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ANALYSIS OF SNI CONFORMITY OF SMOKED STINGRAY (DASYATIDAESP.) PRODUCTS FROM MSME SIN REMBANG DISTRICT

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ABSTRACT

Stingray (Dasyatidae sp.) is a commodity in Indonesian waters with a large population that is used as smoked fish. Smoked fish is a fish processed traditionally through a hot smoking process. The study aims to evaluate the quality and its compliance with the Indonesian National Standard (SNI) for Smoked Fishin MSMEs in Rembang District. The study was conducted using a stratified random sampling technique from a population of 67 MSMEs in Rembang District. The study was conducted using observation, survey, case study, and laboratory testing methods, consisting of 9 MSME locations, namely A1, A2, A3, B1, B2, B3, C1, C2, and C3 with 3 repetitions. The test parameters were sensory, water content, fat content, protein content, total plate count (ALT), lead (Pb), and benzo(α)pyrene (BaP). The data were analyzed using SPSS 16 application, tested using normality, homogeneity, ANOVA, and Tukey HSD, while non-parametric data were analyzed using the Kruskall-Wallis test followed by the Mann-Whitney test. The results of the study showed that UMKM C1 (Bu Dami Smoked Fish) had the best quality based on sensory,nutritional, and foodsafety parameters. Theresults ofthesensoryanalysis ofsmoked stingray from 9 samples showed significant differences in the taste of smoked stingray (P>0.05). UMKM B1 showed high sensory values, water content of (69.91% ± 0.13), fat content of (0.73% ± 0.003), protein content (25.22% ± 0.006), for lead heavy metal contamination (0.096 mg/kg), total plate count (9.2 × 103 colonies/g). Thus, UMKM B1 is recommended as the best smoked stingray producer in RembangDistrict. The Benzo(α)Pyrene (BaP) test results that meet the

requirements are found in UMKM A at 0.35 µg/kg.

KEYWORDS: Stingray, Traditionalsmoking, quality.

1. INTRODUCTION

Rembang Regency is a regency located on the northern coast of Central Java Province, with an area of approximately 1,014 km2 and a coastline length of ±63.5 km. About 35% of the total area of Rembang Regency consists of coastal areas, spanning 355.95 km2. The fisheries sector plays an important role for the community as a livelihood for coastal populations. The potential for ray fish in Indonesia is quite significant.AccordingtodatafromtheDepartmentofMarineAffairsandFisheriesofRembangRegency, it is stated that the total annual smoked fish production reaches 3,081,086/year throughout Rembang Regency, with 168 MSMEs. In Rembang District, there are 67 MSMEs with a total production of 897,980/year. Ray fish (Dasyatidae sp.) has tender and chewy flesh. The meat of ray fish tends to have a sweetand slightlysavory taste.Ray fishisrich in proteinandlow infat.Themeatofray fishisone ofthe food ingredients containing various nutrients that are beneficial for consumers. The valuable contents in ray fish include protein, fat, potassium, sodium, calcium, magnesium, copper, phosphorus, zinc, iron, vitamin B, and vitamin D [1], ray fish contains protein and fat content that is beneficial for the body. Protein levels range from 27.85–29.17% and fat from 1.71–2.11%. Increasing the added value of ray fish can be achieved through product diversification, which can enhance the added value of fishery products and extend shelf life of the materials.

Stingrays are a foodstuff that spoils rapidly due to bacteria and microorganisms. This occurs because the composition of the fish, such as its relatively high water content and environmental conditions, makes it conducive to microbial growth [2], stingrays are a food product that is highly perishable. Spoilage of stingrays occurs immediately after the stingray is caught or dead. In tropical temperatures, stingrays spoil within 12–20 hours depending on the species. Stingray processing to increase shelf life must be carriedout so that stingrays can still be consumed in good condition. The water content in fish is the main factor causingfoodspoilage.Toextendshelflife,watercontentmustbereduced.Watercontentinfood products can be reduced through smoking. Fish smoking is one of the processing methods for fishery products, including using stingrays as raw material. Smoking is a preservation method and can also improve texture. In addition to extending shelf life, the purpose of smoking is to add specific flavor and color. The distinctive taste of smoked fish comes from chemical

compounds present in the smoke. Key components that play an important role in the smoking process include carbonyl compounds, organic acids, alcohols, and hydrocarbons. Antimicrobial compounds found in smoke include various aldehydes, alcohols, acids, and so forth. Fish smoking hasdrawbacks, as the resulting fish texture can become tough, especially if low-temperature smoking is used for an extended period, and it takes a long time to achieve perfect fish smoking. Fish with a tough texture require a rehydration (re-soaking) process before the fish can be consumed. Fish smoking must comply with quality and food safety standards according to the Indonesian National Standard (SNI) for smoked fish processing businesses so that the resulting products are fit for consumption [3].

2. MATERIALSANDMETHODS

Materials

The equipment used in this study includes polyethylene plastic, cool box, petri dish, oven, Soxhlet extractor, Atomic Absorption Spectrophotometer (AAS), fume hood, hot plate, tongs/clamp, analytical balance, burette stand, volumetric flask, Erlenmeyer flask, Soxhlet tube, Kjeldahl flask, fat flask, filter paper, as well as organoleptic testing equipment. The main material used in this study is smoked stingray obtained from fish smoking producers in Rembang District. Materials for chemical and PAH analysis include filter paper, plastic and cotton, n-hexane, diethyl ether, dichloromethane, selenium, sulfuric acid (H2SO4), distilled water, sodium hydroxide (NaOH), boric acid (H3BO3), and hydrochloric acid (HCl).

Survey of smoked fish producers

Smoked stingray samples were obtained from 9 different fish smoking MSMEs in Rembang District. Secondary data were collected from the Department of Marine Affairs and Fisheries of RembangRegency to obtain data on fish smoking MSMEs in Rembang. Primary data collection was conducted by directly observing the fish smoking process, from raw material preparation to the final smoked fish product, as well as by interviewing resource persons.

Smoking Process

The process of making smoked fish begins with selecting the raw materials. To produce high-quality smoked fish, the main factor that must be considered is that the raw materials used must be fresh or stillof good quality. Traditional smoking is carried out inside a para-para shaped structure (open system) measuring 3m x 3m x 3m, where the fish are placed above burning wood at a temperature of around 70-80°C for 20-30 minutes. Large fish require a smoking time of 6 hours, while smaller fish require a smoking time of 3 hours. The smoked

fish is then cooled and packaged [4].

Sample Provision

Smoked stingray samples were collected from 9 MSMEs, then each was cut into pieces weighing 20 grams. The cut samples were then placed into polyethylene plastic and stored in a coolbox before being brought to the laboratory for analysis.

Test Parameters

The test parameters to be conducted in this study are sensory evaluation, moisture content, proteincontent, fat content, total plate count (TPC), Lead (Pb) content, and Benzo(α)pyrene (BaP) content

Data Analysis

The data obtained from the research results were then processed using SPSS version 16. Parametric data analysis in this study was conducted using normality and homogeneity tests. If the data distribution is normal and homogeneous, it will be tested using Analysis of Variance (ANOVA) or analysis of varianceif P>5%. Data analysis uses normality and homogeneity tests to determine the distribution of the parameter data in the study, as well as to determine whether differences in treatments have an effect (P<5%) or not (P>5%) (Leonard and Ratnawati, 2015). Subsequent testing consisted of a Post Hoc test in the form of Tukey HSD. Non-parametric data were analyzed using the Kruskal-Wallis test, followed by the Mann-Whitney test.

3. RESULTS AND DISCUSSION

Sensory Test

Table 1. Sensory Test Results of Smoked Stingray (Dasyatidae sp.) Products at MSMEs in Rembang District.

Sample	Parameter					
		Smell	Flavor	Texture	Fungi	Mucus
A1	7,07 ± 1,44^{a}	7,07 ± 1,44^{a}	7,00 ± 1,66^{a}	7,40 ± 1,22^{a}	9,00 ± 0,00^{a}	9,00 ± 0,00^{a}
A2	7,20 ± 1,61^{a}	6,90 ± 1,40^{a}	7,03 ± 1,66^{a}	7,27 ± 1,46^{a}	9,00 ± 0,00^{a}	9,00 ± 0,00^{a}
A3	6,73 ± 1,55^{a}	6,40 ± 1,19^{a}	6,20 ± 1,54^{ab}	7,13 ± 1,57^{a}	9,00 ± 0,00^{a}	9,00 ± 0,00^{a}
B1	6,67 ± 1,67^{a}	6,73 ± 1,36^{a}	6,80 ± 1,52^{a}	7,00 ± 1,49^{a}	9,00 ± 0,00^{a}	9,00 ± 0,00^{a}
B2	7,13 ± 1,48^{a}	6,67 ± 1,40^{a}	6,47 ± 1,48^{ab}	7,20 ± 1,42^{a}	9,00 ± 0,00^{a}	9,00 ± 0,00^{a}
B3	6,87 ± 1,66^{a}	6,20 ± 1,24^{a}	5,80 ± 1,79^{b}	6,60 ± 1,52^{a}	9,00 ± 0,00^{a}	9,00 ± 0,00^{a}
C1	6,67 ± 1,90^{a}	6,87 ± 1,28^{a}	6,13 ± 1,94^{ab}	7,40 ± 1,61^{a}	9,00 ± 0,00^{a}	9,00 ± 0,00^{a}
C2	6,87 ± 1,57^{a}	6,67 ± 1,75^{a}	6,13 ± 1,63^{ab}	6,60 ± 1,61^{a}	9,00 ± 0,00^{a}	9,00 ± 0,00^{a}
C3	6,60 ± 1,52^{a}	6,93 ± 1,23^{a}	5,67 ± 1,92^{b}	7,00 ± 0,91^{a}	9,00 ± 0,00^{a}	9,00 ± 0,00^{a}

Appearance

The appearance of a product can influence consumer acceptance decisions. In this test data, the highest sensory appearance parameter was shown by sample A2 at 7.20, indicating that this product had the most attractive appearance among all the samples. Texture is one of the factors that can influence consumers' assessment of the final value of a product's appearance, as it is used to determine the product's physical condition. In addition to texture, color is also an important factor in evaluating product appearance [5].

Texture

Texture is a parameter that describes the mouthfeel sensation when biting into fish meat. In this test, the highest texture values were observed in samples A1 and C1, both with a value of 7.40. These results indicate that both samples possess ideal springiness and dryness. Good texture is characterized by moderate chewiness—not too hard or soft—and a dry surface. These texture results demonstrate that the smoking process was carried out properly. Good smoked fish texture, which is firm and chewy, is due to the ability of proteins to bind water within the fish meat. Optimal smoking can also gradually reduce moisture content while preserving the structural integrity of the fish tissue [6].

Smell

Aroma is one of the indicators of freshness and the distinctive flavor profile of smoked fish products. In this sensory test, the aroma parameter had the highest value in sample A1, with a score of 7.07, indicating that the resulting aroma had the characteristic scent of smoked fish without any foreign odors such as fishiness, rancidity, or sourness. A high aroma parameter value shows that the smoking process was carried out properly, with fresh raw materials, and the product was stored correctly, so there was noaroma deterioration in the product. Changes in odor or aroma are caused by the presence of ammonia (NH3) during protein degradation and also H2S gas during the degradation of sulfur-containing proteins by H2S-producing bacteria [7].

Flavor

Flavor is a sensory parameter that plays a crucial role in the final acceptance of a product by consumers. Based on the results, the highest flavor parameter score was shown by sample A2 at 7.03. The lowest test result was shown by sample C3 with a value of 5.67. The best flavor scores were indicated by a savory taste, slightly salty, and possessing the distinctive flavor of smoked fish. The relatively high flavor scores

inmostsamplesindicatethattheseasoningmethodandsmokingprocesswerequitesuccessfulincreating a taste preferred by the panelists. The flavor found in smoked fish has specific characteristics. This is due to phenolic and carbonyl compounds contained in the smoke, which give the fish its distinctive taste [8].

Fungi and Mucus

The fungi and mucus parameters are used to assess the cleanliness and durability of products during storage. All samples yielded the same results or demonstrated excellent outcomes. The fungi and mucus test value was 9.00. This indicates that no fungal growth and no mucus were found on the productsurface, which suggests that the production process was carried out hygienically and storage occurred under dry and clean conditions. The absence of fungal growth in smoked fish products indicates that processing and storage have been conducted properly, especially in terms of moisture content, since fungi are highly dependent on humidity for growth [9].

Proximate Test

Table 2. Test Results of Water Content, Fat Content, Protein Content of Smoked Stingray (Dasyatidae sp.) from MSMEs in Rembang District

Sample	WaterContent(%)	FatContent(%)	ProteinContent(%)
A1	70,45 ± 0,07^{cd}	0,66 ± 0,002^{b}	24,10±0,007^{b}
A2	70,16 ± 0,08^{abc}	0,65 ± 0,003^{a}	24,20±0,011^{c}
A3	70,39±0,04^{bcd}		
B1	69,91±0,13^{a}	0,73±0,003^{f}	25,22±0,006^{d}
B2	70,03 ± 0,08^{a}	0, 72 ± 0,002^{e}	25,39± 0, 006^{g}
B3	70,11 ± 0,12^{ab}	0,74 ± 0,003^{f}	25,28±0,006^{e}
C1	70,83 ± 0,16^{e}	0,71 ± 0,003^{d}	25,92± 0,012^{i}
C2	70, 50 ± 0,12^{de}	0,71 ± 0,003^{d}	25,74±0,008^{g}
C3	70,69±0,16^{de}	0,71±0,002^{d}	25,80±0,008^{h}

The difference in moisture content for each sample in succession was 0.29%, 0.23%, 0.48%, 0.12%, 0.08%, 0.72%, 0.33%, and 0.19%. The highest difference was found in sample C1 at 0.72%, indicating a higher increase in moisture content compared to samples from MSME B3. Based on the test results for moisture content that had undergone normality testing, a sig value of 0.889>0.05 was obtained, indicating that the data were normally distributed, and after homogeneity testing, the data were shown to be homogeneous with a sig of 0.802>0.05. The results of the analysis of variance (ANOVA) indicated a significant effect ($p<0.05$). The LSD test showed that the analysis of moisture content from different MSMEs, namely A2, A3, B1, B3, and C2, exhibited significant differences ($p<0.05$), while A1, B2, C1, and C3 did not show significant differences ($p > 0.05$). The differences in fat content obtained from several smoked stingray MSMEs showed a significant effect ($p<0.05$). The data obtained indicate that the moisture content of stingray smoked by the smoking cabinet method was

lower at 62.54% compared to traditional smoking at 63.68%. This was due to the higher temperature used in smoking with the smoking cabinet, which was 80–130℃, so the evaporation and reduction in moisture occurred more rapidly [10]. High moisture content can result in the product being more susceptible to spoilage, due to spoilage microorganisms utilizing the water contained in the product for their growth. The moisture concentration in each MSME had its own respective levels. This condition is suspected to be due to differences in the processes carried out by each MSME [11].

Fat Content

The differences in fat content for each sample in succession were 0.01%, 0.02%, 0.06%, 0.01%, 0.02%, 0.03%, 0%, and 0%. The highest difference was found in sample B1, at 0.06%, indicating a higher increase in fat content compared to the sample from UMKM C3. This shows that there is a significant difference in fat content quality. Based on the results of fat content testing, the normality test obtained a sigvalueof0.052>0.05, indicatingthedataarenormallydistributed,andthehomogeneitytestshowedthe data are homogeneous because the sig value was 0.991>0.05. The analysis of variance (ANOVA) results showed a significant effect ($p<0.05$). The BNJ analysis indicated that the fat content tests from different UMKM, namely A1, A2, A3, and B2, showed significant differences ($p<0.05$), but C1, C2, C3, B1, and B2 did not show significant differences ($p > 0.05$). The differences in fat content obtained from several smokedstingrayUMKMhadasignificanteffect($p<0.05$).Thedataobtainedshowedthatthefatconte nt of stingray smoked using a smoking cabinet was lower, at 1.85%, compared with traditional smoking at 2.03%. This is due to the high temperature used in smoking with the smoking cabinet, which was 80–130℃, causing the fat content in the fish to degrade and resulting in a reduction in fat content. A longer smoking time can cause fatty acid degradation, leading to a lower fat content [12][13].

Protein Content

The differences in protein content for each sample were 0.1%, 0.39%, 1.41%, 0.17%, 0.11%, 0.64%, 0.18%, and 0.06%, respectively. Thehighest difference was foundin sampleB1, with 1.41%, indicating a greater increase in protein content compared to samples from UMKM C3. This demonstrates that there is a significant difference in protein content quality. Based on the protein content test results that underwent normality testing, a sig value of 0.072>0.05 was obtained, indicating that the data are normallydistributed, and after homogeneity testing,

the data were found to be homogeneous as the sig value was 0.957>0.05. The results of the analysis of variance (ANOVA) showed a significant effect (p<0.05). The BNJ analysis results indicated that protein content testing from 9 UMKMs showed a significantdifference (p<0.05). The differences in protein content obtained from several smoked stingray UMKMs showed a significant effect (p<0.05). The data obtained showed that the protein content of stingrays smoked using a smoking cabinet was higher at 33.46% compared to traditional smoking at 32.39% [14]. This is due to the lower fat content in stingrays smoked using a smoking cabinet compared to traditional smoking. The use of various smoke sources (coconut shells, rice husks, and bamboo leaves) can result in varying protein content. Different smoke sources determine the nature of the fire or temperature during smoking. High heat affects moisture content; the less moisture, the higher the protein content in smoked fish [15].

Total Plate Count (TPC)Test

Table 3. Results of Total Plate Count Test of Smoked Stingrays (Dasyatidae sp.) from MSMEs in Rembang District.

Sample	Total Plate Count of Smoked Stingray	SN Istandard	Description
A1	1,2×10⁴colonies/g		Meetstherequirements
A2	2,4×10³colonies/g		Meetstherequirements
A3	1,3×10⁴colonies/g		Meetstherequirements
B1	9,2×10³colonies/g	5,0x104colonies/g	Meets the requirements
B2	2,7×10⁶colonies/g		Doesnotmeettherequirements
B3	2,7×10⁶colonies/g		Doesnotmeettherequirements
C1	7,1×10⁶colonies/g		Meetstherequirements
C2	1,2×10⁶colonies/g		Meetstherequirements
C3	8,2×10⁶colonies/g		Meets the requirements

The differences in total plate count for each sample in sequence were 9.6 × 10^3 colonies/g, 1.06 ×10^4 colonies/g, 3.8 × 10^3 colonies/g, 2,690.8 × 10^3 colonies/g, 2.55 × 10^6 colonies/g, 1,492.9 × 10^2 colonies/g, 5.9 × 10^2 colonies/g, and 7 × 10^2 colonies/g. The highest difference was found in sample B2, at 2,690.8 × 10^3 colonies/g, indicating a higher increase in total plate count compared to the sample from UMKM B1. According to Amir (2018), the

determined Lead (Pb) content in smoked fish produced in Bulukumba Regency ranged from 0.0170–0.0254 mg/kg. This value still meets the requirements of SNI 2725:2013, which stipulates that the maximum Lead (Pb) content in smoked fish using the hot smoking method is 0.3 mg/kg. The high total plate count in B2 and B3 is likely caused by cross-contamination during processing or storage, suboptimal control of smoking temperature, or insufficient processing time to kill microorganisms. The bacterial content inproducts is used to determine whether the product is still suitable for consumption or not. Essentially, fish is a food material that is highly susceptible to spoilage by spoilage microorganisms [16].

Lead (Pb) Contamination Test

Table 4. Lead (Pb) Test Results for Smoked Stingrays (Dasyatidae sp.) from MSMEs in Rembang District

Sample	Lead (Pb) Contamination in Smoked Stingray (mg/kg)	Standar SNI	Description
A1	0,109		Meets the requirements
A2	0,131		Meets the requirements
A3	0,119		Meets the requirements
B1	0,096	Maks. 0.3 mg/kg	Meets the requirement
B2	0,105		Meets the requirement
B3	0,053		Meets the requirement
C1	0,051		Meets the requirement
C2	0,039		Meets the requirement
C3	0,038		Meets the requirement

The differences in lead metal contamination results for each sample consecutively were 0.022 mg/kg,0.012mg/kg,0.023mg/kg,0.009mg/kg,0.052mg/kg,0.002mg/kg,0.012mg/kg,and0.001 mg/kg. The highest difference was found in sample B3 at 0.052 mg/kg, indicating an increase inlead heavy metal contamination levels higher than the sample from MSME B2. This shows thatthere is a significant difference in quality. The test results for lead (Pb) heavy metal contaminationin smoked Stingray (Dasyatidae sp.) samples from various MSMEs in Rembang District indicated that all samples still met the maximum limit requirements set by SNI. Based on analysis using an Atomic Absorption Spectrophotometer (AAS-Flame), it was found that increasing the concentration ofcoconutshellsmokeliquidresultedin agreaterreductionofPblevelsin skipjacktuna.According to Setyawan (2024), analysis of heavy metals in smoked fish showed that improper use of fuel, such as wood or charcoal contaminated with metals, can lead to increased metal levels [17].

Benzo(a)pyren(BaP)Test

Table 5. Benzo(a)pyrene (BaP) Test Results on Smoked Stingrays (Dasyatidae sp.) from MSMEs in Rembang District

Sample	Benzo(α)pyrene level (µg/kg)	Standart SNI	Description
A	0,35 ± 0,00[a]	Maks. 5 µg/kg	Meets the requirement
B	5,77 ± 0,08[b]		Does not meet the criteria
C	4,90 ± 0,16[c]		Meets the requirement

ThedifferenceinBenzo(α)pyrene(BaP)levelsforeachsampleinsequencewas5.42µg/kgand 0.87 µg/kg. The highest difference was found in sample B at 5.42 µg/kg, indicating a greater increase in BaP levels compared to the sample from UMKM A. This indicates a significant difference in protein quality. Based on the BaP level test results, the normality test yielded a sig value of 0.259>0.05 so the data are normally distributed, and the homogeneity test showed the data to be homogeneous because sig was 0.146>0.05. The results of the analysis of variance (ANOVA) showed a significant effect ($p<0.05$). The BNJ analysis results showed that the BaP level tests from UMKM A, B, and C showed significant differences ($p<0.05$). The results for the difference in BaP levels obtained from several smoked stingray UMKMs showed a significant effect ($p<0.05$). The obtained data show that the benzo(a)pyrene value of stingray smoked using traditional smoking is higherat12.20 mg/kgcomparedtothesmokingcabinetat8.21 mg/kg.Thisisduetothefactthat,in traditional smoking, the distance between the smoking material and the smoked fish is closer,around 50 cm, and there is no barrier between the two, causing melted fat to drip onto the hot fuel, resulting in fat pyrolysis and the formation of PAH compounds on the surface of the smoked fish. The product was analyzed for PAH (Polycyclic Aromatic Hydrocarbon) content. PAH content is influenced by the burning temperature, smoking time, smoke thickness, airflow, raw materials, and smoking conditions [18][19].

4. CONCLUSIONS

The quality parameters of smoked fish according to SNI 2725:2013, especially in sensory tests (appearance, odor, taste, texture, mold, slime), moisture content, fat content, protein content, lead (Pb) contamination, total plate count (TPC), as well as Benzo(α)pyrene (BaP), in general, all MSMEs surveyed have not yet met the SNI requirements. The best MSME in Rembang District is MSME B2, as it scored highest in sensory evaluation, has low moisture

content, and high protein content, although its level so fmicrobial and heavy metal contamination ares lightly higher. The only MSME that met the Benzo(α)pyrene (BaP) test is MSME A.

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