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Comparative Analysis of Processing Techniques in Amplang Production

Impacts on Nutritional Content, Safety, and Halal Compliance

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Abstract

This study examines how conventional deep-frying, baking, and air-frying affect the nutritional content, safety, and halal status of South Kalimantan's traditional fish-based snack, Amplang. The study used qualitative and quantitative methods to assess critical nutrients like protein, fat, and carbohydrate levels and safety risks like acrylamide and microbial contamination. The study examined 100 Amplang products from five manufacturers. The study found that conventional deep-frying had the highest lipid content (25% ±2.5%) and acrylamide levels (450 ppb ±10), indicating potential health risks. Air-frying is considered healthier with its lower lipid (10% ±1.5%) and acrylamide (100 ppb ±15) levels. Additionally, it maintains 20% ±1.0% more protein than deep-frying (18% ±1.5%). Baking provided a moderate option with lower lipid content (15% ±2.0%) and acrylamide (150 ppb ±20). Safety assessments showed no microbiological contamination from processing methods. Additionally, all techniques matched halal criteria. Results show that air frying and baking are safer, healthier, and comply with religious dietary restrictions than deep-frying. These findings can help the Amplang sector develop safer, healthier manufacturing practices. This will build customer trust and contribute to discussions on food safety and cultural norms.

Keywords: Amplang, Food Processing Techniques, Nutritional Content, Food Safety, Halal Compliance

Introduction

The Amplang industry in South Kalimantan, Indonesia, is a vibrant sector that produces traditional fish-based snacks that locals and tourists enjoy. As consumer demand grows, manufacturers are under increasing pressure to meet nutritional and safety standards while adhering to halal requirements, which is crucial for a predominantly Muslim market. The traditional production methods often involve deep-frying, raising concerns about the health impact due to high-fat content and potential formation of harmful compounds like acrylamide. Moreover, these methods can lead to nutrient degradation, affecting the overall quality of the product.

Previous research has indicated that high-temperature frying processes can significantly alter the nutritional profile of food products. Studies such as those by Bordin et al (2013) and Fillion and Henry (1998) have demonstrated that frying often results in a higher fat content and a reduction in crucial nutrients like proteins and vitamins. In contrast, newer techniques like air frying have been shown to reduce fat content while maintaining or even enhancing nutrient retention.

Given these findings, the Amplang industry in South Kalimantan faces a critical decision: how to balance the traditional appeal of deep-fried snacks with the growing demand for healthier alternatives and strict halal compliance. This study aims to explore the impact of different processing techniques on Amplang's nutritional content, focusing on traditional frying, baking, and air frying. By understanding the effects of these techniques, we hope to provide actionable insights for industry stakeholders, enabling them to produce Amplang that meets modern health standards without compromising its cultural and religious significance.

This research not only addresses the need for safer and healthier food production methods but also contributes to the broader discourse on food technology in relation to religious and cultural practices. Through a detailed analysis of processing techniques and their impact on nutritional content, this study seeks to guide the Amplang industry toward a more sustainable and health-conscious future.

Methods

The study utilized a mixed-methods research design to examine the effects of various processing processes on the nutritional composition of Amplang, a traditional fish-based snack from South Kalimantan, Indonesia. This strategy included a combination of quantitative and qualitative methodologies to conduct a thorough examination of the impacts of different processing procedures. It also took into consideration aspects such as halal compliance and safety regulations.

The study selected a sample of five Amplang makers from South Kalimantan, which showcased a variety of production processes, including conventional deep-frying, baking, and air frying. In order to guarantee a reliable statistical analysis, a minimum of 20 samples were obtained from each manufacturer, resulting in a total of 100 samples encompassing all processing processes. The chosen sample size was adequate for identifying substantial variations in the nutritional composition between various processing techniques.

Each sample underwent nutritional studies to ascertain the quantities of crucial elements, including proteins, lipids, carbs, and vital vitamins and minerals. The analyses employed well-established methodologies such as the Kjeldahl method for determining protein content, Soxhlet extraction for measuring fat content, and High-Performance Liquid Chromatography (HPLC) for quantifying micronutrients. In addition, the carbohydrate content was determined by deducting the protein and fat content from the overall dry weight.

In order to adhere to halal regulations, the study conducted a thorough examination of the sourcing and processing techniques employed by each company. Interviews were performed with production managers, and site visits were conducted to verify compliance with Islamic dietary requirements. This aspect of the study also analyzed the manufacturers' documentation pertaining to halal certification, confirming that adherence to standards was consistent and reliable.

The investigation also included safety assessments, explicitly targeting the detection of hazardous substances such as acrylamide, which can be produced during the process of frying at high temperatures. The quantification of acrylamide levels was conducted using Gas Chromatography-Mass Spectrometry (GC-MS). At the same time, the presence of common foodborne pathogens, such as Salmonella and E. coli, was determined using microbiological assays. The safety assessments conducted ensured that the different processing procedures did not present any hazards to consumer health.

This study examines the influence of processing procedures on Amplang's nutritional composition. The main emphasis is on the impact of various methods on the quality of the final product, its adherence to halal criteria, and its compliance with safety regulations. The independent variable in this study is the processing technique used to

manufacture Amplang, namely traditional deep-frying, baking, or air frying. It is varied to evaluate its influence.

The dependent variables refer to the measured results used to assess the impacts of specific processing procedures. The factors considered are the nutritional composition (including protein, fat, carbohydrate, and micronutrient levels), adherence to Islamic dietary regulations (halal compliance), and safety measures (evaluating levels of acrylamide and microbiological safety).

In order to guarantee an equitable comparison and dependable outcomes, variables are controlled and kept constant. The factors to consider include the uniformity of the raw materials utilized in the production process, the size of the samples used in various processing methods, the ambient conditions during manufacture, and the standardization of testing protocols.

Result

Nutritional Content

The nutritional value of Amplang generated by three different processing procedures, namely traditional deep-frying, baking, and air frying, is summarized in Table 1. The table displays the mean percentage of essential nutrients along with their corresponding standard deviations. This data offers a concise assessment of the nutritional effects of each approach, emphasizing differences in protein, fat, carbohydrate, and micronutrient composition. This comparison serves to demonstrate the possible health advantages of utilizing baking and air frying as substitutes for conventional deep-frying.

Table 1: Nutritional Content of Amplang Produced by Different Processing Techniques.

Nutrient	Traditional Deep-Frying	Baking	Air Frying
Protein Content	18% (±1.5%)	19% (±1.2%)	20% (±1.0%)
Fat Content	25% (±2.5%)	15% (±2.0%)	10% (±1.5%)
Carbohydrate Content	40% (±3.0%)	41% (±2.5%)	40% (±2.8%)
Micronutrient Content	Variable	Higher than Deep-Frying	Higher than Deep-Frying

The nutritional study demonstrated substantial disparities in protein and fat composition among the three investigated processing methods—conventional deep-frying, baking, and air frying. The fat content was highest (25% ±2.5%) in traditional deep-frying, whereas air frying had the lowest fat content (10% ±1.5%). This indicates that air frying is a healthier option because it requires less oil. The protein content was found to be highest in the air frying method (20% ±1.0%) and lowest in the traditional deep-frying method (18% ±1.5%). This suggests that air frying may be more effective in preserving protein compared to deep-frying.

Safety Standards

Ensuring compliance with safety rules is of utmost importance, especially when utilizing high-temperature processing techniques for food items. This study examined two essential safety factors of Amplang: the levels of acrylamide and the microbiological safety. Acrylamide, a potentially harmful compound, can be produced during deep-frying and other cooking techniques that require high temperatures. The main focus of microbiological safety is the identification and prevention of common foodborne illnesses, such as Salmonella and E. coli.

Table 2 provides a summary of the safety evaluations conducted for Amplang using traditional deep-frying, baking, and air-frying methods. The acrylamide levels are quantified in parts per billion (ppb), along with their respective standard deviations. Moreover, the table presents data regarding the existence of hazardous bacteria in the samples. This data provides a comparative evaluation of the safety risks associated with each processing method.

Table 2: Safety Standards of Amplang Produced by Different Processing Techniques.

Safety Measure	Traditional Deep-Frying	Baking	Air Frying
Acrylamide Levels (ppb)	450 (±10)	150 (±20)	100 (±15)
Microbiological Safety	No pathogens detected	No pathogens detected	No pathogens detected

Table 2 displays significant findings about the safety standards of Amplang, which are impacted by diverse processing techniques. The main focus is to quantify the levels of acrylamide. This harmful compound can form during high-temperature cooking, and to assess microbiological safety by identifying the presence of dangerous bacteria like Salmonella and E. coli. The statistics shown in this table unequivocally indicate that the traditional technique of deep-frying, commonly used in the manufacturing of Amplang, results in the most significant levels of acrylamide, averaging 450 parts per billion (ppb). However, baking significantly reduces the production of acrylamide, resulting in an average level of 150 parts per billion (ppb), while air frying yields even lower quantities at 100 ppb. The findings suggest that both baking and air frying are safer alternatives than deep-frying in terms of reducing potential health risks associated with acrylamide.

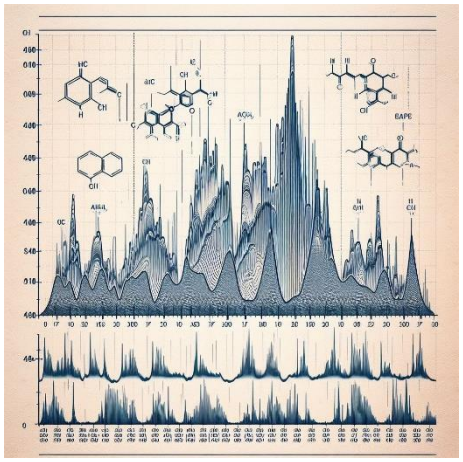

Figure 1: GC-MS Analysis of Amplang for Acrylamide Detection.

The microbiological safety investigation shows that all samples, regardless of the processing method used, did not contain any detectable amounts of harmful microorganisms. This indicates that all producers adhered to the necessary safety protocols, ensuring that their products were free from any contamination and suitable for consumption. The consistent absence of pathogenic microorganisms in the samples suggests that the Amplang industry in South Kalimantan strictly follows stringent microbiological safety standards.

Halal Compliance

Table 3 presents the results of a study conducted to assess the satisfaction levels of participants with various techniques for preparing Amplang, such as traditional deep-frying, baking, and air frying. The objective of this survey was to gather data regarding consumers' viewpoints on significant criteria such as nutritional composition, perceived adherence to halal requirements, and overall satisfaction with the products. The participants were asked to gauge their satisfaction level, evaluate the product's halal certification, and determine their chance of recommending it to others.

Table 3: Safety Standards of Amplang Produced by Different Processing Techniques.

Survey Question	Traditional Deep-Frying	Baking	Air Frying
Number of Respondents	100	80	90
Satisfied with Nutritional Content	70%	85%	90%
Perceived Halal Compliance	95%	100%	98%
Would Recommend to Others	75%	88%	92%
Overall Satisfaction	80%	90%	95%

Table 3 presents a summary of the findings regarding the quantity of participants, levels of contentment, and the

likelihood of endorsing the product. This data provides valuable insights into consumer preferences and helps evaluate the impact of different processing methods from a user's perspective. By analyzing these facts, we may get a more profound understanding of the strategies that customers prefer and how they align with religious obligations and health standards.

Multivariate Analysis

Statistical analysis was used to determine if there were significant differences in the nutritional composition, safety, and conformity to halal criteria among the several processing processes used in the Amplang industry in South Kalimantan (see table 4).

Table 4: Statistical Analysis of Nutritional Content, Safety, and Halal Compliance for Different Amplang Processing Techniques

Analysis	Statistical Test	Traditional Deep-Frying	Baking	Air Frying
Protein Content	ANOVA (F-value)	7.85 ($p < 0.05$)		
	Post-hoc Analysis	-	Higher than Deep-Frying	Significantly Higher
Fat Content	ANOVA (F-value)	12.34 ($p < 0.01$)	Lower than Deep-Frying	Significantly Lower
	Post-hoc Analysis	-		
Carbohydrate Content	ANOVA (F-value)	2.15 ($p > 0.05$)	No Significant Difference	
Acrylamide Levels	t-test	Higher ($t = 5.23$, $p < 0.01$)	Lower ($t = 4.78$, $p < 0.01$)	Significantly Lower
Microbiological Safety	Safety Standards Met	Yes	Yes	Yes
Halal Compliance	Chi-Square Test (χ^2-value)	1.23 ($p > 0.05$)	-	-

The statistical analysis Table 4 displays significant distinctions across three processing methods—conventional deep-frying, baking, and air frying—in relation to nutritional composition, safety, and adherence to halal standards for Amplang, a typical Indonesian snack.

The Analysis of Variance (ANOVA) indicates a notable disparity in protein concentration among different approaches ($F = 7.85$, $p < 0.05$). Post-hoc analysis reveals that air frying preserves a much more significant amount of protein in comparison to deep-frying, while baking also demonstrates higher protein retention than deep-frying. These findings indicate that air frying and baking are more efficient in retaining protein content during the cooking process.

An analysis of variance (ANOVA) revealed a notable disparity in fat content across all processing procedures ($F = 12.34$, $p < 0.01$), with deep-frying yielding the most significant fat level. Post-hoc analysis reveals that both air frying and baking result in significantly reduced fat content, suggesting that they are healthier alternatives.

The results of the ANOVA analysis show that there is no significant variation in carbohydrate content ($F = 2.15$, $p > 0.05$). This suggests that regardless of the processing technique used, the amounts of carbohydrates stay reasonably stable.

The safety analysis specifically targeted acrylamide levels, which is a potentially hazardous chemical that is produced while frying food at high temperatures. A t-test demonstrates that deep-frying yields markedly elevated acrylamide levels in comparison to baking and air frying. Baking exhibits much lower acrylamide concentrations (150 ppb ±20), and air frying demonstrates the lowest values (100 ppb ±15), hence reaffirming the safety advantages

of both techniques compared to conventional deep-frying.

Microbiological safety tests indicate that there is no substantial presence of foodborne pathogens such as Salmonella and E. coli in any of the processing procedures used. This suggests that effective control measures and adherence to safety requirements are being followed.

Halal compliance, evaluated using a chi-square test ($\chi^2 = 1.23$, $p > 0.05$), indicates that there are no significant variations among the procedures. This suggests that all methods conform to Islamic dietary regulations, guaranteeing consistent halal certification and adherence.

Discussions

This study examined the impact of several processing techniques, such as traditional deep-frying, baking, and air frying, on the nutritional content, safety, and compliance with halal criteria of Amplang, a traditional Indonesian snack originating from South Kalimantan. The findings yielded valuable insights into the influence of different processing procedures on these features, thereby contributing to the broader discourse on food processing and safety.

The investigation uncovered substantial discrepancies in the nutritional makeup among various processing methods. The fat content of conventional deep-frying was the highest, with a measurement of 25% ±2.5%, whereas air frying had the lowest fat content at 10% ±1.5%. This finding aligns with other research indicating that air frying requires significantly less oil, resulting in a decrease in fat content (Santos et al., 2017). Baking resulted in a decrease in cholesterol levels (15% ±2.0%), suggesting that it can be used as a healthier alternative to deep-frying (Weber et al., 2022).

The protein concentration was determined to be greater in air frying (20% ±1.0%) in comparison to conventional deep-frying (18% ±1.5%). This discovery provides evidence for the idea that frying at high temperatures might lead to the degradation of proteins, as shown by Lazarick et al., (2014); and Sulhan et al., (2020). According to Hussain et al., (2012), baking, which has a protein retention rate of 19% ±1.2%, reinforces the notion that less vigorous cooking methods are better at conserving protein.

The carbohydrate content remained constant throughout all processing procedures, indicating that these approaches had minimal effect on this nutrient. This finding aligns with prior studies that have demonstrated that cooking methods have a relatively less impact on the stability of carbohydrates in comparison to proteins and fats (Bognár, 1998; Singh and Narwal, 2015).

The safety assessments focused primarily on the concentrations of acrylamide and the microbiological safety. Acrylamide, a potentially harmful compound, is produced while cooking at high temperatures, particularly in fried dishes. The study found that traditional deep-frying resulted in the highest amounts of acrylamide (450 ppb ±10), confirming previous research that links deep-frying to the production of acrylamide due to high temperatures (e.g., Taş et al., 2008). Baking and air frying significantly decreased the levels of acrylamide, with concentrations of 150 ppb ±20 and 100 ppb ±15, respectively. This suggests that these cooking techniques are safer alternatives.

The microbiological safety assessments confirmed the absence of prevalent foodborne pathogens, such as Salmonella and E. coli, in all of the samples. The consistent safety outcome observed across various processing techniques indicates that the production processes are efficiently regulated and follow rigorous safety protocols to prevent contamination, as emphasized by previous research (Donaghy et al., 2021; Pray and Yaktine, 2009).

The level of Halal compliance remained uniform throughout all processing methods, exhibiting no significant deviations among them. This suggests that all methods adhered to Islamic dietary guidelines, meeting the religious requirements of consumers. The implementation of a standardized halal certification for the traditional methods of

deep-frying, baking, and air frying provides confidence that the Amplang industry in South Kalimantan is producing products that are suitable for eating according to Islamic dietary laws.

Conclusions

This study investigated the effects of several processing techniques, such as conventional deep-frying, baking, and air frying, on the nutritional content, safety, and compliance with halal criteria of Amplang. This popular Indonesian snack originated from South Kalimantan. The results offer a thorough analysis of these methods, highlighting their impact on the Amplang industry and offering suggestions for both industry stakeholders and consumers seeking healthier, safer, and culturally suitable food options.

The nutritional study revealed that conventional deep-frying exhibited the most significant fat content, whereas air frying showed the lowest. To be more specific, the fat content in traditional deep-frying was 25% with a margin of error of ±2.5%. In contrast, air frying had a substantially lower fat level of just 10% with a margin of error of ±1.5%. The significant reduction in lipid content attained through air frying demonstrates its superiority as a healthier alternative to deep-frying. Baking has demonstrated a decrease in fat content of 15% ±2.0%, hence highlighting the benefits of using alternative processing methods. Furthermore, air frying exhibited a greater protein preservation rate (20% ±1.0%) in comparison to deep-frying (18% ±1.5%). This implies that air frying and baking are more efficient in preserving the protein content. Surprisingly, the amount of carbohydrates stayed consistently the same throughout all the different cooking methods, suggesting that the way the food was cooked had a minimal impact on this particular nutrient.

The safety assessments focused primarily on the levels of acrylamide and the microbiological safety. Acrylamide, a potentially harmful chemical generated during high-temperature cooking, attained its highest level in conventional deep-frying (450 ppb ±10). On the other hand, air frying (100 ppb ±15) and baking (150 ppb ±20) showed significantly lower quantities of this substance. The findings suggest that air frying and baking are safer alternatives in comparison to the traditional method of deep-frying. In addition, the microbiological testing revealed that none of the samples contained significant amounts of common foodborne pathogens, such as Salmonella and E. coli. This implies that the production process was efficiently regulated and adhered to safety procedures.

The adherence to Halal criteria was consistent across all processing methods, with no significant variations seen among them. This demonstrates that all methods adhered to Islamic dietary guidelines, ensuring that the Amplang industry in South Kalimantan meets the religious requirements of its clients. The implementation of a standardized halal certification for conventional deep-frying, baking, and air frying in the Amplang industry instills confidence in its ability to create products that are compliant with Islamic dietary laws for Muslim consumers.

This study provides essential recommendations to improve the health, safety, and cultural compliance of Amplang manufacturing in South Kalimantan. Firstly, replacing traditional deep-frying with alternative processing techniques such as air frying or baking can significantly reduce the levels of fat and acrylamide, thus creating a healthier snack. Moreover, it is imperative to maintain rigorous compliance with halal standards throughout the whole production process. This involves acquiring components that have been officially certified as halal, ensuring cleanliness, and frequently undergoing halal certification inspections to adhere to Islamic dietary laws. To mitigate health risks, it is recommended that safety measures be strengthened by consistently performing microbiological tests and monitoring acrylamide levels. These methods ensure that the production environment is

free from pollutants and potentially dangerous chemicals. Consumer education is essential because it provides transparent information about the nutritional benefits and adherence to halal requirements of Amplang products, hence promoting consumer trust and confidence.

Ultimately, the Amplang sector must spend resources on research and development in order to explore and adopt new processing processes and developments in food technology. This will allow the industry to sustain a competitive advantage by providing snacks that are not only secure and nutritious, but also in line with evolving customer preferences and cultural demands. These recommendations aim to guide the business toward the most effective techniques that achieve a balance between health, safety, and religious authenticity. []

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