growth, thus it can be processed into other food products such as meat floss to increase the shelf life. Excessive consumption of red meat and processed meat leads to health problems such as cardiovascular disease and obesity, while meatless products are nutritious which can be part in a healthy diet. Therefore, meatless floss made from young jackfruit and banana blossom was developed in this study. This study aimed to develop and characterize the different proportion of young jackfruit and banana blossom in meatless floss formulation. Simplex lattice design was used in generating the proportion of young jackfruit and banana blossom. Sensorial properties, physicochemical properties and textural properties were then evaluated. The sensory evaluation using affective test showed no significant difference ($p > 0.05$) between the floss samples because the panelists could not distinguish the difference. The physicochemical properties of the floss samples including moisture content, ash content, texture and color had significant difference ($p < 0.05$). The optimized meatless floss was 100% banana blossom. The findings conclude that the banana blossom has potential to be used as meat replacer.

Keywords: Meatless floss, Young Jackfruit, Banana Blossom, Simplex Lattice Design, Physicochemical Properties, Optimized Meatless Floss

1. Introduction

Meat is perishable food that can be processed into other food products to prolong the shelf life such as meat floss. Meat floss was usually made from chicken, beef or fish which are popular among Malaysians. Recently, the young generation prefer healthier foods to overcome the health problems due

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to modern diets that include foods with high intake of processed meat, sugar, oils and fats [1]. Meatless products are in high demand with worldwide market worth of US $7.9 billion in 2022 due to growth of flexitarian and vegetarian lifestyles [2]. Meatless product brands like Harvest Gourmet and Quorn developed meatless burger patties to resolve the lower consumption of healthy foods, yet they are not widely known in Malaysia because they are only commercialized in higher-priced supermarkets in urban Kuala Lumpur like Klang Valley [3].

Meat floss can be substituted with plant sources for a healthier option and provide nutrients like protein, vitamins and minerals. In this study, meatless floss made from young jackfruit and banana blossom was developed to increase the consumption of fruits and vegetables as part of healthy diet and diversify meatless products in the market which beneficial to individuals who practice flexitarian and vegetarian lifestyles. The flesh of young jackfruit and banana blossom is rich in nutrients and has a mild flavor [4] that can easily absorb flavors, making them ideal meat substitutes. Besides, young jackfruit has a stringy and tender texture like shredded chicken [5] while banana blossom has a flaky texture which the best alternative for fish [6].

The aim of this research was to develop and characterize optimized meatless floss formulation based on sensory attributes and physicochemical properties analysis for floss quality including moisture content, ash content, protein content, texture and color. The variety used for young jackfruit was Tekam Yellow (J33) or known as 'Nangka Madu' and banana blossom from pisang Nipah (*Musa balbisiana*). The optimized meatless formulation is expected to achieve the floss standard quality and determined based on textural properties of firmness.

2. Materials and Methods

2.1 Materials

The young jackfruit and banana blossom were obtained from Kampung Pauh, Kuala Pilah, Negeri Sembilan, Malaysia and Simpang Renggam, Kluang, Johor, Malaysia, each. Chicken breast, coconut milk (Kara, Pt. Riau Sakti United Plantations, Indonesia), cooking oil (Seri Murni, FFM Berhad, Malaysia), chilli paste (Adabi, Adabi Consumer Industries Sdn. Bhd., Malaysia), tamarind paste (Adabi, Adabi Consumer Industries Sdn. Bhd., Malaysia), coarse sugar (Gula Prai, MSM Prai Berhad, Malaysia), salt (Adabi, Adabi Consumer Industries Sdn. Bhd., Malaysia), cumin powder (Baba's, Baba Products (M) Sdn. Bhd., Malaysia), coriander powder (Baba's, Baba Products (M) Sdn. Bhd., Malaysia), shallots, garlic, ginger, galangal, fresh turmeric and lemongrass were purchased from the local supermarket in Pagoh, Muar, Johor, Malaysia.

2.2 Preparation and formulation of floss

The method of cooking was taken from Bujang *et al.* [7] for preparation of floss mixture. The chicken floss preparation was adopted from Abd Rashid *et al.* [8] and Umar and Mohammed [9]. The preparation of young jackfruit was followed from Islam *et al.* [4] and pre-treatment method by Paranagama *et al.* [10]. Banana blossom was prepared according to Chaiwongsa *et al.* [11]. Then, the flesh of each sample was shredded into floss-like texture and cooked in the floss mixture over low heat until thickened and dried. Finally, each floss sample was cooled and stored in a plastic container at room temperature.

A simplex lattice design was selected to generate a meatless floss formulation as it has a small number of components consisting of young jackfruit and banana blossom. Seven formulations of young jackfruit and banana blossom suggested by the mixture design statistical software (Design Expert software, Version 13, USA) with proportions between 0 and 100% as shown in Table 1 and chicken floss as the control sample.

Table 1: Proportion of young jackfruit and banana blossom for meatless floss formulation

Formulation	Young jackfruit (%)	Banana blossom (%)
F1	66.7	33.3
F2	100.0	0.0
F3	25.0	75.0
F4	33.3	66.7
F5	0.0	100.0
F6	50.0	50.0
F7	75.0	25.0

2.3 Sensory evaluation

Sensory evaluation test was adopted from Bujang *et al.* [7] with 50 untrained panelists randomly selected among students of Universiti Tun Hussein Onn Malaysia. Affective test was used to determine the panelist preference based on sensory attributes such as taste, texture, color and overall acceptability using 9-point hedonic rating scale.

2.4 Moisture content

Moisture analyzer (MX-50, A&D, Japan) was used to measure the moisture content using the method from Asman and Mahadi [12] by drying 5 g of each floss sample at 70℃ until reach the equilibrium value with triplicate measurements.

2.5 Ash content

The dry ashing method was referred from AOAC International Methods 923.03 [13] which 5 g of each floss sample was incinerated in the muffle furnace (RHF 16-8, Carbolite, USA) for 18 hours at 550℃. The ashed sample was weighed after cooling and the ash content was calculated using Equation 1.

$$\%Ash = \frac{Crucible\ and\ ashed\ sample\ weight - crucible\ weight}{Crucible\ and\ sample\ weight - crucible\ weight} \times 100 \qquad Eq.1$$

2.6 Protein content

The protein content was measured using Fourier-transform Infrared Spectrometer (FTIR) (Cary 630 FTIR, Agilent Technologies, USA) by following the method from Sjahfirdi *et al.* [14]. The amide functional group and wavenumbers was referred to Fuzi *et al.* [15]. The protein content was calculated by comparing the absorption value of the sample with the absorption of fatty acid functional group in control sample that was detected at 1743 cm^{-1}.

2.7 Texture

The firmness of the floss samples was determined using texture analyzer (TA.XT Plus, Stable Micro System, USA) with 5 kg load cell of shear probe by following the procedure from Cavitt *et al.* [16]. Data points were collected at a rate of 200 points/s and the analysis was replicated twice.

2.8 Color

The color intensity was analyzed using colorimeter (Miniscan EZ, Hunter Lab, USA) to measure lightness (L*), redness (a*) and yellowness (b*) values by putting 1 g of each floss sample into a plastic petri dish which the method was referred to Chakraborty *et al.* [17]. The measurements were recorded in triplicate.

2.9 Statistical analysis

One-way analysis of variance (ANOVA) was conducted using statistical software (IBM Statistical Package for the Social Science (SPSS) software, Version 20, New York) for sensory evaluation and physicochemical properties analysis to determine significant difference ($p < 0.05$) between the floss samples. The comparison test by Tukey's multiple range test was conducted for samples with significant difference.

2.10 Mixture optimization

The numerical optimization method was applied to determine the optimized meatless floss formulation based on textural properties of firmness. The suggested proportions of young jackfruit and banana blossom with firmness values as responses were run in the software with desirability of 1. The predicted value of the optimized formulation and expected value from the actual experiment was compared to validate the similarities with error below than 10% [18] by calculating using Equation 2.

$$Error = \frac{|Predicted\ value - Expected\ value|}{Predicted\ value} \times 100 \qquad Eq.2$$

3. Results and Discussion

3.1 Sensory evaluation

The mean scores of the floss samples based on sensory attributes of taste, texture, color and overall acceptability were depicted in Table 2. The sensory attributes scores between the floss samples showed no significant difference ($p > 0.05$) as the panelists could not distinguish the differences. All samples had similar taste due to mild flavor [4] flesh of young jackfruit and banana blossom that absorb the flavors of floss mixture. Besides, young jackfruit and banana blossom have tender and flaky textures similar to shredded chicken [5,6]. The color was also identical which golden-brown color since had an initial off-white color. There was not much different for overall acceptability of the floss samples.

Table 2: Sensory attributes of the floss samples

Coded sample	Taste	Texture	Color	Overall acceptability
417 (Control)	6.18±0.29[a]	6.28±0.28[a]	6.44±0.31[a]	6.56±0.29[a]
585 (F1)	5.88±0.24[a]	6.26±0.22[a]	6.46±0.21[a]	6.26±0.20[a]
321 (F2)	5.80±0.25[a]	5.78±0.26[a]	6.20±0.24[a]	6.08±0.24[a]
780 (F3)	5.82±0.21[a]	5.92±0.20[a]	6.30±0.20[a]	6.02±0.19[a]
927 (F4)	6.26±0.21[a]	6.18±0.21[a]	6.46±0.22[a]	6.42±0.20[a]
646 (F5)	5.98±0.19[a]	6.16±0.22[a]	6.40±0.20[a]	6.30±0.20[a]
163 (F6)	6.34±0.20[a]	6.18±0.19[a]	6.68±0.21[a]	6.36±0.21[a]
459 (F7)	5.78±0.24[a]	6.04±0.23[a]	6.56±0.21[a]	5.98±0.22[a]

[a]Different small case superscript letters in the table indicate a significant difference ($p < 0.05$), with the same letters show an insignificant difference ($p > 0.05$) on sensory attributes.

3.2 Moisture content

Floss made from 100% banana blossom had the lowest moisture content of 24.01% while floss made from 100% young jackfruit had the highest moisture content of 36.82% as shown in Table 3 and had significant difference in all floss samples ($p < 0.05$). Young jackfruit flesh was boiled longer as it has firmer texture than banana blossom, hence increasing of water content. Boiling caused the starch in the young jackfruit gelatinized and the granules expanded by absorbing water which led to increase in volume and lower the density [19]. The standard quality of floss product should contain moisture content lower than 7% [20]. All the floss samples do not achieve the requirements for standard quality of floss because the moisture content exceeds the maximum value. Similarly, the moisture content of Malaysian commercial chicken floss was 12.01 to 13.56% which failed to achieve the standard floss quality [21]. The moisture content of the floss samples was above the range value for intermediate moisture products which should be less than 20% moisture [22], but can be stored in chilled storage at 2 to 4℃ to prolong the shelf life. Fish floss with high moisture content kept in chilled storage for 4 weeks was stable with no effects on sensory qualities [23].

3.3 Ash content

The highest ash content was found in 100% banana blossom floss with 5.75% while the lowest ash content of 2.74% was obtained in chicken floss as the data shown in Table 3 and there was significant difference between the floss samples ($p < 0.05$). The various mineral contents in each floss sample resulting differences in ash content as the processing of the initial flesh affected the availability of minerals during washing, soaking and boiling [20]. The banana blossom flesh had minimal loss of minerals due to instant blanching of the flesh. The ash content of the meatless floss increases when the ratio of banana blossom increases. In previous study, little tuna with added banana blossom floss also had high ash content of 4.45 to 5.68% [24]. The standard quality of floss product for ash content should contain maximum of 7% [20]. All the floss samples achieved the requirements for standard quality of floss because the ash content was lower than the maximum value.

3.4 Protein content

The control floss sample made of chicken had the highest amount of protein with 28.11% and the protein content among the meatless floss ranges from 16.46 to 16.51% as depicted in Table 3 which had no significant difference between the floss samples ($p > 0.05$). The initial protein content in both flesh of young jackfruit and banana blossom are low with 1.45% [25] and 1.60% [26], respectively. Addition of dietary spices like mature ginger, turmeric, coriander powder and cumin powder boost the protein content in the floss samples which they are moderately good source of protein [27]. Meat floss contains about twice the protein content per unit weight of raw meat which also incorporates dietary spices [28]. The previous study on protein content in beef sausages included with unripe jackfruit was 10.47 to 16.74% [29] and little tuna with added banana blossom floss had 14.79 to 18.02% [24] which the beef and little tuna increase the amount of protein. The standard quality of floss product should contain minimum 15% of protein content [20]. The protein content in the floss samples met the requirements for standard quality of floss which was greater than 15%.

Table 3: Moisture, ash and protein content of the floss samples

Sample	Moisture content (%)	Ash content (%)	Protein content (%)
Control	24.39 ± 1.38^{cd}	2.74 ± 0.001^{d}	28.11 ± 13.36^{a}
F1	26.79 ± 1.30^{b}	4.02 ± 0.001^{bc}	16.51 ± 3.20^{a}
F2	36.82 ± 0.84^{a}	3.44 ± 0.002^{c}	16.50 ± 3.20^{a}
F3	24.88 ± 0.47^{b}	4.75 ± 0.006^{b}	16.47 ± 3.27^{a}
F4	26.16 ± 0.51^{b}	4.13 ± 0.002^{b}	16.46 ± 3.26^{a}
F5	24.01 ± 0.75^{d}	5.75 ± 0.002^{a}	16.46 ± 3.25^{a}
F6	27.46 ± 0.90^{b}	4.10 ± 0.001^{b}	16.51 ± 3.19^{a}
F7	25.91 ± 0.68^{c}	4.78 ± 0.001^{b}	16.46 ± 3.10^{a}

[abcd]Different small case superscript letters in the table indicate a significant difference ($p < 0.05$), with the same letters show an insignificant difference ($p > 0.05$) on each of the parameters.

3.5 Texture

The firmness in chicken floss had the highest value of 125.03 N and the lowest value of 13.36 N in 100% young jackfruit floss as shown in Table 4 and firmness corresponds with hardness. The firmness values between the floss samples had significant difference ($p < 0.05$). High firmness value in chicken floss related with protein coagulation during cooking as chicken is a high protein food that gives a firm-elastic texture [28] compared to low protein content in young jackfruit. The soft and stringy texture of young jackfruit when cooked also contributed to low firmness value which proven by Faujan *et al.* [29] that the hardness did not affect significantly ($p > 0.05$) with added young jackfruit in the beef sausage. The firmness in banana blossom floss was higher than young jackfruit because it is a great source of dietary fiber [30]. Besides, the hardness increased as various levels of banana blossom replaced shiitake mushroom in the mushroom balls [11]. Based on the one-way ANOVA analysis, the sensory attributes for texture showed no significant difference ($p > 0.05$) but had significant difference ($p < 0.05$) when using texture analyzer. Food texture evaluation by human requires specific judgement skills while instrumental techniques can characterize complex characteristics of food texture [31].

3.6 Color

The color measurement of L*, a* and b* are shown in Table 4 with chicken floss had the highest values for color while 100% banana blossom floss had the lowest values for color. There was significant difference ($p < 0.05$) in color between the floss samples. The flesh of boiled chicken meat, young jackfruit and banana blossom had an off-white color. Throughout the cooking of the floss, non-enzymatic browning called Maillard reaction and caramelization reaction occurred which correlated with the brown color in the floss samples. The ingredients used in the floss mixture contributed to differences for color characteristics [21]. The yellowness values were higher than redness values due to curcumin content pigment from turmeric to provide yellowish color in the floss mixture. The young jackfruit floss and banana blossom floss were slightly darker than chicken floss because the flesh was oxidized during cutting although pre-treatment was done. The standard quality of floss for color is acceptable with desirable color of golden-brown [20].

Table 4: Texture and color measurement (L*, a* and b*) of the floss samples

Sample	Texture (N)	L*	a*	b*
Control	125.03±0.69^{a}	28.06±0.05^{a}	18.70±0.01^{a}	31.16±0.07^{a}
F1	78.70±36.83^{ab}	21.06±0.02^{ab}	12.75±0.03^{b}	17.47±0.15^{bc}
F2	13.36±3.21^{d}	22.80±0.08^{ab}	14.16±0.04^{ab}	20.76±0.10^{bc}
F3	60.26±21.36^{bc}	20.27±0.03^{b}	11.79±0.06^{c}	15.75±0.13^{c}
F4	43.58±1.74^{c}	19.90±0.02^{cd}	12.74±0.03^{b}	16.82±0.04^{bc}
F5	97.91±1.51^{b}	18.21±0.05^{d}	10.14±0.05^{d}	13.91±0.10^{d}
F6	125.03±0.69^{a}	28.06±0.05^{a}	18.70±0.01^{a}	31.16±0.07^{a}
F7	78.70±36.83^{ab}	21.06±0.02^{ab}	12.75±0.03^{b}	17.47±0.15^{bc}

^{abc}Different small case superscript letters in the table indicate a significant difference ($p < 0.05$), with the same letters show an insignificant difference ($p > 0.05$) on each of the parameters.

3.7 Optimization and validation of formulation

Firmness was selected as optimization factor because there was difference in texture between human perception and use of equipment. The optimum proportion was 100% banana blossom with desirability of 1 which the formulation had a desirable firmness for consumer preference. The predicted value of the response and the experimental value from the experiment were compared which 98.989 N and 92.21 N, respectively to validate the model. The error obtained was 6.85% which close to the accepted value as it has small percent error. The calculated standard error, coefficient of variance (CV) and mean difference were shown in Table 5.

Table 5: Predicted and experimental value of firmness

Formulation	Young jackfruit (%)	Banana blossom (%)	Response	Predicted value (N)	Experimental value (N)	Standard error	CV (%)	Mean difference
F5	0.0	100.0	Firmness	98.989	92.21±3.19	2.26	3.46	6.78

4. Conclusion

This study evaluated that the meatless floss made from young jackfruit and banana blossom had similar sensory attributes with chicken floss. The meatless floss only achieved standard quality of floss for ash content, protein content and color that ranges within the required value. The optimized meatless floss based on firmness with optimum proportion of 100% banana blossom. The development of meatless floss can contribute to the growth of meatless products and improve lifestyles by practicing a healthy diet.

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