Palatability Evaluation of Nuggets from Spent Laying Hen Meat Using Arrowroot Flour Substitution as an Alternative Filler

Evaluasi Palatabilitas Nugget Daging Ayam Petelur Afkir dengan Substitusi Tepung Garut sebagai Filler Alternatif

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ABSTRACT

This study aims to evaluate the effect of arrowroot flour substitution on the sensory quality and palatability of chicken meat nuggets. Four nugget formulations were developed based on the proportion of wheat flour and arrowroot flour as fillers, namely 100% wheat flour (control/code 501), 90:10 (code 105), 80:20 (code 201), and 70:30 (code 315). Sensory evaluation was conducted by 29 semi-trained panelists on the attributes of color, aroma, taste, texture, and overall quality. The results showed that an increase in cassava flour substitution gradually affected a decrease in taste and texture quality, particularly in formulations 201 and 315. Formulation 105 achieved the highest scores for texture and overall and was evaluated as having a dominant chicken and spice flavor by 44.8% of the panelists. Conversely, formulation 315 showed a decrease in palatability, with an increase in the perception of a dominant flour flavor and a denser texture. Arrowroot flour was assessed as having potential as a local filler alternative, but its use should be limited to avoid reducing consumer preference. Thus, substituting 10% arrowroot flour is the optimal formulation for producing chicken nuggets that are panelists prefer in terms of color, taste, texture, and overall palatability.

Keywords: arrowroot flour; nuggets; palatability; sensory attributes; spent laying hens

ABSTRAK

Penelitian ini bertujuan untuk mengevaluasi pengaruh substitusi tepung garut terhadap mutu sensoris dan palatabilitas nugget berbasis daging ayam afkir. Empat formulasi nugget disusun berdasarkan proporsi tepung terigu dan tepung garut sebagai bahan pengisi (*filler*), yaitu 100% terigu (kontrol/kode 501), 90:10 (kode 105), 80:20 (kode 201), dan 70:30 (kode 315). Uji organoleptik dilakukan oleh 29 panelis semi terlatih terhadap atribut warna, aroma, rasa, tekstur, dan keseluruhan (overall). Hasil menunjukkan bahwa peningkatan substitusi tepung garut secara bertahap memengaruhi penurunan mutu rasa dan tekstur, terutama pada formulasi 201 dan 315. Formulasi 105 menghasilkan skor tertinggi pada atribut tekstur dan *overall*, serta dinilai memiliki rasa dominan ayam dan bumbu oleh 44,8% panelis. Sebaliknya, formulasi 315 menunjukkan penurunan palatabilitas, dengan peningkatan persepsi rasa dominan tepung dan tekstur yang lebih padat. Tepung garut dinilai memiliki potensi sebagai alternatif *filler* lokal, namun penggunaannya perlu dibatasi agar tidak menurunkan preferensi konsumen. Dengan demikian, substitusi tepung garut sebanyak 10% merupakan formulasi optimal dalam menghasilkan nugget ayam afkir yang disukai panelis dari segi warna, rasa, tekstur, dan palatabilitas secara keseluruhan.

Kata kunci: tepung garut; nugget; palatabilitas; mutu sensori; ayam afkir.

INTRODUCTION

Chicken meat is a high-quality, affordable source of animal protein that can be combined in various processed food products (Mahmudah *et al.,* 2024). In the food industry, in addition to broiler meat (chicken meat), spent laying hens meat (ayam petelur afkir) also commonly consumed. Spent hens are laying hens that have passed their peak production period, with an average age of 64 to 68 weeks. In 2021, broiler chicken production in East Java Province was recorded at 397,184 tons, while spent hen production was 30,720 tons (Disnak Jatim, 2022).

Compared to broiler chickens, spent hen meat has a tougher texture. This hardness is due to the chicken's older age, with higher levels of connective tissue and collagen. According to Nurussyifa *et al.,* (2024), spent laying hen meat has the drawback of a tough texture, although its nutritional content is not significantly different from that of free-range chicken meat. In terms of nutritional value, culled chickens contain 22–24 grams of protein per 100 grams of meat, compared to broiler chickens, which range from 20–23 grams (Irmawaty *et al.,* 2024; Prihatiningsih *et al.,* 2020).

Among the various chicken meat products, nuggets are consumed as a snack or as a side dish. Nuggets are popular among both children and adults due to their small size and delicious taste (Hastuti *et al.,* 2016). Nuggets are processed ground meat products that are mixed with binding agents and spices, then coated with egg white (batter) and breadcrumbs (breading), followed by pre-frying, packaging, and freezing to maintain quality (Mawati *et al.,* 2017). Chicken nuggets are increasingly recognized as a high-nutrient processed food with relatively high availability (Komansilan, 2015).

In nugget production, filler ingredients such as flour significantly influence the final product quality, including sensory quality (Kusumaningrum *et al.,* 2013). Filler ingredients have a

significant impact on yield parameters and color quality (Santosa *et al.,* 2019). Currently, the most commonly used filler ingredient is wheat flour. However, the use of wheat flour is an issue in Indonesia, as it is entirely dependent on imports, which have been increasing annually (Mahmudah *et al.,* 2023).

One potential filler material is arrowroot flour. flour is a natural carbohydrate with strong thickening properties, producing a transparent texture and being easily digestible, as well as beneficial for digestive health (Hakim *et al.,* 2020). Arrowroot (*Maranta arundinacea* L.) is a potential food source that can be used as a substitute for wheat flour. Arrowroot is one of the locally available food sources that is easily accessible and has an affordable purchase price. Arrowroot tubers can be found in various regions of Indonesia, such as Java, Maluku, and Sulawesi. The physical characteristics of this flour are pale white in color, and chemically low in protein (0.7%) and fat (0.26%). Arrowroot flour contains a carbohydrate component called amylopectin at 72% (Qoimah *et al.,* 2021), which provides strong adhesive properties and makes it effective as a binder and stabilizer, and suitable as a filler for nugget products.

Studies on the use of arrowroot flour have been applied in chicken-based nugget products (Kusumaningrum *et al.,* 2013) and rabbit meat (Hakim *et al.,* 2020). However, its implementation in nugget products made from spent laying hens has never been studied. Therefore, this study aims to evaluate the sensory quality of chicken nuggets made fromspent laying hens meat with the substitution of various concentrations of arrowroot flour, thereby determining the optimal formulation preferred by consumers.

METHODS

Biomaterials

The primary raw material used in this study was spent hen meat, obtained from a local poultry slaughterhouse in Karangsari, Blitar, East Java, Indonesia. The meat was deboned,

cleaned, and stored at 4°C prior to processing. The carbohydrate-based filler used in the formulation was arrowroot flour (*Maranta arundinacea* L.), sourced from Blitar, Indonesia. Commercial wheat flour (Bogasari, Jakarta, Indonesia) was used as the control filler. Additional ingredients included iodized salt (Refina®, 99%, Surabaya, Indonesia), granulated sugar (Gulaku®, 99%, Lampung, Indonesia), spices from local market, and cooking oil (Tropical®, Jakarta, Indonesia).

Sample preparation

Nuggets were formulated using spent hen breast meat (100 g) as the main protein source. The formulations differed in the ratio of wheat flour and arrowroot flour (*Maranta arundinacea* L.) used as fillers as follows:

WF = Wheat flour

AF = Arrowroot flour

Sample code 501 (Control): 100% WF; sample code 105 (90% WF:10% AF); sample code 201 (80%WF:20%AF); and sample code 315 (70%WF:30%AF). Other ingredients used per formulation included: garlic (10 g), shallots (10 g), one whole egg, spring onion (10 g), granulated sugar (2 g), iodized salt (2 g), ground pepper (0.5 g), chicken bouillon powder (2 g), and ice cubes (35 g). All ingredients were pre-weighed prior to processing.

The spent hen breast meat was ground and blended with the spices (garlic, shallots, pepper, salt, sugar, bouillon), egg, and chopped spring onions were then added, followed by the filler ingredients (wheat and/or arrowroot flour). The mixture was homogenized using a food processor (Philips HR 7301) until a uniform dough was obtained. The dough was molded into nugget shapes using a standard mold and steamed at 100°C for 15 minutes. After cooling to room temperature, the steamed nuggets were coated with beaten egg and breadcrumbs and then deep-fried in vegetable oil at 170°C for 3 minutes, until golden brown. All formulations followed the same procedure, differing only in the proportion of wheat and arrowroot flour used.

Sensory Evaluation

Sensory evaluation was conducted using a hedonic test involving 29 semi-trained panelists, recruited from students from State Community College of Putra Sang Fajar Blitar, with age 21-51 years old. The panelists evaluated four coded samples (501, 105, 201, and 315) corresponding to different levels of arrowroot flour substitution (0%, 10%, 20%, and 30%). The attributes evaluated included color, aroma, taste, texture, and overall acceptability, using a 5-point hedonic scale (1 = very dislike, 5 = very like). The test was performed under controlled conditions, and panelists were provided with drinking water to cleanse their palate between samples.

RESULTS AND DISCUSSIONS

Panelists Characteristic

There were 29 panelists involved in the sensory test of chicken nuggets, with diverse backgrounds in terms of age and nugget consumption habits. Based on gender, the majority of panelists were female (75.9%), while only 24.1% were male (Fig. 1). This composition reflects the dominance of female respondents, who are typically more involved in household food consumption and evaluation activities.

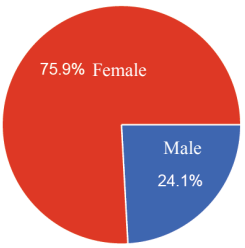

Figure 1. Panelist composition by gender

Based on age grouping, 17.2% of panelists were in the late adolescent group (15–20 years old), 27.6% were young adults (21–35 years old), 27.6% were in the middle-aged group (36–45 years old), and the remaining 27.6% were older adults (≥46 years old). This balanced age

distribution indicates that the panelists represent various age groups, which can enrich the perspectives in the sensory quality assessment of chicken nuggets.

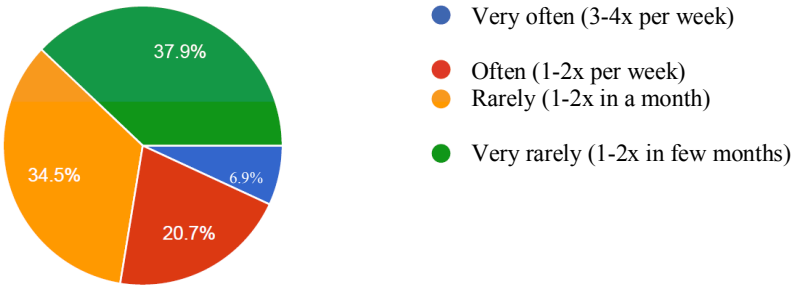

Figure 2. Panelists' intensity of nugget consumption

In terms of chicken nugget consumption frequency, 6.9% of panelists consume nuggets 3–4 times a week (very often), followed by 34.5% who consume them 1–2 times a month (rarely) (Fig. 2). As much 20.7% panelists stated that they often consume nuggets (1–2 times per week), while the remainder only consume nuggets every few months. It shows that the majority of panelists have relatively various nugget consumption experience. The frequent consumption of nugget will enable panelists to be more representative and relevant for sensory evaluations.

Quality of Sensory Attributes

Color and Appearances

Sample 105 (Fig. 3) obtained the highest score in the color attribute, followed by 501, 305, and the lowest score was obtained by 201. This shows that nugget 105 is the most preferred in terms of appearance. The golden yellow or brownish color produced is likely to originate from the Maillard reaction that occurs optimally during the frying process. This browning is primarily caused by the Maillard reaction. A non-enzymatic chemical reaction occurs during cooking or frying, where reducing sugars react with protein groups to form “melanoidins,” compounds that give the product its brown color (Anam *et al.,* 2023).

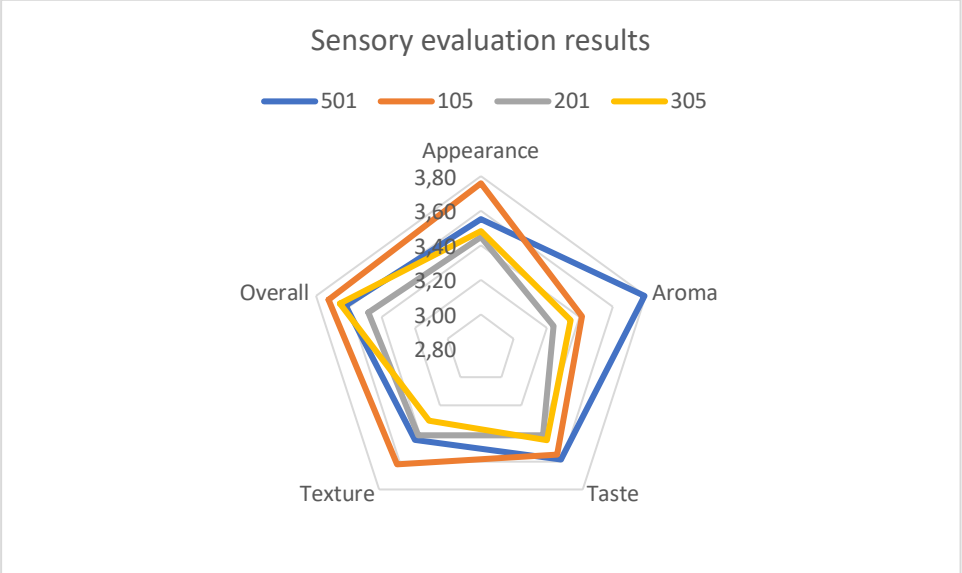

Figure 3. Sensory Quality Evaluation Results

Visually appealing color is often associated with good taste. Nuggets 201 and 305, which have lower color scores, may be due to uneven frying or a dominant pale color caused by high flour content. According to Faloye *et al.,* (2021) from samples of chicken nuggets fried at temperatures of 155–175°C for 3–7 minutes, the best results were obtained at a frying temperature of 173°C for 3 minutes.

The external appearance of the product is the first impression that influences consumer perception. Most panelists rated nugget 501 as having a yellowish-brown color (41.4%), while nugget 105 was more dominated by a golden yellow color (69%) (Fig. 4). Nuggets 201 and 315 both showed a tendency toward a golden yellow color (55.2%).

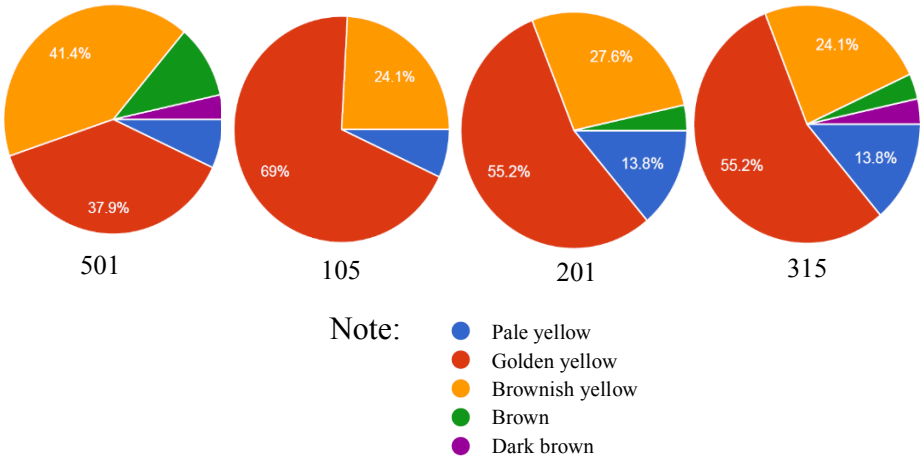

Figure 4. Panelists evaluation to external appearance of nugget samples

In general, golden yellow to golden brown colors are considered attractive and indicate the optimal level of doneness from the frying process. Cooking processes such as frying can cause color changes in both the interior and exterior of the product, making them darker. These changes are related to the Maillard reaction, which is a reaction between proteins and carboxyl groups present in flour ingredients. The higher the proportion of flour used in the formulation, the greater the intensity of the brown color produced. This is supported by (Anam *et al.,* 2023), who stated that proteins in flour reacting with reducing sugars produce non-enzymatic browning reactions, characterized by the formation of brown-colored melanoidin compounds.

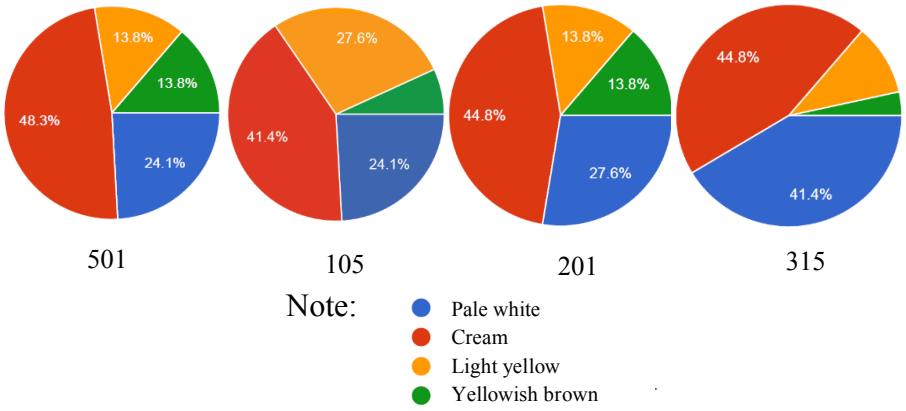

Figure 5. Panelists evaluation to internal appearance of nugget samples

Substituting arrowroot flour has varying effects on the “internal appearance” of nugget products. Although the 80:20 substitution level in sample 201 (Fig. 5) was still able to maintain a high proportion of “cream” color, increasing the proportion of arrowroot flour to 30% in sample 315 significantly shifted the internal appearance toward a “pale white” color.

There is a clear trend toward an increase in the appearance of nuggets becoming “pale white” as substitution increases. These results contrast with some studies on other meat products using flour as a filler. The addition of fillers can cause the color to tend to be darker or have no significant effect on the internal color (e.g., a study on chicken liver nuggets using wheat flour and tapioca showed no significant effect on nugget color (Amertaningtyas *et al.,* 2021). This

difference is due to the unique characteristics of arrowroot flour compared to other filler flours such as tapioca or wheat flour, particularly in terms of amylose-amylopectin starch composition and non-starch components that interact with meat proteins. Arrowroot flour has a natural pale white or nearly white color (Qoimah *et al.,* 2021). When arrowroot flour is added in higher proportions (30% substitution in sample 315), the mass of arrowroot flour in the dough increases.

The color of processed meat products is greatly influenced by various factors, including natural meat pigments, non-enzymatic browning reactions such as the Maillard reaction, and interactions with additives such as fillers. Chicken meat contains a red pigment called myoglobin. Processing and cooking cause the myoglobin compounds to break down, resulting in pale-colored meat (Dewanto *et al.,* 2017). Furthermore, as a comparison, in chicken nugget products, arrowroot flour substitution for wheat flour significantly affects product yield and color (Kusumaningrum *et al.,* 2013).

Aroma

Based on the panelists' assessment in Fig. 3, sample 501 (control) showed the highest aroma score, indicating that the distinctive aroma of chicken meat and spices used in this sample was most preferred by the panelists. Meanwhile, samples 305, 105, and 201 showed lower scores and were relatively close to 3.4–3.6. The aroma in nugget products originates from volatile compounds (easily evaporated) released during heating, particularly from fats, proteins, and spices. The characteristic compounds in chicken meat as components of the distinctive flavor are carbonyl compounds, which are derivatives of fats or lipids (Purba, 2014).

In this study, spent laying hens meat have a distinctive aroma that can be enhanced with the right combination of spices. Sample 501, as the control, has a harmonious balance of meat aroma, wheat filler, and spices, and received the highest score, while the aroma of samples 201 and others was influenced by interactions with filler components.

Taste

Sample 501 received the highest score by taste attribute. This indicates that nuggets made with 100% wheat flour as filler produced the most preferred taste among the panelists. Wheat flour is neutral, does not interfere with the original taste of chicken meat, and functions well in binding ingredients, so that the taste of the seasoning and chicken meat remains dominant.

Meanwhile, as the percentage of arrowroot flour in the nugget formulation increases (codes 105, 201, and 315), the taste score tends to decrease, with formulation 315 (30% arrowroot flour) receiving the lowest score. This is due to the characteristics of arrowroot flour, which has a different ability to absorb seasoning compared to wheat flour because of the differences in the chemical composition of the flour. In addition, arrowroot flour has a higher fiber content (Hapsari & Purwidiani, 2018), which can cause a certain aftertaste, especially for consumers who are not familiar with it.

Texture

Formulation of 105 obtained the highest score for texture (Fig. 3), followed by control sample 501. This indicates that low-level substitution of arrowroot flour can positively contribute to texture. However, as the proportion of arrowroot flour increased in samples 201 and 315, the texture score decreased significantly.

Texture plays a role in determining consumer preference when chewing the product. In sample 501, the majority of respondents rated the texture as “firm and chewy” (44.8% of panelists), with a small portion rating it as “soft and chewy” (24.1% (Table 1). This aligns with the characteristics of wheat flour, which contains gluten, acting as a good binder and forming an elastic matrix in the nuggets. In processed meat products, wheat flour is commonly used as a filler because it contains gluten protein, which helps form the texture and elasticity of the product (Kusumaningrum *et al.,* 2013).

Table 4. Texture Quality Description

Samples	Slightly soft	Soft	Soft and Chewy	Dense and Chewy	Dense and Firm
501	3.4%	17.2%	24.1%	44.8%	10.3%
105	10.3%	27.6%	34.5%	24.1%	3.4%
201	6.9%	27.6%	27.6%	27.6%	10.3%
315	3.4%	17.2%	20.7%	48.3%	10.3%

Sample 105 showed a significant increase in the "soft and chewy" category (34.5%) compared to control 501. This means that a 10% substitution of arrowroot flour has a softening effect on the structure while maintaining chewiness. This is because arrowroot flour contains starch with high gelatinization properties (Qoimah *et al.,* 2021), which supports such texture.

In samples 201 and 315, although still rated as "Dense and Chewy" (27.6% and 48.3%), there was a decrease in the "soft and chewy" value, and the proportion of 'soft' or "slightly soft" remained low. Sample 315 also showed the same value for "dense and firm" (10.3%) as sample 501, which may indicate the presence of protein structure replaced by non-gluten flour.

Overall

The overall assessment reflects the combined perceptions of color, aroma, taste, and texture, and indicates the general level of acceptance among panelists. Based on the graph in Fig. 3, the highest score was given to formulation 105 (90% wheat flour: 10% arrowroot flour), with a score of 3.72. Moderate use of arrowroot flour (10%) is well-accepted by panelists, even imparting an innovative texture and visually appealing appearance. However, excessive substitution can reduce overall acceptability due to a decline in primary sensory attributes (taste and texture), as observed in sample 201.

CONCLUSION

The substitution of arrowroot flour as a partial filler in spent laying hens-based nuggets affected sensory quality, particularly in taste, texture, and overall acceptability. Increasing the

substitution level beyond 10% led to a decline in palatability. The 10% substitution (formulation 105) produced the best sensory scores, maintaining desirable texture and flavor characteristics. Arrowroot flour can serve as a potential local filler alternative, with 10% identified as the optimal level for maintaining product palatability and consumer preference.

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