The effect of liquid smoke on the properties of Bali beef performance in the feed block during fattening

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Abstract. This study aimed to improve the quality of Bali beef cattle through the application of liquid smoke technology as an antioxidant in the feed supplement fattening livestock groups in Tanete Riaja District, Barru Regency. The limitation of feed for a particular season in the maintenance of Bali cattle is the main problem to improve livestock performance, especially the quality of meat. Feeding in the form of Urea Coconut Water Liquid Smoke Multi-Nutrient Block (UCSMB) has been carried out in Bali cattle for 45 days of fattening. The study used 12 male Bali cattle aged 2-3 years through a completely randomized factorial 3 x 3 pattern where the first factor was the concentration of liquid smoke; 0, 10, and 20%, while the second factor is the length of maturation; 0, 7 and 14 days. Muscle Longissimus dorsi dissection after slaughter and was then observed the quality of meat regarding pH, shear force value, and organoleptic assessment, i.e., meat tenderness and juiciness. The results of the research showed that the quality of Bali beef increased with increasing concentration of liquid smoke in feed block and maturation times.

1. Introduction

Tanete Riaja Subdistrict, as a region with a Bali Cattle population that ranked the second highest (11,664 in 2012) in Barru District [1], has implemented livestock cages as the showroom. Farmers in groups conducted business to develop Bali cattle breeding and to fatten at home.

In general, the main problem raised by the partners of the livestock group was the provision of feed. Cutting and carrying, cutting elephant grass or paddy straw and giving it to cattle at home is the consequence of livestock custody requiring farmers to provide forage.

The use of probiotic paddy straw fermentation technology and supplement feeding in the form of Urea Coconut Water Liquid Smoke Multi-Nutrient Block (UCSMB) was carried out with very satisfactory results in the Technology Application in 2015 [2]. In Indonesia, in general, and particularly in South Sulawesi, raising cattle by breeders is characterized by raising Bali cattle more than 55% of the population [3]. However, the contribution of the availability of Bali cattle in Indonesia is immense, which contributes to a cattle population of up to 15.5 million head (more than 80%) [4]. While Bali cattle are known to be able to adapt well to hostile environments with low feed quality [5], another advantage of Bali cattle was that the carcass percentage could hit 52-57.7% with a low fat content of around 4%. [6]. In the traditional raising in South Sulawesi, the fat content of Bali beef was less than 2% [7].
Bali cattle are raised by breeders with the primary purpose of savings with a tiny amount of rearing 1-5 cattle. The characteristics of raising Balinese cattle in Indonesia are marked not only in small numbers of livestock ownership but are preferred as savings that will be released when they need money to meet their needs at certain times.

Bali cattle have an outstanding reproductive and adaptive capacity, a high percentage of carcass 51 to 57 percent, a fat content of meat ranging from 2 to 6.9 percent, and a male 2-year-old weighing up to 210 to 260 kg [6,8]. The percentage of Bali cattle carcasses has been reported to be as high as 52% to 57.7%, with a low fat meat content of about 4% [9]. The level of Bali beef fat content in conventional maintenance in South Sulawesi is below 2%. Bali beef's quality is reasonably good, mainly if better management and feeding are preserved. Weight gain is relatively small at comprehensive treatment ranging from 0.1 to 0.3 kg per day; this can therefore be increased by intensive care by supplying high-quality feed up to 0.65 kg per day [10].

The importance of cattle farms in Indonesia could be seen from the community's need for sources of animal protein derived from fresh meat and processed meat products such as meatballs. Fresh beef needs reached 2.56 kg / capita / day or 654,000 tons for 255,461,700 inhabitants of Indonesia in 2015 [11]. Although the need for meatballs [10] has been illustrated, the value of beef meatballs for public consumption has been defined by around 60% of cattle slaughtered in slaughterhouses (personal communication). In Indonesia, slaughtered cattle reached 1,114,748 [2] in 2017, with an average weight of 50 kg / head of meat to be processed at 33,442.4 tons / year of meatball production or 91,62 tons / day in Indonesia [4,10,12]. Tante Riaja Subdistrict, as a region with a Bali Cattle population that ranked the second highest (11,664 in 2012) in Barru District [1] has implemented livestock cages as the showroom. Farmers in groups conducted business to develop Bali cattle breeding and to fatten at home.

In 2016 feed technology innovations were carried out through the manufacture and feeding of UCSMB block supplements, which were added several levels of liquid smoke concentrations then given as feed fattening to cattle belonging to livestock groups. Through this technological innovation as a form of community empowerment, it was expected that it could be a solution to solving food availability which will have an impact on increasing the productivity of Bali cattle in the showroom.

2. Materials and methods
The application of liquid smoke in feed block was carried out in the Sikapa group farmers during the fattening of Bali cattle.

This research utilized 12 head of Bali cattle age 2-3 years old male. The animals received 6 kg of probiotic fermented rice straw and 500 gr UCSMB per day during 45 of fattening. After the cattle were slaughtered, meat samples were taken on the outer portion (Longissimus dorsi muscle), then meat quality was observed at the Hasanuddin University Meat and Egg Processing Technology Laboratory.

This study used a complete randomized 3x3 factor pattern design, where the first factor was the liquid smoke concentration (0, 10, and 20 percent) and the second factor was the maturation time (0.7 and 14 days). The observed parameter was pH, shear force value of raw meat (RMSF), and organoleptic assessment, i.e. meat tenderness and juiciness.

2.1. Urea Coconut Water Liquid Smoke Multi-Nutrient Block (UCSMB)
There were three different types of UCSMB, which have different concentrations of liquid smoke in block feed formulations, namely concentrations of 0%, 10%, and 20%, with a rate of 2% in the formulation. Table 1 indicates the composition of feed supplements in the form of blocks.
Table 1. Feed material composition in UCSMB [12,13].

| Feed Material            | Feed material composition (%) in liquid smoke concentration |
|--------------------------|------------------------------------------------------------|
|                          | 0%  | 10% | 20% |
| Coconut water            | 30  | 28  | 28  |
| Urea                     | 5   | 5   | 5   |
| Rice Bran                | 30  | 30  | 30  |
| Corn meal                | 10  | 10  | 10  |
| Milled coconut meal      | 10  | 10  | 10  |
| Cement                   | 10  | 10  | 10  |
| Mineral cattle           | 2   | 2   | 2   |
| Salt                     | 3   | 3   | 3   |
| Liquid Smoke             | 0   | 2   | 2   |

2.2. Rice straw fermented with probiotics

For 10-12 days, fermented straw products are developed using organic liquid supplement (SOC) probiotics from rice straw. Sprinkled with diluted SOC probiotic solution with a ratio of 30 ml SOC dissolved into 45 liters of clean water, 150 kg rice straw was stacked several piles. It was sprinkled with very fine rice bran among the sheets. The rice straw was fermented after 10-12 days and ready for use as cattle feed. Laboratory study results showed a higher nutritional value than unfermented rice straw. Until fermentation, the volume of wheat protein was 2% higher than that of straw to 7.87%.

Fermented straw protein content was 2% higher than straw before fermentation to 7.87%. Previous research produced a protein content of 6.44% [2]. The type and age of straw could explain this difference.

2.3. pH Measurement

pH measurement was done using a Lutron pH meter pocket PH-201 with electrode type (spear tip) PE-06 HD specifically for meat.

2.4. Measurement of raw meat shear force

Shear force value of raw meat measurement is meant to see the tenderness of meat by using CD Shear Force. Where samples of meat in the form of a cylinder with a length of 1 cm and 0.5 inches in diameter were placed in the hole of the CD shear force that the blade with a thick 1 mm to cut samples. The higher the load to cut off, the sample of the meat is tough. Shear force values expressed in kg/cm² [7].

2.5. Sensory test on meat cooked at 80°C for 15 minute

Tenderness and juiciness included the parameters measured in the sensory test. The sensory assessment included 20 panelists who had previously been educated and assessed the sensory quality of meat based on the scale translated into an evaluation score ranging from 1 to 6, which means that one is very tough and not juicy, and six is very tender and very juicy.

2.6. 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 [13].
3. Results and discussions

3.1. Meat Quality
The quality of fattened meat from Bali cattle through the provision of fermented probiotic and UCSMB feed could be explained through the measurement of several meat quality parameters, including pH, raw meat shear force value, and organoleptic test, i.e., meat tenderness, and juiciness. The significance level of the mean value of meat quality can be seen in Table 2 and figures 1, 2, 3, 4, 5, 6, 7, and 8.

| Treatments | pH Value | RMSF (kg/cm²) | Tenderness Score | Juiciness Score |
|------------|----------|----------------|------------------|-----------------|
| UCSMB      | Sig: 0.01 | Sig: 0.01      | Sig: 0.01        | Sig: 0.01       |
| - 0%       | 6.52±0.21 | 4.03±0.15      | 4.30±0.79        | 4.67±0.49       |
| - 10%      | 6.02±0.39 | 2.47±0.18      | 4.47±0.82        | 4.94±0.75       |
| - 20%      | 5.98bc±0.45 | 3.23±0.70    | 4.68±0.81        | 5.04bc±0.80     |
| Maturation time | Sig: 0.01 | Sig: 0.01      | Sig: 0.01        | Sig: 0.01       |
| - 0 day    | 5.87a±0.61 | 3.59±0.72      | 3.68±0.12        | 4.34±0.09       |
| - 7 days   | 6.40b±0.26 | 3.25±0.66      | 4.51ab±0.34      | 4.67b±0.09      |
| - 14 days  | 6.25±0.06 | 2.91±0.82      | 5.27bc±0.13      | 5.64c±0.39      |

Numbers on the same column with different letter notation showed a very significant difference (P< 0.01). Sig: 0.01=significant at 1 % (P<0.01). Score: 1-6; 1=very tough, not juicy .......... 6=very soft, very juicy.

Figure 1. The value of pH of meat samples on different urea coconut water smoke molasses block (UCSMB) concentrations and maturation time (MT) on meat; (1) UCSMB0-MT0 = without using UCSMB and maturation time; (2) UCSMB0-MT7 = without using UCSMB and maturation time for 7 days; (3) UCSMB0-MT14 = without using UCSMB and maturation time for 14 days; (4) UCSMB10-MT0 = UCSMB 10% and without maturation time; (5) UCSMB10-MT7 = UCSMB 10% and maturation time for 7 days; (6) UCSMB10-MT14 = UCSMB 10% and maturation time for 14 days; (7) UCSMB20-MT0 = UCSMB 20% and without maturation time; (8) UCSMB20-MT7 = UCSMB 20% and maturation time for 7 days; (9) UCSMB20-MT14 = UCSMB 20% and maturation time for 14 days.
3.2. pH value of beef

Variance analysis showed that the concentration of liquid smoke in block feed had a significant effect on the pH of meat ($P<0.01$). The higher the level of liquid smoke in UCSMB, the lower the final pH at 20% will be 8.28% lower. There is, however, no real difference between 10% and 20% concentration. This indicates that the final pH of Bali beef can be reduced by liquid smoke in block feed for 45 days. Changes in the pH value of Bali beef can be seen in table 2 and figure 1.

Variance analysis showed that the ripening time had a very significant effect ($P<0.01$) on the pH value of meat. The higher the maturation time, the higher the final pH reaches 6.30% (0.37 points) at 14 days maturation.

There was an interaction between liquid smoke concentration and maturation time marked by a decrease in pH with increasing concentration of liquid smoke and an increase in pH with increasing maturation time. The interaction of concentration liquid smoke and maturation time on pH value can be seen in figure 2.

![Figure 2. Interaction of concentration liquid smoke and maturation time on pH value.](image)

3.3. Raw Meat Shear Force value (RMSF)

Changes in the value of raw meat shear force were shown in table 2 and figure 3 based on the concentration of liquid smoke and the maturation time.

Increasing liquid smoke concentration in UCSMB, decreasing RMSF; at the concentration of liquid smoke 10% the decline in the RMSF reached 38.71%, and at a concentration of 20% the decline in the RMSF reached 19.85 percent opposed to smoke-free. It showed that liquid smoke in UCSMB given to Bali cattle for 45 days could improve the quality of meat by the tenderness, which was better at a concentration of 10% than 20%. This showed that liquid smoke in UCSMB given to Bali cattle for 45 days could improve meat quality through increased tenderness, which at a concentration of 10% was better than the concentration of 20%. Previous research in which liquid smoke was added directly to Bali beef showed the concentration of liquid smoke (0, 5, 10, and 15%) did not significantly affect the RMSF even though there was a tendency to decrease the RMSF [14].

As the maturation time increased, the RMSF fell below the start of maturation (0 days) to 18.94 percent on the 14th day of maturation. The lower RMSF said the meat was tenderer than the high RMSF Previous research using buffalo meat smoke flour showed a decrease in RMSF during maturation, reaching the lowest RMSF value at maturation of 14 days, reaching 30.32% [15]. Improvement in fresh meat tenderness during maturation (2-5°C) was generally caused by proteolytic enzymes, especially the enzyme of cathepsin. This
indicated that during maturation, there was an improvement in meat tenderness as the role of proteolytic enzymes (the maturation phenomenon) and the role of liquid smoke in constricting meat [16,17].

There was an interaction between the concentration of liquid smoke with the maturation time of the RMSF marked by a decreased in RMSF that was not linear, lower at a concentration of 10% than the concentration of 20% with increasing concentration of liquid smoke and decreasing RMSF linearly with increasing maturation time. The interaction of concentration liquid smoke and maturation time on RMSF can be seen in figure 4.

3.4. Tenderness score
Table 2 and Figure 5 revealed improvements in the rating of tenderness measured by panelist assessments based on the amount of liquid smoke and the time of maturation.

The higher concentration of liquid smoke in UCSMB feed reduced the value of meat cooking shear force to 55.34 percent lower than without liquid smoke at a concentration of 20 percent. This demonstrates the excellent ability of liquid smoke to reduce the value of meat cooking shear force given directly to livestock via UCSMB feed. The use of direct liquid smoke in fresh meat revealed that the concentration of liquid smoke did not significantly affect the shear force value of cooked meat (80°C-15'), although there was a tendency to decrease the shear force value of meat cooking with increased liquid smoke concentration [15]. In this case, liquid smoke, up to 2% in the feed, can inhibit protein oxidation during maturation that is
characterized by increased tenderness [18]. It was reported that if the protein is oxidized, the tenderness of the meat could decrease [19], indicating that protein oxidation would change the WHC and meat tenderness.

Figure 4. Interaction of the concentration of liquid smoke and maturation time on RMSF.

Figure 5. The value of Tenderness of meat samples on different urea coconut water smoke molasses block (UCSMB) concentrations and maturation time (MT) on meat; (1) UCSMB0-MT0 = without using UCSMB and maturation time; (2) UCSMB0-MT7 = without using UCSMB and maturation time for 7 days; (3) UCSMB0-MT14 = without using UCSMB and maturation time for 14 days; (4) UCSMB10-MT0 = UCSMB 10% and without maturation time; (5) UCSMB10-MT7 = UCSMB 10% and maturation time for 7 days; (6) UCSMB10-MT14 = UCSMB 10% and maturation time for 14 days; (7) UCSMB20-MT0 = UCSMB 20% and without maturation time; (8) UCSMB20-MT7 = UCSMB 20% and maturation time for 7 days; (9) UCSMB20-MT14 = UCSMB 20% and maturation time for 14 days.
The interaction of concentration liquid smoke and maturation time on tenderness can be seen in Figure 6.

![Figure 6](image)

**Figure 6.** Interaction of the concentration of liquid smoke and maturation time on tenderness.

![Figure 7](image)

**Figure 7.** The value of Juiciness (%) of meat samples on different urea coconut water smoke molasses block (UCSMB) concentrations and maturation time (MT) on meat; (1) UCSMB0-MT0 = without using UCSMB and maturation time; (2) UCSMB0-MT7 = without using UCSMB and maturation time for 7 days; (3) UCSMB0-MT14 = without using UCSMB and maturation time for 14 days; (4) UCSMB10-MT0 = UCSMB 10% and without maturation time; (5) UCSMB10-MT7 = UCSMB 10% and maturation time for 7 days; (6) UCSMB10-MT14 = UCSMB 10% and maturation time for 14 days; (7) UCSMB20-MT0 = UCSMB 20% and without maturation time; (8) UCSMB20-MT7 = UCSMB 20% and maturation time for 7 days; (9) UCSMB20-MT14 = UCSMB 20% and maturation time for 14 days.
Variance analysis showed that the maturation time affects the cooked shear force value of meat, where the longer the maturation time, the cooked meat shear force value decreased, and at maturation of 14 days, the shear force value decreased to 27.82 percent below the maturation time of 0 days. This was consistent with the decline in the value of raw meat shear force during maturation due to proteolytic enzyme function that digests proteins during maturation resulting in a decrease in the value of raw meat shear force. However, on the 14th day of maturation, the decrease in the shear force value of cooked meat was higher than the shear force value of 18.94% raw meat. Heating meat at 80°C temperature caused collagen to dissolve, which can explain this by the deposition of raw meat [7].

3.5. Juiciness score
Changes in the juiciness score calculated by the panelist experiment based on liquid smoke concentration and maturation period were shown in table 2 and figures 7 and 8.

Analysis of variance showed that the concentration of liquid smoke and the maturation time affects the juiciness score of meat cooked (P<0.01), where the more concentrated of liquid smoke in the fed block the score of juiciness more increased to reach 7.92% more than at without liquid smoke in the fed block.

The maturation time resulted in the score of the juiciness of meat cooked increased and at 14 days’ maturation the score of juiciness value up to 29.95% higher than the 0-day maturation time. The interaction of concentration liquid smoke and maturation time on juiciness can be seen in figure 8.

Figure 8. Interaction the concentration of liquid smoke and maturation time on juiciness.

4. Conclusion
This current study reveals that the quality of Bali beef increased with increasing concentration of liquid smoke in UCSMB feed and maturation time. The concentration of liquid smoke decreased pH value, and raw meat shear force value increased tenderness score, and juiciness score. While maturation time increased pH value, decreased raw meat shear force value, increased score of tenderness, and increased juiciness score.

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