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CHEMICAL AND SENSORY CHARACTERISTICS OF ANALOGUE *CHICKEN POPCORN* BASED ON SHIITAKE MUSHROOMS, TVP, AND SEITAN

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Abstract

Currently, plant-based foods are becoming a trend among the public, this is due to the increasing awareness of health and environmental sustainability. One potential innovation is analog *popcorn chicken* formulated from high-protein plant ingredients. This study aims to develop and analyze the characteristics of analog *popcorn chicken* based on shiitake mushrooms, TVP, and seitan as an alternative to meat. The study used a Completely Randomized Design (CRD) with four treatments in the form of variations in the concentration of the main ingredients. Chemical analysis included protein content, crude fiber, water content, and ash content, while organoleptic tests were carried out by 25 untrained panelists to assess color, aroma, taste, and texture. Chemical data were analyzed using ANOVA at a significance level of 5%, while sensory data were analyzed using the Kruskal–Wallis test. The results showed that variations in the proportion of ingredients had a significant effect ($p<0.05$) on water content, protein content, crude fiber content, and texture preferences, but did not significantly affect ash content, color, aroma, and taste. The best treatment was obtained in formulation A3 (25% shiitake and seitan mushroom mixture: 75% TVP) with chemical characteristics of 15.67% protein content, 9.32% crude fiber, 41.59% water content, and 3.24% ash content. Organoleptically, the best treatment product had a "like" acceptance level for all parameters with the highest texture preference score of 4.04. This product has the potential to be developed as a nutritious plant-based food alternative to processed meat.

Keywords: vegetable protein; shiitake mushrooms; TVP; seitan.

INTRODUCTION

The shift in global consumption patterns toward plant-based foods is increasing along with public awareness of environmental and health issues. Conventional livestock systems are considered to contribute significantly to greenhouse gas emissions and natural resource use, necessitating more efficient and sustainable food alternatives to ensure future food security (Suwandojo et al., 2021). In addition to environmental factors, health considerations are also driving changes in consumption patterns. Excessive consumption of animal protein is known to increase the risk of cardiovascular disease due to its high saturated fat and cholesterol content. Therefore, consumers are starting to seek healthier alternative food products, rich in protein and fiber, and with better nutritional value (Nolden & Forde, 2023). This situation is driving the rapid growth of the analog meat industry, not only for vegetarians and vegans, but also for flexitarian consumers who reduce meat consumption without eliminating it completely (Andreani et al., 2024).

The development of analog meat is heavily influenced by the selection of functional raw materials. Shiitake mushrooms (*Lentinula edodes*) have a natural umami flavor and a chewy texture that resembles meat, and contain bioactive compounds such as β -glucan and lentinan, which act as immunomodulators and antioxidants (Chaiwongsa et al., 2021; Widyastuti et al., 2011). The application of shiitake in fermented products has also been shown to improve the sensory and functional quality of food products (Indratiningsih et al., 2004). Soy-based Textured Vegetable Protein (TVP) is a meat substitute with a structure similar to meat fibers and a high water and spice binding capacity. TVP has been shown to partially replace meat without compromising the sensory quality of processed products (Pradana et al., 2019; Zhang et al., 2021). Furthermore, seitan (wheat gluten) has a strong elastic protein network and a chewy texture similar to chicken, making it a potential natural binder in meat analog products (Zhang et al., 2021).

Despite the significant potential of shiitake mushrooms, TVP, and seitan, research related to the development of analog meats has generally been conducted separately. Previous studies have demonstrated the superiority of shiitake mushrooms in enhancing sensory acceptability (Septiawati et al., 2023), the physicochemical characteristics of TVP that influence product texture (Hong et al., 2022), and the protein-rich nature of seitan, which tends to be too chewy and bland when used alone (Muneer et al., 2025). In addition to protein, plant-based ingredients also contain structural polysaccharides such as pectin, which are hydrocolloids and play a role in texture formation, matrix stability, and water-holding capacity in processed food systems (Indrawati et al., 2024). To date, no research has been found that combines these three ingredients simultaneously in a popcorn chicken analog formulation. This study aims to develop analogous chicken popcorn based on shiitake mushrooms, textured vegetable protein (TVP), and seitan and evaluate the effect of formulation variations on chemical characteristics including protein, fiber, moisture, and ash content, as well as sensory characteristics such as taste, aroma, color, and texture. In addition, this study also aims to identify the optimal formulation capable of producing analogous meat products with good nutritional quality and a high level of consumer acceptance, thus potentially supporting the development of healthier and more sustainable plant-based foods.

LITERATURE REVIEW

Plant-Based Foods and Analog Meat

Consumption of plant-based foods is increasing rapidly globally as public awareness of health, the environment, and ethics grows. This trend is driving the development of meat analogues designed to mimic the characteristics of animal meat, in terms of taste, texture, and appearance, as a more environmentally friendly alternative without compromising the sensory experience of meat consumption (Andreani et al., 2024). Chicken analogue products such as nuggets and popcorn chicken are among the most popular categories, including among flexitarian consumers.

Standard Analog Popcorn Chicken Quality

Analog popcorn chicken including food processed based plant -based food. To date, there are no national or international standards specifically regulating the chemical and physical quality limits of this product. Therefore, this study refers to ISO 23662:2021 , which emphasizes the integrity of vegetarian/vegan claims and process safety, particularly animal-free and minimal risk of cross-contamination (ISO, 2021). Since the standard does not regulate nutritional quality, the nutritional target was determined by referring to the commercial product Fry's Plant-Based Popcorn Chick'n as a *technical quality benchmark* that has been tested in the global market.

Main Ingredients of Analog Popcorn Chicken

Analogue popcorn chicken is composed of a combination of main ingredients that play a role in forming the nutritional value and sensory characteristics of the product. Shiitake mushrooms (Lentinula edodes) are a functional food ingredient rich in bioactive compounds such as β-glucan and lentinan which function as immunomodulators, antioxidants, and antitumor, as well as providing a natural umami taste that can enhance the sensory acceptance of analog products (Widyastuti et al., 2011; Chaipoot et al., 2023; Putra et al., 2023). Seitan, derived from wheat gluten protein, forms an elastic network resembling meat after heating and has a high protein content with low fat content, although it tends to be bland and too chewy when used alone so it is more optimal when combined with other ingredients such as TVP or mushrooms (Auñón-Lopez et al., 2025; Švarc et al., 2022). Textured vegetable protein (TVP) is a soy protein extrusion product with a porous structure resembling meat muscle fibers, contains high protein (50–70%), and has good water and fat absorption capabilities, thus playing an important role in forming the texture and juiciness of analog meat products (Wang et al., 2025; Oh et al., 2024). In addition to the main ingredients, the use of supporting ingredients such as low-protein flour and cornstarch functions as a coating to produce a crispy texture with lower oil absorption (Liberty et al., 2024; Zhang et al., 2022). Seasonings such as garlic, white pepper, soy sauce, and mushroom broth also contribute to the formation of umami flavor while masking the unpleasant aroma of vegetable ingredients (Eissa et al., 2024; Moss et al., 2023), while sesame oil acts as a distinctive aroma carrier that can strengthen the meat-like impression in analog products (Yuenyong et al., 2024).

Product Quality Analysis

Characterization of analog popcorn chicken was carried out through chemical analysis including protein content (Kjeldahl method), water content (oven method), ash content (dry ashing), and crude fiber content (acid-base hydrolysis) as indicators of nutritional value and product stability (Nurbaya et al., 2020; Fikriyah and Nasution, 2022; Anggela et al., 2024). Additionally, organoleptic testing was conducted to assess sensory acceptability based on color, aroma, taste, and texture attributes using panelists according to food sensory evaluation standards (Gusnadi et al., 2021). The selection of the best treatment was determined through effectiveness testing to obtain the optimal formulation (Septiawati, 2023).

RESEARCH METHODS

This research was conducted starting in October 2025 with a focus on the chemical and organoleptic quality analysis of analog popcorn chicken based on shiitake mushrooms, seitan, and textured vegetable protein (TVP). The research activities were conducted at the Food Processing Laboratory of the Faculty of Food Technology and Fisheries, Dr. Soetomo University, Surabaya for chemical analysis, while organoleptic testing was conducted at the Tristar Institute, Surabaya. The study used a quantitative experimental approach under controlled laboratory conditions to observe the effect of variations in the proportions of the main ingredients on product quality (Munte et al., 2023). The experimental design used was a single-factor Completely Randomized Design (CRD) with four treatment levels based on the ratio of TVP and shiitake mushroom–seitan mixture (1:1) in a total of 100 g of dough, namely A0 (100% shiitake–seitan mixture), A1 (75% shiitake–seitan mixture: 25% TVP), A2 (50%: 50%), and A3 (25%: 75% TVP). Each treatment was repeated three times to obtain 12 experimental units. The selection of the CRD was based on the homogeneity of laboratory conditions and the characteristics of the mixture, so that it did not allow the use of a factorial design.

The research process includes material preparation and product manufacturing. TVP is brewed with hot water, soaked until it expands, washed to remove any unpleasant odors, drained, and weighed according to the treatment. Seitan is made from wheat gluten which is kneaded, washed until elastic gluten forms, then boiled with spices until cooked and weighed according to the requirements. Shiitake mushrooms and seitan are chopped and mixed with TVP according to the treatment, marinated with spices, shaped into small pieces resembling popcorn chicken, coated with dry and wet flour batter, then fried until golden brown. Observed variables included chemical and organoleptic quality. Chemical analysis included protein content using the Kjeldahl method, moisture content using the oven drying method, ash content using the dry ashing method, and crude fiber content using the acid-base reflux method (Nurbaya et al., 2020; Fikriyah and Nasution, 2022; Anggela et al., 2024). Organoleptic tests were conducted on color, aroma, taste, and texture attributes using a hedonic scale of 1–5 by 25 untrained panelists to determine the level of product acceptance (Gusnadi et al., 2021). The chemical analysis data were processed using Analysis of Variance (One-Way ANOVA) with the help of SPSS version 26. If there were significant differences, further tests (DMRT, LSD, or Tukey's BNJ) were carried out which were adjusted to the coefficient of variation value to determine the differences between treatments more specifically (Akbar et al., 2022).

RESULTS AND DISCUSSION

The results of the research on the chemical and organoleptic quality of analog *popcorn chicken* are divided into 2 data, namely chemical quality data and organoleptic data.

1. Test Chemical

Water content

The ANOVA test results for water content (Appendix 14) showed a significance value of $P = 0.003$ ($P \leq 0.05$), indicating a significant difference between treatments. This indicates that variations in the proportions of the shiitake-seitan mushroom mixture and TVP significantly affected the water content of analog popcorn chicken. The average water content is presented in Table 1

Table 1. Average water content of analog *popcorn chicken*

Treatment (X : T)	Water Content (%) ± SD
A0 (100% X : 0% T)	37.93±3.70 [a]
A1 (75% X : 25% T)	51.41±3.91 [b]
A2 (50% X : 50% T)	49.10±2.90 [b]
A3 (25% X : 75% T)	41.59±2.42 [a]

The water content of analog popcorn chicken in all treatments ranged from 37.93% to 51.41%. Treatment A1 (75% X: 25% T) produced the highest water content, while A0 (100% X: 0% T) showed the lowest water content. The Duncan test results showed that A1 and A2 were significantly different from A0 and A3. The increase in water content in A1 and A2 was thought to be influenced by a combination of the water absorption capacity of TVP and the water holding capacity of shiitake mushrooms and seitan. However, in treatment A3 (75% TVP), the water content decreased again and was not significantly different from A0, indicating that too high a proportion of TVP without the support of a mushroom and seitan matrix can reduce the system's ability to retain water during processing.

Ash Content

The ANOVA test results on ash content (Appendix 15) showed a significance value of P = 0.989 (P > 0.05), indicating no significant difference between treatments. This indicates that variations in the proportions of the shiitake-seitan mushroom mixture and TVP did not significantly affect the ash content or total mineral content of popcorn chicken analog. The average ash content is presented in Table **2.**

Table 2. Average ash content of analog *popcorn chicken*

Treatment (X : T)	Ash Content (%) ± SD
A0 (100% X : 0% T)	4.45±0.52 [a]
A1 (75% X : 25% T)	4.23±0.95 [a]
A2 (50% X : 50% T)	4.24±1.66 [a]
A3 (25% X : 75% T)	3.24±0.23 [a]

Table 2 shows that the ash content in all treatments ranged from 3.24% to 4.45%. Treatment A0 (100% X : 0% T) produced the highest ash content, while A3 (25% X : 75% T) produced the lowest ash content. The ANOVA test results showed that the difference in treatment did not significantly affect the ash content of the product (P > 0.05). This indicates that variations in the proportion of shiitake mushrooms, seitan, and TVP did not significantly affect the total mineral content of popcorn chicken analog, which is thought to be due to the relatively balanced mineral contribution of the three main ingredients in each formulation.

Protein Content

The ANOVA test results for protein content (Appendix 16) showed a significance value of P = 0.000 (P ≤ 0.05), indicating a highly significant difference between treatments. This indicates that variations in the proportions of the shiitake-seitan mushroom mixture and TVP significantly affected the protein content of popcorn chicken analog. The average protein content is presented in Table 3.

Table 3. Average protein content *of popcorn chicken* analog

Treatment (X : T)	Protein Content (%) ± SD
A0 (100% X : 0% T)	9.55±0.37 [a]
A1 (75% X : 25% T)	10.58±0.26 [a]
A2 (50% X : 50% T)	13.18±1.86 [b]
A3 (25% X : 75% T)	15.67±0.55 [c]

Table 3 shows that the protein content across all treatments ranged from 9.55% to 15.67%. Treatment A3 (25% X : 75% T) produced the highest protein content, while A0 (100% X : 0% T) produced the lowest. ANOVA results showed a highly significant effect between treatments (P < 0.05). Duncan's test showed that A3 was significantly different from all other treatments, and A2 was significantly different from A1 and A0. The increase in protein content was consistent with the increasing proportion of TVP in the formulation, given TVP's high protein content. The contribution of seitan also strengthened the protein content and created an elastic texture, while shiitake mushrooms complemented the nutritional profile despite their lower protein content.

Fiber Content

The ANOVA test results for crude fiber content (Appendix 17) showed a significance value of P = 0.000 (P ≤ 0.05), indicating a highly significant difference between treatments. This indicates that variations in the proportions of the shiitake-seitan mushroom mixture and TVP significantly affected the crude fiber content of analog popcorn chicken. The average crude fiber content is presented in Table 4.

Table 4. Average fiber content of analog *popcorn chicken*

Treatment (X : T)	Fiber Content Gross (%) ± SD
A0 (100% X : 0% T)	4.51±0.84 [b]
A1 (75% X : 25% T)	2.45±0.31 [a]
A2 (50% X : 50% T)	8.37±0.43 [c]
A3 (25% X : 75% T)	9.32±0.79 [c]

Table 4 shows that the crude fiber content in all treatments ranged from 2.45% to 9.32%. Treatment A3 (25% X : 75% T) produced the highest fiber content, while A1 (75% X : 25% T) produced the lowest. ANOVA results showed a highly significant difference between treatments ($P < 0.05$). Duncan's test showed that treatments A2 and A3 were not significantly different from each other, but both were significantly different from A0 and A1. The increase in fiber content was influenced by the increasing proportion of TVP contributing dietary fiber from the extruded protein-fiber matrix, as well as the fiber contribution from shiitake mushrooms. The combination of these two ingredients forms a more robust product structure and has the potential to produce a popcorn chicken analogue with better nutritional value.

2. Test Organoleptic

Test organoleptic aim For evaluate level favorites panelists to sample use scale hedonic 1–5, from very No Like until very like , and nature subjective (Gusnadi et al ., 2021). Results testing show that all over treatment is at on level reception neutral until Like For all parameters, indicating product can accepted in a way sensory by panelists No The resulting texture, taste, color, and aroma are relatively stable and resemble fried chicken products, making them potentially acceptable to flexitarian, vegetarian, and vegan consumers without the addition of synthetic additives (Andreani et al., 2024) .

Flavor

popcorn chicken taste preference test can be seen in Figure 1.

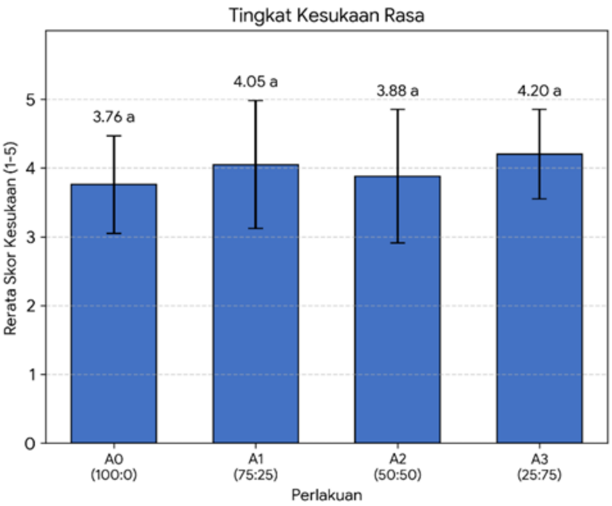

Figure 1. *Organoleptic histogram of analog* popcorn chicken flavor

The average panelists' preference score for the analog popcorn chicken flavor ranged from 3.76 to 4.20, with treatment A3 (25% X : 75% T) obtaining the highest score and A0 the lowest. All treatments were in the liking category. The Kruskal–Wallis test showed that variations in ingredient proportions did not significantly affect the level of taste preference (sig. 0.091 > 0.05), indicating that ingredient substitutions did not significantly change the flavor profile. The order of taste preference was A3 > A1 > A2 > A0, with flavor consistency influenced by the use of the same seasoning and the combination of umami flavors from shiitake mushrooms and TVP.

Color

Result diagram test favorites color analog *popcorn chicken* can seen on Figure 2

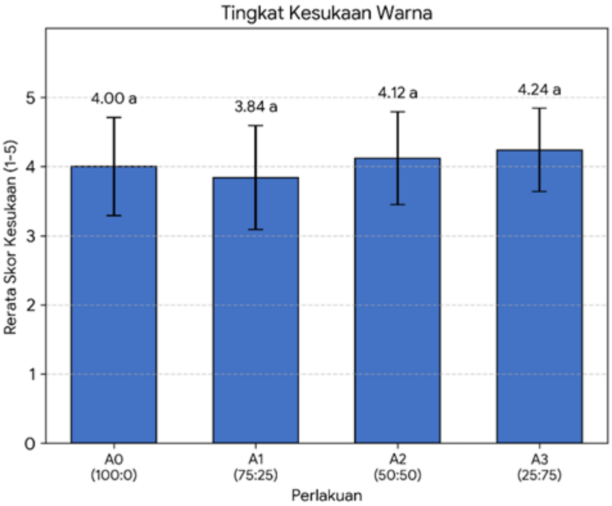

Figure 2. Organoleptic histogram of analog *popcorn chicken color*

Based on Figure 2, the average panelist preference score for the color of analog popcorn chicken ranged from 3.84 to 4.24, with all treatments in the preferred category. Treatment A3 obtained the highest score, while A1 received the lowest, but the difference was not significant. The Kruskal–Wallis test showed that variations in the proportion of shiitake mushrooms, seitan, and TVP did not significantly affect color preference (sig. 0.069 > 0.05). The uniformity of color was due to the use of the same coating material and frying technique, resulting in a consistent golden yellow color that resembles popcorn chicken in general.

Aroma

popcorn chicken aroma preference test can be seen in Figure 3.

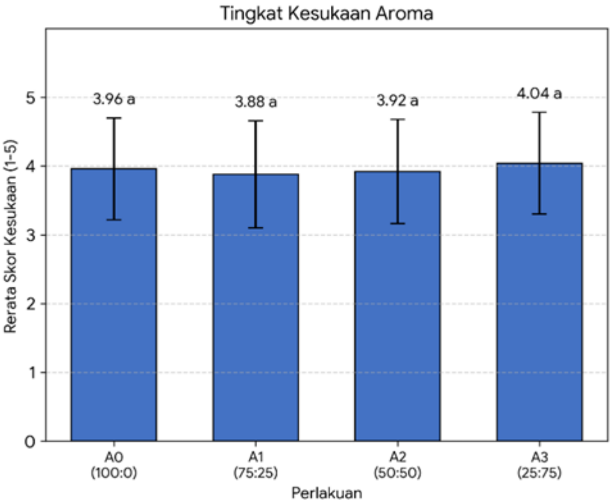

Figure 3. *Organoleptic histogram of analog* popcorn chicken aroma

Based on Figure 3, the average panelist preference score for the aroma of analog popcorn chicken was in the range of 3.88–4.04, with all treatments included in the liking category. Treatment A3 obtained the highest score, while A1 received the lowest, but the difference was not significant. The Kruskal–Wallis test showed that variations in the proportion of shiitake mushrooms, seitan, and TVP did not significantly affect aroma preference (sig. 0.084 > 0.05). The uniformity of aroma was caused by the use of the same marinade and coating ingredients, so that the resulting fried food aroma was relatively uniform across all treatments.

Texture

popcorn chicken texture preference test can be seen in Figure 4.

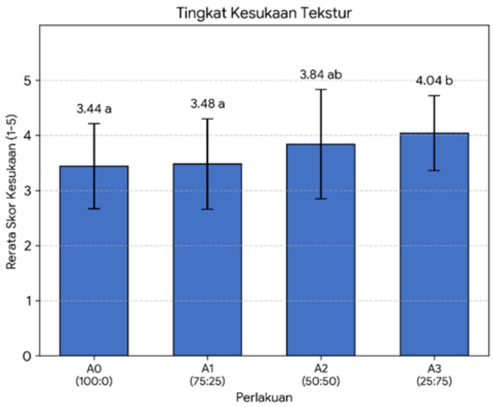

Figure 4. *Organoleptic histogram of analog* popcorn chicken texture

Based on Figure 4, the average panelists' preference score for the analog popcorn chicken texture ranged from 3.44–4.04 . Treatment A3 (25% X : 75% T) obtained the highest score (4.04; like category), while A0 (100% X : 0% T) obtained the lowest score (3.44; neutral to like). The Kruskal–Wallis test results (Appendix 9) showed that variations in the proportions of shiitake mushrooms, seitan, and TVP significantly affected texture preference (sig. 0.016 < 0.05). The order of texture preference based on the mean rank was A3 > A2 > A1 > A0 . Treatment A3 was the most preferred because it had a denser and more fibrous texture resembling meat, in line with the higher crude fiber content due to the addition of TVP (Zhang et al., 2021). On the other hand, the A0 treatment produces a softer and less fibrous texture because it does not contain TVP, so it is considered less similar to the characteristics of chicken-based popcorn chicken.

3. Effectiveness test

An effectiveness test was used to determine the best analog *popcorn chicken treatment* . Based on the effectiveness test results, the chemical and organoleptic parameters in Appendix 18 indicate that the best treatment had the highest yield (NH) value. The average effectiveness test results are presented in Table 5.

Table 5. Effectiveness test analog *popcorn* chicken

Parameter	Mark Results Treatment			
	A0	A1	A2	A3
Protein Content	0.00	0.02	0.09	0.14
Texture	0.00	0.04	0.06	0.14
Flavor	0.00	0.13	0.14	0.14
Fiber Content	0.04	0.00	0.11	0.13
Color	0.06	0.00	0.11	0.06
Aroma	0.11	0.03	0.00	0.08
Water content	0.11	0.00	0.02	0.08
Ash Content	0.00	0.11	0.11	0.02
Total	0.32	0.33	0.64	0.79*

Based on results test effectiveness all research parameters on Appendix 18 shows that popcorn chicken analog treatment A3 (25% Shiitake mushrooms and seitan : 75% TVP) is treatment best with Mark Highest yield (NH) of 0.79. This best treatment has chemical characteristics with a protein content of 15.67%, fiber content of 9.32%, water content of 41.59%, and ash content of 4.42%. As for the organoleptic side, treatment A3 obtained an average score on the parameters of taste of 4.28 (like), color of 4.19 (like), aroma of 4.11 (like), and texture of 4.41 (like/very like).

CONCLUSION

The results showed that variations in the proportion of shiitake mushrooms, TVP, and seitan significantly affected the water, protein, and fiber content of analog popcorn chicken, but not the ash content. Sensori- cally, the differences in formulation did not affect the preference for color, aroma, and taste, but significantly affected the

texture. The best treatment based on the effectiveness test was A3 (25% shiitake mushrooms and seitan: 75% TVP) with an effectiveness value of 0.79, characterized by high protein and fiber content and the panelists' preference level in the like to very like category.

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