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Research Article
Effect of Temperature and Heating Time on Chemical and Proximate Characteristics of Laksan Sauce as a Palembang Traditional Food

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Abstract

Background and Objective: Laksan is one of the traditional foods of Palembang, Indonesia. It is similar to pempek, but it is consumed with coconut milk sauce. It is usually consumed hot so reheating is sometimes required. Coconut milk is the main ingredient in laksan sauce and is susceptible to chemical change, especially the proximate content when heated. This chemical change obviously affects the chemical and proximate characteristics of the laksan sauce. The aim of this study was to determine the effect of temperature and heating time on the chemical and proximate characteristics of laksan sauce. **Methodology:** A factorial completely randomized design was used in this study. **Results:** The results showed that the temperature and heating time had significant effects on the peroxide numbers, free fatty acids, protein content, lipid content, water content, ash content and carbohydrate content of laksan sauce. **Conclusion:** The best treatment for laksan sauce was found to be a heating temperature of 80°C for 20 min.

Key words: Peroxide numbers, free fatty acid, proximate, laksan, traditional food

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Laksan is one of the traditional foods of Palembang, Indonesia. It is similar to pempek, but it is consumed with coconut milk sauce. It is usually consumed hot so reheating is sometimes required. Coconut milk, as the main ingredient in laksan sauce, is susceptible to physical and chemical changes when heated. These physical and chemical changes obviously affect the characteristics of the laksan sauce.

Coconut milk cannot be stored for a long time at room temperature, which is indicated by a quick change in flavor. The change in this flavor is due to the occurrence of off flavor[1]. The occurrence of off flavor is caused by the development of free fatty acids and glycerol resulting from the product of oil hydrolysis[2]. Hydrolysis is accelerated by lipase, which is naturally found in tissue containing oils or lipids[3]. One of the factors that affects lipase activity is temperature. The optimum temperature for lipase is in the range of 30-40°C[4,5].

Coconut milk is a white fluid obtained from shredding coconut flesh (*Cocos nucifera* L.) with or without water. It is an important element of Asian foods and other regions in the world. The composition of coconut milk varies according to the variety, age and environmental growth of the coconut, the preparation method and the processing conditions used for extraction, such as the water added and the temperature during extraction[6]. The chemical composition of coconut milk (without water) is 2.6-4.4% protein, 50-54% water, 32-40% lipid and 1-1.5% ash[7].

Heating results in protein denaturation in coconut milk. This protein denaturation will change the properties and viscosity of the coconut milk if it is heated at 80°C or higher. Heating coconut milk above 80°C makes it susceptible to protein denaturation resulting in unstable conditions of the coconut milk emulsion[8,9].

The longer the heating time, lower the lipid content due to the decrease in fluid during heating[10]. This decrease in fluid accelerates lipid molecule movement, which produces longer distances between lipid molecules and facilitates the release of lipids that are affected by temperature and heating time[11].

The main carbohydrate components in coconut milk are sucrose and starch. Heating will cause water absorption into starch granules. High numbers of hydroxyl groups in starch cause water initially located outside the starch to become absorbed into starch granules, making them unable to move freely[12].

The objective of this study was to analyze the effect of temperature and heating time on the chemical characteristics and proximate contents of laksan sauce.

MATERIALS AND METHODS

The materials used in this study were coconut milk and spices. Coconut milk was obtained from whole coconut flesh from the Km 5 market. The epidermis of the coconut flesh was peeled, washed with flowing water, shredded, squeezed and sieved. The ratio of coconut flesh to water was 1:2. The spices consisted of onion, garlic, ginger, turmeric and candlenut mashed using a blender.

This research study used a factorial completely randomized design with two factors of heating temperature (T) at 3 levels ($T_1 = 60°C$, $T_2 = 70°C$ and $T_3 = 80°C$) and heating time (t) at 4 levels ($t_1 = 10$ min, $t_2 = 20$ min, $t_3 = 30$ min and $t_4 = 40$ min), resulting in 12 treatment combinations. Each treatment was replicated 3 times. Data were presented in tables and an analysis was conducted to determine the effect of temperature and heating time on the chemical characteristics of laksan sauce using one-way analysis of variance (ANOVA) at a 95% confidence level. If ANOVA showed a significant effect, then it is followed by Duncan's *post hoc* test to determine the effect of each treatment.

Analyses of peroxide numbers, free fatty acids, protein content, lipid content, water content and ash content were performed according to AOAC[13] procedures, whereas, carbohydrate content was determined using the difference method.

RESULTS AND DISCUSSION

Peroxide numbers: The deterioration of lipid/oil can be determined by using peroxide numbers. Peroxide numbers are produced due to the oxidation reaction of unsaturated fatty acids that bind oxygen in its double bond, resulting in peroxide formation. This peroxide formation will affect the lipid/oil taste. The results showed that the peroxide numbers in laksan sauce prior to cooking were higher than those after cooking (Table 1). Reheating changed the peroxide number in laksan sauce.

Higher temperatures and longer heating times resulted in higher peroxide numbers in laksan sauce. The highest peroxide number was found from heat treatment at 80°C for 40 min. The results from the ANOVA showed that there was a significant effect of temperature and heating time on peroxide numbers in laksan sauce. The results from Duncan's *post hoc*

Table 1: Peroxide number of laksan sauce before and after cooked

Sample	Peroxide number (meq kg^{-1})
Before cooked	3.219
After cooked	2.364

Table 2: Effect of temperature and reheating on peroxide number of laksan sauce

	Peroxide number (Meq kg^{-1})			
	Heating time (min)			
Heating temperature (°C)	10	20	30	40
60	2.207±0.0210^{c}	2.214±0.159^{c}	2.509±0.025^{g}	2.507±0.030^{i}
70	2.007±0.195^{a}	2.007±0.023^{a}	2.123±0.006^{b}	2.243±0.209^{d}
80	2.305±0.032^{e}	2.441±0.026^{f}	2.511±0.095^{g}	2.545±0.140^{f}

Numbers having different letter at the same columns had significant effect

Table 3: Free fatty acid content before and after cooked

Sample	Free fatty acid (%)
Before cooked	0.40
After cooked	0.53

Table 4: Effect of temperature and reheating on free fatty acid content of laksan sauce

	Free fatty acid (meq kg^{-1})			
	Heating time (min)			
Heating temperature (°C)	10	20	30	40
60	0.52±0.006^{c}	0.48±0.011^{ab}	0.49±0.006^{ab}	0.54±0.021^{cd}
70	0.47±0.015^{a}	0.53±0.026^{cd}	0.56±0.006^{d}	0.54±0.017^{cd}
80	0.51±0.000^{bc}	0.53±0.015^{cd}	0.54±0.006^{cd}	0.67±0.047^{e}

Numbers having different letter at the same columns had significant effect

Table 5: Proximate composition of laksan sauce before and after cooked

Proximate composition	Before cooked	After cooked
Protein content (%)	0.09	0.47
Fat content (%)	1.30	0.80
Water content (%)	52.92	83.86
Ash content (%)	0.48	0.42
Carbohydrate content (%)	45.21	14.45

test showed that there was no significant effect of temperature or heating time on peroxide numbers in laksan sauce (Table 2).

Free fatty acids: The existence of free fatty acids in coconut milk can trigger off flavor occurrence due to oil hydrolysis[1,2]. Hydrolysis is driven by lipase, which is naturally available in tissues containing oil or lipids[3]. Lipase activity is affected by temperature and the optimum temperature for lipase is in the range of 30-40°C[4]. The free fatty acid content of coconut milk was lower prior to cooking than after cooking (Table 3).

Further heating increased the free fatty acid content of laksan sauce. The highest free fatty acid was found with heat treatment at 80°C for 40 min (Table 4). The results of this study were similar to the findings by Qazuini[14], who reported that the free fatty acid content of coconut milk was increased with heating time. The results from the ANOVA showed that there was a significant effect of temperature and heating time on the free fatty acid content of laksan sauce. The results from Duncan's *post hoc* test showed that there was no significant effect of temperature or heating time on the free fatty acid content of laksan sauce.

Proximate content of laksan sauce: Heating resulted in protein denaturation in coconut milk. This protein denaturation changes the properties and viscosity of coconut milk if it is heated at 80°C or higher. Heating of coconut milk above 80°C makes it susceptible to protein denaturation, resulting in unstable coconut milk emulsion[7,15]. The results showed that there was an increase in protein content and water content in laksan sauce after it was cooked, but the lipid content, ash content and carbohydrate content were decreased (Table 5).

Reheating with several combinations of temperature and heating time produced chemical compositions of laksan sauce as follows:

Protein contents: Protein in coconut milk plays a significant role in the stability of the coconut milk emulsion. Several proteins in coconut milk can interact and cover lipid globules, which can impede separation between the cream and skim phases[7].

The results showed that the highest protein content of laksan sauce was found with reheating at 60°C for 40 min. Protein content was decreased at reheating temperatures of 70 and 80°C using the same heating time. The results of this research study agreed with findings of a previous study conducted by Seow and Gwee[7], who reported that protein denaturation generally occurred at 80°C, whereas, heating coconut milk at 90-95°C for several minutes could destroy most of the protein[8]. According to Tangsuphoom and

Table 6: Effect of temperature and reheating on protein content of laksan sauce

	Protein content (%)			
	Heating time (min)			
Heating temperature (°C)	10	20	30	40
60	0.12±0.025[a]	0.16±0.021[ab]	0.87±0.047[e]	0.88±0.053[f]
70	0.77±0.026[e]	0.70±0.015[d]	0.16±0.030[ab]	0.19±0.010[b]
80	0.47±0.020[c]	0.79±0.010[e]	0.16±0.021[ab]	0.18±0.010[b]

Numbers having different letter at the same columns had significant effect

Table 7: Effect of temperature and reheating on fat content of laksan sauce

	Fat content (%)			
	Heating time (min)			
Heating temperature (°C)	10	20	30	40
60	1.54±0.025[a]	1.90±0.020[ab]	1.48±0. 047[f]	1.49±0.053[f]
70	2.90±0. 026[e]	2.97±0. 015[d]	2.71±0. 030[ab]	2.68±0. 010[b]
80	3.42±0. 020[c]	4.24±0. 010[e]	3.27±0. 021[ab]	3.43±0. 010[b]

Numbers having different letter at the same columns had significant effect

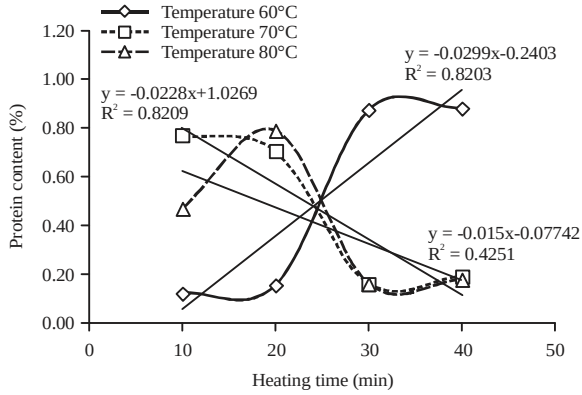

Fig. 1: Effect of temperature and reheating on protein content of laksan sauce

Coupland[16] , some proteins were easily denatured by heating at 70°C, which causes clumping on lipid droplets[9]. Heating at higher temperatures can cause more denatured protein. The results of ANOVA showed that there was a significant effect of temperature and heating time on protein content. The results from Duncan's *post hoc* test also showed that there was a significant effect of temperature and heating time on protein content (Table 6).

The coefficient of determination (R^2) for heating at 60°C was 0.820, which showed that the protein content of laksan sauce was 82.0% affected by temperature and heating time. The R^2 value for heating at 70°C was 0.425, which showed that the protein content of laksan sauce was 42.5% affected by temperature and heating time. The R^2 value for heating at 80°C was 0.820, which showed that the protein content of laksan sauce was 82.0% affected by temperature and heating time. The best laksan sauce protein content was found at a heating temperature of 70°C with the smallest slope of -0.022. This magnitude indicates that every increase in heating time decreased the protein content by 0.022 g (Fig. 1).

Lipid content: Coconut milk contains approximately 35% of lipids, which consists of 45.77 mg g^{-1} saturated lipids[7,9]. The results of this study showed that the highest lipid content was found with a treatment of 80°C for 20 min and the lowest lipid content was found with a 60°C heating temperature for 20 min. This change occurred due to protein denaturation resulting in an unstable coconut milk emulsion[8,15]. The results of the ANOVA showed that there was a significant effect of temperature and heating time on the lipid content of laksan sauce. The results from Duncan's *post hoc* test also showed that there was a significant effect of temperature and heating time on lipid content for each treatment (Table 7).

Heating at temperatures of 80, 70 and 60°C increased the lipid content by 7.4, 7.0 and 13.4%, respectively. The best lipid content was found at heating temperatures of 70°C based on a kinetic rate with slope -0.009. This magnitude indicates that every increase in heating time decreased lipid content by 0.009 g (Fig. 2).

Water content: Heating at 80°C for 22.5 min increased total dissolved solids and viscosity due to protein denaturation and decreased the water content in coconut milk[10,11] The results showed that the higher the temperature and heating time, the lower the water content (Table 8). The results of the ANOVA showed that there was a significant effect of temperature and heating time on the water content of laksan sauce. The results of Duncan's *post hoc* test also showed that there was a significant effect of temperature and heating time on the water content of laksan sauce (Table 7).

Table 8: Effect of temperature and reheating on water content of laksan sauce

	Water content (%)			
	Heating time (min)			
Heating temperature (°C)	10	20	30	40
60	84.28±0.275^{h}	83.33±0.196^{g}	79.24±0. 448de	75.41±0.463^{c}
70	81.41±0. 133^{f}	79.60±0. 232^{e}	78.45±0.102^{d}	75.91±0. 059^{c}
80	79.64±0. 091^{e}	79.05±0. 161de	74.34±0. 440^{b}	71.78±1. 349^{a}

Numbers having different letter at the same columns had significant effect

Table 9: Effect of temperature and reheating on ash content of laksan sauce

	Ash content (%)			
	Heating time (min)			
Heating temperature (°C)	10	20	30	40
60	0.49±0.021^{ab}	0.53±0.025^{bcd}	0.71±0.015^{e}	0.73±0.010^{e}
70	0.52±0.015^{bcd}	0.54±0. 015^{cd}	0.51±0, 015^{bc}	0.52±0. 015^{bcd}
80	0.54±0. 020^{d}	0.47±0. 020^{a}	0,53±0. 020^{cd}	0.54±0. 006^{cd}

Numbers having different letter at the same columns had significant effect

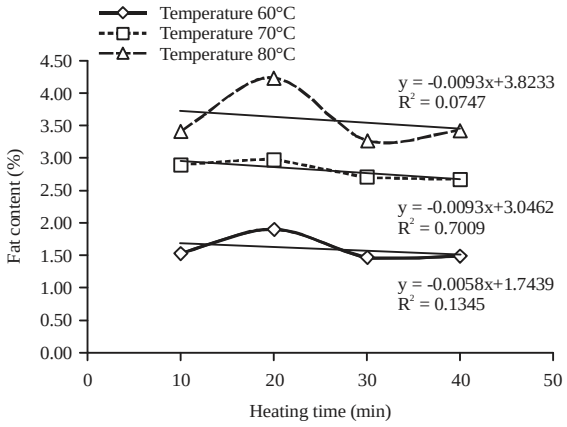

Fig. 2: Effect of temperature and reheating on fat content of laksan sauce

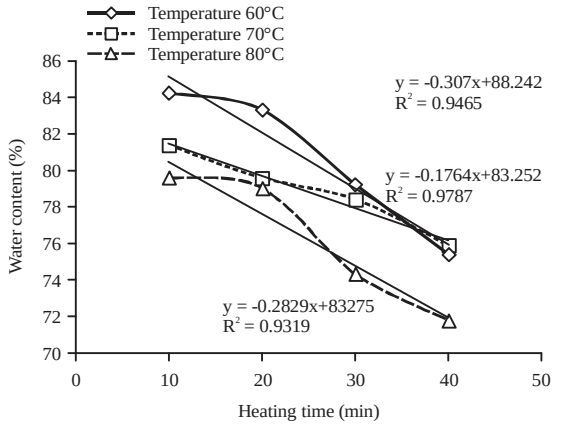

Fig. 3: Effect of temperature and reheating on water content of laksan sauce

Figure 3 shows that temperature and heating time had a significant effect on the water content of laksan sauce. The R^2 values at heating temperatures of 60, 70 and 80°C were 0.946 (94.6%), 0.978 (97.8%) and 0.931 (93.1%), respectively. The best water content was found at a heating temperature of 60°C with a slope of -0.307. This magnitude indicates that the addition of heating time did not decrease the water content of laksan sauce (Fig. 3).

Ash content: Ash content consists of inorganic or mineral components found in food material. Food material consists of 96% inorganic material and water, whereas, the rest is mineral elements known as organic material or ash. The ash content is the total minerals within the food material.

The results showed that the highest ash content was found with treatment at 60°C for 30 min, whereas, the lowest ash content was found with treatment at 80°C for 20 min (Table 9). The results of the ANOVA showed that there was a significant effect of temperature and heating time on the ash content of laksan sauce. The results from Duncan's *post hoc* test also showed that there was a significant effect of temperature and heating time on the ash content of laksan sauce for each treatment.

The highest coefficient of determination (R^2) was found with heating at 60°C with a magnitude of 0.886, which means that heating affected 88.6% of the ash content of laksan sauce. This value was higher than that of heating at 70°C with a magnitude of 0.16 (16.0%) and heating at 80°C with a magnitude of 0.038 (3.8%). Based on the kinetic rate (slope), heating at 80°C had the best ash content with a slope of -0.000, which means that adding heating time did not decrease the ash content of laksan sauce (Fig. 4).

Table 10: Effect of temperature and reheating on carbohydrate content of laksan sauce

	Carbohydrate content (%)			
	Heating time (min)			
Heating time (°C)	10	20	30	40
60	13.57±0.370[a]	14.07±0.251[a]	17.69±0.494[c]	21.49±0.464[de]
70	14.39±0. 195[a]	16.17±0. 220[b]	18.16±0.023[c]	20.70±0. 133[d]
80	15.91±0. 045[b]	15.43±0. 395[b]	21.69±0.356[e]	24.07±1. 347[f]

Numbers having different letter at the same columns had significant effect

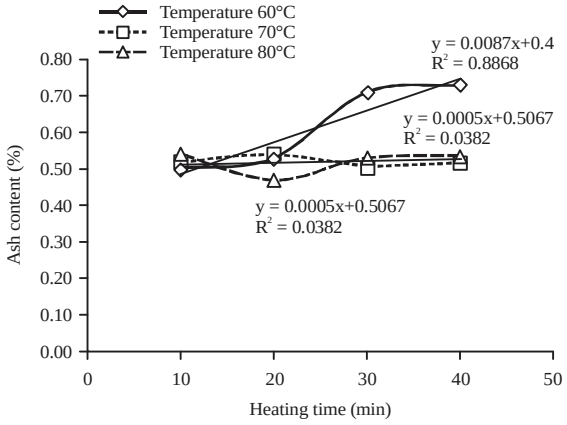

Fig. 4: Effect of temperature and reheating on ash content of laksan sauce

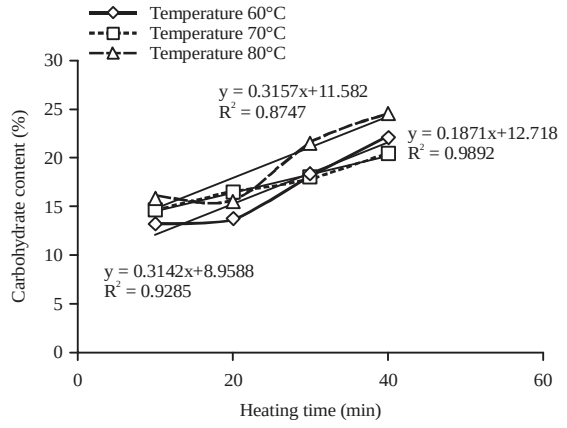

Fig. 5: Effect of temperature and reheating on carbohydrate content of laksan sauce

Carbohydrate content: The main carbohydrate components in coconut milk are sucrose and starch[12]. Heating can cause water to be absorbed (water absorption) into starch granules. High numbers of hydroxyl groups in starch can cause water that is initially located outside starch granules to be absorbed into starch granules and become unable to move freely.

The results showed that the highest carbohydrate content was found with heating at 60°C for 10 min and the lowest content was found with heating at 70°C for 10 min. The results of the ANOVA showed that there was a significant effect of temperature and heating time on carbohydrate content, whereas, the results of Duncan's *post hoc* test showed that there was no significant effect for each treatment (Table 10). Temperature and heating time affected the carbohydrate content of laksan sauce. This effect was shown by heating at 60, 70 and 80°C, which produced R^2 values of 0.922 (92.2%), 0.993 (99.3%) and 0.859 (85.9%), respectively. The best carbohydrate content was found with heating at 70°C with the lowest slope (0.209). This result showed that heating time at 70°C increased carbohydrate content by 0.209 g (Fig. 5).

CONCLUSION

The results of this study showed that there was a significant effect of temperature and heating time on the chemical characteristics and proximate contents of laksan sauce. Heating at 70°C produced the best results in terms of protein content, lipid content and carbohydrate content with respective slopes of -0.022, -0.009 and 0.209. Heating at 60°C was the best treatment with a slope of -0.307 and heating at 80°C produced the best ash content with a slope of -0.000.

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