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NUTRITIONAL PROFILE OF HORSE MEAT

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INTRODUCTION

The consumption of horse meat varies both from individual to individual and from country to country. In many countries horse meat is not eaten at all, while in others where it is sold many people never eat it. Thus, average *per capita* intake does not correspond to the actual situation. In many cases the refusal to eat horse meat is linked to psychological factors as the horse is considered a pet, while others may find the sweet taste of this meat disagreeable. However, where horse meat is consumed it is appreciated for its eating qualities, especially its leanness and high iron content. Over the centuries horse meat has been eaten to varying degrees. In ancient times the Persians, Greeks, Gauls and Romans ate much horse meat as witnessed by Erodotus, Thucydides and Julius Caesar. However, with the coming of christianity this intake was restricted, with a number of Popes actually instigating campaigns against the use of horse meat in the diet of humans. Moreover, religious reasons aside, up to the beginning of this century it was necessary to maintain consistent numbers of horses as this animal was important both for transport and work in periods of war and peace alike. Thus it is that of the numerous breeds of horse, none are specifically designated for meat production.

More recently there has been renewed interest in the horse as a meat producer, especially in a number of European countries. However, research into the nutritive value of horse meat remains limited. This paper aims to provide a series of information on the nutritional value of horse meat.

MATERIALS AND METHODS

Five muscle samples from the hindquarters (proximal pelvic limb) of adult horses were used for the study. The samples of each muscle taken respected the relative proportions existing between them: *semimembranosus* 400g, *adductores* 300g, *semitendinosus* 300g, *gluteus femoralis* 300g, *biceps femoris* 300g, *rectus femoris* 200g, *vastus lateralis* 150g, *vastus medialis* and *vastus intermedius* 150g. The muscles were cleaned of connective tissues and fat, cut into small cubes, minced and homogenized. A part of the sample prepared was used immediately to determine moisture, protein, ash, lipids and fatty acids. A second part of the homogenized sample was frozen at - 20°C for subsequent analyses: phosphorous, cholesterol and vitamins. The third portion of the sample was lyophilized and the fat was removed to determine intramuscular collagen and amino acids.

Moisture, protein and ash were determined according to A.O.A.C. (1990) procedures.

Total lipid content was determined gravimetrically after extraction according to Folch procedure, as modified by Michaelsen *et al.* (1991).

The intramuscular collagen was determined by multiplying the value of hydroxyproline by 7.82 (Korzeniowski *et al.*, 1991). The analysis of hydroxyproline was performed in triplicate with Technicon Auto-Analyzer after acid hydrolysis of the sample.

In order to determine amino acid composition three hydrolyses were performed. Samples were hydrolysed with 6N HCl at 110°C for 23 hours to obtain hydrolysates suitable for analysis of all amino acids except cystine+cysteine, methionine and tryptophan. Samples oxidized with performic acid were also hydrolysed with 6N HCl at 110°C for 18 hours to obtain hydrolysates suitable for the determination of cystine+cysteine as cysteic acid and of methionine as methionine sulfone. Samples were hydrolysed with $Ba(OH)_2$ at 110°C for 22 hours for the determination of tryptophan. The hydrolysates were analyzed in an automatic Amino-analyzer (Carlo Erba mod. 3A29) with an automatic sampler.

In order to determine the fatty acid composition, lipids, extracted as described above, were saponified and fatty acids were liberated and esterified in presence of BF_3 (A.O.A.C., 1990). Fatty acid methyl esters were quantified by gas chromatography using a Carlo Erba Fractovap 2350 chromatograph with a flame ionisation detector. The glass column (1.83m x 3mm ID) was packed with 10% SP-2330 on 100/120 Chromosorb W AW, with nitrogen as carrier gas (flow rate 20ml/min). The oven temperature was programmed with initial T1=160°C, final T2=210°C and a rate of 3°C per minute after the initial holding at 160°C for two minutes. Both detection and injection port temperatures were 250°C. Fatty acids were quantified using a DP 700 computing integrator (Carlo Erba Instruments) and each major peak was identified by comparison of retention times with those of known standard mixtures.

Total cholesterol was determined by direct saponification without derivatization in accordance with Engeseth (1989). Total cholesterol was quantified by gas chromatography using 5-alfa cholestane as an internal standard. The glass column (1.83m x 3mm ID) was packed with 3% OV-17 on 100/120 Gas Chrom Q, with nitrogen as carrier gas (flow rate 20 ml/min). The oven temperature was 270°C and both detection and injection port temperatures were 300°C.

Ashed samples were dissolved in hydrochloric acid and diluted to an appropriate concentration for mineral analysis (Ca, Mg, K, Na, Fe, Cu, Zn) by means of atomic absorption spectrophotometry with a Pye Unicam SP9 equipped with an air-acetylene flame. To determine phosphorous the sample was wet digested and brought to acid solution. An aliquot of the digest was reacted with ammonium molybdate and ascorbic acid to yield a blue colour which was measured by spectrophotometry at 650nm.

Thiamin and riboflavin were determined chemically by fluorometric analysis, while niacin, vit. B6 and vit. B12 were determined with the microbiological method. These latter were determined using *L. arabinosus*, *S. carlsbergensis* and *L. leichmanii* ATCC 78-30 respectively, as the test microorganisms.

RESULTS AND DISCUSSION

Table 1 reports the chemical composition of the horse meat. Compared to the values reported in literature, the fat content of the samples analyzed (6.78%) was generally higher. Catalano *et al.*(1986) found a fat content of 5.4% in 20 samples taken from adult horses of different breeds. Souci *et al.* (1989) report a value of 2.67%; Rossier and Berger (1988), who quote data from a number of researchers, report an average value of 2%; the Istituto Nazionale della Nutrizione (I.N.N.,1989) of 2.7%. On samples taken from weanling and yearling carcasses, Badiani *et al.*(1993) and Catalano *et al.*(1986) report values ranging from 1.3 to 2.11%. The difference in the results is not surprising as the values obtained refer to analyses performed on different muscles from animals of different breeds and ages and the procedures also varied (Folch or ether extract).The energy value is obviously related to the fat content. Our results give a value of 140kcal per 100g of meat, compared to 116 of Souci *et al.* (1989), 113 of Badiani *et al.*(1993) and 100 to 120 of the authors quoted by Rossier and Berger (1988).
The intramuscular collagen was 1.17%. No data were found in literature as regards this parameter.

Table 2 shows the amino acid content. The values obtained agree closely with those reported by Souci *et al.*(1989), Wervack *et al.*(1977) and Catalano *et al.*(1986) with only two exceptions. Souci *et al.* (1989) report a methionine level

of 1.28g/100g of meat (with a protein percentage of 20.60). This value is clearly higher than that found by us or that reported by Wervack *et al.*(1977) and Catalano *et al.*(1986) (0.53 and 0.58g/100g respectively). The values reported for tryptophan in literature vary greatly. Our datum (0.15g/100g) agrees with that (0.12) reported by Souci *et al.* (1989), while Wervack *et al.* (1977) and Catalano *et al.* (1986) report values of 0.24 and 0.36g/100g respectively.

Table 3 reports the fatty acid composition of the intramuscular fat and the cholesterol content. It may be noted that the six fatty acids with 16 and 18 carbon atoms account for over 91% of the total fatty acids. The ratios between the saturated, monounsaturated and polyunsaturated fatty acids are of particular interest. The saturated fatty acids account for approximately a third (34.8%) of the total fatty acids, which is the suggested amount for correct diet adopted in many countries. The monounsaturated fatty acids account for almost half (46.5%) the total fatty acids and the PUFA content (18.6%) is also very high.These values agree with those observed by Renon *et al.*(1979) and Sinell and Langner (1966) for intramuscular fat of horse meat.

The cholesterol content was 60.6mg/100g of meat.

Table 4 shows the values for mineral content. Calcium content (3.77mg/100g) is similar to that found by Catalano *et al.* (1986) (4 mg/100g), but noticeably lower than the values reported by Souci *et al.* (1989) and I.N.N. (1989) (12.6 and 10mg/100g respectively). Sodium content (74.2mg/100g) was found to be much higher than in the works cited above (44 to 45mg/100g). Our results were quite similar to those of the above-mentioned studies for phosphorus, potassium and magnesium.

There is a certain variation as regards iron content of horse meat, with values ranging from 3.2mg/100g (I.N.N., 1989), to 3.7 (Catalano *et al.*,1986), to 3.9 in this study and 4.7 (Souci *et al.*,1989).

The only value found in literature for zinc content in horse meat was that of Catalano *et al.* (1986). This datum was very different from our own (1.28 vs 3.72mg/100g).

Table 5 reports the data regarding some B complex vitamins. On the basis of these results, and bearing in mind the Recommended Daily Allowances recently established by the EEC, it may be seen that 100g of horse meat provide 32% of daily requirements of vitamin B6, 31% of niacin and double the daily requirement of vitamin B12. Compared to the values reported by Souci *et al.* (1989), the meat we examined had higher contents of riboflavin (0.18 vs 0.15mg/100g), vitamin B6 (0.64 vs 0.50), niacin (5.54 vs 4.60) and lower levels of thiamin (0.04 vs 0.11) and vitamin B12 (2.08 vs 3.00μg/100g).

CONCLUSIONS

The results obtained show that horse meat has:
a) good protein levels and limited amounts of fat;
b) a very low saturated/unsaturated fatty acid ratio (0.52), with a high percentage of monounsaturated fatty acids (46.5%) and PUFA (18.6%);
c) a low cholesterol content (60mg/100g);
d) high iron and zinc contents;
e) high levels of vitamins B6, B12 and niacin.

These results confirm the excellent nutritional characteristics of horse meat.

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Table 1. Chemical composition and energy value (/100g).

	Mean	SD	Range
Water, g	70.94	1.49	69.14 - 73.14
Protein, g	19.83	1.13	18.34 - 20.92
Fat, g	6.78	2.24	3.73 - 9.17
Ash, g	0.98	0.05	0.90 - 1.04
Intramuscular collagen, g	1.17	0.21	0.98 - 1.53
Energy value, kcal kJ	140 588	20.42 84.05	117 - 164 494 - 685

Table 2. Amino acid content (g/100g).

	Mean	SD	Range
Alanine	1.18	0.05	1.12 - 1.25
Arginine	1.16	0.08	1.08 - 1.26
Aspartic acid	1.77	0.10	1.66 - 1.90
Cystine	0.20	0.02	0.18 - 0.22
Glutamic acid	2.83	0.15	2.62 - 3.02
Glycine	1.04	0.04	0.99 - 1.08
Histidine	0.90	0.03	0.86 - 0.92
Isoleucine	0.91	0.06	0.81 - 0.98
Leucine	1.52	0.10	1.37 - 1.62
Lysine	1.57	0.10	1.49 - 1.67
Methionine	0.48	0.03	0.44 - 0.51
Phenylalanine	0.82	0.06	0.76 - 0.92
Proline	0.89	0.07	0.81 - 0.99
Serine	0.69	0.05	0.63 - 0.76
Theronine	0.84	0.06	0.77 - 0.91
Tryptophan	0.15	0.02	0.12 - 0.16
Tyrosine	0.67	0.05	0.62 - 0.71

Valine	0.96	0.06	0.88 - 1.02

Table 3. Fatty acid (% total f.a.) and cholesterol content.

	Mean	SD	Range
Caprylic acid (C8:0)	<0.1		
Capric acid (C10:0)	<0.1		
Lauric acid (C12:0)	0.17	0.02	0.15 - 0.19
Myrsitic acid (C14:0)	3.88	0.15	3.62 - 4.01
Myristoleic acid (C14:1)	0.42	0.11	0.32 - 0.58
Pentadecanoic acid (C15:0)	<0.1		
Pentadecanoic acid (C15:1)	1.08	0.43	0.70 - 1.75
Pamitic acid (C16:0)	26.64	0.89	25.28-27.70
Pamitoleic acid (C16:1)	10.25	1.38	9.13-12.29
Margaric acid (C17:0)	<0.1		
Heptadecenoic acid (C17:1)	0.71	0.13	0.56 - 0.86
Stearic acid (C18:0)	3.72	0.61	3.06 - 4.41
Oleic acid (C18:2)	34.08	0.68	33.06-34.96
Linoleic acid (C18:2)	12.01	1.87	9.04-14.07
Arachidic acid (C20:0)	<0.1		
Linolenic acid (C18:3)	4.92	2.12	2.03 - 7.63
Eicosadienoic acid (C20:2)	0.33	0.07	0.25 - 0.43
Eicosatrienoic acid(C20:3)	0.30	0.26	0.12 - 0.75
Arachidonic acid (C20:4)	1.09	0.36	0.68 - 1.59
Saturated F.A.	34.8	0.84	34.0 - 36.0
Monounsaturated F.A.	46.5	1.36	44.9 - 48.4
Polyunsaturated F.A.	18.6	1.64	16.4 - 20.7
Cholesterol (mg/100g)	60.6	8.75	48.9 - 72.8

Table 4. Mineral contents (mg/100g)

	Mean	SD	Range
Sodium	74.2	6.09	68.8 - 82.9
Potassium	331.2	18.28	308.5 - 352.5
Magnesium	28.9	0.19	28.7 - 29.1
Calcium	3.77	0.11	3.64 - 3.88
Phosphorus	23.10	7.55	225.1 - 239.6
Iron	3.90	0.39	3.59 - 4.58
Zinc	3.72	0.48	2.95 - 4.22
Copper	0.20	0.03	0.17 - 0.24

Table 5. Vitamin contents (/100g).

	Mean	SD	Range
Thiamin, mg	0.04	0.01	0.030 - 0.062
Riboflavin, mg	0.18	0.01	0.17 - 0.19
Niacin, mg	5.54	0.33	5.10 - 6.00
Vitamin B_6, mg	0.64	0.16	0.50 - 0.85
Vitamin B_{12}, µg	2.08	0.48	1.45 - 2.60