MEAT COLOUR STABILITY IN BISON AND BEEF

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Abstract –Bison meat has been found to discolour more rapidly than beef in retail display. The influence of tissue levels of PUFA, vitamin E and pigment on the colour stability of bison and beef were examined. *Longissimus* samples from beef and bison were analyzed for fatty acid composition, vitamin E, pigment, TBARS, and retail stability. The change in MetMb in both beef and bison were most influenced by the n-6:n-3 ratio in muscles. Inherent levels of PUFA, pigment and vitamin E in bison seem to be strongly linked to undesirable changes in fresh meat. Further work should investigate strategies to stabilize fresh bison meat in the retail environment while ensuring a desirable fatty acid profile.

Key Words – Bison, Shelf life, Fatty Acid

I. INTRODUCTION

Bison (*Bison bison*) are raised for their meat and other products (hides, breeding stock) in North America. Bison meat composition has been found to be nutrient dense, with a high proportion of protein [1, 2]. Bison meat has been found to discolour more rapidly than beef [3, 4, 5] and the reasons for this accelerated discolouration have not been determined. Meat colour is important because it is used by consumers as an indicator of freshness [6].

Polyunsaturated fatty acids (PUFA) in phospholipid membranes are susceptible to oxidative breakdown resulting in changes to the colour, smell and taste of the meat [7]. Species differences in susceptibility of meat to oxidation have been linked to the heme iron content [8]. Heme iron has been proposed as an initiator and promoter of lipid oxidation in raw meats and H_2O_2-activated metmyoglobin has been seen to promote lipid oxidation [9]. High levels of total iron have been found in raw bison meat compared to those typically found in beef [1, 2]. PUFA levels (weight percentage) in both range and feedlot fed bison were found to be higher than in range or feedlot fed cattle [10]. Thus, the relatively rapid deterioration of colour quality of bison muscle compared with beef may be related to the significantly higher content of both total PUFA's and total iron.

The colour of meat can be attributed to pigments, which absorb certain wavelengths and reflect others. The major pigment in meat is myoglobin (Mb). The colour of fresh meat is impacted by the amount of each derivative of Mb, purple reduced deoxymyoglobin, red oxymyoglobin (MbO_2), and brownish metmyoglobin (MetMb).

The ferric ion will be reduced to the ferrous form and in an aerobic environment, MbO_2 will result. This reaction is dependent on the reducing capacity, oxygen availability and Mb autoxidation rate of the muscle, and will differ depending on intrinsic (age of the animal, species, feeding regime, muscle and fibre type) and extrinsic (temperature, microbial contamination , chilling rate, and final pH) factors [11].

The purpose of this study was to examine the influence of tissue levels of PUFA, vitamin E, and pigment on the oxidative and colour stability of fresh beef and bison in a retail display environment.

II. MATERIALS AND METHODS

Animals and Slaughter

A total of 20 feedlot steers were fed in feedlot pens. Their finishing diet contained approximately 8% grass hay and up to 80% steam-rolled barley. Fourteen intact male bison from three commercial farms were finished on

native grass pasture. All animals were slaughtered at the Lacombe Research Centre abattoir in accordance with the principles and guidelines established by the Canadian Council on Animal Care [12].

Following overnight chill, at approximately 24 h *post-mortem*, the left *longissimus thoracis et lumborum* (LTL) was removed from the beef and bison carcasses respectively. After trimming, one steak was removed for subsequent fatty acid and α-tocopherol determination. The remainder of the muscle was labeled, bagged and aged in a cooler at 2°C. Following the 6 d ageing period, steaks (25 mm thick) were removed for analysis. One steak was placed into a horizontal retail display case under fluorescent room lighting, as previously described [13]. Samples were held at 1°C for retail evaluation after 0, 1, 2 and 3 d.

Lipid Analyses

Lipid extraction and methylation was performed using procedures previously reported [14, 15, 16]. Fatty acid methyl esters were analyzed by gas chromatography [17], and contents were reported as % of total fatty acids quantified.

Pigment and tocopherol

Pigment (myoglobin) was determined using a modified procedure from Trout [18] and reported in mg/g. Tocopherol content was estimated by high performance liquid chromatography according to methods outlined by Hewavitharana et al. [19].

Evaluation of Retail Stability

Treatment samples were placed into the retail display case controlling for known temperature gradients within the retail case. On each specific day in retail objective colour measurements (CIE *L**[brightness], *a**[red-green axis], *b**[yellow-blue axis] values [20]) were collected in triplicate across the face of the steak using a Minolta CM2002 (Minolta Canada Inc.). Spectral reflectance readings were also collected at the same time to calculate the relative contents of MetMb, Mb and MbO_2 as describe by Krzywicki [21]. Following objective colour measurements steaks were evaluated for retail appearance, lean colour score, percent surface discolouration, and colour of discolouration.

Thiobarituric acid reactive substance (TBARS) determination

TBAR substances (0 d and 3 d in retail), were determined as previously reported [22].

Statistical Analyses

A comparison of bison to beef for vitamin E homologues, pigment and fatty acids using PROC MIXED least squares means and standard errors were determined. Differences between species (bison and beef) were determined for retail evaluation data on day 0, 1, 2 and 3 using a repeated measures design with PROC MIXED [23]. The fixed effects were species, day and their interaction. The experimental unit was the individual animal within species.

PROC STEPWISE was used [23] to examine the effect of inherent tissue levels of total fat, omega-3 (n-3), omega-6 (n-6), PUFA, n-6:n-3, pigment and vitamin E on the change in MetMb, % discolouration and appearance scores between d 0 and d 3 in retail display. Only significant factors ($P < 0.15$) were included in the overall model R^2 value.

III. RESULTS AND DISCUSSION

Total fat was significantly less in bison than in beef. All the fatty acid indices were different ($P < 0.01$) between beef and bison (Table 1). PUFA levels and long chain n-3 fatty acids (which are more sensitive to oxidation) were higher in bison than beef.

Table 1 Fatty acid (% FA measured), pigment (mg/g meat) and vitamin E (μg/g meat) in *longissimus* of beef steers and intact bison bulls

	Beef	Bison	SEM	*P*
Number of animals	20	14		
Total Fat, %	5.56	1.00	0.39	<0.01
SFA, mg/100mg	44.0	40.6	1.00	<0.01
MUFA, mg/100mg	49.5	38.3	0.97	<0.01
PUFA, mg/100mg	6.43	21.1	1.44	<0.01
n-3, mg/100mg	0.94	6.16	0.32	<0.01
Pigment, mg/g	6.87	8.45	0.53	<0.01
Vitamin E, μg/g	2.2	3.19	0.24	<0.01

Pigment levels in bison were significantly higher ($P < 0.01$) in bison over beef (Table 1). While the primary structure of Mb between bison and beef have been found to be identical [24], the increased levels of pigment found in bison in the

present study combined with high levels of iron found in bison muscle tissue [1] likely contribute to poor colour stability in fresh bison meat.

Vitamin E was significantly higher ($P < 0.01$) in bison than in beef (Table 1). However levels of α-tocotrienols were higher in beef than in bison. Feeding vitamin E to steers has been shown to improve lipid and MbO_2 stability in several muscles [25]. The TBAR measurements did not support the expected improvement in oxidative stability associated with increased Vitamin E.

TBAR values above about 0.5 are considered critical (in beef) since at this level lipid oxidation products which produce a rancid odour and taste, detectable to consumers are present [7]. In the present study both beef and bison had TBARS values (data not shown) which exceeded this critical level by day 3 of retail display (0.54 and 0.73 respectively). There was no significant differences in TBARS values between beef and bison ($P = 0.28$).

MetMb levels in bison were significantly higher than beef on all retail display days confirming the early browning in bison reported previously [3, 4, 5]. The beef MetMb level on day 3 was equivalent to the level in bison on day 0 and by day 3 the levels in the bison were twice that of beef. Over the same time, MbO_2 decreased ($P < 0.01$) slightly in beef (0.78 to 0.71) and substantially in bison (0.70 to 0.55). Hence it appears that the colour stability of bison was already compromised on entry into the retail case after 6 d of ageing.

There was a significant 'species by day in retail' interaction for objective colour measurements, with L^* values increasing ($P = 0.03$) and chroma and hue values ($P < 0.01$) decreasing over time in retail. Even by d 1 bison were showing less desirable retail characteristics. Retail appearance, lean colour score, and percent surface discolouration were significantly different for bison than beef, with bison scoring less favourably on all of these measurements. In all retail display days bison had higher Met Mb and on display days 1, 2, and 3 had higher % of discolouration than the beef steaks (data not shown).

Overall for both beef and bison, the change in MetMb from d 0 to d 3 was most influenced by the inherent n-6:n-3 levels in the tissue ($R^2 = 59.3$) with total fat ($R^2 = 5.40$) and vitamin E ($R^2 = 4.17$) bringing the model R^2 to 68.9 [change MetMb = 0.374 – 0.026vitE + 0.039n-6: n-3 – 0.015total fat] ($P < 0.05$). A decrease in vitamin E and increase in n-3 levels increased the change in % discolouration between d 0 and d 3. As total fat increased, the change in appearance between d 0 and d 3 increased (improved).

These relationships show that the inherent tissue traits of grass finished bison are strongly linked to undesirable changes in fresh meat colour in a retail display environment. Bison had lower fat, lower n-6:n-3 levels, higher vitamin E levels, and higher n-3 levels than beef and consequently showed an increased rate of MetMb production, greater % of discolouration, and less attractive appearance between d 0 and d 3 in retail.

IV. CONCLUSION

Fatty acid composition was significantly different between grass-finished bison and grain-finished beef for all the fatty acids measured. Bison also had higher tissue levels of pigment and vitamin E. The meat traits of bison were linked to poorer performance in the retail environment when compared to beef. Strategies need to be investigated to improve shelf life of bison meat in the retail environment while still maintaining a desirable fatty acid profile from a health conscious consumer's perspective.

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