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Pre-Rigor Beef Quality Assessment of Bali Cattle Subjected to Different Finishing Systems in Malaysia

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Abstract: The study was carried out in an attempt to assess meat quality of Bali cattle finished in 3 different systems. Twenty one bulls were selected from an existing herd under an oil palm plantation and randomly assigned to 120 days of feeding in; Integration-INT (n = 8), basal energy Feedlot-F (n = 6) and high energy Feedlot-FB (n = 7) System. All animals were humanely slaughtered at a commercial abattoir. Samples of Longissimus Dorsi (LD), Supra Spinatus (SS) and Semi Membranosus (SM) muscles were collected and prepared accordingly for the determinations of pH, cooking loss, shear force and color (L* and a*) values. The animals finished on Integration (INT) demonstrated higher L* values ($p<0.05$) in SS muscle and lower L* values ($p<0.05$) in both LD and SM muscles. Lower cooking losses ($p<0.05$) were observed in LD and SM muscles from the INT group. However, there was no difference in pH, a* (redness) and shear force values among the treatments and these were consistently shown in all three muscles. The results from this study demonstrate the influence of finishing system on Bali cattle meat quality.

Key words: Bali cattle, integration, feedlot, meat quality, cooking, Malaysia

INTRODUCTION

Beef is one of the widely consumed protein sources in the world. Meat consumption is predicted to rise by nearly 73% in the years up to 2050 (FAO, 2011). Due to the increasing demand for beef in recent years, beef cattle have been regarded as a strategic commodity in developing the livestock sub-sector. Therefore, production of good quality meat is vital to fulfill the consumers demands. Bali cattle or *Bos javanicus* is a tropical breed classified as indigenous in Indonesia which are also found in Northern Australia and Malaysia (Toelihere, 2003). With a relatively large-framed and well-muscled body, an adult male may weigh between 600-800 kg while the adult female may range between 500-600 kg. Bali cattle could be a novel beef breed to be used in new Beef Production System in Malaysia for their high dressing percentage which is around 10-20% more than the local cattle. The advantageous characteristics of the breed are its high fertility, its survival and capacity to prosper under poor environmental and climatic conditions in harsh dry land areas such as in the Eastern Indonesia and its capacity to maintain the quality of its lean beef. Thus, they are widely used as a source for draught and meat production (Wirdahayati, 1994). This indicates that Bali cattle have good genetic potential and benefit for consumer preferences because of higher carcass percentage and meat quality in line with market needs. However, they need to be maintained under good feed management systems. Moreover, it may have negative impacts due to genotype-environmental interactions.

Meat quality is of great importance to the beef industry and consumers are willing to pay more for superior products (Shackelford *et al*., 2001). Meat quality refers to the compositional quality and the palatability of meat. Meat quality includes sensory quality traits (tenderness, flavor, juiciness, color and odor), nutritional value, healthiness and technological quality (Geay *et al*., 2001). There are several biochemical processes and products that interact and affect meat quality and the consumer perception of eating quality. Color, together with tenderness and flavor are among the characteristics

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that define sensory quality of beef. However, color is often the most important trait of these characteristics at the point of sale, since it is the first impression perceived by consumers. Color has a critical influence on beef purchase decisions and thus fundamentally important to the beef industry (Cornforth, 1994).

Cattle productivity is dependent on two primary factors, namely genetics and environment and cattle can reach their genetic potential only if the environment provides optimum conditions (Talib *et al.*, 2003). The effects of concentrate supplementation on growth and meat quality of male Bali cattle have been reported by Mastika (2002). In that study there were significant improvements in daily weight gain and meat quality of the concentrate-supplemented animals. To improve their productivity, it is necessary to relate Bali cattle performance with the environmental limitations and management systems. In recent years, consumers have apparently become cautious about the origin of meat and how it is produced with respect to rearing conditions of meat producing livestock which has become an issue in the overall perception of meat quality (Jonsall *et al.*, 2001; Moloney *et al.*, 2001; Sather *et al.*, 1997). Consumers also place greater emphasis on meat products that are perceived as healthy and natural (Morrissey *et al.*, 1998). It seems that grass-fed beef from cattle reared in a free-range or extensive environment may conform to consumers perceptions of ethical quality or what constitutes a natural production system and is gaining popularity (Roosevelt, 2006). Although, beef produced from pasture has been perceived as natural and healthier, it also has been implicated with less tender and darker meat as well as yellower fat color (Allingham *et al.*, 1998; Schroeder *et al.*, 1980). It is well accepted that feed costs are often a major proportion of total variable costs in Beef Production Systems, favorable environment for abundant grass growth ensure that grazed grass is often the cheapest feedstuff (Balcaen *et al.*, 2002; O'Riordan and O'Kiely, 1996). On the other hand, a concentrate-based finishing has been associated with improved meat eating quality of animals initially raised on pasture (Vestergaard *et al.*, 2000a). To date, the effects of concentrate-based finishing particularly on Bali cattle meat quality are yet to be scientifically documented. Thus, this experiment was conducted to determine the differences in Bali cattle meat quality between the more commonly practiced livestock-oil palm integration system and high and basal energy feedlot systems in Malaysia.

MATERIALS AND METHODS

The experiment and sampling: Twenty one Bali bulls (24-30 months old) were selected from an existing herd reared under oil palm plantation at FELDA Tembangau 6, Pahang, Malaysia. The cattle-oil palm integration was routinely managed based on a stocking rate of 4.6 ha per animal. The animals were randomly assigned to three finishing systems, INT-Integration (n = 8), FA-basal energy feedlot (n = 6) and FB-high energy feedlot (n = 7). All animals were acclimatized for 3 weeks before the onset of each finishing system. The animals subjected to the INT group were allowed to graze on the available native forages and legumes with *ad libitum* amount of drinking water. The FA group (basal energy feedlot) were fed 5 kg of PKC pellet with *ad libitum* amount of corn stover while the FB group (high energy feedlot) were offered a mixture of 5 kg PKC pellet + 400 g calcium salt of palm fatty acids (Megalac®, Volac Ingredients Sdn. Bhd., Malaysia) and corn stover. The animals assigned to both feedlot groups were fed twice daily with *ad libitum* drinking water and mineral block available throughout the 120 days of finishing. At a commercial abattoir, all animals were lairaged before humanely slaughtered and processed according to the MS1500:2009 (DSM, 2009). Samples of LD, SS and SM muscles were collected within 45 min post mortem, vacuum packed andstored at -80°C until subsequent analyses.

Muscle pH determination: The respective muscle samples were removed from the chiller and pH was measured using a hand held digital pH meter (Hannah Instrument, USA) fitted with a combination electrode with temperature compensation. The pH meter was calibrated at room temperature (24°C) before measurement. For each measurement, the electrode was inserted into each muscle at least 1 cm below the surfaces. The data were recorded as pH_{45} once the readings had stabilized.

Color analysis: Meat color values were objectively measured using ColorFlex® (HunterLab, USA) with illuminant D65 as the light source and 10° standard observer (aperture opening size of 5 cm). Meat samples were thawed overnight in a chiller and trimmed at least 2.5 cm thick. The instrument was calibrated against black and white reference tiles prior to use. Each sample was initially exposed to the ambient and allowed for 30 min of blooming at room temperature (25±2°C). The triplicate color coordinate values of L* (lightness) and a* (redness) were measured on the cut surface of muscle samples and recorded (Hunter *et al.*, 1987).

Cooking loss: Samples were removed from the -80°C freezer and thawed overnight at 4°C. The thawed meat samples were then cut, weighed (60±2 g) and recorded as W1 (raw meat weight). The samples were then placed in plastic bags and cooked in a water bath (Mermert GmBH, Germany) at 80°C for 30 min. The cooked samples were removed from their plastic bags, cooled in crushed ice for 20 min and kept in a chiller at 4°C, overnight. The samples were then re-weighed and recorded as W2 (cooked meat weight). Cooking loss of meat samples was calculated based on the difference between the weight of raw meat and cooked meat (Dhanda *et al*., 2003) by using the following equation:

$$\text{Cooking loss (\%)} = \frac{\text{W1-W2}}{\text{W1}} \times 100$$

Shear force measurement: The samples for shear force analysis were actually samples earlier determined for cooking loss. Following overnight storage at 4°C, the cooked samples were cut into sub-samples for the measurement. Each core sample (1.27 cm diameter) was sheared once perpendicularly to the fibers at a speed of 1.0 mm sec^{-1} with a Warner-Bratzler blade attached to a texture analyzer fitted with a 5 kg load cell (TA-HD plus, Stable Micro Systems, UK). The thickness, shape and fiber orientation of samples were according to the protocols outlined by Bouton *et al.* (1971). At least five core samples were analyzed from each individual sample. The shear force values were reported as kg force.

Data analysis: The data generated in this study were analyzed using the PROC GLM procedure of SAS (2003) (Version 9.1, SAS Institute Inc., Cary, NC, USA). Cooking loss percentages, color, shear force values and pH of the samples were compared among the treatment groups. Significantly different means were then further differentiated using the Least Significant Difference (LSD) comparison procedures. All statistical tests were conducted at 95% confidence level.

RESULTS AND DISCUSSION

Tenderness (Chrystall, 1994), color (Baardseth *et al*., 1988), juiciness (Hutchings and Illford, 1988) and flavor (Melton, 1990) are among the major factors influencing consumers perception on meat quality. The finishing systems (INT, FA and FB) examined in this study did not affect meat quality traits such as pH, a* (redness) and shear force values and these were consistently observed in SS (Table 1), LD (Table 2) and SM (Table 3) muscles. The earlier reports on the influences of finishing systems on beef textural characteristics, chemical composition and palatability attributes were rather inconsistent. Garmyn *et al*. (2010) reported adverse effects of forage finishing on meat quality traits. The meat produced

Table 1: Quality traits of supraspinatus muscle from Bali cattle subjected to different finishing systems

	Finishing system		
Quality traits	INT (n = 8)	FA (n = 6)	FB (n = 7)
pH_{45} (unit) ^{NS}	6.85±0.04	6.79±0.15	6.67±0.09
Color values			
L*	28.21 ± 1.39^{a}	24.13 ± 1.01^{b}	24.04 ± 0.50^{b}
a^{*NS}	13.73±1.27	15.53±0.57	13.97±0.82
Cooking loss (%) ^{NS}	38.06±1.59	42.48±1.21	41.92±1.06
Shear force (kg) ^{NS}	6.09±0.70	6.76±0.78	6.77±1.23

Table 2: Quality traits of longissimus dorsi muscle from Bali cattle subjected to different finishing systems

	Finishing system		
Quality traits	INT (n = 8)	FA (n = 6)	FB (n = 7)
pH_{45} (unit)^{NS}	6.37±0.08	6.39±0.12	6.26±0.06
Color values			
L*	22.36 ± 0.51^{b}	28.16 ± 0.76^{a}	28.9 ± 1.570^{a}
a^{*NS}	12.59±1.04	12.45±0.20	12.78±1.16
Cooking loss (%)	33.25 ± 0.97^{b}	35.48 ± 0.71^{ab}	37.57 ± 1.03^{a}
Shear force (kg)^{NS}	10.35±1.64	12.55±1.42	11.31±1.29

Table 3: Quality traits of semimembranosus muscle from Bali cattle subjected to different finishing systems

	Finishing system		
Quality traits	INT (n = 8)	FA (n = 6)	FB (n = 7)
pH_{45} (unit)^{NS}	6.33±0.08	6.02±0.11	6.13±0.09
Color values			
L*	26.90 ± 0.46^{b}	30.67 ± 2.01^{ab}	31.9 ± 1.660^{a}
a^{*NS}	14.17±0.60	14.07±1.03	12.01±0.52
Cooking loss (%)	35.54 ± 0.76^{b}	39.40 ± 0.74^{a}	41.18 ± 0.81^{a}
Shear force (kg)^{NS}	8.17±0.74	12.36±0.65	9.61±1.75

Mean±SE, NS: Not Significant, ^{ab}Means within a row with different superscripts differ significantly at $p<0.05$. L*: Lightness; a*: Redness; INT: Integration; FA: Basal energy feedlot; FB: High energy Feedlot

by concentrate-fed heifers was reportedly of lower Warner-Bratzler shear force values than meat from the forage-fed heifers. As for the color measurements, higher L* values were indicated by meat samples from concentrate-fed heifers ($p<0.05$). Varela *et al.* (2004) evaluated the effect of a forage finishing system on meat quality of 30 months old Rubia Gallega cattle in comparison with a group of steers fattened with maize silage plus concentrate. The differences in meat quality between the groups were minimal. In the study, no significant differences in pH were observed between the finishing groups and this further support the earlier findings (Bidner *et al*., 1986; French *et al*., 2000; Morris *et al*., 1997; Wanderstock and Miller, 1948). Muir *et al.* (1998) reported higher ultimate pH values in meat of grass fed steers than the grain fed steers and suggested that the grass fed steers experienced greater pre-slaughter stress than their counterpart. In this study, although not significant, the INT group samples showed a tendency for toughness to be lowered and this was observed in all muscles. Varela *et al*. (2004) have also reported lower shear force values of meat from the pasture finished than those from the maize silage and concentrate finished steers. In contrast, Mitchell *et al.* (1991) and Rumsey *et al.* (1987) reported decreased meat tenderness following the pasture finishing. The color of fresh meat is an extremely important characteristic influencing the consumers purchase decision (Fletcher, 2002). As for the lightness, lower L* values which indicated darker meat ($p<0.05$) were shown by the LD (Table 2) and SM (Table 3) muscles from the INT animals. On the contrary, the integration finishing system (INT) has resulted in significantly higher L* values (lighter meat) of the SS muscle (Table 1). Variability in muscle color values can be affected by factors such as age, exercise and diet (Priolo *et al.*, 2001). Animals reared under free-range or extensive conditions may produce darker meat than those confined and fattened intensively and this could be explained by greater levels of exercise or physical activities experienced pre slaughter (Varnam and Sutherland, 1995).

Cooking loss was measured to obtain an overall assessment of the water-holding capacity of meat. Lower cooking loss indicates higher water holding capacity. In LD (Table 2) and SM (Table 3) muscles, lower cooking losses ($p<0.05$) were shown by the animals subjected to INT finishing. Furthermore, despite not significant, similar trend was also noticed in the SS muscle (Table 1). In general, the results indicated by the samples from INT group suggest that the animals could have experienced prolonged stress condition either through their physical activities during grazing or poor nutritional status which in turn could be associated with the significantly higher water holding capacity and darker meat observed in the LD and SM muscles, conditions similar to the dark, firm and dry amid no changes in pH. The differences in muscle metabolic and contractile properties may influence the variability in response of different types of muscles towards physical activities and metabolic process and this could also explain why the L* values of SS has increased following INT finishing.

The large biological diversity of skeletal muscle may be an important reason for the high inconsistency in meat tenderness amongst different muscles. Every muscle is different structurally and metabolically and these differences reflect their high degree of functional specialization which in turn suggests metabolic plasticity and adaptability according to the function to be performed (Pette and Staron, 1990; Sentandreu *et al.*, 2002). Skeletal muscle is composed of different fiber types which are determined by various factors, such as sex, age, muscle type, breed and hormones (Karlsson *et al.*, 1999). Other researchers have suggested that every muscle may react differently to changes in growth path, diet and production system which may complicate the search for a method to increase tenderness in the entire carcass as muscles may react differently upon the same stimulus (Cassar-Malek *et al.*, 2004, 2009; Stolowski *et al.*, 2006; Therkildsen *et al.*, 2008). Muscle fiber characteristics influence meat quality traits such as color, water-holding capacity, marbling and the texture of meat (Totland *et al.*, 1988). In general, it has been observed that the physical activity induces a fast to slow-twitch fiber transformation (Vestergaard *et al.*, 2000b; Gondret *et al.*, 2005) with no effects on chemical composition, water holding capacity and shear force (Moloney *et al.*, 2004; Dunne *et al.*, 2008). Concerning color, the results are rather inconsistent but indicate that the effects, if any are muscle dependent because they are related to the anatomical location (Moloney *et al.*, 2004; Dunne *et al.*, 2005, 2008). Therefore, future study on the effects of different finishing systems should also consider the possible underlying factors attributed by the differences in muscle fiber distribution and characteristics.

CONCLUSION

In this study, redness and pH of SS, LD and SM muscles did not differ between the finishing systems examined. Generally, the integration system has significantly resulted in higher water holding capacity and darker color with a tendency for a reduction in toughness of beef from Bali cattle. Future studies on the effects of finishing systems on meat eating quality traits should also regard the underlying factors influenced by the differences in muscle fiber metabolic and contractile characteristics.

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