Physical Quality Duck Jerky with Liquid Smoke Sonication

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Abstract. This study aims to determine the effect of adding coconut liquid smoke sonication on pH, Water Holding Capacity (WHC), tenderness, L*a*b* color, and duck jerky aroma. The jerky is made from ground duck meat with additional spices such as salt, brown sugar, garlic, ginger, galangal, and coriander. The concentration of liquid smoke used is 1.5%. This research method used a completely randomized design (CRD) with 6 treatments and 3 replications consisting of P0: without adding liquid smoke, P1: liquid smoke without sonication, P2: liquid smoke sonication for 5 min, P3: liquid smoke sonication for 10 min, P4: liquid smoke sonication for 15 min, and P5: liquid smoke sonication for 20 min. Parameters observed included pH, WHC, tenderness, L*a*b* color, and aroma. Data were analyzed using Analysis of Variance (ANOVA). If the data shows a significant difference, proceed with the Duncan Multiple Range Test (DMRT). The average value of pH was 5.66–6.12, WHC was 70.67%–79.67%, tenderness was 3.27–4.93, lightness (L*) was 42.62%–44.86%, redness (a*) was 11.12%–12.86%, yellowness (b*) was 12.03%–12.49%, the aroma was 1.67–3.87. The results showed that sonication liquid smoke had no significant effect ($P > 0.05$) on pH, WHC, L*a*b color, and aroma but had a very significant effect ($P < 0.01$) on tenderness. Liquid smoke with sonication for 10 min is the duck jerky that panelists must accept because it has the right aroma of smoke and meat taste.

Keywords: Duck jerky · Liquid smoke · Sonication

1 Introduction

Indonesia has enormous potential, especially in the agricultural sector, because it is proven that the livestock sector must be developed more broadly to meet food and the community's nutritional needs. One of the superior products often consumed by the public is poultry products. Poultry products like duck meat are a source of animal protein that benefits society. Duck is a type of poultry that contributes to the fulfillment of animal protein because a fast growth rate supports it. Based on data from the Central Bureau of Statistics [1], the duck production population has increased yearly. The population of

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ducks in Indonesia in 2021 will reach 44,198.05 compared to the population in 2020, which only reached 41,116.23.

Meat is a food product of animal origin which is easily damaged and serves as a medium for microbial growth due to its complete nutritional content. Preservation and processing of meat into various processed products aim to reduce quality degradation while at the same time adding value to the meat products produced. One of the ways of processing meat so that it is not easily damaged is by processing fresh meat into beef jerky. Ground jerky is a processed meat product made from ground beef that is seasoned, printed in thin sheets, and dried.

Adding coconut shell liquid smoke is one of the food diversification efforts. Liquid smoke from coconut shells can preserve food ingredients safe for consumption. Coconut shell liquid smoke did not find Polycyclic Aromatic Hydrocarbon (PAH) compounds, including benzo[a]pyrene. Coconut shell liquid smoke can be used as an alternative food preservative that is safe for consumption and provides sensory characteristics in the form of color, aroma, and taste unique to food products. The content of phenolic compounds in liquid smoke functions as an antioxidant that can extend the shelf life of a food ingredient and can prevent the growth of a microbe in the food ingredient [2].

The sonication method can be applied to food processing, one of which is to homogenize coconut shell liquid smoke. Based on the statement [3], sonication can speed up the process of dissolving a material with the principle of solving intermolecular reactions so that nano-sized particles are formed. Sonication can be used to produce nanoparticles, such as nanoemulsions and nanocrystals. Sonication can also be used to break down intermolecular interactions and analyze molecular dynamics and reaction kinetics in molecule cleavage, so it can help stir samples. The sonication method is a type of top-down method in manufacturing nanomaterials. The sonication waves are channeled into the liquid medium to produce cavitation bubbles which can cause particles to have diameters on the nanoscale.

The effect of sonication causes a decrease in molecular weight with increasing duration of ultrasonic waves [4]. Research on adding coconut shell liquid smoke by sonication in manufacturing duck jerky is still not widely studied. This research was conducted to determine the effect of the addition of coconut shell liquid smoke by sonication on the physical quality of duck jerky.

2 Materials and Methods

2.1 Materials and Tools

The materials used in this study were ground duck meat, coconut shell liquid smoke, aquadest, salt, brown sugar, garlic, ginger, galangal, and coriander. The equipment used is an analytical balance, knife, label, chopper, glass mold with a thickness of 3 mm, pH meter, centrifugation tube, centrifugation, meat shear force, colorimeter (color reader) CS-10, beaker glass, stirrer, dropper pipette, mortal pestle, PE plastic, and food dehydrator.

2.2 Research Methods

This study used an experimental laboratory method using a Completely Randomized Design (CRD) with 6 treatments and 3 replications. The treatment given is:

P0: without the addition of liquid smoke (control)
P1: adding liquid smoke without being sonication
P2: addition of liquid smoke with 5 min of sonication
P3: addition of liquid smoke with 10 min of sonication
P4: addition of liquid smoke with 15 min of sonication
P5: addition of liquid smoke with 20 min of sonication

2.3 Jerky Making Procedure

Making duck jerky begins with washing the duck clean, skinning it, separating the fat from the meat, and grinding it. The ground meat is added with spices such as salt, brown sugar, garlic, ginger, galangal, and coriander, then ground again until it is evenly mixed. After that, the meat is soaked in coconut shell liquid smoke sonication for 20 min. After 20 min of soaking in coconut shell liquid smoke, the meat is drained and printed with a glass mold with a thickness of 3 mm. The printed meat is placed on PE plastic (polyethylene) in a food dehydrator for 3.5 h at 65 °C, occasionally turning to cook evenly. Then the beef jerky is lifted, aerated, and analyzed for physical quality.

2.4 Research Variable

1. Procedure for testing the pH using the AOAC method [5].
2. The WHC testing procedure uses the centrifugation method [6].
3. The procedure for testing tenderness using the Warner Bratzler Shear Force method [7].
4. Procedure for testing color content using the color reader method [5].
5. The aroma testing procedure uses the product test development method (panelist) [8].

2.5 Data Analysis

To The data obtained were analyzed using ANOVA (Analysis of Variance) using a Completely Randomized Design (CRD). If there is a significant difference, proceed with Duncan's Multiple Range Test (UJBD). The completely randomized design (CRD) linear model is as follows:

$$Yij = \mu + \tau i + \varepsilon ij \tag{1}$$

Y_{ij} = Observations on treatment - i and group j
μ = Average value
α = effect of treatment too – i
$\sum$ ij = Error treatment to –i and repetition – j
i = Treatment 1, 2,…,t

j = Deuteronomy 1, 2,….,r

The following formula calculates Duncan's Multiple Distance Test:

$$\text{DMRT}\alpha = q\left(\sqrt{}\text{KT error/r}\right) \quad (2)$$

3 Results and Discussion

3.1 Value of pH

The analysis showed that the addition of coconut shell liquid smoke with different sonication times in the production of duck jerky was not significantly different ($P > 0.05$) from the pH value. This shows that the difference in sonication time of coconut shell liquid smoke does not affect the pH of the duck jerky. The highest average pH was at P4, namely the addition of coconut shell liquid smoke with 15 min sonication, which was 6.12, and the lowest average was at P0, namely as a control or without adding coconut shell liquid smoke, which was 5.66. Based on the research results [9], the pH value of the meat decreased due to the immersion process in liquid smoke. The smoke components attached to the meat cells became many because the smoke components were acidic, namely the presence of carboxylic acids, which included formic acid, acetate, and butyrate.

Based on the results of previous studies [10], the effect of different concentrations of walnut shell liquid smoke, namely 0, 4, 8, and 12%, on beef. The analysis of variance showed that the concentration of liquid smoke had no significant effect on the pH of the meat. However, the pH of the meat at different concentrations of liquid smoke tended to decrease in pH value due to the presence of smoke components attached to the meat, which have acidic properties, including carboxylic acids, which include formic and acetic acids., and butyrate. The highest average of 6.71 was found in the control treatment, and the lowest average was 6.13, namely the addition of 12% liquid smoke.

Table 1 data shows the pH value of duck jerky ranging from 5.66 to 6.12. The pH values at P3 and P4 increased with an average of 6.09 and 6.12. Based on the research results [11], the amount of acid with a high pH is influenced by the high carbonyl compounds, and phenolic compounds found in kasambi wood and permeate well in smoked products so that the pH of the meat becomes alkaline. The best pH value for smoked chicken jerky is around a $\text{pH} < 5.00$, which is efficient enough to produce ready-to-consume beef jerky. According to [12], low pH values between 5.1 to 6.1 can cause the meat to have an open structure making it very good for salting, has a bright pink color and flavor that consumers like, and has better stability against damage by microorganisms.

In the P5 treatment, namely the addition of coconut shell liquid smoke with sonication for 20 min, the pH decreased, presumably due to the high temperature during the longest sonication time in the research treatment. Based on the research results [13], the pH value indicates that coconut shell water smoke is acidic. The pH value will decrease with increasing temperature and burning time. This is because more elements in the coconut shell decompose to form acidic chemical compounds.

Table 1. Average values of pH, WHC, Tenderness, *L, *a, *b Color, and aroma

Variables	Treatment					
	P0	P1	P2	P3	P4	P5
pH	5,66 ± 0,11	5,80 ± 0,14	5,85 ± 0,37	6,09 ± 0,13	6,12 ± 0,20	5,87 ± 0,21
WHC	70,67 ± 4,93	71,67 ± 2,89	72,67 ± 3,21	73,67 ± 1,53	75,00 ± 5,57	79,67 ± 3,06
Tenderness (N)	4,93 ± 0,45	3,27 ± 0,55	3,37 ± 0,15	3,67 ± 0,21	3,77 ± 0,32	3,93 ± 0,45
Lightness (L*)	42,62 ± 2,09	44,54 ± 0,72	44,86 ± 3,39	44,29 ± 2,28	44,38 ± 1,51	43,46 ± 0,94
Redness (*a)	11,12 ± 0,35	12,39 ± 0,13	12,48 ± 0,56	12,47 ± 0,54	12,51 ± 0,93	12,86 ± 1,94
Yellowness (*b)	12,03 ± 0,36	12,15 ± 0,64	12,36 ± 0,23	12,38 ± 0,66	12,42 ± 0,40	12,49 ± 0,17
Aroma	1,67 ± 0,42	2,53 ± 0,99	2,67 ± 0,95	3,87 ± 0,64	3,47 ± 0,61	3,30 ± 0,14

3.2 Water Holding Capacity (WHC)

The results showed that coconut shell liquid smoke with different sonication times had no significant effect ($P > 0.05$) on Water Holding Capacity (WHC) in duck jerky. The highest average of 79.67% was at P5, namely the addition of coconut shell liquid smoke by sonication for 20 min, and the lowest average of 70.67% was at P0, namely as a control or without adding coconut shell liquid smoke. In this study, the addition of liquid smoke was as much as 1.5%. Based on the research results of previous studies [14] that there was a real interaction ($P < 0.05$) in the use of a liquid smoke solution up to a concentration of 8% so that it could affect the water holding capacity of the meat. This significant effect is due to the influence of organic acids in liquid smoke. The higher the concentration of liquid smoke used in curing, the WHC value of meat tends to decrease.

The longer the sonication time of the coconut shell liquid smoke, the higher the WHC value of the duck jerky because the longer the sonication time, the smaller the liquid smoke particles absorb into the meat. Based on the research results of previous studies [10] regarding the addition of walnut shell liquid smoke concentration (0, 4, 8, and 12%) had no significant effect on meat WHC. The concentration of liquid smoke used for smoking does not affect the water holding capacity of the meat, but the more liquid smoke concentration is added, the WHC value in the meat will decrease.

Data from Table 1 shows that the longer the liquid smoke sonication time, the WHC value of duck jerky will increase. According to [15], the more extended the sonication time, the sample particle size tends to be more homogeneous and smaller, leading to stable nanoparticle size and reduced clumping. This is because the sonication method's shock waves can separate particles' agglomeration.

3.3 Tenderness

The analysis showed that adding coconut shell liquid smoke with different sonication times in the production of duck jerky had a very significant effect ($P < 0.01$) on the value of tenderness. This shows that the difference in sonication time of coconut shell liquid smoke affects the tenderness of the duck jerky. The highest average tenderness of 4.93 was in P0 as a control or without adding coconut shell liquid smoke. The lowest average of 3.27 was in P1, namely the addition of coconut shell liquid smoke without sonication. Tenderness is an acceptable consumer taste value.

The tenderness value increases related to the WHC value in a jerky, and a low WHC value will increase. This follows the research [14], which showed that the inter-action between liquid smoke concentration and storage time had a significant effect ($P < 0.05$) on the tenderness of duck meat. A decrease in WHC causes an increase in tenderness in duck meat. Meat tenderness correlates with WHC, where a decrease in WHC will increase tenderness.

Based on the results of previous studies [16] regarding the addition of coconut shell liquid smoke in the production of beef jerky with different concentrations of liquid smoke, namely 3%, 6%, and 9%, with the highest average value found in the addition of 9% of 2.84% and the lowest average value found in the addition of 3% liquid smoke of 1.68%. The addition of 9% coconut shell liquid smoke affects tenderness due to bioactive components that can hydrolyze peptide bonds in a beef jerky protein. Dried meat will toughen because the meat loses its water content during heating. The tenderness of the meat is influenced by water holding capacity and water content.

The results showed that the treatment between P1, P2, P3, and P4 was not significantly different because the short sonication time resulted in no different tenderness. Based on the results of previous studies [17] regarding the effect of smoking rice husks on beef and buffalo beef jerky on the level of tenderness or hardness of the two types of meat, there was no significant difference in both the 0th and 7th day of storage. This is because the beating process carried out evenly before smoking causes a relatively equal reduction in water content resulting in a hardness that is not much different in the products of the two types of meat. Hardness is a factor that affects product quality, especially its relation to consumer tastes, so it will affect general acceptance. Meat tenderness can be determined by measuring its braking power. The lower the breaking strength value, the more tender the meat. One of the factors that can affect the tenderness of postmortem meat is the application of the smoking method.

3.4 L*a*b* Color

The main parameter of concern in measuring the quality of a product is the physical appearance that is visible visually by the senses of sight. The factor that affects the appearance of a product is color. Color is the most important criterion for consumers in selecting food products sold in the market and is a visual parameter of concern to consumers. In food product research, color is often used with the L*, a*, b* color methods. The L*, a*, b* method is an international standard for color adopted by the Commission Internationale de I'Eclairge (CIE) [18].

Based on [19] that the lightness value (L*) indicates reflected light, which produces achromatic colors of white, gray, and black with a range of values: 0 (black) to 100 (light). The redness value (*a) indicates the chromatic color of a mixture of red and green with a value of *a (+) having a range of values from 0 to + 80 for red and *a (-) values having a range of values from 0 to -80 for green. The yellowness color value (*b) indicates a mixed chromatic color of blue to yellow with a range of *b (+) values from 0 to + 70 for yellow and *b (-) values from 0 to -70 for blue.

Lightness (L*)

The results of the analysis showed that the addition of coconut shell liquid smoke with different sonication times had no significant effect ($P > 0.05$) on the lightness (L*) of duck jerky. The average color lightness of duck jerky ranged from 42.62% to 44.86%. The highest lightness level of duck jerky color is found in P2 with the addition of coconut shell liquid smoke with a sonication time of 5 min, so P2 is the duck jerky with the highest brightness level, while the lowest brightness level is in P0 as a control. According to [20], the more significant the L* value (closer to 100), the brighter the product color, and the smaller the L* value (closer to 0), the darker or darker the product color.

Based on the results of previous studies [21] research on the addition of coconut shell liquid smoke with concentrations of 1%, 3%, 5%, and 7% in smoked chicken meat to the lightness value that the higher the concentration of liquid smoke given, the more low lightness value. The lowest lightness value is found at 7% liquid smoke concentration. The lower the lightness (L*) value, the darker the color of the smoked chicken meat.

Redness (*a)

The results of the analysis showed that the addition of coconut shell liquid smoke with different sonication times had no significant effect ($P > 0.05$) on the redness (*a) color of the duck jerky. The highest redness level was at P5, namely sonication for 20 min, 12.86%, and the lowest average were at P0, 11.12%, which was as a control. The research [22] shows that coconut shell liquid smoke is brownish-red.

Based on the results of previous studies [10] on the effect of different concentrations of liquid smoke from walnut shells, namely 0, 4, 8, and 12% in beef on color, it showed no significant effect. The highest meat color score was at a concentration of 12%, 2.11%, while the lowest was at a concentration of 0%, 1.66%. The color of the meat ranges from slightly dark red to dark red. The higher the concentration of liquid smoke, the color of the meat becomes a slightly darker red. The dark color in smoked products results from a non-enzymatic reaction, through a condensation reaction between carbonyl and dicarbonyl in smoke with protein amino acids and free amino acids in food products. The carbonyl and dicarbonyl content of each liquid smoke is very different, so the browning potential is also different.

Yellowness (*b)

The results of the analysis showed that the addition of coconut shell liquid smoke at different sonication times had no significant effect ($P > 0.05$) on the yellowness (*b) of the color of the duck jerky. The highest average yellowness content was 12.49%, found in P5 with the addition of coconut shell liquid smoke with sonication for 20 min, and the lowest average was 12.03%, which was in P0 as a control. The color change in duck jerky is influenced by the presence of phenol and carbonyl in the liquid smoke. According to [22] color of smoked products is also affected by the carbonyl and phenol content in liquid smoke. The combination of carbonyl and amino compounds from the food surface will affect the color of the smoked food. The intense color of smoked food is due to the high carbonyl content in the liquid smoke.

Carbonyl compounds in smoke have a role in forming the color and taste of smoked products. Liquid smoke contains various compounds that can be grouped into phenols, acids, and carbonyls. Liquid smoke contains various organic components that form a distinctive taste, and smoke can also give a golden brown color to meat products [10].

Based on the results of previous research [23] regarding brahman cross beef, the highest yellowness value (b*) was found in the withering of pineapple waste for one month, and the lowest average was in the withering of pineapple waste for two months. Based on the analysis of variance, the results were not significantly different ($P > 0.05$) from the yellowness value. The yellow color of the meat is due to the low content of pigments, myoglobin, and hemoglobin. The fat content of marbling in meat also affects the yellowness of stored meat due to the presence of beta-carotene.

3.5 Aroma

The analysis showed that adding coconut shell liquid smoke with different sonication times did not significantly affect the aroma of duck jerky ($P > 0.05$). The highest average was 3.87, namely at P3 with the addition of coconut shell liquid smoke by sonication for 10 min, and the lowest average was at P0 as a control, which was 1.67. Phenol compounds in liquid smoke can give an aroma to duck jerky. According to [24], the aroma is essential in beef jerky. The type of meat used and the addition of spices can determine the aroma of food. The distinctive aroma of food is due to the content contained in liquid smoke, namely phenol or carboxylic acid. Phenol compounds are essential in smoked products because phenol plays a role in forming the aroma of smoked food.

P3 treatment with the addition of coconut shell liquid smoke with 10 min of sonication had the highest average aroma of duck jerky because it had the right aroma of smoke and meat taste. Based on the results of previous research [10] on the effect of different concentrations of liquid smoke from walnut shells, namely 0, 4, 8, and 12% on beef and the highest score was found at a concentration of 12% liquid smoke and the lowest score was at a concentration 0%. The meat aroma score increases with a higher concentration of liquid smoke. The higher the concentration of liquid smoke and the smell of meat, the more smoke smells. This is because the phenolic compounds contained in the smoke play a role in the formation of flavors in smoked food. Phenol compounds that play a role in the formation of smoke flavor include syringes, guaiacol, 4-methyl guaiacol, 4-methylsyringol, and eugenol. The longer the storage, the more rotten the smell of smoked meat.

4 Conclusions

This study used coconut shell liquid smoke with different sonication times to show a change in the physical quality of duck jerky. However, it did not significantly affect the pH, WHC, L*a*b* color, and aroma, but it significantly affected on tenderness. Liquid smoke sonication for 10 min or P3 produces the highest average value on the aroma of duck jerky, so liquid smoke sonication for 10 min is the duck jerky that panelists most accept in terms of aroma.

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