RESEARCH ARTICLE

Carcass yields of African savanna buffalo (*Syncerus caffer caffer*)

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In contrast to other game species and domestic livestock, there is a paucity of evidence concerning yields and thus meat obtained from the African savanna buffalo (*Syncerus caffer caffer*). The aim of our study was to investigate the effects of age (categorized) and sex on buffalo carcass yields. Towards this goal, male (*n* = 17) and female (*n* = 13), and adult (*n* = 23) and subadult (*n* = 7) buffaloes were slaughtered, and the weight of the carcass and various organs/offal and six major muscles [(*biceps femoris* (BF), *semimembranosus* (SM), *semitendinosus* (ST), *longissimus thoracis et lumborum* (LTL), *infraspinatus* (IS) and *supraspinatus* (SS)] determined. Buffaloes had a high dressing percentage, calculated from the warm carcass weight, and with the heaviest muscle weights measured for the BF, SM and LTL muscles. Adults had heavier muscle weights than subadults, and all parameters except the heart and IS muscle weight differed significantly between these age groups. In addition, the skin and head weight differed significantly between males and females. In summary, African savanna buffalo yields (~58%) compared favourably to other domestic animals, with the heavy weight of valuable muscles suggesting their commercial potential as a high-end value-added product.

Keywords: African savanna buffalo, meats, yield, age and sex, carcass, muscle weight.

INTRODUCTION

The consumption of game meat as an alternative protein source has a rich history in many African countries (Erasmus & Hoffman, 2017). In southern Africa, there is increasing pressure on the Kruger National Park (KNP) to engage nearby communities in biodiversity conservation efforts, ecological development and the promotion of economic prosperity. In this setting, the use of game meat may provide a sustainable source of protein to optimize nutrition and improve health in these often impoverished communities. Recent examples of resource use (*e.g.* mopane worms – *Gonimbrasia belina*, thatch, medicinal plants) have provided valuable lessons (Swemmer & Mmethi, 2016) regarding the positive impact of facilitating access to tangible products from nature that address basic human needs. Similarly, KNP is looking for more options to enable access to basic natural resources. Therefore, involvement of the community in the processing and consumption of meat obtained from harvested animals including the African savanna buffalo (*Syncerus caffer caffer*) may help create a sustainable income for local communities, while also ensuring food security.

Buffaloes are still of high economic value, particularly in the scenario of eco-tourism and trophy hunting. Meat production is therefore still considered a secondary objective. However, in recent years the price of buffalo meat has also decreased due to breeding efforts leading to greater availabil-

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ity for consumption as an alternative protein source. The private buffalo industry currently has more than 30 000 'disease free' buffalo on private land (Oberem & Oberem, 2016). National parks also have large natural buffalo populations (Ryan *et al.*, 2006). Utilization of some of these buffaloes for meat may therefore have the potential to play an important role in benefit programmes aimed at communities adjacent to national parks.

For game farming to become an alternative to domestic farming for meat production purposes, game species should be able to compete in terms of carcass composition and meat quality. To be considered for meat production, information is, however, needed in terms of carcass yield, nutritional composition and consumer acceptability for it to compete with domestic livestock (Hoffman *et al.*, 2005). Increased availability of information may therefore help accelerate expansion of the buffalo meat industry (Hildebrandt, 2014). In particular, there is a need to explore the carcass yield and composition of African savanna buffaloes. In this context, the aim of our study was to describe carcass yield and organ weights obtained during a routine harvesting of buffaloes in the KNP and to explore the effect of age and sex on these measurements.

MATERIALS AND METHODS

Harvest and slaughter

A total of 30 buffaloes were sampled (Table 1) aged between 18 months and eight years. African savanna buffaloes reach sexual maturity at around four years of age. Therefore, adult buffaloes were categorized as being four years and older according to tooth eruption (and horn/boss development) whereas the subadult category were buffaloes younger than four years (Sinclair, 1977). These animals were selected from a total of 49 buffaloes that were randomly harvested by management staff in the Pretoriuskop section in the KNP on four different occasions within a period of eleven days between May and June 2017. Harvesting was part of the routine management plan for buffaloes in the KNP. This meant ethical clearance was not required. The remaining 19 carcasses were condemned or otherwise detained for animal health reasons: typically, if one or more tapeworm cysts (*Cysticercosis* spp.) were detected in the course of the secondary inspection. Furthermore, carcasses can either be partially condemned (*e.g.* bruising and abscesses) or totally condemned (*e.g.* tuberculosis and icterus). If only the red offal is affected, and the rest of the carcass is normal, then only the red offal (lungs, heart, liver, tongue and trachea) is condemned. However, if the intestines are tied to general diseases resulting in enlargement of the lymph glands, fever or hepatitis, etc., the whole carcass is condemned (National Department of Agriculture, 2007).

Table 1. Number of African savanna buffalo (*Syncerus caffer caffer*) sampled according to sex and age category.

Sex	Adult*	Subadult*	Total
Male	12	5	17
Female	11	2	13

*Adult buffalo were categorized as being four years and older according to tooth eruption (and horn/boss development) whereas the subadult category were buffalo younger than four years (Sinclair, 1977).

Animals were collected as per typical buffalo harvesting methods, involving the initial darting of animals from a helicopter. After the drug succinyl choline took effect, animals were killed *via* a shot to the head, bled, suspended by the Achilles heel, and then eviscerated. Prior to field evisceration, undressed carcass weights (or 'live' weight) were recorded. Carcasses, with skins on, were then transported to an abattoir for further processing (skinning and quartering) and inspection by an independent Government veterinary official.

At the abattoir, the weights of some organs were recorded. However, since evisceration took place in the field, some offal weights could not be recorded. Furthermore, the calibrated hanging scale broke during the weighing of 'live' mass in the field, thus carcass yield information is limited. The quartered (between the 9th and 10th rib) carcass was then weighed (sum of the four quarters used to calculate warm carcass weight) and suspended in a chiller (0–5°C) for 24 h.

Processing and sampling

The skin and head from each carcass were weighed, as were any remaining organs (*i.e.* offal) collected from carcasses: heart, liver, and lungs with trachea. A selection of muscles were excised from the right side of each quartered carcass after approximately 24 h of cooling and weighed. The muscles included *biceps femoris* (BF), *semimembranosus* (SM), *semitendinosus* (ST), *longissimus thoracis et lumborum* (LTL), *infraspinatus* (IS) and *supraspinatus* (SS).

Statistical analysis

The individual and combined effects of age (adult *vs* subadult) and sex (male/female) were analysed using SAS™ statistical software (Statistical Analysis System, Version 9.4, SAS Institute Inc., Cary, NC, U.S.A.). An ANOVA was used to test for differences between sexes with age as a co-variant. A one-way ANOVA was used to compare the differences between the age categories. Least squares mean (LSMeans) and standard error (S.E.) were calculated and a *P*-value of 5% was considered significant.

RESULTS

There were no significant interactions between sex and age for any of the carcass or muscle weights recorded. Table 2 shows the effects of sex and age category on mean carcass weights (both ‘live’ and warm), and on carcass variables: head, skin, and offal weights. The results for ‘live’ weight were limited to only six males and six females due to problems that occurred in the field with the weighing equipment. There was no significant difference between male and female buffaloes for ‘live’ weight or warm carcass weight. There was, however, a significant difference between the warm carcass weights of subadult and adult buffaloes ($P < 0.001$). Adults, on average, yielded a higher warm carcass weight of 288 kg; some 40% higher when compared to subadults. For the remaining carcass measures, significant sex effects included heavier head ($P < 0.001$) and skin ($P < 0.001$) weights for males compared to females. Significant age category effects included heavier head ($P < 0.001$), skin ($P < 0.001$), lungs with trachea ($P < 0.001$), and liver ($P < 0.001$) weights for adults relative to subadults.

Significant age category effects were also evident for chilled carcass and muscle weights (Table 3), where adult animals yielded heavier weights compared to subadults. The only exception was for the *infraspinatus* muscle, where there was no significant difference across age groups ($P > 0.05$). Also, chilled carcass and muscle weights did not differ between male and female animals. The highest yielding muscle (based on the LSMean ± S.E.) sampled from the buffaloes was the *biceps femoris* in adult animals (5.9 ± 0.27 kg), followed by the *semimembranosus* in adults (4.8 ± 0.18 kg) and then the *biceps femoris* in subadults (4.3 ± 0.25 kg).

DISCUSSION

The African savanna buffalo is of high economic value based on its role in eco-tourism and hunting, with meat production currently being a secondary objective for economic development. However, the literature on other buffalo species reveal potential human nutritional benefits associated with the consumption of buffalo meat (Naveen & Kiran, 2014). Thus, the potential value of utilizing African buffaloes for meat production is yet to be realized. To date, fundamental information on the carcass yield of the African buffalo remains insufficient. Our study set out to determine the dressing percentages of the African buffalo, as dressing percentage alone is a main determinant of cost for meat production. The preliminary findings show that the dressing percentage of African buffaloes is in the order of 58% (Table 2). This finding is slightly higher when compared to the literature for Indian buffaloes (*Bubalus bubalis*) of 51–53% (Naveen & Kiran, 2014). Nevertheless, these

Table 2. Effect of sex and age on warm carcass weights (LSMeans ± S.E.) in African savanna buffalo (*Syncerus caffer caffer*).

	Sex		*P*-value	Age		*P*-value
	Male	Female		Subadult	Adult	
‘Live’ weight (kg)	478.6 ± 26.87 (*n* = 6)*	451.7 ± 26.87 (*n* = 6)*	0.499			
Warm carcass (kg)	277.2 ± 6.63	258.1 ± 7.59	0.071	206.1 ± 8.31	288.1 ± 10.01	<0.001
Dressing %	58.3 ± 0.99	58.9 ± 0.99	0.701			
Head (kg)	31.3 ± 1.07	23.4 ± 1.22	<0.001	20.5 ± 1.15	30.1 ± 1.59	0.003
Skin (kg)	48.8 ± 2.24	38.8 ± 2.67	0.009	31.4 ± 1.94	48.9 ± 3.18	0.005
Heart (kg)	2.0 ± 0.13	1.9 ± 0.15	0.469	1.8 ± 0.39	2.0 ± 0.09	0.285
Lungs + trachea (kg)	6.3 ± 0.23	5.6 ± 0.27	0.089	4.8 ± 0.39	6.3 ± 0.26	0.008
Liver (kg)	5.4 ± 0.18	5.4 ± 0.20	0.953	4.3 ± 0.26	5.7 ± 0.18	<0.001

*Numbers limited due to scale breaking in the field.

Table 3. Effect of sex and age on chilled carcass and muscle weights (LSMean ± S.E.) in African savanna buffalo (*Syncerus caffer caffer*).

	Sex		*P*-value	Age		*P*-value
	Male	Female		Subadult	Adult	
Hindquarters mean (kg)	59.3 ± 1.99	59.7 ± 2.28	0.873	46.2 ± 2.21	63.5 ± 2.16	<0.001
Forequarters mean (kg)	59.0 ± 2.12	57.6 ± 2.42	0.668	44.3 ± 2.67	62.7 ± 2.40	<0.001
Muscle weights[#] (kg)						
BF	5.7 ± 0.23	5.3 ± 0.26	0.200	4.3 ± 0.25	5.9 ± 0.27	0.003
ST	1.7 ± 0.06	1.7 ± 0.07	0.536	1.2 ± 0.07	1.8 ± 0.06	<0.001
SM	4.6 ± 0.16	4.4 ± 0.19	0.409	3.5 ± 0.21	4.8 ± 0.18	0.001
IS	1.5 ± 0.08	1.5 ± 0.10	0.823	1.3 ± 0.27	1.6 ± 0.44	0.067
SS	1.1 ± 0.05	1.1 ± 0.06	0.477	0.8 ± 0.02	1.2 ± 0.06	0.005
LTL	3.0 ± 0.10	3.0 ± 0.12	0.693	2.5 ± 0.08	3.1 ± 0.10	0.004

[#]BF: *Biceps femoris*; ST: *Semitendinosus*; SM: *Semimembranosus*; IS: *Infraspinatus*; SS: *Supraspinatus*; LTL: *Longissimus thoracis et lumborum*.

dressing percentages for buffaloes are comparable to *Bos taurus* cattle.

In terms of the heaviest yielding muscles, the *biceps femoris*, *semimembranosus* and *longissimus thoracis et lumborum* muscles from buffaloes showed the greatest economic potential (Table 3). These findings are in accordance with those previously reported by Hildebrandt (2014). The maximum 'live' weight obtained for this study was 630 kg for a bull and 596 kg for a cow, with a mean sample weight of 465.17 kg. This is, however, lower than what was reported by Pienaar (1969; 745.3 kg, 618.2 kg and 475.51 kg, respectively). This discrepancy in findings could be due to a smaller sample size, and the lack of available data for 'live' weights in the present investigation.

In a previous study on the 'live' weight of buffalo, Pienaar (1969) recorded that subadult buffalo weights ranged from 81.3 kg to 422.0 kg and 485.2 kg to 696.8 kg for adult buffaloes. The warm carcass weight from the present study corresponds to that noted by Grobler (1996), for buffalo with the subadult weight (206.15 ± 22.00 kg) lying within the 140–220 kg. The mean warm carcass weight for adult female buffaloes in the present study was 275.1 ± 10.12 kg and is in the parameter's range for adult cows (260–330 kg), whilst that for adult bulls in the present study (299.9 ± 16.30 kg) was slightly lower than for the criteria for adult bulls (300–440 kg) of Grobler (1996).

In this study, the dressing percentage of African savanna buffaloes (at 58%) was higher than than that of domestic cattle such as Nguni, Angus and Bonsmara (50.3–53.8%) (Muchenje *et al*., 2008), black wildebeest (*Connochaetes gnou*) bulls (53.1%) (Hoffman *et al*., 2009a) and blue wildebeest (*Connochaetes taurinus*) adults (52.6%) (Van Heerden, 2018), but lower than impala (*Aepyceros melampus*) adult males (59.9%) (Hoffman *et al*., 2009b). Although males had heavier head and skin weights, the dressing percentage did not differ from that of females.

Since game meat is usually sold as price per carcass weight, it is important to know the actual carcass weight of African savanna buffaloes. This weight may include the skin, since game carcasses are often transported in chiller trucks with the skin on to minimize risk for bacterial contamination and weight loss due to dehydration. In the present study, the average skin weight for an adult buffalo bull was 48.9 kg (Table 2); a weight substantial enough to influence the price of the saleable meat.

In the present study, the GIT (gastrointestinal tract) was removed in the field where the field staff take it for home consumption. The GIT is usually cut up in small pieces and stewed in curry sauce and served over rice and is a popular South African dish (Erasmus & Hoffman, 2017). It is therefore important that more information around the various offal weights and their nutritional properties be determined as it does form an important component of local cuisine (Alao *et al*., 2018; Hoffman *et al*., 2013).

As pertaining to the carcasses, larger mammals, including beef cattle, are frequently quartered, particularly in older abattoirs where carcasses are moved manually on the overhead rails. The differences between the forequarter and hindquarter weights were slight, since buffalo have relatively heavy forequarters (Van Zyl & Skead, 1964). Mature female animals are known to have a higher hindquarter to carcass percentage than male animals (Ledger, 1963). This is in agreement with the present study where the females had ~2 kg heavier hindquarters than forequarters (Table 3). The larger difference between the hindquarter and forequarter for the subadult group is indicative that there is still development to come in the neck, shoulders and chest regions for both sexes (Ledger, 1963).

As pertaining to the individual muscles, no significant differences were observed between the two sexes. However, as expected, the adults' muscle weights were significantly heavier than the muscles of the subadults (Table 3) with the exception for *m. infraspinatus*. The *biceps femoris* (commercial cut: silverside), *semimembranosus* (topside), and *longissimus thoracis et lumborum* (sirloin) muscles are regarded as high-value cuts and are thus of economic importance (Ledger, 1963). Within the KNP's social outreach strategy, cooked buffalo meat will be provided as a sustainable source of protein to impoverished local schools and is part of the sustainable resource programmes. In this setting, the use of game meat may provide a sustainable source of protein to optimize nutrition and improve health in these communities. More importantly, it provides an opportunity for a positive engagement with local schools about biodiversity conservation. The high value cuts could typically be aged and sold as steaks within the KNP to upmarket restaurants and camping sites to offset the cost of the lower value muscles which are cooked and given to the schools in the schools' outreach programme. These muscles had the heaviest weights (kg) for both sexes which is promising for offsetting the costs of meat production/sourcing in the KNP.

The primary functions of the *biceps femoris* and *semimembranosus* muscles are for locomotion. Therefore, these two muscles developed throughout time and increased in size, in ratio to other muscles (Frandson *et al.*, 2009). The increase in size of these two muscles result in a coarser grain due to thicker muscle fibres (Herring *et al.*, 1965; Klont *et al.*, 1998), factors that will influence their eating quality. On the other hand, the *infraspinatus* and *supraspinatus* muscles form part of the forequarter and are the smallest and lightest (kg) of all the muscles in the present study. These smaller muscles serve in propulsion; primarily the *infraspinatus* and *supraspinatus* muscles acts as a shoulder joint ligament (Frandson *et al.*, 2009). However, these small muscles form part of the lower valued shoulder muscles and are normally processed to value added products such as mince or used in the production of sausages (fresh and droëwors) or as stewing meat.

In the present study, 19 out of 49 buffalo were condemned or detained for reasons typically due to infection by *Sarcocystis* or beef measles (*Cysticercosis*) (data not presented). This value is higher than that previously reported by Sachs (1966) who reported an infection rate of 30% in the Serengeti. This high infection rate could pose health and food safety issues if carcasses and offal are not monitored and inspected thoroughly, also more research is required to determine whether this high infection rate is typical of buffaloes in KNP and also what the implications are for the KNP buffalo population. All the condemned and partially condemned carcasses, non-trophy worthy heads and offal not destined for human consumption are processed in a rendering plant at WPS, to create a bone and carcass meal product that can be used as fertilizer. However, all the detained carcasses are split frozen for at least 72 h with an air temperature of at least –18°C, to kill the 'measles' parasite (National Department of Agriculture, 2007). This freezing will influence the potential meat quality of the defrosted meat (Leygonie *et al.*, 2012) and therefore alternative uses for these muscles/cuts, such as drying into biltong need to be investigated.

CONCLUSIONS

Carcass yields and muscle weights obtained from African savanna buffaloes compare favourably to those previously reported for other domestic species and game animals. The high weights obtained from the *biceps femoris*, *semimembranosus* and *longissimus thoracis et lumborum* muscles in particular suggest their potential use as value-added products such as aged steaks thereby increasing the profit margin. However, research is required to determine the optimum ageing period and other eating quality factors. Future studies should also include cold carcass weights and evaluate dressing percentage in subadults to provide further insight towards understanding the commercial potential of buffalo in the domestic market. This information will also be important for determining the fixed and running costs per unit weight to evaluate the financial viability of the envisaged resource use strategy. In addition, future research could investigate new harvesting processes and methods that allow for the collection and hygienic processing of offal that is usually discarded in the field, given that these products are highly valued by local communities for home consumption.

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REFERENCES

Alao, B.O., Falowa, A.B., Chulayo, A. & Muchenje, V. (2018). Consumers' preference and factors influencing offal consumption in Amathole District, Eastern Cape, South Africa. *Sustainability*, 10(9), 3323.

Alden, P.C., Estes, R.D., Schlitter, D. & McBride, B. (1995). *National Audubon Society field guide to African wildlife*. New York: Chanticleer Press.

Erasmus, S.W. & Hoffman, L.C. (2017). What is meat in South Africa? *Animal Frontiers*, 7, 71–75.

Frandson, R.D., Wilke, W.L. & Fails, A.D. (2009). *Anatomy and physiology of farm animals*. New Jersey: John Wiley & Sons.

Grobler, D.G. (1996). The potential utilization of the African buffalo with regard to hunting and meat production. In B.L. Penzhorn (Ed.), *The African buffalo as a game ranch animal* (pp. 37–42). Pretoria, South Africa: University of Pretoria.

Herring, H.K., Cassens, R.G. & Briskey, E.J. (1965). Further studies on bovine muscle tenderness as influenced by carcass position, sarcomere length, and fibre diameter. *Journal of Food Science*, 30, 1049–1054.

Hildebrandt, W.R., (2014). *Management and reproduction of the African savanna buffalo* (Syncerus caffer caffer). (M.Sc. thesis). Stellenbosch, South Africa: Stellenbosch University.

Hoffman, L.C., Laubscher, L.L. & Leisegang, K. (2013). Nutritional value of cooked offal derived from free-range rams reared in South Africa. *Meat Science*, 93(3), 696–702.

Hoffman, L.C., Mostert, A.C., Kidd, M. & Laubscher, L.L. (2009b). Meat quality of kudu (*Tragelaphus strepsiceros*) and impala (*Aepyceros melampus*): carcass yield, physical quality and chemical composition of kudu and impala *longissimus dorsi* muscle as affected by gender and age. *Meat Science*, 83, 788–795.

Hoffman, L.C., Muller, M., Schutte, D.W., Calitz, F.J. & Crafford, K. (2005). Consumer expectations, perceptions and purchasing of South African game meat. *South African Journal of Wildlife Research*, 35, 33–42.

Hoffman, L.C., Van Schalkwyk, S. & Muller, N. (2009a). Effect of season and gender on the physical and chemical composition of black wildebeest (*Connochaetus gnou*) meat. *South African Journal of Wildlife Research*, 39, 170–174.

Klont, R.E., Brocks, L., & Eikelenboom, G. (1998). Muscle fibre type and meat quality. *Meat Science*, 49, 219–229.

Ledger, H.P. (1963). Animal husbandry research and wildlife in East Africa. *African Journal of Ecology*, 1, 18–28.

Leygonie, C., Britz, T.J. & Hoffman, L.C. (2012). Impact of freezing and thawing on the quality of meat: review. *Meat Science*, 91, 93–98.

Muchenje, V., Dzama, K., Chimonyo, M., Raats, J.G. & Strydom, P.E. (2008). Meat quality of Nguni, Bonsmara and Aberdeen Angus steers raised on natural pasture in the Eastern Cape, South Africa. *Meat Science*, 79, 20–28.

Naveen, B.M. & Kiran, M. (2014). Buffalo meat quality, composition, and processing characteristics: contribution to the global economy and nutritional security. *Animal Frontiers*, 4(4), 18–24.

National Department of Agriculture. (2007). *Meat inspectors manual, game*. Retrieved from: http://www.nda.agric.za/vetweb/vph/manuals/gamemanual.pdf on 10 August 2018.

Nowak, R.M. (1991). *Walker's Mammals of the World* (5th ed.). Baltimore: Johns Hopkins University Press.

Oberem, P. & Oberem, P. (2016). *The new game rancher*. Queenswood, South Africa: BRIZA Publications CC.

Omujeve. (2018). *Omujeve hunting safaris Namibia*. Retrieved from: https://omujevehuntingsafaris.com/wp-content/uploads/2017/12/Omujeve-download-2018.pdf

Pienaar, U. de V. (1969). Observation on developmental biology, growth and some aspects of the population ecology of the African buffalo (*Syncerus caffer caffer* – Sparrman) in the Kruger National Park. *Koedoe*, 12(1), 29–52.

Ryan, S.J., Knechtel, C.U. & Getz, W.M. (2006). Range and habitat selection of African buffalo in South Africa. *Journal of Wildlife Management*, 70(3), 764–776.

Sachs, R. (1966). Note on cysticercosis in game animals of the Serengeti. *East African Wildlife Journal*, 4, 152–153.

Sinclair, A.R.E. (1977). The African buffalo: a study of resource limitation of populations. *Journal of Mammalogy*, 7, 355.

Swemmer, L.K. & Mmethi, H. (2016). *Biodiversity for society – A reflection on the diversity of direct, local impacts (benefit and costs) of the Kruger National Park*. Retrieved from: https://www.sanparks.org/assets/docs/conservation/publications/biodiversity-for-society.pdf

Van Heerden, A.M. (2018). *Profiling the meat quality of blue wildebeest* (Connochaetes taurinus). (M.Sc. thesis). Stellenbosch, South Africa: Stellenbosch University.

Van Zyl, J.H.M. & Skead, D.M. (1964). The meat production of South African game animals 2: the African buffalo. *Fauna and Flora*, 15, 34–40.

Wintershoek. (2019). *Wintershoek safaris*. Retrieved from: https://omujevehuntingsafaris.com/wp-content/uploads/2017/12/Omujeve-download-2018.pdf

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