Comparison of carcass and meat characteristics of Brahman grade cattle (*Bos indicus*) and crossbred water buffalo (*Bubalus bubalis*) fed on high roughage diet

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ABSTRACT

The objective of this study was to compare the carcass and meat quality in crossbred cattle and crossbred water buffalo at the same younger age and fed with high roughage in the Philippines. Ten crossbred cattle and 10 crossbred water buffalo, with an average age of 22 months (18–24 months) were used in this experiment. The animals were fed a similar diet, which consisted of 85% Napier or Para grass and 15% concentrate mixture on a dry matter basis, for 180 days before slaughter. Slaughter weight of the crossbred water buffalo was higher (*P* < 0.05) than that of the cattle, although the dressing percentage was significantly (*P* < 0.01) lower for the former than for the latter. The estimated lean yield was higher (*P* < 0.05) in crossbred cattle than crossbred water buffalo. The muscle fiber diameter of loin in buffalo meat was smaller (*P* < 0.05) than that in cattle. In regard to carcass and meat quality, the crossbred water buffalo was comparable or slightly superior to the crossbred cattle in tenderness, sensory score of color (*P* < 0.01) and flavor (*P* < 0.05). These results clearly indicate that at a younger age and even under high roughage-based fattening rations, crossbred water buffalo are able to produce good quality meat, which will be by no means inferior to that of crossbred cattle in the Philippines.

Key words: beef, Brahman grade cattle, carabao, carabeef, crossbred water buffalo.

INTRODUCTION

In the Philippines, most of the buffalo meat (so-called ‘carabeef’) production is produced by old buffalo, which are slaughtered after their productive life as draught animal. This is due to concern surrounding the conservation of young buffalo for breeding, milk and draught. Therefore, compared to beef, most carabeef available in the market is of very poor quality. At the moment, the demand for carabeef has gradually become higher and this is associated with rapid population increase and purchasing power.

Until recently, several reports have confirmed that carabeef, compared to beef, has similar sensory characteristics, proximate composition and processing characteristics, lower separable lean meat and less cholesterol. But the buffalo has a significantly lower dressing percentage (Calub *et al*. 1971; Carmona 1971; Arganosa *et al*. 1973; Lemcke 2002). However, there is only a little information available on performance in terms of meat production, carcass and meat quality of crossbred water buffalo at a younger age (18–24 months) in the Philippines. Previously, our recent study (Lapitan *et al*. 2004, 2007) on the performance of meat production, carcasses and meat quality between...
crossbred cattle (Philippine native cattle × Brahman) and crossbred water buffalo (Philippine carabao × Murrah, Bulgarian or Indian) at the same younger age (18–24 months) and fed with high grain-based fattening diets (Corn silage, brewer’s grain, concentrate mixture) in the Philippines found that the performance of crossbred cattle and crossbred water buffalo was comparable in terms of growth, carcass and meat quality. However, there is a higher cost of grain feed for smallholder farmers and also difficulties in silage making, especially in terms of efficiency of land used for corn production, unreliable rainfall and large amount of capital investment (Ichinohe et al. 2004). Hence, there is need for another fattening feed source (fattening system), which can be easily used by small folder farmers in the country.

The aim of this study was: (i) to compare the performance of meat production between crossbred cattle and crossbred water buffalo at the same younger age (18–24 months) and fed with high roughage-based rations based on Napier grass or Para grass and a small amount of concentrate mixture; and (ii) to determine the slaughter, carcass and meat quality of crossbred cattle and crossbred water buffalo.

**MATERIALS AND METHODS**

Study location, animals and diets in the present experiment were the same as described previously (Lapitan et al. 2008).

**Slaughtering procedure**

After the 180 days of feeding trial, all the animals were fasted for 48-h period and then were slaughtered (by stunning, followed by exsanguinations) at the Animal Products Processing Division of the Institute of Animal Science, University of the Philippines at Los Baños. The slaughtering procedure was the same as described by Ibarra (1988). The slaughter by-products were separated and the carcasses were split into quarters. Warm carcass weight was then determined to calculate the dressing percentage. The carcasses were then chilled at a temperature of 4°C for 48 h and the weight was again determined and used to calculate the dressing percentage. The chilled carcasses were separated into different wholesale cuts and then into retail cuts according to the procedure described by Ibarra (1988), and the weight of each cut was recorded to estimate the carcass yield of crossbred cattle and crossbred water buffalo. The cuts of the ninth to the 11th rib from both left and right sides of the carcasses were utilized as samples for physical, chemical composition and sensory analysis.

**Meat quality evaluation**

For pH determination, approximately 10 g of ground muscle was homogenized with 100 mL of chilled distilled water and then the pH was determined directly by dipping the digital pH meter into the ground meat. Water-holding capacity (WHC) of Longissimus dorsi (LD) muscle was determined by the Carver Press method (Wierbicki & Deatherage 1958). Approximately 400–600 mg of LD muscle was weighed and placed on filter paper. The LD muscle was then placed between plexiglass plate and pressed for 1 minute at 500-psi pressure. The total meat area was measured after pressure was released and WHC was expressed in percentage.

Muscle fiber diameter of LD and Semimembranosus (SM) muscle were determined using the compound microscope set at high magnification (×400). A sliced muscle tissue (~one-eighth inch thick) from LD and SM was soaked in fixative solutions for 24 h and single fascicules from a piece of muscle tissue were removed and then placed in a dish. Physiological saline solution was added to cover the fibers and then placed over a glass slide covered with coverslip and observed under a compound microscope a magnification of ×400. The diameter of fiber was measured and expressed in microns.

Shear force values of cooked LD muscle was determined by Warner–Bratzler shear force. The Warner–Bratzler shear force was measured as cores of 1-cm² sizes with fibers perpendicular to the direction of the blade. The force required to shear the samples was recorded (lb/cm²).

The meat color on the surface of rib eye was measured, according to the Commission International de Leclairage (CIE) scale of L* (lightness), a* (redness) and b* (yellowness) using a Minolta Digital Color Meter 200 (Minolta, Tokyo, Japan). The marbling score of rib eye was also measured, using a standard from the US Department of Agriculture (USDA) where 1 denoted very abundant marbling, and 8 denoted devoid or trace marbling.

**Carcass lean–fat–bone yield**

The lean–fat–bone of the ninth to the 11th rib was manually separated into lean meat, fat and bone. Each separated component was weighed and used to estimate the carcass lean–fat–bone.
The percentage of carcass lean, fat and bone were determined using the equation of Ibarra (1983) as followed.

Carcass lean, % = 15.56 + (0.81 × lean percentage from the ninth to 11th rib)
Carcass fat, % = 3.06 + (0.82 × fat percentage from the ninth to 11th rib)
Carcass bone, % = 4.30 + (0.61 × bone percentage from the ninth to 11th rib)

**Chemical composition of meat**

Approximately 100 g of LD muscle and composite samples were collected for chemical analysis. The samples were ground using a meat grinder and were placed into a clean screw-cap glass bottle. The sample bottles were labeled and frozen until analyses. The proximate compositions (moisture, ash, protein and fat) of samples were analyzed following the procedures set by AOAC (1990).

**Sensory evaluation**

Cooked LD muscle was utilized to evaluate the sensory characteristics of beef from crossbred cattle and carabao from crossbred water buffalo. Five laboratory panel sessions were conducted. In each session, four samples comprised of two replicates from each group were presented to the panelists. The samples were cooked in an oven to an internal temperature of 71°C and were sliced into approximately 10-g samples; then, an experienced sensory panel consisting of scientists and students evaluated the color, flavor, off-flavor, tenderness, juiciness and general acceptability using a 7-point Hedonic scale.

**Statistical analysis**

All data gathered were subjected to ANOVA using General Linear Model (GLM) of Statistica for Windows ver. 4.3 (StatSoft, Tulsa, OK, USA).

**RESULTS AND DISCUSSION**

In the present study, there was no gender difference in results obtained from both species (crossbred cattle and crossbred water buffalo). The mean values shown in the tables are indicated as the mean of 10 animals and standard error of the mean (Lapitan et al. 2004, 2007, 2008).

**Dressing percentage**

The slaughter live weight and dressing percentage of crossbred cattle and crossbred water buffalo are presented in Table 1. Crossbred water buffalo showed significantly higher \((P < 0.05)\) slaughter live weight and lower \((P < 0.05)\) dressing percentage calculated from both warm and chilled carcass weight as compared to those of crossbred cattle. This significantly \((P < 0.05)\) lower dressing percentage of crossbred water buffalo can be explained by a significantly higher proportion of head and feet \((P < 0.05)\) than that in crossbred cattle as shown in Table 2. These results were in agreement with the work of Uriyapongson et al. (1996) who also reported that buffalo had a significantly heavier head and shank compared to cattle and that this caused the lower dressing percentage of the former. Moreover, similar trends were observed by Lapitan et al. (2007) who showed that crossbred water buffalo had significantly lower dressing percentage than that of crossbred cattle at the same younger age (18–24 months) and fed with high grain-based fattening diets in the Philippines. Although dressing percentage values from reports by Lapitan et al. (2007) were considerably higher for both crossbred cattle and crossbred water buffalo based on dressing percentage on warm carcass weight (cattle vs buffalo, 58.8% vs 54.9%) and chilled carcass weight (cattle vs buffalo, 56.9% vs 53.6%) than in the present study. These differences in dressing percentage between the present study and those revealed by Lapitan et al. (2007) could be explained by the different energy levels of the diets used in the experiments (i.e. high grain-based fattening diets vs high roughage-based fattening diets) and probably also

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Selected slaughter traits, lean–fat–bone yield and rib eye area of the crossbred cattle and crossbred water buffalo</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cattle ((n = 10))</td>
</tr>
<tr>
<td>Slaughter weight, kg</td>
<td>272.1</td>
</tr>
<tr>
<td>Warm carcass weight, kg</td>
<td>148.2</td>
</tr>
<tr>
<td>Chilled carcass weight, kg</td>
<td>143.9</td>
</tr>
<tr>
<td>Dressing yield, % Based on warm carcass weight, %</td>
<td>54.4*</td>
</tr>
<tr>
<td>Based on chilled carcass weight, %</td>
<td>52.8*</td>
</tr>
<tr>
<td>Chilling loss, %</td>
<td>2.90</td>
</tr>
<tr>
<td>Lean–fat–bone yield, % Lean</td>
<td>65.8*</td>
</tr>
<tr>
<td>Fat</td>
<td>20.9</td>
</tr>
<tr>
<td>Bone</td>
<td>13.3</td>
</tr>
<tr>
<td>Rib eye area, in²</td>
<td>7.07*</td>
</tr>
</tbody>
</table>

*Significantly different among species \((P < 0.05)\). SEM, standard error of the mean \((n = 20)\).
duration of growing period before fattening which is known to have a major affect on dressing percentage.

**Carcass lean–fat–bone ratio and rib eye area**

The estimated carcass lean–fat–bone ratio and rib eye area of crossbred cattle and crossbred water buffalo is presented in Table 1. The crossbred water buffalo showed a significantly \((P < 0.05)\) lower proportion of carcass lean meat and a slightly \((P > 0.05)\) higher proportion of fat compared to those of crossbred cattle and a similar trend was observed in the proportion of bones among animal species. In a comparative study conducted by Carmona (1971), there was significantly higher separable lean yield in cattle than buffaloes. Moreover, Lapitan et al. (2007) showed a higher separable lean yield for crossbred cattle than for crossbred water buffalo under high grain-based diets. On the other hand, Pappa et al. (1986) stated that buffaloes are said to be less responsive to fattening and produce more lean meat than cattle. These contradicted results in lean yield between cattle and buffalo, which could be due to species differences in terms of genetic potential to produce lean meat and also differences of feeding management system. However, there is need for more detailed study to investigate the optimal age for best lean meat production efficiency between crossbred cattle and crossbred water buffalo at various age and diets so that lean production will be more effective.

The rib eye area showed that the crossbred cattle had a significantly \((P < 0.05)\) bigger rib eye area than that of crossbred water buffalo. This result was similar to the previous result of Lapitan et al. (2007).

**Carcass yield**

The crossbred water buffalo showed higher \((P < 0.05)\) slaughter live weight (345.1 vs 272.1 kg) compared to cattle. The yield of slaughter by-products, forequarters and hindquarters of crossbred cattle and crossbred water buffalo are presented in Tables 2 and 3, respectively. The crossbred water buffalo tended to have a significantly higher proportion of head \((P < 0.01)\), feet \((P < 0.05)\) and heart \((P < 0.01)\). The proportion of other slaughter by-products did not differ significantly between animal species except the crossbred cattle had a significantly \((P < 0.01)\) greater proportion of tail than crossbred water buffalo. The yield of the forequarters and hindquarters did not differ significantly among animal species when the weight of forequarters and hindquarters was expressed as percentage of chilled carcass. Similarly, the yield of the rib, plate, foreshank, round and loin did not differ significantly among animal species except the crossbred water buffalo had significantly higher proportions of chuck \((P < 0.01)\) and flank \((P < 0.05)\) while the crossbred cattle had significantly \((P < 0.01)\) more brisket. Because there was no significant difference in yield of forequarters and hindquarters between crossbred cattle and crossbred water buffalo in the present study, it appears that the crossbred cattle and crossbred water buffalo have a similar yield of forequarters and hindquarters if they are slaughtered at the same younger age (18–24 months) and kept under the same growing conditions. These observations agree with the findings of Lapitan et al. (2007) who revealed that yield of the different wholesale cut obtained from crossbred cattle and crossbred water buffalo were essentially equal at the same age (18–24 months) and fed with high grain based fattening diets in the Philippines.

**Proximate composition of meat**

The proximate composition (moisture, ash, crude protein, crude fat) of loin and composite meat samples from Brahman grade cattle and crossbred water buffaloes are presented in Table 4. There was no significant species difference in content of moisture, ash, crude protein and crude fat in loin and composite meat. These results were similar to previous results of Lapitan et al. (2007). Other studies have also shown that the meat from buffaloes and cattle is essentially

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**Table 2** Weight and yield (percentage of slaughter weight) of slaughter by-products of crossbred cattle and crossbred water buffalo (kg)

<table>
<thead>
<tr>
<th></th>
<th>Cattle ((n = 10))</th>
<th>Buffalo ((n = 10))</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood</td>
<td>5.77 (2.12)</td>
<td>8.10** (2.35)</td>
<td>0.48 (0.11)</td>
</tr>
<tr>
<td>Liver</td>
<td>2.74 (1.01)</td>
<td>3.41** (0.99)</td>
<td>0.11 (0.03)</td>
</tr>
<tr>
<td>Heart</td>
<td>0.85 (0.31)</td>
<td>1.62** (0.47**)</td>
<td>0.11 (0.02)</td>
</tr>
<tr>
<td>Lungs</td>
<td>2.26 (0.83)</td>
<td>2.89* (0.84)</td>
<td>0.14 (0.06)</td>
</tr>
<tr>
<td>Kidneys</td>
<td>0.56 (0.21)</td>
<td>0.70** (0.20)</td>
<td>0.03 (0.01)</td>
</tr>
<tr>
<td>Spleen</td>
<td>0.59 (0.22)</td>
<td>0.85** (0.25)</td>
<td>0.04 (0.01)</td>
</tr>
<tr>
<td>Esophagus</td>
<td>0.43 (0.16)</td>
<td>0.61* (0.18)</td>
<td>0.04 (0.02)</td>
</tr>
<tr>
<td>Stomach</td>
<td>8.55 (3.14)</td>
<td>12.1 (3.52)</td>
<td>0.59 (0.20)</td>
</tr>
<tr>
<td>Intestines</td>
<td>6.25 (2.30)</td>
<td>8.36 (2.42)</td>
<td>0.34 (0.07)</td>
</tr>
<tr>
<td>Tail</td>
<td>1.32 (0.48**)</td>
<td>1.31 (0.38)</td>
<td>0.04 (0.02)</td>
</tr>
<tr>
<td>Feet</td>
<td>6.22 (2.29)</td>
<td>8.76** (2.54*)</td>
<td>0.33 (0.09)</td>
</tr>
<tr>
<td>Hide</td>
<td>27.6 (10.2)</td>
<td>39.2** (11.5)</td>
<td>1.66 (0.38)</td>
</tr>
<tr>
<td>Head</td>
<td>9.71 (3.57)</td>
<td>15.8** (4.56**)</td>
<td>0.77 (0.15)</td>
</tr>
<tr>
<td>Ears</td>
<td>0.61 (0.22)</td>
<td>0.95 (0.28)</td>
<td>0.07 (0.02)</td>
</tr>
<tr>
<td>Tongue</td>
<td>0.85 (0.31)</td>
<td>1.20** (0.35)</td>
<td>0.06 (0.02)</td>
</tr>
</tbody>
</table>

*Significantly different among species \((P < 0.05)\). **Significantly different among species \((P < 0.01)\). SEM, standard error of the mean \((n = 20)\).
the same in terms of its proximate composition, especially when the animals are of the same age and fed with the same kinds of ration (Calub et al. 1971). Accordingly, in agreement with published work results, the crossbred water buffalo meat and beef from Brahman grade cattle have a comparable nutrient composition at the same younger age (18–24 months) and kept under the same growing conditions.

**Meat characteristics**

The physical and quality parameters (pH, water-holding capacity, muscle fiber diameter, shear force, meat color and marbling score) of beef from crossbred cattle and crossbred water buffalo meat are presented in Table 4.

**pH**

The pH of meat from crossbred cattle and crossbred water buffaloes were similar and were within the acceptable range value. This may be due to the similar rate of postmortem metabolism among animal species. Previously, Forrest et al. (1975) reported that stressful conditions prior to slaughter could cause depletion of glycogen reserve in the muscles resulting in a higher
ultimate pH of meat. Moreover, Lemcke (2002) pointed out that increased stress levels before slaughter will increase post-slaughter pH in the carcasses, and lower pH gives a lighter color and increased tenderness. The lack of muscle glycogen at slaughter is of paramount importance as it controls the level of lactic acid, which reduces the muscle pH (Lemcke 2004). Therefore, in order to attain high quality meat, it is necessary to create less stressful conditions prior to slaughter.

Water-holding capacity
As presented in Table 4, no significant differences were obtained among animal species in water-holding capacity. The results were in line with previous reports (Oliveros et al. 1982; Lapitan et al. 2007). In connection with water-holding capacity, some workers have reported that water-holding capacity is affected by pH value (Hamm 1963; Bouton et al. 1971) whereby meat with low pH usually has a low water-holding capacity (Bouton et al. 1971); thus, because we found similar pH among animal species in the present study, it is reasonable that the water-holding capacity were essentially the same between crossbred cattle and crossbred water buffalo.

Muscle fiber diameter and shear force
The muscle fiber diameter measured from LD and SM muscle of crossbred cattle and crossbred water buffalo showed that the crossbred water buffalo had significantly \( P < 0.01 \) smaller fiber diameter in uncooked LD muscle than that of crossbred cattle. The cooked LD and both cooked and uncooked SM muscle of crossbred water buffalo also tended to have smaller fiber diameter compared to those of crossbred cattle, but were not significantly different among animal species. Previously, Tuma et al. (1962) confirmed that muscle fiber diameter was related to meat quality characteristics especially tenderness and texture of meat. Accordingly, the tendency of crossbred water buffalo to have smaller muscle fiber diameter compared to crossbred cattle would indicate that crossbred water buffalo meat has a higher quality in terms of tenderness and texture compared to crossbred cattle.

In connection with tenderness of meat, the result of shear force values from cooked LD muscle of crossbred cattle and crossbred water buffalo showed that the buffalo meat had significantly \( P < 0.01 \) lower shear force values than that of crossbred cattle, which may have resulted in the buffalo meat being significantly \( P < 0.01 \) more tender than beef from the crossbred cattle in the present study. These results support the above data for muscle fiber diameter that crossbred water buffalo meat have smaller fiber diameter compared to crossbred cattle. On the other hand, results of muscle fiber diameter and shear force value in the present study are not similar to previous work (Lapitan et al. 2007), which confirm that both muscle fiber diameter and shear force value are similar between crossbred cattle and crossbred water buffalo fed high grain-based diets. Therefore, it is likely that crossbred water buffalo have an advantage in terms of meat quality especially tenderness and texture compared to crossbred cattle if they are same younger age (18–24 months) and fed higher roughage-based diets in the Philippines.

Meat color
The result of meat color expressed as L* (lightness), a* (redness) and b* (yellowness) values obtained from the surface of rib eye of crossbred cattle and crossbred water buffalo showed that the buffalo meat had significantly \( P < 0.01 \) lower L* values and b* values than those of crossbred cattle, but the a* value was not significantly different among animal species. The result for L* value in present study was in agreement with Lemcke (2002), who suggested that the color of buffalo meat tends to be slightly darker than beef of comparable age and growing conditions because of its higher myoglobin pigment content. But, in contrast to the above result, some reports have shown redder meat for buffalo than cattle (Valin et al. 1984). Moreover, previous work (Lapitan et al. 2007) also showed that crossbred water buffalo meat had higher \( P < 0.01 \) a* values (redness) than beef from crossbred cattle while lightness and yellowness was statistically similar among animal species under high grain-based fattening diets. Previously, some workers found that an increase in muscle fat lead to a reduction in muscle myoglobin and which could reflect major illuminant, resulting in lower a* values and higher L* values in meat (Troutt et al. 1992; Lyon & Carson 1995). Therefore, a difference of meat color values in muscle between crossbred cattle and crossbred water buffalo originates from many factors and not only myoglobin content in muscle and the kinds of diet that are used in the experiment. The stress level before slaughter is also of paramount importance for meat color changes.

Sensory evaluation
The sensory evaluation scores of cooked LD muscle from crossbred cattle and crossbred water buffalo are
The significantly higher rating by the sensory panel in the present study. The buffalo meat had significantly higher sensory scores for color ($P < 0.01$) and flavor ($P < 0.05$) as compared to those of beef from crossbred cattle, but no significant difference was detected in off-flavor, juiciness, general acceptability and tenderness. However, the shear force and muscle fiber diameter data tended to show higher tenderness in the buffalo meat than beef from crossbred cattle. Compared to crossbred cattle, the significantly ($P < 0.01$) higher score for color in the buffalo meat can be attributed to higher myoglobin content of the muscle (Lemcke 2002) which reflects a meat with a more reddish brown color and was the cause for the higher rating by the sensory panel in the present study. The significantly ($P < 0.05$) higher score of flavor in the buffalo meat compared to beef from crossbred cattle was probably as a consequence of different fatty acid composition which have been associated with flavor enhancement (Nigel 2003). However, a more detailed study is required to investigate the fatty acid profile between crossbred cattle and crossbred water buffalo in the Philippines. Discrepancies between physical methods and sensory evaluation of tenderness may have been caused by individual variation of the sensory panel, which may have been influenced by factors such as the psychological state (e.g. influence of feelings, difference of expression) and physical regulation (e.g. chewing pattern, chewing force). Based on sensory evaluation scores, the present study clearly shows that the buffalo meat has higher eating quality than beef from crossbred cattle. Moreover, because we did not find any sensory score difference between beef from crossbred cattle and meat from buffalo fed with high grain-based fattening diets in our previous work (Lapitan et al. 2007), it is likely that buffalo meat will have higher eating quality compared to crossbred cattle if they are raised under high roughage rations at the same younger age (18–24 months). Finally, in regard to sensory evaluation methods, there is a need for new sensory methods designed to minimize the above individual variation of sensory panelists so that data will be more reliable.

### Conclusion and implications

In a previous work reported by Lapitan et al. (2004, 2007), crossbred water buffaloes had comparable production performance in terms of meat production, carcase and meat quality to the crossbred cattle under high grain-based fattening rations. However, in this study, crossbred water buffalo showed comparable or superior production performance (weight gain and meat quality; tenderness, sensory characteristics) to the crossbred cattle at the same younger age (18–24 months) and fed with high roughage-based fattening rations such as Napier grass or Para grass supplemented with a limited amount of concentrate mixture. It is therefore concluded that at a younger age and under high roughage-based fattening rations, crossbred water buffalo are not only better able to utilize the roughages and perform better in terms of live weight gains than the crossbred cattle but also produce good quality meat, which is equal to beef, in the Philippines. There is also need for more detailed study in relation to meat production as well as to quantify the production potential of the crossbred water buffalo, especially in terms of milk production and under various production systems in order to cater for the needs of various small holder farmers in the Philippines.

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