WESTERN CANADA RETAIL BISON (*BISON BISON*) MEAT FATTY ACID PROFILES

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Abstract – Canadian bison (*Bison bison*) is perceived as a leaner, healthier alternative to conventional beef; however, knowledge on the dietary effects on the fatty acid (FA) profile is limited. Herein, FA profiles of retail bison representing grain-fed (Grain), early and late season pasture-concentrate supplemented (Early-Con and Late-Con, respectively) and grass-fed (Grass) feeding programs were compared. Bison fat content was below 3%, with Early-Con lower than other bison (*P*<0.05). Seasonal growth patterns affecting intramuscular fat synthesis made assessing dietary effects difficult. Proportions of saturated FA were similar, but *cis*-monounsaturated (*c*-MUFA) was greater for Late-Con than Early-Con bison (*P*<0.05). In contrast, polyunsaturated FA proportions were greatest for Early-Con and lowest for Late-Con bison (*P*<0.05). Proportions of omega-6 (n-6) FA were also greater for Early-Con than Late-Con (*P*<0.05); however, omega-3 (n-3) was greater for Early-Con and Grass than Grain and Late-Con bison (*P*<0.001). As such, the n-6/n-3 ratio for Early-Con, Late-Con and Grass bison was ~3:1 compared to >7:1 for Grain bison (*P*<0.001). Early-Con and Late-Con bison had greater proportions of potentially beneficial biohydrogenation intermediates (BI), mainly *trans*11-18:1, and *cis*9, *trans*11-CLA (*P*<0.01). General leanness contributes to the healthfulness of bison; however, desirable BI and lower n-6/n-3 ratio make Early-Con, Late-Con and Grass bison a preferred choice over Grain bison.

I. INTRODUCTION

North American bison (*Bison bison*), once on the brink of extinction, now represent a vibrant, growing alternative livestock industry in Canada. Part of the popularity stems from the perceived wholesomeness of bison meat, free from feed additives, providing a leaner, healthier alternative to conventional feedlot beef whilst having a similar protein, vitamin, and mineral content (1-2). Currently, there is little information regarding the content of beneficial fatty acids in bison produced under Canadian conditions. With today's consumers more conscientious of dietary fats and fatty acids, seeking to lower total fat while increasing polyunsaturated fatty acid (PUFA) intake, bison can be an attractive option. Moreover, for many cultures, lean red meat contributes significantly to daily omega-3 (n-3) long-chain PUFA (LC-PUFA, ≥20 carbon) intake (3). Likewise, ruminant products are also a source of other potentially bioactive fatty acids, such as *t*11-18:1 and *c*9,*t*11-conjugated linoleic acid (CLA) (4). The fatty acid profile of bison, similar to other species, is likely largely related to diet, although sex, season, and age can also be contributing factors (4). US studies comparing feedlot and forage-fed bison suggest high grain diets increased total fat and lowered PUFA, specifically 18:3n-3 content, resulting in an elevated n-6/n-3 ratio compared to grass-fed bison (5-6). Given the short grazing season in Canada, limited seasonal concentrate supplementation while on pasture may be more suited to Canadian conditions. The challenge for Canadian bison producers is to find the optimal forage-to-grain ratio to promote greater content of beneficial fatty acids. Herein, bison fatty acid profiles of *longissumus dorsi*, representing grain-fed and grass-fed production systems, were compared to pasture + concentrate systems with early and late seasonal harvest periods.

II. MATERIALS AND METHODS

Retail samples

Bison ribeye steaks (*longissumus dorsi*) from grass and grain finishing programs were purchased at retail, sold under various farm labels. Determination of bison diets was attempted by contacting producers directly. In general, grain-fed bison (Grain, n = 19) were fed oats in drylot pens with access to conserved hay, whereas grass-fed bison (Grass, n = 19) were grazed on fresh native pasture. Age and sex of the animals were not available. Targeted seasonal feeding effects using a combination of fresh forage and concentrate prior to slaughter were also investigated as means of enhancing the bioactive fatty acid content. Samples were collected from a single producer representing two groups. Early-Con (n = 59) grazed pasture and supplemented with 3.7 kg/head/day oats plus 0.5 kg of a commercial pea screening pellet containing 15% dry matter crude protein, from May until July. Late-Con (n = 53) bison grazed pasture from May until slaughter and were fed the same supplement from July until slaughter. Collected samples were stored at -80 °C until lipid extraction.

Fatty acid analysis

Total lipids were extracted from bison samples using a modified Folch extraction (7) and methylated using sodium methoxide and methanolic HCl. Analysis of fatty acid methyl esters by gas chromatography was performed using conditions described by Prema *et al*. (8). Peak identification was determined from commercial reference standards (Nu-Chek Prep. Inc. MN, USA).

Statistical analysis

The data was analyzed as a one-way ANOVA using the PROC MIXED of SAS v9.2 (Statistical Analysis System, NC, USA). Farm was used as a random factor. Sex and slaughter date were not known and subsequently excluded from the model. Significance was set at $P<0.05$, with means and standard error of the means reported.

III. RESULTS AND DISCUSSION

Total fat content of bison *longissumus dorsi* was below 30 mg/g muscle for all groups; however, Early-Con was lower than the other groups ($P<0.05$, Table 1). The fat content of bison finished under presently described feeding programs are within the range of grass- and feedlot-fed bison reported earlier from Canadian and US studies (1; 5-6). The lower lipid content of the Early-Con bison was likely a consequence of compensatory gain in spring and reduced intramuscular fat deposition. Bison, like other wild species, tend to reduce their metabolic rate in winter, undergoing rapid growth in spring and summer corresponding to more plentiful vegetation, and building body reserves in fall for winter survival (9).

The proportion of PUFA was greater for Early-Con bison than Late-Con bison, whereas Grain and Grass bison were intermediate ($P<0.01$, Table 1). Interpreting dietary effects on the proportions of the individual PUFA were complicated owing to the influence of the relative fat content from the different bison programs. As such, the 18:2n-6 proportion was greatest for Early-Con bison followed by Grain, then Grass and lowest for Late-Con bison ($P<0.05$). The proportion of 20:4n-6 was not affected by feeding program. In perspective, the total n-6 content (mg/100 g muscle) did not differ between bison programs. Diet was more influential on the proportion of 18:3n-3, which was greater for the Early-Con and Grass bison than the Late-Con and Grain bison ($P<0.01$). This was also reflected in the long-chain PUFA (LC-PUFA) metabolites, with 20:5n-3, 22:5n-3 and 22:6n-3 proportions greater for Early-Con and Grass bison than Grain and Late-Con bison ($P<0.01$). In absolute amounts, Grass bison had the greatest n-3 content, intermediate for Early-Con and Late-Con, and lowest for Grain bison, at 90, 69, and 38 mg/100 g muscle, respectively ($P<0.01$). Differences in n-3 content highlights the impact feeding programs can have towards increasing daily intake of n-3 PUFA. Furthermore, the n-6/n-3 ratio of Grass, Early-Con, and Late-Con bison were all near the recommended 3:1, whereas Grain bison exceeded 7:1. Recent studies have shown that regular human consumption of red meat with an n-6/n-3 ratio below 4:1 increases circulating n-3 LC-PUFA, a factor which may contribute towards reducing the risk of cardiovascular disease and pro-inflammatory responses (10). Equivalent results would be anticipated following habitual bison consumption with a similar n-6/n-3 ratio.

Ruminal microbial biohydrogenation of dietary unsaturated fatty acids produce a number of intermediates, predominantly as *trans*-MUFA (*t*-MUFA). Interestingly, Early-Con and Late-Con bison had greater proportions of *t*-MUFA than Grain or Grass bison ($P<0.01$, Table 1). The combination of the pea screening supplement enhancing PUFA intake as well as reducing rumen retention time probably contributed to the greater proportion of *t*-MUFA of Early-Con and Late-Con bison. For all bison groups, *t*11-18:1 was the predominant *t*-MUFA, with Early-Con and Late-Con bison having a greater proportion compared to Grain or Grass bison (P<0.01). Diet can affect the relative proportion of the individual *t*-MUFA, as indicated by the *t*11-/*t*10-18:1 ratio, which was highest for Grass, intermediate for Early-Con and Late-Con and lowest for Grain bison (P<0.01). Diets rich in rapidly fermentable starches can affect microbial populations which result in an undesirable shift in biohydrogenation pathways towards *t*10-18:1 rather than *t*11-18:1 (7). Feeding programs that enhance the proportion of *t*11-18:1 are desirable as further desaturation via stearoyl-CoA desaturase (SCD) accounts for the majority of *c*9,*t*11-CLA in muscle. As such, Early-Con and Late-Con bison had greater contents of *c*9,*t*11-CLA than Grain or Grass bison (P<0.01). Greater proportions of *t*11-18:1 and *c*9,*t*11-CLA in meat may have potential desirable health effects as both have demonstrated positive bioactivity in animal models (4; 7).

The proportion of *cis*-monounsaturated fatty acid (*c*-MUFA) was greater for Late-Con than Early-Con bison, whereas Grain and Grass bison were intermediate (P<0.05). As the predominant *c*-MUFA isomer, *c*9-18:1 was proportionally greater for the Late-Con than Early-Con and Grass bison, while Grain bison was intermediate (P<0.05). In beef, greater SCD expression and desaturation of 18:0 to *c*9-18:1 corresponds with increased intramuscular fat deposition (i.e. marbling). Dietary factors such as lower energy or greater PUFA intake typical of forage-based diets can decrease SCD expression. Similar effects are expected for bison, with relative fat content and forage feeding contributing to the lower *c*-MUFA content of Early-Con and Grass bison, respectively. It is unclear if the greater *c*9-18:1/MUFA content of the Late-Con bison was related solely to total fat content.

The proportion of SFA did not differ between bison programs in spite of minor differences in total fat content (Table 1). With similar SFA proportions, the PUFA/SFA ratio reflected differences in PUFA, with Early-Con greater than Late-Con, whereas Grain and Grass were intermediate (P<0.01). As an indirect indicator for reducing cardiovascular disease risk, the desired PUFA/SFA ratio ≥0.4 was achieved by the Early-Con and Grass bison. In conjunction, compared to conventional beef, regular consumption of leaner bison has been demonstrated to have more positive effects on

Table 1 Influence of bison finishing program on the fatty acid profile (% FAME) of m. *longissumus dorsi.*

	Grain	Early-Con	Late-Con	Grass	s.e.m.	*P* value
Lipid (mg/g tissue)	25.6^{a}	15.7^{b}	28.0^{a}	23.0^{a}	2.55	<0.05
PUFA	13.1^{bc}	17.7^{a}	9.5^{c}	14.7^{ab}	1.5	<0.01
18:2n-6	7.8^{ab}	9.3^{a}	4.8^{c}	7.2^{bc}	0.8	<0.01
20:4n-6	2.69	3.23	1.76	2.91	0.43	
18:3n-3	0.68^{b}	1.69^{a}	1.10^{b}	1.67^{a}	0.13	<0.01
20:5n-3	0.31^{b}	0.90^{a}	0.44^{b}	0.83^{a}	0.08	<0.01
22:5n-3	0.59^{b}	1.48^{a}	0.74^{b}	1.36^{a}	0.12	<0.001
22:6n-3	0.17^{b}	0.41^{a}	0.24^{b}	0.30^{ab}	0.04	<0.05
n-6/n-3	7.4^{a}	3.1^{b}	2.8^{b}	2.7^{b}	0.2	<0.001
trans-MUFA	1.58^{b}	2.84^{a}	2.63^{a}	1.77^{b}	0.21	<0.01
*t*11-18:1	0.74^{b}	1.57^{a}	1.51^{a}	1.00^{b}	0.16	<0.01
*t*11-/*t*10-18:1	4.9^{c}	6.8^{b}	7.1^{b}	9.2^{a}	0.03	<0.01
*c*9,*t*11-CLA	0.19^{b}	0.36^{a}	0.40^{a}	0.25^{b}	0.04	<0.01
cis-MUFA	43.4^{ab}	38.1^{b}	46.3^{a}	40.7^{ab}	1.94	<0.05
*c*9-18:1	38.6^{ab}	33.7^{b}	41.6^{a}	36.1^{b}	1.75	<0.05
SFA	39.9	38.7	39.3	40.4	0.93	
16:0	18.7^{ab}	17.9^{b}	20.0^{a}	19.1^{ab}	0.45	<0.05
18:0	18.1	18.3	16.4	18.2	1.06	
PUFA/SFA	0.3^{bc}	0.5^{a}	0.2^{c}	0.4^{b}	0.03	<0.01

s.e.m.: standard error of the mean; significance (P<0.05) indicated by letters a-c.
PUFA = n-6 + n-3; n-6 = 18:2n-6 + 18:3n-6 + 20:3n-6 + 20:4n-6; n-3 = 18:3n-3 + 20:3n-3 + 20:5n-3 + 22:5n-3 + 22:6n-3; *trans*-MUFA = *t*9-18:1 + *t*10-18:1 + *t*11-18:1 + *t*12-18:1 + *t*13/*t*14-18:1 + *t*16-18:1; *c*9,*t*11-CLA = *t*7,*c*9- + *c*9,*t*11- + *t*8,*c*12-

CLA; *cis*-MUFA = *c*9-14:1 + *c*9-16:1 + *c*9-18:1 + *c*11-18:1 + *c*13-18:1 + *c*9-20:1; SFA = 14:0 + 16:0 + 18:0 + 20:0.

blood triglyceride and inflammatory marker levels, reducing atherogenic risk (11). Among individual SFA, 16:0 and 18:0 were present in roughly equal proportions, accounting for 90% of the SFA. The proportion of 16:0 was greater for Late-Con bison than the Early-Con bison, whereas Grain and Grass bison were intermediate (P<0.05). Lower endogenous FA synthesis relating to rapid lean growth in spring and summer in combination with grazing duration likely contributed to the lower 16:0 of Early-Con compared to Late-Con bison. The proportion of 18:0 did not differ between bison groups.

IV. CONCLUSION

Available retail bison was lean, containing less than 3% fat. Grass bison had the greatest n-3 content; however, the equivalent ~3:1 n-6/n-3 ratio of Early-Con, Late-Con and Grass bison was more desirable than the >7:1 of Grain bison. Additionally, seasonal supplementation of Early-Con and Late-Con bison increased proportions of potentially healthful *t*11-18:1 and *c*9,*t*11-CLA. Seasonal pasture supplementation may be a useful management option to enhance the healthfulness of bison during short Canadian grazing periods, without resorting to grain-based diets.

ACKNOWLEDGEMENTS

The authors would like to thank the British Columbia Bison Association and Canadian Rocky Mountain Ranch of Calgary, Alberta for their generous donation of meat samples. The Canada-British Columbia Ranching Task Force Initiative provided the funding that made this study possible.

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