

EFFECT OF TEMPEH AND ARROWROOT FLOUR SUBSTITUTION ON THE PHYSICAL AND SENSORY CHARACTERISTICS OF CATFISH NUGGETS

Laela Nur Rokhmah¹, Syahdan Nabila^{1*}, Bilqis Bunga Anugraini¹, Yenita Cahya Dewi¹,
Binardo Adi Seno Mawarno¹, Umar Hafidz Asyari Hasbullah²

Duta Bangsa University Surakarta¹, Indonesia, Katsetsart University, Thailand²

*Correspondence Email: syahdannabila452@gmail.com

ABSTRACT

Catfish is a widely available freshwater commodity that can be developed into value added products such as nuggets. The use of local ingredients, including tempeh flour and arrowroot flour, may modify the physical, sensory and textural characteristics of catfish nuggets. This study aimed to evaluate the effects of different proportions of tempeh flour and arrowroot flour on catfish nugget characteristics. Four formulation were prepared F0 (15:0 g), F1 (10:5 g), F2 (5:10 g) and F3 (0:15 g) of tempeh flour and arrowroot flour, respectively. Nuggets were steamed and weight and color were evaluated before and after steaming. Sensory characteristics were evaluated before and after bread coating, while instrumental texture was analyzed using Texture Profile Analysis (TPA). All formulation showed weight loss after steaming, ranging from 1,45% to 9,53% with F1 showing the lowest weight loss. Color characteristics varied among formulations after steaming. Bread coating modified sensory characteristics, particularly color and aroma. TPA showed that F1 had the lowest hardness and gumminess. F3 had the highest hardness and gumminess, and F2 had the highest chewiness (21,25±4,56). Overall, flour proportion influenced the physical, sensory, and textural characteristics of catfish nuggets.

KEYWORDS

Arrowroots flour; Catfish; Flour; Nuggets; Tempeh



This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International

INTRODUCTION

Catfish (*Clarias* sp.) is an important freshwater fish commodity in Indonesia due relatively affordable price, ease of cultivation, and high nutritional value. Catfish provides

high quality animal protein and essential nutrient and is widely available in the market. The development of value added processed products is therefore important to diversify the utilization of catfish and increase its potential as a convenient food ingredient. One product that can be developed from catfish is a nugget, which provides a convenient form of fish consumption and can be modified through the use of different filler and binder ingredients.

The quality of fish nuggets is strongly influenced by the formulation and functional properties of the ingredient used. Filler and binders contribute to the formation of the product matrix and can affect its physical, textural and sensory characteristics. The use of locally available flour as an alternative ingredient is therefore of interest in the development of fish based products. Previous research has shown that the addition of tempeh flour can affect the physicochemical and sensory characteristics of catfish based products, indicating that tempeh flour has potential as a functional ingredient in fish processing (Ayu et al., 2022).

Tempeh flour and arrowroot flour have different functional characteristics that may influence nugget quality. Tempeh flour is derived from fermented soybean and contributes protein and fermentation derived components that may affect the structure, flavor and sensory characteristics of the product. Arrowroot flour, in contrast is predominantly composed of starch and has suitable gelatinization characteristics for food applications. Faridah et al. (2014) reported that arrowroot starch contains approximately 24.64% amylose and exhibits characteristic gelatinization behavior, indicating its potential to contribute to structure formation during heating. The different contributions of protein from tempeh flour and starch from arrowroot flour may therefore result in the different textural properties when their proportions are varied in a catfish nugget formation.

Processing conditions can further modify nugget characteristics. Steaming induces protein denaturation and starch gelatinization, which may affect product weight and color. Subsequent breading and frying can further alter color, aroma, flavor, and texture. These changes can be evaluated through sensory testing and instrumental Texture Profile Analysis (TPA), including hardness, cohesiveness, gumminess and chewiness (Putri et al., 2022).

Different proportions of tempeh and arrowroot flour may therefore produce different physical, texture, and sensory characteristics. This study aimed to evaluate the effect of their substitution on catfish nuggets by assessing weight and color changes before and after steaming, sensory characteristics before and after breading and frying and instrumental texture using TPA.

RESEARCH METHOD

Tools and Materials

The materials used in this study were catfish fillets (*Clarias sp.*), tempeh flour, arrowroot flour, ice cubes, eggs, breadcrumbs, cooking oil, and seasonings (salt, garlic, and white pepper). The equipment used included a chopper, steamer, frying pan, baking pans, knives, cutting boards, porcelain crucibles, an oven, and a Texture Analyzer.

Method

This research was conducted at the Food Engineering Laboratory, Universitas Duta Bangsa Surakarta, to analyze the effects of tempeh flour and arrowroot flour substitution on the characteristics of catfish nuggets. The equipment used included a chopper, steamer, frying pan, baking pans, knives, cutting boards, porcelain crucibles, an oven, and a Texture Analyzer. The raw materials comprised catfish fillets (*Clarias sp.*), tempeh flour, arrowroot

flour, ice cubes, eggs, breadcrumbs, cooking oil, and seasonings (salt, garlic, and white pepper).

Nugget Preparation

The manufacturing process initiated with mincing the catfish fillets and ice cubes using a chopper. The minced meat was then blended with arrowroot flour and tempeh flour according to the treatment formulations (F0, F1, F2, and F3), seasonings, and eggs until a homogeneous batter was formed. The batter was molded into baking pans, steamed at 100 for 30 minutes, cooled, cut into pieces, coated with egg wash and breadcrumbs, and deep-fried until golden brown.

Experimental Design and Formulation

The experimental design employed consisted of four formulation treatments involving varying proportions of tempeh flour and arrowroot flour, as presented in Table 1.

Table 1. Composition of Arrowroot

Ingridients (gram)	F0	F1	F2	F3
Catfish Meat	125	125	125	125
Ice Water	3	3	3	3
Arrowroot Flour	0	5	10	15
Tempeh Flour	15	10	5	0
Salt	1,5	1,5	1,5	1,5
Pepper	0,2	0,2	0,2	0,2
Garlic	0,4	0,4	0,4	0,4
Egg	5	5	5	5
Total Weight	140	140	140	140

Color evaluation

Color was evaluated visually before and after steaming under with untrained panelist.

Sensory Evaluation

Sensory evaluation was conducted on cooked nuggets before breading and on breaded nuggtes. Eight untrained panelists assess the sensory characteristics of the catfish nuggets and evaluated the samples using a five point descriptive scale overing six parameteres : texture, taste, aroma, hardness, chewiness and color. Each parameter was scored from 1 to 5 according to the sesnory charateristics presented to the panelists. For the texture, the score ranged from1 (not compact) to 5 (compact), with score 2,3,4 representing slightly compact, neutral and less compact, respectively. Color was scored from 1 (dull) to 5 (very bright), with intermediate scores representing slightly dull, bright, and more bright charateristics.

Texture Profile Analysis

Instrumental texture was evaluated using a Texture Profile Analysis (TPA) was conducted using Brookfield CT3 Teture Analyzer (AMETEK Brookfiled, USA) equipped with cylinder probe TA39. The instrument was operated in TPA mode to determine hardness, cohesiveness, gumminess, and chewiness of the catfish nuggtes.

RESULT AND DISCUSSION

Weight Testing Before and After Steaming

Table 2. Weight Testing Before and After Steaming

Sampel	Weight Before Steaming (g)	Weight After Steaming (g)
F0	145,9	132
F1	145,1	143
F2	144,3	136
F3	143,1	136

The weight of all catfish nuggets formulation decreased after steaming, indicating that thermal processing resulted in a loss of mass from the products. Based on the initial and final weights, F0 showed the highest weight loss, decreasing from 145,9 to 132,0 g, equivalent to 9,53%. F1 showed the lowest weight loss from 145,1 to 143,0 g (1,45%), followed by F3 at 4,96% and F2 at 5,75%. Thus the weight loss did not show linear relationship with the increasing proportion of arrowroot flour.

The differences among formulation can be related to the different proportions of tempeh flour and arrowroot flour. F0 contained 15 g tempeh flour without arrowroot flour, whereas F1 contained 10 g tempeh flour and 5 g arrow root flour. Tempeh flour contributes protein to the food matrix, while arrowroot flour predominantly starch. Arrowroot starch contains approximately 98,10% starch, with 24,64% amyloses and 75,36% amylopectin and exhibits an A-type gelatinization profile (Faridah et al., 2014). During heating, starch gelatinization and protein denaturation can modify the structure of the product and its ability to retain water. The interaction between starch, protein and water therefore may affect the amount of mass lost during steaming. Similar relationships between formulation, water retention and cooking loss have been reported in meat based systems containing different fillers and starches. (Cornet et al, 2021). Suggests that the combination of 10 g tempeh flour and 5 g arrowroot flour may have produced relatively effective protein starch matrix for retaining water during steaming. The protein contributed by tempeh flour can be participate in the formation of the heated product matrix, while the starch fraction from arrowroot flour can absorb water and gelatinize during heating. Previous research on tempeh flour in catfish based products has demonstrated that changes in tempeh flour proportion can affect physicochemical and sensory characteristics, indicating that its functional contribution can influence the characteristics of fish based products (Ayu et al., 2022). In addition, research on processed meat systems has shown that starch and protein ingredients can influence water retention and cooking loss through their interaction during thermal processing.

The higher weight loss observed in F2 (5,75%) and F3 (4,96%) compared with F1 (1,45%) indicates that increasing arrowroot flour substitution did not continuously improve mass retention. This non linear pattern suggests that weight retention was influenced not only by starch content but also by the balance between fish protein, tempeh protein, starch and water in the product matrix. During steaming, protein denaturation and starch gelatinization can alter water distribution and product structure, while the absence of arrowroot starch in F0 may have contributed to its highest weight loss (9,53%). Conversely, the lowest weight loss in F1, containing 10 g tempeh flour and 5 g arrowroot flour, suggest that this proportion provided a favorable balance for maintaining product mass during steaming. However, because water holding capacity was not directly measured, these results should be interpreted as changes in product mass rather than direct evidence of water retention. Similar effects of steaming and starch incorporation on cooking loss, water

holding capacity and structural properties have been reported in fish based product. (Zhang et., 2024)

Color Testing Before and After Steaming

Table 3. Color Testing Before and After Steaming

Sample	Color Before Steaming	Color After Steaming
F0	Pale White	Pale White
F1	Pale White	Pale White Slightly Black Brown
F2	Pale White	Brownish White
F3	Pale White	Dull White

All formulation showed a pale whote color before steaming, indicateing that differences in the proportions of tempeh and arrowroots flour did not produce clearly distiguishable initial color characteristics. After steaming, however, differences in color were observed among formulation. F0 containing 15 g tempeh flour without arrowroot flour, remined pale white, whereas F1 (10 g tempeh flour and 5 g arrowroot flour) developed a slightly blackish brown appearance. F2 (5 g tempeh flour and 10 g arrowroot flour) appeared brownish white, while F3 containg 15 g arrowroot flour without tempeh flour, appeared dull white. These differences indicate that the proportion of tempeh and arrowroot flour influenced the visual appearance of the nuggets after steaming.

The observed differences may be assoicated with the composition and physicochemical characteristics onf the two flours. Tempeh flour contributes protein and other components derived from soybean fermentation, whereas arrowroots flour is predominantly starch and has a relatively light color. Recent characterization of arrowroor starch showed that its color similar to that of wheat flour, indicating that arrowroot starch itself has limited contribution to dark coloration (Malki et al., 2023). Meanwhile, proteins and their associated components can influence food appearance during thermal processing through structural changes and browning reaction (Damodara, 2018). Thus, the difference among F0-F3 may reflect interaction between the protein rich tempeh flour and starch rich arrowroot flour during steaming darter than the effect of arrowroot flour alone.

Thermal processing cal also promote non enzymatic browning throught the Maillard reaction, which involves amino groups from proteins or amino acids and reducing sugars and can generates melanoidins responsible for brown coloration (Chen et al., 2025). However, The present color observations were qualitative and the concentrations of reducing sugars, amino compunds, phenolic compounds, or Maillard reactions produtcs were not determined. Therefore, the color differences observed after steaminf cannot be attributed specifiially to the Maillard reations. The results are more appropriately interpreted as changes in visual color associated with differences in formulation an thermal processing, with F1 the nost apparent shift toward a bownish color among the formulations.

Sensory Testing Before and After Bread-Coating

Table 4. Sensory Evaluation Before Bread Coating

Sample	Texture	Taste	Aroma	Hardness	Chewiness	Color
F0	2,00±0,93	1,38±0,52	1,00±0,00	3,00±0,00	1,00±0,00	2,38±0,00
F1	3,00±0,00	2,00±0,00	1,88±0,33	2,00±0,00	2,00±0,00	2,00±0,00
F2	4,25±0,00	3,25±0,46	2,75±0,71	2,00±0,00	3,38±0,52	2,63±0,74
F3	4,12±1,64	2,00±0,53	2,50±0,53	1,75±1,04	4,25±1,04	1,50±0,76

Based on table 4, before bread coating, the sensory characteristics varied among the formulations. F2 showed the highest scores for texture (4,25±0,00), taste (3,25±0,46), aroma(2,75±0,71) and chewiness (3,38±0,52), indicating a relatively stronger expressions

of these attributes compared with the other formulations. F3 showed a similar texture score ($4,12 \pm 1,64$) and the highest chewiness score ($4,25 \pm 1,04$), while F0 generally showed the lowest scores for textures, taste, aroma, and chewiness. The hardness scores range from $1,75 \pm 1,04$ to $3,00 \pm 0,00$ with F0 receiving the highest score. These differences may be associated with the different proportions of tepeh and arrowroot flour, which modify the protein starch matrix and consequently influence the perceived texture of the cooked nuggets.

The color scores before bread coating ranged from $1,50 \pm 0,76$ in F3 to $2,63 \pm 0,74$ in F2. This indicates that F2 had the most favorable color intensity according to the sensory scale used, whereas F3 had the lowest score. The sensory differences in the texture and color were consistent with the formulation differences in the texture and color were consistent with the formulation differences, particularly the increasing proportion of arrowroot flour and decreasing proportion of tempeh flour. Starch based ingredients can contribute to the structural properties of food through water binding and gelatinization while protein contributes to matrix formation during heating. Thus, the sensory characteristics observed before coating may reflect difference in the protein starch composition of the cooked nuggets. However, because the sensory scale used in this study measures attribute intensity rather than overall liking, the higher score should be interpreted as a stronger expression of the respective attribute rather than greater consumer preference. Descriptive sensory scales are commonly used to quantify the intensity of defined sensory attributes using numerical categories (Cahyono et al., 2026)

Table 5. Sensory Evaluation After Bread Coating

Sample	Texture	Taste	Aroma	Hardness	Chewiness	Color
F0	$1,25 \pm 0,71$	$1,38 \pm 0,52$	$1,00 \pm 0,00$	$2,13 \pm 0,35$	$1,00 \pm 0,00$	$2,63 \pm 0,00$
F1	$2,50 \pm 0,53$	$2,25 \pm 0,46$	$2,75 \pm 0,46$	$2,00 \pm 0,00$	$2,13 \pm 0,35$	$3,00 \pm 0,00$
F2	$3,50 \pm 0,93$	$3,50 \pm 1,85$	$4,50 \pm 0,76$	$2,00 \pm 0,00$	$3,13 \pm 0,35$	$3,00 \pm 0,00$
F3	$3,63 \pm 1,19$	$2,00 \pm 0,53$	$2,75 \pm 1,28$	$1,38 \pm 1,06$	$3,75 \pm 1,16$	$2,75 \pm 0,46$

Table 5 showed sensory after bread coating. After bread coating, several sensory attributes showed changes compared with the uncoated cooked nuggets. Texture scores decreased in all formulations, from 2,00 to 1,25 in F0, from 3,00 to 2,50 in F1 from 4,25 to 3,50 in F2 and from 4,12 to 3,63 in F3. In contrast color scores increased in all formulation, particularly F3 which increased from $1,50 \pm 0,76$ to $2,75 \pm 0,46$. Aroma also increased in F1, F2, F3 with the largest increase observed in F2 from $2,75 \pm 0,71$ to $4,50 \pm 0,76$. The increase in color and aroma scores may be associated with the additional sensory contribution of the breading layer. Flour based coatings can modify the surface appearance and aroma of coated food products while their composition and structure influence coating characteristics and sensory properties (Mahmudah et al, 2022; Mansyur et al, 2022)

The changes in taste, hardness, and chewiness after bread coating were relatively formulation dependent. Taste increased slightly in F1 and F2, remained unchanged in F0 and remained at 2,00 in F3. Hardness decrease in F0 dan F3 but remained unchanged in F1 and F2 while chewiness increased slightly in F1, remained unchanged in F0 and decreased in F2 dan F3. These results indicates that bread coating modified some sensory attributes but did not produces the same response in all formulations. The coating forms an additional outer layer that can contribute to surface texture, appearance, and flavor perception, while the underlying nugget matrix remains determined by tempeh arrowroot formulation. Studies of breaded nuggets products have similarly shown that coating characteristics can influence sensory texture, color, aroma, and other quality attributes.

Nugget Texture Testing

Table 7. Nugget Texture Testing

Sample	Hardness	Cohesiveness	Gumminess	Chewiness	Texture Characteristics	Texture Interpretation
F0	14,63±0,59	1,02±0,03	262,87±13,04	4,35±0,70	Compact and Elastic	Stable
F1	13,67±2,17	1,09±0,43	260,53±54,94	18,31±5,98	Flexible	Easy to Chew
F2	16,34±2,96	0,94±0,14	304,07±63,75	21,25±4,56	Balanced	Ideal
F3	17,01±3,04	1,18±0,39	311,93±41,50	13,83±3,90	Solid	Hard

Texture profile analysis (TPA) was used to characterize the mechanical properties of the cooked catfish nuggets based in hardness, cohesiveness, gumminess and chewiness. These parameters describes different aspects of the response of a food matrix to repeated compression. Hardness represents the maximum force required during the first compressions. Cohesiveness reflects the ability of the structure to withstand repeated deformation gumminess is a derived parameter related to hardness and cohesiveness and chewiness represents the work required to chew the product until it is ready for swallowing (Chen et al., 2025; Harsita et al., 2024). TPA has also been widely applied to fish nuggets and fish protein products to evaluate the effects of formulation and processing on the textural properties.

The hardness values ranged from 13,67±2,17 to 1,01±3,04 F1 containinf 10 g tempeh flour and 5 g arrowroot flour, showed the lowest hardnest, whereas F3, containing 15 g arrowroot flour without tempeh flour, showed the highest hardness. F0 and F2 had intermediate values of 14,63± 0,59 and 16,34±2,96, respectively. The increase in hardness at higher arrowroot flour proportions may be associated with starch gelatinization during steaming. Arrowroot flour contributes starch that ansorbs water and forms a gelatinized structure during heating, which can increase the firmness of the product matrix. In fish protein starch system, starch incoporation has been reported to modify gel structure and increase machanical strength through interaction between gelatinized stacrh and the protein network (Cornet et al., 2021). Similar effects of formulation and processing conditions on the hardness of fish nuggets have also been reported in previous studies (Zhang et al., 2025).

Cohesiveness values were 1,02±0,03; 1,09± 0,43; 0,94±0,14 and 1,12 ± 0,39 for F0, F1, F2 and F3 respectively. F3 showed the highest mean value while F2 showed the lowest. The relatively high cohesiveness in F3 may indicate that the arrowroot based matrix maintained its structural response during repeated compression, whereas the lower value in F2 suggests greater structural breakdown under the test conditions. The variation among formulation may be related to the balance between tempeh protein and arrowroot starch. Tempeh flour provides protein that contributes to matrix formation, while gelatinized starch can interact with the protein matrix and modify its structural integrity. However, because the cohesiveness values obatined from the instrument exceed the commonly reported range for conventional TPA cohesiveness the calculation and utput definition of cohesiveness from the Brookfiled CT3 software should be verified before drawing a definitive mechanistic conclusion. Conventional TPA defines cohesiveness as the ration of the work performed during the second compression to that during the first compressions (A2/A1) (Nishinari et al., 2019).

Gumminess ranged from 260,53±54,94 to 311,93±41,50 with F1 showing the lowest value and F3 highest. F0 and F2 had intermediate values of 262,87±13,04 and 304,07±63,75, respectively. The higher gumminess observed in f2 dan F3 generally coincided with their higher hardnessvalues, suggesting a more resistnt structure during deformation. This may be associated with the high proportion of arrowroot flour which can

form a gelatinized starch network during heating. Previous studies on fish based protein starch system have demonstrated that starch can modify gel strength and textural properties by interacting with the protein matrix during heating (Putri et al., 2022). However, gumminess is derived TPA parameter and should be interpreted together with hardness and cohesiveness rather than as an independent indicator of product quality.

Chewiness showed a different from hardness and gumminess. F2 had the highest chewiness value ($21,25 \pm 4,56$) followed by F1 ($18,31 \pm 5,98$), F3 ($13,83 \pm 3,90$), and F0 ($4,35 \pm 0,70$). The highest chewiness in F2 indicates that this formulation required the greatest mechanical work during chewing under the instrumental test conditions. The result demonstrates that chewiness does not necessarily increase proportionally with hardness. Although F3 had the highest hardness and gumminess, its chewiness was lower than of F2. This difference may be related to the combined contribution of the primary and secondary TPA parameters, particularly cohesiveness and springiness, which determine the derived chewiness value. In conventional TPA, chewiness is calculated from gumminess and springiness, while gumminess is derived from hardness and cohesiveness (Chen et al., 2010). Similar differences among hardness, gumminess, and chewiness have been reported in fish based products, indicating that these parameters describe different aspects of the mechanical response of the product (Zhang et al., 2024).

Overall, the TPA results indicate that the replacement of tempeh flour with arrowroot flour modified the mechanical texture of the catfish nuggets. F1 produced the lowest hardness and gumminess while F3 produced the highest hardness and gumminess. In contrast, F2 exhibited the highest chewiness, indicating that its texture required greater mechanical work during chewing despite not having the highest hardness. These results suggest that the texture of the nuggets was determined by the interaction between fish protein, tempeh protein and arrowroot starch rather than by the proportion of arrowroot flour alone. The TPA results should subsequently be compared with the sensory evaluation, particularly sensory hardness and chewiness to determine whether the instrumental measurements correspond to the panelists' perceived texture.

CONCLUSION

The substitution of tempeh flour with arrowroot flour affected the physical, sensory and instrumental textural characteristics of catfish nuggets. During steaming, all formulations experienced weight loss, with F1 showing the lowest weight loss (1,45%) while F0 showed the highest (9,53%). Color changes after steaming varied among formulations, with F1 showing the most apparent change toward a brownish color. Sensory evaluation of the cooked nuggets before and after bread coating showed changes in texture, aroma, taste, hardness, chewiness and color indicating that bread coating modified the sensory characteristics of the nuggets, although the magnitude of the changes varied among formulations. TPA showed that F1 had the lowest hardness and gumminess, F3 had highest hardness and gumminess while F2 exhibited the highest chewiness ($21,25 \pm 4,56$). Overall, the 10:5 ratio of tempeh flour to arrowroot flour in F1 showed the most favorable weight retention and relatively softer instrumental texture, whereas F2 demonstrated the highest instrumental chewiness, indicating that the formulation influenced different quality attributes of the catfish nuggets.

REFERENCES

- Ayoib, C.A., & Nosakhare, P.O (2015). Directors culture and environmental disclosure practice of companies in Malaysia. *International Journal of Business Technopreneurship*, 5(1), 99-114. <https://doi.org/10.36574/jpp.v4i2.118>
- Ayu, Y. A., Herdiana, N., Sartika, D., & Hidayati, S. (2022). Pengaruh Penambahan Tepung Tempe Terhadap Sifat Fisikokimia Dan Sensori Pada Kerupuk Ikan Lele. *Jurnal Agroindustri Berkelanjutan*, 1(2).
- Cornet, S. H. V., Snel, S. J. E., Lesschen, J., van der Goot, A. J., & van der Sman, R. G. M. (2021). Enhancing the water holding capacity of model meat analogues through marinade composition. *Journal of Food Engineering*, 290, 110283. <https://doi.org/10.1016/j.jfoodeng.2020.110283>
- Chen, J., Gao, X., Hou, Y., & Liang, G. (2025). Dietary melanoidins as emerging functional components: Interactions with gut microbiota and implications for nutritional modulation of intestinal health. *Frontiers in Nutrition*, 12, 1672681. <https://doi.org/10.3389/fnut.2025.1672681>
- Cahyono, Hari., Arbajayanti, Rahma Dini. (2026). Comparison of the Sensory Quality of Nuggets Made from Catfish (*Clarias* sp.) and Ikan Patin (*Pangasius* Sp.). *Agrinexa Informatics Journal*, 1(2), 38-43.
- Faridah, D. N., Fardiaz, D., Andarwulan, N., & Sunarti, T. C. (2014). Karakteristik Sifat Fisikokimia Pati Garut (*Maranta arundinaceae*). *AGRITECH*, 34(1).
- Harsita, P. A., Herlina, H., & Najah, S. (2024). Daya Ikat Air, Keempukan, Kadar Abu, dan Susut Masak Naget Ayam KUB dengan Penambahan Tepung Daun Kelor. *Jurnal Peternakan*, 21(2), 224–237. <https://doi.org/10.24014/jupet.v21i2.31832>
- Mahmudah, K., Fitrianiingsih, F., & Bain, A. (2022). Susut Masak, Daya Ikat Air dan Kadar Protein Daging Ayam Broiler yang Diberi Pakan Mengandung Tepung Ikan. *Jurnal Ilmiah Peternakan Halu Oleo*, 4(3), 214. <https://doi.org/10.56625/jipho.v4i3.27022>
- Naani, N., Fitrianiingsih, F., & Hafid, H. (2023). Pengaruh Penambahan kacang Merah Terhadap Kualitas Fisik Naget Ayam Petelur Afkir. *Jurnal Ilmiah Peternakan Halu Oleo*, 5(2), 104. <https://doi.org/10.56625/jipho.v5i2.29532>
- Mansyur, Mariani Haji. (2022). Acceptability of Dumbo Catfish Nuggets (*Clarias gariepinus*) Rean Bean Addition. *Agriculture Technology Journal*, 5(2). <https://doi.org/10.32662/gatj.v5i1.2478>
- Muhyiddin. (2020). Covid-19, New Normal and Development Planning in Indonesia. *The Indonesian Journal of Development Planning*, 4(2), 240–252. <https://doi.org/10.36574/jpp.v4i2.118>
- Nishinari, Fang, dan Rosenthal (2019), *Journal of Texture Studies* 50(5), 369–380
- Putri, I. E., Iswahyudi, I., & Nuraida, N. (2022). Sifat fisik permen jeli berbasis gelatin tulang ikan nila merah (*Oreochromis niloticus*) dengan penambahan sari kacang merah (*Phaseolus vulgaris* L.). *Jurnal Teknologi dan Mutu Pangan*, 1(1), 31–36. <https://doi.org/10.30812/jtmp.v1i1.2177>
- Widianto, T. N., Novianto, T. D., & Zulfia, N. (2016). Disain Pisau Bowl Cutter untuk Pembuatan Nugget Ikan. *Jurnal Pascapanen dan Bioteknologi Kelautan dan Perikanan*, 11(1), 1. <https://doi.org/10.15578/jpbkp.v11i1.250>
- Zhang, S., Wang, L., Wang, Q., Wang, Y., Wang, L., & Du, R. (2024). Effects of different types of starch on physicochemical properties and microstructure of beef during cold storage. *Foods*, 13(17), 2767. <https://doi.org/10.3390/foods13172767>

Author's short biography

Authors Name:

Name : Laela Nur Rokhmah
Affiliation : Duta Bangsa University
Phone Number : 08529574787
Email : laena_nurrokhmah@udb.ac.id

Let people know you and your contribution in the area. A short biography of author. Font size 10pt, Cambria, Justified alignment. Write here mainly about research interest. It should be about authors academic degree, Research area, and Years of experience

Authors Name:

Name : Syahdan Nabila
Affiliation : Duta bangsa University
Phone Number : 0882-0080-18792
Email : syahdannabila452@gmail.com

Let people know you and your contribution in the area. A short biography of author. Font size 10pt, Cambria, Justified alignment. Write here mainly about research interest. It should be about authors academic degree, Research area, and Years of experience

Authors Name:

Name : Bilqis Bunga Anugraini
Affiliation : Duta bangsa University
Phone Number : 0856-4659-9546
Email : bilqisbunga27@gmail.com

Let people know you and your contribution in the area. A short biography of author. Font size 10pt, Cambria, Justified alignment. Write here mainly about research interest. It should be about authors academic degree, Research area, and Years of experience

Authors Name:

Name : Yenita Cahya Dewi
Affiliation : Duta bangsa University
Phone Number : 0819-1701-6103
Email : yenitacahya03@gmail.com

Let people know you and your contribution in the area. A short biography of author. Font size 10pt, Cambria, Justified alignment. Write here mainly about research interest. It should be about authors academic degree, Research area, and Years of experience

Authors Name:

Name : Binardo Adi Seno Mawarno
Affiliation : Duta bangsa University
Phone Number : 0818-043100315
Email : binardo_adiseno@udb.ac.id

Let people know you and your contribution in the area. A short biography of author. Font size 10pt, Cambria, Justified alignment. Write here mainly about research interest. It should be about authors academic degree, Research area, and Years of experience
