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Nutrient Composition of Grass- and Grain-Finished Bison

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NUTRIENT COMPOSITION OF GRASS- AND GRAIN-FINISHED BISON[1,2]

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ABSTRACT—The North American buffalo (*Bison bison*) has survived near extinction to become a commodity (meat, hides, and hair) in a consumer-driven market. Since this is a growth industry, primarily young bulls are slaughtered for meat, while most females are used to build the herd. Bison meat is highly palatable, and previous research showed that grain-finished bison meat is low in fat and high in protein. However, bison may be grain- or grass-finished. In this study we found few differences in nutrient content of the meat between grain- or grass-finished bison. Grass-finished animals had a little more moisture (75.9 vs. 74.6 %) and less fat (1.7 vs. 2.2%). The largest difference was in fatty acid profiles (expressed as percentages of total fat), with grass-finished bison containing on average 5% more saturated fatty acids, 6% more polyunsaturated fatty acids, and 11% less monosaturated fatty acids than meat from grain-finished bison. Bison meat is low in sodium. It is also an excellent source of phosphorus, zinc, selenium, and vitamin B_{12}, as well as, iron, niacin, vitamin B_6, and other minerals and vitamins. In summary, bison meat is a low-fat, low-sodium, nutrient-dense food, making it a nutritious food, whether it is grain- or grass-finished.

KEY WORDS: bison, grasslands, nutrition

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Introduction

The North American buffalo (*Bison bison*) once freely roamed the grasslands but was hunted nearly to extinction by 1885. A few animals were kept on ranches and in parks as symbols of the past. In recent years bison numbers have been increasing rapidly. The females are being used now for replacement stock, while the young bulls are being slaughtered for meat. There are approximately 300,000 head of bison in North America today (Albrecht, personal communication 2000).

Historically, bison meat has provided an important source of meat for many North American societies (Isenberg 2000). Currently agricultural researchers seek evidence of nutritional qualities in order to understand how well bison meat actually contributes nutrients essential for human life. The objective of our study was to determine the protein, fat, mineral, and vitamin content of meat from bison raised and finished on grass. Then we compared these results to data on grain-finished bison obtained in an earlier study (Marchello et al. 1998).

Methods

No previous research has been published in which the nutrient content of meat from grass- and grain-finished bison were compared. In this study we used cuts of meat from animals from a number of Great Plains herds and feeding regimes in order to approximate the typical consumer's access to bison meat. Specifically we examined cuts of bison meat from 31 grass-finished animals. Four individual cuts were taken: the ribeye (longissimus thoracis muscle), top sirloin (gluteus medius muscle), top round (semimembranosus muscle), and shoulder clod (triceps brachii muscle), representing the four major areas of a carcass. The 31 bison represented various geographic areas of the United States: one bull coming from Colorado, eight from Kansas, five from Nebraska, two from North Dakota, five from South Dakota, three from Texas, and seven from Wisconsin. Because of the diversity of grasses from these regions, we believe that the meat from these bulls is representative of the meat from grass-finished bison that is available for consumers to purchase. All animals were males, approximately 30 months old. Frozen meat samples (approximately 1 kg per cut) were shipped to North Dakota State University. All subcutaneous fat was removed prior to lyophilization (freeze-drying) and homogenization. Freeze-dried samples were homogenized with a household blender. Samples were stored at -20°C for later chemical analysis.

Dry matter, protein, gross energy (total calories), ash (which represents total mineral content), crude fat, fatty acids, cholesterol, potassium, sodium, phosphorus, calcium, copper, iron, magnesium, zinc, manganese, and selenium content of the samples were determined. Dry matter, protein, gross energy, ash, vitamin A, and vitamin C were determined using methods of the Association of Official Analytical Chemists (1995). Crude fats, referred to hereafter as fats, were determined gravimetrically using the method of Folch et al. (1957). The colorimetric method of Stadtman (1957) was used in measuring cholesterol. Fatty acids were determined by the procedure of Ulberth and Henniger (1995). Concentrations of potassium, sodium, phosphorus, calcium, copper, iron, magnesium, zinc, and manganese were measured by atomic emission spectrometry (Dahlquist and Knoll 1978). Selenium was determined by hydride-generator atomic absorption (Finley et al. 1996). Further details of chemical analyses made by our research groups are published elsewhere (Marchello et al. 1998).

ANOVA and Tukey's multiple range test were used to determine statistical significance of difference in nutrient concentrations in grass-fed beef among the four muscles analyzed (Sokal and Rohlf 1995). Differences in nutrient concentrations among muscles were considered significant at $P < 0.05$. The data were summarized as means and standard errors of the mean (SEM).

The nutritional content of the same four cuts from 100 grain-finished bison from various geographic areas of the United States (nine states) and Canada (three provinces) has been published (Marchello et al. 1998; Driskell et al. 1997). The same analytical methods were used in that study to determine the nutrient content of the meat cuts. According to the producers, the animals in the current study had been pasture raised and grass fed throughout, but in the previous study the producers supplied information as to the length of time that the animals had been grain-finished (minimum of 180 days). In both studies, the animals were slaughtered at an inspected processing facility.

Since few differences were observed in the nutrient content among the four cuts from grass-finished bulls, the content values by cut were averaged; the same was true for the grain-finished animals. The mean nutrient content values for the four cuts combined of the 31 grass-finished animals (slaughtered at approximately 30 months of age) in the current study were compared to those of the 100 grain-finished animals (slaughtered at approximately 25 months of age). Statistical comparisons beyond means were not done because the sample sizes and the ages that the animals were slaughtered were different for the grass- and grain-finished bulls. Because little published data on the nutrient content of bison meat are available (with the exception of Marchello et al. 1989; Koch et al. 1995), the mean nutrient content values of bison meat from our previous and current studies are compared. Information on the methods for finishing animals was not given in one of the studies (Marchello et al. 1989), and castrated dehorned bulls were used in the other study (Koch et al. 1995).

Results

For grass-finished bison, no differences were observed in protein, moisture, fat, and food energy content among the four cuts from the 31 grass-finished bison (Table 1). However, the top round cut contained only 1.3% fat, while the other muscles contained 1.8-1.9%. Also, the cholesterol content varied significantly from 57 mg/100 g in the ribeye, to 64.2-70.0 mg/100g in the other cuts (Table 1).

Statistical differences in fatty acid content among the four cuts from grass-finished bison were few (Table 2). The ratio of palmitic to stearic acid was 1 to 1.2. The ribeye cut contained a significantly smaller percentage of polyunsaturated fatty acids than did the top round cut ($P < 0.05$), but the sirloin or clod cuts did not. Of the total fats in all four cuts combined, 47% were saturated fats, 35% were monounsaturated, and 17% were polyunsaturated fats. The ribeye muscle had the greatest percentage of saturated fats (48.5%) and monounsaturated fats (36.3%) and had the lowest percentage of polyunsaturated fats (15.3%) compared to the other muscles studied.

Significant differences among the cuts of the grass-finished bison were observed for magnesium, phosphorus, zinc, and sodium ($P < 0.05$) (Table 3). However, these statistical differences were small and unlikely to be of nutritional importance when one compares nutrient content values to nutrient intake recommendations for humans (National Research Council 1989b). The vitamin A content of the ribeye muscle (0.5 ± 0.01 μg retinol equivalents/100 g) and the clod muscle (0.5 ± 0.02 μg retinol equivalents/100 g) were significantly lower than that of the sirloin (0.7 ± 0.02 μg retinol equivalents/100 g) and top round (0.7 ± 0.02 μg retinol equivalents/100 g)($P < 0.05$) muscles. The vitamin C composition of cuts was below detectable limits.

The meat from grass- and grain-finished animals had nearly identical profiles for protein (21.5% vs. 21.7%, respectively), ash (1.2% vs. 1.2%), and cholesterol (65 vs. 66 mg/100 g); however, small differences were observed for moisture (75.9% vs. 74.6%), fat (1.7% vs. 2.2%), and food energy (133 vs. 141 kcal/100 g). The fatty acid profiles of meat from grass-

TABLE 1

NUTRIENT COMPOSITION OF RAW SEPARABLE LEAN FROM GRASS-FINISHED BISON

Nutrient	Ribeye	Top sirloin	Top round	Clod
Protein (%)	21.5 (0.20)	21.6 (0.25)	21.6 (0.26)	21.3 (0.16)
Moisture (%)	76.0 (0.22)	75.5 (0.28)	75.9 (0.28)	76.1 (0.28)
Fat (%)	1.9 (0.26)	1.9 (0.18)	1.3 (0.12)	1.8 (0.21)
Ash (%)	1.14[b] (0.01)	1.18[a] (0.02)	1.17[a,b] (0.01)	1.16[a,b] (0.01)
Cholesterol (mg/100 g)	57.5[b] (1.4)	70.0[a] (1.9)	64.2[a] (2.0)	66.7[a] (1.6)
Food energy (kcal/100 g)	131.9 (1.8)	135.9 (1.9)	131.8 (1.8)	131.1 (1.3)

Notes: N = 31. Standard error of the mean is given in parentheses.
[a,b]Means within a row followed by different letters differ significantly ($P < 0.05$) (Tukey test).

vs. grain-finished bison (Fig. 1) showed considerable differences in fatty acids expressed as a percentage of total fats. Meat from grass-finished bison averaged approximately 5% more saturated fatty acids, 6% more polyunsaturated fatty acids, and 11% less monounsaturated fatty acids than did meat from grain-finished bison. These differences in fatty acid profiles were primarily due to differences in stearic, oleic, linoleic, and linolenic acids (Fig. 1).

Although there were slight differences in actual numerical values, differences in the mineral content of meat from grass- and grain-finished bulls were minimal (Table 4). The exception was selenium content, which was four times greater in grass-finished than grain-finished bison meat. The mean vitamin A content of meat from grass-finished animals was 0.5 μg retinol equivalents/100 g, while that from grain-finished animals was 0.8 μg

TABLE 2

FATTY ACID COMPOSITION OF RAW SEPARABLE LEAN FROM GRASS-FINISHED BISON

	Percentage			
Fatty acid	Ribeye	Top sirloin	Top round	Clod
Myristic	0.3	0.2	0.2	0.3
(14.0)	(0.10)	(0.09)	(0.08)	(0.09)
Myristoleic	------	------	------	0.02
(14.1)				(0.02)
Pentadecanoic	1.7	1.6	2.1	1.9
(15.0)	(0.43)	(0.42)	(0.55)	(0.48)
Palmitic	17.2[a]	16.3[a,b]	16.2[a,b]	15.4[b]
(16.0)	(0.3)	(0.4)	(0.4)	(0.4)
Palmitoleic	1.1	1.4	1.2	1.5
(16.1)	(0.19)	(0.18)	(0.21)	(0.17)
Margaric	1.9	2.0	1.8	2.0
(17.0)	(0.39)	(0.36)	(0.39)	(0.38)
Stearic	21.6[a]	20.9[a,b]	19.5[b]	20.1[a,b]
(18.0)	(0.5)	(0.4)	(0.4)	(0.5)
Oleic	35.1	34.3	32.9	33.7
(18.1)	(1.2)	(1.1)	(1.0)	(1.2)
Linoleic	12.3	13.4	14.8	14.5
(18.2)	(0.9)	(0.6)	(0.7)	(0.7)
Linolenic	2.9	3.4	3.7	3.7
(18.3)	(0.26)	(0.25)	(0.25)	(0.28)
Eicosenoic	0.1	0.0	0.3	-----
(20.1)	(0.04)	(0.02)	(0.16)	
Behenic	5.9	6.5	7.4	6.8
(22.0)	(0.65)	(0.47)	(0.49)	(0.45)
Saturated	48.5	47.5	47.2	46.6
	(0.8)	(0.8)	(0.7)	(0.7)
Monounsaturated	36.3	35.7	34.3	35.2
	(1.4)	(1.3)	(1.2)	(1.3)
Polyunsaturated	15.3[b]	16.8[a,b]	18.5[a]	18.2[a,b]
	(1.0)	(0.8)	(0.8)	(0.9)

Notes: N = 31, but some individual fatty acids were not detected in some animals. Standard error of the mean is given in parentheses.
[a,b] Means within a row followed by different letters differ significantly ($P < 0.05$) (Tukey test).

TABLE 3

MINERAL CONTENT OF RAW SEPARABLE LEAN FROM GRASS-FINISHED BISON

Minerals	Wet Weight (mg/100) except where noted			
	Ribeye	Top Sirloin	Top Round	Clod
Calcium	4.7 (0.4)	7.4 (1.9)	5.3 (0.9)	4.6 (0.5)
Copper (μg/100 g)	140 (18)	183 (15)	145 (11)	172 (11)
Iron	2.7 (0.17)	3.0 (0.09)	2.7 (0.10)	3.0 (0.09)
Magnesium	24.3[b] (0.6)	27.0[a] (0.4)	26.5[a] (0.6)	25.6[a,b] (0.6)
Manganese (μg/100 g)	11.1 (3.5)	11.41 (0.6)	9.91 (0.6)	13.5 (1.6)
Phosphorous	171[b] (4)	189[a] (2)	185[a] (4)	178[a,b] (3)
Zinc	3.0[a,b] (0.10)	3.3[b] (0.09)	2.8[c] (0.12)	4.3[a] (0.10)
Sodium	44.9[a,b] (1.4)	46.6[a] (1.5)	39.7[b] (1.4)	47.7[a] (1.4)
Potassium	292 (15)	312 (17)	313 (16)	301 (14)
Selenium (μg/100 g)	101.5 (23.8)	105.4 (23.6)	104.9 (25.1)	109.3 (25.3)

Notes: N = 30 for all minerals except n = 20 for selenium. Standard error of the mean is given in parentheses.

[a,b,c] Means within a row followed by different letters differ significantly ($P < .05$) (Tukey test).

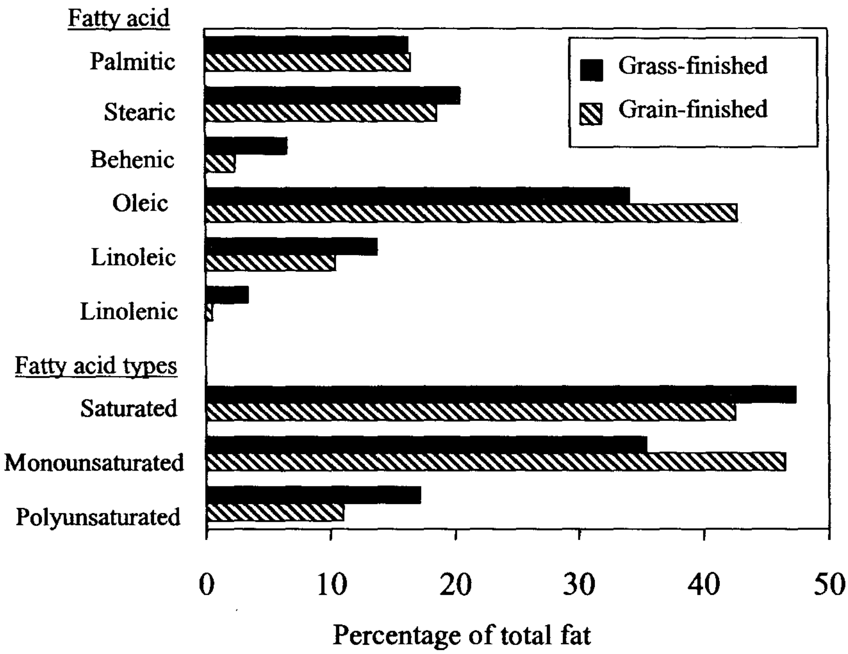

Figure 1. Comparison of Fatty Acid Profile of Raw Separable Lean from Grass- vs. Grain-Finished Bison. The following saturated fatty acids were present in quantities too low to be included (values are percentages in grass-fed vs. grain-fed animals): myristic, 0.3 vs. 1.1; myristoleic, 0.01 vs. 0.07; pentadecanoic, 1.8 vs. 0.3; palmitoleic, 1.3 vs. 2.4; margaric, 1.9 vs. 1.2; and erucic, nondetectable vs. 1.1. Percentage of total fat refers to the mean fatty acid composition. The mean total fat content of meat from grass- and grain-finished bison are 1.7% and 2.2% (or g/100 g), respectively.

retinol equivalents/100 g. However, both quantities of vitamin A are too low to be of importance nutritionally in meeting human needs (National Research Council 1989b). The vitamin C content of meat from both grass- and grain-finished animals was below detectable limits.

Discussion

Nutrients in Bison Meat

This paper is the first to report the nutrient content of meat cuts from bison bulls, raised and finished on grass. We observed that meat from grass-

TABLE 4

COMPARISON OF THE MINERAL CONTENT OF RAW SEPARABLE LEAN FROM GRASS- VS. GRAIN- FINISHED BISON

	Wet weight (mg/100 g) except where noted	
Mineral	Grass	Grain
Calcium	5.5	4.9
Copper (μg/100 g)	160.0	142.0
Iron	2.8	2.9
Magnesium	25.8	24.2
Manganese (μg/100 g)	11.5	13.4
Phosphorus	181.0	198.0
Zinc	3.3	3.8
Sodium	44.7	52.2
Potassium	305.0	336.0
Selenium (μg/100 g)	105.3	25.5

finished animals had slightly more moisture (75.9% vs. 74.6%) and less fat (1.7% vs. 2.2%) than that from grain-finished animals. Koch et al. (1995) studied the meat qualities of castrated and dehorned bison and compared them to beef, even though this is not the typical means of handling bison for slaughter. However, our results, which reflect typical bison raising and feeding methods (Hawley 1989; Anderson et al. 1997; Anderson and Miller 1999), varied only slightly from that of Koch et al. (1995), who reported finding 2.9% fat in the ribeye muscle compared to the 1.9% in our study).

The fatty acid composition of meat from grain-finished bison (Fig. 1) was similar to that reported previously for the ribeye cut from bison (Marchello et al. 1989), although that study presented no information on how the animals were finished. However, amounts of some of the fatty acids differed in meat from grass- and grain-finished animals (Fig. 1). The fat and fatty acid profile of beef has been shown to be associated with the flavor and palatability characteristics (Melton 1990). The fats in meat are known to be responsible for much of the aroma of meat cooking (Bennion 1995).

We found the mineral content of meat from grass- and grain-finished bison to be similar, except that the selenium content was four times greater in meat from grass-finished animals (105.3 μg/100g) (vs. 25.5) (Table 4). Selenium content of cattle is known to vary with the amount of selenium in the feed source and supplements. Medeiros et al. (1993) reported that the selenium content of free-roaming bison was 30 to 70 μg/100 g, depending on the muscle and the sex of the animal. The average for free-roaming bison was 49 μg/100 g, compared to 10 μg/100 g for grain-finished beef. The current US Department of Agriculture nutrient database (1999) indicated that the average selenium content of lean tissues from all grades of beef is 18.3 μg/100 g.

Several studies (Allaway et al. 1966; Paulson et al. 1968; Hoffman et al. 1972; Hintze 1999) indicate that the selenium content of meat from beef cattle and lamb are related to the selenium content of the soil where they are raised. We expect that this is also true for bison. For example, beef calves raised in Brandon, Manitoba, Canada (a high seleniferous area) had muscle-tissue selenium concentrations of 134 μg/100 g, whereas those raised in Ontario (a low seleniferous area) contained only 7 μg/100 g (Hoffman et al. 1972). Furthermore, the muscle-tissue selenium content of lambs raised in Laramie, WY (a high seleniferous area) averaged 156 μg/100 g (Paulson et al 1968), while that of lambs raised in Corvallis, OR, contained only 4 μg/100 g (Allaway et al. 1966). More recently, Hintze (1999) found that the selenium concentration in grass-fed beef cows from different regions in North Dakota varied from 19 to 111 μg/100 g of tissue. In this case, the greatest source of variation in selenium content of beef muscle tissue was related to the geographic region in which the animals were raised.

Other studies indicate vitamin contents are similar among cuts of grain-finished bison. Driskell et al. (1997) reported the content of selected vitamins found in four cuts (ribeye, top sirloin, top round, and clod) of 12 grain-finished bison bulls. The vitamin content of meat from another 12 grain-finished bulls was also determined (Driskell, unpublished data). These 24 bulls were representative of bison raised for meat in the United States and Canada, since they were randomly selected from the 100 grain-finished bulls in our larger study (Marchello et al. 1998). Two of the bulls were from

California, one from Colorado, one from Delaware, one from Kansas, one from Michigan, five from North Dakota, six from South Dakota, one from Wyoming, one from Alberta, one from British Columbia, and three from Manitoba. The vitamin concentrations for the four cuts, per 100 g, were 0.043 mg thiamin, 0.240 mg vitamin B_6, 2.565 μg vitamin B_{12}, and 0.048 mg -tocopherol equivalents of vitamin E. The mean riboflavin and niacin content of the four cuts from the same 24 grain-finished bulls was 0.94 and 1.910 mg/100 g, respectively (Driskell et al. 2000).

The nutrient content data presented here are based on raw meats (four lean cuts). However, consumers and food service staff cook meat differently and sometimes improperly. This cooking can affect the nutrient content of meat. For example, the concentrations of potassium, phosphorus, sodium, calcium, copper, iron, magnesium, and zinc in ribeye increased following broiling because of the loss of moisture in the meat during cooking (Marchello et al. 1989). However, only 59% of the thiamin, 68% of the vitamin B_6, 67% of the vitamin B_{12}, and 76% of the vitamin E were retained following either broiling or grilling of bison patties to an internal temperature of 71°C (Yuan et al. 1999). Vitamins are much more labile to cooking procedures than are minerals (US Department of Agriculture 1998). The patties used in the study by Yuan et al. (1999) came from bulls from four producers, and animals from one of those producers were grass finished. The vitamin content of the patties from the producer who grass-finished was similar to that from the three producers who grain-finished their animals (Yuan et al. 1999); however, mean values for vitamin B_6 and vitamin$_{12}$ were lowest for the grass-finished animals.

Consumers prefer food that tastes good. We broiled or grilled patties obtained frozen from the North American Bison Cooperative, which slaughters about half the grain-finished bison (all) used for meat in the United States and Canada (Sexhus 2000). A trained sensory panel indicated that both broiled and grilled bison patties from these grain-finished animals had the desirable sensory characteristics, of surface color, interior color, juiciness, tenderness, aromatic intensity, and flavor intensity (McClenahan et al. 2001).

Possible Health Benefits of Consuming Bison Meat

Although the whole diet is important for health, the consumption of foods containing certain nutrients can be more beneficial to one's health than those containing other nutrients. If we assume that the data from the four lean cuts we studied are typical of the meat from all bison used in meat production, we can compare the nutrient content of bison meat to nutrient labeling regulations of the Food and Drug Administration and to dietary recommendations (National Research Council 1989b).

Bison meat, whether from grass- or grain-finished animals, is low in fat (1.7%-2.2%). Food and Drug Administration (1992b) regulations label a serving of food (100 g in the case of bison meat) that contains less than 5 g fat (5%) as low in fat. Since the bison meat is so low in total fat, it is not unexpected that it is also low in saturated fat. It contains less than 1 g saturated fat, and less than 15% of its calories per serving come from saturated fat (Food and Drug Administration 1992b). Also, bison meat from both grass- and grain-finished animals may be called lean, since it contains less than 95 mg cholesterol per serving (Food and Drug Administration 1992b). Consumption of a diet high in fat, especially one high in saturated fat, has been associated with an increased incidence of certain chronic diseases in humans such as atherosclerotic cardiovascular diseases and several cancers (National Research Council 1989a). Consumption of a diet high in fat, as well as high in saturated fat has been associated with increased incidence of obesity and its health complications (National Research Council 1989a). This report recommended that humans' total fat intake be less than 30% of calories, that saturated fat intake be less than 10% of calories, and that cholesterol intake be less than 300 mg daily. The newly updated "Dietary Guidelines for Americans" indicates that one should "choose a diet that is low in saturated fat and cholesterol and moderate in total fat" (US Departments of Agriculture and of Health and Human Services 2000).

Oleic acid, a monounsaturated fatty acid, has been shown to produce cholesterol responses similar to carbohydrates in humans and, thus, responses of other fatty acids are compared to that of oleic acid (Grundy 1996). The meat from grain-finished bison had a higher mean concentration of oleic acid than that from grass-finished animals (Fig. 1). Saturated fatty acids (those containing no double bonds in their chemical structure) appear to be the most atherogenic group of fatty acids; however, not all saturated fatty acids have the same effects on serum cholesterol levels of humans (Grundy 1996). The consumption of palmitic acid increases levels of low-density lipoprotein, or LDL, cholesterol (the so-called "bad" cholesterol) and modestly increases levels of high-density lipoprotein, or HDL, cholesterol (the so-called "good" cholesterol) in some, but not all, people (Grundy 1996). The mean palmitic acid concentrations in meat from grass- and grain-finished bison were similar. Myristic acid, known to be a cholesterol-raising fatty acid (Zock et al. 1994), was present in very low amounts in meat from grass- and grain-finished bison (Fig. 1). Stearic acid has been shown not to be a cholesterol-raising fatty acid (Kris-Etherton et al. 1993), and mean stearic acid concentrations in meat from the grass- and grain-finished bison were approximately the same (Fig. 1).

The American Heart Association (1999) recommended that healthy Americans' intake of saturated fatty acids should be 8%-10% of calories, polyunsaturated fatty acids should be up to 10% of calories, and monounsaturated fatty acids should be up to 15% of calories. These recommendations are for total dietary intake, not just that of a specific food; however, fats in specific foods do contribute to fats in the total diet. The bison meat, whether from grass- or grain-finished animals, contains larger percentages of saturated and monounsaturated fatty acids than polyunsaturated fatty acids. Bison meat does contain a saturated: monounsaturated: polyunsaturated fatty acid mix, thus making contributions to the recommended proportions of these fatty acids in the total diet. There is some evidence, though not conclusive, that the consumption of diets rich in monounsaturated and polyunsaturated fatty acids may be beneficial with regard to serum cholesterol levels (National Research Council 1989a).

Bison meat contains the essential fatty acids linoleic acid (an omega-6 polyunsaturated fatty acid) and linolenic acid (an omega-3 polyunsaturated fatty acid); these fatty acids are called omega-6 and omega-3 because of the location of a double bond in their chemical structure. The Committee on Diet and Health (National Research Council 1989a) recommended that the average populations intake of omega-6 polyunsaturated fatty acids remain around 7% of calories. The consumption of 100 g lean bison meat, from either grass- or grain-finished animals, contains enough omega-6 polyunsaturated fatty acids to supply about 2 calories (or 1% of calories in a 2000-calorie diet).

For many years linoleic acid was known as a cholesterol-lowering fatty acid; however, more recent research indicates that its effect on cholesterol concentration is little or no different from that of oleic acid, particularly with respect to LDL cholesterol (Mattson and Grundy 1985; Mensink and Katan 1992). So, if a difference in cholesterol response exists, it is relatively small. However, in some individuals dietary linoleic acid may slightly reduce LDL-cholesterol levels (Mensink and Katan 1992). The parent omega-3 polyunsaturated fatty acid is linolenic acid. The omega-3 polyunsaturated fatty acids do not seem to have any effects on the metabolism of either LDL- or HDL-cholesterol (Grundy 1996). Currently, nutrition experts are divided over whether unsaturated fatty acids in the diet should be reduced in favor of dietary carbohydrates. Higher unsaturated fatty acid intakes may promote obesity, while higher carbohydrate intakes may reduce HDL-cholesterol levels (Grundy 1996).

Bison meat from both grass- and grain-finished animals (Table 4) is low in sodium, as it contains less than 140 mg of sodium per serving (Food and Drug Administration 1992b). The Committee on Diet and Health (National Research Council 1989a) recommended that American adults and children limit their daily intake of salt to 6 g or less, which is equivalent to 2400 mg of sodium. Most Americans consume more sodium than is recommended. A recent survey of men and women 20 years and over found that the mean daily sodium were 4,074 and 2,752 mg respectively (US Department of Agriculture 1997). Sodium has been classified as a current public health issue (Federation of American Societies for Experimental Biology 1995) because high intakes of sodium are associated with a prevalence of hypertension. The newly updated Dietary Guidelines for Americans (US Departments of Agriculture and Health and Human Services 2000) indicates that one should "choose and prepare foods with less salt."

The Food and Drug Administration indicated that the terms "high," "rich in," or "major source of" a certain nutrient can be used when a serving of food contains 20% or more of the "Daily Value" for that nutrient (Food and Drug Administration 1992a). Also, the terms "source," "good source of," or "important source of" can be used when a serving of food contains 10% to 19% of the "Daily Value" a term used by the Food and Drug Administration (1992a) in nutrient labeling of food products. By these criteria, bison meat is an excellent source of vitamin B_{12}, selenium, phosphorus, and zinc, and a good source of niacin, vitamin B_6, and iron. A Daily Value does not exist for selenium, but if the newly released "Recommended Dietary Allowance" (Institute of Medicine 2000) for men is utilized as a Daily Value, then bison meat, whether from grass- or grain-finished animals, would be considered an excellent source of selenium. Low selenium intakes in humans may increase the incidence of cancer, but high doses can be toxic (National Research Council 1989a).

The nutrient content of meat from bison bulls that reportedly received the same diets varied greatly from animal to animal (Driskell et al. 1997, 2000; Marchello et al. 1998). Genetic factors influence the nutrient content of the meat from other species (Larick et al. 1989; Koch et al. 1995), and likely also has an influence in bison, but we need controlled experiments in which the genetic factors are held constant. Humans also vary greatly with regard to how they utilize nutrients; this variation is also influenced by genetics.

In conclusion, bison meat is a low-fat, low-sodium, nutrient-dense food. Only small differences exist in the nutrient content of meat from bison that have been finished on grass and those finished on grain, with the primary exception of the fatty acid profile. Meat from grass-finished bison is higher in polyunsaturated fatty acid concentration, while that from grain-finished animals is higher in monounsaturated fatty acids. Consumption of meat from either grass- or grain-finished bison provides 1% of the 7% of caloric intake of omega-6 polyunsaturated fatty acids recommended by the Committee on Diet and Health (National Research Council 1989). Only small amounts of the various fatty acids are found in the meat from both grass- and grain-finished animals, as the meat is low in fat and low in saturated fat.

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