Malaysian Journal of Chemistry, 2024, Vol. 26(3), 330-338
(Special Issue: *3rd Virtual International Symposium on Sciences 2023*)

Unveiling the Impact of Various Flours and Cooking Strategies on the Quality of Formulated Keropok Lekor

Farah Faiqah Fazial[1]*, Normarina Abd Razak[1] and Azfar Al Ariff Ahmad[2]
[1]Faculty of Chemical Engineering & Technology, Universiti Malaysia Perlis (UniMAP) Kampus UniCITI Alam, 02100 Padang Besar, Perlis
[2]Bioresource Technology Division, School of Industrial Technology, Universiti Sains Malaysia, 11800 Penang, Malaysia
*Corresponding author (e-mail: farahfaiqah@unimap.edu.my)

Keropok lekor has now journeyed across Malaysia's culinary landscape especially in Terengganu. However, its presence beyond Terengganu often features a meagre 60% fish content (KLB (60)), contrasting the Terengganu version that boasts a remarkable 70% fish content (KLA (70). This study aims to revitalise KLB (60) keropok lekor by replacing tapioca flour with diverse plant-based proteins - chickpea, soybean, and corn flour. The subsequent culinary exploration involves both boiling and frying methods. All cooked formulated keropok lekor was evaluated in terms of nutritional composition, texture characteristics, and sensory evaluation. KLSoybean has the highest protein content (29.62%-30.81%) followed by KLChickpea (25.60%-26.30%) and KLCorn (23.10%-24%). Texture aspects include hardness, springiness, cohesiveness, and chewiness were meticulously gauged using a texture analyser and cross-referenced with sensory assessments. The results showed that most respondents preferred fried keropok lekor to boiled keropok lekor. Keropok lekor, which comprises plant flour protein is dominant in protein content, chewiness, and preferred for its colour and aroma during sensory evaluation. This study convincingly demonstrates the potential of replacing tapioca flour with other plant-based alternatives like chickpea, soybean, and corn flour. This innovation not only enriches nutritional profiles but also maintains desired physical attributes, ensuring satisfaction for human consumption.

Keywords: Keropok lekor; chickpea; soybean; corn; texture

Received: September 2023; Accepted: February 2024

Keropok lekor from Terengganu is categorised as high protein content due to its high amount of fish flesh (around 70%), while keropok lekor with lesser amount of fish flesh is categorised as low protein keropok lekor (around 50%). The low fish flesh amount and tough texture due to the high amount of tapioca flour used resulted in low protein and tough-textured keropok lekor. Therefore, the use of different flours such as chickpea, soybean, and corn in a certain amount can replace the role of tapioca flour as a binder because the flours contain starch which can serve as a binder for some foods like keropok lekor. Innovation of keropok lekor formulations has been reported recently where green banana flour has been added in the formulations to increase the nutrient content and aroma of keropok lekor [1]. Incorporating grey oyster mushrooms powder in keropok lekor to create a variation high in dietary fibre and protein, but low in fat, indicates a shift towards a more nutritious keropok lekor [2-3]. Therefore, formulating KLB (60) keropok lekor with the replacement of certain ingredients while maintaining or enhancing its original taste and aroma is a good alternative to increase the nutrient value and produce a more innovative keropok lekor-based products. This study aims to formulate keropok lekor by substituting tapioca flour with different flours such as chickpeas flour, soybean flour, and corn flour as alternative ingredients to improve its nutritional value, texture, and consumer acceptance. Chickpea (*Cicer arietinum L.*) is one type of legume with high nutrient content such as protein, β-carotene, fibre, and minerals (calcium, phosphorus, iron, zinc, and magnesium) [4]. Because of this, chickpea is a healthy food, as they are a good source of unsaturated fatty acids, which can help control weight, and reduce blood pressure. Soybean is one type of legume with high amount of methionine and cysteine amino acid that are beneficial for human health [5]. Corn flour (*Zea mays*), another plant-based protein, is high in B-complex vitamins including thiamine, niacin, and pantothenic acid, and serve as co-factor for enzymes during substrate metabolism [6]. In Malaysia, chickpea, soybean, and corn are available at an affordable price and their high protein content can help for the development of food product. Innovation of keropok lekor with different flours substitution can improve protein content, texture properties, and consumer acceptance of keropok lekor.

†Paper presented at the 3rd Virtual International Symposium on Sciences (3rd VISoS 2023)

EXPERIMENTAL

Chemicals and Materials

All raw materials for keropok lekor preparation such as Selayang fish flesh, chickpea flour, tapioca flour, sago flour, soybean flour, corn flour, salt, and sugar were obtained from local market. Sodium hydroxide (NaOH) and sulphuric acid (H_2SO_4) were purchased from QReC (Selangor, Malaysia).

Preparation of Keropok Lekor

Five different formulations of keropok lekor were prepared according to the method of Iqmal Afifi and coworkers [3] with slight modifications and illustrated in Table 1. KLA(70) is control keropok lekor sample having 70% fish flesh following original menu from Terengganu whereas KLA(60) is control keropok lekor sample having 60% fish flesh usually being prepared by non-Terengganu manufacturers. As for other formulations, tapioca starch was substituted with chickpea flour, soybean flour, and corn flour to the KLA(60) to increase its nutritional content. Detailed description of ingredients for each formulation is tabulated in Table 1.

To prepare keropok lekor, about 500g of boneless Selayang fish was grind until obtained as smooth paste. In a mixing bowl, the fish paste was mixed with flour, salt, sugar, and water (Table 1). The paste was then shaped into cylindrical pieces and briefly boiled until they float (5 – 7 minutes). After boiling, half of the keropok lekor was assigned to frying procedure in hot oil (180-190°C) until they turned golden brown and crispy, which would have taken approximately 5-7 minutes.

Cooking Methods

For the boiling method, it involves boiling of keropok lekor that have been formed into cylinders for 13 minutes. After 13 minutes, the boiled keropok lekor were lifted and placed on a clean tray and allowed to cool at room temperature. Once cooled, the keropok lekor were vacuumed in plastic bags and labelled before being stored in the refrigerator for further analysis.

For the frying method, two processes were involved for cooking. Cylinder-shaped keropok lekor were boiled for 13 minutes. After 13 minutes, the keropok lekor were lifted and placed on a clean tray and allowed to cool at room temperature. All formulated keropok lekor were cut using a knife at 3 cm length following the standard. The second step involves frying. The frying process entails using palm oil for 3 minutes. During the cooking process, it was essential to ensure that the oil is at a high temperature (185±5 ºC). The keropok lekor were carefully placed into the hot oil for 3 minutes. After the 3-minute frying duration, the keropok lekor were removed and transferred onto a clean tray lined with tissues. The fried keropok lekor were then left to cool at room temperature. Once they have cooled down, the keropok lekor were ready for analysis.

Table 1. Formulation of different types of keropok lekor (KL).

Ingredients (g)	Different formulations of keropok lekor, KL (g)				
	KLA (70) (commercial control)	KLB (60)	KLChickpea	KLSoybean	KLCorn
Selayang fish flesh	70	60	60	60	60
Tapioca flour	7	12	-	-	-
Sago flour	7	12	12	12	12
Chickpeas flour	-	-	12	-	-
Soybean flour	-	-	-	12	-
Corn flour	-	-	-	-	12
Water and Ice	14.09	24.09	24.09	24.09	24.09
Salt	1.26	1.26	1.26	1.26	1.26
Sugar	0.5	0.5	0.5	0.5	0.5
Monosodium Glutamate (MSG)	0.15	0.15	0.15	0.15	0.15
Total (g)	**100**	**100**	**100**	**100**	**100**

Nutritional Analysis

Nutritional analysis (protein, fat, moisture, and ash contents) was conducted according to the standard method described by the Association of Official Analytical Chemists (AOAC, 2016). This analysis was done using boiled and fried keropok lekor samples for all formulations. The samples were mashed using mortar and pestle before each analysis. Measurements for proximate analysis were carried out in triplicates.

Texture Profile Analysis

Texture profile analysis such as hardness, springiness, cohesiveness and chewiness were analysed using TA.XT-Plus texture analyser (Stable Micro System, Surrey, UK) and Exponent (1024 x 768 x 24-bit graphics) software. All the keropok lekor samples were cut to approximately 2 cm in size and the load cell used was 5 kg. Parameters setting was set up as following: pre-test at 3 mm/sec and post-test speed at 5 mm/s, the distance measurement was set at 10 mm, and the time was set for 5 seconds. The analysis was conducted in five replicates. The probe and platform were cleaned upon completion of the analysis.

Sensory Evaluation

Sensory evaluation of keropok lekor was conducted according to the hedonic scale. 30 panellists were selected and were instructed to evaluate based on colour, aroma, chewiness, taste, and overall acceptance. A seven-point hedonic scale from one "very dislike" to scale seven "Like very much" was employed to evaluate all types of keropok lekor using boiling and frying methods.

Data Analysis

All data was collected and recorded in software Statistical Package for the Social Sciences (SPSS). One-way ANOVA was conducted using Duncan's test with confidence level at $p \leq 0.05$.

RESULTS AND DISCUSSION

Proximate Composition

The protein content of the same sample showed no significant difference between fried and boiled methods (Figure 1). The range of protein content varied from lowest to highest among different formulations: KLCorn (23.10% - 24%), KLA(60) (23.50% - 24.09%), KLChickpeas (25.60% - 26.30%), KLA(70) (25.78% - 26.96%), and KLSoybean (29.62% - 30.81%). Notably, KLSoybean exhibited the highest protein content, attributed to the inherent richness of protein, especially essential amino acids that are crucial for the human body [8]. As for legumes-based flour, the availability of nitrogen-fixing bacteria in their roots allows legumes to convert unusable nitrogen gas into ammonium, facilitating protein synthesis [9]. Since raw soybean flour contained 38.43% protein, chickpea flour contained 24.61% protein, and corn flour contained 10.20% protein, substituting tapioca flour with legume flour in keropok lekor formulation notably boosted protein content of the formulated keropok lekor [10].

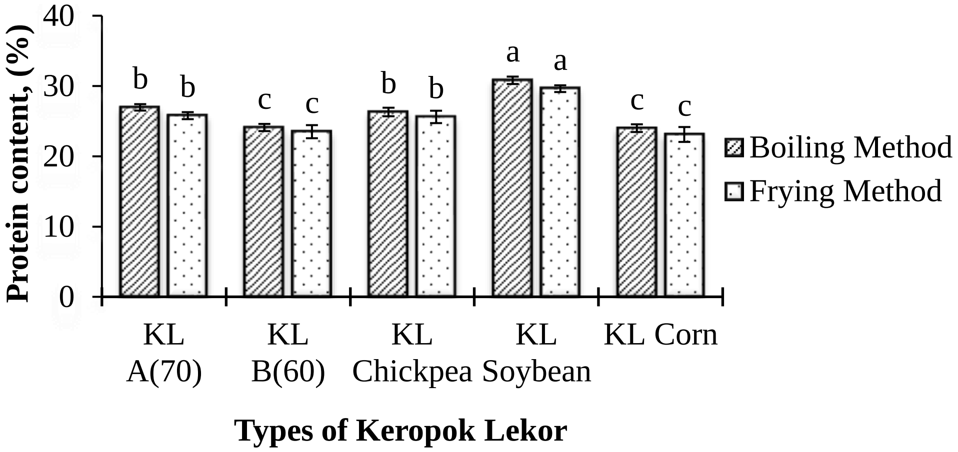


Figure 1. Protein content (%) for different formulations of keropok lekor. Different alphabets represent significant difference (p≤0.05.

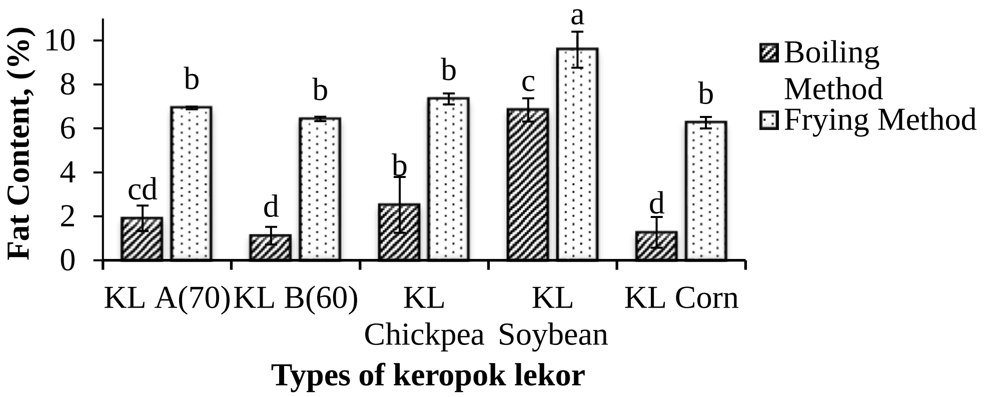


Figure 2. Fat content (%) for different formulations of keropok lekor. Different alphabets represent significant difference (p≤0.05).

For fat content (Figure 2), keropok lekor prepared through the frying method displayed a higher fat content compared to the boiling method. The increase in fat content in fried keropok lekor can be attributed to the rapid loss of moisture content during the cooking process, influenced by temperature and heating duration. This loss of moisture creates space within the keropok lekor, which is then occupied by oil molecules from the cooking oil used [11]. KLSoybean prepared through the frying method had the highest fat content among the various formulations. The fat content of keropok lekor using the frying method is as follows: KLA(70) (6.93±0.06%), KLB(60) (6.43±0.1%), KLChickpea (7.34±0.25%), KLSoybean (9.58±0.82%), and KLCorn (6.26±0.26%). This outcome was attributed to the inherently higher fat content of plant-based flours, particularly legumes, which are rich sources of unsaturated fatty acids such as linoleic and oleic acid. Soybean, chickpea, and corn contain around 20% [11], 5% [4], and 2.18% [12] of these fatty acids, respectively.

For moisture content (Figure 3), boiled keropok lekor has higher moisture content than fried keropok lekor. During boiling water will easily penetrate into the keropok lekor and will absorb the water according to its ability which is determined by the amount of protein contained [13]. Since keropok lekor contain starch, water molecules will be absorbed in the amorphous structure of starch, leading to swelling of the amylopectin structure while boiling at high temperature. As for frying, water content inside keropok lekor will be easily evaporated due to the penetration of oil from the cooking oil into keropok lekor causing the surface temperature to rise and subsequently the water evaporates as steam [14]. Among all samples, KLsoybean has the highest moisture content. Because soybeans contain the highest protein content, they frequently have powerful water-binding abilities. This is because proteins are composed of amino acids that have both hydrophilic and hydrophobic regions. Proteins' hydrophilic areas can effectively attach to and retain water due to their attraction for water molecules [15].

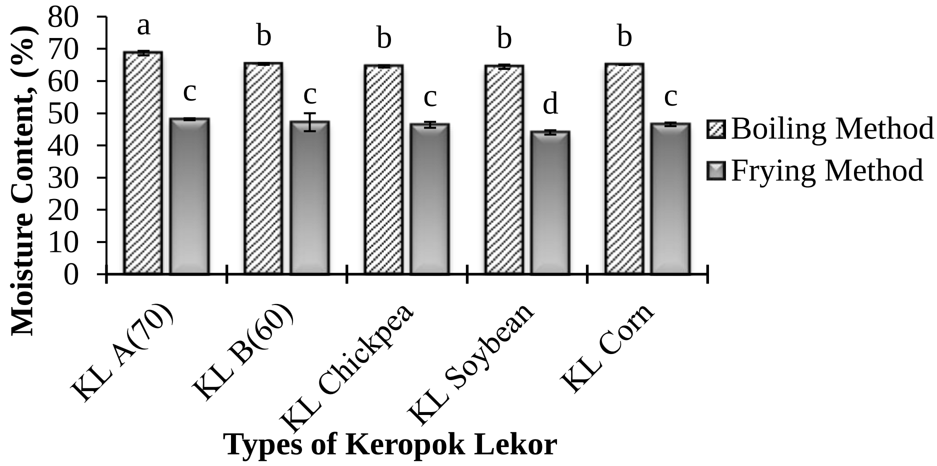


Figure 3. Moisture content (%) for different formulations of keropok lekor. Different alphabets represent significant difference (p≤0.05).

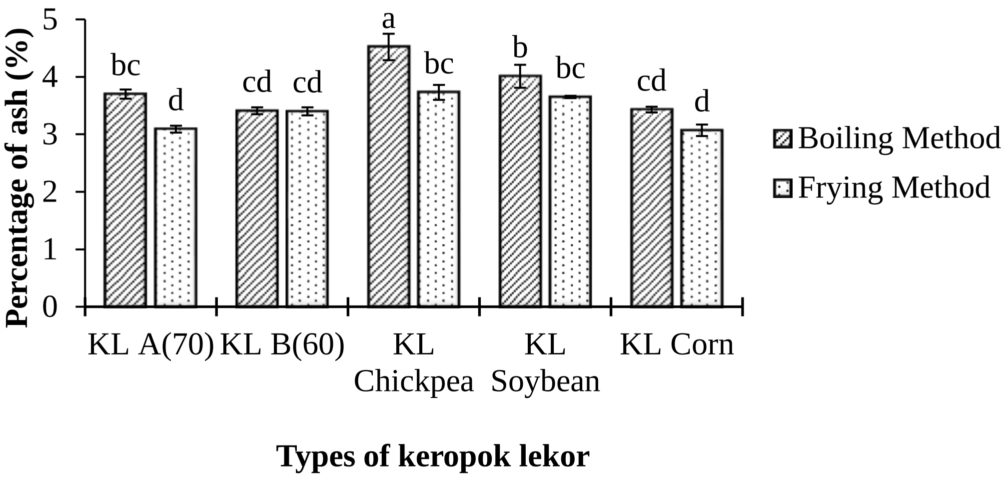


Figure 4. Ash content (%) for different formulations of keropok lekor. Different alphabets represent significant difference (p≤0.05).

Analysis of ash content is shown in Figure 4. Boiled keropok lekor has higher ash content than fried keropok lekor. As for boiled keropok lekor, the ash content of KLA(70) was 3.70±0.08%, followed by KLB(60) (3.41±0.06%), KLChickpea (4.52±0.23%), KLSoybean (4.01±0.20%), and KLCorn (3.42±0.05%). Legume-based flours like chickpea and soybean generally have a high mineral content. Raw soybean flour, chickpea flour, and corn flour were reported to have 4.23%, 7.45% and 1.1% mineral content, respectively [16]–[18]. When tapioca flour was substituted with legume flour or other plant-based proteins, the ash level of formulated keropok lekor can be improved. Previous investigation on the physicochemical properties of commercial fish sausage produced in Malaysia by Rosnah et al. (2014) revealed that the ash concentration only varied between 1.73-2.61%. Moreover, Yousefi & Moosavi-nasab (2014) reported the ash content of keropok lekor using Talang Queenfish and surimi was in the range of 1.40-3.01%.

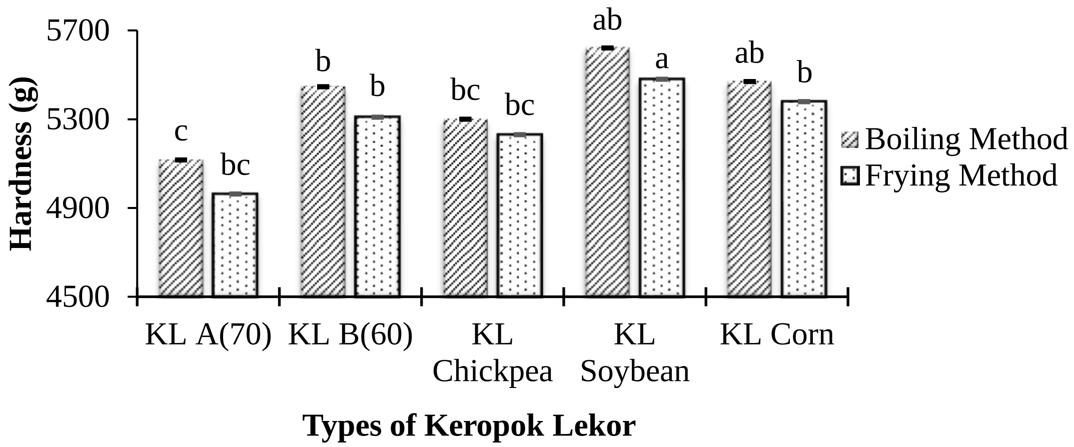
Texture Analysis

Figures 5 (a) to 5 (d) demonstrate the results of texture analysis for all types of keropok lekor prepared using boiling and frying methods. The hardness of various formulations created using both methods is shown in Figure 5 (a). According to the findings, there were no significant difference in the level of hardness using the two techniques. KLA(70) has a hardness range of 4963 to 5116.33 g, followed by KLChickpea at 5230.11 to 5300 g, KLB(60) at 5309 to 5446.33 g, KLCorn at 5379 to 5469.67 g, and KLSoybean at 5480 to 5620.90 g. The highest hardness was shown by KLSoybean when compared to other formulations. This can be correlated to the lowest moisture content in soybean (Figure 3) causing compactness of the KLSoybean structure. As for KLChickpea and KLCorn, the hardness was contributed by the presence of higher starch approximately 4% - 8% [20].

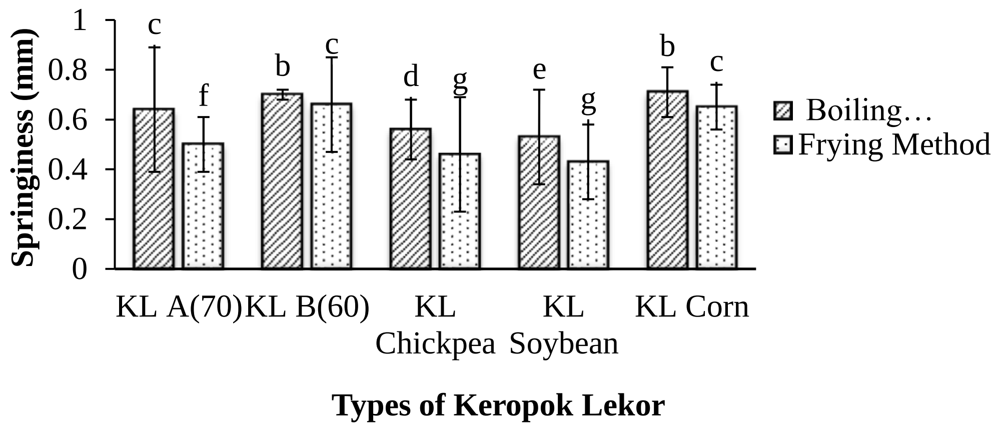
The springiness values for various formulations prepared using both cooking procedures are shown in Figure 5 (b). The outcomes revealed variations in springiness between the two approaches. Due of the preserved moisture, boiled keropok lekor may have a chewier texture and showed higher springiness. The crisp and brittle texture of fried keropok lekor, on the other hand, can cause it to be less bouncy. KLA(70) (0.5-0.64 mm), KLB(60) (0.66-0.70 mm), KLChickpea (0.46-0.56 mm), KLSoybean (0.43-0.53 mm), and KLCorn (0.65-0.71 mm) were the springiness values.

Cohesiveness analysis for all types of keropok lekor was also performed. The cohesiveness values for different formulations prepared using both cooking procedures are shown in Figure 5 (c). Because the moisture content helps to bind the keropok lekor components together, boiled keropok lekor can be more cohesive, have a smoother and chewy texture. In contrast, because of the moisture loss while frying, keropok lekor may become crumblier. The findings showed that there were no significant differences in cohesion between the two approaches. KLA(70) (0.23-0.24), KLB(60) (0.36-0.38), KLChickpea (0.24-0.26), KLSoybean (0.23-0.24), and KLCorn (0.37-0.39) were the cohesiveness values. These findings were consistent with a study by Huda and coworkers (2012) [21], who found that keropok lekor's cohesiveness values ranged from 0.28 to 0.42. The chewiness values for various formulations prepared using both cooking procedures are shown in Figure 5 (d). The findings revealed no significant difference in chewiness between the two methods. KLA(70) (2481.5-3274.45 g mm), KLB(60) (503.94-3812.43 g mm), KLChickpea (2405.85-2968 g mm), KLSoybean (2356-2979.08 g mm), and KLCorn (3496.35-3883.47 g mm) had the highest chewiness values. Compared to other formulations, KLCorn had the highest chewiness, although it did not differ significantly from KLB(60).

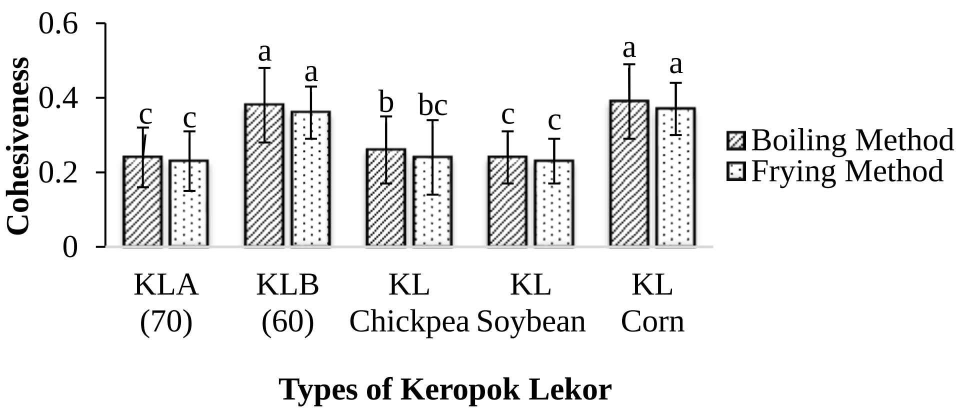
(a)



(b)



(c)



(d)

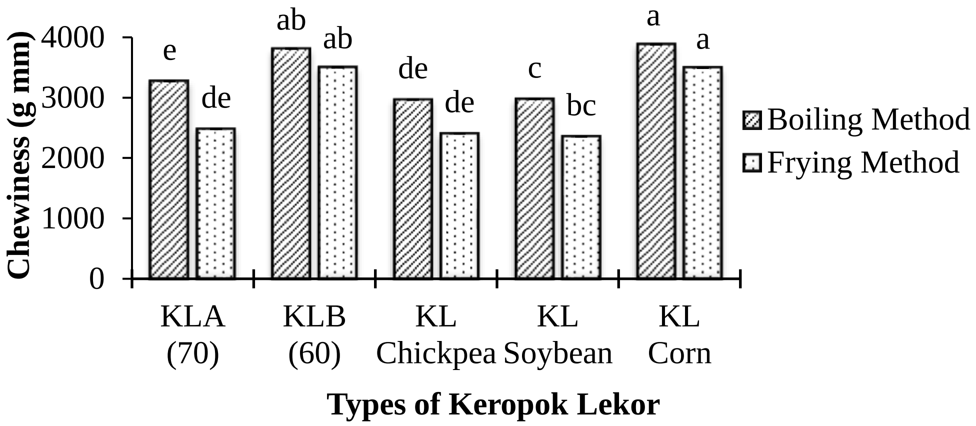
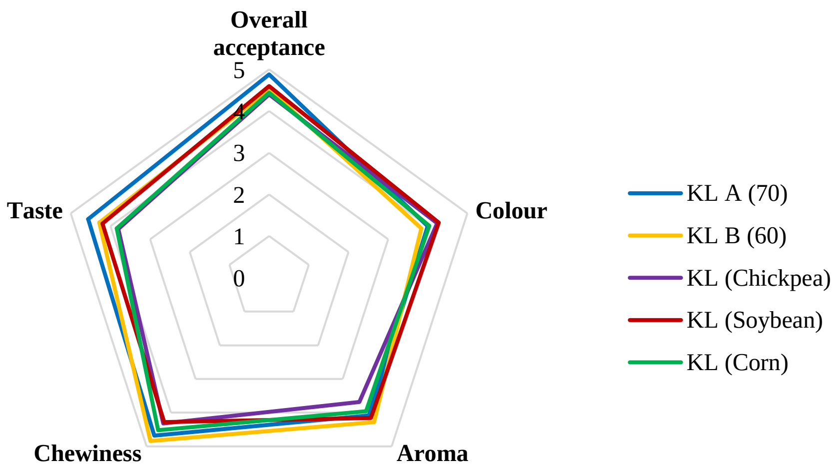


Figure 5. Hardness (a), Springiness (b), Cohesiveness (c), and Chewiness (d) for different formulations of keropok lekor. Different alphabets represent significant difference (p≤0.05).

(a)



(b)

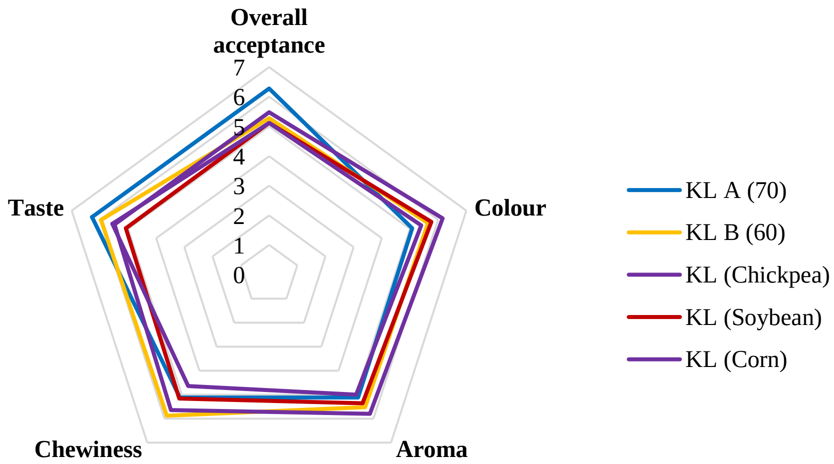


Figure 6. Sensory score of boiled keropok lekor (a) and fried keropok lekor (b).

Sensory Analysis

A sensory assessment of all varieties of keropok lekor was done to determine their general acceptability. The sensory evaluation of overall acceptance for various formulations made using both cooking methods for all formulations is shown in Figure 6. The findings revealed that both techniques' overall acceptability ratings varied. In comparison to other varieties of keropok lekor, fried KLA(70) obtained the greatest overall acceptability score from the panellists for the frying procedure. The overall acceptability still heavily leans towards original formulation whereby high fish flesh was used such in KLA (70), suggesting that the intrinsic qualities of high fish flesh content such as specific texture and taste profiles are crucial to consumer preferences [22]. According to the findings, the panellists favoured frying over boiling for all formulations of keropok lekor. For all varieties of keropok lekor made using various plant-based flours, such as chickpea, soybean, and corn, the rating scores for all characteristics, including colour, aroma, chewiness, taste, and overall acceptance, did not differ significantly from those formulated with tapioca starch. As a result, the formulated keropok lekor using other plant-based flours (chickpea, soybean, and corn) have the potential to replace tapioca starch in keropok lekor.

CONCLUSION

In conclusion, the different plant-based flours had different effects on the proximate compositions, texture behaviours, and sensory acceptability of keropok lekor. The proximate analysis of the formulated keropok lekor showed that KLSoybean has the highest protein content (29.62%-30.81%) either in boiled or fried keropok lekor. Fat content clearly showed that the fried keropok lekor contained more fat content in the range of 30% - 250% higher than boiled keropok lekor due to oil absorption during the frying procedure. Apart from this, different types of plant-based flours showed greater hardness, springiness, and cohesiveness in boiled compared to fried keropok lekor. Among all samples, KLSoybean possessed the highest hardness value whereas KLB (60) and KLCorn have higher value of springiness, cohesiveness, and chewiness. Overall acceptability demonstrated that the most preferable sample that panellists like to choose was fried KLA (70). Even so, new formulations of keropok lekor showed some promising data since the overall score demonstrated more than 4 marks, which might be due to the first introduction of alternative ingredients which displayed different aroma, texture, and taste. Thus, these findings can be used to develop keropok lekor from alternative plant-based flour with further improvement to achieve excellent nutritional elements with desirable quality than conventional keropok lekor made with tapioca or sago starch.

ACKNOWLEDGEMENTS

The authors want to thank the Faculty of Chemical Engineering & Technology, Universiti Malaysia Perlis for providing the laboratory facilities in completing this manuscript.

REFERENCES

1. Jalil, S. J. A. and Musa, N. (2023) The utilization of Green Banana (Musa Acuminata X Musa Balbisiana) Flour in the Development of Keropok Lekor. In *Proc. International Agrotechnology Innovation Symposium, Melaka*, **4**, 9–17.
2. Salasiah, N., Faridah, Noorzainah, Ashadi, Rawaida and Mazliana (2023) Mushroom keropok lekor, an innovative food product. *Food Research*, **6**, 268–276.
3. Iqmal-afifi, L., Arifin, N. and Huda-faujan, N. (2023) Physicochemical Properties and Sensory Preference of Keropok Lekor with Partial Replacement of Fish Flesh with Oyster Mushroom. *Malaysian Journal of Science Health Technology*, **9**, 128–135.
4. Rasool, S., Latef, A. A. H. A. and Ahmad, P. (2015) *Chickpea. Legumes under Environmental Stress*, *Wiley*.
5. Burssens, S., Pertry, I., Diasolua, D., Kuo, Y. H., Van, M. and Lambei. F. (2011) Soya, Human Nutrition and Health. *Soybean and Nutrition*, 157–177.
6. Siyuan, S., Tong, L. and Liu, R. (2018) Corn Phytochemicals and Their Health Benefits. *Food Science and Human Wellness*, **7**, 185–195.
7. AOAC International (2016) Appendix F: Guidelines for Standard Method Performance Requirements. *Association of Official Analytical Chemists*.
8. Ndife, J., Abdulraheem, L. O. and Zakari, U. M. (2011) Evaluation of the nutritional and sensory quality of functional breads produced from whole wheat and soya bean flour blends. *African Journal of Food Science*, **5**, 466–472.
9. Maphosa, Y. and Jideani, V. A. (2017) The Role of Legumes in Human Nutrition. *Intech*.
10. Prandi, B. (2021) Targeting the Nutritional Value of Proteins from Legumes By-Products Through Mild Extraction Technologies. *Frontiers in Nutrition*, **8**.

11. Liu, K. (1997) Soybeans. *Chemistry and Nutritional Value of Soybean Components*, *Springer, US*.

12. Dehghan Nasiri, F., Mohebbi, M., Tabatabaee Yazdi, F. and Haddad Khodaparast, M. H. (2012) Effects of Soy and Corn Flour Addition on Batter Rheology and Quality of Deep Fat-Fried Shrimp Nuggets. *Food Bioprocess Technology*, **5**, 1238–1245.

13. Syamsuri Riswita, Dewayani, W., Erina Septianti and Maintang (2020) Chemical characteristic and sensory of tempeh sausage on different soybean varieties and cooking methods variation. *IOP Conf. Ser. Earth Environ. Sci.*, **575**.

14. Tamsir, M. M., Ramli, N. S., Nor-Khaizura, M. A. R., Shukri, R. and Ismail-Fitry, M. R. (2021) Comparison of boiling, Steaming, Air Frying, Deep frying, microwaving and Oven-Cooking on Quality Characteristics of keropok lekor (Malaysian Fish Sausage). *Malaysian Applied Biology*, **50**, 77–85.

15. Awuchi., Godswill, C., Somtochukwu, V. and Kate, C. (2019) The Functional Properties of Foods and Flours. *International Journal of Advanced Academic Research*, **5**, 2488–9849.

16. Ratnawati, L., Desnilasari, D., Surahman, D. N. and Kumalasari (2019) Evaluation of Physicochemical, Functional and Pasting Properties of Soybean, Mung Bean and Red Kidney Bean Flour as Ingredient in Biscuit. *IOP Conf. Ser. Earth Environ. Sci.*, 251.

17. Matovu, H., Muyanja, C. and Byenkya, S. (2015) The proximate and chemical composition of improved chickpea cultivars grown under the pure stand and banana intercrop systems in south western Uganda agro ecological zone. *African Journal of Food, Agriculture, Nutrition and Development*, **15**, 10474–10490.

18. Bamidele, O. P. and Fasogbon, B. M. (2020) Nutritional and functional properties of maize-oyster mushroom (Zea mays-Pleurotus ostreatus) based composite flour and its storage stability. O*pen Agriculture*, **5**, 40–49.

19. Yousefi, A, R. and Moosavi-nasab, M. (2014) Textural and chemical attributes of minced fish sausages produced from Talang Queenfish (*Scomberoides commersonnianuus*) minced and surimi. *Iranian Journal of Fish Sciences*, **13**, 228–241.

20. Rahman, M. S., Al-waili, H., Guizani, N. and Kasapis, S. (2007) Instrumental-sensory evaluation of texture for fish and its storage stability. *Fisheries Science*, **73**, 1166–1176.

21. Huda, N., Alistair, T., Lim, H. and Nopianti, R. (2012) Some Quality Characteristics of Malaysian Commercial Fish Sausage. *Pakistan Journal of Nutrition*, **11**, 798–803.

22. Nordin, L. N., Nor Khaizura, M. A. R. and Ismail-Fitri, M. R. (2018) Effect of substituting tapioca starch with various high protein legume flours on the physicochemical and sensory properties of keropok lekor (Malaysian fish sausage). *Food Research*, **3**, 40–48.