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Effect of Sodium Alginate and Coconut Shell Liquid Smoke Concentration on the Characteristics of Restructuring Catfish (*Pangasius* sp.) Jerky

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A B S T R A C T

Restructuring is the process of recombining crushed materials into new products with the help of binding agent. The use of sodium alginate as a binding agent and the addition of liquid smoke are expected to improve the character of catfish jerky during restructuring. The purpose of this study was to determine the effect of sodium alginate and liquid smoke addition to physical, chemical and organoleptic properties on the quality of restructuring catfish jerky. This study used a Complete Randomised Design factorial pattern with two factors: calcium alginate concentration (0,5%, 0,75%, 1%) and liquid smoke concentration (1%, 2%, 3%). The data obtained were then analysed using analysis of variance (ANOVA). If there were differences, the Duncan multiple-range test (DMRT) was used. The research results indicate that there was an interaction between sodium alginate concentration and liquid smoke concentration, with both significantly affecting the yield, moisture content, ash content, protein content, and hardness of the restructured catfish jerky produced. Sensory evaluation showed significant effects on texture, taste, and colour parameters, but no significant effect on aroma.

Contribution to Sustainable Development Goals (SDGs):

SDG 6: Clean Water and Sanitation

SDG 11: Sustainable Cities and Communities

SDG 13: Climate Action

SDG 15: Life on Land

1. INTRODUCTION

1.1. Research Background

Catfish is a fishery product with a very large market share, both domestically and internationally. This is due to the delicious taste of catfish and its relatively low price. Based on the nutritional analysis, catfish contains 16.08% protein, approximately 5.75% fat/oil, 1.5% carbohydrates, 0.97% ash, and 75.7% water [1]. However, processed products made from catfish remain low, given that catfish cultivation costs increase each year. It is therefore necessary to develop catfish-based processed products, including catfish jerky.

1.2. Literature Review

The term jerky is often used for "dry cured meat" which is characterized by low moisture and high protein content. Restructuring refers to the process of breaking small pieces of meat and reforming them into either the same or a new form [2]. Catfish jerky is a product made by processing catfish meat using the restructuring method, which uses pieces of meat with relatively small, irregular sizes and glues them back together into a larger size with a binder. One of the binders that can be used in making catfish jerky is sodium alginate. Sodium alginate has the ability to form a gel without a heating process when it interacts with polyvalent cations (except magnesium), especially calcium. The ability of alginate to form a gel is then used as a binder in the



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food industry, such as a binder for particles in restructured meat [3]. However, the addition of alginate to food ingredients can increase water content and shorten product life, so it is necessary to add liquid smoke, which can bind free water [4].

Coconut shells are widely used to produce liquid smoke because the wood's lignin, cellulose, and methoxyl content provide good organoleptic properties [5]. Coconut shell liquid smoke has various functional properties, among others, including the ability to add the desired flavour and colour, which is imparted by phenols and carbonyls. The phenol content in coconut shell liquid smoke has antioxidant properties that can help prevent food damage by donating very small amounts of hydrogen to inhibit fat auto-oxidation. The acids contained in liquid smoke are also effective in inhibiting or killing microbes during storage [6]. Adding liquid smoke at different concentrations can affect the chemical properties of the product, such as water, ash, fat, protein, and carbohydrate content, as well as organoleptic value.

The research results of Lestario et al. [7] showed that adding 1% sodium alginate provided the best treatment results for restructured dried fruit. The immersion treatment of liquid smoke into beef jerky at a concentration of 1% produces the best results [8]. Based on the description above, it is necessary to research the effect of adding sodium alginate and liquid smoke on the characteristics of restructured catfish jerky.

1.3. Research Objective

This research aims to determine the effect of sodium alginate and liquid smoke addition on the physical, chemical, and organoleptic characteristics of restructured catfish jerky.

2. MATERIALS AND METHODS

2.1. Materials

The materials used in this research were catfish meat from Kalanganyar, Sidoarjo, sodium alginate, coconut shell liquid smoke from Madaniyah shop, Surabaya, brown sugar, coriander, garlic, shallots, galangal, and salt. The chemical used were

alcohol 70% (OneMed), ethanol 96% (Merck, Germany), Na₂CO₃ (Merck, Germany), chloroform, anhydrous NaSO₄ (Merck, Germany), CuSO₄ (Merck, Germany), Zn, NaOH (Merck, Germany), HCl (Merck, Germany), methyl red indicator (Sigma-Aldrich, USA), NaCl, distilled water. The equipment used in this research were: Texture Analyzer (model TA-TX2), spectrophotometer, oven, desiccator, furnace, incubator, vortex, electric heater, fume cupboard, analytical balance (Sartorius), petri dish, porcelain cup, burette, pipette, distillation apparatus, tube reaction, clamping tools, glassware.

2.2. Method

The process for making restructured jerky was to weigh the catfish fillet meat, grind it in a blender, then mix it with complementary spices, sodium alginate, and liquid smoke according to the treatment. After that, it was printed on a lined baking sheet and baked in a cabinet dryer at 70°C for 5 hours. The parameters observed were water content [9], ash content [9], protein content [9], hardness [10], and sensory evaluation [11]. This study used a completely randomized design (CRD) which was arranged in a factorial pattern and consisted of two factors where factor I was the concentration of sodium alginate which consisted of three levels (0.5%, 0.75%, 1%) and factor II was the concentration liquid smoke consisting of three levels (1%, 2%, 3%), each treatment was repeated 2 times.

3. RESULT AND DISCUSSION

3.1. Physicochemical Analysis

Data on yield, water content, ash content, protein content, and hardness, influenced by sodium alginate and liquid smoke concentration, are shown in Table 1.

Table 1. The mean value ± std. deviation of physicochemical constituents of restructured catfish jerky influenced by the treatment of sodium alginate concentration and liquid smoke

Treatment		Water content (%)	Ash Content (%)	Protein (%)	Hardness (gf)	Yield (%)
Na alginate (%)	Lq. smoke (%)					
0.50	1	23.80 ± 0.25 ^a	0.12 ± 0.04 ^a	22.94 ± 0.07 ^f	996.74 ± 1.94	35.89 ± 0.03 ^a
	2	23.80 ± 0.09 ^a	0.16 ± 0.05 ^a	22.88 ± 0.01 ^f	967.09 ± 1.02	35.95 ± 0.04 ^a
	3	24.01 ± 0.08 ^a	0.31 ± 0.11 ^{ab}	22.78 ± 0.02 ^{ef}	919.38 ± 3.56	35.98 ± 0.01 ^a
0.75	1	24.73 ± 0.09 ^b	0.30 ± 0.13 ^{ab}	22.68 ± 0.04 ^e	901.99 ± 3.59	36.30 ± 0.13 ^b
	2	24.94 ± 0.04 ^b	0.50 ± 0.01 ^b	22.29 ± 0.11 ^d	894.68 ± 4.87	36.50 ± 0.01 ^c
	3	25.38 ± 0.07 ^c	0.93 ± 0.08 ^c	22.08 ± 0.04 ^c	890.39 ± 2.12	36.84 ± 0.04 ^d
0.10	1	25.94 ± 0.04 ^d	0.79 ± 0.04 ^c	21.80 ± 0.01 ^b	863.12 ± 6.77	37.12 ± 0.04 ^e
	2	26.34 ± 0.04 ^e	0.81 ± 0.01 ^c	21.69 ± 0.02 ^b	848.95 ± 1.64	37.21 ± 0.02 ^e
	3	26.44 ± 0.02 ^c	0.98 ± 0.17 ^c	21.40 ± 0.19 ^a	839.56 ± 6.92	37.41 ± 0.03 ^f

3.1.1. Yield

Based on the analysis of variance, there is a significant interaction ($p \leq 0.05$) between the alginate and liquid smoke concentrations, and both have a significant effect on the yield of restructured

catfish jerky. It is known that the yield of restructured catfish jerky increased with increasing sodium alginate concentration in the sodium alginate treatment. This is because sodium alginate can bind water and form a gel. Alginate is a fiber compound composed of mannuronic acid and guluronic acid groups which

has the ability to absorb water very well and strongly by forming a gel or thick solution [12]. The higher the liquid smoke added, the higher the yield value of the jerky. This is caused by liquid smoke's ability to bind free water. Adjis and Sugiarto [8] stated that phenol is the main component of liquid smoke and can form hydrogen bonds with water, thereby increasing the water-binding capacity and, consequently, the yield.

3.1.2. Water Content

Based on the results of the analysis of variance, there was a significant interaction ($p \leq 0.05$) between the sodium alginate and liquid smoke concentration treatments, and each had a significant effect on the water content of the restructured catfish jerky. The higher the concentration of alginate and liquid smoke added, the higher the water content of the catfish restructuring jerky. This is caused by sodium alginate's ability to bind water and form a gel. Sodium alginate is a hydrocolloid characterised by its ease of water absorption and gel formation. The concentration of liquid smoke can affect the jerky's water content. Liquid smoke contains phenol which can bind water so that the higher the level of liquid smoke added, the higher the phenol contained in the restructured catfish jerky. This is in accordance with Budaraga et al. [13], who reported that phenolic compounds in liquid smoke act as hydrogen donors and, in small amounts, are effective in preventing oxidation.

3.1.3. Ash Content

Based on the results of the analysis of variance, there was a significant interaction ($p \leq 0.05$) between the sodium alginate concentration treatment and liquid smoke, and both had a significant influence on the ash content of restructured catfish jerky. The higher the concentration of sodium alginate and liquid smoke, the higher the ash content. Sodium alginate which contains salt and liquid smoke, which contains minerals, where these minerals will accumulate, causing the ash content in the restructured catfish jerky to increase. This is in accordance with Iryanti et al. [14], who stated that ash content in sodium alginate indicates the presence of mineral salts. Hutomo et al. [15] also stated that the chemical composition of liquid smoked coconut is possible due to the decreasing water content in restructured catfish jerky.

3.1.6. Hardness

Based on the analysis of variance, there was a significant interaction ($p \leq 0.05$) between sodium alginate concentration and liquid smoke treatments, and both had a significant influence on the hardness of restructured catfish jerky. The higher the concentration of sodium alginate and liquid smoke added, the lower the hardness value obtained. The higher the hardness value, the firmer and denser the texture of the restructured catfish jerky will be. Alginate has water-binding properties that can affect the texture of protein-based processed products, such as restructured catfish jerky. As the amount of alginate added increases, the gel matrix formed becomes stronger, allowing more water to be retained during drying. Yufidsari et al. [12] added that the hardness texture of a product is also closely related to the gel formation process that occurs. The ability of alginate to form a gel upon interaction with calcium can be used as a binding agent in restructured meat products, both raw and ready-to-eat [16].

shell consists of several chemical components such as 26.6% cellulose, 27.7% hemicellulose, 29.4% lignin, 4.2% extralif components, and 0.6% ash.

3.1.4. Total Soluble Solids

The statistical analysis of the data presented in **Table 1** showed that there was no significant interaction ($p > 0.05$) between the proportion of lamtoro gung juice to pineapple juice and carrageenan addition on the total soluble solids of the jelly drink. This result was presumably due to the relatively small differences in the proportion of lamtoro gung juice to pineapple juice among treatments (10% intervals), resulting in similar ranges of soluble components that were not detected as significantly different by the hand refractometer.

The addition of sugar in equal amounts across all treatments made sugar the dominant component in total soluble solids measurements, thereby masking minor differences that might arise from variations in the proportion of lamtoro gung juice to pineapple juice. This finding is consistent with Irawan [27], who reported that sugar is the dominant contributor to total soluble solids measurements using a hand refractometer due to its high solubility. Carrageenan primarily functions as a gelling agent and does not contribute soluble compounds; therefore, it is not detected in total soluble solids measurements [28]. This result is in agreement with Maleki [29], who stated that carrageenan addition does not significantly increase total soluble solids values, although it may affect other physical parameters.

3.1.5. Protein Content

Based on the results of analysis of variance, there was a significant interaction ($p \leq 0.05$) between the sodium alginate concentration and liquid smoke treatments, and each had a significant influence on the protein content of restructured catfish jerky. The higher the concentrations of sodium alginate and liquid smoke, the lower the protein value will be. This is because the addition of non-protein additives reduces the protein content of restructured catfish jerky. The decrease in protein content is in line with the increase in water content. According to Inna and Sirappa [4], the increasing protein content

3.2. Sensory Evaluation

In the sensory evaluation, the restructured catfish jerky was fried and then presented to the panellists. The evaluation was conducted using a scoring test for texture, aroma, taste, and colour. The results of the sensory evaluation are shown in Table 2.

Table 1. The mean score \pm standard deviation of sensory parameters in restructured catfish jerky

Treatment		Texture	Aroma	Taste	Color
Sodium alginate(%)	Liquid smoke(%)				
0.50	1	3.17 \pm 0.76	4,17 \pm 0.70	3.50 \pm 0.59	2.75 \pm 0.85
	2	3.54 \pm 0.93	4.08 \pm 0.72	3.63 \pm 0.65	3.42 \pm 0.83
	3	3.63 \pm 0.92	4.04 \pm 0.81	3.79 \pm 0.59	3.33 \pm 0.82
0.75	1	3.75 \pm 0.74	4.17 \pm 0.70	3.75 \pm 0.79	3.00 \pm 1.06
	2	3.42 \pm 0.93	4.17 \pm 0.70	3.71 \pm 0.46	2.92 \pm 1.02
	3	3.33 \pm 0.82	4.00 \pm 0.72	3.67 \pm 0.64	3.25 \pm 0.99
0.10	1	4.00 \pm 0.93	4.04 \pm 0.86	3.79 \pm 0.66	2.88 \pm 0.95
	2	3.29 \pm 0.91	4.17 \pm 0.64	3.92 \pm 0.65	3.13 \pm 1.15
	3	4.08 \pm 0.72	4.13 \pm 0.85	3.83 \pm 0.56	2.58 \pm 0.88

Discription : Texture : Scale: 1 - very tough; 2 - tough; 3 - tender; 4 - fairly tender; 5 - very tender, Aroma : Scale: 1 - very low smoky aroma; 2 - low smoky aroma; 3 - smoky aroma; 4 - fairly smoky aroma; 5 - very smoky aroma. Taste : Scale: 1 - very low smoky flavor; 2 - low smoky flavor; 3 - smoky flavor; 4 - fairly smoky flavor; 5 - very smoky flavor. Color : Scale: 1 - black; 2 - dark brown; 3 - brown; 4 - reddish brown; 5 - dark red.

Based on the analysis of variance, it was found that the concentrations of sodium alginate and liquid smoke significantly affected the texture, taste, and colour parameters ($p \leq 0.05$). Still, it did not significantly affect the aroma parameters ($p \geq 0.05$). The concentration of alginate, in the form of sodium alginate, affects the texture of restructured catfish jerky. Fitria [17] states that as the concentration of alginate added to the jerky increases, the texture of the jerky becomes firmer and stronger. The alginate concentration strongly influences the hardness of the gel in semi-moist products containing alginate; the higher the concentration, the stronger the gel texture. The addition of liquid smoke

4. CONCLUSION

The research results indicate that there is an interaction between the concentrations of sodium alginate and liquid smoke, with each significantly affecting the yield, moisture content, ash content, protein content, and hardness of the restructured catfish jerky produced. Sensory analysis shows a significant effect on the texture, taste, and colour parameters, but no significant effect on the aroma parameter.

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primarily influences the taste of restructured catfish jerky. The volatile compounds in liquid smoke that penetrate the product, along with other compounds formed during heating, will impart a specific flavour to the restructured catfish jerky [18]. The brown colour observed is due to the presence of carbonyl compounds, including acetol, methylglyoxal, and glycolaldehyde, which interact with amino compounds in meat [19].

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