Effect of Liquid Smoke Concentration In Feed Block Supplement and Time of Meat Maturation on Bali Beef Quality

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ABSTRACT

An experiment was carried out to study the effect of liquid smoke concentration in feed block supplement and time of meat maturation on Bali beef quality. The addition of liquid smoke together with coconut water into the feed block (UCSMB) in fattening Bali cattle is one of the innovations to enhance the growth of livestock and meat quality after aging. This research conducted on 9 Bali cattle aged two years fattened for 45 days. After the slaughtering, the Longissimus dorsi muscles were dissected and aged for 14 days. This study used an entirely randomized design of factorial pattern of 3 x 3, where factor 1 was concentrations of liquid smoke (0, 10, 20%) and factor 2 was maturation time (0, 7, 14 days). All treatments replicated for three times. The variables measured were water holding capacity (WHC), cooked meat shear force (CMSF) value, cooking loss, thiobarbituric acid reactive substances (TBARS) value, and meat color (L*, a*, b*). The results of this study showed that when the concentration of liquid smoke was higher, WHC and meat color (L*, a*, b*) dropped. It can be concluded that the liquid smoke in UCSMB can improve the quality of the flesh.

KEY WORDS
Aging, Bali cattle, liquid smoke, longissimus dorsi, meat quality, UCSMB

INTRODUCTION

Paradigm farm development was the realization of a healthy society and productive and creative through a tough farm based on local resources [1,2,3]. As a maritime continent, Indonesia has vast natural resources of the agricultural sector. One of the natural resources is coconut tree frequently found on the coast to the extent of certain altitudes. Coconut water can be used as a substitute for molasses in feed supplement blocks [4], and coconut shells can be utilized as raw materials to produce liquid smoke [5], [6].

Bali cattle (Bos sondaicus) are local Indonesian cattle that are a domestication form of the Banteng. Indonesian farmers have raised approximately 55% of Bali cattle [7] targeting a population of 1,450,000 individuals in South Sulawesi in 2016 [8]. According to [9] that the possession of a cow head 1-4 scale reached 92%. Bali cattle have an excellent reproduction and adaptation capacity, a high percentage of 51 to 57% of a carcass, meat fat content ranging from 2 to 6.9%, and a 2-year-old male weighs up to 210 to 260 kg [10], [11]. [12] State that the percentage of Bali cattle carcasses reaches up to 52 to 57.7% with a low-fat content of meat of around 4%. In the traditional maintenance in South Sulawesi, the level of Bali beef fat content is below 2%.

The quality of Bali beef is reasonably good, particularly if maintained by better management and feeding. Weight gaining is relatively small at extensive maintenance ranging from 0.1 to 0.3 kg per day; hence, it can be improved through an intensive care by providing high-quality feed reaching up to 0.65 kg per day [4].
Coconut water and liquid smoke produced from the coconut shell pyrolysis [4] is added into the feed supplement in blocks, i.e., Urea, Coconut Water, Liquid Smoke, and Multi-nutrient Blocks (UCSMB) in fattening the Bali cattle. Liquid smoke, as an antioxidant and binder, is expected to protect proteins contained in the feed from rumen bacteria degradation; therefore, they can be absorbed efficiently in the intestine with a better growth impaction and higher meat quality.

Some previous studies reveal that an additional liquid smoke on Bali beef meatballs is capable of increasing the water holding capacity and decreasing the cooking loss of meatball product [13]. Similarly, the functional property of Bali beef is increased by adding post-rigor liquid smoke on Longissimus dorsi muscle. Liquid smoke can lower TBA value of 41.67% and a total bacterial colony of 57.3% at 10% concentration compared with that of without liquid smoke [14]. The use of liquid smoke in flour in Bali beef and buffalo meatballs produces the same sensory characteristics on different smoke flour types; however, the level of firmness and elasticity of buffalo meatballs is higher than that of Bali beef meatballs [15]. The use of liquid smoke in mice was conducted by [16] in which in 14 days of observation, the body weight of mice increased at all levels of liquid smoke exposures. Meanwhile, the liquid smoke as an antioxidant in catfish was studied by [17].

The use of liquid smoke in fattening Bali cattle feed is new and innovative, and it is expected to increase the yield and meat quality to reduce the amount of meat used in the processing and simultaneously improves the durability of the product.

Methodology:

This study utilized the post-rigor Longissimus dorsi (LD) muscle, from 9 males of 2-year-old cattle fed with Urea Coconut Smoke Multi-nutrient Blocks (UCSMB) and probiotic fermented rice straw for 45 days. The liquid smoke concentrations of 10 and 20% added to the UCSMB feed at 2% (w/w) functioned as the binder and preservative. Longissimus dorsi muscles (LD) were dissected from all of the nine male cattle after the slaughtering and aged for 14 days.

Urea, coconut water, liquid smoke multi-nutrient block (UCSMB) is a modification of UMMB (urea-molasses block multi-nutrient) where molasses replaced with coconut water, and liquid smoke was added as an antioxidant and binder [4]. There were three kinds of UCSMB used with liquid smoke treatment adapted to the concentrations of 0% (control), 10%, and 20% with the addition of 2% level in the formulation (w/w). The composition of the feed material in UCSMB shows in Table 1.

The probiotic fermented rice straw produced from the fermentation process by using an organic liquid probiotic supplement (SOC brand made by CV. HCS Powerindo) for ten to 12 days. One hundred and fifty kilograms of rice straw was stacked with piles after they sprinkled with SOC probiotic solution diluted with 30 ml of SOC dissolved into 45 liters of clean water (v/v). Rice polish or fine bran sprinkled on the piles. After ten to 12 days, the rice straw had already fermented and ready to be used as feed for cattle [4].

<table>
<thead>
<tr>
<th>Feed materials</th>
<th>Composition (g/kg) at Liquid smoke concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0%</td>
</tr>
<tr>
<td>1. Coconut water</td>
<td>30</td>
</tr>
<tr>
<td>2. Urea</td>
<td>5</td>
</tr>
<tr>
<td>3. Rice Bran</td>
<td>30</td>
</tr>
<tr>
<td>4. Cornmeal</td>
<td>10</td>
</tr>
<tr>
<td>5. Copra meal</td>
<td>10</td>
</tr>
<tr>
<td>6. Cement</td>
<td>10</td>
</tr>
<tr>
<td>7. Cow Mineral</td>
<td>2</td>
</tr>
<tr>
<td>8. Table salt</td>
<td>3</td>
</tr>
<tr>
<td>9. Liquid smoke</td>
<td>0</td>
</tr>
</tbody>
</table>

This study used an entirely randomized design of factorial pattern of 3 x 3. The first factor was the concentration of liquid smoke in the feed block (0, 10%, and 20%) and the second factor was the duration of maturation (0, 7, and 14 days) at a temperature of 2° - 5°C replicated for three times. Thus, the variables measured included water holding capacity (WHC), cooked meat shear force value (CMSF), cooking loss (CL), TBARS value, meat color (hunter system; L*, a*, and b*).

Every animal received feeds in the form of 500 g of UCSMB, and 5 kg of fermented rice straw per day for 45 days.

WHC measurement conducted about Hamm Method 1972; 0.3 g of meat on a filter paper between two stainless steel plates was given a weight of 35 kg for 5 minutes. On the filter paper, we look the area covered by the sample of meat that had become flattened, and the wet area around the meat area. Both areas were measured. The size of the wet area obtained by subtracting the area covered with meat from the total area. WHC was calculated based on the percentage of the wet area from the entire area [14].
CMSF measurement is intended to examine the degree of meat tenderness after cooking at a temperature of 80°C for 15 minutes at 50 g sample. The shear force measured by using CD Shear Force, in which the meat samples in cylinder form with 1 cm length and a diameter of 0.5 inches placed in the hole on CD shear force. Thus, the samples have torn by using CD shear force knife with 1 mm thickness. The bigger the weight to tear the meat samples, the harder the meat tenderness. SF value was in kg/cm² unit [10].

The measurement of cooking loss is performed based on the ratio between the weights before and after the meat is cooked at a temperature of 80°C for 15 minutes [15].

The measurement of TBARS values (malonaldehyde mg/kg samples) was conducted to determine the fat oxidation level by using Tarladgis method of 1960. The result of the example distillation with 4m HCL reagent was added by 5 ml TBA (0.2883g/100 ml of glacial acetic acid 90%) and heated for 35 minutes in boiling water. After it had become cold, the absorbance level (D) measured at a wavelength of 528 nm with the blank solution as the zero point. The new solution contained 5 ml of distilled water with 5 ml of reactant. The number of TBA 7.8 x D was expressed in mg malonaldehyde per kg samples [16].

Meat color measurement refers to the Hunter system of L*, a*, b* wherein L* is the level of lightness, a* is the degree of redness and b* is the standard of yellowness ranging from 0 to 100%. The higher the percentage of reflection, the more the color becomes lighter, darker red and darker yellow [17]. Color measurement conducted by using a portable colorimeter TES-135 Digital Color.

The data processed by utilizing analysis of variance (ANOVA) and means compared by LSD based on [18] with SPSS (SPSS 16.0, SPSS Ltd., West Street Working, Surrey, UK).

RESULTS AND DISCUSSION

The results of UCSMB nutrient values showed in Table 2. The high protein value of UCSMB10% (30.59%) will be able to meet the protein requirement for cattle fattening, along with the high crude fiber value (9.72%) which can replace grass as the primary feed commonly used in feeding at the barn.

In the comparison between UMMB and UCSMB, the fundamental difference can be seen from the color appearance in which UCSMB product has the bright color of light brown, while UMMB product is dark brown. The values of protein, crude fiber, and ash are lower, while the values of fat and NFE are higher in UMMB [1]. Thus, the high values of protein, fat, and fiber on UCSMB can consider as feed supplement which fulfills the needs of nutrient substances of Bali cattle. Table 2 indicates the feed containing 10% UCSMB had higher protein and fat values and lower crude fiber and ash value compared to UCSMB of 0% and UCSMB of 20%.

The results of laboratory analysis showed that the nutritional values of fermented probiotic rice straw are better than those of rice straw without fermentation (Table 2). The protein amount of fermented hay is 2% higher than that of non-fermented straw, i.e. 7.87%.

Table 2: Nutrient values of UCSMB and rice straw fermentation (g/kg)

<table>
<thead>
<tr>
<th>No</th>
<th>Feed</th>
<th>Water</th>
<th>Protein</th>
<th>Fat</th>
<th>Crude fiber</th>
<th>NFE</th>
<th>Ash</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>UCSMB 0%</td>
<td>32.74</td>
<td>28.83</td>
<td>7.05</td>
<td>11.21</td>
<td>27.57</td>
<td>25.34</td>
</tr>
<tr>
<td>2</td>
<td>UCSMB10%</td>
<td>31.81</td>
<td>30.59</td>
<td>8.13</td>
<td>9.72</td>
<td>26.37</td>
<td>25.19</td>
</tr>
<tr>
<td>3</td>
<td>UCSMB20%</td>
<td>31.79</td>
<td>28.53</td>
<td>8.12</td>
<td>10.93</td>
<td>26.51</td>
<td>25.91</td>
</tr>
<tr>
<td>4</td>
<td>Rice straw</td>
<td>12.13</td>
<td>5.87</td>
<td>2.85</td>
<td>38.19</td>
<td>32.20</td>
<td>20.89</td>
</tr>
<tr>
<td>5</td>
<td>UCSMB fermentation</td>
<td>10.61</td>
<td>7.87</td>
<td>3.08</td>
<td>36.90</td>
<td>27.90</td>
<td>24.25</td>
</tr>
</tbody>
</table>

Remark: 1) The analysis result of the Laboratory of Chemistry and Livestock Feed at Faculty of Animal Sciences, University of Hasanuddin
2) Except for water, the analysis result was calculated based on the dry material
3) NFE = Nitrogen Free Extract

The change of WHC value based on the concentration of liquid smoke and maturation time showed in Table 3. The level of different liquid smoke on UCSMB produced roughly the same WHC, although there was a tendency that WHC increased as the concentration of liquid smoke increased. At a fluid smoke level of 20%, WHC reached up to 20.23% which was 22% higher than the concentration at 10% and without liquid smoke.

The previous research with the provision of liquid smoke directly on fresh meat showed significant differences between smokeless liquid and vapor-liquid at the concentrations of 10% and 15% [11]. The higher rate of addition of liquid smoke at a concentration of 10% made WHC value higher.

The longer the maturation time, the higher the WHC value (P<0.001) reaching 32.55% which was greater than the maturation time of 0 days although there were no significant differences between the maturation time of 7 and 14 days. The increase of meat WHC with the increasing maturation time indicates that liquid smoke in UCSMB given to Bali cattle for 45 days can improve the quality of meat through the increased WHC during maturation. This increase explained by the fact that during the maturation period, meat protein protected from oxidation by liquid smoke which acted an antioxidant. [19] stated that if the flesh protein undergoes oxidation,
WHC can decrease. The WHC change due to oxidation of the protein is also reported by [20]. Previous research showed a decline in WHC of *Longissimus dorsi* muscle of Bali cattle with increased storage time of 8 hours where the WHC reached 31.40% [11]. The maturation time did not significantly affect WHC although there was an increasing trend of WHC in the first week, i.e., 31.0%, and then it decreased in subsequent maturation time [11].

The higher the concentration of liquid smoke in UCSMB, the lower the CMCSF value (P<0.001) reaching 55.34% at a concentration of 20% lower than that without the liquid smoke (Table 3). This matter indicates the high capabilities of liquid smoke given directly to livestock through UCSMB feed to lower the value of CMCSF. The decrease of SF value with the increasing concentration of liquid smoke indicates that the liquid smoke can inhibit oxidation of proteins as an antioxidant. [19] stated that if the meat protein undergoes oxidation, it can decrease the tenderness of the flesh. [20] suggest that the protein oxidation will change the WHC and tenderness of the meat. The previous research on the addition of liquid smoke directly on fresh meat shows that the concentration of liquid smoke does not significantly affect the shear force of cooked meat at a temperature of 80°C for 15 minutes. There is a tendency of SF values to decrease with increasing levels of liquid smoke [11].

**Table 3:** Effects of liquid smoke concentrations in UCSMB and aging time of *Longissimus dorsi* on the properties of meat quality of Bali cattle (means and SE)

<table>
<thead>
<tr>
<th>Treatments</th>
<th>WHC (%)</th>
<th>CMSF (kg/cm²)</th>
<th>CL (%)</th>
<th>TBA (mg MDA/kg)</th>
<th>L*(%)</th>
<th>a*(%)</th>
<th>b*(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LS Conc.:</td>
<td>Sig: NS</td>
<td>Sig:0.001</td>
<td>Sig:0.001</td>
<td>Sig:0.001</td>
<td>Sig:0.001</td>
<td>Sig: NS</td>
<td>Sig:0.001</td>
</tr>
<tr>
<td>0%</td>
<td>18.38±2.41</td>
<td>8.34±1.96</td>
<td>23.41±6.75</td>
<td>0.25±0.04</td>
<td>46.41±3.84</td>
<td>17.31±2.30</td>
<td>5.82±2.06</td>
</tr>
<tr>
<td>10%</td>
<td>18.58±3.26</td>
<td>4.13±0.54</td>
<td>15.38±2.22</td>
<td>0.20±0.01</td>
<td>37.03±8.95</td>
<td>16.73±0.76</td>
<td>7.92±1.27</td>
</tr>
<tr>
<td>20%</td>
<td>20.73±4.97</td>
<td>3.68±0.41</td>
<td>13.42±2.39</td>
<td>0.15±0.02</td>
<td>42.60±0.71</td>
<td>16.66±0.79</td>
<td>8.99±0.62</td>
</tr>
<tr>
<td>Aging:</td>
<td>Sig:0.001</td>
<td>Sig:0.001</td>
<td>Sig:0.001</td>
<td>Sig:0.001</td>
<td>Sig: NS</td>
<td>Sig: NS</td>
<td>Sig:0.05</td>
</tr>
<tr>
<td>0 days</td>
<td>15.79±2.06</td>
<td>6.11±2.87</td>
<td>20.41±6.50</td>
<td>0.19±0.02</td>
<td>41.78±3.83</td>
<td>17.55±4.47</td>
<td>8.18±2.07</td>
</tr>
<tr>
<td>7 days</td>
<td>20.47±2.34</td>
<td>4.59±1.35</td>
<td>18.54±6.63</td>
<td>0.21±0.06</td>
<td>42.35±4.75</td>
<td>16.96±1.71</td>
<td>8.00±1.74</td>
</tr>
<tr>
<td>14 days</td>
<td>20.98±2.39</td>
<td>5.34±2.67</td>
<td>13.25±1.44</td>
<td>0.21±0.05</td>
<td>41.91±5.36</td>
<td>16.19±0.83</td>
<td>6.55±1.72</td>
</tr>
</tbody>
</table>

Description: Numbers with different superscripts in the same column stated a significant difference (p<0.05) and a highly significant difference (p<0.01). LS Conc.: Liquid smoke concentrations

The maturation time affected CMSF, in which the longer the maturation period, the higher the decrease of the CMSF (P<0.01) reaching up to 27.82% at 14 days of the maturation process, i.e. lower than 0-day maturation. Decrease in CMSF value during maturation in line with the reduction of occupational CMSF during maturation as a result of a proteolysis enzyme that digests proteins resulting in reduced of raw meat shear force (RMSF). Nonetheless, greater lowering of CMSF compared with RMSF was up to 18.94% on the 14th day of maturation time. Meat heating at a temperature of 80°C caused collagen dissolution which is an explanation of raw meat tenderness. Another report shows that meat protein oxidation does not occur as liquid smoke protects it as an antioxidant. In line with what is proposed by [22], if the protein does not oxidize, the meat tenderness increases during maturation. The previous studies show that the length of the maturation time, the higher the decrease of meat shear force (tenderer). The maturation of week 0, 2 and three was a significantly different (P<0.01), but the second and the third week was no different. Maturation in the second week improved the tenderness by 26.72% [11]. As the concentration of liquid smoke in UCSMB increased, the cooking loss (Table 3) decreased, reaching up to 34.30% at the level of 20%, although there was no significant difference between the concentrations of 10% and 20%. The decrease in the cooking loss of liquid smoke levels in the UCSMB feed creates a positive result that the intensity level lower cooking loss which has an implication in the increased yield of meat and processed meat products. This notion is in line with WHC which tends to grow as the liquid smoke concentration in UCSMB increases although the differences in concentration levels are not significant. Previous studies reveal that cooking loss decreases as the levels of liquid smoke increases, yet there are no important differences between the concentrations of 5 and 10% [14].

As the maturation time increased, the cooking loss decreased reaching up to 35.08% on the 14th day of maturation time, although there was no significant difference between the maturation days of 0 and 7. Liquid smoke in UCSMB feed can inhibit free and half-free water loss and the possibility of water bound to proteins during maturation. It will have implications for high yield in processed meat products as well as on meat which has undergone maturation. This notion is in line with the increase of WHC as the maturation time increases. The previous studies in which an addition of liquid smoke with different concentrations given directly to fresh meat reveal that maturation does not significantly affect the cooking loss of Bali cattle *Longissimus dorsi* muscle.

The higher the concentration of liquid smoke in UCSMB, the greater the decrease in the TBARS value (P<0.001) reaching up to 39.76% lower at a level of 20% compared with that of no liquid smoke. TBARS value in this study MDA ranged between 0.15 to 0.25 mg/kg of meat based on the concentration of liquid smoke and 0.19 to 0.21 mg MDA/kg of meat based on the maturation. This value is minimal when compared with the critical value of 3 mg MDA/kg in which the level of rancidity is detectable [24]. The intensity of significantly
low fat oxidation and liquid smoke concentration in the UCSMB feed as a natural antioxidant can inhibit Bali beef fat oxidation. [25] Point out that the low intensity of fat oxidation during storage occurs if TBARS value remains little below the threshold to detect rancidity but remain high in meat maturation sampling. This study supports the previous research in which the higher the concentration of liquid smoke, the greater the decrease in TBARS value reaching up to 41.67% at a concentration of 10% and 31.94% at 5% [14]. An addition of vitamin E to the pasture as an antioxidant in cattle increases the vitamin E in muscle and decreases the impact of fat oxidation on beef [26].

The length of the maturation time, the higher the TBARS value (P<0.001) reaching up to 12.23% greater in the maturation of day 14 compared with the maturation of day 0, even though there is no significant difference between day 7 and day 14. Indicating that liquid smoke in UCSMB feed can maintain the level of fat oxidation until the 7th day after the maturation and makes it stagnant. The previous research using smoke flour showed that the maturation time did not significantly affect TBARS value on Bali beef and chicken meat (breast and thigh), although there was a tendency of the increase of TBARS value during the maturation.

The changes of meat color of L* during maturation process about the concentration of liquid smoke in UCSMB and aging time shown in Table 3.

The higher of the mass of liquid smoke in UCSMB, the lower the level of the lightness of the meat. The L* lightness level (P<0.001) reaching up to 8.21% at a concentration of 20% compared with that of no liquid smoke. Meanwhile, at a concentration of 10%, the lightness level decreased up to 20.21%. The high degree of the reduced lightness occurred at a level of 10% then dropped to 8.21% at a concentration of 20%. Indicating that higher level of liquid smoke can restore the color lightness of the (L*) Bali beef; although it is still lower than that of (L*) without liquid smoke. The concentration of 20% liquid smoke inhibits the myoglobin protein oxidation of meat stronger than a level of 10%. Previous research in which that the smoke flour is added directly to the raw meat of Bali beef showed that the higher the level of smoke, the lightness the color of Bali beef. There were real differences among the levels of 0%, 1%, and 2%, but no significant differences between levels of 1% to 2%. The smoke flour can increase the brightness of Bali beef in the range of L* values. The lightness level (L*) of Bali beef in this study met the range that typically occurs in meat that is between 35 to 60% [20].

Liquid smoke concentration in UCSMB feed has not been able to provide a significant effect on meat color a* (redness) on Bali beef (Table 3). Supporting previous studies in which the addition of smoke flour at different levels does not significantly affect the meat color a* of Bali beef [15]. The results of this study indicate that liquid smoke given in the feed can maintain the beef meat color of a*.

Maturation time provides no significant effects on meat color a* of Bali beef which added by liquid smoke in UCSMB feed. Indicating that there is not support the previous research in which smoke flour is capable of increasing the redness level (meat color a*) up to the 7th day of maturation [15]. The value for redness level (a*) of beef Bali in this study fulfilled the range that typically occurs in meat, i.e., between 2 to 30% [17].

The higher the concentration of liquid smoke in UCSMB feed, the greater the increase in the meat color of b* (P<0.001), although there were no real differences between the concentrations of 10 and 20%. There was an increase in the value of meat color of b*, i.e., 54.47% at a concentration of 20% compared with that of 10% concentration. Liquid smoke in UCSMB feed can increase the level of yellowness (b* color meat) in Bali beef. The results of previous studies showed meat color of b* (yellowness) is not affected by the provision level of liquid smoke, although there was a tendency that the value of meat color of b* increases at a higher liquid smoke level [14].

As maturation time increased, there was a decrease in Bali beef color of b* (P<0.05) by 19.93% on the 14th day of maturation compared with the maturation day of 0, even though there was no significant difference between day 0 to day 7. The results of previous studies utilizing smoke flour directly added to raw meat reveal that smoke powder was only able to increase the yellowish level of meat (b*) up to 7 days of storage. Thus, a decrease occurs although b* level was higher than the 0-day storage [15]. Meanwhile, the results of the present research indicate that the decrease in Bali beef color value of b* (yellowness) during maturation can be preserved until the 7th day, supporting the results of the previous studies.

Conclusion:

The current study revealed that meat quality of Bali cattle is improved as marked by increasing of WHC value and meat color of b*, decreasing of CMSF, cooking loss, TBA value, and meat color of L* with increasing concentration of liquid smoke. Meanwhile, the maturation time increases WHC and TBA values but lowers the CMSF, cooking loss, and meat colors of a* and b*. It can be concluded that the liquid smoke in UCSMB feed can improve meat quality.
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