Physicochemical Characteristics of Smoked Dumbo Catfish Sausage Due to Differences in Liquid Smoke Concentration and Immersing Duration

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Abstract

Dumbo catfish (*Clarias gariepinus*) is currently in high demand among consumers. Product diversification is essential to increase its market value and competitiveness. One of the processing methods for dumbo catfish is smoked sausage production using liquid smoke. Smoked sausage is reported to contain antioxidants derived from smoke components. This study aimed to determine the physicochemical characteristics of smoked dumbo catfish sausage processed with liquid smoke. The research employed a factorial randomized block design with two treatment factors. The first factor was liquid smoke concentration (15%, 20%, and 25%), while the second factor was immersion time (15, 30, and 45 minutes). The parameters analyzed included moisture, fat, protein, phenol, and total acid content. The variation in liquid smoke concentration and immersion time significantly affected phenol and total acid content, while moisture, protein, and peroxide values were not significantly different. Moisture content ranged from 61.52% to 62.68%, protein content from 42.96% to 43.88%, phenol levels from 234.92 to 366.81 ppm (equivalent to 0.023–0.037%), and total acid content ranged from 5.72 to 7.25 mg/100 g. Overall, the analysis indicated that smoked dumbo catfish sausages produced with different combinations of liquid smoke concentration and immersion time still met the standards of SNI 01-3820-1995 on Fish Sausage and SNI 2725:2013 on Smoked Fish.

Keywords

Concentration, Dumbo catfish, Liquid smoke, Sausage, Immersing

Introduction

Catfish (*Clarias* sp.) farming is one of the most important sectors in Indonesia's freshwater aquaculture industry. National catfish production (including dumbo catfish) in 2023 reached 1,136,619 tons according to data from the Ministry of Marine Affairs and Fisheries (KKP, 2024), making it the second largest aquaculture commodity after tilapia (1.37 million tons) (Kristiany,

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2020). Product diversification is crucial to increase market value and competitiveness (Nurlaila, 2016). One such effort is the production of smoked dumbo catfish sausage using liquid smoke. This alternative not only enriches the diversity of available food products but also provides nutritious and affordable options for consumers. Catfish farming has several advantages, including low investment costs, short production cycles, and high market demand (Anonymous, 2024).

One approach to improving the added value and safety of fish-based products is the application of liquid smoke. Liquid smoke possesses functional properties such as antioxidant and antibacterial activity, while also contributing to the development of color and distinctive flavor. It has been recognized as safe for use in food when applied at appropriate concentrations (Andika et al, 2020). Redistilled liquid smoke, according to Henggu et al. (2020), undergoes repeated distillation processes to produce a clear or slightly yellowish product. This type of liquid smoke is commonly applied in food products such as meatballs, noodles, sausages, and others. Coconut shell is widely used as the raw material for liquid smoke production. Previous studies include Balikan et al. (2021), who investigated the use of coconut shell waste for activated charcoal and liquid smoke, and Guillen et al. (2002), who examined smoke compounds derived from different wood types.

Previous research has shown that applying liquid smoke at a concentration of 20% with a 30-minute immersion time produced the best sensory and microstructural quality in smoked dumbo catfish sausage (*Clarias gariepinus*), resulting in a finer and more uniform emulsion structure (Ernawati, 2015). Studies on fish sausages and liquid smoke application include Bora (2023) on liquid smoke effects on skipjack tuna, Muri (2023) on smoked tuna floss, and Dwumfour et al. (2023) on the presence of polycyclic aromatic hydrocarbons (PAHs) in tilapia. Investigations into liquid smoke concentration and different woods have also been conducted by Oz (2020) on anchovy nuggets stored under refrigeration, and Bora (2023) on the sensory characteristics of smoked skipjack sausage.

Research on the physicochemical characteristics of smoked dumbo catfish sausage produced with liquid smoke is highly important, given that liquid smoke has already been commercially applied in the food industry (Aliyu et al., 2024). One of the advantages of liquid smoke technology is its ability to reduce harmful compounds such as benzo(a)pyrene, a known carcinogen. Understanding the physicochemical and sensory properties of smoked fish sausages processed with liquid smoke is essential, since parameters such as moisture, fat, protein, and phenol strongly influence the quality of the final product. Systematic studies on variations in liquid smoke concentration and immersion time are therefore necessary to optimize the quality of smoked fish sausage.

Methodology

The research was conducted at the Laboratory of the Faculty of Agricultural Technology, Universitas Brawijaya Malang, and the Agricultural Product Processing Laboratory, Universitas Yudharta Pasuruan. The main materials used were dumbo catfish (*Clarias gariepinus*) of consumption size (6–7 fish/kg) and redistilled liquid smoke derived from coconut shells. Additional ingredients included tapioca flour, skim milk, salt, and spices. Chemicals for analysis were obtained from the Agricultural Product Technology Laboratory and CV Dian Pharmacy Malang. The equipment used included an analytical balance, MMM Medeenter oven, Kjeldahl apparatus, UV-2100 spectrophotometer (Unico), titration set, magnetic stirrer, Whatman No. 42

filter paper, distillation apparatus, and Soxhlet extractor. The research stages comprised raw material preparation and smoked catfish sausage production.

An experimental method was applied using a factorial randomized block design (RBD) with two factors. The first factor was liquid smoke concentration: A1 (15%), A2 (20%), and A3 (25%). The second factor was immersion time in liquid smoke: B1 (15 minutes), B2 (30 minutes), and B3 (45 minutes), along with a control (catfish sausage without liquid smoke immersion). Each treatment was replicated three times. The parameters analyzed included moisture content (AOAC, 2005), fat content by Soxhlet method (AOAC, 2005), protein content by Kjeldahl method, phenol content (Madeno and Kaim, 2021), and total acid content.

Results and Discussion

Moisture, Fat, and Protein Content of Smoked Dumbo Catfish Sausage

Research result These three parameters are shown in Table 1.

Table 1. Average water, fat, and protein content of smoked dumbo catfish sausage

Liquid smoke concentration (%)	Immersion (minute)	Average water content (%)	Average fat content (%)	Average protein content (%)
15 (A1)	15 (B1)	62.52 ± 0.02	11.37 ± 0.89	43.88 ± 0.39
	30 (B2)	62.54 ± 0.66	12.22 ± 0.73	43.56 ± 0.61
	45 (B3)	62.56 ± 0.03	11.34 ± 0.43	42.96 ± 0.48
20 (A2)	15 (B1)	62.54 ± 0.01	11.78 ± 0.82	43.26 ± 0.30
	30 (B2)	62.56 ± 0.02	12.32 ± 0.61	43.87 ± 0.34
	45 (B3)	62.59 ± 0.29	12.89 ± 0.39	43.34 ± 0.47
25 (A3)	15 (B1)	62.59 ± 0.60	11.61 ± 0.94	43.35 ± 0.47
	30 (B2)	62.62 ± 0.05	12.85 ± 0.37	43.45 ± 0.45
	45 (B3)	62.68 ± 0.38	12.12 ± 0.60	43.67 ± 0.68

Information : Each data is the average of 3 repetitions ± standard deviation

Moisture content can influence the freshness and shelf life of food products. High moisture levels promote the growth of bacteria, molds, and yeasts, leading to deterioration of the product (Mbalur et al, 2021). The average moisture content resulting from different concentrations of liquid smoke and immersion times ranged from 61.52% to 62.68% (wet basis). The combination of treatments showed no significant effect according to Duncan's test ($\alpha = 0.05$). The dominant compounds in smoked dumbo catfish sausage are phenolic compounds, which are polar (water-soluble). However, phenols were not sufficiently strong to significantly influence moisture content. According to Setyastuti (2022), phenols in liquid smoke primarily act as antioxidants. The compact structure of the sausage also restricted water penetration into the product. Ashari et al. (2023) noted that the physical form of dissolved substances affects their penetration into food matrices. The average moisture content of the sausages still met the quality standard of SNI 01-3820-1995, which specifies a maximum of 67%. **The fat content** ranged from 11.34% to 12.89%. Both treatment factors had no significant effect. Fat is an organic compound that is insoluble in water but soluble in nonpolar organic solvents. The treatments did not influence fat content

because liquid smoke compounds cannot dissolve nonpolar fats. The fat content of smoked sausages in this study was comparable to that reported by Ernawati et al. (2021), who found fat content in smoked Dumbo catfish sausages ranging from 12.08% to 15.94% (dry basis). Fresh dumbo catfish contains approximately 4.22% fat, which increased after processing into sausages. This increase may be attributed to the effect of steaming during processing, as heating reduces water content, thereby increasing the relative levels of fat and protein. The fat content of the smoked sausages still complied with SNI 01-3820-1995, which specifies a maximum of 20%. **Protein content** ranged from 42.96% to 43.88%. Neither treatment significantly affected the protein levels of smoked dumbo catfish sausages. Proteins in smoked sausages are polar in nature; however, the compact sausage structure limited the ability of liquid smoke to penetrate and interact with proteins. The protein content results also met the quality standard of SNI 01-3820-1995, which requires a minimum of 9%.

Phenol and total acid content Smoked Dumbo Catfish Sausage

Phenolic compounds are highly important in smoked products because they contribute to the specific aroma and flavor of smoked foods (Guillén et al., 2002). The average phenol content ranged from 234.92 ppm (liquid smoke concentration 15% with immersion time of 15 minutes) to 366.81 ppm (liquid smoke concentration 25% with immersion time of 45 minutes), equivalent to 0.023–0.037% (Figure 1). These values are not significantly different from the study of Firdaus (2005) on beef sausage smoked using sawdust, which reported phenol levels of 0.03% or equivalent to 300 ppm.

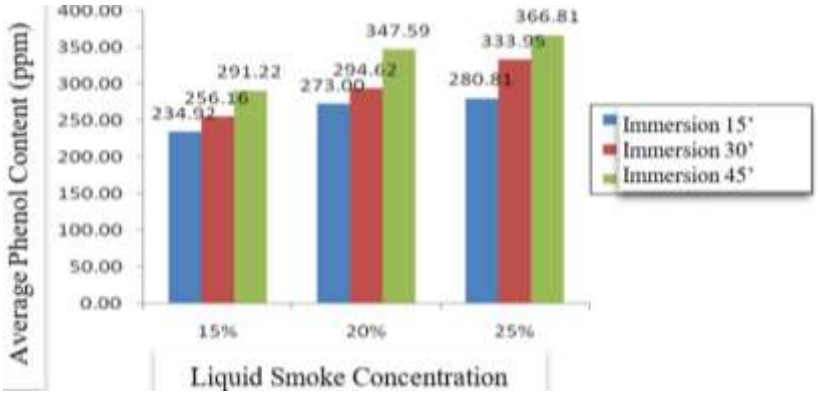

Figure 1. Changes in Phenol Content (ppm) of Smoked Dumbo Catfish Sausage Due to Differences in Liquid Smoke Concentration and Immersion Time

The treatments of liquid smoke concentration and immersion time, as well as their interaction, had a highly significant effect according to Duncan's test ($\alpha = 0.01$). According to Guillén et al. (2001), compounds identified in smoke components include phenolic derivatives, acids, aldehydes, ketones, alcohol derivatives, and alkyl aryl ethers. Girard (1992) stated that the main factors determining phenol levels in smoked products are smoking temperature, the concentration of liquid smoke added, and the type of smoking material, which typically consists of hardwood or combustible materials such as cellulose, hemicellulose, lignin, proteins, and minerals that influence the presence of smoke chemical compounds. Davidson and Branen (1981) reported that the safe limit of phenol content in smoked products for consumption is 0.02–1.0%.

Phenol may affect health because it is toxic if consumed in high amounts above the safe limit, with potential impacts on the respiratory system.

The analysis of total acid showed that both liquid smoke concentration and immersion time had highly significant effects, while their interaction was not significant according to Duncan's test ($\alpha = 0.05$). The increase in total acid values was attributed to the greater number of acidic components in the liquid smoke that adhered to and penetrated the sausage matrix. The average total acid values of smoked dumbo catfish sausage ranged from 5.72 to 7.25 mg/100 g. The trend of changes in total acid content is presented in Figure 2.

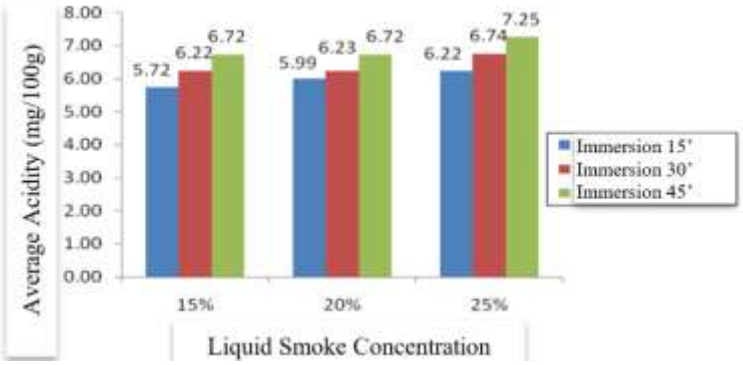

Figure 2. Changes in Total Acid Content (mg/100 g) of Smoked Dumbo Catfish Sausage due to Differences in Liquid Smoke Concentration and Immersion Time

Conclusion

The treatments of liquid smoke concentration and immersion time had significant effects on phenol and total acid contents but did not significantly affect moisture, fat, and protein levels. According to the Indonesian National Standard (SNI) for sausage products, the values remained within acceptable limits: maximum moisture content of 67%, minimum protein content of 13%, and maximum fat content of 25%. Moreover, the phenol content in smoked sausage was within the safe consumption threshold of 0.02–1.0%, and the total acid content ranged between 5.72 and 7.25 mg/100 g.

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