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The Effect of Tomato Paste Addition on the Quality of Catfish Nuggets and the Estimation of Shelf Life by the ASLT (Accelerated Shelf-Life Testing) Method Based on the Arrhenius Approach.

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A B S T R A C T

Catfish nuggets are a type of processed restructured fish meat, namely catfish meat (Clarias sp), which is ground and seasoned, steamed, then covered with flour adhesive, breadcrumb coating (breading), and fried. In this research, the manufacture of catfish nuggets with the addition of tomato paste was studied. Tomato paste is used to improve color, texture, fiber addition, and the addition of antioxidant compounds in catfish nuggets. The purpose of this study was to determine the effect of the addition of tomato paste on the quality and organoleptic properties of catfish nuggets and to estimate the shelf life of catfish nuggets products with the addition of tomato paste in the best treatment. This study used a single-factor Completely Randomized Design (CRD) with three replications. Where the factor is the concentration of tomato paste added consisting of six levels (0%, 10%, 15%, 20%, 25%, 30% w/b). Data were analyzed using ANOVA and BNT further test at 5% level and organoleptic test using a scoring test with 25 trained panellists. The treatment of adding 30% concentration of tomato paste is the best treatment that produces tomato paste catfish nuggets with a moisture content of 59.974% ± 0.495, ash content of 1.991% ± 0.120, the protein content of 7.840% ± 0.092, the fat content of 1.583% ± 0.271, carbohydrate content 28.612% ± 0.742, crude fibre content 0.413% ± 0.025, vitamin C content 4.713 mg/100g ± 0.042, and organoleptic test colour 4.36 (slightly yellow), texture 4.44 (slightly chewy), aroma 3.84 (slightly pleasant) and taste 3.92 (slightly savoury). The best catfish nuggets with 30% paste addition had a shelf life of 12 days at 25°C, a shelf life of 94 days at 3°C, and a shelf life of 474 days at -12°C.

1. INTRODUCTION

1.1. Research Background

Meat is one of the important food ingredients to fulfill the human body's nutritional needs. In addition to the high level of protein quality in meat, there is also a balanced and complete essential amino acid content. However, meat is basically easily damaged. Therefore, it requires preventive measures, one of which is by creating innovations in the field of processing. One of the products of meat processing technology that is quite developed is making nuggets. Nuggets can usually be made from various types of meat, including catfish meat mixed with other ingredients and seasonings that are still permitted for consumption.

Catfish is one source of protein that is relatively cheaper than meat. Catfish production has increased every year, proven by [1] that catfish production in Indonesia has increased since 2010 to 2013. In 2011, it increased by 39% from the previous year; in 2012, it increased by 30% from the previous year; and in 2013, it increased by 41.8%. To compensate for the increasing amount of production, it is necessary to diversify the processed catfish products, one of which is nuggets. Nuggets include ready-to-eat foods that are consumed by the middle level of society. In addition to raw materials, additional ingredients for making nuggets are also very important. Each variation of raw materials, additives, and formulation methods produces different qualities, with the hope of obtaining quality products. Nugget is usually used as a single side dish for children because it has nutritional content such as water content, protein content, carbohydrates, and fat content.

Catfish nuggets can be added with other food ingredients, such as tomatoes, which can increase fiber content and can make catfish nuggets have better nutritional value. Research [2] shows that in 180 g of fresh tomatoes, there is 1.98 g of fiber content; in other words, the fiber content is 1.10% (b / b).

Tomatoes are one of the foods that are good for health and have many benefits. In addition to having relatively high fiber content, tomatoes also have other advantages, namely high vitamin C content and high lycopene content that can prevent people from getting cancer. Innovation in the form of tomato addition is expected to improve the quality in terms of protein, fat, fiber and active substances contained in catfish nuggets. In addition to good nutritional content, tomatoes have an attractive color, the red color makes tomatoes have their own charm. In addition, tomatoes have a dominant organic acid content, namely citric acid and malic acid. The content of citric acid and malic acid makes tomatoes an acidulant material that can function to acidify, maintain the acidity of processed food ingredients, as a flavor, color, and preservative, and eliminate fishy taste in nuggets.

Tomatoes have a high water content of about 95 grams/100 grams so it is necessary to make tomato paste because it will affect the physical quality and organoleptic assessment of catfish nuggets to consumers. Tomato paste is a tomato concentrate containing 24% or more soluble solids of natural tomatoes. According to Ref. [3], the increase in tomato paste level is very significant at 10% and 15%, namely improving the quality of chewiness (10% = 4.10) (15% = 4.19), color (10% = 2.62) (15% = 2.88), taste (10% = 3.90) (15% = 4.04), and liking (10% = 3.80) (15% = 4.23), but has no effect on the aroma test. Increasing the level of tomato paste to 15% was the best treatment in the organoleptic test..

The addition of young tomatoes to nugget products in certain concentrations can increase the savory taste of the product because young tomatoes have a lower water content than old tomatoes. However, the addition of too much tomato paste will affect the taste that is too sour, so consumers do not like it. Therefore, it is necessary to conduct research on the addition of tomato paste to catfish nuggets with various concentrations. Catfish nuggets added with tomato paste, in addition to increasing the nutritional value and organoleptic properties of consumers, are also expected to increase shelf life due to the presence of acidic acid content in tomatoes.

Based on the description above, innovation in the form of adding tomato paste at certain levels is expected to improve the quality of catfish nuggets in terms of consumer liking and can increase the shelf life of the product. Therefore, the author is interested in conducting research and further examining "The Effect of Tomato Paste Addition on the Quality of Catfish Nuggets and Estimating Shelf Life with the ASLT (Accelerated Shelf-Life Testing) Method Based on the Arrhenius Approach."

1.2. Literature Review

Catfish nuggets are a type of processed fish meat restructuring, namely fish meat that is ground and seasoned, steamed then covered by flour adhesive, breadcrumb coating (breading), and fried [4]. In frying nuggets, it takes 1 minute at 150°C. Nugget itself is basically a Structured meat product that uses meat processing techniques by utilizing low-quality meat or relatively small and irregular pieces of meat, then reattached to a larger size [2].

Tomato fruit is used as one of the raw materials for making pasta because of its antioxidant content contained in tomatoes which is very good for the body. Antioxidants that are often obtained from food intake contain vitamin C, vitamin E, vitamin A, beta carotene, phenolic compounds, and carotenoid compounds [5]. The use of tomato paste as an additional raw material for making catfish nuggets is because tomato paste contains low amounts of fat and calories, is cholesterol-free, contains many antioxidant compounds, and is a good source of fiber and protein. In addition to that content in terms of organoleptic, tomatoes have an attractive color, the red color of tomatoes formed from the presence of carotenoid pigments, namely lycopene and β-carotene, has its own charm.

The addition of tomato paste to nuggets also affects the water content of the product to be high because tomato paste has a high water content of 93.80% [6], so the more tomato paste added, the higher the water content in the material. The high water content in the nuggets can be caused because the water content in the tomatoes mixes with the catfish nugget dough added with flour, flour functions as a binder. Binders are ingredients used in food to bind the water contained in the dough. Flour as a filling material contains starch in the form of amylopectin which will bind water when heated. The nature of starch has the ability to absorb water because it has hydroxyl groups. Starch molecules contain very large hydroxyl groups, so their ability to absorb water is also large. If the concentration of starch is greater, the greater the hydroxyl group and its ability to absorb water. In addition, the function of binders is to improve emulsion stability, reduce shrinkage due to cooking, give color, give a solid texture, and draw water from the dough.

Previous research conducted by Ref [7] showed that the higher the addition of tomato paste, namely 15%, made the crude fibre content in chicken nuggets increased. The increase in fiber content is caused by the low fiber content in chicken meat so that after adding tomato paste, the fiber content in chicken nuggets increases. Tomatoes have fiber content that can bind water in the nugget matrix and the protein content in tomato paste also plays a role in the ability to retain water in food ingredients. This is in line with the opinion of Ref. [8] that the higher the protein contained in a material, the greater the ability to bind water.

Estimating the shelf life of food products can be done by conventional/traditional methods commonly referred to as the ESS (Extended Storage Studies) method or using accelerated methods, namely the ASLT (Accelerated Shelf-Life Testing) method. Conventional shelf life estimation is done by storing the product in everyday conditions until it reaches the expiration date. This method is considered to require a long time and expensive analysis costs, but it is very accurate and precise. At the same time, the accelerated method can be done in a shorter time with good accuracy [9]. The characteristic parameters used can be physical, chemical, microbiological, or sensory acceptance responses to the product being tested [10]. However, microbiological parameters are one of the parameters that can show quality degradation accurately and quickly. This is supported by [11], one indicator of damage to food products is when the number of microorganisms that grow exceeds the set limit. At a certain limit, the microbial content of food does not have much effect on the durability of the food. However, if environmental conditions allow microbes to grow and develop faster, the food will be damaged.

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Acceleration methods can be approached using the Arrhenius model and the critical moisture content model. The Arrhenius model is used for products that are sensitive to changes in storage temperature, while the critical moisture content model is used for products that are easily damaged due to water absorption from the environment during storage. The application of the acceleration method needs to pay attention to the characteristics and causes of damage to the product whose shelf life will be determined. Shelf life is determined based on the factors that most affect the product. Factors that can affect the shelf life of a product include temperature. Determination of shelf life with temperature limiting factors can be done with the Arrhenius quality deterioration kinetics approach [12].

The Arrhenius model is generally used to estimate the shelf life of food products sensitive to temperature changes, including those prone to rancidity (fat oxidation), discoloration by browning reactions, or vitamin C damage. In principle, the Arrhenius method is carried out by storing food products at extreme temperatures, where damage to food products occurs more quickly, and then the shelf life is determined based on extrapolation to the storage temperature. Temperature can affect microorganisms in two ways: if the temperature rises, the metabolic rate rises, and growth is accelerated, and vice versa. If the temperature drops, the metabolic rate also drops, and growth is slowed. Cold and freezing storage can also destroy spoilage microbes. At cold and freezing temperatures, there is an increase in the concentration of intracellular solids, resulting in physical and chemical changes in microbial cells, and growth will stop, and slowly, microorganisms begin to stop [9].

1.3. Research Objective

This study aims to determine the effect of tomato paste addition on the quality and organoleptic properties of catfish nuggets, determine the best percentage of tomato paste addition in making catfish nuggets, and estimate the shelf life of catfish nuggets products with the addition of tomato paste in the best treatment at different temperature conditions.

2. MATERIALS AND METHODS

2.1. Materials and Tools

The materials used in this study were catfish, tomato, wheat flour, bread flour, flavouring, salt, onion, garlic, pepper, and ice. Materials used for analysis are distilled water, iodine solution, H2SO4, NaOH. Formaldehyde, HCl, phenol red indicator, pH 4 buffer solution, pH 7 buffer solution, Trichloro Acetic Acid (TCA) solution, Plate Count Agar (PCA).

The tools used in this study are tools for processing and tools for analysis. The equipment used for nugget processing consists of a blender, stove, steamer, scales, baking sheet, pan, cutting board, knife. The equipment used for analysis is an autoclave, incubator, distillation device, oven, furnace, analytical scales, porcelain cup, erlenmeyer, test tube, pipette, filter paper, watch glass, weighing bottle, funnel.

2.2. Design Experiment and Analysis

This research was conducted in two stages of research, namely stage one research and stage two research. Phase one research is to determine the addition of quality to catfish nuggets added with tomato paste by analyzing water content, ash content, fat content, protein content, carbohydrate content, crude fiber content, and vitamin C. Organoleptic test of color, texture, aroma, and taste. The process of making catfish nuggets with the addition of tomato paste uses a single-factor Completely Randomized Design (CRD), where the factor is the concentration of tomato paste added consisting of six levels (0%, 10%, 15%, 20%, 25%, 30%, %), with each treatment carried out 3 replications. The data obtained were processed using Analysis of Variance (ANOVA) at the 5% level if there were significant differences, further tests were carried out using the LRD (Least Real Difference) method at the 5% level. Organoleptic test using Scoring Test with 25 trained panelists.

The second stage of research is estimating the shelf life of catfish nuggets using the Arrhenius method with TPC (Total Plate Count) parameters. The catfish nugget products to be observed were divided into three temperature conditions: storage at -12°C, storage at 3°C, and storage at 25°C.

2.3. Implementation of Research

2.3.1. Tomato Paste Preparation

The first step is washing the tomatoes, then soaking them in hot water at a temperature of ± 100 ºC for ± 3 minutes. Furthermore, tomatoes, after soaking, are crushed in a blender until the texture is like porridge.

2.3.2. Catfish Nugget with Tomato Paste Addition

The procedure for making catfish nuggets with the addition of tomato paste is as follows, 300 grams of catfish fillet meat is mashed in a blender along with spices, namely 5 grams of salt, 5 grams of garlic, 5 grams of shallots, and 2 grams of ground pepper. The ground meat and tomato paste will then be homogenized using a blender by adding 125 grams of eggs, 150 grams of wheat flour, 100 grams of tapioca flour, ± 40 grams of ice cubes.

The dough that has been homogenized is continued to print the dough in a pan and steamed at 100ºC for 30 minutes, then remove and place at room temperature for 30 minutes, cut the nuggets into a square shape and give egg yolk and panir flour. After that, store in the freezer for 24 hours and then do the test analysis, namely analysis of water content 13], ash content [13], protein content [14], fat content [14], carbohydrate content [15], crude fiber content [15], and vitamin C content [13]. organoleptic analysis, namely texture, aroma, color, and taste.

2.3.3. Estimation of Shelf Life

Shelf life estimation test using Arrhenius model application with total bacteria parameter using TPC (Total Plate Count) method. The catfish nugget products to be observed were divided into three storage temperature treatments. The first temperature is storage at freezing temperature, which is -12°C, the second is storage at cold temperature, which is 3°C, and the third is storage at room temperature, which is 25°C.

3. RESULT AND DISCUSSION

3.1. Water Content

Analysis of water content values Table 1. shows that the higher the treatment of tomato paste addition, the water content value of catfish nuggets will also increase. The average moisture content

of catfish nuggets ranged from 53.310%-59.974%. The treatment of 0% tomato paste addition produced the lowest moisture content of 53.310% and the treatment of 30% tomato paste addition produced the highest moisture content of 59.974%.

Table 1. Average Value of Water Content of Catfish Nuggets

Treatment of Tomato Paste Addition (%)	Water Content (%)	
	Average	Notations
0%	53.310 ± 0.428	d
10%	53.663 ± 0.457	d
15%	54.934 ± 0.317	c
20%	54.869 ± 0.317	c
25%	55.858 ± 0.508	b
30%	59.974 ± 0.495	a

Note: Mean values accompanied by different letters indicate significant differences (p≤0.05)

The moisture content produced has met the nugget quality standard [16], which is a maximum of 60%. The value of water content in catfish nugget samples tends to increase along with the increase in the addition of tomato paste. This is because tomatoes have a high water content of 93.80% [7], so the more tomato paste added, the higher the water content in the material. The high water content in the nuggets can be caused by the reduction of dry matter due to the increasing water content contained in it.

The water content in tomatoes mixes with catfish nugget dough added with flour, where wheat flour and tapioca flour are binding ingredients. This is in line with the opinion of Ref. [17] in Ref. [2] that binders are ingredients used in food to bind the water contained in the dough. Flour as a filling material contains starch in the form of amylopectin which will bind water when heated. This is in accordance with Ref. [18], that starch has the ability to absorb water because it has hydroxyl groups. Starch molecules contain very large hydroxyl groups, so their ability to absorb water is also large. If the concentration of starch is greater, the greater the hydroxyl group and its ability to absorb water. In addition, the function of binders is to improve emulsion stability, reduce shrinkage due to cooking, give colour give a solid tester and draw water from the dough.

3.2. Ash Content

Based on Table 2. it can be seen that the treatment of tomato paste addition has a significant effect on the ash content of catfish nuggets. The higher the addition of tomato paste, the ash content of catfish nuggets will also increase. The average ash content of catfish nuggets ranged from 1.480%-1.991%. The 0% tomato paste addition treatment produced the lowest ash content of 1.480% and the 30% tomato paste addition treatment produced the highest ash content of 1.991%.

Table 2. Average Value of Ash Content of Catfish Nuggets

Treatment of Tomato Paste Addition (%)	Ash Content (%)	
	Average	Notations
0	1.480 ± 0.094	c
10	1.540 ± 0.134	c
15	1.643 ± 0.097	bc
20	1.754 ± 0.107	b
25	1.767 ± 0.126	b
30	1.991 ± 0.120	a

Note: Mean values accompanied by different letters indicate significant differences (p≤0.05)

The higher the addition of tomato paste causes the ash content of catfish nuggets to increase. This can be caused because the raw material of tomato paste is high in minerals. According to [19], 100 grams of ripe tomatoes contain 7.85 mg of lycopene, 12 mg of vitamin K, 20 mg of vitamin C, folic acid, 0.06 mg of vitamin B1, B6, and minerals (0.5 mg of iron and 5 mg of calcium), which causes more inorganic minerals to remain from the combustion process. The results showed that the ash content of each treatment in catfish nuggets with the addition of tomato paste met the standard [16] regarding the quality requirements for ash content of fish nuggets, which is a maximum of 2.5%.

3.3. Protein Content

Analysis of protein content Table 3. shows that the treatment of tomato paste addition significantly affects the protein content of catfish nuggets. The higher the addition of tomato paste, the protein content of catfish nuggets will decrease. The average protein content of catfish nuggets ranged from 7.840%-9.983%. The treatment of 0% tomato paste addition produced the highest protein content of 9.983% and the treatment of 30% tomato paste addition produced the lowest protein content of 7.840%.

The higher the addition of tomato paste causes the protein content of catfish nuggets to decrease. This is because the protein content of tomato paste is lower than the protein content of catfish meat, so after being added, it will cause a reduction in the percentage of protein in catfish nuggets. The same results were stated by [20] who conducted research on the addition of pumpkin to chicken sausage, namely the decrease in protein levels with the higher addition of pumpkin, this is thought to be due to the low protein content in the pumpkin so that after being added to chicken sausage causes the percentage of protein to decrease.

Table 3. Protein Content of Catfish Nuggets

Treatment of Tomato Paste Addition (%)	Protein Content (%)	
	Average	Notations
0	9.983 ± 0.081	a
10	9.163 ± 0.156	b
15	9.037 ± 0.186	b
20	8.340 ± 0.191	c
25	8.070 ± 0.132	d
30	7.840 ± 0.092	d

Note: Mean values accompanied by different letters indicate significant differences (p≤0.05)

In addition, the decrease in protein content is also influenced by the increase in product water content, in accordance with [21] which states that the shrinkage of food water, it will increase the protein content of the material, and if the opposite happens, the higher the water content, the lower the protein content. The protein content of all treatments has met [16] which is at least 5%.

3.4. Fat Content

Based on Table 4. shows that the treatment of tomato paste addition has a significant effect on the fat content of catfish nuggets. The higher the addition of tomato paste, the lower the fat content of catfish nuggets. The average fat content of catfish nuggets ranged from 1.583%-3.307%. The treatment of 0% tomato paste addition produced the highest fat content of 3.307% and the treatment of 30% tomato paste addition produced the lowest fat content of 1.583%.

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Table 4. Fat Content of Catfish Nuggets

Treatment of Tomato Paste Addition (%)	Fat Content(%)	
	Average	Notations
0	3.307 ± 0.180	a
10	2.777 ± 0.199	b
15	2.470 ± 0.296	b
20	2.027 ± 0.289	c
25	1.827 ± 0.110	cd
30	1.583 ± 0.271	d

Note: Mean values accompanied by different letters indicate significant differences (p≤0.05)

The higher addition of tomato paste causes the fat content of catfish nuggets to decrease. The decrease is caused by the low fat content of tomato paste so which if added to catfish meat will reduce the percentage of fat content in catfish nuggets. The high water content contained in tomatoes also affects the fat content of the nuggets, where the higher the water content contained therein, the fat content of the product will decrease [22]. The decrease in fat content in the product can be caused by a decrease in the ability of water to evaporate so that the water content in the product is still high, which causes there to be no free space for oil absorption during frying [23].

In line with research [24] regarding the addition of vegetables to beef burgers which states that the addition of vegetables in the form of peas and carrots significantly reduces the fat content of beef burgers. The addition of 30% tomato paste can be said to be the best because it contains the lowest fat content of 1.583%, and in accordance with the recommendations of [16], which is a maximum of 15% in this study, the higher addition of tomato paste gives the best results.

3.5. Carbohydrate Content

The results of the analysis of the average carbohydrate content of catfish nuggets (Table 5) ranged from 28.612% to 33.009%. The treatment of adding 20% tomato paste produced the highest carbohydrate content of 33.009%, and the treatment of adding 30% tomato paste produced the lowest carbohydrate content of 28.612%.

Table 5. Average Value of Carbohydrate Content of Catfish Nuggets

Treatment of Tomato Paste Addition (%)	Carbohydrate Content (%)	
	Average	Notations
0	31.920 ± 0.469	b
10	32.856 ± 0.557	a
15	31.916 ± 0.129	b
20	33.009 ± 0.137	a
25	32.478 ± 0.530	ab
30	28,612 ± 0,742	c

Note: Mean values accompanied by different letters indicate significant differences (p≤0.05)

The results of the calculation of carbohydrate content in this study showed that the highest carbohydrate content was in the 20% sample and the lowest was in the 30% sample, this is because the carbohydrate control is obtained from the components of water content, ash content, fat content and protein content. carbohydrate content produces a non-linear graph because the method used is Carbohydrate by Difference so that if the water, ash, protein, and fat content increases, the carbohydrate content will decrease, therefore this method is influenced by water, ash, protein, and fat content in the product [25]. According to Ref. [16], there is no minimum limit on how much carbohydrate content in fish nugget products, but according to the AKG, the carbohydrate requirement for adolescents and adults is 100g/org/day. So it can be said that the sample of catfish nuggets adding tomato paste is still able to meet daily nutritional needs.

3.6. Crude Fiber Content

The results of the analysis of fiber content showed that the higher the addition of tomato paste, the crude fiber content will increase. Tomato paste treatment also significantly affects the value of crude fiber content. The average crude fiber content of catfish nuggets ranged from 0.203% - 0.413%. The treatment of adding tomato paste with 0% concentration produced the lowest crude fiber content of 0.203% and the treatment of adding 30% tomato paste produced the highest crude fiber content of 0.413%.

Table 6. shows that the higher addition of tomato paste causes the crude fiber content of catfish nuggets to increase. The increase in fiber content is caused by the low fiber content in catfish meat, so after adding tomato paste, the fiber content in catfish nuggets increases. This supports research [26] suggested in his research on the effect of the addition of vegetables (carrots, turnips and capsicum) as functional ingredients in mutton nuggets, namely the addition of these ingredients by 10% has the potential to increase fiber content and active substances such as β carotene and carotenoids, further supported by research Ref. [7] showing that the higher the addition of tomato paste, which is 15%, makes the crude fiber content in chicken nuggets increase.

The increase in fiber content is caused by the low fiber content in catfish meat so that after adding tomato paste, the fiber content in catfish nuggets increases. The addition of 30% tomato paste can be said to be the best because it contains the highest crude fiber content of 0.413%.

Table 6. Average Value of Crude Fiber Content of Catfish Nuggets

Treatment of Tomato Paste Addition (%)	Crude Fiber Content (%)	
	Average	Notation
0	0.203 ± 0.023	E
10	0.243 ± 0.021	D
15	0.263 ± 0.012	D
20	0.307 ± 0.021	C
25	0.347 ± 0.025	B
30	0.413 ± 0.025	A

Note: Mean values accompanied by different letters indicate significant differences (p≤0.05)

3.7. Vitamin C Content

The results of the analysis showed that the treatment of tomato paste addition had a significant effect on the vitamin C content of catfish nuggets. The higher the addition of tomato paste, the higher the vitamin C content of catfish nuggets. The average value of vitamin C content of catfish nuggets ranged from 3.823 - 4.713 mg/100g. The treatment of adding tomato paste with 0% concentration produces the lowest vitamin C content of 3.823 mg/100g and the treatment of adding 30% tomato paste produces the highest vitamin C content of 4.713 mg/100g.

Table 7. Average Value of Vitamin C Content of Catfish Nuggets

Treatment of Tomato Paste Addition (%)	Vitamin C Content (mg/100g)	
	Average	Notation
0	3.823 ± 0.061	d
10	4.100 ± 0.144	c
15	4.240 ± 0.075	bc
20	4.347 ± 0.055	b
25	4.410 ± 0.185	b
30	4.713 ± 0.042	a

Notes: Mean values accompanied by different letters indicate significant differences (p≤0.05)

Based on Table 7, it can be seen that the higher the addition of tomato paste, the higher the vitamin C content of catfish nuggets. The increase in vitamin C levels is due to the very low levels of vitamin C in catfish meat, so after adding tomato paste, the levels of vitamin C in catfish nuggets increase.

However, vitamin C is very easily damaged by processing, cooking, and long storage. This supports research [39] that the decrease in vitamin C content is due to the evaporation or diffusion of water and the nature of vitamin C which is easily soluble in water. This is in line with the opinion of [27] showing that vitamin C is easily damaged by processing, cooking, long storage, and various food technology processes so that the vitamin C left behind is much smaller than the vitamin C content in fresh food ingredients. Vitamin C is easily soluble in water, so in slicing, washing, and boiling food sources of vitamin C, most of the vitamin C will be lost. The decrease in vitamin C content after the heating process is due to the presence of vitamin C which is oxidized to form dehydroascorbic acid. With increasing temperature, the oxidation process of vitamin C accelerates, but the stability of vitamin C usually increases with decreasing storage temperature.

3.8. Hedonic Test

Hedonic testing was conducted on the color, texture, aroma, and taste parameters of catfish nugget samples with 25 semi-trained panelists. Table 8 shows the average results of the panelists' favorability.

Table 8. Mean value Hedonic test of catfish nuggets

Sample	Color	Texture	Aroma	Taste
0%	1.96 ± 0.79^{e}	2.52 ± 0.77^{d}	2.2 ± 0.71^{d}	3.00 ± 0.87^{c}
10%	2.56 ± 0.82^{d}	2.6 ± 0.76^{d}	2.8 ± 0.91^{c}	2.44 ± 0.82^{d}
15%	2.32 ± 0.69^{de}	3.08 ± 0.81^{c}	2.93 ± 0.86^{bc}	2.84 ± 0.85^{cd}
20%	3.08 ± 0.81^{c}	3.64 ± 0.86^{b}	3.4 ± 0.87^{ab}	3.2 ± 0.87^{c}
25%	3.84 ± 0.75^{b}	4.24 ± 0.83^{a}	3.68 ± 0.95^{a}	4.44 ± 0.87^{a}
30%	4.36 ± 0.64^{a}	4.44 ± 0.71^{a}	3.84 ± 0.85^{a}	3.92 ± 0.86^{b}

Note: Mean values accompanied by different letters indicate significant differences (p≤0.05)

Panelists most liked catfish nuggets with a color level of 4.36, which is slightly yellow in the treatment of adding tomato paste with a concentration of 30%. The texture parameter of the panelists liked the catfish nuggets the most with an average favorability level of 4.44, namely a slightly chewy texture obtained by the treatment of adding tomato paste with a concentration of 30%. In the aroma parameter, panelists liked the catfish nuggets the most with an average value of 3.84, which is a rather pleasant aroma obtained by the treatment of adding tomato paste with a concentration of 30%. While in the taste parameter, panelists liked catfish nuggets the most with an average liking level of 4.44, which has a rather savory taste obtained in the treatment of adding tomato paste with a concentration of 25%.

3.9. Analysis of The Best Treatment

The sample with a 30% concentration of tomato paste addition was the best treatment in this study. So, we continued with the estimation of shelf life with the Accelerated Shelf Life Testing (ASLT) method of the Arrhenius model of total bacteria with the Total Plate Count (TPC) method.

Based on the results of the analysis, it can be seen that the number of TPC of catfish nuggets with the addition of 30% tomato paste increased along with the length of storage and storage temperature. Storage at high temperatures causes the total number of microbes to be high. The total number of microbes stored on day 0 in all temperature treatments was the same as 3 x 10 colonies/g. According to the quality requirements of catfish nuggets [16], the maximum number of molds in dodol is 5 x 104 colonies/g, so the storage of catfish nuggets on day 12 at 3ºC is considered still suitable for consumption, while at 25ºC on day 9 it is said to be unfit for consumption.

The shelf life of catfish nuggets stored at -12ºC is 474 days; those stored at 3ºC are 94 days, while the shelf life of catfish nuggets stored at 25ºC is 12 days. The number of microbes stored at -12ºC, 3ºC, and 25ºC increased with the length of storage time. Most microbial growth is found in catfish nuggets stored at 25ºC, so the microbes that grow on catfish nuggets are categorized as mesophilic microbes that grow well at temperatures of 25-30ºC. The results of shelf life estimation can be seen in Table 9.

Table 9. Shelf Life Estimation Results

Calculation of k values at specific Storage temperatures			
Ordo 0			
Temperature (ºC)	-12	3	25
Temperature (K)	261	276	298
1/T	0.003831	0.003623	0.003356
ln k	2.970659	4.58758	6.664617
K	19.50477	98.25633	784.1634
T	474.0892	94.11098	11.79218
Expiration time	474 days	94 days	12 days
	1 year 3 months 19 days	3 months 4 days	12 days

The results of the research estimating the shelf life of catfish nuggets showed that based on the total microbial parameters (TPC) the longest shelf life of catfish nuggets was catfish nuggets stored at -12ºC. The use of room temperature in the study is only limited to a reference to accelerate the occurrence of damage reactions in catfish nuggets so that the shelf life can be predicted,

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in accordance with the theory of the Arrhenius method where the use of extreme temperatures is intended to accelerate the reaction of damage to the product so that the shelf life of the product can be simulated. The constant rate of quality deterioration based on the number of TPC increases with each increase in storage temperature, which causes the estimation of the shelf life of catfish nuggets at higher temperatures to spoil faster.

4. CONCLUSION

The treatment of adding tomato paste to catfish nuggets has a significant effect on chemical characteristics, namely water content, ash content, protein, fat, carbohydrates, crude fiber, and vitamin C. As well as on organoleptic characteristics, namely color, texture, aroma, and taste. As well as on organoleptic characteristics, namely color, texture, aroma, taste. The treatment of adding 30% concentration of tomato paste is the best treatment that produces tomato paste catfish nuggets with a moisture content of 59.974%, ash content of 1.991%, protein content of 7.840%, fat content of 1.583%, carbohydrate content of 28.612%, crude fiber content of 0.413%, vitamin C content of 4.713 mg/100 g, and organoleptic test of color 4.36 (slightly yellow), texture 4.44 (slightly chewy), aroma 3.84 (slightly tasty) and taste 3.92 (slightly savory). The best catfish nuggets with 30% paste addition had a shelf life of 12 days at 25ºC, 94 days at 3ºC, and 474 days at -12ºC.

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