Enhancing Quality of Frozen Chicken Satay Lilit: Effect of Tapioca Variations on Physicochemical and Sensory Properties

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Abstract. Frozen chicken satay lilit represents an innovative adaptation of traditional satay lilit, developed in a processed form comparable to nuggets, sausages, and meatballs. This study evaluated the effect of tapioca starch addition on physicochemical and sensory properties of frozen chicken satay lilit, as well as to determine the optimal formulation for product quality. Completely Randomized Design (CRD) was applied with 5 levels of tapioca addition, including 0% (T0), 2.5% (T1), 5% (T2), 7.5% (T3), and 10% (T4), each replicated 3 times to yield 15 experimental units. The parameters observed were color (before and after grilling), texture profile analysis, sensory evaluation (aroma, taste, texture, overall acceptance), and proximate composition (moisture, ash, fat, protein, carbohydrate). Data were statistically analyzed, and significant differences ($P<0.05$) were further tested using Duncan's Multiple Range Test (DMRT). The results showed that tapioca had a significant effect on sensory and physicochemical properties of the product. The 10% tapioca treatment (T4) produced the most desirable characteristics, indicated by the color values before baking (L* 37.5, a* 7.8, b* 20.2) and the values after baking (L* 26.2, a* 13.3, b* 20.7). Sensory evaluation showed a balanced sweet-savory aroma, savory taste, acceptable texture, and overall positive acceptance. Proximate analysis at 0 and 35 days of storage showed a stable composition with moisture content (56.80–56.15%), ash (3.81–2.84%), fat (3.81–2.84%), protein (7.31–9.10%), and carbohydrate (21.53–21.37%). These results indicate that the addition of 10% tapioca provides the best formulation for frozen chicken satay lilit with good stability and consumer acceptance.

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1 Introduction

Bali is renowned for its culture, natural beauty, and culinary delights, which often captivate tourists. Culinary tourism has become a powerful tourist attraction and has significantly improved the well-being of the island's residents. Several studies have shown that culinary tourism is a planned journey to discover food and drink as well as create unforgettable experiences. Bali offers traditional dishes with potential for development, such as lawar (a traditional Indonesian dish), ayam betutu (traditional Indonesian chicken), and satay lilit (traditional Indonesian satay) [1].

According to previous studies, satay lilit is a Balinese specialty that is widely known by both domestic and international tourists [2]. Initially, it was used as a means of Hindu religious ceremonies, such as cremations and temple celebrations. However, the food is now easily found in restaurants and has become one of Bali's typical side dishes. The ingredients used in making satay lilit are ground beef, *base genep*, grated coconut or coconut milk, and brown sugar. The dish is served by wrapping satay mixture on skewers made from large pieces of coconut fronds or using *katik sate* made from bamboo strips [3]. The process of making satay lilit often takes longer compared to the skewers commonly sold in the community. The processing process involves longer stages, and several people lack the ability to wrap the mixture on *katik sate*. The increasing demand for foods such as satay lilit requires practical and long-lasting processing and serving methods. Therefore, frozen products are needed to make it easier for people to get and consume satay lilit.

Frozen chicken satay lilit is an improvement of satay lilit, which is served in the form of nuggets, sausages, samosas, and meatballs. The availability of the product can make it easier for consumers to get satay lilit if needed for religious ceremonies or as a daily meal. Based on the experience of sellers, frozen dough products (raw dough) have the advantage of a longer shelf life of around a month when stored at temperatures below -18°C. The Food and Drug Monitoring Agency (BPOM) issued guidelines for the processing and handling of frozen processed foods, stating that the storage temperature must be at -18°C or colder. Processed products, such as sausages, nuggets, and samosas, have an average shelf life of more than 1 month [4]. The disadvantage of frozen chicken satay lilit products is that the texture becomes harder when stored at low temperatures for a long period. Therefore, a study is needed to explore the addition of certain ingredients to maintain a soft and chewy texture.

Chicken satay lilit stored at frozen temperatures for 3-4 days often becomes hard. To address the challenge, a more appropriate formulation is needed to restore its original texture. Several studies have shown that tapioca plays an important role in enhancing texture, increasing acceptability, and modifying physical properties of processed products. Lekahena [5] explored the addition of tapioca to food products, and the results showed that the additive had an effect on the nutritional composition (moisture content, ash, protein, fat, and carbohydrates) of yellowfin tuna nuggets. In addition to affecting the nutritional composition, tapioca also increased the preference for the texture, color, and aroma of the nuggets. Another study conducted by Indra et al. [6] added the same material to dumbo catfish surimi meatball products, leading to an increase in the preference for appearance, texture, aroma, and taste. Tapioca is often used in the food industry as a thickener, chewing agent, and leavening agent [7]. Despite the potential, studies specifically examining the effect of tapioca addition on the quality and stability of frozen satay lilit have not been widely reported. Therefore, this study emphasizes the novelty of optimizing the formulation of frozen chicken satay lilit by adding tapioca to maintain its chewy texture, nutritional stability, and consumer acceptance during storage. The current study not only supports the development of traditional Balinese food products in a modern form but also opens up opportunities for the commercialization of satay lilit as a competitive global culinary product. Therefore, this study aimed to determine the effect of varying tapioca concentrations on the physicochemical and sensory properties of frozen chicken satay lilit, and to identify the optimal formulation.

2 Materials and Methods

2.1 Place and Time

This study was conducted in the Process Engineering and Quality Control Laboratory, Food Analysis Laboratory, and Organoleptic Laboratory, Agrocomplex Building, 3rd Floor, Faculty of Agricultural Technology, Udayana University.

2.2 Materials and tools

The materials used in this study included ground chicken, *base genep* or complete seasoning, tapioca, brown sugar, coconut milk, cooking oil, salt, water, lime leaves, bamboo satay sticks, vacuum packaging, lead paper, methyl red, methyl blue, distilled water, as well as hexane, H_2SO_4, NaOH, H_3BO_3, and HCl from Merck.

The tools used were digital scales, color readers, knives, basins, stoves, pans, satay grills, spoons, scissors, vacuum sealers, texture analyzers (T.A plus), freezers, steamer pans, weighing bottles, porcelain cups, test tubes (Pyrex), desiccators, ovens (Labo), ashing furnaces, Erlenmeyer flasks (Pyrex), Soxhlet flasks (SAHM-250x4), distillators (behrotest).

2.3 Experimental Design

Experimental design used was completely randomized design (CRD) with a factor, namely the addition of tapioca (T) at 5 levels and 3 replications, conducted to produce 15 experimental units. Tapioca addition treatment was presented in Table 1.

Table 1. Treatment of adding tapioca

Treatment	Total (%) of meat				
	T0	T1	T2	T3	T4
Addition of Tapioca	0	2.5	5	7.5	10

2.4 Implementation

The experiment of adding tapioca to the making of frozen chicken satay lilit went through several processes, namely making *base genep*, making the dough, rolling, steaming, packaging, and freezing satay lilit.

2.4.1 Making Seasoning

Base genep was made by mixing several ingredients, such as garlic (60g), shallots (150g), coriander (6g), ginger (30g), turmeric (15g), galangal (30g), red chilies (6 pieces), pepper (7.5g), salt (15g), bay leaves (2 leaves), and lime leaves (1 leaf), then puree using a blender.

2.4.2 Making Satay Lilit

The preparation of satay lilit dough began by mixing ground chicken with *base genep*s, coconut milk, brown sugar, and tapioca according to the treatment variations of 0%, 2.5%, 5%, 7.5%, and 10% of the total meat used. Subsequently, it was stirred until the dough was evenly mixed. Satay lilit dough was weighed as much as 20g to be wrapped around a bamboo skewer. This dough was placed on the end of the bamboo skewer, then pulled down while rotating it, ensuring that it formed a long circle. Satay lilit was steamed using a steamer for 7 minutes over medium heat, then packed into a vacuum package, and the air in the package was absorbed using a vacuum sealer. One vacuum package contained 10 satay lilit skewers, which was frozen using a freezer at a temperature below -18°C. Chicken satay lilit product formulation was seen in Table 2.

Table 2. Chicken satay lilit product formulation

Ingredients	Total
Ground Chicken	33%
Brown Sugar	10%
Base genep	25%
Coconut Milk	19%
Fried Onions	4%
Fried Garlic	4%
Fried Chilies	4%
Tapioca	As needed

2.4.3 Serving Satay Lilit

Frozen chicken satay lilit was served after freezing and thawing for 30 minutes, then steamed for 5 minutes over medium heat. Next, satay lilit was grilled until golden brown.

2.5 Observed variables

The variables observed were color intensity (L*, a*, and b*) before and after baking, texture test with a texture analyzer, organoleptic test with a scoring method for aroma, taste, and texture attributes, as well as organoleptic test with a hedonic method for overall acceptance attribute [8]. Testing was conducted every 7 days for 28 days. Proximate tests were moisture and ash [9], fat, protein, and carbohydrate content [10]. Testing was conducted on day 0 (not yet frozen) and on day 28 after freezing.

2.5.1 Color Intensity Test (L, a*, and b*)*

Color testing was performed using colorimeter software (Android). The color intensities measured were L*, which indicated lightness, a*, showing redness, and b*, signifying yellowness.

2.5.2 Organoleptic Test

The organoleptic tests conducted were scoring tests (aroma, taste, and texture) and hedonic tests (overall acceptance), referring to Soekarto [8]. Furthermore, the testing was carried out using a questionnaire containing sensory questions about frozen wrapped chicken satay products. A total of 30 semi-trained panelists aged 20–30 years participated in this test. Scoring measurements used a Likert scale with 5 answer criteria for the scoring test and 7 answer criteria for the hedonic test. Aroma scoring test criteria were 5 (savory aroma), 4 (caramel aroma), 3 (balanced sweet and savory aroma), 2 (slightly sweet and savory aroma), and 1 (burnt aroma). Taste scoring test criteria included 5 (very savory), 4 (savory), 3 (ordinary), 2 (not savory), and 1 (very not savory); texture scoring test criteria were 5 (very soft), 4 (soft), 3 (ordinary), 2 (hard), and 1 (very hard). Meanwhile, the hedonic test criteria included 7 (very like), 6 (like), 5 (somewhat like), 4 (ordinary), 3 (somewhat dislike), 2 (dislike), 1 (really don't like it).

2.5.3 Moisture content

Moisture content measurement was carried out using the oven method, referring to AOAC 90.46 [9]. The cup used was dried in an oven at 105°C for 60 minutes. Subsequently, it was cooled in a desiccator for 30 minutes and then weighed. The sample was weighed as much as 3 g, then put into the cup, and dried in an oven at 105°C for 4 hours. After that, the sample was cooled in a desiccator for 30 minutes and weighed. This sample was placed back into the oven for 2 hours and then weighed to obtain a constant weight. The calculation of moisture content was carried out using the following formula:

$$\text{Moisture Content (\%)} = \frac{initial\ sample\ weight - final\ sample\ weight}{initial\ sample\ weight} x\ 100\%$$

2.5.4 Ash Content

Ash content measurement was conducted using the dry ashing method, referring to AOAC 923.03[9]. The cup to be used was dried using an oven at a temperature of 100 to 105°C for 30 minutes, then cooled using a desiccator for 30 minutes or until room temperature, and weighed (A). Furthermore, the sample was weighed as much as 1 gram and placed on the dry cup, and then weighed (B). The cup containing the sample was put into an ashing furnace and burned at a temperature of 400°C until gray ash was obtained. Those that had become ash was cooled in a desiccator for 30 minutes and was weighed (C). The calculation of ash content was carried out using the following formula:

$$\text{Ash content (\%)} = \frac{C - A}{B - A} x\ 100\%$$

Description:
A = Weight of empty cup (g)
B = Weight of cup + initial sample (g)
C = Weight of cup + dry sample (g)

2.5.5 Fat Content

Fat content measurement was carried out using the Soxhlet method, according to Sudarmadji et al. [10]. The sample was weighed as much as 3 grams (A), then wrapped in filter paper and tied. This was then placed into a previously weighed volumetric flask (B). Subsequently, the sample was extracted using a Soxhlet apparatus with hexane solvent for 5 hours. After obtaining the extract, the flask was heated in an oven at 105°C until the solvent evaporated, then cooled in a desiccator for 30 minutes and weighed (C). The calculation of fat content was carried out using the following formula:

$$\text{Fat Content (\%)} = \frac{C - B}{A} x\ 100\%$$

Description :
A = Sample weight
B = Initial flask weight
C = Final flask weight

2.5.6 Protein Content

Protein content was measured using the Kjeldahl method, as cited by Sudarmadji et al. [10]. A 0.5-gram sample was weighed and placed into a Kjeldahl flask. Catalyst and 3 ml of H_2SO_4 were added to the flask, then digested for 1 hour until the solution was clear. The clear solution was cooled, then 50 ml of distilled water and 20 ml of 40% NaOH were added, and it was distilled. Furthermore, the distillate was collected in an Erlenmeyer flask containing 15 ml of boric acid solution and 2 drops of methyl red and methyl blue. The mixed distillate was titrated with 0.02 N HCl until a light purple color was obtained. This same treatment was carried out on the blank. Protein content was calculated using the following formula:

$$\text{Nitrogen (\%)} = \frac{(ml\ Hcl\ sample - ml\ Hcl\ blanko) x\ N\ Hcl\ x\ 14}{sample\ weight\ \ x\ 1000} x\ 100\%$$

$$\text{Protein content (\%)} = \text{\% Nitrogen}\ x\ 6{,}25$$

2.5.7 Carbohydrate Content

According to Sudarmadji et al, measurement of carbohydrate levels was carried out using different methods [10]. Carbohydrate calculations were as follows:

$$\text{Carbohydrate Content(\%)} = 100\% - (\text{Moisture content} + \text{ ash} + \text{fat} + \text{protein})$$

2.6 Data analysis

The data obtained from the results of L*, a*, and b* color intensity tests and the texture (hardness) test were presented descriptively. Subsequently, the results of the organoleptic test were analyzed using analysis of variance (ANOVA) method. When the analysis result was significantly affected (P<0.05), it was further tested using the Duncan Multiple Range Test (DMRT) method to determine the differences between treatments and obtain results that were used as answers to the research problems. The best treatment was selected through overall organoleptic acceptance, which was then tested by comparing the best treatment with the control. Furthermore, the organoleptic test data obtained were analyzed using the Least Significant Difference (LSD) test, while the color intensity and proximate data were presented descriptively. The analysis tool used to process the data was Microsoft Office Excel 2013 software.

3 Results and Discussion

3.1 Color Intensity (L*, a* and b*)

Color intensity values of satay, consisting of brightness level (L*), redness level (a*), and yellowness level (b*) before and after grilling, was presented in Table 3.

Table 3. Color intensity of frozen grilled and ungrilled chicken satay lilit after 28 days of storage

Day	Tapioca Addition (%)	grilled			Ungrilled		
		L*	a*	b*	L*	a*	b*
7	0	26,7	13,7	22,4	31,9	6,4	15,3
	2,5	29,3	12,4	21,9	32,8	7,8	15,7
	5	25,6	11,9	19,8	36,9	9,3	15,3
	7,5	20,9	9,9	20,9	38,6	8,2	15,2
	10	20,4	9,8	18,6	40,5	8,4	14,6
14	0	36,4	13,4	24,8	48,3	9,8	18,9
	2,5	38,7	10,6	23,6	49,6	9,9	19,3
	5	32,7	10,4	23,9	36,8	10,5	20,3
	7,5	34,9	10,7	22,9	45,5	9,7	19,7
	10	39,7	10,2	20,1	48,3	9,6	15,5
21	0	37,7	12,5	21,6	37,3	8,8	19,3
	2,5	38,9	17,8	21,5	36,1	7,5	18,9
	5	40,7	12,9	20,8	41,3	8,4	19,6
	7,5	27,4	13,3	21,7	41,5	9,4	18,9
	10	41,2	12,6	20,3	47,7	7,5	15,8
28	0	39,8	10	22,6	33,6	8,6	20,1
	2,5	41,9	11,5	22,2	41,1	8,4	19,6
	5	35	10,4	21,2	43,9	9,6	19,4
	7,5	26,9	9,7	20,6	45,5	9,1	19,2
	10	31,7	8	20,4	46,9	7,1	17,3

L* value was a parameter for brightness level with a value of 0 to 100. According to Suyatma [11], a value of 0 is an indicator of black, while a value of 100 is white. Table 3 showed that brightness level of frozen chicken satay lilit before grilling tended to be higher than brightness level of frozen chicken satay lilit after grilling. This occurred because the sugar content in frozen chicken satay lilit experienced a Maillard reaction and caramelization when heated, ensuring that the color of chicken satay lilit became darker [12]. The Maillard reaction was a reaction between reducing sugars and amino acids with heating [13].

a* value referred to a parameter to measure the level of redness, which had positive and negative values in the range of -80 to 80. Table 3 showed that the redness value of frozen chicken satay lilit before grilling tended to be higher than the redness value of frozen chicken satay lilit after grilling, but the value did not show a large difference. This occurred because ungrilled satay lilit exhibited a color that was more yellow than red, which came from the *base genep*. Furthermore, the heating process also caused changes in the intensity of red color to increase due to the Maillard reaction [13].

b* value was a parameter to measure the level of yellowness, which has positive and negative values in the range of -70 to 70. Table 3 showed that the yellowness value of frozen chicken satay lilit before grilling tended to be higher than the yellowness value of frozen chicken satay lilit after grilling. This occurred due to the Maillard reaction caused by the sugar contained in frozen chicken satay lilit dough, resulting in a brownish-yellow color. According to Hustiany [13], color development increased with increasing temperature and heating time.

3.2 Organoleptic

3.2.1 Aroma

Based on the results of ANOVA, the addition of tapioca significantly affected the aroma of frozen chicken satay lilit (P<0.05). The average aroma score for frozen chicken satay lilit was shown in Table 4.

Table 4. Average aroma score of frozen chicken satay lilit with tapioca addition treatment

Tapioca Addition (%)	Aroma			
	Day 7	Day 14	Day 21	Day 28
0	3,27 ± 0,8b	2,8± 1,01b	2,67± 1,05c	2,87± 0,92c
2,5	3,00 ± 0,65b	3,00± 0,85b	3,13± 1,13bc	3,07± 0,80b
5	3,00 ± 0,76b	3,6± 1,18a	3,07± 1,16bc	3,27± 0,88abc
7,5	3,27± 0,96b	2,93± 0,96b	3,47± 1,13b	3,53± 0,74ab
10	3,87± 0,83a	3,73± 0,96a	4,07± 0,96a	3,8± 0,77a

Description: Different letters after the mean value in the same row and column indicate a significant difference (P<0.05) with the 5% DMRT test. The aroma scoring criteria are 5 (savory aroma); 4 (caramel aroma); 3 (balanced sweet and savory aroma); 2 (slightly sweet and savory aroma); 1 (burnt aroma).

In Table 4, the lowest average score of frozen chicken satay lilit aroma on the 7th day was observed in the treatment of 2.5% and 5% tapioca addition, resulting in a score of 3 with the criteria of balanced sweet and savory aroma. The addition of 0% and 7.5% tapioca resulted in a score of 3.27 with the criteria of caramel aroma, which was not significantly different from the treatment of 2.5% and 5%, while the highest average score was found in the 10% treatment, namely 3.87 with the criteria of caramel aroma. On the 14th day, the treatment with the lowest score, namely the addition of 0% tapioca, led to a score of 2.8 with the criteria of balanced sweet and savory aroma, which was not significantly different from the addition of 2.5% and 7.5%. Meanwhile, the highest score was found in the treatment of 10% tapioca addition, which resulted in a score of 3.73 with the criteria of caramel aroma. The highest score on the 21st day was found in the treatment of 10% tapioca addition, producing a score of 4.07 with the savory aroma criteria, and the lowest score was in the 0% treatment, which was 2.67 with the balanced sweet and savory aroma criteria. This was significantly different from the 7.5% and 10% treatments. On the 28th day, the treatment of 0% tapioca addition produced the lowest average score of 2.87 with the balanced sweet and savory aroma criteria, while the addition of 10% tapioca produced the highest score of 3.8 with the balanced sweet and savory aroma criteria. This was significantly different from the addition of 2.5% tapioca and not significantly different from the addition of 7.5%.

The aroma of food could determine the deliciousness of the food itself and could be an attraction in determining the taste of food products. The aroma of frozen chicken satay was influenced by the formulation of chicken meat, *base genep*, brown sugar, and tapioca used. Adding too much *base genep* and brown sugar increased the savory and sweet aroma, while adding tapioca could suppress the aroma [14]. Therefore, the higher the percentage of tapioca added, the lower the resulting aroma was.

Lekahena's study [5] on the addition of tapioca concentration to the nutritional composition of red meat nuggets of yellowfin tuna showed that the addition of tapioca had a significant effect on the level of liking for the aroma of the nuggets produced. Therefore, different tapioca concentrations resulted in different nugget aromas. Dwiani & Rahman's study [15] showed that the highest addition of tapioca provided the best aroma. This was because tapioca had neutral properties that could reduce the natural fishy smell of seaweed. The aroma of spices or other additional ingredients could be mixed evenly without being disturbed by the distinctive aroma of seaweed.

3.2.2 Flavor

Based on the results of ANOVA, it was shown that the addition of tapioca had a significant effect ($P<0.05$) on the taste of frozen chicken satay lilit. The average taste score for frozen chicken satay lilit was seen in Table 5.

Table 5. Average taste score of frozen chicken satay lilit with the addition of tapioca

Tapioca Addition (%)	Flavor			
	Day 7	Day 14	Day 21	Day 28
0	3,60±0,51ab	3,47±0,64b	3,20±0,77c	2,93±0,59b
2,5	3,40±0,91b	3,53±0,64b	3,40±1,12bc	3,53±0,92ab
5	3,40±0,51b	3,27±0,46b	3,33±0,82c	3,80±0,41a
7,5	3,47±0,64b	3,40±0,91b	4,00±0,65a	3,40±1,06ab
10	4,07±0,7a	4,07±0,88a	3,93±0,80ab	3,13±0,92b

Description: Different letters after the mean value in the same row and column indicated a significant difference ($P<0.05$) with the 5% DMRT test. Taste scoring test criteria included 5 (very savory), 4 (savory), 3 (normal), 2 (not savory), and 1 (very not savory).

Table 5 showed that the highest average score of frozen chicken satay lilit taste on the 7th day was in the treatment of 0% tapioca addition, resulting in a score of 3.6 with savory taste criteria. The addition of 2.5% and 5% tapioca resulted in a score of 3.4 with savory taste criteria that were not significantly different from the 0% and 7.5% treatments but significantly different from the 10% treatment, while the lowest average score was in the 10% treatment, namely 3.07 with savory taste criteria. On the 14th day, the treatment with the highest score, namely the addition of 10% tapioca, led to a score of 4.07 with savory taste criteria that were not significantly different from the addition of 0%, 2.5% and 5%. Meanwhile, the lowest score was in the treatment of 5% tapioca addition, which resulted in a score of 3.27 with savory taste criteria. The lowest score on the 21st day was found in the treatment of 0% tapioca addition, producing a score of 3.20 with a savory taste criterion, and the highest score in the 7.5% treatment was 4 with a savory taste criterion, which was significantly different from the 0% and 5% treatments. On the 28th day, the treatment of 5% tapioca addition produced the highest average score of 3.80 with a savory taste criterion, while the addition of 0% tapioca produced the lowest score of 2.93 with a normal taste criterion. This was different from the addition of 5% tapioca and not significantly different from the addition of 2.5%, 7.5% and 10%.

Taste was one of the main factors that affected consumer acceptance of a product. Tapioca had no distinctive taste, but it was neutral, thereby absorbing other flavors from the mixed food ingredients. According to Sahubawa et al. [16], tapioca could absorb spices contained in the dough. Therefore, the higher the concentration of tapioca used in the dough, the more the taste of the resulting product will fade. A study by Tondang et al. [17] showed that the higher the concentration of tapioca added, the higher the average value. This was due to the ability of tapioca to retain spices. The taste became even and strong, but when the concentration of tapioca was too high, it caused the taste of the meat to be reduced. This was because tapioca could reduce the original taste of the meat, giving a more neutral taste.

3.2.3 Texture

Based on the results of the analysis of diversity, the addition of tapioca treatment had a very significant effect (P<0.05) on the texture of frozen chicken satay lilit produced. The average texture score of frozen chicken satay lilit was presented in Table 6. Meanwhile, the texture (hardness) value of frozen satay lilit could be seen in Table 7.

Table 6. Average texture score of frozen chicken satay lilit with tapioca addition treatment

Tapioca Addition (%)	Texture			
	Day 7	Day 14	Day 21	Day 28
0	3,00±0,65c	3,33±0,72bc	3,07±0,80b	3,07±0,59c
2,5	3,20±0,94bc	3,60±0,83b	3,20±0,77b	3,67±0,72ab
5	3,33±0,62bc	3,47±0,52bc	3,60±0,74ab	3,00±0,76c
7,5	3,87±0,64a	4,13±0,64a	4,07±1,16a	4,13±0,99a
10	3,67±0,96ab	3,07±0,80c	4,13±0,52a	3,13±0,83bc

Description: Different letters after the mean value in the same row and column indicated a significant difference (P<0.05) with the 5% DMRT test. The texture scoring test criteria were 5 (very soft), 4 (soft), 3 (normal), 2 (hard), 1 (very hard)

Table 7. Results of the texture (hardness) test of frozen chicken satay lilit (grilled and ungrilled)

Day	Tapioca Addition (%)	Grilled	Ungrilled
7	0	6,83	6,67
	2,5	6,61	6,31
	5	4,00	3,90
	7,5	3,34	3,17
	10	3,10	2,61
14	0	7,12	6,83
	2,5	6,86	6,35
	5	4,63	4,44
	7,5	3,36	4,21
	10	3,85	3,69
21	0	7,82	6,95
	2,5	6,95	6,45
	5	5,87	5,06
	7,5	5,65	4,97
	10	4,17	3,83
28	0	8,01	7,52
	2,5	7,33	6,78
	5	6,25	5,98
	7,5	6,05	5,54
	10	5,58	5,29

Table 6 showed that the highest average score of frozen chicken satay aroma on the 7th day was observed in the treatment of 7.5% tapioca addition, resulting in a score of 3.87 with a soft texture criterion. The addition of 2.5% tapioca resulted in a score of 3.2 with a soft texture criterion, which was not significantly different from the treatment of 5% tapioca addition. This led to a score of 3.33 with a soft texture criterion, while the lowest average score was found in the 0% treatment, namely 3 with a normal texture criterion. On the 14th day, the treatment with the highest score, namely the addition of 7.5% tapioca, led to a score of 4.13 with a very soft criterion, which was significantly different from other tapioca addition treatments. The highest score on the 21st day was found in the treatment of 10% tapioca addition, resulting in a score of 4.13 with a very soft texture criterion, and the lowest score was in the 0% treatment, namely 3.07 with a texture criterion which was not significantly different from the 2.5%, 5% and 7.5% treatments. On the 28th day, the treatment of adding 5% tapioca produced the lowest average score of 3 with the criteria of normal texture, while the addition of 7.5% tapioca produced the highest score of 4.13 with the criteria of very soft texture. This was significantly different from the addition of 5% tapioca and not different from the addition of 2.5%, showing that the addition of tapioca played a role in the texture produced in frozen chicken satay lilit products. According to Sarofa et al. [18], the high amylopectin content in tapioca could form products with a chewy and denser texture.

Firmansya [19] stated that texture was a physical property of food that could change due to processing. Texture was one of the most important factors determining the quality of meat products [20]. Generally, the texture of good processed meat products was characterized by being tender, soft, juicy, and chewy. This ideal texture was not only pleasant to chew, but it could also enhance the overall culinary experience.

Table 7 showed that the higher the percentage of tapioca addition, the softer the texture of frozen chicken satay lilit product, and the longer the storage time of chicken satay lilit at freezing temperature, the harder the texture became. This occurred because the freezing process caused the formation of ice crystals originating from the moisture content in frozen chicken satay lilit. When thawed, the ice crystals were easily freed and caused the texture to become harder [21]. The grilling process also had a role in the texture of the product, grilled satay lilit had a higher texture value compared to satay lilit before grilling. According to Kasim et al. [22], grilling process caused water evaporation, the greater the water evaporation, the firmer, harder, and denser the texture was.

3.2.4 Overall Acceptance

ANOVA showed that the addition of tapioca had a highly significant effect ($P < 0.01$) on the overall acceptance of frozen chicken satay lilit. Furthermore, the average overall acceptance of frozen chicken satay lilit was shown in Table 8.

In Table 8, the highest average overall acceptance score for frozen chicken satay lilit on the 7th day was found in the treatment of 0%, 2.5%, and 10% tapioca additions, resulting in a score of 5.6 with the criteria of 'like'. The addition of 2.5% and 5% tapioca resulted in a score of 5.4 with the criteria of 'like', which was different from the 7.5% treatment, resulting in a score of 4.4 with the criteria of 'somewhat like'. On the 14th day, the treatment with the highest score, namely the addition of 10% tapioca, resulted in a score of 5.67, which met the criteria of 'like', and was not different from the addition of 7.5%. In comparison, the lowest score was observed in the treatment with 2.5% tapioca addition, leading to a score of 4.47, corresponding to the criterion of 'somewhat like'. The lowest score on the 21st day was observed in the 0% tapioca addition treatment, which yielded a score of 4 using the ‘ordinary' criteria. Furthermore, the highest score was in the 7.5% treatment, which was 5.6, with 'like', which was different from the 0%, 2.5%, 5% treatments, and not significantly different from the 10% treatment.

Table 8. The mean value of the overall acceptance of frozen chicken satay lilit with the addition of tapioca

Tapioca Addition (%)	Texture			
	Day 7	Day 14	Day 21	Day 28
0	5,60±0,63a	4,53±1,51c	4,00±1,00c	4,20±0,86c
2,5	5,40±0,1,30a	4,47±0,74c	4,80±1,47b	4,20±1,61c
5	5,40±0,91a	4,93±0,88b	4,73±0,80b	5,13±0,99ab
7,5	4,40±0,91b	5,60±0,91a	5,60±0,83a	5,00±1,25b
10	5,60±0,99a	5,67±1,18a	5,27±1,10ab	5,67±0,82a

Description: Different letters after the mean value in the same row and column showed a significant difference (P<0.05) with the 5% DMRT test. The overall acceptance hedonic test criteria included 7 (very like); 6 (like); 5 (somewhat like); 4 (ordinary); 3 (somewhat dislike); 2 (dislike); 1 (really don't like it).

On the 28th day, the 10% tapioca addition treatment yielded the highest average score of 5.67, meeting the 'like' criteria. In comparison, the 0% and 2.5% tapioca additions yielded the lowest score of 4.2, corresponding to the 'somewhat like' criteria, which was different from the scores of the other treatments. Based on the results of the organoleptic test for overall acceptance, the panelists selected the 10% tapioca addition treatment as the best option.

3.3 Best Treatment

Based on the results of the organoleptic test for overall acceptance, the panelists selected frozen chicken satay lilit treatment with 10% tapioca added as the best treatment. This was then compared organoleptically and proximately with the control (without tapioca added) on day 0.

3.3.1 Aroma

ANOVA revealed that the best treatment, compared to the control, had a highly significant effect ($P < 0.01$) on the aroma of frozen chicken satay lilit. Furthermore, the average aroma score for frozen chicken satay lilit is shown in Table 9.

Table 9. Average aroma score of frozen chicken satay lilit with the best treatment and control on day 28

Tapioca Addition	Score
0%	4,20 ± 0,86a
10%	3,1 ± 1,10b

Description: Different letters behind the mean values in the same row and column indicate significant differences (P<0.05) with the 5% BNT test.

Table 9 showed that the treatment with 0% tapioca addition on day 0 yielded an average score of 4.2, with a savory aroma criterion that was significantly different from the treatment with 10% tapioca addition on day 0, which obtained a score of 3.1, characterized by a caramel aroma criterion according to the panelists. The aroma of chicken satay lilit originated from the *base genep*, chicken meat, and sugar. However, tapioca suppressed the aroma because it did not have a distinctive aroma on its own. The higher the concentration of tapioca addition, the lower the aroma was. Dwiani et al.’s study [15] on the effect of tapioca addition on the organoleptic quality of seaweed sticks showed that the highest addition of tapioca provided the best aroma. This was because tapioca exhibited neutral properties that could reduce the natural fishy odor of seaweed. Therefore, the aroma of spices or other additives could be mixed evenly without being disturbed by the distinctive aroma of seaweed.

3.3.2 Taste

ANOVA revealed that the best treatment, compared to the control, had a highly significant effect (P < 0.01) on the taste of frozen chicken satay lilit. The average taste score for frozen chicken satay lilit was shown in Table 10.

Table 10. Average taste score of frozen chicken satay lilit with the best treatment and control on day 28

Tapioca Addition	Score
0%	4,10 ± 0,35a
10%	3,50 ± 0,64b

Description: Different letters behind the mean values in the same row and column indicate significant differences (P<0.05) with the 5% BNT test.

This showed that the treatment with 0% tapioca addition on day 0 received an average score of 4.1, which was significantly different from the treatment with 10% real tapioca addition on day 0, receiving a score of 3.5, with a savory taste criterion from the panelists. Furthermore, this happens because tapioca absorbed the flavor of the spices used in chicken satay lilit dough [16]. Tondang et al. [17] on the addition of tapioca with different levels to the organoleptic quality of meatballs, showed that the concentration of tapioca addition had the highest mean value. This was due to the ability of tapioca to retain the spices, thereby the taste became even and stronger, but when the concentration of tapioca was high, it also caused the taste of the meat to be reduced because tapioca could reduce the original taste of the meat, giving a more neutral taste.

3.3.3 Texture

ANOVA revealed that the best treatment had a highly significant effect (P<0.05) on the texture score of frozen chicken satay lilit compared to the control. The average texture score and hardness test results for frozen chicken satay lilit were shown in Table 11.

Table 11. Average texture score and hardness test results for frozen chicken satay lilit with the best treatment and control on day 28

Tapioca Addition, Day 0	Texture Score	Hardness (N)	
		Grilled	Ungrilled
0%	4,20 ± 0,56a	6,59 ± 0,16a	5,95± 0,51a
10%	3,40 ± 0,63b	5,44± 0,13b	5,2± 0,11b

Description: Different letters behind the mean values in the same row and column indicate significant differences (P<0.05) with the 5% BNT test.

This showed that the treatment with 0% tapioca addition on day 0 yielded an average score of 4.2, characterized by a very soft texture, significantly different from the treatment with 10% tapioca addition on day 0. Furthermore, this obtained a score of 3.4 with a soft texture criterion as perceived by the panelists. According to Firmansya [19], texture was a physical property of food that could experience changes due to processing. Texture was one of the most important determining factors in the quality of meat products [20]. Generally, the texture of well-processed meat products exhibited characteristics such as softness, tenderness, juiciness, and chewiness. This ideal texture was not only pleasant to chew, but also enhanced the overall culinary experience. According to Mahendra [22], the texture of good satay lilit was soft and evenly disintegrated with the spices, sticking well to *katik sate*. Furthermore, the results of the analysis showed that satay lilit, receiving a treatment of 10% tapioca addition, had a softer texture compared to satay lilit with no tapioca added. This occurred because the starch content in tapioca played a crucial role in determining the texture of food. When the mixture of starch granules and water was heated, it formed a gel [23], thereby creating a softer texture. Furthermore, the texture of satay lilit after grilling was harder than that of satay lilit before grilling. This was because the heating and grilling process evaporated water, producing a harder or firmer texture [22].

3.3.4 Overall Acceptance

ANOVA revealed that the best treatment, compared to the control, had a highly significant effect ($P < 0.01$) on the overall acceptance of frozen chicken satay lilit. Furthermore, the average overall acceptance of frozen chicken satay lilit was shown in Table 12.

Table 12. Average overall acceptance value of frozen chicken satay lilit with the best treatment and control on day 28

Tapioca Addition	Score
0%	4,10 ± 0,35a
10%	3,50 ± 0,64b

Description: Different letters behind the mean values in the same row and column indicate significant differences ($P<0.05$) with the 5% BNT test.

This showed that the 0% tapioca addition treatment on day 0 received an average score of 6, meeting the 'like' criterion, significantly different from the 10% tapioca addition treatment on day 0. Furthermore, this received a score of 4.9, meeting the 'somewhat like' criterion, as determined by the panelists. Based on the results of the organoleptic test, the panelists selected the 0% tapioca addition treatment as the best treatment. This occurred because the taste of satay lilit without the addition of tapioca on day 0 still had a fresh aroma, taste, and texture.

3.3.5 Color Intensity (L*, a* and b*)

The results of color measurements using colorimeter software were in L*a*b* color units were presented in Table 13.

Table 13. Color intensity values of frozen chicken satay lilit from the control and best treatment on day 0

Treatment		Color Intensity		
		L*	a*	b*
Without Tapioca (0%)	Ungrilled	40,2	9,7	21,3
	Grilled	29,4	14,7	18,8
10% Tapioca Addition	Ungrilled	37,5	7,8	20,2
	Grilled	26,2	13,3	20,7

In this study, L* value was a parameter of brightness level, a* value is a parameter of redness level, and b* value is a parameter of yellowness level. L*, a*, and b* color values of the control and best treatment frozen chicken satay lilit on day 0

Based on Table 13, brightness level (L*) of frozen chicken satay lilit before grilling was higher than that of frozen chicken satay lilit after grilling. This occurred because the sugar content in chicken satay lilit underwent a Maillard reaction and caramelization when heated, leading to a darker color of chicken satay lilit [12]. The intensity of the reddish color (a*) in the 0% treatment was higher than in the treatment with the addition of 10% tapioca. Furthermore, the heating process also affected the level of redness (a*); grilled satay lilit had a higher redness level (a*) value than ungrilled satay lilit. According to Hustiany [13], the heating process caused an increase in the intensity of the red color due to the Maillard reaction. Similarly, the level of yellowness (b*) rose as the heating process increased.

3.3.6 Proximate Analysis

A proximate analysis of frozen chicken satay lilit with the best treatment, namely the addition of 10% tapioca, was compared to the control (without tapioca) on days 0 and 35. Several parameters were observed, including moisture, ash, fat, protein, and carbohydrate content, as shown in Table 14.

Table 14. Results of proximate analysis of frozen chicken satay lilit with the best treatment and control on days 0 and 28

Tapioca Addition	Day	Moisture Content (%bb)	Ash Content (%bb)	Fat Content (%bk)	Protein Content (%bk)	Carbohydrate Content (%bb)
0%	0	56,46	4,94	12,43	7,57	18,58
10%	0	56,80	3,81	10,53	7,31	21,53
10%	28	56,15	2,84	10,51	9,10	21,37

Based on the results presented in Table 14, moisture content analysis showed that the treatment without tapioca (0%) on day 0 showed a lower moisture content, at 56.46%, compared to the treatment with 10% tapioca on day 0, which reached 56.80%. This result suggested that the higher the concentration of tapioca added, the greater the increase in moisture content of frozen chicken satay lilit tended to be. Similar results were reported by Lekahena [5], who stated that increasing tapioca concentration was directly proportional to the increase in product moisture content. However, the lowest moisture content (56.15%) was obtained in the treatment with 10% tapioca added on day 35. This phenomenon could be explained by the presence of hydroxyl groups in amylose and amylopectin in tapioca, which played a role in absorbing and binding water [24].

According to the data presented in Table 14, ash content analysis showed that the treatment without tapioca (0%) on day 0 produced the highest ash content, at 4.94%. The addition of 10% tapioca on day 0 reduced the ash content to 3.81%, while the treatment with the addition of 10% tapioca on day 35 produced the lowest ash content, at 2.84%. This decrease was due to the lower mineral content in tapioca compared to the meat used [5]. Similar results were also found in the study by Wellyalina et al. [24], where increasing the concentration of cornstarch in red tuna nuggets led to a decrease in ash content.

The results of fat content test showed that the treatment without tapioca (0%) on day 0 had a higher fat content compared to the treatment with 10% tapioca added on day 0. In comparison, the 10% treatment on day 28 resulted in the lowest fat content, as shown in Table 14. This result was consistent with the study of Lekahena [5], showing that the addition of tapioca in the manufacture of yellowfin tuna red meat nuggets reduced fat content along with the increase in tapioca concentration. Furthermore, the decrease in fat content could be caused by damage to the fat structure during the heating process [25].

In Table 14, the protein content test showed that the treatment without tapioca (0%) on day 0 had a slightly higher protein content (7.57%) compared to the 10% treatment on day 0, which reached 7.31%. Interestingly, the treatment with the addition of 10% tapioca on day 28 produced the highest protein content, at 9.10%. This result confirmed that the addition of tapioca did not significantly affect protein content of frozen chicken satay lilit, as the relatively low protein content of tapioca was likely to have had a minimal impact. The increase in protein content on day 28, with the addition of 10%, was most likely due to a decrease in moisture content, thereby increasing the relative protein concentration. This result was consistent with Ratnajunita et al. [26], reporting that the addition of tapioca to soybean tempeh production could increase protein content.

Based on the results of carbohydrate content analysis, the treatment without the addition of tapioca (0%) on day 0 produced the lowest carbohydrate content (18.58%). In comparison, the treatment with the addition of 10% tapioca on day 0 reached 21.53% according to the results presented in Table 14. Meanwhile, the treatment with the addition of 10% on day 28 also showed a high carbohydrate content, namely 21.37%. This suggested that increasing the concentration of tapioca contributed to an increase in the carbohydrate content of the product. According to Eni et al.[26] , this was due to the high carbohydrate content in tapioca (85%) and fiber of 0.5%. This result was consistent with Feraldo et al. [27], showing that increasing tapioca concentration in pora-pora fish crackers significantly increased the carbohydrate content.

4 Conclusion

In conclusion, this study demonstrates that the addition of tapioca has a significant influence on sensory quality of frozen chicken satay lilit, with a concentration of 10% identified as the most optimal formulation based on hedonic acceptance tests. Chemically, tapioca plays a role in reducing ash and fat content, while simultaneously triggering variations in protein, water, and carbohydrate levels during storage. These results confirm the important role of tapioca in maintaining sensory attributes and chemical stability of frozen meat products. Practically, these results show the potential of tapioca as a functional ingredient to improve product quality while extending shelf life. Future research should evaluate the interaction of tapioca with other hydrocolloids, storage stability under different freezing conditions, and consumer acceptance in various market segments to strengthen its application on an industrial scale.

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