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Physicochemical and Sensory Properties from Indonesian White Shrimp (*Penaeus merguiensis*) Jerky

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ABSTRACT

Dendeng or jerky is the Indonesian traditional dried meat. It is commonly produced by using some spices and addition of starch at various levels. In this research, jerky was made by using fresh white shrimp flesh. White shrimp jerky is a versatile food product for consumption as a snack or meal. This research used three formulations with tapioca flour additions at 0% (A0, control), 5% (A1), 10% (A2), and 15% (A3) based on shrimp flesh weight. Shrimp does not have a wide surface like beef meat, so the processing of shrimp jerky involved only two steps, namely grinding and pressing. The protein, ash and water contents decreased with an increase in the percentage of tapioca flour. The sensory analysis of quantitative data revealed that no parameters were significantly different, except for textural properties. Overall, the addition of tapioca flour not exceeding 10% produced better physicochemical and sensory properties, similar to those of A0, the control. Shrimp jerky produced with or without flour could be a potential food product for consumption as a snack or meal.

Keywords: Jerky, physicochemical, sensory, tapioca flour, white shrimp

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INTRODUCTION

Dendeng or jerky is the Indonesian traditional dried meat. It is commonly produced by using some spices and addition of starch at various levels. Therefore, its flavor is spicy, tasteful, and stable for several weeks at room temperature. Jerky is considered one of the oldest types of meat products. An et al. (2010) stated that jerky was commonly preserved through salting and drying to reduce moisture content and water activity.

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Jerky is convenient to eat, lightweight, and nutritious, as it is high in protein and low in fat (Choi et al., 2006).

Jerky is most often made from beef rather than other meats. Jerky can be produced using several types of meats, such as pork (Han et al., 2007), and poultry (Pegg et al., 2006). Shrimp jerky is a versatile product that could help The Healthy and Agriculture Department Programs. In this research, jerky was made by using fresh white shrimp (*Penaeus merguiensis*) flesh. The processing of shrimp jerky includes only two steps, namely, grinding and pressing. The characteristics of jerky are strongly influenced by curing, temperature and drying time, in terms of water content, Aw (water activity), chemical composition, etc. All these factors may ultimately affect the tenderness and acceptability of the final product. Konieczny et al. (2007) noted that the technological processing step, meat type, spices, extender or filler, and additives affected the characteristics of jerky. Many studies have used various processing procedures to investigate the effect of such factors on jerky quality, such as the marination method, drying time and temperature, and type of flour used as filler (Choi *et al*., 2006; Han *et al*., 2008; Konieczny et al., 2007). As known, consumers have commonly associated high quality jerky with good texture, color, flavor, and nutritional value (Konieczny et al., 2007). To improve the quality of jerky, our research introduced shrimp jerky as a new product with the addition of carbohydrates, such as a tapioca flour, as filler. The tapioca flour in jerky as the filler or binder, should have a strong binding, but weak emulsification properties. Therefore, binders, such as flour from wheat, tapioca, and sago, usually have a high carbohydrate content and low protein content.

Tapioca flour is commonly used to make a snack food in Indonesia. Jerky was expected to be a food product with high nutritional value that would add variety existing food. In any case, white shrimp and tapioca flour are used in many applications, especially for food diversity. The ratio of white shrimp and flour influences the physicochemical and sensory attributes of shrimp jerky. This research aimed to evaluate physicochemical properties such as proximate analysis, color, texture, structure morphology, and water holding capacity (WHC), and then conduct sensory evaluation by using a hedonic scale for white shrimp jerky.

MATERIALS AND METHODS

Preparation of Shrimp Jerky

The white shrimp (*Penaeus merguiensis*) jerky was prepared based on the method of (Garnida et al., 2015) with minor modifications. Fresh shrimp flesh was bought from a commercial slaughterhouse in Sungsang, Banyuasin, South Sumatera, Indonesia. The fresh shrimp flesh was ground, added to anchovy and brown sugar, and mixed with spices (garlic, onion, tamarind, coriander, galangal). The tapioca flour was added and mixed until homogeneous. The shrimp dough was molded using a roller on a pan with a thickness of ± 3 mm, and dried in an oven at 60^{o}C for 6 h. The addition of tapioca flour was based on the weight of fresh shrimp meat on a wet weight basis. The formulations of shrimp jerky were 5% addition of tapioca flour (A1), 10% addition of tapioca flour (A2), and 15% addition of tapioca flour (A3). The formulations of shrimp jerky are shown in Table 1.

Table 1
Formulation of the shrimp jerky

Components	Formulation A0 (g)	Formulation A1 (g)	Formulation A2 (g)	Formulation A3 (g)
Fresh shrimp flesh	500	475	450	425
Tapioca flour	0	25	50	75
Anchovy	20	20	20	20
Brown sugar	15	15	15	15
Onions	5	5	5	5
Garlic	1.5	1.5	1.5	1.5
Coriander	2	2	2	2
Galangal	2	2	2	2
Tamarind	3	3	3	3
Salt	2	2	2	2

The Proximate Analysis

Samples of shrimp jerky were analyzed for nutrient substances, such as moisture, ash, protein, fat, and carbohydrate contents. These were determined based on AOAC methods (Association of Official Analytical Chemist [AOAC], 2006). Amino acid composition was analyzed by using High Performance Liquid Chromatography determined by AOAC (2006) methods, wherein Alpha Amino Butyrate Acid (AABA) was used as a standard solution.

Color Measurement

The color of shrimp jerky sample surfaces was determined by using a Spectrophotometer CM-3500d, Konica Minolta Sensing, Inc., Osaka, Japan, and Hunter color values, L* (lightness), a* (redness), and b* (yellowness). The instrument was calibrated to standard black and white plates before analysis. The Hunter values were monitored by a computerized system using spectra magic software (Konica Minolta Sensing, Inc., Japan) and the measurements were performed in triplicate.

Hardness Analysis

An Instron Universal Testing Machine (Model 4400, Instron Co., USA) type TA18 (12.7MM DIA) probe was used for analysis. The samples were prepared as a uniform shape (1.0×2.0×0.3 cm) were measured by a cylindrical probe (12.7 mm diameter) to obtain the hardness data. A texture analyzer was prepared, and then a new test parameter was arranged. The test run was pressed and continued, then the probe above the sample dropped and cut the sample. Then, the biting force data (Network / sec)) obtained were stored.

Structural Morphology

The morphology of shrimp jerky was examined by using an SEM (Scanning Electron Microscope) JEOL-2200 series. The control (shrimp jerky without addition tapioca flour) was also analyzed as a standard. All of the treatments were determined with three replicates.

Water Holding Capacity (WHC)

The WHC of shrimp jerky was determined by the method of Zhuang et al. (2007) with slight modifications. A sample of shrimp jerky (1 g) was added to 25 mL distilled water in centrifuge tube, stirred then incubated at 10°C for 1 hour. After incubation, the sample was centrifuged at 3000 rpm for 20 min. The supernatant was separated and measured. The ability of shrimp jerky to bind water was determined with the supernatant. The supernatant refers to the water holding capacity, and is then calculated using the following formula:

$$\text{WHC} = \frac{\text{Water holding (mL)}}{\text{Sample (g)}}$$

Sensory Evaluation

The sensory analysis was conducted by 30 panelists who were trained to analyze sensory like or dislike of jerky. Furthermore, all of the sample treatments were assessed for their color, flavor, texture, and palatability with a 5 – point hedonic scale, where 5 implies extreme like and 1 implies extreme dislike. The panelists evaluated all the qualities. The samples were placed on a transparent plastic dish, and labeled randomly by assignment of a 3-digit numerical code. Each panelist was given mineral water for rinsing their oral cavity after every sample. All procedures were conducted in triplicates.

Statistical Analysis

The collected data were analyzed using one-way analysis of variance (ANOVA) using SAS 9.1.3. programme, and Duncan's multiple range test to detect if there was a significant difference between treatments.

RESULTS

Proximate and Amino Acid Analyses

In this study, we determined not only the components of protein, fat, carbohydrate (crude fiber), ash, and moisture but also performed amino acid analysis. The addition of tapioca flour to shrimp jerky had a statistically significant effect on the components of jerky substances. The control (A0) contained 46.71 ± 0.16% water content, which was higher than that of the other treatments. A decrease in ash and protein content was observed, otherwise carbohydrate and fat content gradually increased with the percentage of tapioca powder addition, compared to the control (Table 2).

The protein content of shrimp jerky supplemented with 15% tapioca powder (A3) was lower than that of the A1 and A2 treatments. Nevertheless, the A3 protein

Table 2
The proximate analysis of white shrimp (Penaeus merguiensis) *jerky (% g/100 g, dry basis)*

Treatment	Water (wet basis)	Ash	Fat	Protein	Carbohydrate
Control	46.71 ± 0.16a	8.06 ± 0.14a	0.32 ± 0.03c	77.61 ± 0.57a	13.37 ± 0.16d
A1	37.70 ± 0.35c	6.88 ± 0.16b	0.45 ± 0.04d	61.14 ± 0.41b	31.34 ± 0.34c
A2	45.27 ± 0.05b	6.13 ± 0.28c	0.72 ± 0.12b	55.79 ± 0.27c	36.84 ± 0.07b
A3	38.17 ± 0.07c	5.39 ± 0.02d	0.95 ± 0.07a	47.53 ± 0.17d	45.80 ± 0.24a

Note: Different letters in the same column show significantly different values ($P < 0.05$)
Control : no addition of tapioca flour
A1 : 5% addition tapioca flour
A2 : 10% addition tapioca flour
A3 : 15% addition tapioca flour

content was still considered high. The protein content as the main substance in jerky product, our study stated that A1 was the best treatment compared to the other treatments, as its protein content decreased only 20% in relation to the control. The amino acid composition of shrimp jerky changed after the addition of tapioca powder. Glutamic and lysine acids were the highest amino acid components in the shrimp jerky. However, the levels of glutamic and lysine acids decreased from 8.72 ± 0.02% to 7.05 ± 0.01% and 5.70 ± 0.01% to 4.50 ± 0.01%, respectively, after the addition of tapioca flour (Table 3). The decrease in amino acids was greater for tryptophan and cystine, which decreased more than 50% compared to the control.

Table 3
The amino acid profiles of white shrimp (Penaeus merguiensis) *jerky (% w/w protein, dry basis)*

Amino acids	No addition of tapioca (control)	With addition of tapioca (the best treatment, A1)
Tryptophan	0.83 ± 0.02	0.32 ± 0.01
Cystine	0.54 ± 0.30	0.09 ± 0.01
Methionine	1.64 ± 0.02	1.39 ± 0.02
Serine	2.38 ± 0.02	2.03 ± 0.02
Glutamic acid	8.72 ± 0.02	7.05 ± 0.01
Phenylalanine	2.41 ± 0.03	2.26 ± 0.01
Isoleucine	2.47 ± 0.02	2.14 ± 0.03
Valine	2.33 ± 0.02	2.03 ± 0.01
Alanine	3.14 ± 0.01	2.60 ± 0.04
Arginine	4.20 ± 0.02	3.72 ± 0.01
Glycine	2.78 ± 0.04	2.40 ± 0.02
Lysine	5.70 ± 0.01	4.50 ± 0.01
Aspartic acid	4.83 ± 0.01	3.88 ± 0.01
Leucine	4.53 ± 0.01	3.98 ± 0.01
Tyrosine	1.57 ± 0.02	1.22 ± 0.02
Proline	1.51 ± 0.01	1.33 ± 0.03
Threonine	2.32 ±0.02	2.09 ±0.01
Histidine	1.19 ± 0.02	1.07 ± 0.02

The Morphological Characteristics

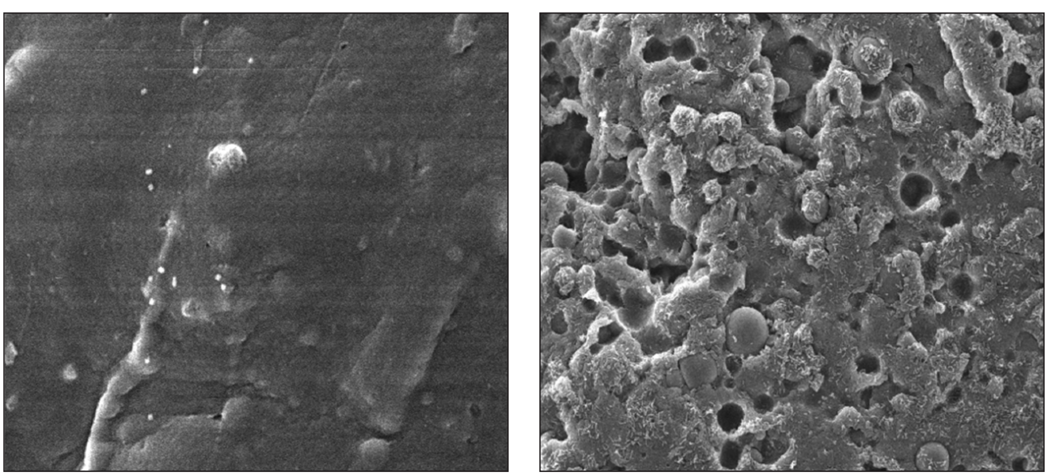
For this research, the characteristics of shrimp jerky including color, hardness, and WHC, are shown in Table 4. The addition tapioca powder as a filler in shrimp jerky affected the physical properties of the jerky. The textural properties of A1, A2 and A3 treatments were neither tender nor easily broken. A0, the control, could hold a large amount of water, so it had a texture that was tenderer and easily broken than that of jerky added tapioca powder (A1, A2 and A3) (Table 4). There was a correlation between hardness and WHC, indicating that shrimp jerky that could hold more water had a better texture than of the others jerkies, based on the WHC and hardness from the A0 treatment, conversely, A3 had 103.46 ± 10.63% hardness, and 1.33 ± 1.06% WHC. The colors of A2 and A3 were lighter, increasing the a* and b* values, compared to those of the A0 treatment. This means that the addition of tapioca powder influenced color.

Table 4
Hardness, color, water holding capacity (WHC) of white shrimp (Penaeus merguiensis) *jerky*

Treatment	Hardness (N/s)	WHC (ml/g)	Color		
			L*	a*	b*
A0	51.26±6.31b	7.94±1.02a	43.50 ± 5.02b	9.53 ± 1.25b	8.56 ± 4.65b
A1	52.33±10.65b	2.69±1.62b	50.06 ± 0.20b	10.53 ± 0.46ba	10.90 ± 0.26b
A2	77.93±10.95b	2.16±0.86b	55.70 ± 1.24a	11.83 ± 0.32a	15.60 ± 0.91a
A3	103.46±10.63a	1.33±1.06b	55.20 ± 0.43a	11.20 ± 0.60a	14.96 ± 0.15a

Note: Different letters in the same column show significantly different values ($P < 0.05$)
Control : no addition of tapioca flour
A1 : 5% addition tapioca flour
A2 : 10% addition tapioca flour
A3 : 15% addition tapioca flour

The surface structure of shrimp jerky visualized with SEM (scanning electron microscopy) showed the existence of gaps or cavities on shrimp jerky added tapioca (500× magnification), shown in the following Figure 1.



(a) (b)

Figure 1. Microscopic analysis of shrimp jerky without adding tapioca starch as a control (a); and shrimp jerky with the addition of tapioca starch (b) at 500× magnification

The Sensory Evaluation

The sensory evaluation of the products prepared with different levels of tapioca flour, is shown in Table 5. There were no differences between the control and other treatments in color, taste, or flavor attributes, except for the texture (hardness) of the jerky. In these cases, A3 had a score of 2.96 ± 0.88 for textural properties. Otherwise, overall, the jerky palatability did not significantly differ among treatments or the control, and ranged from 3.16 ± 0.80 to 3.68 ± 0.52. An et al. (2010) reported similar results for sensory evaluations was under the same treatment (addition of kimchi powder) and the control (no addition kimchi powder) for semidried pork jerky.

Table 5
The sensory parameter of white shrimp (Penaeus merguiensis) *jerky*

Treatment	Sensory				
	Color	Taste	Flavor	Texture	Palatability
A0	3.20±0.76a	3.24±0.92a	3.28±0.79a	3.16±1.14a	3.16±0.80a
A1	3.48±0.96a	3.52±0.71a	3.44±0.82a	3.08±0.99a	3.24±1.09a
A2	3.84±0.68a	3.88±0.72a	3.88±0.66a	3.52±1.04a	3.68±0.52a
A3	3.72±0.67a	3.48±0.82a	3.60±1.00a	2.96±0.88b	3.44±0.86a

Note: Different letters in the same column show significantly different values ($P < 0.05$)
Control : no addition of tapioca flour
A1 : 5% addition tapioca flour
A2 : 10% addition tapioca flour
A3 : 15% addition tapioca flour

DISCUSSION

Food processing can increase or decrease the nutritional value of foods. In this study, the contents of ash and protein decreased, and the amino acid content also decreased with addition of tapioca flour. It was inversely related to the carbohydrate and fat nutrients, which increased due to processing. The nutritional components and amino acids from white shrimp jerky changed due to food processing, cooking time and temperature, the addition of spices (ginger, tamarind and galangal), in the presence or absence of filler. William and Phillips (2000) stated that the chemical composition of meat depended on animal species, animal condition, carcass meat type, preservation process, storage and packing method. The chemical composition of meat is strongly influenced by its fat content. The content of fat in meat increased such that the protein and water contents decreased (William & Phillips, 2000). Jerky product is a high moisture food product, although these products in this study were heated for 6 h to prevent spoilage. Some studies of jerky have not only used seasoning but also increased drying time. This still resulted in an increase in the moisture of the meat product. In this study, the water content of shrimp jerky was decreased not only by water binding to other compounds but also by water release during the 6 h heating process.

The protein content decreased when the tapioca flour percentage increased (Table 2). This research agreed with studies by King (2002), Mohamed et al. (1989) and Yu (1991). However, their studies with varying percentages of addition differed in flour and spices. In Table 2, the fat content was less than 1% for all treatments. The fat content of tapioca flour is only 0.1% (Yu, 1991). However, protein could be maintained as the main component of shrimp jerky. The method to produce a more nutritional food product was to adjust carbohydrates and protein, either lower or higher.

The physicochemical characteristics of white shrimp jerk also changed after adding tapioca powder as a filler during processing (Table 3 and 4). The color and hardness of raw shrimp jerky increased, but sensory panelist judgments on the attributes of color, taste, aroma, and appearance of raw shrimp jerky did not differ significantly between treatments (Table 5). The hardness properties of shrimp jerky were different. The texture of raw shrimp jerky (A0 as control) was softer because the hardness level was low. For sensory properties, regarding the texture of the shrimp jerky the panelist indicated that a preference for shrimp jerky with added tapioca flour not exceeding 10% over A0 as the control (Table 5). The addition of tapioca as a binder made the texture of shrimp jerky more elastic than the control. Beef jerky is generally chewier than shrimp jerky (Ashlan et al., 2010; Kim et al., 2014).

The hardness values can be associated with the sensory evaluation of the shrimp jerky texture. A study on the effect of using flour as a binder or filler on the sensory properties of shrimp jerky showed that the texture of the shrimp jerky was acceptable by panelists (Chu-Ja & Cha-Sung, 2007). The higher quantity of tapioca flour used beyond 10%, the less panelists preferred the texture of shrimp jerky produced. This may be caused by the difficulty in cutting the jerky and the hardness when eaten.

Type and quantity of flour could influence texture, for example hardness, crispiness, and chewiness (Han *et al*., 2008). Texture is influenced by water content, fat content and type of filler, plus the morphological properties of the product (Carr et al., 1997). The function of filler (flour or starch) is to bind water. Subsequent binding of water can reduce the hardness of shrimp jerky, similar to the control, A0 (Table 3). These results agree with those of Yang et al. (2009) who reported that the moisture content affected the shear force or hardness.

Color and appearance are the most important attributes of food quality for users to enable them to visually detect the rate of quality damage and deterioration (Mardiah et al., 2010). The color of a food product is an index of quality in relation to aspects of damage and deterioration of fresh or cured product nutritious food, those with good texture and other appropriate features will not be eaten unless they have suitable and attractive colors (Pegg et al., 2006). The surface color values of shrimp jerky can change according to the drying time at the same temperature, i.e., the Hunter L-values and a* and b* values increased with increasing of drying time up to 6 h. However, in the present study, because the same drying conditions, such as temperature (60°C) and time (6 h), were applied to the treatments, the change in jerky color was also caused by tapioca powder. Peralta et al. (2008) noted that the brown color intensity of shrimp jerky increased with increasing of the tapioca percentage. In the present study, tapioca flour caused a steep increase in the surface color values, especially a* (redness), and b* (yellowness). The shrimp flesh replaced with 5% (A1), 10% (A2), and 15% (A3) tapioca flour experienced increased a* and b* values compared with the control. The variation in protein content was responsible for the degree of increase in the L* value. The increase in the L*value was higher in samples with decrease in the ratio of shrimp flesh.

The use of tapioca as a filler could significantly change the value of L*,a* and b*, increasing the texture value during the later stage of drying. There is a similar trend that is seen with unfried samples: increasing the tapioca flour but decreasing the shrimp flesh amount will contribute lighter color to the product, as shown by the higher L*value. Shrimp flesh has some pigments that contribute more to the color of the shrimp jerky, than does the color of tapioca flour. There are browning reaction between proteins and carbohydrates, called the Maillard reaction. In this study, the colored compounds formed due to H_2O released from amino acids (King, 2002). The difference in the myoglobin of meat could make the color of the product different. The light red color of myoglobin was kermesinus, oxymyoglobin, but taupe brown was from metmyoglobin. Actually, the drying process could also oxidize myoglobin. The research of Xiaolei et al. (2015) showed that hot air drying sometimes could not improve jerky color.

There are several factors that can cause variation in the water binding capacity of meat such as: pH, maturation treatment, cooking or heating, and biological factors such as muscle type, animal type, gender and livestock age. Similarly feeding factors, transport, temperature, humidity, storage and preservation, animal health, precutting and intramuscular fat treatment also affected WHC. Water binding capacity by a meat protein also called Water Holding Capacity (WHC), is defined as the ability of the meat to retain water and the influence of that on strength, such as effects on meat cutting, heating, grinding, and pressure. Meat also has the ability to absorb water spontaneously from water-containing environments (water absorption).

There are three forms of water bonds in muscle. Water that is chemically bonded by a muscle protein of 4 - 5% is as the first monomolecular layer. The two water bonds are rather weak as the second layer of water molecules to the hydrophilic group, amounting to approximately 4% this second layer is bound by the protein when the vapor pressure increases. The third is a layer of free water molecules between protein molecules, with a magnitude of about 100%. Denaturation of proteins will not affect the molecular changes in bound water (first and second layer), while the free water between the molecules will decrease when the meat protein is denatured (Bourne, 1978; Carr et al., 1997).

The muscle proteins with extremely high water holding abilities are firm, with a tight structure, and a dry or sticky texture. Conversely, the network with low water binding ability has a soft, open structure (loose) and the texture is wet or seeded. The differences between intracellular water equilibrium in the first case and extracellular water in the latter case were related to water-binding ability. This is because tapioca flour contains carbohydrates, especially starch and cellulose in large amounts. The high carbohydrate content in food will cause free bonded water to be easily released because the water is physically bonded, followed by a decrease in the WHC of shrimp jerky (Table 4). The addition of more starch or flour should increase water absorption because of the hydroxyl group (OH) that can bind water (hydrophilic). Nevertheless, amylose in the material could bind water and will be more easily released during drying, as shown in the A3 treatment.

Zhuang et al. (2007) stated that the number of hydroxyl groups containing starch was large enough to have a great ability to absorb water. This hydrogen bond has not only bound water molecules to one another, but also water and other compounds with elements of O or N, such as carbohydrates with OH (hydroxyl) groups (Rabah & Abdalla, 2012; Suryati et al., 2014). Although, the amount of carbohydrate in the tapioca flour has the ability to bind water, it cannot emulsify fat (Rabah & Abdalla, 2012; Singh et al., 2001; Zhuang et al., 2007).

SEM data showed that, compared with the control, tapioca as a binder could improve the myofiber shape in jerky because the shrinkage of myofiber and sarcomere was reduced. The water on the surface of and inside was spread evenly, which could improves jerky texture. Cheow et al. (2004) studied the microstructure of shrimp jerky. In their research, they found that poorly-expanded shrimp jerky contained large aggregates of added flour. This prevented the starch from expanding in hot cooking oil, and made the filaments denser and thicker. Therefore, the final result was an increase in the hardness value of the jerky (Table 4). Water in starch grains could not move freely because the molecules were bound by the hydroxyl group in the starch molecules. Thus, cavities in the shrimp jerky were observed for jerky with added tapioca flour, compared to the control treatment (Figure 1). Furthermore, starch granules can swell excessively and irreversibly. The higher amounts of tapioca flour in the shrimp jerky formed more gaps or cavities in jerky product.

For the sensory data, this study did not show any significant improvement in color, taste, flavor, texture and palatability with the treatments used. The panelist reacted the same to the shrimp jerky, with and without added tapioca flour. This means that tapioca flour not exceeding 10% could be used to make shrimp jerky. If the addition is higher than that, the shrimp jerky will very hard, observed in the A3 treatment. The sensory analysis could also determine the hardness, commonly by using the terms for crispiness. A low crispiness score will show high hardness. All the sensory data showed that the panelists could still accept the shrimp jerky product with the addition of flour not exceeding 10%. Mohamed et al. (1989) reported that fish crackers with lower hardness values along with rising linear expansion would decrease the hardness score of fish crackers. Similar to the shrimp jerky without tapioca powder in this research. To improve the physical characteristics of white shrimp jerky, this study can offer a better theoretical foundation for the application of tapioca as a filler on shrimp jerky to improve the physical and sensory characteristics, compared to shrimp jerky without tapioca flour.

CONCLUSION

The addition of tapioca flour as a filler at a rate less than 15% could improve the color, texture, and sensory properties of white shrimp jerky, although the characteristics did not differ significantly between treatments. For the nutrient component, the addition of tapioca powder decreased the ash, protein, and amino acid contents. However, the shrimp jerky could still maintain shrimp as the main source of protein. There was a negative correlation between WHC and hardness properties after the addition of tapioca flour. Overall, 5% tapioca flour had been added to white shrimp jerky, showing not only low hardness properties but also high protein, similar to shrimp jerky without flour (control treatment). This research can offer better options for using tapioca flour as a binder or filler in shrimp jerky. Thus, this study could be utilized by producers and fishermen for making jerky from white shrimp with or without tapioca as a versatile food product for consumption.

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