

## Effect of Meat Proportion and Flour Type on the Physicochemical and Sensory Characteristics of Chicken–Duck Combination Sausages

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### ABSTRACT

This study aimed to evaluate the effects of meat proportion and filler type on the physicochemical and sensory characteristics of emulsion-type chicken and duck sausages. Four formulations were prepared using different proportions of chicken and duck meat combined with potato flour or sago flour, namely P1 (75% chicken, potato flour), P2 (75% chicken, sago flour), P3 (75% duck, potato flour), and P4 (75% duck, sago flour). Physicochemical analyses included cooking loss, pH, water holding capacity (WHC), water activity (aw), and color parameters (L\*, a\*, b\*). Sensory evaluation was conducted to assess aroma, color, chewy texture, juiciness, taste, aftertaste, and overall acceptability. The results showed that P2 had the lowest cooking loss (2.35%) and highest WHC (95.18%), indicating superior emulsion stability. In contrast, P3 exhibited the highest cooking loss (3.34%) and lowest WHC (90.19%). Duck-dominant formulations showed slightly higher pH values and produced darker, redder, and more yellow sausages due to higher myoglobin and fat pigment content. Water activity values were relatively similar among treatments (0.80–0.81). Sensory analysis revealed that chicken-dominant formulations were generally preferred for aroma and taste, while duck-dominant sausages were perceived as juicier. In conclusion, meat proportion and filler type significantly influenced sausage quality. The use of sago flour improved physicochemical stability, particularly in chicken-dominant formulations, while duck meat contributed positively to juiciness and color characteristics.

**KEY WORDS:** chicken-duck sausage; sago flour; potato flour; meat proportion; physicochemical properties; sensory evaluation.

Published online: May 29, 2026

*Cite the Article: Afidah, U., Syahputra, D.S., AAtqiyaa, A., Tamimi, M.H. (2026). Effect of Meat Proportion and Flour Type on the Physicochemical and Sensory Characteristics of Chicken–Duck Combination Sausages. International Journal of Life Science and Agriculture Research, 5(5), 375-382.*

<https://doi.org/10.55677/ijlsar/V05I05Y2026-11>

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### INTRODUCTION

The global demand for processed meat products, including sausages, remains high due to changing dietary patterns and consumer preference for convenient protein-rich foods, with sausages accounting for approximately 24% of total processed meat consumption in the United States between 1999 and 2016 and ranking among the five most commonly consumed processed meat products (Henchion & Zimmermann, 2021). In Indonesia, sausage consumption has expanded beyond traditional chicken-based formulations, creating opportunities for product diversification using alternative protein sources (Afifah & Adi, 2024). Chicken meat (*Gallus gallus domesticus*) remains the most widely utilized raw material in sausage production due to its high myofibrillar protein content, favorable water holding properties, and mild flavor profile (Ungkusionmongkol et al., 2025). However, reliance on a single meat source imposes constraints on the nutritional diversity, flavor complexity, and sensory breadth of the final product.

Duck meat (*Anas platyrhynchos domesticus*) presents a compelling complementary ingredient due to its distinct compositional profile. Relative to chicken, duck meat contains higher concentrations of intramuscular fat, myoglobin, and unsaturated fatty acids, which collectively contribute to a stronger umami flavor, deeper color, and greater juiciness in processed

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products (Kowalska et al., 2020). Despite these functional and sensory advantages, duck meat has been underutilized in emulsion type sausage formulations, largely due to its higher fat content, which complicates emulsion stabilization, and its characteristic strong odor, which may limit consumer acceptance when used in isolation (Li et al., 2024). The strategic combination of chicken and duck meat in variable proportions may reconcile these competing properties. Chicken meat contributes to emulsification efficiency and structural integrity through its protein network, while duck meat supplies flavor intensity and juiciness. Ungkusionmongkol et al. (2025) demonstrated that sausages formulated with increasing duck to chicken ratios exhibited progressively darker color, higher hardness, and distinct proximate composition changes, confirming the measurable impact of meat proportion on product quality. However, that study did not evaluate the influence of filler type as a co variable.

In emulsion type sausage systems, the stability of the protein fat water matrix is primarily governed by myofibrillar proteins and emulsifying agents such as egg white albumin. Starch based ingredients are commonly incorporated not as primary emulsifiers but as fillers that physically occupy the interstices of the protein gel matrix, modifying viscosity, texture, and water retention characteristics without directly stabilizing the oil water interface (Aewsiri et al., 2023). The distinction between a binder and a filler is mechanistically important, while a binder interacts chemically with the protein matrix to enhance cohesiveness, a filler modulates the physical properties of the gel network through swelling, gelatinization, and the formation of a secondary viscoelastic matrix within the pre formed protein structure (Kang et al., 2026).

Potato flour and sago flour represent two starch fillers with fundamentally different compositional profiles. Potato flour is characterized by large granule size, high water absorption capacity, and a relatively balanced amylose to amylopectin ratio, producing a soft, expansive gel upon gelatinization (Kang et al., 2026; Xu et al., 2021) demonstrated that potato flour outperformed wheat, corn, and tapioca starches in terms of cooking loss reduction and sensory firmness in meat sausages, attributing this to its lower gelatinization temperature and high swelling power. Sago flour, in contrast, contains approximately 73% amylopectin, yielding a highly viscous, cohesive, and thermally stable gel that resists retrogradation and provides superior water-immobilization capacity within the protein matrix (Ghalambor et al., 2022). Surfiana et al. (2024) stated that the addition of sago flour to duck sausages produced the highest elasticity and overall acceptability scores among several filler types tested, highlighting its favorable functional attributes in poultry-based sausages.

Despite numerous studies on single-species poultry sausages using various fillers, as well as separate investigations on chicken and duck meat combination products, limited research has systematically evaluated the interaction between meat proportion and filler type on the physicochemical and sensory characteristics of combination sausages. Increasing the proportion of duck meat alters the protein-to-fat ratio of the meat matrix, potentially reducing emulsion stability and making the functional role of fillers more critical in maintaining product quality. Therefore, this study aimed to evaluate the effects of filler type (potato flour and sago flour) and meat proportion (75:25 and 25:75, chicken meat:duck meat) on the physicochemical and sensory properties of chicken and duck combination sausages.

## MATERIALS AND METHODS

### Materials

The tools used in this study were plastic gloves, a digital scale, a hand mixer, a 100 mL measuring cup, scissors, mattress straps, a steamer, a piping bag, bowls, a stove, knives, collagen casings, needles, spatulas, a digital balance, a mortar, a digital pH meter, centrifuge tubes, a refrigerated centrifuge, an analytical balance, an aw meter, oil paper, and a colorimeter.

The materials used in this study were chicken meat, duck meat, potato flour, sago flour, granulated sugar, salt, garlic powder, onion powder, oregano, nutmeg powder, mustard, egg white, baking powder, cooking oil, ice water, and collagen sausage casings.

### Preparation of sausage

Four sausage formulations were prepared based on different proportions of chicken and duck meat and the type of filler used. The treatments consisted of P1 (75% chicken meat : 25% duck meat with potato flour), P2 (75% chicken meat : 25% duck meat with sago flour), P3 (25% chicken meat : 75% duck meat with potato flour), and P4 (25% chicken meat : 75% duck meat with sago flour).

Ground chicken and duck meat were weighed according to each treatment and placed into a mixing bowl. For formulations containing 75% chicken meat and 25% duck meat, 112.5 g chicken meat and 37.5 g duck meat were used, while formulations containing 25% chicken meat and 75% duck meat used 37.5 g chicken meat and 112.5 g duck meat. Sugar (4.5 g) and salt (2.25 g) were added and mixed using a hand mixer until the batter became sticky and fibrous. Garlic powder (1.7 g), onion powder (1.7 g), oregano (0.3 g), nutmeg powder (0.3 g), mustard (5.6 g), egg white (30 g), baking powder (1.9 g), cooking oil, and the respective flour (potato flour or sago flour, 12 g each) were then added and mixed thoroughly. Ice water (30 g) was gradually incorporated into the mixture and mixed until homogeneous. The bowl was covered with plastic wrap and refrigerated for 20 minutes. After refrigeration, the batter was transferred into a piping bag and stuffed into collagen sausage casings. The

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sausages were twisted at regular intervals and pressed gently by hand to separate each portion. The sausage links were tied with string at 6 cm intervals and pricked using a needle to remove trapped air. The sausages were steamed for 15 minutes using a steamer. After cooking, the sausages were cooled to room temperature.

### Cooking Loss Determination

Cooking loss was determined by wrapping approximately  $5 \pm 1$  g of sample in heat-resistant aluminum foil and heating it in a water bath at  $75^{\circ}\text{C}$  for 30 minutes. After cooking, the sample surface was dried and reweighed (Kabir et al., 2025). The percentage of cooking loss was then calculated based on the reduction in sample weight using the following formula:

$$\text{Cooking loss (\%)} = \frac{W_2 - W_3}{W_2} \times 100$$

where  $W_2$  and  $W_3$  represent the weight of the sausage batter before and after cooking, respectively.

### pH Determination

For pH measurement, 5 g of cooked sausage sample was homogenized with 25 mL of distilled water using a high-speed blender for 1 minute. The pH of the resulting homogenate was then determined using a digital pH meter (Model 210, HANNA Instruments) to obtain accurate pH readings (Kabir et al., 2025).

### Water Holding Capacity (WHC)

After excess moisture was removed using absorbent tissue, the samples ( $M_0$ ) were wrapped in three layers of absorbent paper, placed into 50 mL tubes, and centrifuged at 5000 rpm for 10 minutes at room temperature. Subsequently, the samples were removed from the tubes, the filter paper was discarded, and the samples were reweighed as  $M_1$  (Bai et al., 2026). All sample groups were analyzed in triplicate, and the values were calculated using the following formula:

$$\text{WHC (\%)} = \frac{M_1}{M_0} \times 100$$

Where  $M_0$  and  $M_1$  represent the sample weight (g) before and after centrifugation, respectively.

### Water Activity (aw)

The water activity value of the sausage samples was measured using an aw meter. Prior to measurement, the samples were ground using a mortar to obtain a uniform texture (da Silva Araujo et al., 2021).

### Color Analysis

Color measurement was conducted using a digital colorimeter. The lightness ( $L^*$ ), redness ( $a^*$ ), and yellowness ( $b^*$ ) values were recorded. Three random measurements were taken from different locations of each sausage sample, and the average values were calculated (Chen et al., 2026).

### Sensory Evaluation

Sensory evaluation consisted of hedonic tests using evaluation forms. The evaluation involved five treatments, P1 (75% chicken meat : 25% duck meat with potato flour), P2 (75% chicken meat : 25% duck meat with sago flour), P3 (25% chicken meat : 75% duck meat with potato flour), and P4 (25% chicken meat : 75% duck meat with sago flour). Panelists ranked the four sausage samples according to the intensity of each attribute. The hedonic test was conducted to evaluate aroma, color, chewy texture, juiciness, taste, aftertaste, and overall acceptability. Panelists evaluated each attribute using a 5-point hedonic scale ranging from 1 (strongly dislike), 2 (dislike), 3 (neutral), 4 (like), and 5 (strongly like).

### Data Analysis

The data were initially evaluated for normality and homogeneity of variance using the Shapiro–Wilk and Levene’s tests, respectively. Data that met the assumptions of normality and homogeneity ( $p > 0.05$ ) were analyzed using two-way Analysis of Variance (ANOVA), followed by Duncan’s multiple range test for post hoc analysis. In contrast, data that violated either assumption ( $p < 0.05$ ) were analyzed using the non-parametric Kruskal–Wallis test. Significant differences identified by the Kruskal–Wallis test ( $p < 0.05$ ) were further examined using Dunn’s test for pairwise comparisons. All statistical analyses were carried out using IBM SPSS Statistics version 25.

## RESULTS AND DISCUSSION

The results of the physicochemical and sensory analyses indicated that differences in meat proportion and filler type produced distinct physical and sensory characteristics across the four chicken-duck sausage formulations. The observed parameters included cooking loss, pH, water holding capacity (WHC), water activity (aw), color ( $L^*$ ,  $a^*$ ,  $b^*$ ), and sensory attributes.

**Table 1. Physicochemical characteristics of chicken duck sausage with the addition of sago and potato flour**

Sample	WHC <sup>*ns</sup>	Cooking Loss <sup>*ns</sup>	pH <sup>*ns</sup>	Moisture
P1	93.43 ± 2.24	3.11 ± 0.20	6.50 ± 0.07	72.12 ± 4.98 <sup>a</sup>
P2	95.18 ± 1.25	2.35 ± 0.31	6.53 ± 0.06	68.68 ± 0.53 <sup>a</sup>
P3	90.19 ± 4.85	3.34 ± 0.48	6.58 ± 0.32	64.58 ± 0.90 <sup>b</sup>
P4	94.14 ± 1.71	3.06 ± 0.67	6.67 ± 0.12	63.90 ± 1.14 <sup>b</sup>

\*P1: 75% chicken meat : 25% duck meat with potato flour, P2: 75% chicken meat : 25% duck meat with sago flour, P3: 25% chicken meat : 75% duck meat with potato flour, P4: 25% chicken meat : 75% duck meat with sago flour

Cooking loss represents the amount of weight lost during thermal processing and serves as an indicator of the product’s ability to retain water and fat within the protein–gel matrix during heating. Based on Table 1, the lowest cooking loss was recorded in P2 (2.35%), corresponding to the formulation with 75% chicken meat and sago flour as filler. The dominance of chicken meat in this formulation provides a higher concentration of myofibrillar proteins, which form a more compact gel network upon thermal denaturation, thereby reducing fluid exudation during steaming. Higher protein concentrations generally reduce cooking loss because protein gel networks inhibit liquid exudation by increasing water-binding capacity during heating (Wibowo et al., 2024). The role of sago flour as a filler further contributed to this outcome, upon gelatinization, the high amylopectin content of sago flour (approximately 73%) produced a viscous, cohesive gel matrix that physically occupied the interstices of the protein network and impeded the outward migration of free water and lipid (Jiang et al., 2024).

Conversely, the highest cooking loss was observed in P3 (3.34%), which combined 75% duck meat with potato flour as filler. Duck meat has a substantially higher intramuscular fat content than chicken meat (Kowalska et al., 2020), and when fat content increases, the myofibrillar protein to fat ratio decreases, weakening the protein network’s ability to encapsulate all available lipid. Under these conditions, the capacity of potato flour as a filler to compensate for this structural deficit was limited. Potato starch granules undergo extensive swelling during gelatinization and can absorb large amounts of water, yet under high-fat conditions the granule structure is more susceptible to disruption, resulting in greater fluid release. Tao et al. (2020) stated that increasing potato starch concentration may disrupt the gel-like network structure and create larger gaps within the matrix, resulting in a looser product and greater fluid loss during cooking.

Based on the Shapiro-Wilk test, the standardized residuals for cooking loss were normally distributed within both filler groups ( $p > 0.05$ ). Levene’s test showed that the variance among treatments was homogeneous ( $p = 0.274 > 0.05$ ). Both assumptions being fulfilled, two-way ANOVA was applied. The significance value for filler type was 0.040 ( $< 0.05$ ), indicating a significant difference in cooking loss based on filler type. The significance value for meat proportion was 0.061 ( $> 0.05$ ), indicating no significant difference in cooking loss based on meat proportion, although a trend toward higher cooking loss in duck-dominant formulations was observed. The significance value for the interaction was 0.306 ( $> 0.05$ ), indicating no significant interaction between meat proportion and filler type on cooking loss.

The pH value is an important quality parameter because it governs protein net charge, which in turn affects water holding capacity, emulsion stability, color, and flavor characteristics of meat products. Based on Table 1, pH values across all treatments ranged from 6.50 (P1) to 6.67 (P4), with formulations containing higher proportions of duck meat showing slightly elevated pH compared to those dominated by chicken meat. This pattern is consistent with the known pH characteristics of duck meat, which is generally higher than chicken meat due to lower postmortem glycolytic enzyme activity and consequently reduced lactic acid accumulation (Jerez-Timaure et al., 2022). Fresh duck meat commonly exhibits a pH of approximately 6.4, which is higher than that of chicken meat at approximately 6.12 (Wirjatmadja et al., 2021). The slight elevation in pH associated with increasing duck meat proportion is mechanistically relevant, as pH rises further above the isoelectric point of myofibrillar proteins, electrostatic repulsion between protein chains increases, opening the protein structure and enhancing water-binding sites, which may partly explain the higher WHC observed in duck-dominant formulations. Neither potato flour nor sago flour exerted a discernible effect on pH, as both fillers are chemically neutral and do not participate in acid–base reactions with meat proteins.

Based on the Shapiro-Wilk test, the standardized residuals for pH were normally distributed within both filler groups ( $p > 0.05$ ). Levene’s test showed that the variance among treatments was homogeneous ( $p = 0.136 > 0.05$ ). Both assumptions being fulfilled, two-way ANOVA was applied. The significance value for meat proportion was 0.253 ( $> 0.05$ ), indicating no significant difference in pH based on meat proportion. The significance value for filler type was 0.485 ( $> 0.05$ ), indicating no significant difference in pH based on filler type. The significance value for the interaction was 0.710 ( $> 0.05$ ), indicating no significant interaction between meat proportion and filler type on pH.

Water holding capacity (WHC) reflects the ability of meat products to retain water within the protein matrix during processing and heating. Based on Table 1, the highest WHC value was recorded in P2 (95.18). The elevated WHC in P2 can be attributed to the interaction between two factors, the higher myofibrillar protein concentration derived from chicken meat, and the

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physicochemical properties of sago flour as a filler. Myofibrillar proteins exposed to salt during mixing become solubilized and provide abundant hydrophilic polar groups that interact with water molecules through hydrogen bonding, forming a rigid three-dimensional structure capable of entrapping water (Rahma et al., 2024). The high amylopectin content of sago flour additionally reinforces WHC by forming a compact, branched gel network that physically immobilizes water within the protein matrix post gelatinization. In contrast, the lowest WHC was observed in P3 (90.19%), which combined 75% duck meat with potato flour. The lower WHC in this formulation is consistent with the higher cooking loss recorded for P3, suggesting that the protein gel matrix in duck dominant formulations with potato flour is less effective at retaining water under thermal stress. While potato flour has a relatively high swelling capacity, its gel network under high fat conditions is more susceptible to disruption, as the fat phase can interfere with granule protein interactions. Sandy et al. (2022) stated that excessive heating may reduce the functional properties of amylopectin by causing molecular stretching and release, thereby decreasing the ability of starch to retain water; a parallel mechanism may apply to potato starch granules under the steaming conditions used in this study.

Based on the Shapiro-Wilk test, the standardized residuals for WHC were normally distributed ( $p = 0.171 > 0.05$ ). Levene’s test showed that the variance among treatments was homogeneous ( $p = 0.163 > 0.05$ ). Both assumptions being fulfilled, two-way ANOVA was appropriate. The significance value for meat proportion was 0.163 ( $> 0.05$ ), indicating no significant difference in WHC based on meat proportion. The significance value for filler type was 0.071 ( $> 0.05$ ), indicating no significant difference in WHC based on filler type. The significance value for the interaction was 0.459 ( $> 0.05$ ), indicating no significant interaction between meat proportion and filler type on WHC. Despite the absence of statistical significance, descriptive means showed a consistent pattern, sago flour produced higher WHC than potato flour in both meat proportion groups, a trend that can have reached significance with a larger sample size.

Moisture content is a critical factor affecting sausage texture, juiciness, and shelf life. The highest moisture content was observed in P1 (72.115%), whereas the lowest value was recorded in P4 (63.902%). The higher moisture content in P1 was associated with the dominance of chicken meat, which naturally contains higher water content and finer muscle fibers than duck meat, in addition to the use of potato flour. Potato starch granules are capable of significant swelling and water absorption during mixing and cooking, resulting in greater water retention within the final product. Increased dietary fiber content may also contribute to higher moisture levels because fiber components containing hydroxyl (-OH) groups can interact with water molecules through hydrogen bonding, allowing water to be absorbed and retained within the food matrix (Rahma et al., 2024). Consequently, sausages with higher moisture content tended to exhibit softer and slightly wetter textures. In contrast, P4, which contained sago flour and a higher proportion of duck meat, exhibited lower moisture content because a greater amount of water became tightly entrapped within the gel matrix and was no longer detected as free water. Estinur et al. (2024) stated that increasing sago flour concentration may reduce measurable moisture content due to interactions between starch and protein molecules, where hydrogen bonds are utilized in starch–protein complex formation rather than free water binding.

Based on the Shapiro-Wilk test, the standardized residuals for moisture content were normally distributed within both filler groups ( $p > 0.05$ ). However, Levene’s test showed that the variance among treatments was not homogeneous ( $p = 0.011 < 0.05$ ), indicating that the homogeneity of variance assumption was violated. This violation was primarily caused by the substantially larger standard deviation in P1 (SD = 4.983) relative to the remaining groups (SD range: 0.535–1.135). Interpretations from the following ANOVA results should therefore be made with caution. The significance value for meat proportion was 0.000 ( $< 0.05$ ), indicating a significant difference in moisture content based on meat proportion; duck-dominant formulations produced lower moisture content than chicken-dominant formulations, consistent with the higher intramuscular fat content of duck meat displacing water in the product matrix. The significance value for filler type was 0.141 ( $> 0.05$ ), indicating no significant difference in moisture content based on filler type. The significance value for the interaction was 0.311 ( $> 0.05$ ), indicating no significant interaction between meat proportion and filler type on moisture content.

**Table 2. Color values (L, a, b\*) of chicken duck sausage with the addition of sago and potato flour**

Sampel	L* <sup>ns</sup>	a* <sup>ns</sup>	b* <sup>ns</sup>
P1	52.96 ± 5.67	2.50 ± 0.32	14.60 ± 2.72
P2	57.06 ± 1.84	2.88 ± 1.28	15.21 ± 1.01
P3	54.54 ± 3.93	2.89 ± 0.19	15.80 ± 2.81
P4	54.09 ± 2.45	3.60 ± 0.42	16.61 ± 0.76

\*P1: 75% chicken meat : 25% duck meat with potato flour, P2: 75% chicken meat : 25% duck meat with sago flour, P3: 25% chicken meat : 75% duck meat with potato flour, P4: 25% chicken meat : 75% duck meat with sago flour

Color measurements demonstrated that the highest lightness value (L\*) was observed in P2 (57.06), whereas the lowest value was found in P1 (52.96). The higher L\* in P2 compared to the other formulations reflect the combined contribution of the

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whitish appearance of sago gel upon gelatinization and the relatively pale myoglobin profile of chicken dominant meat. In contrast, P3 and P4, exhibited intermediate L\* values, consistent with the darker appearance expected from the higher myoglobin concentration in duck meat. According to Rahayu et al. (2012), meat color is primarily influenced by myoglobin pigment concentration, and duck meat generally contains higher myoglobin levels than chicken meat, producing darker color in the final product. The observation that P2 and not P1 exhibited the highest L\* suggests that filler type also modestly influences lightness, with sago flour gelatinized matrix contributing slightly higher whiteness compared to the potato flour gel. Conversely, increasing duck meat proportions produced darker sausages due to higher myoglobin and unsaturated fat contents.

The redness value (a\*) showed an increasing trend from P1 (2.50) to P4 (3.60), suggesting that increasing duck meat proportion elevated redness intensity in the sausage. This is consistent with the higher myoglobin content of duck meat relative to chicken meat, as myoglobin is the primary pigment responsible for the red color in muscle tissue. The effect of filler type on redness was less pronounced, however, P4 and P3 both showed higher a\* values compared to their chicken dominant counterparts, confirming that meat composition was the dominant driver of redness. Yuniar & Azizah (2021) stated that increasing potato starch concentration tends to reduce redness intensity in meat sausages. Regarding yellowness (b\*), the highest value was observed in P4 (16.61), while P1 showed the lowest value (14.60). The progressive increase in b\* values from P1 to P4 aligns with the increasing proportion of duck meat, which contains a higher concentration of carotenoid rich yellow fat. Duck fat is known to have a more pronounced yellow hue compared to chicken fat due to differences in carotenoid deposition (Liu et al., 2024). Additionally, the interaction between sago flour and duck fat in P4 may have contributed to a slightly more yellow appearance, as the viscoelastic sago gel matrix encapsulates fat droplets more uniformly, making the yellow pigment more evenly distributed and perceptible on the product surface.

**Table 3. Sensory quality of chicken duck sausage with the addition of sago and potato flour**

Sampel	Aroma	Color	Chewy Texture* <sup>ns</sup>	Juiciness	Taste	Aftertaste	Overall* <sup>ns</sup>
P1	3.76 ± 0.793 <sup>a</sup>	3.29 ± 0.875 <sup>ac</sup>	3.36 ± 0.868	3.11 ± 0.854 <sup>a</sup>	3.62 ± 0.933 <sup>a</sup>	3.51 ± 0.858 <sup>a</sup>	3.56 ± 0.788
P2	3.65 ± 0.985 <sup>ab</sup>	3.13 ± 0.695 <sup>a</sup>	3.44 ± 0.898	3.02 ± 0.913 <sup>a</sup>	3.64 ± 0.778 <sup>a</sup>	3.44 ± 0.834 <sup>a</sup>	3.58 ± 0.738
P3	3.38 ± 0.913 <sup>bc</sup>	3.62 ± 0.782 <sup>b</sup>	3.45 ± 1.152	3.71 ± 0.936 <sup>b</sup>	3.51 ± 1.184 <sup>a</sup>	3.09 ± 1.005 <sup>a</sup>	3.58 ± 0.956
P4	3.20 ± 1.129 <sup>c</sup>	3.53 ± 0.879 <sup>bc</sup>	3.29 ± 1.212	3.49 ± 1.103 <sup>b</sup>	3.04 ± 1.217 <sup>b</sup>	2.65 ± 1.004 <sup>b</sup>	3.31 ± 1.086

\*P1: 75% chicken meat : 25% duck meat with potato flour, P2: 75% chicken meat : 25% duck meat with sago flour, P3: 25% chicken meat : 75% duck meat with potato flour, P4: 25% chicken meat : 75% duck meat with sago flour

The sensory evaluation results are presented in Table 3. Regarding aroma, P1 received the highest score (3.76). This score suggests that panelists were less favorable toward the characteristic aroma of duck dominant formulations, which is consistent with duck meat’s known stronger off odor profile arising from its higher myoglobin and unsaturated fat content. For color preference, P3 (3.62) and P4 (3.53) received higher scores, indicating that the darker appearance associated with higher duck meat proportion was visually preferred. In terms of chewy texture, P2 received the highest score (3.44), reflecting the superior gel cohesiveness conferred by sago flour’s high amylopectin content in combination with the compact protein network of chicken dominant meat. Fat contributes to tenderness in sausages, while lower fat concentrations generally produce firmer textures (Apriantini et al., 2021), which is consistent with the higher chewiness scores observed in chicken dominant formulations. For juiciness, P3 achieved the highest score (3.71), which is attributable to the higher intramuscular fat content of duck meat acting as a natural lubricant within the sausage matrix, as well as the water retention properties of potato flour creating a perceived moisture release upon mastication. For taste and aftertaste, P2 (3.64) and P1 (3.62) received the highest scores, show that the combination of strong duck flavor and the slightly more neutral sensory contribution of sago flour resulted in a less balanced flavor profile at high duck proportions.

The role of fillers in sausage production must be distinguished from that of emulsifiers or binders. In the present formulation, the primary emulsification system was established by myofibrillar proteins (actomyosin) extracted from chicken and duck meat through salt addition during mixing, with egg white providing supplementary emulsification via albumin. Starch fillers (potato flour and sago flour) were incorporated as passive structural modifiers that fill the interstices of the protein gel matrix formed during gelatinization, modulating viscosity, texture, and water retention without directly stabilizing the oil water interface. During the initial mixing stage, myofibrillar proteins from chicken and duck meat became solubilized due to salt addition,

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enabling them to coat fat globules and function as the primary emulsifiers. Widjanarko et al. (2013) stated that sausage emulsion stability depends on the ability of proteins to bind water and fat effectively, which occurs when fat globules are fully coated by emulsifying proteins.

Upon heating, starch granules absorb water, swell extensively, and eventually rupture, releasing amylose and amylopectin molecules into the system. These polysaccharides subsequently form a three-dimensional viscoelastic gel matrix (Tao et al., 2020). This gel matrix acts as a filler within the protein network while simultaneously entrapping fat globules and water molecules released during heating. Potato flour contains relatively higher amylose content than sago flour, resulting in softer and more elastic gels. However, potato starch granules are less stable under high temperature processing and rupture more easily, reducing water retention capacity and increasing cooking loss. In contrast, sago flour producing a thicker, more cohesive, elastic, and thermally stable gel with superior water binding ability. Amylopectin forms a three dimensional structure capable of effectively retaining water and fat within the protein matrix, leading to sausages with higher WHC and lower cooking loss values (Sandy et al., 2022).

### CONCLUSION

This study showed that meat proportion and filler type significantly affected the physicochemical and sensory properties of chicken and duck sausages. Chicken dominant formulations produced lower cooking loss and higher water holding capacity, while sago flour performed better than potato flour in maintaining product stability due to its high amylopectin content. The combination of 75% chicken meat and sago flour (P2) resulted in the best physicochemical characteristics. Increasing duck meat proportion produced darker sausage color and higher juiciness, whereas chicken dominant formulations were more preferred for aroma and taste. Overall, sago flour is a more effective filler for emulsion-type poultry sausages, particularly in chicken dominant formulations.

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