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Nutritional characteristics of horsemeat in comparison with those of beef and pork

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Abstract

This study was conducted to determine the nutritional characteristics of horsemeat and bone meal in comparison with those of beef and pork presented by Dietary Reference Intakes For Koreans. Longissimus muscle and large metacarpal bone samples were collected from 20 fattened Jeju horses. Muscle samples were subjected to proximate analysis, assays for fatty acid profile and minerals, and bone samples to mineral assays. Horsemeat had similar levels of protein (21.1 vs 21.0 or 21.1%) and lower levels of fat (6.0 vs 14.1 or 16.1%) compared with beef or pork, respectively. Horsemeat had much higher levels of palmitoleic (8.2 vs 4.4 or 3.3%) and α-linolenic (1.4 vs 0.1 or 0.6%) acids than beef or pork, respectively. Linoleic acid was much higher in horsemeat (11.1%) and pork (10.1%) than in beef (1.6%). PUFA:SFA and n-6:n-3 ratios in horsemeat were 0.29 and 10.2, respectively. There were no big differences in mineral contents between horsemeat, beef and pork. For daily recommended mineral intakes of male adults (Dietary Reference Intakes For Koreans), phosphorus, sodium, potassium, iron, zinc and copper can be provided up to 24, 2.5, 6.7, 21, 26 and 40%, respectively, by 100 g raw horsemeat, but calcium and manganese levels are negligible. Horse cannon bone had much higher mineral contents especially in calcium (10,193 mg/100 g), phosphorus (5,874 mg/100 g) and copper (0.79 mg/100 g). Thiamin, riboflavin, niacin and retinol contents were 0.20, 0.21, 1.65 mg/100 g and 30 μg/100 g, respectively. But ascorbic acid and beta-carotene were not detected. Our data demonstrated that higher levels of palmitoleic and α-linolenic acid in horsemeat than in beef and pork may be beneficial for human health. Horsemeat and bone meal are a good source of some minerals and vitamins.

Key Words: Horsemeat, beef, pork, bone, fatty acid, mineral

Introduction

Horses have long been domesticated as an animal for draft, ride and a food source, and are still very important in many countries. In some countries including Japan and Korea, horsemeat is considered a delicacy. Horse bones have also been used as a traditional medicine for bone diseases including bone fracture and arthritis in Korea. In recent years, horsemeat consumption has steadily increased with increasing number of horses being raised on Jeju island.

However, health-conscious consumers tend to avoid red meat because of the public perception of the adverse effects of saturated fatty acids that are linked to coronary heart disease. Therefore, it is desirable to have animal products that have a low level of saturated fatty acids (Wood *et al.*, 2002). The PUFA:SFA and n-6:n-3 ratios are recommended to be above 0.4 and less than 4, respectively. Among red meats, horsemeat has been known to contain high levels of unsaturated fatty acids such as α-linolenic (18:3 n-3) and monounsaturated fatty acids, indicating that consumption of horsemeat may be more beneficial for health than that of beef (Badiani *et al.*, 1997; Yoo *et al.*, 1993). To evaluate horsemeat and bone meal as a source of nutrients and as a health-promoting food, we determined various nutrients including protein, fat and minerals and fatty acid profile, which were compared with those of beef and pork presented by Dietary Reference Intakes For Koreans (The Korean Nutrition Society, 2005).

Materials and Methods

Preparation of meat and bone samples

Ten castrated and 10 intact male Jeju horses were slaughtered at 30-36 months of age after a 12-mo fattening period. Each bone sample (large metacarpal bone) was taken right after slaughter and vacuum-packaged. The remaining carcasses were stored for 24 hours at 1℃ and the left side of M. *longissimus dorsi* was cut between the last and the first rib, vacuum-packaged and aged at 4℃ for 7 d as usual in commercial practice. All

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samples were stored at -70°C until analysis.

Proximate analysis and determination of fatty acid profile of muscle samples

The proximate analysis of *longissimus* muscle was done by the AOAC procedure (1996). Fatty acid composition was measured according to Morrison and Smith (1964). For lipid extraction, 50 g of frozen M. *longissimuss dorsi* was homogenized in 150 mL chloroform:methanol (1:2) mixture and filtered through Whatman No. 1 into a centrifuge bottle. Lipid layer was separated and dried using evaporator at 50°C. Lipid extracted from each sample was saponified in 0.5 N NaOH methanolic solution and esterified in BF3-methanol, according the AOAC procedure (1996). Fatty acids were determined using a gas chromatography (Varian star 3600, Varian, Inc., Walnutcreek, CA) equipped with flame ionization detector and Omagawax 205 fused-silica bond capillary column (30 m x 0.32 mm, I.D. x 0.25 μm film thickness). Temperature of oven, injection port and detector was 140°C, 250°C and 260°C, respectively, and nitrogen flow rate was 50 mL/min. Fatty acid profile was expressed as percentages of individual fatty acids detected.

Vitamin and mineral contents in meat and bone

Vitamins and minerals in muscle (wet basis) and bone (DM basis) were measured by the AOAC procedures (1996). Macro and trace minerals were analyzed by using an inductively coupled plasma atomic emission spectrometer (ICP-AES; SPECTRO Analytical Instruments, GmbH, Kleve, Germany).

Statistical analysis

Mean values and standard deviations were calculated using SAS-PC software (The SAS System for Windows ver. 8.02). All data were presented as the mean ± SD.

Results

Proximate components and fatty acid profile of horsemeat

In the present study, nutritional characteristics of horsemeat were compared with those of beef (food code: 91025000) and pork (food code: 92003000) presented by Dietary Reference Intakes For Koreans (2005). Crude protein, ether extracts and ash contents in horsemeat are shown in Table 1. Horsemeat had similar levels of protein (21.1 vs 21.0 or 21.1%) and lower levels of fat (6.0 vs 14.1 or 16.1%) compared with beef or pork, respectively. Referring to Dietary Reference Intakes For Koreans, 100 g of horsemeat (on a wet basis) is able to provide about 40% of protein requirement recommended for male adults (at

Table 1. Proximate analysis of *M. longissimus dorsi* of horses

Component	Content
	%[1)], wet basis
Crude protein	21.1 ± 0.9
Ether extracts	6.0 ± 1.9
Ash	1.8 ± 0.4
Moisture	71.4 ± 1.5
Calculated energy, kcal/100 g	138 ± 17

[1)] Values are means with SD of 20 samples.

Table 2. Fatty acids profile of *M. longissimus dorsi* of horses

Fatty acids	Content
	% total FA[1)]
14:0	5.8 ± 1.6
16:0	33.7 ± 1.8
16:1 n-7	8.2 ± 2.5
18:0	7.0 ± 1.1
18:1 n-9	31.4 ± 2.6
18:2 n-6	11.1 ± 2.8
18:3 n-3	1.2 ± 0.2
20:1 n-9	0.5 ± 0.1
20:2 n-6	0.4 ± 0.1
20:3 n-6	0.3 ± 0.1
20:4 n-6	0.5 ± 0.2
SFA[2)]	46.4 ± 2.5
PUFA[3)]	13.5 ± 3.0
MUFA[4)]	40.1 ± 4.2
PUFA/SFA ratio	0.29 ± 0.06
n6/n3 ratio	10.2 ± 3.0

[1)] Values are means with SD of 20 samples.
[2)] SFA, saturated fatty acid (14:0, 16:0, 18:0).
[3)] PUFA, polyunsaturated fatty acid (18:2, 18:3, 20:2, 20:3, 20:4).
[4)] MUFA, monounsaturated fatty acid (16:1, 18:1, 20:1).

30-49 yr of age) with 63.6 kg of body weight.

Fatty acids profile of M. *longissimus dorsi* of horses is shown in Table 2. Horsemeat had much higher levels of palmitoleic (8.2 vs 4.4 or 3.3%) and α-linolenic (1.4 vs 0.1 or 0.6%) acids than beef or pork, respectively. Linoleic acid was much higher in horsemeat (11.1%) and pork (10.1%) than in beef (1.6%). PUFA:SFA and n-6:n-3 ratios in horsemeat were 0.29 and 10.2, respectively.

Vitamin and mineral contents in meat and bone

The macro and trace mineral contents in meats and bones are shown in Table 3 and Table 4, respectively. There were no big differences in mineral contents between horsemeat, beef and pork. For daily recommended mineral intakes of male adults (Dietary Reference Intakes For Koreans), phosphorus, sodium, potassium, iron, zinc and copper can be provided up to 24, 2.5, 6.7, 21, 26 and 40%, respectively, by 100 g raw horsemeat, but

Table 3. Minerals contents of *M. longissimus dorsi* of horses

Minerals	Contents
	mg/100 g[1)], wet basis
P	168.7 ± 6.7
K	315.5 ± 17.6
Ca	6.3 ± 0.5
Mg	21.0 ± 1.3
Na	38.1 ± 3.3
Fe	2.1 ± 0.4
Mn	0.022 ± 0.004
Zn	2.3 ± 0.5

[1)] Values are means with SD of 20 samples.

Table 4. Minerals contents in horse cannon bone

Minerals	Contents
	mg/100 g[1)], DM basis
P	5,874.3 ± 369.5
K	82.2 ± 13.8
Ca	10,193.7 ± 3,107.9
Mg	132.1 ± 12.3
Na	549.2 ± 43.6
Fe	12.3 ± 5.2
Mn	0.12 ± 0.03
Zn	4.7 ± 0.5
Cu	0.79 ± 0.20

[1)] Values are means with SD of 20 samples.

Table 5. Vitamins contents of *M. longissimus dorsi* of horses

Vitamins	Content[1)], wet basis
Thiamin, mg/100 g	0.20 ± 0.02
Riboflavin, mg/100 g	0.21 ± 0.04
Niacin, mg/100 g	1.65 ± 0.13
Ascorbic acid	ND[2)]
Retinol, μg/100 g	30.0 ± 8.0
Beta-carotene	ND[2)]

[1)] Values are means with SD of 20 samples.
[2)] Not detected.

calcium and manganese levels are negligible. Although cannon bone had much higher mineral contents especially in calcium (10,193 mg/100 g), phosphorus (5,874 mg/100 g) and copper (0.79 mg/100 g), it is difficult to calculate the intakes available from whole bone due to different availability and processing methods.

Horsemeat had high levels of retinol (30 vs 12 or 5 μg/100 g) and low levels of niacin (1.6 vs 5.9 or 5.7 mg/100 g) compared with beef or pork, respectively. Riboflavin content in horsemeat was similar with that in beef or pork (0.21 vs 0.19 or 0.16 mg/100 g), respectively. Thiamin content in horsemeat was higher than that in beef or lower than that in pork (0.20 vs 0.07 or 0.56 mg/100 g), respectively. Ascorbic acid and beta-carotene in horsemeat were not detected (Table 5).

Discussion

Red meat consumption in developed countries has plateaued or decreased in some cases for the last 30 years. Many health-conscious consumers avoid red meat because it contains high levels of saturated fatty acids and cholesterol. Red meat market has lost its share to poultry and fish as well as to vegeterianism. Animal industry and animal scientists have been working to develop animal products that are leaner through selection and breeding, and feeding regime and diet modification including using feed additives such as nutrient partitioning agents.

Traditionally, horsemeat has been known to be leaner but tougher than beef. However, recently horsemeat consumption has steadily increased with increasing number of horses being raised on Jeju island. Horsemeat gains popularity due to its delicacy and potential health benefits such as those with low fat and high unsaturated fatty acid contents. It is worthy to evaluate horsemeat in terms of its nutrient composition especially its fatty acid profile and its potential health benefits in comparison with the other most popular red meat, beef and pork.

As expected, no differences were noticed in protein content of *longissimus* muscles among the three species, but horsemeat tended to have lower fat contents. However, the three species are different in fatty acid profile in their muscle fat. Horse fat had a much higher α-linolenic acid than the others, probably due to the more intakes of fatty acids through hay by horses. Grasses usually contain significant amounts of α-linolenic acid. Although cattle gain the same amount of α-linolenic acid through hay, unsaturated fatty acids will be hydrogenated in the rumen and as a result very little α-linolenic acid will reach the animal's fat storage.

Our data showed that PUFA:SFA and n-6:n-3 ratios in horsemeat were 0.29 and 10.2, respectively (Table 2). The recommended dietary PUFA:SFA and n-6:n-3 ratios are above 0.4 and less than 4, respectively (Wood *et al.*, 2002). The fatty acid profile of horse fat used in our study is still to be improved maybe through diet modification. By adding canola oil to a fattening diet, we were able to increase the level of unsaturated fatty acid and n-3 fatty acid in our recent studies (Joo *et al.*, 2006).

In addition to α-linolenic acid content, horse fat is unique containing a high level of monounsaturated fatty acid, palmitoleic acid. Yoo *et al.* (1993) and Banduani *et al.* (1997) also reported similar values for palmitoleic acid content in horse fat. Palmitoleic acid levels have been reported to range from 2.63 to 4.36% in pork fat (Wood *et al.*, 2004) and beef fat (Realini *et al.*, 2004).

Recently, palmitoleic acid has been known to have functions, possibly in improving human health. Plasma LDL-cholesterol level was lowered in human fed a diet based on Macadamia nut which contains a high level of palmitoleic acid (Curb *et al.*, 2000). Maedler *et al.* (2001) showed that palmitoleic acid promoted beta-cell proliferation at low glucose concentrations, counteracting the negative effects of palmitic acid as well as improving beta-cell function without affecting beta-cell apoptosis.

Horse fat has also been used as a skin cream and as a traditional medicine for skin diseases and wound healing especially skin burn. Wille and Kydonieus (2003) demonstrated that free fatty acids in human sebum account for the self-disinfecting activity on the skin surface, and that palmitoleic acid accounts for most of this activity. They also suggested that palmitoleic acid may be useful in topical formulations for treatments of secondary gram-positive bacterial infections, as a gram-positive bacteria antimicrobial in wound dressings and as a natural gram-positive antimicrobial preservative in skin and hair care products. It is interesting to know that fatty acid profile in the sebum changes when one consumes horsemeat or fat.

Horse meat is found to be a good source of P, Fe, Zn and Cu, whereas horse bone meal contains high levels of Ca and Cu. Bandiani *et al.* (1997) reported the contents of various minerals in thigh muscle, of which P, Na, Fe and Zn levels were lower, but Ca and Cu levels were higher, compared with our findings. Mineral contents in horsemeat may be varied with diet, exercise, age, muscle types, etc.

Based on our data (Table 5) and the recommendation of Dietary Reference Intakes For Koreans, 100 g of M. *longissimus dorsi* for thiamin, riboflavin, niacin and retinol is able to provide 16.6, 14.0, 10.3 and 4% of adult (at the age of 30-49) male requirement, respectively. Some animals such as cattle and horses are able to deposit carotenoids in the tissues if it is high in the diet. In this study beta-carotene was not detected, indicating that retinol is a major store form in horse M. *longissimus dorsi.*

In conclusion, higher levels of palmitoleic and α-linolenic acid in horsemeat than in beef and pork may be beneficial for human health. Horsemeat and bone meal are a good source of some minerals and vitamins.

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