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Effects of corn silage-based diets on carcass and meat characteristics of Philippine native swamp buffalo (*Bubalus bubalis carabanensis*)

Vince Randolf R. Sumajit*, Phoebe Lyndia T. Llantada, Ann-Sherly R. Dugyon

Cagayan State University Piat, Cagayan, Philippines

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ABSTRACT

This study evaluated the effects of corn silage-based diets on the carcass characteristics, meat quality and consumer acceptability of Philippine native swamp buffaloes or carabao. Two corn silage-based diets were separately offered at 60% corn silage + 40% concentrate and 100% corn silage to six (6) young male carabaos aged 18–24 months for 150 days finishing period in which the parameters measured included carcass traits, meat quality, and consumer acceptability. The growth performance observed that carabaos fed with corn silage with concentrate had heaviest final body weight, higher ADG and more efficient FCR compared to those fed with 100% corn silage. After 5 months of the finishing phase, carabaos were slaughtered and samples of longissimus dorsi muscle were collected. The result showed carcass characteristics and meat quality parameters, including pH, color, and water holding capacity, were not significantly affected by corn silage-based diets ($p > 0.05$). The Carabeef of T2 received higher juiciness, tenderness, taste and overall acceptability scores. In conclusion, integrating concentrate with corn silages improves ADG and FCR without compromising carcass and meat quality for practical feeding strategy for enhancing carabao productivity. However, further studies with larger sample sizes are recommended to validate these findings.

***Corresponding author:** Vince Randolf R. Sumajit ✉ svincerandolf@gmail.com

INTRODUCTION

Philippine native swamp buffalo or also known as carabao (*Bubalus bubalis carabanensis)* is the farmer's companion that plays a very important contribution in the Philippine backyard farming systems. In decades, Carabao was used by the farmers as draft power before the mechanized farming. The carabaos are also a significant source of good quality meat referred to as carabeef (PCC, 2024). In the recent research by the Philippine Carabao Center highlights carabeef are option to alternate to beef and its healthier because of the lower fat content, calories and cholesterol (PCC, 2019). The carabeef is characterized as dark red with lower intramuscular fat that the beef this makes it a valuable source of meat when fattened (Lapitan, 2008). In the backyard farming system, the most crucial problems in the production of carabeef are the slow growth that leads to poor meat quality. This will lead to limiting the carabaos potential in contribution to the livestock industry.

Corn plays a major role in the ruminants' diets, as one of the major sources of forage (Khan *et al.*, 2015). In Region 2, corn production is widely available with recorded data of 1.9MT in 2024 (PNS, 2025). Corn silage is a promising feed source to ruminants because of its high energy and high digestibility with 33-35% dry matter and 49% neutral detergent fiber (Sá *et al.*, 2023). Corn silage is highly effective energy feeds for growing ruminants and feedlot because of its good fermentation characteristics helps ruminal microflora leading to having a good carcass and meat quality (Khaing *et al.*, 2015).

Early studies are primary focused on the benefits of corn silage to the performance of other ruminants such as cattle and even sheep. The studies focus on buffaloes have limited evidence. Evidence from Lapitan (2008), who stated that carabeef can be comparable to beef when fattened in terms of dressing yield and fat content.

Recent studies have demonstrated that improved feeding strategies such as silage-based diets can enhance the carcass characteristics and meat quality of large ruminants. Corn silage is recognized as energy-rich source forage because of its nutritional value, high digestibility and palatability. Several studies reported that silage-based diets can improve feed efficiency and weight gain in cattle and buffaloes (Wanapat *et al.*, 2007; Devendra *et al.*, 2002).

In the Philippines, research in native swamp buffalo has focused on the reproductive performance and general feeding management, while limited studies have investigated in the effect of corn silage-based diets on the carcass characteristics and meat quality traits of Philippine native swamp buffalo. Furthermore, data regarding on the suitability of corn silage-based diets for improving meat production in Philippine native swamp buffalo remains insufficient. These gaps highlight the need for further research to develop effective and nutritionally efficient feeding strategies for buffalo.

Therefore, the study aims to bridge the research gaps by improving the nutritional management of Philippine native swamp buffalo. By evaluating the potential of corn silage based diets to improve the carcass yield and meat quality. The findings of the study are expected to contribute to the improvement of sustainable meat production of Philippine native swamp buffalo.

MATERIALS AND METHODS

Experimental site and animals

The experiment took place in the Philippine Carabao Center-Cagayan State University (PCC-CSU) located in Piat, Cagayan, Philippines from July 14 until December 7, 2025. A total of six clinically healthy Philippine native swamp buffalo bulls (*Bubalus bubalis carabanensis*) aged 18-24 months old were used as the experimental animals.

Experimental design and dietary treatments

Completely Randomized Design (CRD) with two treatments having three replicates each was used for this experiment. The experimental animals were divided into two dietary groups including Group (1) 60% corn silage + 40% concentrate (T1) and Group

(2) 100% corn silage (T2). Daily Dry Matter Intake (DMI, kg) was calculated through the use of the IFEED ration formulation software from the Philippine Carabao Center.

It is a computer-based program designed to estimate the nutrient requirements and body weight of an animal. Based on the computed DMI, the feed was allocated daily for each animal.

Feed preparation and chemical analysis

The corn used for silage preparation came from the PCC-CSU farms along with additional locally available materials. The cut forage was put through silo and stored under anaerobic conditions. After 21 days, fermentation took place.

The collected feed sample underwent a chemical analysis to calculate its content of dry matter (DM), moisture content (MC), ash, crude fat (CFat), crude protein (CP), acid detergent fiber (ADF), and neutral detergent fiber (NDF) through the use of standard analytical techniques (Table 1).

Feeding and housing management

Each individual animal was kept in pens measuring 3 m × 5 m (15 m²) where they stayed for 7 days before the experiment. Feeding was done using a restricted feeding system. Each day, the total ratio fed to the animal was divided into two equal amounts and fed twice per day at 07:00 h and 16:00 h. Clean drinking water was offered and libitum all throughout the experimental period.

Table 1. Nutrient composition of corn silage and grower concentrate used in the study

Feeds	%DM	%MC	%ASH	%CFAT	%CP	%ADF	%NDF
Corn silage	24.87	5.29	8.77	2.46	10.88	36.34	56.99
Grower concentrate	88	3.94	8.4	18.07	16.24	21.79	55.44

DM= dry matter; MC= moisture content; ASH= ash; CFAT= crude fat; CP= crude protein; ADF= acid detergent fiber; NDF= neutral detergent fiber.

Slaughter procedures and ethical considerations

The animals were brought to a Double A accredited slaughterhouse in Luna, Apayao. They were slaughtered as per Administrative Order No. 18 (Series of 2008) and Republic Act 8485, otherwise known as the Animal Welfare Act of the Philippines. The animals were fasted for 12 hours before being slaughtered while being allowed to drink water during that time.

Carcass traits and meat quality evaluation

After slaughter and evisceration, the weight of the hot carcass (kg) was taken. The carcasses were then chilled for 24 hours at 4 °C before measuring the cold carcass weight (kg). Carcass length was measured in centimeters, starting from the atlas vertebra to the aitch bone. Rib eye area (cm²) was measured at the longissimus thoracis muscle area between the 12th and 13th rib with the grid tracing method. The backfat thickness (mm) at the same rib position was also measured with the use of a ruler. Muscle pH level was measured at 45 min and 24 h postmortem using a calibrated portable pH meter. The meat color (L*, a*, and b*) was measured after 25 min of blooming with the use of a colorimeter. Water Holding Capacity (WHC%) was estimated by the drip loss method. First, 2g muscle tissue was weighed. It was suspended in a sealed bag at 4 °C for 48 h before being reweighed again to measure weight loss.

Consumer acceptability evaluation

The sensory evaluation of the beef was done with the use of a nine-point Hedonic Scale. Thirty untrained panelists were asked to evaluate the sensory characteristics of cooked beef samples prepared under standardized conditions. The cooked samples were presented in thin strips (≈ 2mm thick). Panelists evaluated beef for its color, aroma, taste, juiciness, tenderness, and overall acceptability.

Statistical analysis

All obtained results were presented in the form of mean ± Standard Deviation (SD). They were compared statistically using an independent sample t-

test through the use of STAR software. Differences between treatments were considered significant when $p < 0.05$.

RESULTS AND DISCUSSION

Growth performance as supplemental data

Although growth performance indicators were not included as primary parameter, growth performance data were recorded to support the interpretation of carcass and meat quality. The data observed in the study showed clear differences in performance between experimental animals fed with Treatment 1 corn silage 60% + concentrate 40% and Treatment 2 corn silage 100%. While the initial body weight and final body weights observed not significantly different, this indicates comparable baseline conditions and overall weight, the average daily gain and feed conversion were significantly different as observed a key performance indicator. Animals under Treatment 1 fed with corn silage with concentrate exhibited significantly higher ADG and better FCR compared to those animals under Treatment 2 fed with corn silage alone, this indicates a faster growth and more efficient in feed utilization.

Carcass characteristics

Table 2 provides the carcass characteristics of Philippine native swamp buffaloes fed with either treatment consisting of 60% corn silage + 40% concentrate (T1) or treatment of 100% corn silage (T2). On all measured parameters, the value was numerically higher on animals fed with treatment T1 compared to T2. The following are the measured parameters of Philippine native swamp buffaloes where treatment T1 provided a numerically higher value: hot carcass weight (122.05 ± 26.43 kg vs. 91.55 ± 7.62 kg); cold carcass weight (116.93 ± 23.23 kg vs. 88.77 ± 8.15 kg); carcass length (198.67 ± 9.02 cm vs. 185.67 ± 5.13 cm); ribeye area (37.33 ± 6.05 cm^2 vs. 31.50 ± 5.89 cm^2); and backfat thickness (14.33 ± 8.14 mm vs. 6.33 ± 3.51 mm). Moreover, major internal organs (8.02 ± 1.82 kg vs. 6.37 ± 0.47 kg) and non-carcass weight (51.42 ± 12.87 kg vs. 40.87 ± 5.56 kg) were also higher in T1. However, according to the results of independent t-test analysis, there were no statistical differences among the measured parameters. The statistical significance among hot carcass weight (t= 1.92, p= 0.1271); cold carcass weight (t= 1.98, p= 0.1186); carcass length (t= 2.17, p= 0.0958); ribeye area (t= 1.20, p = 0.2976); backfat thickness (t= 1.20, p= 0.2976); major internal organs (t= 1.52, p = 0).

The observed carcass characteristics indicates that both corn silage supplemented with concentrate feeds and corn silage alone fed to Philippine native swamp buffalo provides a high energy to support the carcass development in buffaloes.

The corn silage with concentrates showed a slightly higher carcass value score in terms of hot and cold carcass weight, non-carcass weight, ribeye area and backfat thickness. A high concentrate finishing ration on beef cattle and silage inclusion has no direct effect on the carcass traits of animals (He *et al.* 2018). Processed corn silage in finishing diets improved carcass weight and backfat without any negative effect (Costa *et al*, 2023). Major internal organs such as heart, kidney and liver were not different, while the liver weight were near significant among the treatments, however the non-carcass weight including hide, feet and tail found no significant among the diets (Abera *et al.*, 2022). The increase level of concentrate improved carcass weight and fat deposition indicating high energy in diets improved carcass traits (Melo *et al.*, 2023) while it was also revealed that 75% of corn silage can enhance the carcass weight and dressing percentage of ruminants (Mahmoud, 2003).

Meat quality

The results of meat quality of Philippine native swamp buffaloes raised on the two diet formulations are presented in Table 3. As can be observed from the table 3, it appears that treatment T1 showed slightly higher values than those in T2 for nearly all of the meat quality parameters investigated. Treatment T1 showed higher muscle pH at 45 minutes (6.50 ± 0.33 vs. 6.42 ± 0.03) and 24 hours (5.45 ± 0.27 vs. 5.42 ± 0.02), along with higher meat color L* (lightness)

(30.02 ± 1.02 vs. 29.04 ± 2.72) and b* (yellowness) (5.48 ± 0.33 vs. 5.29 ± 1.08). On the other hand, treatment T2 exhibited higher values of meat color a* (redness) (3.26 ± 1.71 vs. 2.67 ± 0.64) and drip loss percentage (0.02 ± 0.0042 vs. 0.01 ± 0.0036). However, despite these variations in numerical value, independent t-test analysis of variance has revealed that there were no significant differences in the different meat quality parameters analyzed, such as the decrease in muscle pH at 45 minutes ($t = 4.036$, $p = 0.7249$) and at 24 hours ($t = 2.366$, $p = 0.8347$), meat color L* ($t = 0.5829$, $p = 0.5912$), a* ($t = -0.5542$, $p = 0.6090$), b* ($t = 0.2581$, $p = 0.8090$), and drip loss ($t = -0.7071$, $p = 0.5185$).

Table 2. Effect on the carcass characteristics of Philippine native swamp buffalo (*Bubalus bubalis carabanensis*) fed with corn silage-based diets

Parameter	T1 (M ± SD)	T2 (M ± SD)	Mean difference	t-value	*p*-value
Hot carcass weight (kg)	122.05 ± 26.43	91.55 ± 7.62	30.50	1.92	0.1271
Cold carcass weight (kg)	116.93 ± 23.23	88.77 ± 8.15	28.16	1.98	0.1186
Carcass length (cm)	198.67 ± 9.02	185.67 ± 5.13	13.00	2.17	0.0958
Ribeye area (cm²)	37.33 ± 6.05	31.50 ± 5.89	5.83	1.20	0.2976
Backfat thickness (mm)	14.33 ± 8.14	6.33 ± 3.51	8.00	1.56	0.1933
Major internal organs (kg)	8.02 ± 1.82	6.37 ± 0.47	1.65	1.52	0.2039
Heart (kg)	4.10 ± 0.96	3.70 ± 0.20	0.40	0.70	0.5206
Liver (kg)	3.33 ± 0.76	2.17 ± 0.29	1.17	2.47	0.0686
Kidney (kg)	0.58 ± 0.14	0.50 ± 0.00	0.08	1.00	0.3739
Non-carcass weight (kg)	51.42 ± 12.87	40.87 ± 5.56	10.55	1.30	0.2624

Table 3. Effect on the meat quality of philippine native swamp buffalo (*Bubalus bubalis carabanensis*) fed with corn silage-based diets

Parameter	T1 (M ± SD)	T2 (M ± SD)	Mean difference	t-value	*p*-value
Muscle pH (45 min)	6.50 ± 0.33	6.42 ± 0.03	0.08	0.4036	0.7249
Muscle pH (24 h)	5.45 ± 0.27	5.42 ± 0.02	0.04	0.2366	0.8347
L* (Lightness)	30.02 ±1.02	29.04 ± 2.72	0.98	0.5829	0.5912
a* (Redness)	2.67 ± 0.64	3.26 ± 1.71	-0.58	-0.5542	0.6090
b* (Yellowness)	5.48 ± 0.33	5.29 ± 1.08	0.20	0.25812	0.8090
Drip Loss (%)	0.01 ± 0.0036	0.02 ± 0.0042	-0.00	-0.7071	0.5185

Table 4. Effect on the consumer acceptability of Philippine native swamp buffalo (Bubalus bubalis carabanensis) fed with corn silage-based diets

Parameter	T1 (M ± SD)	Rating	T2 (M ± SD)	Rating	MD	t-value	*p*-value
Color	6.68 ± 0.71	Like slightly-moderately	7.34 ± 0.28	Like moderately	-0.67	-1.51	0.2060
Aroma	6.82 ± 0.48	Like slightly	7.44 ± 0.37	Like moderately	-0.62	-1.78	0.1502
Taste	7.06 ± 0.51	Like moderately	7.44 ± 0.41	Like moderately	-0.38	-1.01	0.3699
Tenderness	7.33 ± 0.47	Like moderately	7.83 ± 0.32	Like moderately-very much	-0.50	-1.54	0.1985
Juiciness	7.00 ± 0.60	Like moderately	7.88 ± 0.24	Like moderately-very much	-0.88	-2.37	0.0768
Overall acceptability	7.70 ± 0.32	Like moderately	8.07 ± 0.21	Like very much	-0.37	-1.68	0.1860

In the present study, Philippine native swamp buffalos fed with corn silage with concentrate showed a better meat quality value score but not significantly significant in most parameters including the muscle pH decline, lightness and yellowness while corn silage resulted a redness in meat color and higher water holding capacity. This indicates that concentrating feeds supplementation did not adversely effect the meat quality of buffalo. It concludes that both feeding treatments are comparable in terms of postmortem stability. The ultimate meat pH was not affected by corn silage-based diets producing a tender to slightly tougher meat (Abera *et al.*, 2022). In addition, intramuscular fat content enhanced by corn silage diets and produced a brighter color compared to animals fed with sorghum silage (Wu *et al.*, 2021). Furthermore, processed corn silage produces a low carcass pH that reduces risk of dark, firm and dry meat (Costa, 2023). This confirms that corn silage maintains the acceptable meat.

Consumer acceptability

Table 4 presents result on the consumer acceptability of meat samples from native swamp buffalo fed with 60% corn silage with 40% concentrate (T1) and 100% corn silage (T2). It can be observed from the table that T2 consistently had higher mean scores than T1 for all evaluated sensory attributes. This includes color, wherein T2 received ratings of 7.34 ± 0.28 ("like moderately"), while T1 received a lower rating of 6.68 ± 0.71 ("like slightly–moderately"). The same applies to aroma, where T2 got a higher mean score of 7.44 ± 0.37 ("like moderately") compared to T1, which obtained a lower mean score of 6.82 ± 0.48 ("like slightly"). Similar to the aforementioned sensory attribute, T2 obtained higher ratings for taste (7.44 ± 0.41; "like moderately"), compared to T1 with lower ratings (7.06 ± 0.51; "like moderately"). Likewise, T2 obtained higher mean scores in tenderness (7.83 ± 0.32; "like moderately–very much") compared to T1 (7.33 ± 0.47; "like moderately"), and juiciness (7.88 ± 0.24; "like moderately–very much") compared to T1 (7.00 ± 0.60; "like moderately"). For overall acceptability, T2 also received higher ratings (8.07 ± 0.21; "like very much") than T1, whose ratings were lower (7.70 ± 0.32; "like moderately").

However, despite the aforementioned observations, results from the Independent t-test indicated that there were no significant differences between T2 and T1 with respect to all evaluated sensory attributes, such as color (t= -1.51, p= 0.2060), aroma (t= -1.78, p= 0.1502), taste (t= -1.01, p= 0.3699), tenderness (t= -1.54, p= 0.1985), juiciness (t= -2.37, p= 0.0768), and overall acceptability (t= -1.68, p= 0.1860) ($p > 0.05$).

The consumer acceptability results revealed that both treatments are well accepted by the consumer with a rating of like slightly to like very much. Dietary treatments were comparable to each other, but animals fed to corn silage alone was more acceptable by the consumers but this also indicates that addition of concentrate did not significantly influence the sensory characteristics of the carabeef. High energy corn silage rations improved the flavor, tenderness, juiciness and overall acceptability (Nogalski *et al.*, 2023; Silva *et al.*, 2024; Soares *et al.*, 2025).

CONCLUSION

Based on the findings of the study, it is concluded that carcass characteristics and meat quality were not significantly affected by the diet, indicting that feeding corn silage to carabaos can be used without negative affecting the meat quality. Also, it is concluded that the consumer acceptability evaluates indicate that the carabeef from animal fed with 100% corn silage was generally more preferred. The study provides baseline data addressing the research gap on corn silage-based diets use in Philippine Carabao. While corn alone is a viable feed source, its effectiveness is enhanced with concentrate supplementation. Nonetheless, due to the limited number of experimental animals, further validation is necessary. Furthermore, the researcher strongly recommended adopting combined feeding system of corn silage and concentrating rather than using corn silage alone to address the issue of slow growth of Philippine native carabaos without any negative effect on carcass characteristics and meat quality. It also recommended conducting additional studies using a larger sample size to strengthen the reliability of the results and validate finding specific to Philippine native carabaos. For future research, should continue investigating different levels of corn silage and concentrate combinations to determine the most effective ratio for carcass yield and meat quality.

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