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Research Article

The Effect of Slaughter Age on Chemical and Physical Characteristics of Beef of Bali Cattle Reared Extensively

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ABSTRACT
The purpose of this study was to determine the effect of slaughter age on chemical and physical characteristics of beef of Bali cattle reared extensively in Bima District, West Nusa Tenggara. The treatment in this study was the difference in slaughter age, namely P1 = 1.5-2 years of slaughter age; P2 = slaughter age 2.1-2.5 years and P3 = slaughter age 2.51-3 years. The design used was completely randomized design with 3 treatments and 3 replications. The data obtained were analyzed using analysis of variance (ANOVA) and continued with Duncan's New Multiple Range Test. The results showed that slaughter age had a significant effect ($P < 0.05$) on protein content and water binding capacity of Bali beef, while its effect on water, fat and ash contents, cooking losses, tenderness, pH, was not significantly different ($P > 0.05$). Male Bali cattle slaughtered at the age of 2.1-2.5 years could provide better meat quality compared with other slaughter ages. They also could produce meat with protein content 18,16%, high water binding capacity (21.09%), low cooking losses (42.12%), tenderness (1.51 kg/cm^2), and had normal meat pH value (5.6). It could be concluded that Protein content of Bali beef reduced as the age of slaughter increased; slaughter age influenced physical characteristics of Bali beef, the age of slaughter increased the water holding capacity of Bali beef.

Keywords: Physical and chemical characteristics, Slaughter age, Bali beef

INTRODUCTION

Beef was the one of the most preferred sources of animal protein by consumers because of its delicious taste. In general, the chemical characteristics of beef consist of water, protein, fat and ash content (Lawree, 2003), whereas the physical characteristics of beef consist of Water binding capacity, cooking loss, breaking power/ tenderness and pH of the meat (Soeparno, 2005). Good chemical and physical characteristics of meat if processed into fast food processed products will provide good quality processed products (Kuswati, 2011). Feed management almost 70% could affect the quality of the meat produced, the remaining 30% was a genetic factor (Kadarsih, 2004). West Nusa Tenggara, which until now has been referred to as a cattle stock warehouse along with present of the one million cattle Earth Program of the province government. On the other hand, management of cattle especially on Sumbawa Island, were still dominated by raising Bali cattle extensively in the grazing fields in Bima which covers an area of 438,940 hectares (Anonymous, 2015). The extensive management system affect the growth and quality of meat both chemical and physical characteristics. Various studies had shown that the physical characteristics of male Bali beef at the age of 2-2.5 years of cutting based on muscle type show that Longisimus Dorsi Muscle (LD) has DIA 39.5862% with cooking loses of 25.73%, while BF muscle (Bicep Femoris) has water holding capacity (WBC) of 36.65% with cooking loss of 24.64% (Bulkaini et al., 2016). Kuntoro et al. (2013) reported that Bali beef male LD muscle parts had a higher percentage of free water (61.80%) compared to BF muscle (53.53%). Amertaningtyas (2012) stated that Balinese beef circulating in the traditional market in Poncokusuma Malang District had 37.10% WHC with a cooking shrinkage of 24.60%. Komariah et al. (2009) stated that WHC Bali beef was higher and significantly different ($P < 0.05$) compared to WHC buffalo and lamb meat. Faridah (2016) found that male Bali beef in the LD muscle that was reared intensively (in the pen) had WHC of 29.5% with cooking loss of 28.66%, while BF muscle had WHC of 25.9% with cooking loss 34.8%. There are no description of the physical and chemical characteristics of male Balinese beef in Bima Regency yet, so there was a need to conduct a study to reveal the chemical and physical characteristics of male Bali beef which are extensively reared and slaughtered at different slaughter ages. These data was very much needed

by the local government in making policies related to the strategy for developing male Bali cattle populations to meet the demand for meat from outside Sumbawa Island and Lombok Island.

MATERIALS AND METHODS

The materials used in this study were nine male Bali cattle randomly obtained from extensive Bali cattle farm in Bima Regency. They were grouped into three different slaughter ages namely 1.5-2-year-old (group 1), 2.1-2.5-year-old (group 2) and 2.51-3-year-old (group 3). All cattle were slaughtered according to the Islamic method in the Slaughterhouse, in Bima Regency. 300 g of meat samples (*Longissimus dorsi*) derived from each carcass were collected and kept for analysis of chemical and physical characteristics in Laboratory of Technology of Animal Products Processing, Faculty of Animal Husbandry, University Mataram, Lombok. The variables observed in this study were chemical characteristics included water content, protein, fat and ash content, and physical characteristics included the value of Water Holding Capacity (WHC), cooking loss, tenderness, pH value of the meat samples. The measurement of chemical characteristics was carried out by the Proximate analysis method (AOAC, 2005), while measurements of physical characteristics of meat were carried out using the Warner-Bratzler method and Hamm method (Soeparno, 2005). The design used in this study were Completely Randomized Design. Data collected were analysed statistically by using analysis of variance (ANOVA) and continued with Duncan's New Multiple Range Test (Steel and Torrie, 1997).

RESULTS AND DISCUSSION

Chemical characteristics of Bali beef: The chemical characteristics of beef of Bali cattle maintained extensively in Bima Regency were showed in Table 1. The results of variance analysis showed that slaughter age had a significant effect ($P < 0.05$) on the level of male Bali beef protein which was extensively maintained, whereas for water content, fat and ash content had no significant effect ($P > 0.05$). The results showed that the moisture content of male Bali beef which was maintained extensively based on slaughter age ranged from 73,362-75,231%. The results of this study indicate that the moisture content of male Bali beef which is extensively maintained was still in the normal range of fresh meat water content, which ranges from 65-80% (Prasetyo, 2002). The results of this study were not much different from the water content of Bali beef which was fed with bioplus fermented cocoa fruit skin concentrate which was equal to 74,765-76,834% (Karda et al., 2016). This shows that the water content of Bali beef, both extensively and intensively maintained, was still at the standard of the normal meat water content range of 60-70% (Soeparno, 2005). The results of this study indicate that cattle slaughtered at 1.5-2 years old had lower water content (73,363%) compared to those slaughtered at 2.1-2.5 years (75.231%) and with slaughter age 2, 51-3 years (74.602%). The results of this study were different from Soeparno (2005) which stated that young age livestock were higher in water content compared to cattle of adult age and old age. Factors that influence meat water content were livestock species, age, sex, and feed, and the location and function of muscle parts in the body (Kuswati, 2011). Furthermore, Lawrie (2003) stated that meat that had a moisture content still below 80% was still feasible to be consumed with a note that it may soon be processed or cooked.

Table 1: Chemical Characteristics of beef of Bali cattle at different slaughter age

Chemical Composition	Slaughter age (year)		
	1.5- 2	2.1-2.5	2.51-3
Water (%)^{NS}	73.363±0.560	75.231±0.605	74.602±0.293
Protein (%) *	19.448±0.166^{a}	18.156±0.101^{a}	16.882±0.037^{b}
Fat (%) ^{NS}	0.836±0.010	0.924±0.007	1.481±0.041
Ash (%) ^{NS}	0.021±0.001	0.024±0.001	0.020±0.001

Note

1. * Description: S = Significant; ^{NS} = Non Significant.
2. Different superscripts on the same line show significant differences ($P < 0.05$)

The beef protein content of Bali cattle maintained extensively that slaughtered at different ages ranged from 16.882 to 19.448%. The beef protein content of Bali cattle slaughtered at 1.5-2 years (19,448%) was significantly higher than the other two slaughtering ages (2.1-2.5 years, 18.15% and 2.51-3 years, 16.82% ($P < 0.05$). The beef protein content resulted of this study were lower than meat protein obtained from research by Bulkaini *et al*. (2016), which ranged from 18,367-21,983%. The results of this study indicated that the protein content of meat obtained in this study was still in the normal range of beef protein according to opinions of Forrest *et al*, (1992) of 19%, Lawrie (2003) of 18% and Romans *et al*, (1994) of 20 % in Nurwantoro *et al*. (2012). Karda *et al*. (2016)

reported that Bali cattle fed using bioplus fermented cocoa peel concentrate had protein content of beef ranged from 17-19%. Buckle *et al*. (2007) stated that beef protein ranged from 16 - 22%. Wistuba and Apple (2006) stated that the average protein content of meat from Angus Crossbred cattle was about 15.2%, this was the lowest level of meat protein. Differences in protein levels were caused by differences in the water content of the meat, differences in the structure of meat, especially myofibrils and connective tissue (Bahendra, 2007). The mean fat content of beef of Bali cattle slaughtered at different ages ranged from 0.836 to 1.481%. The results of this study indicated that the fat content of Bali beef obtained in this study was lower than the normal range of beef fat according to other studies (Forrest *et al*, 1992 of 5%, Lawrie, 2003 of 3.5% and Romans *et al*., 1994 in Brahmantiyo, 2000 of 9%. In the study of Karda et al. (2016) regarding the utilization of bioplus fermented cocoa peel concentrate on the fat content of Bali beef obtained that the fat content of Bali beef ranged from 0.5 to 1.5%. Furthermore, when compared with male Bali beef fat levels based on muscle type, it was 1.028% in muscle LD and 1.317% in muscle BF (Bulkaini, 2016).

The mean ash content of male Bali cattle which was extensively maintained in Bima Regency based on cutting age ranged from 0.020 to 0.024%. The results of this study indicated that the ash content of meat obtained in this study is lower than the normal range of beef ash content according to opinion (Forrest et al, 1992) of 2.5%, Lawrie (2003) of 3.5% and (Romans et al, 1994) of 1% in Brahmantiyo (2000). In the study of Karda et al. (2014) regarding the utilization of bioplus fermented cocoa peel concentrate on the content of Bali ash content of beef obtained that the ash content of male Balinese beef ranged from 1.1 to 1.4%, while the results of research by Bulkaini et al. (2016) found that the meat ash content in the LD muscle part was 0.839 and 0.594 in the BF muscle.

Table 2: Physical characteristics of beef of Bali cattle at different slaughter age

Variable	Slaughter age (years)		
	1.5-2	2.1-2.5	2.51-3
pH ^{ns}	6.000±0.608	5.633±0.513	5.433±0.058
Water Holding Capacity (%)*	10.756±8.37^{c}	15.779±4.778^{b}	21.009±5.84^{a}
Cooking loss (%) ^{ns}	44.777±3.259	42.121±6.199	44.948±0.767
Tenderness (kg/cm^2) ^{ns}	0.811±0.201	1.159±0.200	1.159±0.200

Note: * Different superscripts on the same line show significant differences (P <0.05), ns=not significant

pH and water holding capacity of Bali beef

The pH value of beef of Bali cattle extensively maintained in Bima Regency showed that the beef was still in the normal range of meat pH which is 5.4-5.8 in accordance with the standards set by SNI (BSN 2008). According to Lawrie (2003), a decrease in meat pH varies, this can be influenced by intrinsic factors (species, muscle type, muscle glycogen and variability between livestock) and extrinsic factors (environmental influences and treatment before cutting). Research results from Bulkaini et al. (2016) showed that the pH of Bali beef cut at the age of 2-2.5 years for LD (Longisimus Dorsi) was 5.933 and 5.533 in the BF muscle (Bicep Fimoris). The range of pH value of the meat shows the pH value that was in accordance with the limits of the isoelectric pH point which indicates that the regormortis process had been completed at a slaughter age of 2.1-2.5 years with a pH value of 5.63 and at a cutting age of 2.51-3 years with the pH value was 5.433, while at the cutting age of 1.5 - 2 years the pH value of the meat was above the normal pH of the meat which reaches 6.00.

The results of variance analysis showed that slaughtering age had significant effect on WHC (P < 0.05). The average beef WHC of beef of Bali Cattle with different slaughter ages ranged from 10.756-21.009%. The WHC of beef of Bali cattle at slaughter age 1.5-2 years was significantly lower (P <0.05) than with Bali beef of 2.1-2.5-year-old and of 2.51-3-year-old. The results of this study were still in the range of meat WHC 15-50% stated by Soeparno (2005). Many factors could influence WHC values such as pH, breed, relative humidity, aging, muscle type and location, muscle function, age, feed, and intramuscular fat (marbling) (Alvarado and McKee, 2007). Nurwantoro *et al*. (2012) and Abustam (2009) stated that the binding capacity of meat would affect color, tenderness, elasticity, juiciness and texture of the meat. According to Aberle *et al*. (2001); Komariah et al. (2009); Lan *et al*. (1995) in Amertaningtyas (2012) the size of water binding capacity were influenced by the ratio of water and protein levels, the type of protein myosin, pH, the composition of myofibril proteins, especially myosin and fibers (filaments).

The difference in DIA could be caused by differences in the pH of the meat. There were a relationship between ultimate pH and DIA. In a state of low pH because of the large amount of

lactic acid, the protein reactive group decreases and causes more meat water to be released, so that it was reduced (Kadarsih, 2004). The tensile strength between adjacent molecules decreases, due to an increase in the negative charge between protein contents or weakens the hydrogen bonds, so the protein tissue would expanded, so that the swelling increased and more water was bounded by proteins which would increased the value of the binding power of the water. Soeparno (2005) adds that a decrease in pH will increase actomyosine contraction and resulting in a reduction in DIA due to rapid ATP breakdown, which would increased protein denaturation. Riyanto (2004), stated that the binding capacity of water would increased if the pH value of meat increased maximum pH 7. This is due to the low pH value of meat resulting in the structure of open meat there by reducing the binding capacity of water, and the high pH value of meat resulting in closed meat structure so that the power high water tie. Furthermore according to Aberle et al. (2001); Arief et al. (2006), the binding power of meat decreases from high pH around 7-10 to the pH of the isoelectric point between 5.0–5.1. At this isoelectric pH meat protein was not charged (the amount of positive charge equals the amount of negative charge) and its solubility is low. At a pH higher than the isoelectric pH of a meat protein, a number of positive charges were released and there was a surplus of negative charge which results in rejection of the miofilament and gives more space for water molecules. Similarly at pH lower than the isoelectric point of protein there was excess positive charge and gives more space for bonded water molecules.

Cooking loss of Bali beef

The cooking loss of beef male Bali cattle extensively maintained in Bima Regency ranged from 42.121 to 44.948%. The results of this study indicated that the cooking losses of beef of Bali cattle extensively maintained in Bima District were higher than the cooking loss of beef Bali cattle fed concentrated fermented cocoa pods which ranged from 36.514 to 38.613% (Karda et al., 2016). Male Bali cattle slaughtered at 2.1-2.5 had lower cooking loss value (42.121%) than others. This means that at the cutting age of 2.1-2.5 years the meat was more better and less loss during cooking. It was also evident that DIA of meat with 2.5 years of cutting age was high followed by a decrease in cooking shrinkage value. The results of this study were in accordance with the opinion of Tantan (2011), that good quality meat was meat that had high DIA with a low cooking shrinkage. Soeparno (2005) further stated that cooking shrinkage values were also influenced by post mortem time. Changes in cooking shrinkage were caused by a decrease in post mortem meat pH which results in a large number of damaged miofibriller proteins, followed by a loss of the ability of proteins to bind water, which ultimately results in greater cooking losses. According to Lawrie (2003), good meat had a variation of cooking shrinkage between 1.5% to 54.5% with a range of 15% to 40%. The size of the value of cooking losses was an indicator of determining the quality of meat. Meat with a high cooking shrinkage was an indicator that more and more of the lost nutritional value of meat. Meat with a low cooking shrinkage had a relatively better quality than meat with a high percentage of cooking shrinkage, because the loss of nutrients during the cooking process will be less. According to Shanks et al. (2002) in Komariah et al. (2009), the amount of cooking shrinkage was influenced by the amount of cellular membrane damage, the amount of water that comes out of meat, protein degradation and the ability of meat to bind water.

Tenderness of Bali beef

The results of study showed that tenderness value of beef of Bali cattle maintained extensively in Bima Regency ranged from 0.811 to 1.159 kg /cm^2. There was a tendency that the value of tenderness Bali beef was getting higher or in other words the meat was getting tough. Bali cattle that slaughtered at 2 years old and above had tenderness value of 1,159 kg/cm^2 while Bali cattle that slaughtered at the age below 2 years had lower tenderness value of 0,811 kg/cm^2. According to Brahmantiyo (2000), the tenderness value of beef ranges between 1.58-2.79kg/cm^2, the smaller the value, the more tender the meat was. The testing of beef tenderness could also be done subjectively by using panelists or taste panels (Setyaningsih et al., 2010). The results of the study by Bulkaini et al. (2016) found that Balinese beef which was extensively maintained in Bima Regency with a slaughter age of more than 3 years had a breaking strength of 5.5 kg/cm^2 in muscles LD and 6.0 kg/cm^2 in muscles BF.

According to Purnamasari et al. (2013), tenderness was determined by the level of matrix structure density formed by heating. Soeparno (2005) states that antemorten and postmortem factors were two factors that affect meat tenderness. Antemortem factors such as genetics, species, sex, age, management and stress. Posmortem factors include the method of chilling, refrigeration, weathering, freezing, length and temperature of storage, and methods of processing or cooking. Changes in the value of meat tenderness when withering was affected by changes in the binding capacity of water. Decreasing the binding capacity of water causes a decrease in the value of tenderness of meat, then the tenderness value of

meat increases again after achieving isoelectric pH (Soeparno, 2005). Meat that has a pH in the normal range has a loose muscle structure, especially the actin and myosin bonds, so the meat was more tender.

CONCLUSION AND RECOMMENDATION

Three conclusion of this study: (i) Protein content of Bali beef reduced as the age of slaughter increased. (ii) Slaughter age influenced physical characteristics of Bali beef, the age of slaughter increased the water holding capacity of Bali beef. (iii) Overall physical properties and chemical composition of beef of Bali cattle maintained extensively meet the standards set by SNI.

As recommendation, in an effort to get male Balinese beef with good physical and chemical characteristics and meet the standards set by SNI, the cattle should be slaughtered at the age of 3 years.

Conflicts of interest: The authors declare no conflicts of interest.

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