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Effect of aging on the characteristics of meat from water buffalo grown in the Delta del Paraná region of Argentina

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Abstract

Fifteen crossbreed water buffalos were selected from a farm in Delta del Paraná, Entre Ríos Province, Argentina. Animals were castrated males 20–24 months old reaching final live weights of 400–420 kg. They were predominantly of Mediterranean and Murrah breeds and were feed in naturally grown pastures. Tenderness and chewiness increased with postmortem aging ($p < 0.05$). Aging did not affect flavour and odour scores, even though certain off-flavours and off-odours were reported. Changes in colour with aging were similar to those seen in beef.

Keywords: Pasture-fed buffalo; Delta del Paraná; Quality traits

1. Introduction

In Argentina, beef cattle have been the traditional source of red meat but buffalo meat is increasing in importance. Buffalo meat has high protein levels, low fat content and cholesterol compare to beef (Murthy & Devadason, 2003). Due to these characteristics, there has been an increased interest in meat from this species. It is important to note that in February 2007, the enterprise Fuska S.A. exported the first batch of buffalo meat from Argentina to Europe.

The total population of Asiatic water buffalo (*Bubalus bubalis*) in Argentina is around 70,000 animals mainly from Mediterranean, Murrah and Jafarabadi breeds. Those animals are located in Chaco, Formosa, Corrientes and Entre Ríos provinces (north and east from Argentina). The performance of this species exceeds that of other bovine species in tropical or sub tropical regions in which the pastures are poor in terms of its quality. These differences have been attributed mainly to the capacity of the buffalo to transform and digest feeds of low quality (Ranjhan, 1992).

The results presented in this work form part of a mayor project entitled *Buffalo fitting to Delta del Paraná* (FONTAR PMTII-ANR NA 240/00) financed by the National Agency for Scientific and Technological Promotion of Argentina. The general aims of the Project were: (1) to verify that the water buffalo can increase its weight more efficiently than the traditional bovine in the Delta del Paraná region, and (2) to corroborate that it is possible to obtain tender and natural meat from animals fed only in naturally grown pastures.

It is well established that aging procedures affect meat quality traits (Ruiz de Huidobro, Miguel, Anega, & Blázquez, 2003) and several papers described these modifications (Campo, Santolaria, Sañudo, Lepetit, & Olleta, 2000; Jayasooriya, Torley, D'Arcy, & Bhandari, 2007; Silva, Patarata, & Martins, 1999). In the case of buffalo meat, some authors reports results considering either older

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animals or/and animals grown under different handling and feeding practices. A good description of some results is presented by Neath et al. (2007) and Naveena et al. (2004).

The aim of the work described in this article was to evaluate the effect of three aging periods on certain quality traits of buffalo meat, from animals grown in Delta del Paraná, Argentina.

2. Materials and methods

2.1. Animals and diets

Fifteen crossbreed water buffalos were selected from a farm in Delta del Paraná, Entre Ríos Province, Argentina. The animals employed in this study were castrated males of 20–24 months old, with a final live weight of 400–420 kg. All the animals had a predominance of Mediterranean and Murrah breeds and were feeding in naturally grown pastures of this typical wet area with predominance of *Axonopus jesuiticus*, *Luziola peruvian*, *Schoenoplectus californicus*, *Zizaniopsis bonaerensis* and *Panicum elephantipes*.

2.2. Slaughtering and sample collection

The animals were slaughtered by conventional procedures in a commercial abbatoir. Carcasses were refrigerated (4 °C) for 48 h and after that *Longissimus dorsi* (LD), *Biceps femoris* (BF), *Gluteus medius* (GM), *Gastrocgnemius* (GG), *Semimembranosus* (SM) and *Semitendinosus* (ST) muscles from the left carcass were removed and cut into three portions of uniform size. Each portion was then randomly assigned to each aging period. They were vacuum packaged (Cryovac BB4L, Sealed Air Co., Buenos Aires, Argentina), and refrigerated (2 ± 1 °C) during the corresponding aging periods after which they were frozen until analysis (-20 ± 0.5 °C). The times of analysis were T1 = fresh meat, T2 = 15 days and T3 = 25 days of aging.

2.3. Ribeye area and marbling

Frozen blocks of beef were split between 12th and 13th rib using an electric saw. Trained and experienced personnel from Instituto Tecnología de Alimentos (ITA) of the Instituto Nacional de Tecnología Agropecuaria (INTA) determined fat thickness and *L. dorsi* muscle (LD) area at the 12th rib. First, a calcography of the frozen ribeye was made manually and then it was measured using a digital planimeter and a mill metric ruler. Once the samples were thawed, they were compared to the USDA standards set of coloured pictures.

2.4. Water holding capacity (WHC)

The WHC was determined following the filter paper press methodology described by Zamorano and Gambaruto (1997). Briefly, this technique implies the compression of the sample over a reticular filter paper and measures the liquid impregnation area on it. This procedure assumes that the area of ring of expressed juice absorbed by the filter paper is related to the amount of the meat free water.

2.5. Colour

Colour measurements were carried out using a ByK Gardner Colour View Spectrophotometer (model 9000, USA) following the recommendations of AMSA (1991). Determinations were done in 2.5 cm thick steaks. CIE Lab system (1976) provides the values of three colour components; L^* (black–white component, luminosity), and the chromaticness coordinates, a^* (+red to −green component) and b^* (+yellow to −blue component). The instrumental conditions were large area aperture (5 cm diameter), D65-artificial and 10° standard angle observer. The measuring aperture was covered with a glass plate (ByK Gardner Inc., USA), and the instrument was calibrated against a white plate. Each sample was allowed to bloom for 45 min prior to the first measurement, and four scans from each steak were averaged for statistical analysis.

2.6. Instrumental tenderness

Warner-Bratzler shear force (WBSF) was determined following the general guidelines established by AMSA (1995) on eight cores (2.0 cm height; 1.27 cm diameter) obtained from a 2.0 cm-thick stick from the medial portion of the muscle using a Warner-Bratzler meat shear machine (model 3000; G-R Manufacturing Co., Manhattan, KS, USA).

After the samples were thawed and deboned, they were weighed and cooked in a Philips electric grill until they reached a final internal temperature of 71.5 ± 0.5 °C. Percentage of cooking loss was determined by dividing the weight loss during cooking by the pre-cooked weight.

2.7. Sensory analysis

Thick steaks of 2.5-cm each were obtained from the 13th rib. Once thawed, they were deboned, weighed and placed in a pre-heated electric grill until they reached a final internal temperature of 71 ± 0.5 °C (AMSA, 1995).

After cooking, each steak was trimmed of fat and connective tissue, and the *L. dorsi* muscle was cut into cubes 1 cm × 1 cm × steak thickness and was immediately served to an eight-member trained sensory panel. Each panel member (Cross, Moen, & Stanfield, 1978) evaluated two random cubes of each steak in a cabin supplied with green light and built according to ISO 8589, 1988; and were provided with an evaluation form, a salt free cracker and a glass of distilled water to rinse the palate. The samples were evaluated using a nine-point non-structured linear scale for odour, juiciness, initial and sustained tenderness, beef flavor intensity and amount of connective tissue (1 = extremely bland, extremely dry, extremely tough, extremely

bland and very much to 9 = extremely intense, extremely juicy, extremely tender, extremely intense and nothing, respectively). Panel members were also asked to report the description and the intensity of off-odours and off-flavors (if present) in separate scales.

2.8. Statistical analysis

Statistical analysis was performed by ANOVA. Differences between mean values at different aging periods were assessed by Duncan test ($p < 0.05$). All procedures were carried out using the statistical package SAS (version 8, SAS Institute Inc., 2004, Cary, NC).

3. Results and discussion

As stated by Neath et al. (2007), there are not reports describing a direct comparison between quality of buffalo and beef meat. Even though this comparison is out of the scope of our experiment, some published results are presented from cattle grown in Argentina are considered as orientation values. These results were determined following the same protocols than those presented in the article.

3.1. Ribeye area and marbling

In Table 1 are shown the results for ribeye area and fat thickness. Previous results from three crossbreed cattle grown in intensive grassing system in the Pampean region of Argentina (Latimori, Kloster, Carduza, & Margaria, 1997) are included in Table 1. It can be seen that ribeye area in buffalo was lower than those obtained in cattle.

The score of marbling obtained for the buffalo corresponded to "small amount" in USDA scale for cattle. This reference was used because there are not standard sets to determine marbling of buffalo meat in Argentina.

3.2. Muscle colour

L. dorsi muscle colour was affected by the aging time. Lightness (L^*) parameter increased significantly ($p < 0.05$) at 25 days postmortem while red index (a^*) and yellow index (b^*) decreased ($p < 0.05$) at 15 and 25 days postmortem.

Aging time did not affect the L^* parameter in *Gluteus medius*, *Gastrocgnemius* and *Semitendinosus* muscles while in *B. femoris* and *Semimembranosus* were found higher values at 15 days postmortem. The a^* parameter was not affected by aging time in *Gluteus medius*, *Gastrocgnemius* and *Semimembranosus* muscles. While significative differences ($p < 0.05$) in a^* values were observed for *B. femoris* and *Semitendinosus*. Both of them shown the same trend in variation, the lowest values were observed in fresh meat and the highest at 25 days postmortem.

Parameter b^* increased during aging in *Semitendinosus* and *B. femoris*, while decreased in *Gluteus medius* and *Semimembranosus*. No changes were observed in *Gastrocgnemius* muscle.

The results presented are in accordance to Jayasooriya et al. (2007). These authors reported that aging time (8 days at 5 °C) significantly affected colour parameters a^* and b^* in *Longissimus lumborum et Thoracis* and *Semitendinosus* beef muscles. In this study, an increase in that parameters was observed, while no differences were found in L^*. Also, colour results in buffalo agreed with previous work in beef muscle done by our research group (Langman et al., 2006). In this work, *L. dorsi* colour evolution in long term aging as a function of the temperature of storage (0 and 3 °C). It was observed that L^* parameter increased significantly ($p < 0.05$) along aging, while a^* and b^* decreased ($p < 0.05$) for both temperature.

3.3. Water holding capacity

WHC increased significantly ($p < 0.05$) in *L. Dorsi* up to 15 days, while *B. femoris* and *Semitendinosus* muscles increased during the hole aging period. No significant differences were found in WHC in *Gluteus medius*, *Gastrocgnemius* and *Semimembranosus* muscles through aging time. These results agree with previous research in muscles of bovine meat (Ruiz de Huidobro et al., 2003). These authors found in raw meat, that as the aging period increased the released water weight decreased in heifers although they did not find significant differences in bulls (see Table 2).

3.4. Instrumental tenderness

In Table 3 are presented the results obtained for WBSF and cooking loss. In *L. dorsi* muscles significant differences ($p < 0.05$) were found. Even though in *Gastrocgnemius* no differences ($p > 0.05$) were seen, a remarkable tendency to decrease in WBSF values was observed. In the case of *B. femoris*, the values obtained corresponded to "slight tender" meat. This qualification is based on a correlation established between WBSF values and the scores determined by the sensory trained panel of ITA.

Table 1
Longissimus dorsi area and fat thickness for buffalo (from Delta del Paraná) and cattle (from Pampean region) grown in grazing systems in Argentina

Trait	Area (cm^2), mean ± s.d.	Large (cm), mean ± s.d.	Wide (cm), mean ± s.d.	Fat thickness (mm), mean ± s.d.
Buffalo	50.92 ± 4.8	12.51 ± 0.9	5.39 ± 0.9	13.60 ± 4.4
Brangus × Angus	62.16 ± 9.0	11.60 ± 0.7	7.12 ± 0.8	20.7 ± 11.9
Fleckvieh × Angus	76.90 ± 13.9	12.54 ± 0.6	7.82 ± 1.2	11.0 ± 2.7
Limousin × Angus	74.82 ± 7.1	11.88 ± 0.6	8.26 ± 0.4	12.10 ± 3.6

Cattle results were reported in Latimori et al. (1997).

Table 2
Colour parameters and water holding capacity in buffalo grown in Delta del Paraná in Argentina

Muscle	Aging time	L^*, mean ± s.d.	a^*, mean ± s.d.	b^*, mean ± s.d.	WHC, mean ± s.d.
LD	T1	33.35 ± 1.34 ab	19.39 ± 2.32 a	15.68 ± 1.62 a	37.72 ± 2.4 ab
	T2	32.39 ± 2.24 a	16.28 ± 1.91 b	12.91 ± 2.58 b	39.76 ± 2.4 a
	T3	34.29 ±2.56 b	12.20 ± 2.85c	12.85 ± 1.17 b	36.05 ± 2.05 b
BF	T1	33.49 ± 1.34 a	17.68 ± 2.12 a	16.62 ± 0.97 a	28.37 ± 2.50 a
	T2	36.79 ± 2.79 b	19.60 ± 1.35 b	17.37 ± 1.3 ab	29.82 ± 2.13 a
	T3	33.71± 2.00 a	20.80 ± 1.35 b	17.74 ± 1.25 b	33.54 ± 1.49 b
GM	T1	33.88 ± 2.95 a	21.01 ± 2.17 a	17.96 ± 1.68 a	29.49 ± 1.70 a
	T2	31.49 ± 3.22 a	20.15 ± 1.66 a	16.17 ± 1.26 b	31.13 ± 2.63 a
	T3	33.44 ± 3.17 a	19.44 ± 2.46 a	16.69 ± 2.0 ab	29.99 ± 1.65 a
GG	T1	31.93 ± 2.35 a	20.53 ± 2.52 a	16.44 ± 2.31 a	30.32 ± 2.51 a
	T2	31.80 ± 2.64 a	19.76 ± 1.86 a	16.02 ± 1.75 a	32.05 ± 2.38 a
	T3	33.29 ± 2.95 a	20.29 ± 2.27 a	16.47 ± 1.73 a	31.18 ± 1.41 a
SM	T1	31.70 ± 1.84 a	19.94 ± 3.09 a	17.58 ± 2.19 a	31.12 ± 3.53 a
	T2	33.55 ± 2.30 b	21.17 ± 1.73 a	18.16 ± 1.75 a	31.85 ± 3.17 a
	T3	33.03 ± 1.91 ab	19.06 ± 2.36 a	15.80 ± 2.2 ab	32.61 ± 3.12 a
ST	T1	37.60 ± 3.80 a	14.68 ± 2.45 a	16.13 ± 1.36 a	23.73 ± 1.80 a
	T2	40.57 ± 4.32 a	18.37 ± 3.29 b	18.81 ± 1.44 b	30.24 ± 2.51 b
	T3	38.80 ± 5.43 a	18.87 ± 3.42 b	18.23 ± 1.13 b	29.67 ± 2.10 b

Muscles: *Longissimus dorsi* (LD), *Biceps femoris* (BF), *Gluteus medius* (GM), *Gastrocgnemius* (GG), *Semimembranosus* (SM), *Semitendinosus* (ST). Different letter within the same column differ significantly ($p < 0.05$).

Table 3
Warner-Bratzler shear force values and cooking loss percentage in buffalo grown in Delta del Paraná in Argentina

Muscle	Aging time	WBSF (*N*), mean ± s.d.	Cooking loss (%), mean ± s.d.
LD	T1	33.45 ± 4.85 a	28.09 ± 4.21 b
	T2	24.91 ± 4.98 b	23.62 ± 6.05 c
	T3	22.95 ± 4.40 b	32.02 ± 4.12 a
BF	T1	40.35 ± 9.34 a	32.73 ± 7.81 a
	T2	40.57 ± 12.37 a	33.94 ± 4.40 a
	T3	41.64 ± 7.38 a	33.63 ± 3.35 a
GM	T1	26.73 ± 4.76 a	30.18 ± 3.44 a
	T2	27.13 ± 5.25 a	32.83 ± 6.81 a
	T3	25.93 ± 4.40 a	33.11 ± 9.34 a
GG	T1	32.03 ± 6.58 a	33.91 ± 3.81 a
	T2	30.60 ± 4.72 a	35.69 ± 5.48 a
	T3	29.00 ± 3.96 a	36.11 ± 5.24 a
SM	T1	39.63 ± 8.05 a	30.20 ± 1.81 b
	T2	38.08 ± 7.43 a	35.87 ± 2.70 a
	T3	41.28 ± 7.38 a	37.87 ± 3.36 a
ST	T1	40.52 ± 4.89 a	35.04 ± 3.02 a
	T2	41.77 ± 7.52 a	34.28 ± 6.88 a
	T3	44.08 ± 8.32 a	38.02 ± 5.34 a

Muscles: *Longissimus dorsi* (LD), *Biceps femoris* (BF), *Gluteus medius* (GM), *Gastrocgnemius* (GG), *Semimembranosus* (SM), *Semitendinosus* (ST). Different letter within the same column differ significantly ($p < 0.05$).

For *Semimembranousus* muscles the results are in accordance to Neath et al. (2007). These authors found not significant differences in WBSF for *Longissimus thoracis* and *Semimembranousus* muscles for 14 days of aging at 4 °C. Even though the cooking procedures in our work differed from the one used by Neath et al. (2007), the tendency along aging observed in both experiments could be compared.

From these results it seems that further investigation is needed in order to establish optimal aging temperature to observe significant differences in shear force in these muscles.

Cooking loses are dependent on the type of meat, aging, temperature and cooking method. As expected, cooking loses increased along aging period (Table 3).

3.5. Sensory analysis

Sensory results are presented in Table 4. Flavour, odour and amount of connective tissue scores were not ($p > 0.05$) affected by aging. Flavour and odour scores corresponded to "slightly intense" and amount of connective tissue to "practically nothing", for the all aging periods studied. Tenderness, chewiness and juiciness scores presented the same behaviour: they showed an increment at 15 days ($p < 0.05$) and then not changes were observed. For tenderness and chewiness the scores corresponded to "slightly tender" for fresh samples and "tender" for aged ones. In the case of juiciness, fresh samples were classified as "slightly dry" and then "neither dry, nor juicy". Tender and juiciness are closely related because when meat is tender, the juices are released by chewing more quickly and then meat appears juicier (Vasanthi, Venkataramanujam, & Dushyanthan, 2007).

Panel members reported the presence of off-flavour (acid, metallic and spoiled) for 15 and 25 days of aging. The frequency of mention of these off-favours was less than 5% for 15 days and less than 10% for 25 days of aging.

In Table 5 are shown previous results in fresh beef muscles from Angus steers (Grigioni, Carduza, & Irurueta, 2005) and heifers (Pordomingo, 2005) with pasture as

Table 4
Sensory scores (mean ± s.d.) in buffalo grown in Delta del Paraná in Argentina

Aging time	Flavour	Odour	Tenderness	Chewiness	Juiciness	Connective tissue
T1	5.99 ± 1.25 a	5.9 ± 1.43 a	5.59 ± 1.54 b	5.98 ± 1.65 b	4.35 ± 1.52 b	7.65 ± 1.23 a
T2	5.85 ± 1.39 a	5.94 ± 1.32 a	7.08 ± 1.02 a	7.37 ± 1.00 a	5.38 ± 1.50 a	7.95 ± 1.21 a
T3	5.67 ± 1.45 a	5.72 ± 1.47 a	6.88 ± 1.06 a	7.19 ± 1.08 a	5.36 ± 1.42 a	7.72 ± 1.30 a

Different letter within the same column differ significantly ($p < 0.05$).

Table 5
Beef sensory scores (mean ± s.d.) for fresh LD muscle from Angus steers (Case 1) and heifers (Case 2) with pasture as based diet (Grigioni et al., 2005; Pordomingo, 2005)

Beef sensory profile	Flavour	Tenderness	Chewiness	Juiciness	Connective tissue
Case 1	6.37	6.17	6.26	6.07	6.43
Case 2	6.50	6.07	6.62	4.93	7.40

based diet. In both experiment the sensory evaluation was performed by the sensory trained panel of ITA. As it is possible to seen, different profiles were determined in *L. dorsi* muscle.

4. Conclusions

As stated by Naveena, Mendiratta, and Anjaneyulu (2004), tenderness has been identified as the most important factor affecting consumer satisfaction and perception of taste. Aging is a common method used to tenderize meat. The mayor disadvantages are related to the requirement of large amounts of controlled chiller spaces (Jayasooriya et al., 2007). The results obtained in this work showed that tenderness and chewiness were increased during aging as expected, and showed the same behavior as in bovine (cattle). On the other hand, juiciness was a matter of concern when meats with very little intramuscular fat are aged. Aging period did not affect flavour and odour scores, even though certain off-flavours and off-odours were reported. In the relation to colour parameters, the evolution observed during aging was in accordance to results found in beef.

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