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Comparative study of meat composition from various animal species*

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A b s t r a c t: The meat of various species of animals has specific composition, structure and odor, however, the identification of meat raw materials is a difficult problem.

Fatty and amino acid composition of meat components being a part of recipes of meat products has been investigated. The factors influencing the results of analytical determination of individual fatty and amino acids are shown. The main ratios for sheep, pigs, boars, cows, turkeys, horses, chicken, pheasants and wild boars, allowing their use in production of modern meat products with variable nutrition value are presented, too.

Calculation of specific ratios of fatty acids in fats from various species of animals allows revealing the characteristic features. Thus, horsemeat has a high share of fatty acids with 18 atoms of carbon; these are mainly; oleinic, linoleic and linolenic acids. The C18:C12 ratio in horsemeat is 6 times higer than in pork, 18 times higher than in beef, 8 and 2 times higher than in mutton and turkey meat, respectively.

The ratios of amino acids – arginine, histidine and lysine for the investigated species of animals have been obtained. These ratios do not depend on age or weight of the animal. For example, for mutton it is 2:3:1 and for pork 1.5:2.0 – 2.2:1.

Comparative analysis of the readings of the sensors of VOCmeter instrument, as obtained during investigations of volatile components of beef, pork, mutton, chicken meat, ostrich and turkey meat, and their processing by principal components methods, allowed revelation of meat from different species of animals and poultry with a high degree of reliability.

The data obtained can be used for production of advanced meat products.

Key words: *animal species, meat composition, fatty acids, amino acids.*

Introduction

Meat from animals of different species is characterized by specific composition, structure and odour, but in most cases it is difficult to identify species origin of meat raw material by simple methods of physical-chemical and sensor analysis (*Demirel et al.*, 2006; *Lisitsyn et al.,* 2004; *Saadoun and Cabrera*, 2008).

The aim of this paper is to present the results and show the possibility to identify meat from different wild and domestic animals using amino acids (AA) and fatty acids (FA) analysis followed by the E-nose comparison.

Material and methods

M. longissimus dorsi with the weight of 5.0 ± 0.5 g taken from the adult wild and domestic animals including female sheep, pigs, cows, turkeys, horses, chickens seals, walrus and others were analyzed.

As analytical methods, extraction of lipids from muscle tissues and GC/FID fatty acids methyl esters' determination were applied.

For fat content determination lipids were extracted from muscle tissues by the method described by *Folch, Lees,* and *Stanley* (1957).

Fatty acid content: after isolation lipids were subjected to methylation according to official methods (*ISO 5509,* 1978; *AOAC,* 1990). Fatty acid methyl esters (FAMEs) were analyzed by using a HP6890 Hewlett-Packard (USA) gas chromatograph equipped with flame ionization detector (FID) and silica capillary column HP-Innowax 30m x, 32mm x 0,5mkm. Nitrogen was used as a carrier gas as well as automatic data processing Winpeak by Bruker-Franzen Analytic SCPA;

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Amino acid content was determinate with amino acid analyser, PMA GmbH Aracus;

Censor analysis was performed by using multisensory analyser VOCmeter.

Results and discussion

Up to 34 essential fatty acids were determined in the studied samples (fig.1).

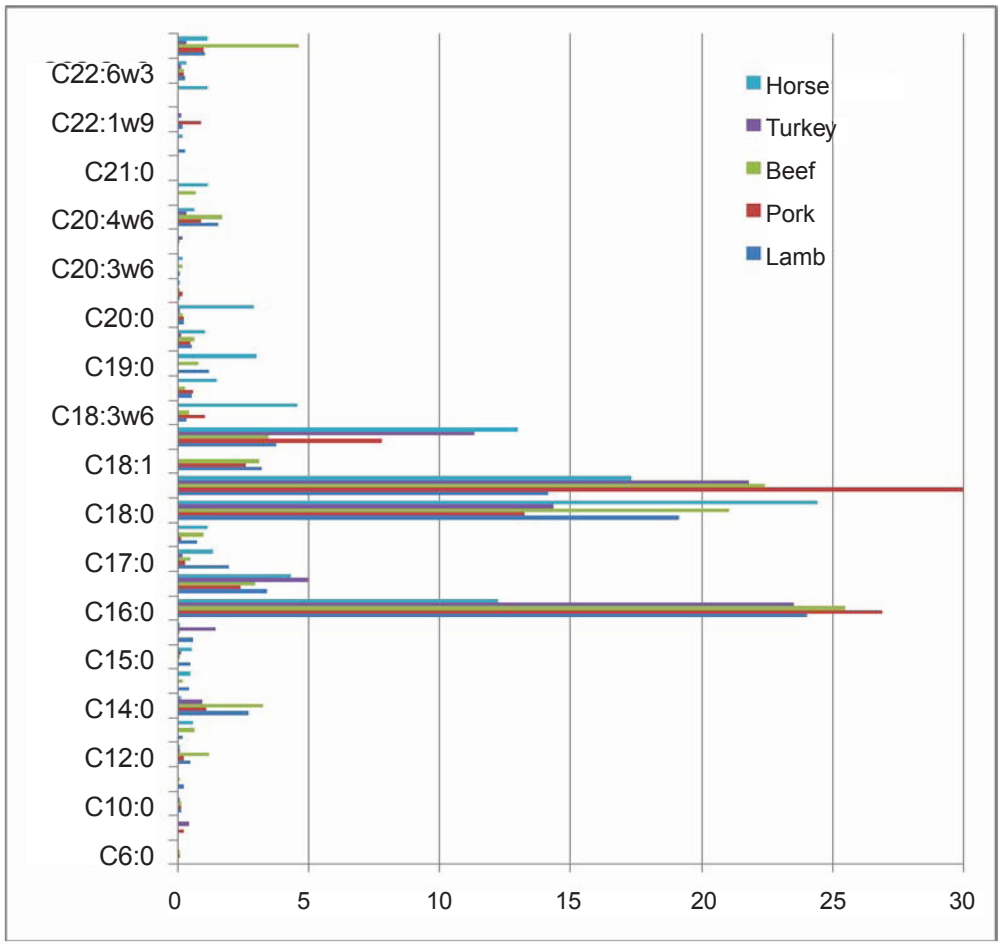

Figure 1. Chromatograms of fatty acids in different type of meats
Figura 1. Masne kiseline u različitim vrstama mesa

From figure 1 it can be distinguished the presence of tridecanoic acid [$CH_3(CH_2)_{11}COOH$] in lipids of sheep and cattle. Its content in beef is 3.7 times higher than in ovine and 15 times higher than in pork and turkey meat.

For ovine presence of pentadecanoic acid with a branched skeleton is typical (0.6% of the total lipids), while in pork only trace amounts of C15:0 are found occasionally.

Horse meat has much higher (1.2%) content of pentaenoic fatty acid than other meat samples. In pork, ovine and turkey meat, these acid range from 0.05% to 0.07%. In beef quantity of this fatty acid is ten times higher (0.7%).

High content of lauric acid (C 12:0) is typical for beef (1, 7%). In pork, ovine, horse, and turkey lauric acid content is 5.5; 2.5 and 1.7 times less than in beef, respectively.

In general, beef is rich in fatty acids of medium molecular weight (from C 8 to C 13). This value is two times higher than that in horse, two and a half times higher than in ovine (1.06%), three times higher than in pork or turkey (0.68 – 0.77%).

Turkey meat reveals almost complete absence of fatty acids with 17 carbon atoms (heptadecanoic acid, heptadecenoic acid, and branched heptadecanoic acid), which can be a specific indicator for turkey meat.

C 19 and C 21 fatty acids were not found in the lipids of pork (*Chernuha et al*., 2009; *Lisitsyn and Shumkova*, 2002)

The main fatty acids ratios are presented for meat from various animal species allowing their use in production of modern meat products with variable nutrition value.

Calculation of specific fatty acid ratios in fats from different animal species allows revealing the distinctive features (*Alfaia et al.,* 2007). For example, the high proportion of fatty acids with 18 carbon atoms (mostly oleic, linoleic and linolenic acids) is characteristic for horse meat. The C18/C12 ratio in horse meat is 325.60, and it is 6 times higher than in pork, 18 times higher than in beef, and 8 times higher than in lamb and two times higher than in turkey meat.

For turkey meat the specific fatty acid ratio can be the C16/C12 ratio. In turkey meat this ratio is 276.47, which is 5.5 times higher than in lamb and 3, 13 and 2 times higher than in pork, beef and horse meat, respectively. The distinctive characteristics of beef and lamb are minimal values of C18:1/C12 and C18:2/C14 ratio.

Table 1. Some fatty acid ratios in lipids from different animal species
Tabela 1. Odnosi nekih masnih kiselina u lipidima različitih vrsta životinja

	C16/C12	C18/C12	C18:1/C14	C18:2/C14
lamb	50.03	39.89	5.22	1.38
pork	105.41	51.82	27.22	7.09
beef	21.49	17.78	6.84	1.056
turkey	276.47	168.94	22.95	11.93
horse	163.47	325.6	111.74	83.94

On the basis of the above mentioned data on the fatty acid composition of meat/raw material from different animal species it appears to be possible to distinguish between these investigated types of meat with high confidence. It would be possible to distinguish beef and lamb from other types of meat by detection their fatty acid composition. The most difficult is to distinguish lamb from beef on the basis of their fatty acid profile.

Data for fatty acid ratios correspond to the results obtained with the electronic nose (fig.2)

The comparative analysis of the visual fingerprints of meat raw material used in meat products manufacture showed that the highest odour intensity was characteristic for samples from fresh venison while the samples of lamb were characterized by the least odour intensity. Differences in the odour visual fingerprint patterns of the tested samples can be explained by differences in the quantitaties and profiles of volatile compounds, including those that are formed during the process of autolytic changes in meat tissue.

Unlike the currently available methods for meat species detection (polymerase chain reaction. enzyme immunoassay. etc.). The use of multisensor systems (E-nose) does not require significant material costs. As well as durable and labour consumption for preparation of samples.

In order to distinguish more clearly between beef and lamb we have made attempts by comparative analysis of their amino acid composition. There is scientific opinion that myoglobin and myogen can

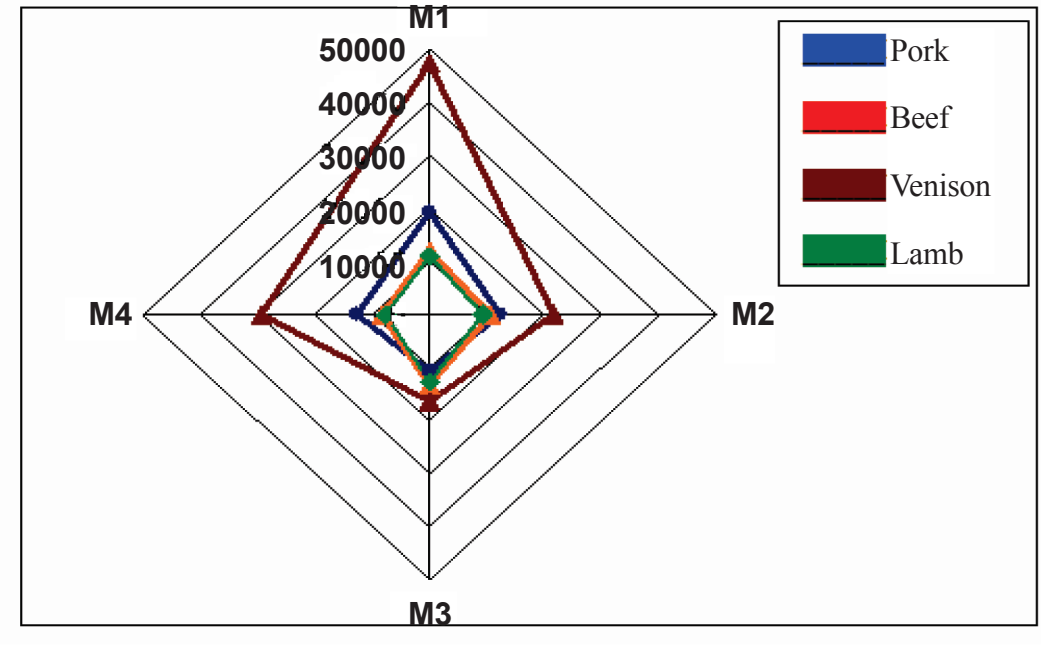

Figure 2. „Visual prints“ of pork, beef, lamb and venison made with the „E-nose“
Figura 2. „Vizuelni otisak“ svinjskog, junećeg, jagnjećeg mesa i divljači pomoću „Elektronskog nosa“

be regarded as biomarkers of meat tissue (*Demirel et al.,* 2006). Our interest was focused on myogen. Myogen accounts for 20 to 30% of all meat tissue proteins. In this study we attempted to calculate species-specific changes in proteins by investigation dynamics of the changes in the ratio of arginine, histidine and lysine. Using the pair correlation method we found that the ratio arginine: histidine (0.42) is the weightiest.

In four experiments the ratios of arginine, histidine and lysine for examined animal species were investigated, because these ratios do not depend on the animal age or fatness. For instance, the ratios we obtained are 2:3:1 and 1.5:2.0–2.2:1 for lamb and pork respectively (fig.3).

At the same time E-nose shows positive results when we compared meat samples of wild and domestic poultry (chicken, ostrich, duck, turkey).

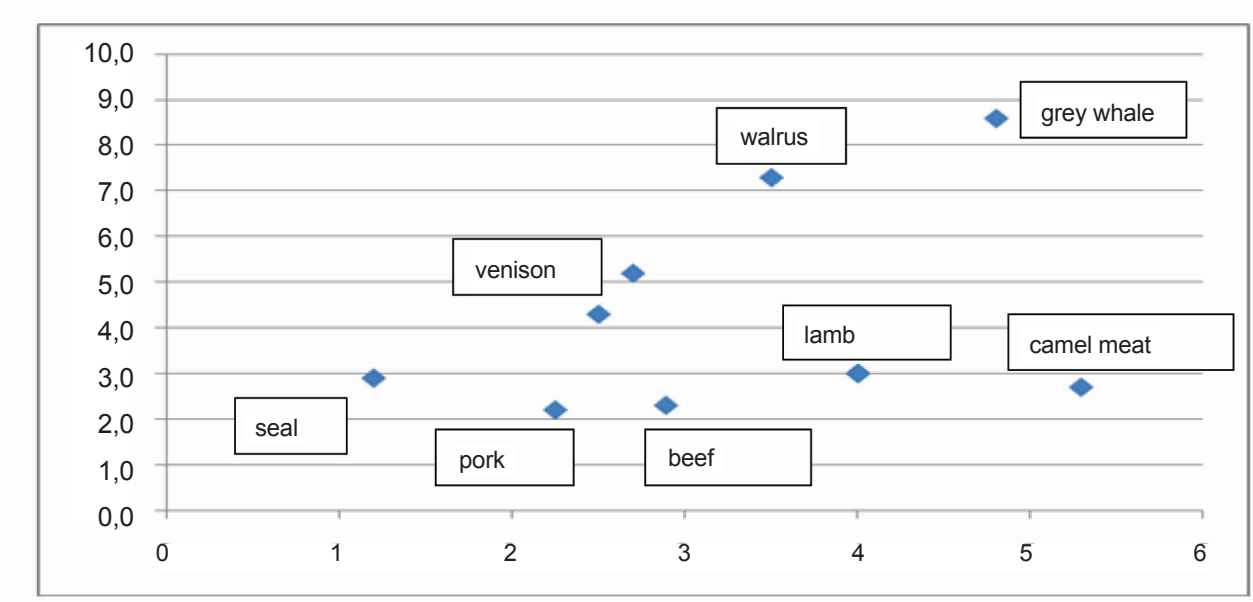

Figure 3. Differentiation of animal species by arginin/histidin ratio
Figura 3. Diferencijacija različitih vrsta životinja pomoću odnosa ariginin/histidin

The areas of points that characterize each meat species are situated close to each other, which allow identifying the areas (clusters) inherent to each meat species. It should be noted that the cluster determinative for venison is situated at the significant distance from the cluster of rabbit meat and has the significantly higher coordinates of the first principal component (PC1). It should be noted that in some cases clusters are situated near each to other in some cases, but they lie at different angle in the space which enable to carry on the analysis of species origin of meat raw material with high confidence.

Meat raw material as different morphological parts of carcasses do not influence the objectivity of the results obtained for determination of the origin of species by multisensor method.

Conclusion

Fatty and amino acid composition of meat components as being a part of meat products has been investigated. Factors influencing the results of analytical determination of individual fatty and amino acids in various animal species were evaluated.

Possibility of the use of multisensor instrumental systems for determination of species origin of meat raw material was established.

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Komparativna studija sastava mesa različitih životinjskih vrsta

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R e z i m e: Meso različitih vrsta životinja ima specifičan sastav, strukturu i miris, Međutim, identifikacija mesa kao sirovine predstavlja veliki problem.

Ispitivan je sastav masnih i amino kiselina u mesu odnosno. delovima mesa koje se prema recepturi koristi u proizvodnji proizvoda od mesa. Faktori koji utiču na rezultate analitičkog određivanja pojedinih masnih i aminokiselina su prikazani u radu. Glavni odnosi utvrđeni kod ovaca, svinja, nerastova, krava, ćuraka, konja, pilića, fazana i divljih nerastova su predstavljeni u radu. čime je omogućena njihova upotreba u proizvodnji savremenih proizvoda od mesa različite hranljive vrednosti.

Izračunavanje specifičnih odnosa masnih kiselina u masnom tkivu različitih vrsta životinja omogućava otkrivanje karakterističnih svojstava. Prema tome, meso konja ima visok udeo masnih kiselina sa 18 atoma ugljenika; a to su uglavnom oleinska, linolna i linolenska kiselina. Odnos C18:C12 u mesu konja je 6 puta veći od svinjskog mesa, 18 puta od goveđeg i 8 odnosno 2 puta nego u mesu ovaca i ćuraka.

Odnosi aminokiselina – arginin, histidin i lizin u ispitivanim vrstama životinja su takođe utvrđeni. Ovi odnosi nisu u zavisnosti od uzrasta ili mase životinje. Npr. za ovčije meso 2:3:1 a za svinjsko meso – 1.5:2.0 – 2.2:1.

Uporedna analiza očitavanja senzora na instrumentu VOCmeter koji su dobijeni u ispitivanju isparljivih komponenti goveđeg, svinjskog, ovčijeg, pilećeg, nojevog i ćurećeg mesa. kao i njihova obrada korišćenjem osnovnih metoda. omogućila je otkrivanje mesa različitih vrsta životinja sa visokim stepenom pouzdanosti.

Dobijeni podaci mogu se koristiti za izradu naprednih proizvoda od mesa.

Ključne reči: *životinjske vrste, sastav mesa, masne kiseline, aminokiseline.*

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