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# PHYSICOCHEMICAL CHARACTERISTICS OF VANAME SHRIMP SAUSAGE USING WALNUTS (*Canarium indicum L.*) PROTEIN CONCENTRATE AS EMULSIFIER AND TAPIOCA STARCH BINDER

Karakteristik Fisikokimia Sosis Udang Vaname dengan Penggunaan Konsentrat Protein Kacang Kenari (*Canarium indicum L.*) Sebagai Emulsifier dan Binder Pati Tapioka

Nurul Putri Mariska[1], Rizky Muliani Dwi Ujianti[1*], Fafa Nurdyansyah[1], Arief Rakhman Affandi[1], Mega Novita[2], Abdillah Fathan Generus Annajah[1]

[1]Food Technology Study Program, Faculty of Engineering and Informatics, Universitas Persatuan Guru Republik Indonesia Semarang
[2]Natural Science Education, Postgraduate Program, Universitas Persatuan Guru Republik Indonesia Semarang

*Sidodadi Timur Street, Karangtempel, East Semarang, Semarang City, Central Java, Indonesia 50232*

*Corresponding Author: rizkymuliani@upgris.ac.id

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## ABSTRACT

.Sausage is a food product made from minced meat stabilized with emulsifiers and binders to produce a desirable texture. However, the use of shrimp meat, such as whiteleg shrimp, often experiences emulsion instability problems because some of its proteins do not support the process. Walnuts have a high content of vegetable protein and fat and good functional properties as an emulsifier, so they have the potential to improve emulsion stability, texture, and quality of shrimp meat sausages. Therefore, research is needed on the addition of walnut protein concentrate to tapioca flour as a binder to produce shrimp meat sausages that are more stable, chewy, and acceptable to consumers. This study aimed to evaluate the effect of adding walnut protein concentrate as a natural emulsifier on the functional and physicochemical characteristics of whiteleg shrimp sausage. The parameters analyzed included moisture content, fat content, water-holding capacity (WHC), protein content, emulsion stability, and texture (hardness, cohesiveness, and springiness). The research employed a factorial randomized block design (RBD) with two factors: the concentration of walnut protein concentrate (2%, 3%, and 4%) and the concentration of tapioca starch binder (3% and 4%). The results showed that adding walnut protein concentrate and tapioca starch had a significant influence on all tested parameters. The moisture content ranged from 75.05% to 76.56%, fat content from 1.27% to 1.77%, WHC from 83.42% to 93.09%, protein content from 12.41% to 12.65%, emulsion stability from 82.67% to 86.67%, and hardness from 11.42 N to 18.65 N cohesiveness was 0.7, and springiness was 0.9. The best treatment was found to be a combination of 4% walnut protein concentrate and 3%–4% tapioca binder, depending on the parameter measured. The 4% concentrate and 4% binder combination yielded the highest moisture, fat content, and WHC, while the 4% concentrate and 3% binder combination produced the best emulsion stability and protein content. These findings suggest that walnut protein concentrate has strong potential as an effective plant-based emulsifier in shrimp-based sausage products.

Key words: Emulsifier, Shrimp, Starch, Walnut

**ABSTRAK**

Sosis merupakan produk pangan berbasis daging cincang yang distabilkan dengan emulsifier dan binder agar menghasilkan tekstur yang baik, namun penggunaan daging udang seperti udang vaname sering mengalami kendala ketidakstabilan emulsi karena sebagian proteinnya kurang mendukung proses tersebut. Kacang kenari memiliki kandungan protein nabati dan lemak yang tinggi serta sifat fungsional yang baik sebagai emulsifier, sehingga berpotensi meningkatkan kestabilan emulsi, tekstur, dan kualitas sosis daging udang. Oleh karena itu, penelitian mengenai penambahan konsentrat protein kacang kenari bersama tepung tapioka sebagai binder diperlukan untuk menghasilkan sosis daging udang yang lebih stabil, kenyal, dan diterima konsumen. Penelitian ini bertujuan untuk mengevaluasi pengaruh penambahan konsentrat protein kacang kenari sebagai emulsifier alami terhadap karakteristik fungsional dan fisikokimia sosis udang vaname. Parameter yang dianalisis meliputi kadar air, kadar lemak, kapasitas menahan air (WHC), kadar protein, stabilitas emulsi, dan tekstur (hardness, cohesiveness, springiness). Penelitian menggunakan rancangan acak kelompok (RAK) faktorial dengan dua faktor, yaitu konsentrasi konsentrat protein kacang kenari (2%, 3%, dan 4%) dan konsentrasi binder pati tapioka (3% dan 4%). Hasil menunjukkan bahwa penambahan konsentrat protein kacang kenari dan pati tapioka memberikan pengaruh terhadap seluruh parameter yang diuji. Kadar air produk berkisar antara 75,05% – 76,56%, kadar lemak 1,27% – 1,77%, WHC 83,42% – 93,09%, kadar protein 12,41% – 12,65%, stabilitas emulsi 82,67% – 86,67%, hardness 11,42N – 18,65N, cohesiveness 0,7, dan springiness 0,9. Perlakuan terbaik diperoleh pada kombinasi konsentrat protein kacang kenari 4% dan binder pati tapioka 3%–4%, tergantung pada parameter yang diuji. Kombinasi 4% konsentrat dan 4% binder menghasilkan kadar air, lemak, dan WHC tertinggi, sementara kombinasi 4% konsentrat dan 3% binder memberikan stabilitas emulsi dan kadar protein terbaik. Hal ini menunjukkan bahwa konsentrat protein kacang kenari berpotensi sebagai emulsifier nabati yang efektif dalam pengolahan produk sosis berbasis udang.

Kata Kunci: Emulsifier, Kacang Kenari, Pati, Udang

## INTRODUCTION

Sausage is a food product made from minced meat with a meat content of ≤ 75% and can be added with permitted food additives before being put into the casing and through a cooking process or served without cooking (BPOM (Indonesian Food and Drug Authority), 2016). (Holck *et al*., 2017) stated that meat has a significant influence on the stability of the emulsion and the physical properties of sausages because it is the main ingredient. Sausage raw materials consist of the main ingredients in the form of meat, ice cubes or ice water, salt, and oil, as well as additional ingredients such as fillers, binders, spices, flavorings, and other permitted food ingredients. The fat used can be solid fat or oil, and this study used cooking oil as a fat source (Zhou *et al*., 2018).

Common meats used in sausage production are beef and chicken, but this study used shrimp as the main ingredient. Shrimp is a high-value fishery commodity with significant market demand in the aquaculture industry (Berliana & Hariono, 2024). Whiteleg shrimp

(Litopenaeus vannamei) was chosen because it is widely cultivated in Central Java, West Java, East Java, South Sulawesi, and other regions in Indonesia (Fito & Mubarok, 2024). Shrimp is also the highest export commodity compared to tuna, skipjack tuna, mackerel, and crab, with whiteleg shrimp production increasing from 498,174 thousand tons to 757,790 thousand tons in 2018, thus increasing its use in processed foods (Bernard & Bolatito, 2016; Seychelles *et al*., 2018).

Despite their high animal protein content, shrimp sausages often experience emulsion stability issues because most of the protein does not support optimal emulsion formation. A common problem is the separation of the water and fat phases during or after the heating process, which reduces the sausage's texture, elasticity, sensory quality, and shelf life due to the potential for increased microbial contamination. To address this, the addition of functional proteins such as walnut (*Canarium indicum* L.) protein concentrate and binders such as tapioca flour is necessary to improve emulsion stability and sausage texture (Bulkaini *et al.,* 2020). Walnuts have a high protein content of 18–24% and fat, and are able to bind water and fat, thus functioning as a natural emulsifier in shrimp sausage dough (Priyanto & Djajati, 2020).

Walnuts are endemic to eastern Indonesia and have high water content when harvested so they need to be dried to extend their shelf life (Nurhayati *et al*., 2018). The fat content of dried walnuts reaches 71.3%, while fresh walnuts have a water content of 25%, protein 8.2% and fat 43.5% (Wahyuningtyas, 2016). The good solubility of walnut protein at neutral to slightly alkaline pH makes it suitable for sausage formulation and has potential as an emulsifier in food products. Several other seeds such as nutmeg, ketapang, jatropha curcas, kluwih, and saga also have potential as emulsifiers, but have disadvantages such as the need for expensive extraction technology or natural toxic content that makes them less safe or difficult to process (Abdullah *et al*., 2020; Holck *et al*., 2017; Widhiantoro *et al*., 2019).

Protein concentrate can increase protein purity by up to 70% as reported byDjarkasi et al., 2017. Walnuts themselves have around 15 g of protein per 100 g, thus potentially increasing the stability of sausage emulsions and preventing shrimp sausages from drying out or breaking (Ma'ruf *et al*., 2019). To date, there has been no research utilizing walnuts as an emulsifier in shrimp meat sausages, so further research is urgently needed. The addition of walnut protein concentrate with binders such as tapioca flour is expected to improve the quality, texture, acceptability, and safety of sausages, in accordance with the characteristics of good-quality sausages that are free of preservatives and synthetic dyes (Ayam, 2022; Iqbal & Ma'ruf, 2016).

## RESEARCH METHODS

### Tools and Materials

The leading equipment for making protein concentrate includes a cabinet dryer, hotplate, water bath, oven, and digital balance. Equipment for making whiteleg shrimp sausage consists of a food processor and digital scales. Analytical equipment includes a Kjeldahl unit, Soxhlet apparatus, centrifuge, refrigerator, texture analyzer, beaker, vacuum Erlenmeyer flask, and vacuum funnel.

The main ingredients are walnuts, whiteleg shrimp meat, and tapioca starch. Other ingredients include cooking oil, ice cubes, garlic powder, nutmeg powder, pepper, seasonings, and 18 mm sausage casings.
Analytical materials include n-hexane, 96% food-grade ethanol, Kjeldhal tablets, 45% NaOH, 0.1N HCl, concentrated $H_2SO_4$, 4% boric acid, distilled water, distilled water, methyl red indicator, and filter paper.

### Place and Time

This research was conducted at the Food Processing Engineering Laboratory and the Food Chemistry and Biochemistry Laboratory, Food Technology Department, Faculty of Engineering and Informatics, Universitas Persatuan Guru Republik Indonesia Semarang. This research was conducted for 10 months, starting from September 2024 to July 2025.

**The process of making low-fat walnut flour (Zhou *et al.*, 2018)**

The production of low-fat walnut flour involves grinding, washing with n-hexane, filtration, and drying. Seventy grams of walnut flour was washed three times with n-hexane (a ratio of 1:1.5 w/v) for 15 minutes each cycle, then filtered and dried at room temperature for 24 hours.

**Making walnut protein concentrate (Zhou *et al.*, 2018)**

Walnut protein concentrate was prepared by dissolving 15 grams of low-fat walnut flour in 96% food-grade ethanol (1:2 w/v ratio), then stirring using a magnetic stirrer for 15 minutes at 500 rpm. The mixture was extracted in a water bath at 30°C for 60 minutes, then filtered to separate the liquid and solid phases. The resulting precipitate was dried in an oven at 40°C for 20 hours and ground using a mortar to form a protein concentrate powder.

**Making vaname shrimp sausage**

The process of making vaname shrimp sausage begins with cleaning the shrimp, then weighing ingredients such as ice cubes, garlic powder, pepper, nutmeg, and cooking oil. All ingredients are mixed and ground using a food processor, then placed into 10 cm long cellulose casings and steamed for 10 minutes.

**Observation parameters**

**Yield Analysis**

The yield is obtained from the number of kilograms of product formed from each kilogram of processed material.

**Protein analysis**

Protein content testing was conducted using the Kjeldahl method, which includes digestion, distillation, and titration.

Vanessa Shrimp Sausage Product Analysis

The vaname shrimp sausage product analysis applied in this study included water content, fat content, protein analysis, WHC test, emulsion stability test, texture analysis, and sensory testing.

**Water Content Analysis**

Determination of water content is carried out using the drying oven method until a constant weight is obtained (0.050 gr).

**Fat Content Analysis**

Fat content analysis using a Soxhlet extraction apparatus.

**WHC test**

The WHC (Water Holding Capacity) test was conducted to determine the ability of vaname shrimp sausage to retain water during the heating and storage process using the centrifugation method.

**Protein analysis**

Protein content testing is carried out using the Kjeldahl method, which includes the stages of destruction, distillation, and titration.

**Emulsion Stability Test**

Emulsion Stability Testing refers to the testing procedure according to AOAC 2007.

**Texture Analysis**

Texture analysis of vaname shrimp sausage using a texture analyzer.

**Organoleptic Test**

The organoleptic test used descriptive analysis. Descriptive analysis of the vaname shrimp sausage included color, shrimp aroma, firmness, shrimp flavor, and umami levels. Ten trained panelists were used.

**Data analysis**

The data obtained in this study will be processed using SPSS software. Furthermore, the physicochemical test results will be analyzed using ANOVA (Analysis of Variance) to determine whether there are differences. If differences are found, the Duncan Multiple Range Test (DMRT) will be used at a 5% threshold.

## RESULT

**Raw Material Analysis**

Physicochemical characteristics, such as water content, protein, fat, emulsion stability, texture, and color, are the main indicators of the quality of whiteleg shrimp sausage. Walnut protein concentrate (*Canarium indicum* L.) as an emulsifier is expected to improve emulsion stability and maintain the texture and homogeneity of the sausage during processing and storage, thanks to the walnut protein's ability to absorb water and stabilize the emulsion.

| Component | Content |
|---|---|
| Rendement (%) | 92,76% ± 0,36 |
| Proteins (%) | 37,77% ± 0,17 |

Based on the results of the table above, it shows that the yield value is 92.76% and the protein value is 37.77%.

**Water Content Analysis**

Water content is an important parameter in evaluating sausage quality, because its percentage can affect the appearance, texture and taste of the product. The results of water content can be seen in graph 1

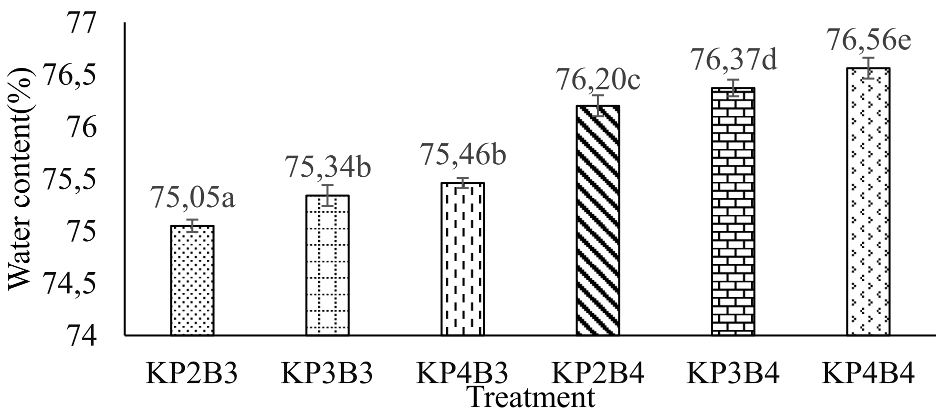



Figure 1. Results of water content analysis

The results of the table above show that the higher the concentration added to the two materials, the higher the water content value.

**Fat Content Analysis**

Fat content is essential in determining sausage quality, as it plays a significant role in the product's flavor, texture, and emulsion stability (Holck *et al.,* 2017). Fish-based sausages, such as whitebait shrimp sausages, generally contain less fat than sausages made from red meat.

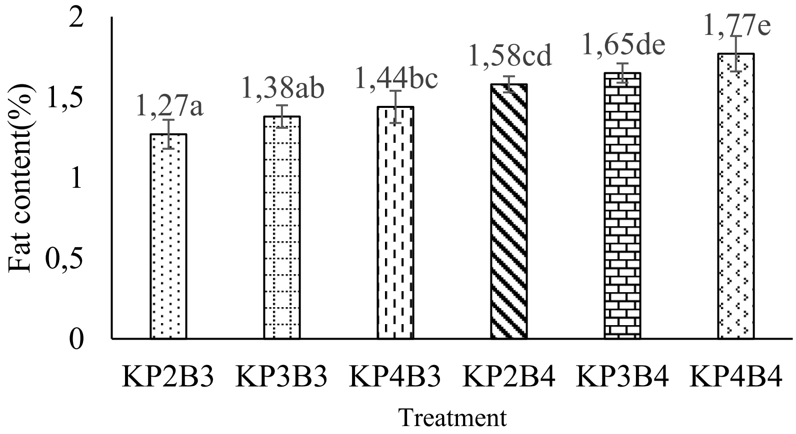



Figure 2. Results of fat content analysis

Based on the results of the graph above, it shows that the higher the addition of the two ingredients, the higher the fat content in the shrimp sausage.

**WHC Test Analysis**

Water Holding Capacity (WHC) is a crucial parameter in assessing the quality of processed meat products, including whitebait shrimp sausage. WHC refers to the ability of the protein matrix to retain water during processing and storage without fluid loss.

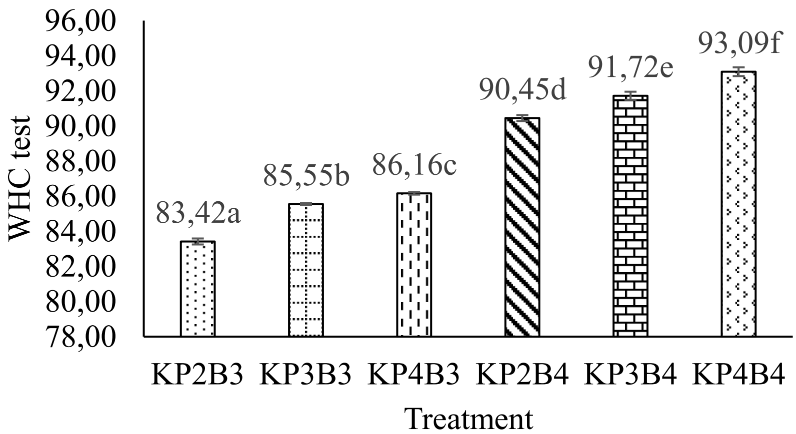



Figure 3. Results of WHC test analysis

The results of the WHC test values above show that with the addition of the two additional ingredients, the WHC test value increases.

**Protein Analysis**

Based on the data from the results of protein analysis on vaname shrimp sausage products using canary protein concentrate and tapioca starch binder, the results can be seen in the Figure 4.

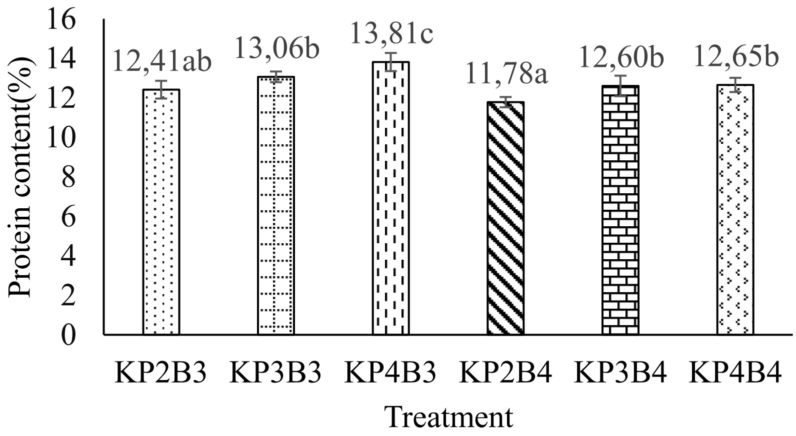
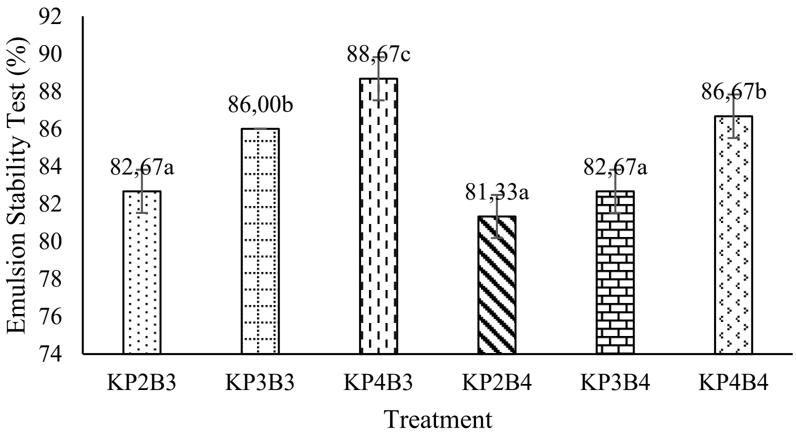



Figure 4. Results of protein content analysis

The KP4B3 treatment produced the highest value based on the protein analysis results.

**Emulsion Stability Test Analysis**

The results of the data from the analysis of the emulsion stability test on the vaname shrimp sausage product using canary protein concentrate and tapioca starch binder can be seen in Figure 4.5.




Gambar 5. Results of the Emulsion Stability Test Analysis

Based on Figure 4.5, the use of walnut protein concentrate and binder in the production of vaname shrimp sausage showed significantly different and non-significant results. The KP4B3 treatment produced the highest emulsion stability value of 88.57%, which was statistically significantly different ($P>0.005$) from the other treatments.

**Texture analysis**

Texture analysis of vaname shrimp sausage includes hardness, cohesiveness, and springiness.

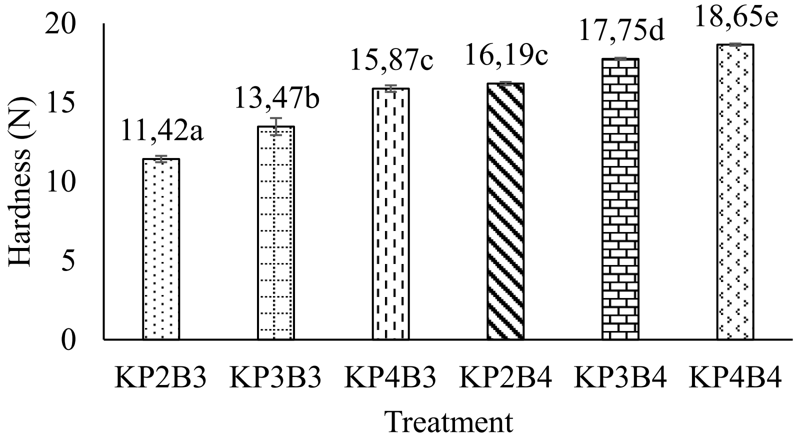



Figure 6. Results of hardness texture analysis

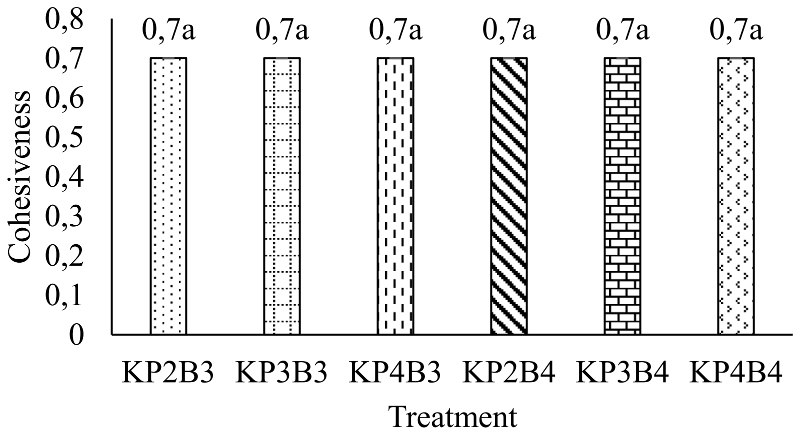



Figure 7. Results of cohesiveness texture analysis

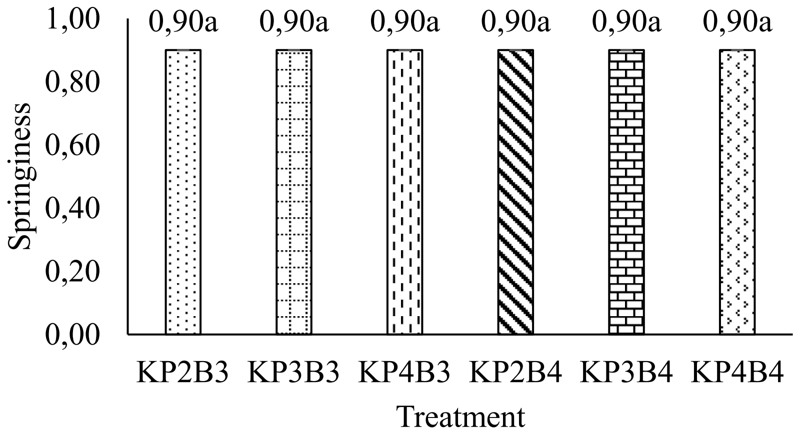



Figure 8. Results of springiness texture analysis

Based on these results, although the levels of walnut protein concentrate and tapioca starch binder increased in each treatment, there was no significant change in cohesiveness. This is likely because within the range of protein concentrate concentrations (2%, 3%, and 4%) and tapioca starch binder (2% and 3%), the sausage emulsion system has reached its optimal capacity to form a cohesive network. Higher levels or other combinations of ingredients are likely required to produce a difference.

Tabel 2. Descriptive analysis results of vaname shrimp sausage

| Treatment | Parameter | | | | |
|---|---|---|---|---|---|
| | Color | The aroma of shrimp | Elasticity | Flavour shrimp | Umami |
| KP2B3 | 2,45±2,12[a] | 3,83±2,15[a] | 4,85±1,39[a] | 4,50±1,32[a] | 4,87±1,78[a] |
| KP3B3 | 2,96±2,18[a] | 3,77±2,01[a] | 4,08±1,99[a] | 5,06±1,54[a] | 4,62±1,80[a] |
| KP4B3 | 2,90±1,80[a] | 4,04±1,46[a] | 4,28±0,86[a] | 4,81±0,95[a] | 4,80±1,27[a] |
| KP2B4 | 2,18±1,87[a] | 4,41±1,83[a] | 4,61±1,45[a] | 5,35±1,12[a] | 4,51±1,26[a] |
| KP3B4 | 2,76±1,93[a] | 4,47±2,05[a] | 3,46±1,96[a] | 4,43±1,74[a] | 4,36±1,71[a] |
| KP4B4 | 2,52±2,03[a] | 3,46±1,34[a] | 3,51±1,75[a] | 4,59±1,97[a] | 5,07±1,91[a] |

Descriptive analysis is a method used to describe the sensory characteristics of a food product and identify its attributes with the help of specially trained panelists. In this study, the parameters measured were color, shrimp aroma, firmness, shrimp flavor, and umami (Holck et al., 2017). Results are presented as average values with standard deviations and statistically tested ($P<0.005$) to identify significant differences between treatments.

## DISCUSSION

Physicochemical characteristics, such as water content, protein, fat, emulsion stability, texture, and color, are key indicators of the quality of whiteleg shrimp sausage. Walnut (Canarium *indicum* L.) protein concentrate, used as an emulsifier, is expected to improve emulsion stability and maintain the sausage's texture and homogeneity during processing and storage, thanks to the walnut protein's ability to absorb water and stabilize the emulsion.

Raw material selection is crucial in the production of walnut protein concentrate, which is known to be rich in protein, fiber, and minerals. Before protein extraction, walnuts are dried using a cabinet dryer at 40°C for 20 hours and defatted to increase protein yield and solubility (Zhou *et al*., 2018). High fat content can inhibit protein solubility and reduce emulsion stability. Protein concentrate yield indicates extraction efficiency, while high protein content reflects the quality of the raw material for food functions, such as emulsion stability in sausages. Zhou *et al*.. (2018) reported that walnut protein concentrate contains at least 50% protein. The results of the raw material characteristics are shown in Table 4.1. After extraction, the walnut protein concentrate yielded 92.76% with a protein content of 37.77%. This indicates that high yields consist not only of protein, but also carbohydrates, residual fat, minerals, and water content. Protein concentrate does contain more non-protein components than purer protein isolates (Nurhayati *et al*., 2018). This yield aligns with the results of Abdullah *et al*., (2020), who obtained 93% from komak nuts. The extraction process with 95% ethanol successfully increased the protein content from 12.04% in whole walnuts (Fito & Mubarok, 2024) to 37.77%.

Water content is crucial in evaluating sausage quality, as it impacts appearance, texture, and flavor (Ma'ruf *et al*., 2019). During cooking, water replaces hydrogen bonds in starch, causing the starch to expand and soften, resulting in a softer sausage texture (Ayam, 2022). The results of the water content analysis in whiteleg shrimp sausage with walnut protein concentrate and tapioca starch are shown in Figure 4.1. The water content of whiteleg shrimp sausage with varying concentrations of walnut protein concentrate and tapioca starch binder ranged from 75.05% to 76.56%, indicating a significant effect of the combination of ingredients on water content. Increasing the protein concentrate concentration from 2% to 4% increased the water content because walnut protein is hydrophilic and can bind more water (Zhou *et al*., 2018). Likewise, increasing tapioca starch from 3% to 4% also increases the water content because starch can absorb water and form a compact structure that prevents water loss during cooking (Priyanto & Djajati, 2020). The combination of 4% walnut protein and 4% tapioca starch yielded the highest moisture content (76.56%), creating a stable and soft sausage structure. However, this moisture content exceeded the Indonesian National Standard (SNI) limit (≤67%) due to the natural moisture content of the shrimp and the hydrophilic nature of the additives (Seychelles et al., 2018). The ideal moisture content for texture and emulsion stability is 70–75% (Bernard & Bolatito, 2016), as moisture content above 75% increases the risk of biological damage (Berliana & Hariono, 2024), while low moisture content (<65%) results in a hard texture and less juicy texture.

Fat content is a crucial parameter that influences the flavor, texture, and stability of sausage emulsions (Zhou *et al.,* 2018). Whiteleg shrimp sausages generally have lower fat content than red meat sausages. Walnut protein concentrate, used as an emulsifier, is believed to help retain fat in the protein matrix during processing, thereby reducing fat loss. Fat content analysis revealed values ranging from 1.27% to 1.77%, with the concentration of walnut protein and tapioca starch binder contributing to the increase in fat content. KP2B3 treatment resulted in the lowest fat content (1.27%), while KP4B4 treatment yielded the highest fat content (1.77%), with a significant difference ($p < 0.05$). The amphiphilic walnut protein can bind fat, while tapioca starch strengthens the gel structure and retains fat during cooking (Zhou *et al.,* 2018). Optimal fat content is crucial for maintaining the texture, flavor, and juiciness of the product; a fat content that is too low results in dry sausages, while a fat content that is too high increases the risk of rancidity due to oxidation (Wahyuningtyas, 2016). In general, the fat content of sausages ranges from 1% to 10%, and this study demonstrates that the addition of protein concentrate and binder has a significant impact on the final fat content of the sausages.

Water Holding Capacity (WHC) refers to the ability of a product, such as vaname shrimp sausage, to retain water during processing and storage, which affects the product's texture and juiciness. Walnut protein concentrate as an emulsifier and tapioca starch binder significantly increases WHC. The test results showed that WHC ranged from 83.42% (KP2B3) to 93.09% (KP4B4), with increasing concentrations of both ingredients significantly increasing the water-holding capacity ($p < 0.05$). High WHC supports emulsion stability, resulting in a softer, juicier texture and a better final yield. Therefore, the combination of walnut protein and tapioca starch effectively maintains the quality of low-fat shrimp sausage.

The protein content of sausages was significantly influenced by the concentration of walnut protein concentrate and tapioca starch ($p<0.05$). Treatment KP4B3 (4% walnut protein concentrate and 3% tapioca starch) produced the highest protein content of 13.81%, meeting the minimum SNI standard of 13%. Increasing the concentration of walnut protein concentrate increased the protein content due to the high protein content of walnuts (37.77%). Conversely, increasing the low-protein tapioca starch tended to decrease the protein percentage due to the dilution effect. Protein content was also influenced by water content and protein loss during the cooking process. The best formulation combined 4% walnut protein and 3% tapioca starch, optimally increasing the protein content without excessive dilution. These results are consistent with previous studies on the effect of starch and protein proportions on the protein content of processed products.

The stability of sausage emulsions was significantly influenced by the concentration of walnut protein concentrate and tapioca starch ($p<0.05$). The KP4B3 treatment (4% walnut protein and 3% tapioca starch) produced the highest emulsion stability of 88.57%, followed by KP4B4 with 86.67%, which was not significantly different. The 4% protein concentration was optimal for forming a strong protective layer of fat, resulting in a more stable emulsion. Increasing the tapioca starch binder from 3% to 4% had no significant impact and could even increase excessive viscosity. A 2% protein concentration provided the lowest emulsion stability because the protein layer was not strong enough. Overall, increasing the concentration of walnut protein concentrate enhanced emulsion stability, while tapioca starch served as a water-binding agent that strengthened the structure, albeit with a more limited effect. The KP4B3 formulation was optimal and efficient for maintaining emulsion stability in vaname shrimp sausages.

The hardness value increased with increasing concentration of walnut protein concentrate and tapioca starch binder. The KP2B3 treatment (2% protein, 3% binder) produced the lowest hardness (11.42N), while KP4B4 (4% protein, 4% binder) produced the highest value (18.65N). The increase in protein formed a strong gel network, binding water and fat. In contrast, the tapioca starch formed a gel that strengthened particle cohesion, resulting in a more complex and denser texture when combined with the other ingredients.

The cohesiveness value for all treatments was the same, at 0.7, and showed no significant differences ($p>0.05$). This indicates that variations in protein and binder concentrations within the range used did not significantly affect the cohesiveness of the sausage's internal structure. Both ingredients play a role in gel formation and water binding, resulting in a stable emulsion system across all treatments.

This indicates high elasticity and the product's ability to return to its original shape after being subjected to pressure or biting. Variations in protein and binder concentrations did not significantly affect elasticity because the formation of a protein and starch gel network was optimal within this range.

This method assesses panelists' preference for a product based on their senses (eyes, tongue, nose, and skin). Parameters tested include taste, aroma, color, and texture. Descriptive analysis identifies the sensory characteristics of a product, including color, shrimp aroma, firmness, flavor, and umami.

Descriptive Analysis Results Table 4.2:

1. Color:

The highest values were found in KP3B3 (2.96) and KP4B3 (2.90). Color tended to increase with increasing protein at the same binder level. The treatment with high binder and low protein (KP2B4) produced the palest color, likely due to pigment dilution by tapioca starch.

2. Shrimp Aroma

All treatments showed a relatively similar shrimp aroma with no significant differences. The concentration of walnut protein and tapioca starch binder did not affect aroma, which was more determined by the shrimp base.

3. Chewiness:

The highest chewiness value was found in KP2B3 (4.85), which was achieved through the combination of low protein (2%) and medium binder (3%-4%), resulting in the chewiest texture. Increasing protein tended to decrease chewiness due to an overly dense gel formation.

4. Shrimp Flavor

The highest flavor values were found in KP2B4 (5.53) and KP3B3 (5.06). Specific protein and binder combinations (KP4B3 and KP4B4) showed a decrease in flavor, possibly due to the interaction of the walnut protein with the shrimp volatile compounds or the dilution effect of tapioca starch.

5. Umami

Umami values were relatively high in all treatments, with the highest values being observed in KP4B4 (5.07) and KP2B3 (4.87). The addition of walnut protein did not reduce, but rather tended to enhance, the umami flavor of the sausage.

## CONCLUSION

Based on the results of the analysis of the physicochemical characteristics of whiteleg shrimp sausage using walnut protein concentrate (Canarium indicum L.) as an emulsifier and tapioca starch as a binder, the following conclusions can be drawn:

1. Based on the analysis, it can be concluded that using walnut protein concentrate as an emulsifier and tapioca starch as a binder has been proven to improve the functional properties of whiteleg shrimp sausage. Combining the two enhances emulsion stability, increases water and fat binding capacity, and yields a more compact texture with desirable sensory characteristics. Adding walnut protein concentrate increases protein content and emulsion matrix stability, while tapioca starch strengthens the gel, improving product elasticity and acceptability. Overall, this combination can support the development of whiteleg shrimp sausage with better physicochemical quality.
2. Adding walnut protein concentrate and tapioca starch significantly affects the physicochemical characteristics of whiteleg shrimp sausage. Variations in the concentration of both ingredients contribute to improving emulsion quality and water binding capacity, and influence the protein, fat, and texture of the product. Combining walnut protein concentrate as an emulsifier and tapioca starch as a binder can produce vaname shrimp sausage with more stable physicochemical characteristics and meet quality standards.

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## REFERENCES

Abdullah, N., Latief, R., Bastian, F., Sukendar, N. K., Djalal, M., & Pala'langan, M. R. (2020). The Effect of Kluwih (Artocarpus communis) Fruit Flesh Addition to the Nutrition Content of Mackerel Tuna Fish Abon. *Canrea Journal: Food Technology, Nutritions, and Culinary Journal*, 34–41.

Ayam, R. S. (2022). Effect of fat replacement with different types of eggplants on the physicochemical and sensorial properties of chicken sausages: a chemometric approach. *Malaysian Journal of Analytical Sciences*, *26*(6), 1313–1331.

Berliana, J. N., & Hariono, B. (2024). Implementation of A Traceability System for Canned Fish Products using The FMECA Approach. *Jurnal Teknik Pertanian Lampung (Journal of Agricultural Engineering)*, *13*(3), 863–872.

Bernard, E., & Bolatito, A. Y. (2016). Nutritional Composition Of The Pink Shrimp (Penaeus Notialis) And Tiger Shrimp (Penaeus monodon) FROM LAGOS LAGOON, SOUTHWEST NIGERIA. *Nigerian Journal of Animal Production*, 578–581.

BPOM (Indonesian Food and Drug Authority). (2016). *Supervision of Claims on Processed Food Labels and Advertisements* (Vol. 13). BPOM RI.

Bulkaini, B., Kisworo, D., Sukirno, S., Wulandani, R., & Maskur, M. (2020). Kualitas Sosis Daging Ayam Dengan Penambahan Tepung Tapioka. *Jurnal Ilmu Dan Teknologi Peternakan Indonesia (JITPI) Indonesian Journal of Animal Science and Technology)*, *6*(1), 10–15. https://doi.org/10.29303/jitpi.v5i2.62

Djarkasi, G. S. S., Raharjo, S., & Noor, Z. (2017). Isolasi dan akitivitas spesifik enzim lipase indigenous biji kenari. *Jurnal Teknologi Pertanian (Agricultural Technology Journal*, *8*(1).

Fito, A., & Mubarok, A. S. F. Q. R. (2024). Studi Proses Pengolahan Udang Vaname Mentah Beku (Litopenaeus vannamei) Bentuk Butterfly Tail On (BTO). *Juvenil: Jurnal Ilmiah Kelautan Dan Perikanan*, *5*(2), 138–144. https://doi.org/10.21107/juvenil.v5i2.24295

Holck, A., Axelsson, L., McLeod, A., Rode, T. M., & Heir, E. (2017). Health and safety considerations of fermented sausages. *Journal of Food Quality*, *2017*(1), 9753894.

Iqbal, M., & Ma'ruf, W. F. (2016). Pengaruh Penambahan Mikroalga Spirulina Platensis Dan Mikroalga Skeletonema Costatum Terhadap Kualitas Sosis Ikan Bandeng (Chanos Chanos Frosk). *Jurnal Pengolahan Dan Bioteknologi Hasil Perikanan*, *5*(1), 56–63.

Ma'ruf, W., Rosyidi, D., Radiati, L. E., & Purwadi, P. (2019). Physical and Organlopetic Properties of Nuggets from Domestic Chicken (Gallus domesticus) Meat with Different Corn Flours as Filler. *Research Journal of Life Science*, *6*(3), 162–171.

Nurhayati, N., Mappiratu, M., & Musafira, M. (2018). Pembuatan Konsentrat Protein Dari Biji Kelor (Moringa oleifera L.) Dan Analisis Profil Asam Amino. *Kovalen: Jurnal Riset Kimia*, *4*(1), 24–32. https://doi.org/10.22487/kovalen.2018.v4.i1.10180

Priyanto, A. D., & Djajati, S. (2020). Effect of Binder Types and Its Concentrations on Sausage Formulations from Asian Green Mussel and Tempeh Flour. *Jurnal Ilmu Pangan Dan Hasil Pertanian*, *4*(1), 28–42. https://doi.org/10.26877/jiphp.v4i1.5895

Seychelles, L. H., Happe, S., Palacios, E., Ludwig, M., Hollmer, S., Ehlers, R., Schulz, C., & Mercier, L. (2018). Successful rearing of whiteleg shrimp Litopenaeus vannamei larvae fed a desiccation-tolerant nematode to replace Artemia. *Aquaculture Nutrition*, *24*(2), 903–910.

Wahyuningtyas, R. (2016). *Formulation of Analogous Meat from Mackerel Based on Swordtail Beet Molef in Sausages*.

Widhiantoro, S. Y., Pratama, Y., & Susanti, S. (2019). Pengaruh Substitusi Kacang Tanah Dengan Biji Ketapang (Terminalia cattapa) Terhadap Sifat Fisik dan Organoleptik Selai Kacang. *Jurnal Teknologi Pangan*, *3*(1), 147–151. https://doi.org/10.14710/jtp.2019.23408

Zhou, X., Gao, H., Mitcham, E. J., & Wang, S. (2018). Comparative analyses of three dehydration methods on drying characteristics and oil quality of in-shell walnuts. *Drying Technology*, *36*(4), 477–490.