The influence of Moringa leaf flour ratio with smoke flour and maturation time on performance Bali beef *Pectoralis profundus* muscle characteristics

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Abstract. The use of moringa leaves and coconut shell liquid smoke in the form of flour as an antioxidant in Balinese beef has been carried out to see changes in the functional properties of fresh meat during aging. One of the roles of antioxidants is to inhibit protein oxidation in meat during cold storage. The combination of moringa leaf flour and smoked flour as an antioxidant is used in the form of marination in the muscles of *Pectoralis profundus* during maturation at a temperature of 2-5°C for eight days. Maturation will improve the functional properties of meat that have an impact on improving the quality of fresh meat. This study used six male Bali cattle aged three years old from the MBC (Maiwa Breeding Center) in Enrekang and slaughtered at the Faculty of Animal Science Hasanuddin University. *Pectoralis profundus* muscle was dissected from the carcass after rigor mortis. Antioxidants used are 100% Moringa leaf flour and 20% smoke flour concentration. The experimental design used was a complete design with a 3 x 5 factorial pattern where factor 1: ratio of moringa leaf flour: smoked flour: 25%: 75%, 75%: 25%, and 50%: 50%, factor 2: maturation time; 0, 2, 4, 6, 8 days. The parameters observed were pH, water holding capacity (WHC), shear force value of cooked meat (SFCM), and cooking loss (CL) after the meat was cooked at 80°C for 30 minutes. The results of the study showed the ratio of Moringa leaf flour: smoked flour produces the values of the four parameters more or less the same even though there was a tendency of the ratio of 75: 25% better. While the maturation time produced the lowest pH on the sixth day, the highest WHC, the lowest SFCM, and CL on the second day, it can be concluded that maturation time improved the functional properties of Bali beef while the ratio of moringa leaf flour to smoked flour has not been able to improve the functional properties of Bali Beef.

1. Introduction

Indonesia is characterized by abundant natural resources from the agricultural sector. Moringa tree with moringa leaf products is a plant that can be found anywhere, especially widely planted in the household yard as a source of vegetables. It is known that Moringa leaves contain antioxidants which are quite high and are very liked by the public for consumption as vegetables. Moringa trees that grow well, their leaves can be used as an antioxidant that is rich in flavonoid compounds. Moringa leaves contain phenol compounds and vitamin C content, which is quite high and is very well used as an antioxidant. Moringa...
leaves contain high antioxidants in the form of tannin, steroids, triterpenoids, flavonoids, saponins, interquinones and alkaloids [1]. Moringa (*Moringa oleifera Lam*) is a herbaceous plant that contains flavonoids, cytokinin saponins, caffeoylquinic acid and contains unsaturated fatty acids such as linoleic (omega 6) and omega 3 [2]. The fresh Moringa's antioxidant power leaves seven times greater than the antioxidants in Vitamin C. Dried Moringa leaves per 100 grams contains 205 calories of energy; 27.1 grams of protein; 23 grams of fat; 38.2 grams of carbohydrates; and 19.2 grams of fiber. For 100 grams of dried Moringa leaves, 18.9 mg beta-carotene vitamin A; 2.64 mg thiamine (B1); 20.5 mg riboflavin (B2); 8.2 mg niacin (B3); and 17.3 mg vitamin C are contained [3]. Meanwhile, in the coastal areas to a certain height, there are coconut trees that can be utilized; one of them is coconut shell as raw material for producing liquid smoke. Use liquid smoke in meat and processed meat products to date has shown satisfactory results as preservatives and antioxidants [4–7]. Liquid smoke contains phenolic compounds, acids, and carbonyl. The antioxidant ability of smoked flour and moringa leaves will be able to increase the natural antioxidants in beef. Natural antioxidants in beef are found in connective tissue (collagen), assuming the higher the levels of muscle collagen, the antioxidant capacity increases.

*Pectoralis profundus* muscle is a muscle with robust qualifications characterized by a higher collagen content compared to the *Longissimus dorsi* muscle which has a lower collagen content [8]. Muscles with high collagen content are also high antioxidants, which will play a useful role when they get an external response as a trigger for the action of the antioxidant content they have [8].

The availability of Bali cattle with a population of more than 2 million head in South Sulawesi [9] still needs to get a touch to improve productivity and quality through technological innovation in research. The need for increased meat consumption in line with population growth requires the supply of processed meat and meat products that are safe, healthy, halal, and whole (ASUH) guaranteed. National meat demand is increasing and not balanced with availability; in 2015, needs were estimated at 654,000 tons (2.56 kg/capita), while production capacity from local cattle was only 523,927 tons resulting in a deficit of 130,073 tons. The government imported 214,690 tons of meat, of which 83,260 tons were in the form of meat and 131,430 tons in the form of cattle equivalent to 773,149 heads [10].

The yield of meat products can be improved by enhancing the functional properties of fresh meat by the addition of additional ingredients that act as antioxidants, preservatives, and binders. The functional nature of meat decreases with increasing post-mortem time, if it is used as raw material, resulting in the functional properties of processed meat products (elasticity, emulsion stability, suppleness) and decreased yield.

2. Material and methods

This study used fresh Bali beef (*Pectoralis profundus*) from 6 male Bali bovine heads aged 3 years. New beef from Balinese were added with moringa flour concentration of 100% and smoke flour concentration of 20%, resulting from freeze-drying. Fresh meat was rubbed with moringa flour and smoked flour and cooked for 6 hours. After that, for eight days, aging took place at a temperature of 2-5°C. The research design used was a complete design of factorial patterns 3x5, in which a factor of 1 ratio of moringa leaf flour: smoked flour; 25%: 75%; 75%: 25%; and 50%: 50%; a factor of 2 maturation time; 0, 2, 4, 6, 8 days. The research has been replicated three times. The measured parameters were pH, water holding capacity (WHC), cooked meat shear force quality (SFCM), and cooking loss (CL) after 30 minutes of cooking at 80°C.

2.1. pH measurement

The pH measurement was performed using a PH-201 pH Meter type Lutron pocket with a specific PE-06 HD meat spear tip electrode.
2.2. Measurement of Water Holding Capacity
WHC measurements were performed on Hamm Method 1972; 0.3 g of meat was given a weight of 35 kg for 5 minutes on a filter paper between two stainless steel plates. On the filter paper, we look at the area covered by the flattened meat specimen and the wet area surrounding the meat area. All fields have been assessed. The width of the wet area obtained by excluding from the total area the area covered with water. WHC has been determined based on the percentage of the whole area's wet area. Measurement of water holding power on raw meat is carried out using the 1986 Hamm-based Filter-Paper Press Method [10].

2.3. Meat shear force measurement
Value of the shear force (kg/cm²) is an indicator of the assessment of fresh and cooked beef tenderness using the Modified Shear Force CD [8].

2.4. Cooking loss measurement
Cooking loss calculation is conducted based on the weight ratio before and after the meat is cooked for 15 minutes at a temperature of 80°C. Cooking loss (percentage) is determined on the basis of the ratio of weight lost during cooking to meat weight before cooking [11].

2.5. Data analysis
Results was analyzed by variance analysis (ANOVA) and the LSD experiment was performed. While, by using the SPSS software (SPSS 16.0, SPSS Ltd., West Street, Woking, Surrey, UK), the real effect was focused on Steel and Torrie [12].

3. Results and discussions

3.1. pH
Analysis of variance showed that the ratio of moringa flour to smoke had no effect, and the maturation period had a significant effect on the pH value (table 1). The Moringa leaf smoke flour ratio does not significantly affect the pH value, but in terms of numbers decreases with increasing ratio reaching 0.13 points. It can be stated in this study that the ratio of Moringa smoked flour given to Balinese beef 75: 25% can be applied to produce a comfortable pH value. Normal meat pH is 5.5 - 5.8 [8]. The average pH value of 5.64 in PP muscles is the recommended normal pH, which is pH 5.5 - 5.8, which can explain that the rigor-mortis formation process is as it should be. This is where the pH by the theory will be achieved if the livestock gets enough rest before slaughter. The pH value achieved when rigor-mortis is formed depends on the temperature of the slaughterhouse and the condition of the animal before it is slaughtered; livestock fatigue and stress will result in pH well above normal pH. The timing of the rigor mortis is primarily determined by the condition of the livestock; fast time due to conditions of fatigue or stressed cattle are not matched with adequate rest before being slaughtered.

Increasing the maturation time further decreases the pH value to reach 0.11 points at six days maturity higher than without maturation (day 0) and increases at 8 days maturity at 0.14 points. It can be stated that the increase in pH during maturation indicates that the average pH value after 5.5 - 5.8 can be maintained by giving a different ratio of moringa flour that acts as an excellent antioxidant, which can be explained that during maturation the pH value will not be much influenced by the feed given during fattening but will have implications for the pH value at the time of the formation of rigor mortis.
Table 1. Mean value level of pH, WHC, SFCM, and CL.

| Treatments | pH     | WHC (%) | SFCM (kg/cm²) | CL (%) |
|------------|--------|---------|---------------|--------|
| Moringa:Smoke Flour Ratio | Sig: ns | Sig: ns | Sig: ns | Sig: ns |
| 25%:75%   | 5.74±0.26 | 23.59±4.37 | 0.21±0.06 | 2.16±0.54 |
| 75%:25%   | 5.61±0.36 | 24.15±3.18 | 0.23±0.08 | 2.19±0.72 |
| 50%:50%   | 5.72±0.24 | 25.44±4.81 | 0.22±0.06 | 2.41±0.62 |
| Maturation Time (days): | | | | |
| 0          | Sig:0.05 | Sig:0.001 | Sig:0.05 | Sig:0.05 |
| 2          | 5.70±0.21ab | 21.77±3.80a | 0.19±0.04a | 2.27±0.55ab |
| 4          | 5.69±0.30bc | 24.16±2.53bc | 0.19±0.05a | 1.86±0.47a |
| 6          | 5.63±0.35ab | 25.99±3.87cd | 0.21±0.08a | 2.19±0.33ab |
| 8          | 5.59±0.38b | 27.08±4.36d | 0.26±0.05b | 2.41±0.80b |

WHC: Water holding capacity, SFCM: Shear power of the cooked meat, CL: Loss in cooking

3.2. Capacity to hold water (WHC)

Analysis of variance showed no effect on the ratio of Moringa Leaf Flour Smoke and the maturation period had a very significant effect (P < 0.01) on the water holding power (Table 1). Even though it was not significantly different, the ratio of Moringa Smoke Flour in numbers increased by 0.56 points from the ratio of 75: 25% and 1.85 at the ratio of 50: 50%. Theoretically, liquid smoke or Moringa flour as a binding agent and antioxidant should be able to significantly reduce the binding capacity of meat water, but based on the results obtained tendency to decrease water holding capacity by increasing the ratio of Moringa flour to smoke is in line with the theory.

The maturation time of 0 days is significantly different from 2, 4 and 6 days. Water holding capacity of meat increases at six days maturation and decreases at eight days maturation. It can be explained that the ratio of moringa to smoke can increase the water holding capacity during maturation. Previous studies using liquid smoke as an antioxidant showed that the longer the maturation time, the higher the WHC value reached 32.55 percent, which was higher than the 0-day maturation time although there was no significant difference between the 7-14-day maturation. As WHC increases with the increasing maturation time, liquid smoke in the Urea Coconut Water Multi-nutrient Block (UCSMB) given to Bali cattle for 45 days can improve meat quality by increasing WHC during maturation [13].

3.3. Shear Force Value of cooked meat

Analysis of variance showed that the smoke moringa flour ratio had no significant effect, and the maturation time had a significant effect (P < 0.05) on the cooked meat shear force value (table 1).

Even though there is no real difference between the ratio of moringa flour to smoke, but in numbers there is a tendency for the shear force value of cooked meat to increase when the ratio increases to 0.02 points higher at the ratio of 75: 25% compared to the ratio of 25: 75% or lower than the ratio of 50: 50%.

Maturation time 0, 2, and 4 days is significantly different from 6 and 8 days maturation tendency of the value of cooked meat plus increases with increasing maturation time. Theoretically, it is suggested that the raw meat breaking down decreases with increasing maturation time as a result of the degradation of muscle myofibril by the enzyme cathepsin. In this study, it can be explained that the decrease in the braking power of cooked meat has not been able to give a real effect between maturation times. However, the maturation time on the sixth and eighth day gives a real difference with no maturation. Cooking that lasts for 30 minutes at a temperature of 800C in meat originating from cattle that get a different ratio of moringa flour to feed has not been able to increase tenderness until maturity on the 8th day. It is necessary to consider a longer cooking time so that the braking power of cooked meat increases due to the increased ratio of moringa flour...
to flour will give a significantly lower breakout value both by ratio and by maturation time. Previous studies using liquid smoke as an antioxidant showed the maturation time affected by cooked meat shear force (CMSF), in which the longer the maturation period, the higher the CMSF decrease (P < 0.01) reaching up to 27.82% at 14 days of maturation, i.e. below 0-day maturation [13,14].

3.4. Cooking loss

Analysis of variance showed no significant effect on the ratio of moringa flour to smoke, whereas the maturation period had a significant effect (P < 0.05) on cooking losses (Table 1). Although not significantly different between the ratio of given Moringa Smoke Flour, based on the figures, there is a tendency for cooking losses to increase during the increase in the ratio of moringa flour to smoke. Cooking losses increased 0.03 points at a ratio of 75: 25%. However, cooking losses increase 0.25 points greater at a ratio of 50: 50% than the ratio of 25: 75%, which can explain that although statistically, the highest ratio of moringa flour (75:25) has not been able to provide a real difference with the ratio of moringa smoke flour which is lower, but in a better figure than other ratios.

Maturation times 0, 2 and 4 are significantly different from days 6 and 8. Increasing the maturation time, the value of cooking losses tends to increase. With the increase in cooking shrinkage during maturation, indicates that the ratio of the smoke, Moringa flour has not been able to inhibit the increase in cooking losses. Moringa flour as a binding agent and antioxidants play a role in reducing cooking losses. Theoretically the binding capacity of raw meat water increases during maturation will decrease cooking losses, although in this study, the water holding capacity was not significantly different during maturation, but the water holding capacity increased until the 4th-day maturation. Previous studies using liquid smoke as an antioxidant showed increased maturation time, but on the 14th day of maturation the cooking loss decreased to 35.08 percent, although there was no significant difference between the maturation days of 0 and 7 [13]. Throughout maturation, liquid smoke in UCSMB feed can prevent free and half-free water loss and the potential for water bound to proteins.

4. Conclusion

It can be concluded that Pectoralis profundus Bali beef's ratio of moringa flour to smoke flour yielded more or less the same pH, water holding capacity, shear force quality of cooked meat, and cooking losses of muscle meat. Although maturation caused a decrease in pH, during maturation the water holding capacity, shear force quality of cooked meat and cooking loss increased. The combination of Moringa flour with smoke has not been able to spin as a perfect combination of antioxidants

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