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Article

Physicochemical Properties and Sensory Preference of *Keropok Lekor* with Partial Replacement of Fish Flesh with Oyster Mushroom

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***Abstract*— *Keropok lekor* is a famous fish-based traditional food from Terengganu, Malaysia. Due to the progressive cultivation activity of oyster mushrooms in Malaysia and their high nutritional values, they were selected to be incorporated in *keropok lekor* formulations to replace a partial percentage of fish flesh. In this study, the determination of nutritional composition and physical as well as evaluation of sensory acceptability of oyster mushroom-containing *keropok lekor* were carried out. Three formulations of *keropok lekor* with different ratios of fish flesh to oyster mushroom were prepared as follows: control (100:0), sample A (75:25), and sample B (50:50). In terms of nutritional composition, the results found that the value of ash, moisture, and carbohydrate contents of *keropok lekor* with oyster mushroom substitutions were significantly higher (P<0.05) than control *keropok lekor*. However, the experimental *keropok lekor* (sample A and sample B) had significantly lower (P<0.05) protein and fat contents than the control sample. The highest value of hardness, springiness, cohesiveness, and chewiness of the control sample (100% fish flesh) was obtained in comparison to *keropok lekor* substituted with oyster mushroom. In the context of colour, the value of L^* (whiteness) increased by substituting oyster mushrooms into *keropok lekor* formulations due to the light colour of the mushroom. The 9-point hedonic scale test indicated that consumers' preferences for experimental *keropok lekor* (sample A and sample B) were significantly (P<0.05) higher scores as compared to the control sample in terms of texture, taste, and overall acceptance. In contrast, appearance, colour, and aroma attributes obtained lower scores. The findings also suggested that replacing fish flesh with oyster mushrooms in *keropok lekor* has great potential to be commercialized in the market and represented as a new variety of *keropok lekor* in the food industry.**

Keywords*— *Keropok lekor characteristics; Oyster Mushroom cracker; Cracker Preference; Vegetables Cracker; Nutritious Cracker

I. INTRODUCTION

The food market nowadays provides various types of food products to consumers. Among the famous food products is *keropok lekor*, which is to be a hit and loved by Malaysians [1]. The preparation of *keropok lekor* dough is done by mixing the ingredients, such as fish flesh, sago flour, salt, Monosodium Glutamate (MSG), and iced water. Next, the mixture is usually rolled to a cylinder shape and boiled before serving [2]. *Keropok lekor* is usually served in a boiled snack or deep-fried with a dipping sauce. Various types of fish can be used in making *keropok lekor*, such as Sardine, Mackerel, and many more. As *keropok lekor* comprises a high fish flesh percentage in the formulation, this contributes to the high protein content while simultaneously producing a healthy food [3]. *Keropok lekor* is primarily produced by Small and Medium-sized Enterprises (SMEs), and it serves as the locals' primary economic activity and a tourist attraction [4]. Besides, according to Omar et al. [1], the commercialization of *keropok lekor* has great potential in the global market.

On the other hand, it is suggested that farming mushroom activity may be one of the practical options to develop a more reliable income source primarily for small-scale farmers and to improve food security by diversifying mushroom-based food products [5]. Food and Agriculture Organization [6] reported that more than 74.64% of world mushroom markets are produced by Asian countries, followed by 19.63% produced by European countries in 2014. Meanwhile, in Malaysia, 17 types of mushrooms have been marketed and cultivated, including white oyster, grey oyster, red oyster, yellow oyster, king oyster, button, enoki, paddy straw, chestnut, morning glory, monkey head, ling zhi, shaggy mane, fungus, shiitake, abalone, and black jelly [5].

Oyster mushroom, with the scientific name *Pleurotus ostreatus*, is widely cultivated worldwide [7, 8, 9]. Note that mushrooms are high in vitamins and essential amino acids [10]. The chemical composition of fresh oyster mushroom that was grown on the waste of cottonseed as a substrate indicates 88.75% moisture content, 28.85% of protein content, 2.47% of fat content, 9.76% of ash content, and 48.16% of carbohydrate content [11]. According to Cheung [12], mushrooms are classified as a functional food since they can provide health benefits in addition to the traditional nutrients they contain. Many studies have been conducted to improve the nutritional quality of food products by incorporating mushrooms into product formulations, such as pasta [13], muffins [14], patties [15], and snacks [16].

Therefore, the purpose of this paper was to propose a new formulation of *keropok lekor* with oyster mushrooms. The mushroom was ground with fish fillet as a fish-based snack to produce food products in the market that are high in nutritional value.

II. MATERIALS AND METHODS

A. *Materials*

Fresh oyster mushrooms were purchased from Jaya Grocer supermarket at Mesamall (Nilai, Negeri Sembilan). Fresh Japanese scad (*Decapterus maruadsi*), commonly known as *selayang*, used in the production of *keropok lekor*, was purchased at the wet market at Taman Semarak (Nilai, Negeri Sembilan). Ingredients, such as sago flour, table salt, MSG, and ice, were bought from Lotus supermarket (Nilai, Negeri Sembilan).

B. *Oyster mushroom preparation*

The whole part of the mushroom (cap and stalk) was used in this experiment. The mushrooms were weighed prior to the washing and rinsing processes. Subsequently, the mushrooms were air-dried for one hour and a half to remove excess water. The air-dried mushrooms were then chopped into small pieces prior to blending with the fish flesh.

C. *Keropok lekor processing*

The fish was cleaned thoroughly and filleted to remove the fish bone prior to the mixing process. The formulations of *keropok lekor* are provided in Table I. The fish flesh and oyster mushroom were then ground together for 5 mins using a multipurpose food processor (meat mincer). Then, the mixture was mixed with sago flour, salt, iced water, and MSG using a dough mixer for 15 mins to form a well-blended dough. The dough was then rested for another 15 mins. Subsequently, 150g dough was shaped manually into a long uniform cylinder shape (17 cm: length; 2.5 cm: diameter; 2.5 cm: thickness) on the surface pre-dusted with sago flour. The prepared *keropok lekor* were then immersed in boiling water for 8 mins until they floated on the surface of the water. After *keropok lekor* had been boiled, it was cooled at room temperature before being stored in the freezer at -18°C in vacuum packaging until further use.

TABLE I. FORMULATIONS OF DIFFERENT COMPOSITIONS OF *KEROPOK LEKOR*

Formulation	**Control**	**Sample A**	**Sample B**
Ingredient	**Weight (g)**	**Weight (g)**	**Weight (g)**
Fish flesh	250	187.5	125
Oyster mushroom	0	62.5	125
Sago flour	92.5	92.5	92.5
Ice water	33	33	33
Salt	4	4	4
Monosodium Glutamate (MSG)	3	3	3
Total	382.5	382.5	382.5

Control- *Keropok lekor* with 100% fish flesh without oyster mushroom
Sample A- *Keropok lekor* with 75% fish flesh and 25% of oyster mushroom
Sample B- *Keropok lekor* with 50% fish flesh and 50% of oyster mushroom

D. *Proximate analysis*

The proximate analysis was conducted following the Association of Official Analytical Chemists (AOAC) method [17]. To facilitate the analysis and make the samples more manageable, frozen *keropok lekor* was thawed overnight in a chiller, resulting in a softer texture.

1. *Protein analysis*

Nitrogen content or crude protein in *keropok lekor* was determined using the Kjeldahl method. The percentage of crude protein indicating the total nitrogen percentage present in the sample was calculated by multiplying it with a conversion factor of 6.25. Approximately 1.0 g of *keropok lekor* samples were weighed, and the sample was then put in the tube with one Kjeltabs as a catalyst tablet. Consequently, 10 ml (10) of sulfuric acid (98% concentration) was added prior to running the automated machine of digestion and distillation processes.

2. *Fat analysis*

The crude fat content of mushroom *keropok lekor* samples was analyzed using the Automatic Soxhlet extraction method

(Soxhterm® extraction, Gerhardt). Beforehand, 2.0 g of each *keropok lekor* that had been homogenized was weighed and then added to the Soxhterm® extraction based on Gerhardt's manual. Eventually, the air-drying oven was used to dry the extraction residue at 105°C overnight and then cooled in a desiccator. After drying, the weight of the extraction beaker was taken and used in the calculation to determine fat content.

3. Ash analysis

Total ash content was expressed as mineral content in the *keropok lekor* samples. Approximately 3.0 g of *keropok lekor* sample was weighted in pre-dried crucibles. The samples were charred on an electric hot plate (Favorit, HS0707V2) until no smoke was produced. The crucibles containing the charred samples were placed inside the furnace, and the temperature was set to 550°C. After being ignited overnight or until ash (grey mass) formed, the samples were cooled in a desiccator for one hour. Ash percentage was calculated by dividing the weight of the sample after the dry-ashing procedure by the weight of the fresh sample.

4. Moisture analysis

Determination of the moisture content of *keropok lekor* was carried out by forced draft oven-drying method (Memmert GmbH + Co. KG, Germany) at 105°C until the weight obtained was constant. The weight of pre-dried crucibles and lids was taken before 3.0 g of samples was added into the crucibles. Then, the crucibles with sample and lid were placed in the oven for at least 16 hours or overnight at 105°C to evaporate the moisture from the samples. Subsequently, the crucibles were transferred and cooled in a desiccator for 45 mins, and reweighed the crucibles with their lid and dried sample. Lastly, the crucible and lid were replaced in the oven for one hour and then transferred and reweighed until a constant weight was achieved. During the moisture analysis, it is crucial to maintain the integrity of the samples by taking precautions to prevent moisture contamination from bare hands and the surroundings.

5. Carbohydrate analysis

The carbohydrate content of boiled *keropok lekor* samples was determined using the following equation.

Percentage of carbohydrate: 100% - [% of moisture content + % of ash content + % of protein content + % of fat content]

E. Physical analysis

1. Texture profile analysis (TPA)

TPA parameters such as hardness, springiness, cohesiveness, and chewiness [18] of *keropok lekor* were obtained using a TA.XT2i texture analyzer (Stable Micro Systems, UK) with a 2 mm diameter cylindrical probe. Prior to conducting a TPA, an overnight thawed *keropok lekor* sample (in a chiller) was cut to a height of 5 cm. The samples were set to be penetrated to a depth of 5 mm. During the pre-test and penetration, the probe's speed was 2.0 mm/s. Texture Expert (Version 1.0) from Stable Micro Systems recorded force and time data. Hardness is defined as the maximum force from the force versus time curves (Newton, N). Springiness is expressed as a ratio or percentage of a product's original height. At the same time, the area of work calculates cohesiveness during the second compression divided by the area of work during the first compression. Conversely, chewiness is the texture property employed only on solid food and is determined by multiple gumminess and springiness values. Triplicates of *keropok lekor* samples were performed to determine the measurements.

2. Colour analysis

The colour of overnight thawed *keropok lekor* was measured using a colourimeter (Minolta Spectrophotometer CM-3500D Model, Osaka, Japan). Before conducting a colour analysis, *keropok lekor* samples were chopped into small pieces. Approximately 20.0 g of keropok lekor was placed within a plastic Petri dish with the lid on until the surface of the petri dish was fully covered. The colour parameters, including L^* (whiteness), a^* (redness), and b^* (yellowness) of *keropok lekor* samples, were measured.

F. Sensory analysis

Sensory analysis of fried mushroom *keropok lekor* was conducted by 60 untrained panellists (students and staff at USIM). Frozen *keropok lekor* were thawed overnight in a chiller prior to deep-frying. Correspondingly, *keropok lekor* was fried in palm oil for 3 mins at 150°C. Each panellist was given three samples of *keropok lekor* with uniform size (1.5 cm: length; 2.5 cm: diameter; 2.5 cm: thickness) encoded by the three-random-digit codes. They were asked to evaluate their preference for the appearance, colour, texture, aroma, taste, and overall acceptability of the samples given. A 9-point hedonic scale with a range of extremely dislike (score = 1) to extremely like (score = 9) was used to evaluate the samples of mushroom *keropok lekor*.

G. Statistical analysis

Minitab statistical software (Minitab 19, Minitab Inc., Pennsylvania) was used for the statistical analyses. The data were compared using analysis of variance (ANOVA). Tukey's test was run with 95% confidence limits (P<0.05). All analyses were performed in triplicates.

III. RESULTS AND DISCUSSION

A. Proximate composition

Table II provides the nutritional composition, including protein, fat, ash, moisture, and carbohydrate, of three *keropok lekor* formulations. Results revealed that the sample of control *keropok lekor* (with 100% fish) was significantly the lowest (P<0.05) in values for ash and moisture. The protein content of *keropok lekor* substituted with oyster mushroom formulations (25% and 50% fish substitution with oyster mushroom) ranging from 7.47% to 11.61% were significantly lower (P<0.05) compared to control *keropok lekor* (14.53%). Substitution of mushrooms to fish flesh in *keropok lekor* formulations significantly reduced the protein content of the samples. *Ikan selayang* (*Decapterus russelli*) generally contains a higher amount of protein with a value of 27.97% [19] rather than mushroom with a percentage of 28.85 [11] resulting in the decrement of protein in mushroom-based *keropok lekor*.

TABLE II. NUTRITIONAL COMPOSITION OF *KEROPOK LEKOR*

Percentage (%)	Formulation of *keropok lekor*		
	Control	Sample A	Sample B
Protein	14.53±0.59^a	11.61±0.32^b	7.47±0.17^c
Fat	0.49±0.04^a	0.36±0.03^b	0.14±0.02^c
Ash	1.45±0.02^c	1.56±0.01^b	1.72±0.02^a
Moisture	62.31±0.25^c	64.91±0.13^b	67.36±0.38^a
Carbohydrate	21.22±0.49^b	21.55±0.44^b	23.31±0.41^a

Mean ± standard deviation values with different superscript letters in the same row are significantly different at *P*<0.05

Control- *Keropok lekor* with 100% fish flesh without oyster mushroom
Sample A- *Keropok lekor* with 75% fish flesh and 25% of oyster mushroom
Sample B- *Keropok lekor* with 50% fish flesh and 50% of oyster mushroom

Similarly, fat content in sample A (25% oyster mushroom substitution) and sample B (50% oyster mushroom substitution) were also found to be significantly lower (*P*<0.50) with values of 0.36% and 0.14%, respectively, in comparison to the control sample (0.49%). The fat content of the *keropok lekor* decreased proportionally to the increasing amount of oyster mushrooms used. The low percentage of fat content in oyster mushrooms compared to fish flesh of *Selayang* subsequently reduced the fat content of mushroom *keropok lekor* formulation. This finding was in line with the results from Husain and Huda-Faujan [20] on the Imitation Chicken Nugget (ICNs) from oyster mushroom (*Pleurotus ostreatus*) stems and chickpea flour where the fat content of ICNs ranged from 0.47% to 0.62% were lower than the fat content of control nugget samples (1.30%). In addition, similar results were also reported in the declining pattern of fat content from 17.60% to 14.82% on sausage incorporated with the increasing amount of *Pleurotus ostreatus* [21]. In fact, the fat content of edible mushrooms (*Pleurotus ostreatus*) was 1.50% [22], while the fat content of Indian scad (*Decapterus russelli*) was recorded as less than 4.00% [23]. Hence, as a result of the partial substitution of oyster mushrooms for fish flesh in *keropok lekor* in this study, the fat content of the samples has been reduced.

The ash content of sample B was the highest (1.72%) (*P*<0.05) compared to the control *keropok lekor* (1.45%) and sample A (1.56%). Oluwafemi et al. [22] reported that the ash content of oyster mushrooms was 6.60%, subsequently explaining that the highest ash content (*P*<0.05) was in sample B compared to all other *keropok lekor* samples. In fact, the inorganic (mineral) content of *keropok lekor* was measured by ash determination.

The moisture content of the control sample (62.31%) was significantly lower (*P*<0.05) than the sample (64.91%) and sample B (67.36%). The low moisture content observed in *keropok lekor*, which consists of 100% fish flesh, can be attributed to the water-binding ability of fish proteins. These proteins can bind water molecules tightly, resulting in water being held within the protein structure. Consequently, this bound water does not evaporate during the oven-drying process and is therefore not included in the moisture content calculation. In contrast, oyster mushrooms have a different structural composition where water is not tightly held within the structure. As a result, when oyster mushrooms are subjected to oven-drying, the water easily evaporates off, adding to the weight of moisture loss.

As anticipated, the carbohydrate content in *keropok lekor* incorporated with oyster mushroom increased with the increasing amount of substitution with oyster mushroom (*P*<0.05). The carbohydrate content of sample B had the highest carbohydrate percentage (23.31%), followed by sample A (21.55%) and control (21.22%). However, insignificant data was found between sample A and the control *keropok lekor*. The increment in carbohydrate value for samples with oyster mushrooms is probably due to the high carbohydrate content in oyster mushrooms. The research by [11] supports the current findings as they reported that the carbohydrate content in fresh oyster mushrooms (*Pleurotus ostreatus*) was approximately 48.16%.

B. *Physical analysis*

1. *Textural properties of keropok lekor*

Table III provides the texture profile of *keropok lekor*, including hardness, springiness, cohesiveness, and chewiness. The different levels of oyster mushrooms incorporated in *keropok lekor* formulations were found to be decreased insignificantly (*P*>0.05) for hardness values as compared to control *keropok lekor*. This result was in line with the previous study from Yahya and Ting [24], as the hardness value of chicken sausage substituted with oyster mushroom (*Pleurotus sajor-caju*) obtained decreased with an increasing amount of mushroom substitution in the samples with 15% mushroom substitution (1.96), 30% mushroom substitution (1.62), 45% mushroom substitution (1.13), and 60% mushroom substitution (0.83) compared to the sample without substitution of mushroom (4.57).

TABLE III. TEXTURE ANALYSIS OF *KEROPOK LEKOR*

Parameter	Formulation of *keropok lekor*		
	Control	Sample A	Sample B
Texture Profile			
Hardness (g)	276.50±23.80^a	270.70±73.40^a	262.12±2.45^a
Springiness	2.06±1.84^a	0.99±0.00^a	1.00±0.01^a
Cohesiveness	0.57±0.06^a	0.48±0.08^a	0.53±0.02^a
Chewiness	7.02±6.62^a	2.73±0.47^a	3.21±0.09^a
Colour			
*L**	62.36±0.15^b	62.42±0.14^b	67.79±0.04^a
*a**	0.94±0.02^c	1.46±0.04^b	1.56±0.01^a
*b**	14.25±0.06^{ab}	14.39±0.08^a	14.20±0.04^b

Mean ± standard deviation values with different superscript letters in the same row are significantly different at *P*<0.05.

Control- *Keropok lekor* with 100% fish flesh without oyster mushroom
Sample A- *Keropok lekor* with 75% fish flesh and 25% of oyster mushroom
Sample B- *Keropok lekor* with 50% fish flesh and 50% of oyster mushroom

Sample B had the lowest value of hardness (262.12), followed by sample A (270.70) and the control sample (276.50), indicating that the samples with oyster mushroom substitution were softer in texture. The high protein content of fish might account for the highest hardness value for the control sample. Gel formation is influenced by the protein content in fish, known as myofibrillar protein [25], contributing to the elastic texture of fish-based products. The low hardness values for experimental *keropok lekor* might also be related to the high moisture content of the *keropok lekor*. Huda and co-researchers [26] reported a high correlation between the hardness value and the moisture content of the fish sausages.

Generally, the mushroom-based *keropok lekor* had a lower value of springiness, cohesiveness, and chewiness than control samples with insignificant differences (P>0.05). In terms of springiness, the mean value of the control sample was significantly higher (2.06) compared to mushroom-based *keropok lekor* (0.99-1.00). Previously, Yahya and Ting [24] reported that samples without fresh oyster mushrooms obtained the highest springiness value, 9.12, compared to mushroom-based sausages, which ranged from 7.69 to 8.57. Similarly, the increasing amount of oyster mushrooms in the formulation reduced the springiness of the product [27] due to the moisture content of oyster mushrooms. Pereira et al. [28] stated that the springiness was reduced with increasing water content. These findings were strongly related to the moisture content observed in Table II, with a correlation value of 0.87. Furthermore, the protein content of muscle food products can play a significant role in determining their texture. Specifically, the myofibrillar muscle found in fish flesh can develop a gel-like texture when heated.

In addition, the control sample of *keropok lekor* (0.57) expressed a higher degree of cohesiveness than the *keropok lekor* incorporated with mushroom (0.48-0.53). Cohesiveness is referred to as a mechanical textural attribute related to the degree to which a food can be deformed before it breaks. Previously, Yahya and Ting [24] reported that the sample of chicken sausage incorporated with fresh oyster mushroom provided a lower cohesiveness value ranging between 0.47 and 0.52 compared to the control sample, with a value of 0.71. The protein content was reduced with the decreased amount of fish flesh used in the *keropok lekor* formulations, subsequently affecting the cohesiveness value of *keropok lekor*. According to de Oliveira Filho et al. [29], the protein content had a linear relationship with the cohesiveness attribute. Proteins in the food system can bind water via hydrophilic-hydrophilic interaction, enhancing the texture of food products.

The *keropok lekor* formulated with oyster mushroom obtained a lower degree of chewiness, ranging between 2.73 and 3.21, than *keropok lekor* without oyster mushroom incorporation, with a value of 7.02. The chewiness of *keropok lekor* samples had a similar trend to hardness, as chewiness is a secondary parameter determined by the product's hardness [30]. This finding is confirmed by the high positive correlation between the hardness and chewiness of keropok lekor samples, which is 0.74.

Manual preparation of the dough *keropok lekor* may affect the inconsistency in values for the textural properties of the control and mushroom-based samples. During the dough preparation, the force and time given to mix the dough were different between the samples, resulting in some parts of the dough being harder in texture than other parts instead of having a homogenous texture. These actions influenced the texture of the end product.

2. *Colour profile of keropok lekor*

Results on the colour profile of *keropok lekor* are provided in Table III. The parameter values of L^* are for lightness from 0 (dark) to 100 (white), a^* is from 100 (green) to 100 (red), and b^* is from 100 (blue) to 100 (yellow) [31], of *keropok lekor* were affected with the different level of mushroom substituted in the sample. Sample B was recorded with the highest L* (67.79) and a* (1.56) values (P<0.05). However, it was found to be the lowest in the b* value, with a mean score of 14.20.

For L^* (whiteness) of the sample, the value in sample B (67.79) was significantly higher (P<0.05) than in sample A (62.54) and the control sample (62.36). The increasing percentage level of mushroom substitution significantly increased the whiteness of the *keropok lekor* sample. This might be due to the lower content of myoglobin. As stated by Bao et al. [32], the concentration of metmyoglobin was decreased in meat products with the presence of mushroom extracts. Besides, fish flesh combines two types of meat: white meat and dark meat. Dark muscle was rich in lipids as well as water-soluble proteins like haemoglobin and myoglobin [33]. Myoglobin is a pigmented protein that gives dark colour to the meat as its percentage is high. Thus, the dark meat in fish flesh was associated with the darker colour in the sample as myoglobin and fat were oxidized [24]. On the contrary, Yahya and Ting [24] reported that chicken sausage incorporated with the highest percentage of oyster mushrooms showed the lowest value in whiteness (L^*), which was 72.16 compared to the control sample without mushrooms (75.59). These results might be due to the white meat in chicken breast used in sausage production, which contained less myoglobin than in fish meat.

The a^* (redness) values of the mushroom *keropok lekor* samples (sample A and sample B) were significantly higher (P<0.05) compared to the control sample (0.94). The mushroom *keropok lekor* samples' redness values were between 1.48 (25% substitution of oyster mushroom) and 1.56 (50% substitution of oyster mushroom). Hence, the value of a^* of *keropok lekor* increased with the increased amount of mushroom in the sample since oyster mushroom contains flavonoid [35], which improved the a^* values in samples. These results aligned with the study of chicken sausage incorporated with oyster mushroom, where the highest a^* value was obtained from the formulation with the highest (45%) amount of mushroom incorporation in the sample [24].

In the context of b^* (yellowness), the mean values of control, sample A, and sample B were 14.25, 14.39, and 14.20, respectively. Therefore, adding oyster mushrooms did not significantly influence the b* values, with sample A having the highest value (14.39), indicating the sample is more yellowish in colour than the other samples.

C. *Sensory acceptability of keropok lekor*

Table IV presents the data of the 9-point hedonic test based on the mean score of consumer's preference of *keropok lekor* formulated with 0%, 25%, and 50% percentages of oyster mushrooms (*Pleurotus ostreatus*) involving 60 panellists. The attributes investigated include appearance, colour, texture, aroma, taste, and overall acceptance of *keropok lekor* samples, where sample B was stated as the sample with the highest mean score in all attributes. However, no significant difference (P>0.05) was found among the samples for appearance and colour attributes. Contrarily, the mean score for texture, aroma, taste, and overall acceptance attributes were significantly higher (P<0.05) for mushroom-containing samples than for control *keropok lekor*.

TABLE IV. SENSORY ANALYSIS OF *KEROPOK LEKOR*

Attribute	Formulation of *keropok lekor*		
	Control	Sample A	Sample B
Appearance	7.07±1.64^{a}	7.22±1.24^{a}	7.33±1.49^{a}
Colour	7.17±1.55^{a}	7.27±1.27^{a}	7.45±1.31^{a}
Texture	5.98±1.67^{b}	7.28±1.37^{a}	7.70±1.39^{a}
Aroma	6.70±1.52^{b}	7.12±1.34^{ab}	7.38±1.38^{a}
Taste	6.53±1.59^{b}	7.27±1.48^{a}	7.55±1.56^{a}
Overall acceptance	6.65±1.39^{b}	7.35±1.27^{a}	7.53±1.32^{a}

Mean ± standard deviation values with different superscript letters in the same row are significantly different at P<0.05

Control- *Keropok lekor* with 100% fish flesh without oyster mushroom
Sample A- *Keropok lekor* with 75% fish flesh and 25% of oyster mushroom
Sample B- *Keropok lekor* with 50% fish flesh and 50% of oyster mushroom

On the contrary, results found that the apparent preference of panellists among mushroom-formulated *keropok lekor* was not significantly higher (P>0.05) to control *keropok lekor* sample (7.07) for sensory attributes of appearance with the mean score in formulated *keropok lekor* ranged from 7.22 to 7.33. Similarly, the mean scores for colour attributes of *keropok lekor* incorporated with oyster mushroom ranged from 7.27 to 7.45 was insignificantly different (P>0.05) compared to the control sample (7.17). Sample B (*keropok lekor* with 50% oyster mushroom incorporation) had the highest mean score in colour attributes, with a score of 7.45. This finding was in agreement with Aishah and Wan Rosli [36], where consumers prefer rice-based products with a higher percentage of mushroom incorporation (4.57). In addition, according to Shewfelt and Brückner [37], colour and appearance attract the 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.

In the context of texture attribute, it was found that mean scores given by the panellists were between 7.28 and 7.70 for experimental *keropok lekor* compared to control *keropok lekor* (5.98) with a significant difference (P<0.05). Sample B obtained the highest mean score for texture, indicating the 50% oyster mushroom substitution in *keropok lekor* formulation was well accepted in texture compared to the control and sample A. This result was strongly related to the hardness parameter analyzed using a texture analyzer (Table III) with a correlation value of 0.99, indicating that the softer texture is preferable to the panelists than the harder texture.

In the assessment of the aroma of *keropok lekor*, the results showed that the panellists' preference for mushroom *keropok lekor* was significantly higher (P<0.05) than control *keropok lekor*. The findings revealed that incorporating oyster mushrooms in *keropok lekor* improves the aroma compared to *keropok lekor* without oyster mushroom addition. *Pleurotus spp.* Mushrooms, according to reports, have a high potential for producing non-polar fungal aroma compounds that give mushroom dishes a distinct flavour and stimulate appetite [38, 39, 40]. Consumers highly desired a "mushroom-like" flavour, a sensory characteristic that imparts a distinct aroma, and it is crucial as well as plays a significant role in mushroom acceptance [41]. Aishah and Wan Rosli [36] supported the score given by the panellist on aroma attributes using a 7-point hedonic scale stated that the mean score of rice-based product incorporated with oyster mushroom (*Pleurotus sajor-caju*) was reported with the highest means score which was 4.68. Additionally, the mean score of 6.30 in the sample containing the highest amount of oyster mushroom (*Pleurotus ostreatus*) incorporated in red tilapia flesh sausage [42].

In terms of taste, the range of the panellists' mean scores of samples of *keropok lekor* incorporated with oyster mushrooms ranged between 7.27 and 7.55. The panellists' mean score of *keropok lekor* incorporated with oyster mushroom samples was significantly higher (P<0.05) compared to the mean score of the control sample, which was 6.53. Previously, Hleap-Zapata and Rodriguez-de-la-Pava [42] reported that the sample of red tilapia flesh sausage incorporated with oyster mushroom as the partial substitute for phosphate with the balance formulation of sodium pyrophosphate. It recorded the highest mean taste score (6.26) compared to other formulations, ranging between 6.06 and 6.18. Similarly, this study recorded sample B (50% fish flesh and 50% oyster mushroom) with the highest mean score (7.55). Besides, mushrooms from species of *Pleurotus spp.* are cultivated widely due to their taste and flavour that was contributed by chemical compounds to be used in the production of functional foods [43, 44]. In addition, according to Moliszewska [45], the taste and aroma of mushrooms are frequently associated.

Lastly, the overall acceptance of *keropok lekor* incorporated with mushrooms that were given by the mean score of panellists showed a higher significance (P<0.05) compared to the control sample (6.65). The mean score of experimental *keropok lekor* ranged between 7.35 and 7.53. This result might be related to the lower hardness value of formulated keropok lekor than the control sample. This indicates the softer texture that can be observed in Table III with the correlation value of 0.90 indicates that the softer the texture of the *keropok lekor* sample. The higher overall acceptance of consumers towards the sample is due to the aromatic properties and rich flavour of mushrooms [46, 47]. This finding was in agreement with research from Aishah and Wan Rosli [36], who reported that the mean score of overall acceptance of rice-porridge incorporated with oyster mushroom with different levels of 2%, 4%, and 6% ranging from 4.19 to 4.39 was significantly higher (P<0.05) than in control sample (4.05). Overall acceptance of chicken sausage incorporated with oyster mushroom samples stated that the panellists' mean score ranged from 4.86 to 5.20 was higher than the mean score in the control sample, which was 4.51 [24]. In short, *keropok lekor* incorporated with oyster mushrooms was acceptable among consumers.

IV. CONCLUSION

The substitution of oyster mushroom to fish flesh in the *keropok lekor* formulations with different percentages significantly (P<0.05) affects the nutritional composition of *keropok lekor* except in carbohydrate content. The increase of mushroom substitution in *keropok lekor* decreased the protein and fat content but increased the ash content. *Keropok lekor* formulated with the highest percentage of mushroom substitution (50% oyster mushroom, sample B) was the softest in texture and lightest in colour among the samples. Moreover, the incorporation of oyster mushroom in *keropok lekor* significantly (P<0.05) affects the consumer acceptability in terms of texture, taste, and overall acceptance except for appearance, colour, and aroma, with sample B obtaining the highest mean score in all attributes. These results concluded that using oyster mushrooms as a substitute for fish flesh in *keropok lekor* formulations is an effective way to produce a variety of *keropok lekor* products. In future work, it is recommended to use different types of mushrooms and different ratios of mushroom to fish flesh using the same formulation of *keropok lekor*, and their effect on the overall quality of the *keropok lekor* will be investigated.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this paper.

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