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Physicochemical Properties and Sensory Evaluation of 'Keropok Lekor Banana Heart'

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Abstract

The Keropok Lekor Banana Heart is a new snack product designed to promote its nutritional value. The product's physicochemical properties were thoroughly examined, providing insights into its composition and potential health benefits. The formulation was optimized using the simplex lattice mixture design method, facilitated by Design Expert software. This innovative approach not only introduces a unique product to the market but also addresses the dietary needs of individuals allergic to fish, a common ingredient in traditional keropok lekor. Formulation 13 (grated coconut, oyster mushroom, potato) has the highest moisture level ever measured, with an impressive 48.41% moisture content. Formulation 13 (30.61±1.05) has a much higher lightness than the other formulations when it comes to L* values, which measure the lightness of keropok lekor. The pH of all keropok lekor banana heart composition is ranging from 5.9 to 7.2. Formulation 1 records the shear value and firmness for physicochemical parameters. The sensory evaluation revealed that all 13 variations of the Keropok Lekor Banana Heart were well-accepted by panelists. The nutritional analysis highlighted the richness of vital vitamins, minerals, and dietary fiber in the new formulation, positioning it as a healthful complement to a balanced diet.

1. Introduction

Banana heart, the flower of a banana bunch (Musa spp.), is a byproduct of bananas (*Musa Paradisiaca*). While people typically consume only ripening bananas, banana hearts in Malaysia include Banana Heart Nipah, Banana Heart Nangka, Banana Heart Embun, and Banana Heart Raja, are taken as ulam die to their high fiber content [1]. The fiber content component of banana hearts can aid digestion as well as bind fat and cholesterol thrown away with the dirt. Because it improves blood circulation and is anticoagulant (prevents blood clotting), the banana heart can also help us avoid heart disease and stroke. The outside is dark reddish-brown-purple, and the inside is white and creamy. Between the petals (sheaths) is a fruit (comb), and in the middle is a soft flower stalk (rahis) [2]. Since the structure of the fibres in banana heart is the same as that of meat fibres ,it can be added to prepared fish flesh like keropok lekor banana heart [3].

'Keropok Lekor,' a traditional processed fish product and popular street food in Terengganu, Malaysia [4], is made by blending fish flesh, sago flour, and flavour enhancers. In Malaysia, the fish processing industry is an agro business that uses fisheries products as raw material and produces fish by products (FBPs), which account for around 36% of total fish weight [Rozaini, 2018]. The best fish to be used for creating keropok lekor was 'ikan

selayang'. Fish is the main ingredient in keropok lekor to vegetarian diet is replacing protein as the major source in our body. Protein should be obtained from a range of plant sources by vegetables. 'Keropok lekor' is made up of minced freshwater fish, water, sago flour or/and tapioca flour, salt, monosodium glumate (MSG), sugar and flavoring. The process of making 'keropok lekor' is divided inti five stages: mincing, combining the minced fish with other ingredients, kneading and shaping the dough, frying and chilling the result before packing [4].

Vegetarian diets exclude meat, poultry, and fish, whereas vegan diets exclude dairy products and eggs. Cross-sectional studies of vegetarians and vegans have revealed that they had a lower BMI and a lower plasma cholesterol concentration on average [5]. Textured proteins, the major component of which is soy, are a popular ingredient in vegan food items. They are part of the vegan diet because they are high in fibre, low in fat, have no cholesterol, and have a low-calorie level; also, they retain a rubbery texture that resembles meat [6].

According to Bredehorst *et al.,* (7), allergies develop in response to certain proteins known as allergens, which can cause rapid (Type I) hypersensitivity responses. Allergy is a multistep process, and the processes that lead to sensitization, IgE antibody formation, and allergic disorders are complicated and not entirely understood. The binding of at least two Ige antibody molecules to a multivalent allergenic protein, on the other hand, is the critical step in particular allergic response. As a result, allergens have been classified based on their structural, biochemical, and functional similarities. There is evidence that some allergens have intrinsic adjuvant characteristics that promote innate immunity.

The objective of this study was to analyze physicochemcal properties of keropok lekor banana heart. This involved detailed of physiochemical properties such as moisture content, ph, color and texture analyzer. Secondly, the study evaluated the sensory acceptability of keropok lekor banana heart. This involved details such as appearance, aroma, color, taste, texture and overall acceptance. Lastly, to optimize keropok lekor banana heart formulation with grated coconut, oyster mushroom or potato using Design Expert Software (Stat-Ease, Inc., Trial Version 13.0.11.0, Minneapolis, USA).

2. Methodology

2.1 Materials

Banana heart, wheat flour, tapioca starch, baking powder, salt, grated coconut, oyster mushroom and potato were purchased at L& L supermarket in Pagoh Jaya, Pagoh.

2.1.1 Preparation of Keropok Lekor Banana Heart

The method of production of keropok lekor banana heart is cleaned by cutting off any parts that cannot be used before being peeled and cut into a smaller piece. After being cutting into small pieces, the banana heart is soaked in a salt solution for 30 minutes before being cleaned. Finally, heart bananas are boiled for 30 minutes [8]. After filtering the banana heart, it is necessary to rinse it in three separate batches of water, need to blend the banana heart first. After blend by using blender, the banana heart need to mixed with that component (grated coconut, oyster mushroom and potato). Mixed all the ingredient from blended banana heart, three component, wheat flour, tapioca flour, baking powder, and salt. After all the ingredient are mixed, need to make a cylinder of 1.5 cm in diameter and 5 cm in length was formed. Placed the shaped dough into boiling water and wait until the keropok lekor floats. Then, transfer the keropok lekor to the full of bowl of ice and water a minute. After that, take out the keropok lekor sample and leave keropok lekor on room temperature for 10 minutes. Deep fried the keropok lekor for one and a half minutes at 180°C [9]. According to amount of formulation that has been set in Table 1. The keropok lekor banana heart were frozen and then fried for sensory testing.

2.2 Experimental design on optimization process for the preparation of keropok lekor banana heart by using Simplex-centroid Mixture Design from Design Expert 13 (Trial version)

The Design Expert software (Stat-Ese, Inc., Trial Version 13.0.11.0, Minneapolis, USA) was used in determining the formulation of three components in keropok lekor banana heart. Table 1 shows the experimental design of three components in keropok lekor banana heart formulation according to Mixture Design.

Table 1 *Experimental design of keropok lekor banana heart formulation according to Mixture Design*

	Grated coconut (g)	Oyster mushroom (g)	Potato (g)
*1	0	0	345
2	115	115	115
#3	0	345	0
4	57.5	230	57.5

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5	230	57.5	57.5
*6	0	0	345
7	172.5	0	172.5
^8	345	0	0
9	0	172.5	172.5
#10	0	345	0
11	172.5	172.5	0
^12	345	0	0
13	57.5	57.5	230

Duplicate samples are denoted by the same symbol (*, #, ^). Value was expressed in mean ± standard deviation in triplicate.

2.3 Physicochemical Properties Analysis

2.3.1 Moisture content

A moisture analyzer (Thermo Scientific, Eutech Ph 700) was used to determine the moisture content of each formulated keropok lekor banana heart. The plate was calibrated first. 1 grams of each sample was put in the aluminium dish, heated for 20 minutes at 170 degree Celcius.

2.3.2 Color

The CIE system approqch (L*, a*, and b*) were used todetermine the color of each of the formulated keropok lekor banana heart by using handheld spectrophometer (MiniScan EZ 500: Portable Spectrophotometer). The cooked keropok lekor banana heart's colour was be assessed using a calorimeter and represented by lightness level (L*), redness level (a*), and yellowness level (b*) [10].

2.3.3 pH

A pH meter (Thermo Fisher Scientific, Ottawa, ON, Canada) was used to measure the pH of each formulated keropok lekor banana heart. Each sample of formulated keropok lekor banana heart with weight 20g of each formulated were homogenized with 20 ml deionized distilled water for 2 minutes [11].

2.3.4 Texture Profile Analysis (TPA)

A texture analyzer (TA.XTplusC Stable Micro System Ltd., Godalming, United Kingdom) was used for determining TPA via measuring the firmness and work of shear of each of the formulated keropok lekor banana heart. The longest side of samples was cut parallel at 1x2x5 cm to the principal axis of the myofibre. Up until 80% of penetration, they were sheared perpendicular to the fibre axis, and the biting force was measured in Newtons [12].

2.4 Nutritional value

2.4.1 Carbohydrates content

The differential weight of all components was used to determine the carbohydrate content. The value was calculated by subtracting all other components percentages (protein, fat, ash and moisture content). The percentage of scavenging activity was calculated using Equation (1):

$$\text{Total carbohydrate (\%)} = 100\% - \%\,(\text{Protein} + \text{Moisture} + \text{Ash} + \text{Total Fat}) \quad (1)$$

2.4.2 Protein content

The protein content of the keropok lekor banana heart sample was determined using a Kjeldahl apparatus in accordance with AOAC (2000) recommendations. The 1 g of sample keropok lekor banana heart was treated with catalysts before digestion, and then 12 mL of concentrated sulfuric acid, along with 2 tablets of Cu 3.5 catalyst sulfuric acid (H_2SO_4) was added. The percentage of scavenging activity was calculated using Equation (2) :

$$\% \text{ N} = \frac{0.1 \times (A-B) 14.007 \times 100}{weight\ of\ sample\ (g) \times 1000} \times 100 \qquad (2)$$

2.4.3 Fat content

The Soxhlet extraction method was used to calculate the amount of crude fat, which is specified in the AOAC (2000). 2 g of sample will be placed in a thimble, and inserted into the Soxhlet extraction device and coated with fat-free cotton. The percentage of scavenging activity was calculated using Equation (3):

$$\text{Fat (\%)} = \frac{W_3 - W_1}{W_2} \times 100 \qquad (3)$$

2.4.4 Energy content

The method of AOAC, Association of Official Analytical Chemists (AOAC,2000) was determined the energy content analysis on the keropok lekor banana heart. The energy content was calculated by multiplying the amount of protein, fat and carbohydrate with their specific physiological energy values and then calculated values was summed up. The percentage of scavenging activity was calculated using Equation (4):

$$\text{Energy(kcal)} = (4 \times carbohydrate)\ g + (4 \times protein)\ g + (9 \times fat)\ \text{g} \qquad (4)$$

2.4.5 Total sugar

The total sugar content of the sample will be measured as instructed in (AOAC 923.09, Lane-Eynon titration 2000). Prior to sample analysis, the sucrose solution will be standardised. 100 mL of distilled water and 10 g of the sample keropok lekor banana heart was combined, then the mixture was neutralised with 1 N NaOH.

2.4.6 Sodium content

Sodium content was determined by Mohr titration method. By knowing the amount of chloride ions that need to be titrated with AgNO3 will find the sodium ions content of keropok lekor banana heart [13].

2.4.7 Moisture content

The AOAC [14] was used to determine the moisture content of the patty sample. First, the weight of the cleaned and dried aluminum dish was calculated, and 5 g of sample patties was transferred and weighed with its contents. After that, the dish and its contents was heated for 3 hours in a 105°C oven. After drying, the sample was cooled in desiccators before reweighed until it reaches a steady weight. The percentage of scavenging activity was calculated using Equation (5) :

$$\text{Moisture (\%)} = \frac{W_2 - W_3}{W_2 - W_1} \times 100 \qquad (5)$$

2.4.8 Ash content

The total ash content of the sample was measured as instructed in AOAC (2000). Around 5 g of the sample was placed in the crucible. The sample was placed in a muffle furnace at 555°C for 5 hours. The crucible was removed and cooled to room temperature in a desiccator. The percentage of scavenging activity was calculated using Equation (6):

$$\text{Ash (\%)} = \frac{W_3 - W_1}{W_2} \times 10 \qquad (6)$$

3. Results and Discussion

3.1 Physicochemical analysis

3.1.1 Moisture content

Moisture content in food that impacts the keropok lekor are from taste, texture, appearance, shape and weight. In this research, there were significant *($p<0.05$)* differences among all the formulation. Table 2 shows the data

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obtained for moisture content in keropok lekor banana heart formulation. The moisture content of all 13 formulation of keropok lekor banana heart were analyzed by using moisture.

Table 2 *Moisture of keropok lekor banana heart*

Formulation	Moisture (%)
1	42.20 ± 0.007
2	44.29 ± 0.012
3	47.09 ± 0.006
4	47.59 ± 0.011
5	43.50 ± 0.007
6	42.20 ± 0.007
7	45.28 ± 0.006
8	41.09 ± 0.004
9	47.26 ± 0.007
10	47.09 ± 0.006
11	43.51 ± 0.005
12	35.55 ± 0.004
13	48.41 ± 0.003

Moisture content in food that impacts the keropok lekor are from taste, texture, appearance, shape and weight. Table 2 shows the data obtained for moisture content in keropok lekor banana heart formulated with different component.

The combination 57.5gram grated coconut, 57.5gram oyster mushroom and 230gram potato, with a moisture content of an astounding 48.41%, formulation 13 has clearly emerged as the highest recorded option. Contrary to common assumption, potatoes are mostly constituted of water, with about 80% of their composition coming from water by George, 2023 [15]. This formulation in moisture retention because it contains grated coconut, which is known for its inherent moisture content, as well as potatoes and oyster mushroom. Comprehending the subtleties of moisture content in various formulations is essential for the product's overall quality and shelf life in addition to sensory features.

In this research, formulation 12 has been examined in the framework of this study for its special qualities, especially on moisture content. To make keropok lekor banana heart, the formulation for a precise ratio of ingredients: 230 gram of grated coconut, 57.5 gram of oyster mushroom, and 57.5 gram of potato. Formulation 12 stands out from the other formulations that were analyzed because it had the lowest moisture content ever measured, at 35.55%. The lower contribute the dry ingredient which are grated coconut can change the texture of keropok lekor, it can affect the extent to which water is bound in the product. One of the most important factors in the formulation is the component makeup. The total moisture content may be decreased by using more components that naturally contain less water, like potatoes, in place of items that could have more water, such grated coconut. A factor may also be played by environmental conditions throughout the production or storage process. The product's interaction with the surrounding air might be influenced by the ambient temperature and humidity levels.

3.1.2 Color

The color changes caused by the addition of binders might vary depending on the type and percentage of binders used. The results of the color measurement are shown in Table 3. As can be seen from the table, after being cooked, all of the keropok lekor banana heart had significant differences ($p<0.05$) in term of lightness (L*), redness (a*) and yellowness (b*).

Table 3 *Color of keropok lekor banana heart*

Formulation	L*	a*	b*
1	28.85 ± 0.55	-0.73 ± 0.09	-4.36 ± 0.28
2	29.45 ± 0.37	-0.6 ± 0.49	-3.87 ± 0.30
3	28.64 ± 0.01	-0.44 ± 0.10	-4.64 ± 0.01
4	27.83 ± 0.10	0.31 ± 0.08	-4.21 ± 0.10
5	28.79 ± 0.15	-0.61 ± 0.04	-4.59 ± 0.13
6	29.57 ± 0.55	-0.79 ± 0.09	-4.29 ± 0.28
7	27.08 ± 0.09	-0.81 ± 0.03	-5.2 ± 0.04
8	28.44 ± 0.03	-1.05 ± 0.00	-5.45 ± 3.17
9	27.22 ± 0.11	-0.75 ± 0.10	-5.08 ± 0.11
10	28.59 ± 0.01	-0.49 ± 0.10	-4.69 ± 0.01
11	27.35 ± 0.11	-0.38 ± 0.05	-4.51 ± 0.05
12	28.60 ± 0.03	-1.09 ± 0.00	-5.59 ± 3.17
13	30.61 ± 1.05	-0.59 ± 0.03	-3.88 ± -0.40

The color changes caused by the addition of binders might vary depending on the type and percentage of binders used. The results of the color measurement are shown in Table 3. As can be seen from the table, after being cooked, all of the keropok lekor banana heart had significant differences ($p<0.05$) in term of lightness (L*), redness (a*) and yellowness (b*). The more longer cooking times keropok lekor it can also decrease the color.

In term of the L* values, color of keropok lekor in formulation 13 (30.61± 1.05) as replicate had higher lightness value compared to other formulations while the grated coconut in formulation 12 had the lowest value of L*. For a* values, formulation 4 with addition 57.5gram grated coconut, 230gram oyster mushroom and 57.5gram potato are recorded a higher value which is 0.31 ± 0.08 compared to other formulations while the formulation 12 are the lowest value of a*. In values of b* for all the formulation were in ranges of -3.19 to 5.55. Formulation 13 with addition 57.5gram grated coconut, 57.5gram oyster mushroom and 230gram potato are recorded were the highest values compared to formulation 8 are the lowest values.

3.1.3 pH

In this research, there were not significant ($p<0.05$) differences among tested component in the pH of cooked keropok lekor banana heart. The pH of all 13 formulation of keropok lekor banana heart were determined via a pH meter.

Table 4 *pH of keropok lekor banana heart*

Formulation	pH
1	6.06 ± 0.04
2	7.05 ± 0.06
3	6.54 ± 0.18
4	6.15 ± 0.28
5	6.94 ± 0.05
6	6.29 ± 0.04
7	6.47 ± 0.09
8	7.07 ± 0.04
9	6.51 ± 0.02
10	6.59 ± 0.18
11	6.62 ± 0.005
12	7.17 ± 0.04
13	6.69 ± 0.03

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According to Abdullah *et al., 2017*, reported that the range of pH values of nuggets were between pH 6.52 to pH 6.7. It was found that the pH of ICN B (pH 6.61) and ICN C (pH 6.62) were not significantly different (*p<0.05)* from the control nugget (pH 6.59). In this research, there were not significant (*p<0.05*) differences among tested binders in the pH of cooked keropok lekor banana heart.

Based on Table 4, the pH range obtained from all keropok lekor banana heart formulations in the range with the lowest midpoint is pH 5.9 to pH 7.2 and the range between the higher values of pH keropok lekor 7.17 ± 0.04. Keropok lekor formulation is closer to a neutral pH, the factors and amounts of substances utilised, together with the processing techniques used in the procedure, may all have an impact on this particular pH. The grated coconut has a slightly acidic to neutral pH. It can contribute the coconut's ripeness can change the pH of keropok lekor. The ph of oyster mushroom typically falls within mildly acidic to neutral range depend on the maturity of mushroom. Potatoes may have helped the keropok lekor formulation's pH, which was 7.17 ± 0.04 become neutral to slightly alkaline. The intended qualities of the keropok lekor and the standards for taste and texture determine whether the pH is deemed appropriate. They change in pH observed in keropok lekor after freezing and thawing can be attributed to the keropok lekor. During the freezing, ice crystals develop inside the product can cause damage to the structure. Certain enzymes may continue during thawing at low temperature after they are frozen. Enzymatic processes can have the ability to produce chemicals, which can alter pH levels.

3.1.4 Texture Profile Analysis

The different of formulations of keropok lekor banana heart were found that the moisture varied significantly *(p<0.05)* for firmness among the tested binders and not significantly for work of shear. Firmness was defined as the higher the force to shear, the firmer the sample while the work of shear was determined from a larger value indicating a firmer sample. The texture of all 13 formulations of keropok lekor banana heart were analyzed by using texture analyzer.

Table 5 *Textural properties of keropok lekor banana heart*

Formulation	Firmness (N)	Work of shear (N-sec)
1	116.06 ± 5.69	480.06 ± 21.04
2	90.06 ± 8.56	196.49 ± 3.04
3	40.096 ± 7.53	509.93 ± 12.30
4	35.04 ± 5.24	220.47 ± 31.61
5	93.19 ± 17.49	490.23 ± 60.36
6	105.01 ± 5.69	465.06 ± 21.04
7	60.87 ± 1.35	370.36 ± 8.41
8	73.81 ± 5.38	360.03 ± 50.5
9	56.25 ± 1.53	256.36 ± 8.63
10	28.06 ± 7.53	499.91 ± 12.30
11	70.09 ± 4.27	340.02 ± 45.3
12	64.79 ± 5.38	300.13 ± 50.5
13	54.79 ± 4.98	256.78 ± 17.05

Table 5 provides the texture profile of keropok lekor banana heart including firmness and work of shear. The different of formulations of keropok lekor banana heart were found that the moisture varied significantly *(p<0.05)* for firmness among the tested binders and not significantly for work of shear. Firmness was defined as the higher the force to shear, the firmer the sample while the work of shear was determined from a larger value indicating a firmer sample.

From The table 5, as the firmness and work of shear value of keropok lekor banana heart formulation 1 obtained highest (116.06) with an amount of potato in the sample compared with other formulation. In comparison tat potatoes may require more flour easy to form keropok lekor compared to formulation with different amounts of potatoes. If this is the case, it could be due to potatoes have that more qualities than affect the texture and structure of keropok lekor.

Formulation 10 had the lowest value of firmness (28.06), the amount of grated coconut 345gram. It becomes and easily kneadable texture all the mixture can influence with high moisture content can enhance the texture of keropok lekor.

3.2 Sensory evaluation

A sensory evaluation for all 60 panelists that test out the keropok lekor banana heart sample in Table 6 below.

Table 6 *Hedonic scale keropok lekor banana heart*

Formulation	Appearance	Aroma	Color	Texture	Taste	Overall acceptance
*1	6.81 ± 1.21	6.71 ± 1.19	6.78 ± 1.30	6.48 ± 1.63	6.6 ± 1.42	6.75 ± 1.20
2	6.26 ± 1.58	6.28 ± 1.18	6.46 ± 1.37	5.98 ± 1.73	6.15 ± 1.52	6.4 ± 1.22
#3	6.36 ± 1.54	6.28 ± 1.56	6.35 ± 1.64	6.08 ± 2.05	5.81 ± 1.63	6.01 ± 1.63
4	6.88 ± 1.66	6.8 ± 1.24	6.91 ± 1.33	5.8 ± 1.98	6.51 ± 1.91	6.55 ±1.67
5	6.56 ± 1.68	6.45 ± 1.50	6.6 ± 1.83	6.15 ± 1.71	6.01 ± 1.72	6.5 ± 1.33
*6	6.81 ± 1.21	6.71 ± 1.19	6.78 ± 1.30	6.48 ± 1.63	6.6 ± 1.42	6.75 ± 1.20
7	6.03 ± 1.85	5.83 ± 1.69	5.95 ± 2.02	4.6 ± 2.10	5.28 ± 2.12	5.4 ± 1.98
^8	6.46 ± 1.56	6.36 ± 1.46	6.48 ± 1.58	6.18 ± 1.73	6.38 ± 1.76	6.36 ± 1.59
9	4.91 ± 1.96	6 ± 1.87	4.46 ± 1.66	4.45 ± 2.10	5.66 ± 1.81	5.21 ± 1.76
#10	6.36 ± 1.54	6.28 ± 1.56	6.35 ± 1.64	6.08 ± 2.05	5.81 ± 1.63	6.01 ± 1.63
11	6.73 ± 1.81	6.43 ± 1.59	6.63 ± 1.81	5.58 ± 2.03	5.5 ± 2.02	5.78 ± 1.72
^12	6.46 ± 1.56	6.36 ± 1.46	6.48 ± 1.58	6.18 ± 1.73	6.38 ± 1.76	6.36 ± 1.59
13	6.83 ± 1.53	6.6 ± 1.53	6.7 ± 1.55	6.38 ± 2.02	6.75 ± 1.77	6.78 ± 1.70

Duplicate samples are denoted by the same symbol (*, #, ^). Value was expressed in mean ± standard deviation in triplicate.

The sensory evaluation results for keropok lekor banana heart with grated coconut, oyster mushroom and potato in Table 6. The three components generally had an effect towards the acceptability of keropok lekor among consumers. There were significant *($p<0.05$)* changes in all of the attributes including appearance, aroma, color, texture, taste and overall acceptance. Each attribute was determined using 9-point hedonic scale. All 13 formulation were accepted by the 60 panelists with scores of 4 to 7.

In terms of appearance and color, it was observed that sample 4 recorded are the highest for appearance (6.88 ± 1.66) and for color (6.91 ± 1,33). The panelists slightly liked of appearance of the sample 4. Referring back to the sample, keropok lekor banana heart sample 4 was made up as grated coconut 57.5g, oyster mushroom 230g, potato 57.5g, the color combination three component might be very appealing. The visual appeal is frequently derived from a well balance color combination. The visual attractiveness can be improved by using components that are colorful and fresh. A sample that seems vibrant, new, and evenly distributed in terms of color may be preferred by panellists. This might be contributed to a visually interesting by presence the different ingredients with varied colours, such as the lighter color of grated coconut and potatoes, the earthy hues of oyster mushroom. In addition, according to Shewfelt and Briickner, color and appearance attract to consumer to a product and can help in impulse purchases. At the point of purchase, the consumer uses appearance factors to indicate freshness and flavour quality.

A food's aroma signals its acceptability toward the food whose odor it signals [18]. In the assessment of aroma of keropok lekor banana heart, the results showed that the formulation 4 (6.8 ± 1.24) was the highest. The panelists slightly liked for aroma of the sample 4. It was significantly higher *($p<0.05$)* than the other sample. Comparing keropok lekor with 230 g of oyster mushroom and keropok lekor with 57.5 g of oyster mushroom, enhances its aroma when compared that keropok lekor with with different amount. The aroma of oyster mushroom s combined with aroma of banana heart produces a slightly floral and vegetal aroma.

In the context of texture attribute, it was found the lowest scores given by the panelists were recorded for texture (4.45 ± 2.10) in sample 9 for sensory. The panelists dislike slightly because after cooked keropok lekor and served to panelist it can contributes the temperature due to the surroundings, that can change the texture of keropok lekor. The panelist dislike slightly maybe in preparation, cutting the keropok lekor slightly thin for sensory sample that makes the panelist hard to bite the keropok lekor. In sample 9 used 172.5 g of oyster mushroom and 172.5 g of potato in keropok lekor can influence the texture of keropok lekor. The amounts of

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potatoes and contain starch, it can affect the overall texture same to oyster mushroom, being fungi. They may provide the texture of keropok lekor some toughness and stiffness when added. If the pieces of oyster mushroom are larger in the process making keropok lekor is not precise.

Taste is one of the important sensory attributes in all the sample of keropok lekor banana heart. It was observed that sample 7 was recorded are the lowest for taste of keropok lekor (5.28 ± 2.12). The panelists neither like nor dislike of taste of the sample 7. Referring back to the sample, keropok lekor sample 7 was made up of grated coconut (172.5 g) and potato (172.5 g) had an equal composition. The pleasant taste of keropok lekor banana heart. The combination of grated coconut and potatoes creates a harmonious blend of flavors. The sweetness from the coconut complements the mild earthiness of the potatoes, resulting in a well-balanced taste. When preparing keropok lekor banana heart, additional ingredients, flavors, and cooking techniques that can affect the final flavour.

Typically, overall acceptance was the final consideration of the panelists before choosing the most preferred keropok lekor banana heart sample. Whether food is accepted or rejected entirely depends on expectations and needs of the consumer [18]. Keropok lekor banana heart sample 13 was highly accepted among panelists (6.78 ± 1.70). Rather than accepting foods they consider less tasty, consumers prefer foods that satisfy their enjoyment needs [15]. However, the duplicate sample of keropok lekor banana heart sample 9 was less accepted by panelists (5.21 ± 1.76). It was probably due to the different ingredients, where the panelists could not acceptence the taste of keropok lekor.

3.3 Nutritional value

8 nutrient compositions for sample 13 in keropok lekor banana heart including moisture, ash, protein, fat, carbohydrate, energy, total sugar and sodium were recorded.

Table 7 *Nutrient analysis of sample 13 keropok lekor banana heart*

Parameter	Unit	Value
Moisture	g/100g	55.1
Ash	g/100g	0.4
Protein	g/100g	3.11
Fat	g/100g	9.5
Carbohydrate	g/100g	32.0
Energy	kcal/100g	226
Total Sugar	g/100g	1.4
Sodium	mg/100g	414.6

The nutritional content of sample 13 of keropok lekor banana heart, was analyzed and the results are shown in Table 7. Eight different nutritional compositions, including moisture, ash, protein, fat, carbohydrates, energy, total sugar and sodium were tested. The Ministry of Health Malaysia has amended the Food Regulation on 29 September 2005 to make nutrition labelling compulsory for certain foods, as well as regulate health and nutrition claims.

Based on Table 7, moisture content of keropok lekor banana heart sample 13 was 55.1g/100g. Moisture content can influence microbial growth and the quality of keropok lekor banana heart sample. When the keropok lekor banana heart sample 13 stored for 2 weeks in fridge for a longer time, the keropok lekor stored in a humid environment, it can absorb moisture from the air. The excess moisture can lead to a slimy or sticky texture. The moisture value of keropok lekor sample 13 might be due to temperature during the sample preparation.

The ash content of keropok lekor banana heart sample 13 was 0.4g/100g of product, there were 0.4 g of mineral elements. This formulated keropok lekor banana heart has a mineral in keropok lekor original. In table 4.3, the protein of keropok lekor banana heart sample 13 was 3.11g/100g. According to Table 4.3, the total fat of keropok lekor banana heart sample 13 was found to be 9.5 g/ 100g.

Total carbohydrate of keropok lekor sample 13 was recorded at 32.0g/100 g. A carbohydrate food is a good source of fiber and other nutrients. Nevertheless, carbohydrates with a high glycemic index are a major cause of obesity and cardiometabolic diseases in developed countries (13). As a result, keropok lekor banana heart sample 13 with a carbohydrates content would be preferable.

For the total sugar analysis, the result of keropok lekor banana heart sample 13 had a sugar content of 1.4g/100g. Generally, natural sugars and added sugars can both be found in foods by Erickson & Slavin, 2015 (22). The sugar content appeared to be directly related to health concerns.

The sodium content of keropok lekor banana heart sample 13 was 414.6mg/100g. The sodium value was mainly due to the salt ingredient added to the sample. In order to prevent chronic diseases, there is a suggestion for reducing salt intake by 5 to 6 grams a day by Calliope & Samman, 2019 (22).

3.4 Statistical Simplex Lattice Mixture Design

The findings of mixture design studies are shown in Table 8. Low predicted sum of squares, low standard deviation, and high predicted R-squared define the ideal model [7]. Following these guidelines, it was discovered that the special quartic model was the best for lightness, yellowness, pH and work of shear. Additionally, the linear was found for firmness and sensory. The quadratic model was found to be for moisture and redness. All the of the model types of significant *(p<0.05*) which mean. Based on the Table 8, all models had non-significant lack of fit at *p > 0.05*, which indicated there was less error in models [17]. Lack of fit for all the model were shown are not significant. The r-squared were ranged from 0.4665 to 0.9674.

Table 8 *Experimental results for moisture, color, ph, texture and sensory of keropok lekor banana heart*

Response variables	Sum of square	Degree of freedom	Mean square	F-value	*p*-value	
Moisture - Quadratic	124.10	5	24.82	6.73	0.0132	Significant
Lack of fit	10.46	4	2.61	0.5111	0.7374	Not Significant
R2						0.8279
L* - Special Quartic	11.51	8	1.44	8.91	0.0254	Significant
Lack of fit	0.3725	1	0.3725	4.09	0.1364	Not Significant
R2						0.9469
a* - Quadratic	0.6351	5	0.1270	20.57	0.0005	Not Significant
Lack of fit	0.0394	4	0.0098	7.67	0.0629	Not Significant
R2						0.9363
b* - Special Quartic	3.59	8	0.4488	33.66	0.0021	Significant
Lack of fit	0.0398	1	0.0398	8.85	0.0588	Not Significant
R2						0.9854
pH – Special Quartic	1.38	8	0.1721	6.55	0.0436	Significant
Lack of fit	0.0724	1	0.0724	6.65	0.0819	Not Significant
R2						0.9291
Firmness - Linear	5141.46	2	2570.73	7.28	0.0112	Significant
Lack of fit	3355.12	7	479.30	8.26	0.0552	Not Significant
R2						0.5930
Work of shear – Special Quartic	1.506	8	18830.58	18830.58	0.0099	Significant
Lack of fit		1	3117.20	3117.20	0.1167	Not Significant
R2	3117.20					0.9674
Sensory - Linear	0.3058	2	0.1529	0.1529	0.0432	Significant
Lack of fit	0.2999	7	0.0428	0.0428	0.2342	Not Significant
R2						0.4665

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3.5 Optimization od Mixture Proportion using Simplex Lattice Mixture Design

Simultaneous optimization also can be accomplished by maximizing, minimizing, or limiting parameters as shown in Fig. 1. In this study, the response of the moisture, firmness and work of shear was minimized while the responses for L*, a*, b* and sensory qualities of the keropok lekor banana heart was maximized. Meanwhile, responses for pH were set in the range. From the optimization result generated by Design Expert (Stat-Ease, Inc., Trial Version 13), this sample with 57.5 g grated coconut, 57.5 g oyster mushroom and 230 g potato should be used. The desirability value was 0.568 (Fig. 1), which was close to 1000, indicating that all optimization criteria are met.

Each parameter calculated from the optimizes mixture for the keropok lekor banana heart incorporated with other grated coconut, oyster mushroom and potato was tabulated. According to the result, the moisture content was 46.31%, and the color, L*, a* and b* recorded values of 30.28, -0.67 and -3.96, the pH value was 6.78. For texture profile analysis, firmness and work of shear of value was 80.88 and 202.47. For sensory recorded values of 6.588. With that sample 13 of keropok lekor banana heart with grated coconut, oyster mushroom and potato as the parameters calculated from optimization of the mixture the responses.

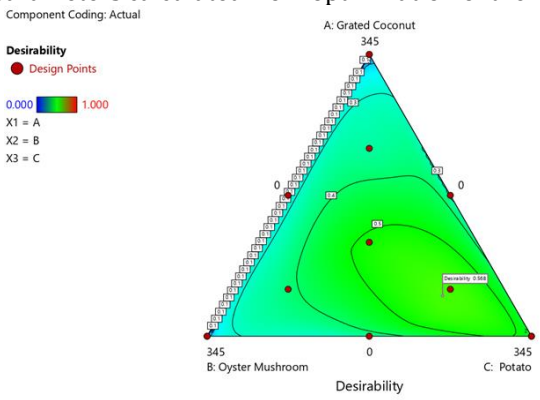

Fig. 1 *Optimization based on sensory and physicochemical properties and its desirability*

4. Conclusion

In this study, keropok lekor banana heart incorporated with grated coconut, oyster mushroom and potato were successfully formulated and optimized by using simplex-lattice mixture design. Besides that, physicochemical properties of all keropok lekor banana heart samples were analyzed. Meanwhile, the nutrient compositions of an optimized keropok lekor banana heart sample were evaluated. For the physicochemical properties analysis of keropok lekor banana hearts, resulted in moisture content in formulation 13 are the higher. Formulation 13, which is the higher value of L* (30.61 ± 1.05), while the formulation 4 recorded a higher value of a* keropok lekor banana hearts which is (0.31 ± 0.08). In values of b* for all the formulation were in ranges of -3.19 to 5.55. The pH of all formulations was found to be between midpoint pH 6.52 to pH 6.7, which is slightly lower than it should be. For the highest moisture content was formulation 13. For firmness, formulation 1 was the maximum firmness of keropok lekor. And formulation 3 was higher work of shear for texture of keropok lekor banana heart. The sensory results showed that all the panelists accepted all the 13 samples of keropok lekor banana heart samples with sensory scores between 5 and 7. Keropok lekor banana heart sample 13 had the highest sensory scores for taste and overall acceptance among the other samples. The panelists slightly liked the keropok lekor banana heart sample 13.

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Conflict of Interest

Authors declare that there is no conflict of interest regarding the publication of the paper.

Author Contribution

This journal requires that all authors take public responsibility for the content of the work submitted for review.

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