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CHARACTERISTICS OF VANNAMEI SHRIMP POWDERED BROTH WITH THE ADDITION OF CORNSTARCH

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ABSTRACT

Vannamei shrimp (Litopenaeus vannamei) is one of the major fishery commodities in Indonesia. The processing of vannamei shrimp generates a by-product in the form of shrimp broth, which is rarely utilized and may potentially cause environmental pollution. However, shrimp broth contains glutamic acid. Therefore, shrimp broth has potential to be processed into powdered broth. The production of powdered broth requires a filler. Cornstarch is one filler that can produce good product consistency. In addition, cornstarch can improve product texture and stability. Therefore, this study investigated the addition of cornstarch to vannamei shrimp powdered broth. This study aimed to determine the effect of adding cornstarch at different concentrations on the physical and chemical characteristics of vannamei shrimp powdered broth. The study used a completely randomized design with one factor, namely differences in cornstarch concentration: 0% (K), 5% (A), 10% (B), and 15% (C). The resulting vannamei shrimp powdered broth was analyzed for physical properties (yield and color) and chemical properties (moisture, protein, and glutamic acid). The results showed that higher cornstarch addition increased yield and moisture content, whereas protein and glutamic acid contents decreased. For color attributes, cornstarch addition increased lightness. The best vannamei shrimp powdered broth was obtained with 5% cornstarch addition, containing 5.70% moisture, 41.13% protein, and 1.93% glutamic acid. The addition of 5% cornstarch produced a yield of 9.58%, with L*, a*, and b* color values of 80.69, 6.72, and 16.65, respectively.

KEYWORDS: Glutamic Acid; Powdered Broth; Cornstarch; Vannamei Shrimp.

1. INTRODUCTION

Vannamei shrimp (Litopenaeus vannamei) is one of the major fishery commodities in Indonesia. According to BPS data in 2023, aquaculture production of vannamei shrimp reached 941,646 tons [5]. This production is mainly carried out through brackish-water pond cultivation in coastal areas. The high production value is partly supported by the diversity of shrimp-based processed products in Indonesia. Vannamei shrimp can be processed into various products, such as peeled frozen shrimp, ebi furai, and shrimp paste. The high consumption of vannamei shrimp is also associated with its nutritional content. Bastian et al. [7] reported that vannamei shrimp contains 77.12% moisture, 1.42% ash, 15.12% protein, and 2.22% fat. Its high protein content indicates that vannamei shrimp has potential as a source of animal protein. In line with its protein content, vannamei shrimp also contains a relatively complex amino acid profile. Zhang et al. [26] reported that fresh vannamei shrimp contains various amino acids, including glutamic acid, glycine, and arginine. Glutamic acid is the most abundant amino acid, reaching 234.75 mg/g. This compound contributes to savory or umami taste, making vannamei shrimp a potential raw material for powdered broth.

Powdered broth is one type of broth widely used in Indonesia. This type of broth is a solid product in the form of fine powder. Unlike liquid broth, powdered broth has physical characteristics as a fine powder, is easy to store, and readily absorbs water. Vannamei shrimp, with its high glutamic acid content, has potential as a raw material for powdered broth. Karomah et al. [15] reported that the use of vannamei shrimp heads as powdered broth produced a product with low moisture content, high protein content, and high glutamic acid content. These characteristics produce a savory taste and are preferred by panelists. The main advantage of powdered broth is ease of storage. Powdered broth is a finely powdered solid product that can be packaged in aluminum foil sheets. This packaging allows the broth to be stored at room temperature for an extended period. Shahin et al. [21] stated that aluminum foil layers in packaging provide protection against exposure to moisture, oxygen, and light. This protective layer increases product shelf life compared with other types of packaging. However, powdered broth has a major limitation, namely low yield. In addition, broth solutions that are dried into powder may lose nutritional content due to exposure to high temperatures. The main cause is the absence of a filler capable of retaining the nutritional content of the broth raw material, which results in a significant decrease in broth yield. One filler that can be used for broth is cornstarch. Ermawati et al. [9] explained that cornstarch is needed in the production of green mussel shell paste. Cornstarch functions as an emulsifier, aroma encapsulant, and filler that improves flavor characteristics.

Cornstarch is a type of flour that is widely available in Indonesia. It is produced from ground corn and is often referred to as corn flour. Cornstarch is a material with potential as a filler because of its ability to improve texture, bind water, and increase product elasticity. Tamaya et al. [22] stated that cornstarch has advantages as a thickener and relatively stable filler. This stability is caused by carbohydrate bonds that form when water is added. These bonds make solutions containing cornstarch relatively suitable for high-temperature cooking. Atika and Handayani [4] demonstrated that the addition of starch-based flour provides benefits in increasing yield and maintaining flavor quality. Ermawati et al. [9] reported that corn flour is highly suitable as a product mixture because it can function as a good filler and emulsifier. This is associated with its amylopectin content, which reaches 71.3-73%. However, excessive use may decrease product quality, taste, and texture, causing the product to be dominated by a corn-starch flavor. Cornstarch as a filler is expected to maintain the quality of the resulting shrimp broth; therefore, the addition of cornstarch in the production of vannamei shrimp powdered broth needs to be studied. Accordingly, this study aimed to determine the effect of adding cornstarch at different concentrations on the physical and chemical characteristics of vannamei shrimp powdered broth.

2. MATERIALS AND METHODS

2.1 Materials and Equipment

The main materials used were fresh size-40 vannamei shrimp, eggs, and cornstarch obtained from a local market in Semarang, Central Java, Indonesia.

2.2 Production Process of Vannamei Shrimp Powdered Broth

The production of vannamei shrimp powdered broth referred to the method of Karomah et al. [15], with several modifications. Fresh vannamei shrimp were prepared and separated into heads, carapaces, tails, and meat. The shrimp meat was separated from the digestive tract, and each part was washed thoroughly under running water. The heads, carapaces, and tails were cut into 1-2 cm pieces to reduce their size. A total of 500 g of material was mixed with 1,000 mL of water at a ratio of 1:2 and then boiled. The boiling process was carried out to extract compounds from the shrimp. Extraction was performed at 80°C for 40 min. The shrimp meat was prepared, homogenized using a blender, and added to the boiling water. Extraction was continued at 80°C for 20 min. The extract was filtered and cooled to room temperature (30°C). Cornstarch was added to the extract according to the treatment levels of 0% (K), 5%

(A), 10% (B), and 15% (C), and egg white was added according to the formulation shown in Table 1. Each treatment was foamed using a mixer for approximately 10 min at high speed. Iron trays were prepared and fully lined with parchment paper. The foamed mixture was placed in the tray and spread evenly to a thickness of 5-8 mm. The samples were dried at 60°C for 10-12 h. The dried products were ground using a blender, sieved through a 60-mesh sieve, and stored in airtight containers. Several samples were separated and packaged in aluminum foil, with 6 g of sample placed in each package.

Table 1. Formulation of Vannamei Shrimp Powdered Broth.

Ingredient (%)	K	A	B	C
Vannamei shrimp broth	95	90	85	80
Egg white	5	5	5	5
Cornstarch	0	5	10	15
Total	100	100	100	100

Note: K = vannamei shrimp powdered broth without cornstarch addition; A = vannamei shrimp powdered broth with 5% cornstarch addition; B = vannamei shrimp powdered broth with 10% cornstarch addition; C = vannamei shrimp powdered broth with 15% cornstarch addition.

2.3 Yield

Total yield was determined according to the procedure of Amini et al. [2]. Product yield was measured by comparing the final product weight with the raw material weight and multiplying the result by 100%.

2.4 Protein Content

Protein content was determined according to SNI 01-2354.4-2006 [6]. Approximately 2 g of sample was weighed and placed into a digestion flask. Two Kjeldahl catalyst tablets were added to the flask, followed by an H2SO4-H2O2 mixture (15 mL:3 mL). Digestion was carried out at 410°C for 2 h until the solution became clear. The digested solution was cooled and diluted with 75 mL of distilled water. A 25 mL aliquot of 4% H3BO3 solution was prepared as the distillate receiver. A total of 75 mL sodium hydroxide-thiosulfate solution was prepared and added to the digestion tube. Distillation was performed until 150 mL of distillate was obtained. The distillate was titrated with 0.2 N HCl until a neutral gray color was formed. The measurement was repeated three times for each sample. Blank testing using distilled water was performed as a calibration basis. Protein content was calculated using the following equation:

Protein content (%) =

Where:

VA : mL HCl used for sample titration

VB : mL HCl used for blank titration

N : normality of the HCl standard used

14.007 : atomic weight of nitrogen

6.25 : protein conversion factor for fish

W : sample weight

2.5 Moisture Content

Moisture content was determined using the gravimetric method according to SNI 2354.1:2015 [6]. A non-vacuum oven was used. The oven was preheated to 105°C until the temperature stabilized. Empty dishes were placed in the oven for 2 h. They were then cooled in a desiccator for 30 min until room temperature was reached and weighed (weight A). Approximately 2 g of sample was placed in a dish and weighed (weight B). The dish containing the sample was placed in an oven at 105°C for 24 h. The dish was then cooled in a desiccator for 30 min until room temperature was reached and weighed (weight C).

Moisture content was calculated using the following equation:

Moisture content (% w.b.) =

2.6 Glutamic Acid Content

Glutamic acid content was determined using the spectrophotometric method according to Larasati et al. [16]. A 0.5 g sample was dissolved in 25 mL of distilled water and homogenized thoroughly. The solution was filtered and stored in a closed container. A standard MSG solution (50 mM) was prepared and transferred into several vials at volumes of 100-400 µL. A 200 µL aliquot of sample solution was placed in each vial and homogenized. A 700 µL aliquot of iron(III) salicylate stock solution was added and brought to a final volume of 10 mL with distilled water. The mixture was homogenized, incubated for 30 min, and read at a wavelength of 525 nm. The readings were used to construct a regression curve and calculate the glutamic acid content.

2.7 Color

Color analysis was performed using a chromameter with modifications based on Lazuardi and Haryanto [17]. The sample was placed on a flat surface and the color was measured. The color values obtained as L*, a*, and b* were recorded, with at least three repetitions. Repetition was considered complete when the results obtained differed by a minimum of 5 points. The last three replications were averaged to obtain the color value for each sample. Each sample was subjected to three color-reading replications.

2.8 Data Analysis

This study used a completely randomized design with one factor, namely different concentrations of cornstarch addition in vannamei shrimp powdered broth. The data obtained were analyzed using ANOVA. When significant differences were found, the analysis was continued with Tukey's test.

3. RESULTS AND DISCUSSION

Table 2. Physical Characteristics of Vannamei Shrimp Powdered Broth.

Parameter	Yield (%)	L*	a*	b*
K	5.79±0.17^{a}	66.64±0.54^{a}	11.57±0.66^{c}	19.04±0.55^{b}
A	9.58±0.05^{b}	80.69±0.04^{b}	6.72±0.04^{b}	16.65±0.07^{a}
B	14.11±0.12^{c}	83.48±0.05^{c}	6.91±0.05^{b}	16.47±0.06^{a}
C	16.88±0.08^{d}	90.30±0.04^{d}	4.31±0.03^{a}	16.27±0.05^{a}

Note: Data followed by lowercase letters indicate significant differences at the 5% level. K = vannamei shrimp powdered broth without cornstarch addition; A = vannamei shrimp powdered broth with 5% cornstarch addition; B = vannamei shrimp powdered broth with 10% cornstarch addition; C = vannamei shrimp powdered broth with 15% cornstarch addition.

3.1 Yield

Based on yield testing, the control sample had a yield of 5.79%, followed by the 5% sample at 9.58%, the 10% sample at 14.11%, and the 15% sample at 16.88%. The yield value increased in line with the increasing concentration of cornstarch. The results indicate that increasing cornstarch concentration affected the yield obtained. These findings are consistent with Ermawati et al. [9], in which green mussel shell flavor produced a yield of 79.10% in the control sample and 85.71% with 10% addition. The increase in yield was caused by the addition of cornstarch to the shrimp flavor raw material. Cornstarch is a filler that can increase the amount of solids in the broth raw material. The increase in solids causes the yield to rise as the filler concentration increases. This is in line with Cahyani [8], who explained that the use of fillers increases total dissolved solids in the sample. This increase causes yield to rise along with increasing filler concentration. The factor affecting product yield is cornstarch concentration. According to Haryati et al. [11], cornstarch is a type of flour that has the ability to bind free water. This ability causes the solution to become more viscous due to the added solids. Cornstarch can bind with liquid flavor when dissolved at the tested concentrations. This binding increases product yield and helps prevent nutrient evaporation.

3.2 Color

The L* value, or lightness, indicates sample brightness. Lightness has an interval of 0-100, where 0 represents a dark color and 100 represents white. This value interval provides a clear indication of brightness. The higher the L* value, the brighter the product produced [10]. The values obtained were 66.64±0.54 for treatment K, 80.69±0.04 for treatment A, 83.48±0.05 for treatment B, and 90.30±0.04 for treatment C. The lightness values differed significantly with the addition of cornstarch. Cornstarch has a clean white color that can dilute the original color of shrimp broth, thereby increasing the L* value of shrimp powdered flavor. According to Xu et al. [24], corn flour can mask natural pigments in the material, producing a brighter color. The increase in color brightness can be explained by the physical characteristic of corn flour, which is clean white. Homogenization of shrimp flavor with cornstarch or corn flour causes the original color of the shrimp flavor to fade. This can significantly reduce color intensity.

The a* value, or redness-to-greenness, indicates the red-to-green color attribute of a product. Negative a* values represent the green color interval from 0 to -80, whereas positive a* values represent the red color interval from 0 to 100. The results showed that all samples differed significantly among treatments; however, treatment A was not significantly different from treatment B. This indicates that increasing cornstarch concentration reduced the a* value. The decrease in a* value reflects the increasingly visible effect of cornstarch addition. A reduction in the red-to-green color attribute can produce a product with a more neutral color. Shrimp powdered flavor is produced from boiled shrimp; therefore, the resulting color tends to be yellowish. The addition of cornstarch reduces color intensity, making the shrimp flavor brighter. Abidin et al. [1] reported that mushroom broth powder given additional ingredients showed decreased a* values. This was attributed to a screening effect against material pigments. Additional ingredients in flavor products are used to stabilize proximate content, provide filler, and increase yield.

The b* value indicates yellowness-to-blueness and represents the yellow-blue color attribute. Negative b* values have an interval of 0 to -70 and represent blue, whereas positive b* values represent yellow [20]. The results showed that the b* value was not significantly affected across the samples as a whole. The b* value decreased with increasing cornstarch addition. Cornstarch added at certain concentrations can reduce color intensity. According to Yelliantty et al. [25], the b* degree in color measurement indicates yellowness in a material. Shrimp contains astaxanthin, which is present in the shell. Astaxanthin produces a dominant yellow-orange color, but the use of certain ingredients can reduce the intensity of the color produced by pigments contained in the shrimp shell. Cornstarch addition had an effect in the form of a significant decrease in color intensity. This is one reason why appropriate use of cornstarch is necessary. Cornstarch or corn flour has a bright white characteristic, which can fade product color when homogenized with other ingredients. Umah et al. [23] stated that b* color intensity may increase along with increased yellowness in the material. In certain materials, the use of additional ingredients can reduce yellow color intensity, thereby reducing product color intensity. In tomato powdered flavor, the use of cornstarch as an additional ingredient reduced yellow intensity, resulting in a lower b* value.

Table 3. Chemical Characteristics of Vannamei Shrimp Powdered Broth.

Parameter	Moisture (%)	Protein (%)	Glutamic Acid (%)
K	5.44 ± 0.24^{a}	52.84 ± 0.40^{d}	2.34 ± 0.006^{d}
A	5.70 ± 0.46^{ab}	41.13 ± 0.36^{c}	1.94 ± 0.018^{c}
B	5.80 ± 0.13^{ab}	28.47 ± 0.78^{b}	1.71 ± 0.010^{b}
C	6.30 ± 0.20^{b}	14.37 ± 0.63^{a}	1.51 ± 0.010^{aP}

Note: Data followed by lowercase letters indicate significant differences at the 5% level. K = vannamei shrimp powdered broth without cornstarch addition; A = vannamei shrimp powdered broth with 5% cornstarch addition; B = vannamei shrimp powdered broth with 10% cornstarch addition; C = vannamei shrimp powdered broth with 15% cornstarch addition.

3.3 Moisture

Based on the analysis, the moisture content of sample K was 5.44%, sample A was 5.70%, sample B was 5.80%, and sample C was 6.30%. The results showed that moisture content in shrimp powdered flavor increased with increasing cornstarch concentration, although the increase was not significant. A significant increase was only observed between treatments K and C. Based on SNI 01-4273-1996 concerning beef-flavored seasoning, the maximum moisture content for powdered broth products is 4%. All shrimp powdered flavor products had moisture values above 4%, and thus did not meet the SNI standard. The results of this study were better than those of Tamaya et al. [22] for seasoning products derived from fish-boiling water. Boiling-water samples from threadfin bream had a moisture content of 6.13%, and those from pomfret had 7.98% moisture content with 2.5% cornstarch addition. The 5% concentration sample in this study had a better moisture content, namely 5.70%, indicating that cornstarch is more suitable as a filler for shrimp powdered flavor. The increase in moisture content is associated with the ability of cornstarch to bind liquid. This is supported by Amini et al. [2], who explained that cornstarch has relatively good water absorption capacity. This ability increases the viscosity of the raw material solution. Increased viscosity makes shrimp broth more difficult to dry. According to Lazuardi and Haryanto [17], viscosity affects sample drying rate. Samples with high viscosity generally require a longer drying time than samples with low viscosity. Husaini et al. [12] reported that dry products, such as powder products, generally indicate material characteristics that are more durable and have longer shelf life. Excessive addition of fillers in powder products can increase moisture content. This condition occurs because additional materials also contain moisture. Maulina et al. [18] also stated that the addition of supplementary materials affects moisture content in dried shrimp materials. An appropriate drying process is required to obtain a product that is durable and has suitable moisture content.

3.4 Protein

The protein content of vannamei shrimp powdered broth showed significant differences. Protein content decreased with increasing cornstarch concentration. Based on SNI 01-4273-1996 concerning beef-flavored seasoning, the minimum protein content for powdered broth is 7%. The lowest protein value in this study was found in sample C at 14.37%. This value was higher than the minimum limit; therefore, all treatments met the SNI standard. The results of this study were higher than those reported by Karomah et al. [15], who used shrimp carapace powder with 15% wheat flour addition. The protein content obtained in that study was 13.10%, which was lower than the value in this study, namely 14.37% in sample C. This indicates that cornstarch is more suitable as a filler for shrimp powdered flavor. Increasing cornstarch concentration influenced the decrease in protein content in shrimp powdered flavor. Arjun et al. [3] reported that protein content in corn starch ranges from 0.3% to 0.5% per 100 g serving. This content is very low compared with the protein content in the control sample and therefore does not substantially contribute to total sample protein content. The factor affecting protein content was cornstarch concentration in the sample. Samples with high cornstarch concentration had the lowest protein content, and vice versa. This is because cornstarch functions as a filler that increases solids in the product. Although solids increase, cornstarch does not bind shrimp broth components effectively. This results in a significant decrease in protein content as cornstarch concentration increases. Novitasari et al. [19] explained that the use of carbohydrate-rich fillers decreases sample protein content.

3.5 Glutamic Acid

The glutamic acid analysis showed that sample K had the highest value at 2.324%, followed by sample A at 1.934%, sample B at 1.705%, and sample C with the lowest value at 1.513%. The glutamic acid values differed significantly among treatments. A significant decrease was observed with increasing cornstarch concentration. The values in this study were higher than those reported by Yelliantty et al. [25], whose best treatment produced 507.46 ppm, equivalent to 0.05%. The shrimp broth flavor produced in this study had a higher glutamic acid value, indicating that cornstarch is suitable as a filler for shrimp powdered flavor. Shrimp contains relatively high glutamic acid, particularly in the head and shell. The addition of cornstarch reduces the concentration of shrimp-boiling water, causing glutamic acid content to decrease. This occurs because glutamic acid in shrimp broth flavor originates from shrimp-boiling water, not cornstarch. The amount of glutamic acid derived from the boiling water decreases, causing the measured value to decline as cornstarch concentration increases. According to Jin et al. [14], glutamic acid in fresh shrimp is higher than in processed products. Glutamic acid in shrimp is the third most abundant amino acid. Shrimp shells and heads are among the parts with the highest amino acid content. Karomah et al. [15] reported that fishery products have high glutamic acid content due to amino acid accumulation in fishery materials. Other ingredients added to fishery products can reduce glutamic acid intensity. Janitra and Dewi [13] stated that glutamic acid content in products homogenized with additional ingredients, such as maltodextrin as a filler, is affected by filler composition. The higher the composition of additional ingredients used, the lower the glutamic acid content in the product. Another factor causing decreased glutamic acid content is binding with water. Glutamic acid is an amino acid that readily binds with water. Water binding causes chemical changes in glutamic acid and alters its structure. These changes can reduce the measured glutamic acid content because the chemical structure has changed. Larasati et al. [16] stated that compound changes due to water binding in glutamic acid result in structural alteration. This bond forms pyroglutamic acid and causes a decrease in glutamic acid of approximately 63%. The reaction causes the side-chain carboxyl group of glutamic acid to lose its OH group. The loss of this group allows protons from the amine group to form water (H2O), producing pyroglutamic acid. The newly formed acid cannot be detected within the absorbance interval of glutamic acid.

4. CONCLUSIONS

The addition of cornstarch affected the physicochemical and sensory properties of shrimp powdered broth. Increasing the concentration of cornstarch increased yield, moisture content, L* value, and sensory scores for appearance and texture. However, increasing cornstarch concentration also decreased protein content, glutamic acid content, a* and b* values, and pH value. These changes resulted in significant differences among samples. The best vannamei shrimp powdered broth was obtained with 5% cornstarch addition, containing 5.70% moisture, 41.13% protein, and 1.93% glutamic acid. The addition of 5% cornstarch produced a yield of 9.58%, with L*, a*, and b* color values of 80.69, 6.72, and 16.65, respectively.

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