



Journal home page: <http://ajarcde-safe-network.org> ISSN 2581-0405

Study of the Proportion of Catfish and Duck Meat on the Physicochemical Characteristics of Nugget with the Addition of Sodium Alginate Binding Material

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ARTICLE INFO

Article History:

Received: 17 July 2025

Final Revision: 17 August 2025

Accepted: 19 September 2025

Online Publication: 19 September 2025

KEYWORDS

Nugget, Pangasius Catfish, Duck meat, Sodium alginate

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A B S T R A C T

A nugget is a type of processed meat restructuring, namely, meat that is ground and seasoned, then enveloped by flour adhesive and breadcrumb coating (breadring). The purpose of this study was to evaluate the effects of different proportions of catfish and duck meat, as well as the addition of sodium alginate, on the physicochemical and organoleptic characteristics of nuggets. This study employed a completely randomised design (CRD) with two factors and two replications. Factor I is the treatment of the proportion of catfish and duck meat. Factor II is the addition of sodium alginate binder (0.5%; 0.75%, or 1%). The data obtained were analyzed using analysis of variance (ANOVA) with a significance level of 5%. If there were differences between treatments, then a DMRT 5% further test was conducted. The best results were obtained using a mixture of 70% catfish and 30% duck meat with 1% sodium alginate, which produced nuggets with 59.32% moisture, 1.28% ash, 8.75% fat, 16.86% protein, a texture value of 563.470 gf, and a water binding capacity of 81.74%. In the taste test, the average scores were 4.12 for colour (slightly liked), 4.01 for aroma (slightly liked), 3.88 for taste (liked), and 3.72 for texture (liked).

Contribution to Sustainable Development Goals (SDGs)

SDG 2 – Zero Hunger:

SDG 3 – Good Health and Well-being:

SDG 9 – Industry, Innovation, and Infrastructure:

SDG 12 – Responsible Consumption and Production:

1. INTRODUCTION

1.1. Research Background

The development of meat processing technology into ready-to-cook or ready-to-serve products makes one alternative to increase the economic value and shelf life of meat. Meat is one of the essential food ingredients that help fulfil the nutritional needs of the human body. In addition to its high protein quality, meat also contains a balanced and complete profile of essential amino acids. However, meat is easily damaged; therefore, it requires preventive measures, one of which is creating innovations in the field of processing. One of the products of advanced meat

processing technology is the manufacture of nuggets. Nuggets are made from processed ground meat using the restructuring method, which involves utilising pieces of meat with a relatively small and irregular size, adding seasonings, mixing them with a binder, and then moulding them into a certain shape [1]. The use of meat as an ingredient in making nuggets is generally made from chicken meat. The most suitable meat substitute for making nuggets is fish. Fish is a source of animal protein. Protein in fish is very easy to digest and has almost the same essential amino acids as red meat.

Catfish contains 16.08% protein, about 5.75% fat content, 1.5% carbohydrate, 0.97% ash and 75.7% water content. However, currently processed products made from catfish are still



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low, considering the increasing production costs of catfish cultivation every year. Therefore, catfish is processed into various foods to extend their shelf life, one of which is used to make nuggets. Ref. [2]. The primary issue in making nuggets is the cooking process, which results in uneven texture. When making catfish nuggets, the addition of duck meat is necessary.

Duck meat is one source of animal protein from poultry. So far, people have not widely processed duck meat. According to Ref. [3], duck meat has a higher protein content (21.4%) compared to beef (18.7%) and lamb (14.8%). Myofibrillar proteins, such as actin and myosin, found in duck meat, influence the texture of nuggets. When nuggets undergo the cooking process, actin and myosin can develop structures that give the nuggets their texture. If the nuggets are made from meat that contains a high amount of myofibrillar proteins, their texture tends to be more chewy and dense.

Binders also play a crucial role in forming a compact texture that is not easily broken and can adhere to each other. One of the binders that can be used in making nuggets is sodium alginate. The formation of the bond that occurs causes the gel to form. Sodium alginate acts as a binder to improve texture consistency, bind water, and reduce syneresis [4].

1.2. Literature Review

Nuggets are a type of processed meat product, specifically ground and seasoned meat that is enveloped in a flour adhesive and a breadcrumb coating (breading), then frozen to maintain quality during storage [5].

Restructuring is a process of uniting or reshaping carcasses into a form that adds value and has characteristics resembling those of steak and meat in general. Restructuring is essentially the incorporation of secondary parts of the carcass, which are then bound with alginate, forming a single unit. Most restructured meat products are made from meat extracts using salt, phosphate, and mechanical manipulation, where sufficient cooking forms a gelatinised matrix through heating [6].

The physical characteristics of catfish have an elongated body shape, have a silver white color while the back is bluish, have no scales, body size can reach 120 cm, relatively small head size with a mouth located at the end of the lower head, there are two pairs of short whiskers at the end of the mouth that function as a feeler, the fins on the back have hard fingers that can turn into large and jagged patils, and there are soft fingers on the back fin which number 6-7 pieces [7].

Duck has the advantages of a high protein content and low calories, but it also has the disadvantages of a fishy odour, toughness, and a relatively high fat content. The fat in duck meat contains saturated fatty acids that are easily autoxidised, causing a fishy smell and resulting in lower consumption of duck meat compared to chicken meat [8].

Sodium alginate is a natural biopolymer extracted from brown algae species, including *Ascophyllum nodosum*, *Laminaria hyperborea*, and *Macrocystis pyrifera*. Commercially available alginate is typically in the form of sodium alginate, a salt. The main property of alginate is its ability to gel in the presence of divalent cations. The addition of multivalent cations can form a thermostable alginate gel, which is heat-stable and can be formed at room temperature. The ability of alginate to form a gel is mainly related to the proportion of polyguluronate. The higher the polyguluronate content in alginate, the stronger the gel and the more stable the texture [9].

1.3. Research Goals

This study was conducted to determine alternative ingredients that can be used as additives in making nuggets. The formulation of catfish and duck meat nuggets with the addition of a sodium alginate binder is favoured by consumers in terms of both organoleptic and chemical content. Additionally, it is anticipated that the inclusion of these ingredients will enhance the nutritional value of the nuggets, yielding a compact and dense interior with a dry and crispy exterior.

2. MATERIALS AND METHODS

2.1 Materials

Catfish, duck fillet. Chemicals used for quality analysis and determination of the physicochemical properties of nuggets include distilled water, hexane solvent, 25% HCl, 30% NaOH, 45% NaOH, and H₂SO₄.

2.2 Methods

This research was conducted experimentally using a randomized complete block design (CRD) factorial pattern consisting of 2 factors, namely: Factor I is the proportion of catfish meat and duck meat (50:50; 60:40; 70:30) and Factor II is the addition of sodium alginate (0.5%; 0.75%; 1%). The data obtained were analyzed using ANOVA to determine the effect of treatment with 2 replicates. If a significant difference is found, further tests are conducted using the DMRT (Duncan Multiple Range Test) method at the 5% significance level.

2.3 Nugget Making

Weighing raw materials according to treatment, catfish meat and duck meat and spices are ground until smooth using a food processor, mixing flour to form nugget dough, the dough is put into a pan and steaming process is carried out at 800c for 30 to 45 minutes, the nuggets that have been steamed are then cooled to room temperature, the nuggets are cut with a size of 2 x 2 x 1 cm, the cut nuggets are coated with eggs and bread flour.

3. RESULT AND DISCUSSION

3.1. Physicochemical Characteristics of Nugget

Table 1. Analysis result of water content, ash content, fat content, and protein content.

Treatment	Moisture (%)	Ash (%)	Fat (%)	Protein (%)
A1B1	48.16 (a)	0.95 (a)	14.32 (g)	14.35 (c)
A1B2	51.95 (c)	1.04 (b)	12.25 (f)	13.65 (b)
A1B3	53.66 (d)	1.11 (c)	10.56 (de)	12.80 (a)
A2B1	49.84 (b)	1.13 (c)	11.16 (ef)	14.61 (c)
A2B2	55.00 (d)	1.15 (ef)	10.90 (e)	15.43 (d)
A2B3	57.67 (ef)	1.22 (d)	9.60 (cd)	15.59 (d)
A3B1	54.47 (d)	1.27 (de)	8.75 (bc)	17.75 (f)
A3B2	57.24 (e)	1.24 (f)	8.00 (ab)	17.52 (f)
A3B3	59.32 (g)	1.29 (g)	7.25 (a)	16.86 (e)

Description :

A1B1 = Catfish : Duck Meat (50:50) and 0.5% Sodium Alginate
A1B2 = Catfish : Duck Meat (50:50) and 0.75% Sodium Alginate
A1B3 = Catfish : Duck Meat (50:50) and 1% Sodium Alginate

- A2B1 = Catfish : Duck Meat (40:60) and 0,5% Sodium Alginate
 A2B2 = Catfish : Duck Meat (40:60) and 0,75% Sodium Alginate
 A2B3 = Catfish : Duck Meat (40:60) and 1% Sodium Alginate
 A3B1 = Catfish : Duck Meat (70:30) and 0,5% Sodium Alginate
 A3B2 = Catfish : Duck Meat (70:30) and 0,75% Sodium Alginate
 A3B3 = Catfish : Duck Meat (70:30) and 1% Sodium Alginate

The water content shows that the higher the proportion of catfish meat and the lower the proportion of duck meat, the higher the water content of the nuggets. This is because the water content in catfish is higher than that of duck meat. According to Refs. [10] and [11], the water content in catfish is 72.66%, whereas in duck meat, it is 61.00%. This difference causes catfish to contribute more to the value of the resulting water content. The higher the proportion of catfish meat added, the higher the water content value in the nuggets will also be.

Meanwhile, sodium alginate can bind water. Sodium alginate is a polysaccharide compound consisting of mannuronic and gluronic groups, these compounds can bind water and form a strong gel. According to Ref. [12]), alginate components can form complex interactions with proteins and water, resulting in strong gel properties.

The ash content shows that the higher the proportion of catfish meat and the lower the proportion of duck meat, the higher the ash content of the nuggets. This is because the ash content in catfish is higher than that of duck meat. According to Ref. [10,11], the ash content in catfish is 1.41%, and in duck meat, it is 1.39%. Therefore, as the composition of catfish meat increases, the value of ash content in nuggets also increases. Meanwhile, sodium alginate has a high ash content, which affects the final ash content of the nuggets. The high and low ash content is caused by salts and minerals, in accordang with Ref. [13], which states that the ash content contained in sodium alginate shows the presence of mineral salts with values ranging from 18% to 28%.

The fat content indicates that the higher the proportion of catfish meat and the lower the proportion of duck meat, the lower the fat content in the nuggets. And the higher the addition of sodium alginate, the lower the fat content of the nuggets. This is because the fat content in catfish is lower than that of duck meat. According to Ref [10,11] the fat content in catfish is 5.94% and duck meat is 6.25% so that duck meat has more contribution to the value of fat content, as the composition of duck meat increases, the fat content also increases, and vice versa as the increase in catfish meat, the fat content in the nuggets will decrease. While sodium alginate is a hydrocolloid that forms gel matrix bonds, these bonds function to trap nutritional components in nuggets. As a result, some fat and other components are trapped by sodium alginate, preventing them from participating in fat solvents during extraction.

The protein content shows that the higher the proportion of catfish meat and the lower the proportion of duck meat, the lower the protein content of the nuggets. According to Ref. [10] and [11], the protein content in catfish is 17.62%, and in duck meat, it is 18.07%. This causes catfish to have more contribution to the value of the resulting protein content. The higher the proportion of catfish added, the value of protein content in the nuggets will also increase. Meanwhile, the higher the addition of sodium

alginate, the lower the protein content of the nuggets. This can occur because alginate can form intermolecular gel bonds with proteins and water. The formation of an alginate gel through the cross-linking of alginate bonds creates a three-dimensional network that traps proteins.

Table 2. Analysis result of water holding capacity (WHC), and hardness

Treatment	WHC (%)	Hardness (gf)
A1B1	73.85 (a)	850.55 (d)
A1B2	75.19 (b)	979.71 (g)
A1B3	77.45 (c)	1208.05 (i)
A2B1	78.19 (cd)	786.30 (c)
A2B2	78.86 (d)	956.91 (f)
A2B3	79.88 (e)	1007.23 (h)
A3B1	80.03 (ef)	563.47 (a)
A3B2	80.41 (g)	671.90 (b)
A3B3	81.74 (h)	953.95 (e)

Description :

- A1B1 = Catfish : Duck Meat (50:50) and 0.5% Sodium Alginate
 A1B2 = Catfish : Duck Meat (50:50) and 0,75% Sodium Alginate
 A1B3 = Catfish : Duck Meat (50:50) and 1% Sodium Alginate
 A2B1 = Catfish : Duck Meat (40:60) and 0,5% Sodium Alginate
 A2B2 = Catfish : Duck Meat (40:60) and 0,75% Sodium Alginate
 A2B3 = Catfish : Duck Meat (40:60) and 1% Sodium Alginate
 A3B1 = Catfish : Duck Meat (70:30) and 0,5% Sodium Alginate
 A3B2 = Catfish : Duck Meat (70:30) and 0,75% Sodium Alginate
 A3B3 = Catfish : Duck Meat (70:30) and 1% Sodium Alginate

The water binding test shows that the higher the proportion of catfish meat and the lower the proportion of duck meat and the higher the addition of sodium alginate, the higher the water binding capacity of the nuggets. This is because catfish and duck meat contain myofibrillar proteins, which play a role in their ability to bind water. According to Ref. [14], the factors that affect water binding capacity are the arrangement of myofibril proteins, specifically actin and myosin. Meanwhile, the higher the addition of sodium alginate, the higher the value of nugget water binding capacity. The amount of water that can be retained in the product depends on the interaction between hydrocolloids, proteins, and water. A strong gel matrix can be formed when there is a charge equilibrium in the gel system. A strong gel indicates that a solid gel matrix has formed, allowing the increase in water binding capacity to coincide with the increase in sodium alginate concentration.

The hardness test shows that the higher the proportion of catfish meat and the lower the proportion of duck meat, the lower the hardness value of the nuggets. However, the higher the addition of sodium alginate, the higher the hardness value of the nuggets. This is because catfish has a lower myofibrillar protein content compared to duck meat. Ref. [15] added that myofibrillar protein can produce a more compact and denser tissue structure that can increase the strength of the gel. The moisture content of an ingredient also influences the high and low hardness values.

Meanwhile, the higher the addition of sodium alginate, the higher the hardness value of the nuggets. This is because sodium alginate has water-binding properties, which enable it to influence the texture of protein-based processed products, such as nuggets. As the amount of sodium alginate added increases, the gel matrix formed becomes stronger, allowing for the retention of more water during the cooking process.

3.2. Physicochemical Characteristics of Nugget

Table 1. Organoleptic test result of nugget.

Treatment	Colour (%)	Aroma (%)	Taste (%)	Texture (%)
A1B1	3.88	4.03	3.48	3.08
A1B2	3.76	3.84	3.92	3.76
A1B3	4.04	4.08	4.16	4.2
A2B1	3.96	3.92	3.56	3.24
A2B2	3.68	3.92	2.88	3.48
A2B3	3.68	3.84	3.44	3.8
A3B1	3.8	3.72	3.4	3.56
A3B2	3.88	4	3.64	3.76
A3B3	4.12	4.01	3.88	3.72

Description :

A1B1 = Catfish : Duck Meat (50:50) and 0.5% Sodium Alginate
 A1B2 = Catfish : Duck Meat (50:50) and 0,75% Sodium Alginate
 A1B3 = Catfish : Duck Meat (50:50) and 1% Sodium Alginate
 A2B1 = Catfish : Duck Meat (40:60) and 0,5% Sodium Alginate
 A2B2 = Catfish : Duck Meat (40:60) and 0,75% Sodium Alginate
 A2B3 = Catfish : Duck Meat (40:60) and 1% Sodium Alginate
 A3B1 = Catfish : Duck Meat (70:30) and 0,5% Sodium Alginate
 A3B2 = Catfish : Duck Meat (70:30) and 0,75% Sodium Alginate
 A3B3 = Catfish : Duck Meat (70:30) and 1% Sodium Alginate

The results of organoleptic testing of nugget aroma showed that the proportion of 70% catfish meat and 30% duck meat, combined with the addition of 1% sodium alginate, produced the highest number of ratings according to the panellists. The treatment received an average value of 4.12 and was classified as “slightly like” according to the panelists. This is because a colour change occurs during the heating process. According to the statement by Ref. [16], the heating process results in a brown colour change in the nuggets due to the Maillard reaction. The Maillard reaction is a reaction between reducing sugars and amino acids that occurs upon heating. The Maillard reaction is crucial in the formation of flavour and colour in food products. The addition of sodium alginate did not affect the colour of the nuggets. According to Ref. [17], hydrocolloid does not contain volatile ingredients that can cause colour or aroma in the final product.

The results of organoleptic testing on the aroma of nuggets showed that the treatment with a proportion of 50% catfish meat and 50% duck meat, combined with the addition of 1% sodium alginate, received the highest number of ratings from the panellists. The treatment received an average value of 4.08 and was classified as “slightly like” according to the panelists. This is

because the treatment produces an aroma that is not fishy. According to Ref.[18], catfish contains hydrogen sulfide, methyl mercaptan, and dimethyl sulfide, which contribute to the aroma of the fish in the product. Ref. [19], added that the aroma in nuggets comes from volatile compounds found in fish meat and added spices. Volatile compounds are substances that readily evaporate when the temperature increases [20]. The addition of sodium alginate does not affect the aroma of the nuggets. According to Ref. [21], hydrocolloids do not contain volatile ingredients that can cause aroma or color in the final product.

The results of organoleptic testing on the taste of nuggets showed that the treatment with a proportion of 50% catfish meat and 50% duck meat, combined with the addition of 1% sodium alginate, produced the highest number of ratings among the panellists. The treatment received an average value of 4.16 and was classified as “slightly like” according to the panelists. This is because the proportions used are the same (50:50) as those in other treatments. Catfish and duck have a distinctive, savoury taste, ensuring the resulting product is not bland. Ref supports this. [22], which states that animal food contains protein and fat that can produce a savoury and delicious taste. The treatment that involved adding 1% sodium alginate produced the highest value, with an average value of 4.16. The addition of alginate did not affect the flavour of the nuggets. This is following Simanulang [23], which states that sodium alginate does not affect the taste of nugget products. The addition of spices influences the taste of nuggets.

The results of organoleptic testing of nugget texture showed that the treatment with a 50% catfish meat and 50% duck meat proportion, combined with the addition of 1% sodium alginate, received the highest number of ratings from the panellists. The treatment received an average value of 4.2 and was classified as “slightly like” according to the panelists. This is because the proportion of duck meat is higher than that of catfish meat, resulting in a denser texture. Sodium alginate has water-binding properties that can affect the texture of protein-based products, such as nuggets. As the amount of sodium alginate added increases, the gel matrix formed becomes stronger, allowing for the retention of more water during the cooking process.

4. CONCLUSION

There is a significant interaction between the proportions of catfish and duck meat and the addition of sodium alginate on the parameters of water content, ash content, fat content, protein content, hardness, water binding capacity. The treatment of the proportion of catfish: duck meat (70: 30) and the addition of 1% alginate is the best treatment with the value of water content (59.32%), ash content (1.28%), fat content (8.75%), protein content (16.86%), texture value (563.470 gf), water binding capacity (81.74%), hedonic organoleptic test with an average color of 4.12 (slightly like), aroma 4.01 (slightly like), taste 3.88 (like), texture 3.72 (like).

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