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THE QUALITY OF GOAT MEAT AND IT’S IMPACT ON HUMAN HEALTH

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Review paper

Abstract: Today, goats are spread throughout the world. They live in small or large herds and in different areas and environments.Because of its distinctive taste and desired chemical composition, goat meat is increasingly consumed in Serbia. As animal foods, it is rich in protein, vitamins and minerals, but contains very little fat, especially cholesterol.The aim of this review paper is to highlight some health benefits, nutritional values and potential use of goat meat.On the chemical composition of goat meat affect race, gender, productivity and adaptability to stress, environment, management, diet, weight at slaughter and health condition as well as slaughter and procedures with the carcasses after slaughter.Average chemical composition of lean goat meat contains about 75.42% water, 3.55% fat, 19.95 % protein and 1.06% mineral matter.The energy value is about 580 kJ per 100 g.The goat meat has about the same nutritional value as well as sheep meat.Due to low content of saturated fatty acids and cholesterol, goat meat in the human diet is healthier alternative compared to other types of red meat.Polyunsaturated fatty acids prevalent in goatmeat, andthe diet rich in unsaturated fatty acids is correlated with a reduced risk of stroke and coronary disease.In addition, in goat meat are present the essential amino acids such as lysine, threonine and tryptophan.Regardless to the nutritional value,goat meat is still less appreciated due to their specific smell and taste, the more if the animal is older.

Key words: goat meat, quality, nutritional value, health

Introduction

Today, goats are spread throughout the world, with the exception of extreme cold areas.The goats are highly present in the countries with the extensive agricultural production, although their population rising in the richer countries, mainly due to the intolerance of certain groups of people to cow's milk.

They live in small or large herds and in different regions and environments: plain, desert, hilly and mountainous areas. *Devendra (2010)* states

that exist 1 156 different breeds of goats. The largest number of goat breeds are nourishing in Asia and Africa. According to *FAOSTAT (2012)* number of goats in the world is estimated to 957.40 million, while on the territory of Serbia in 2014 that number was 219 000 according to *Statistical Office of the Republic of Serbia (Republički zavod za statistiku, 2015)*.

Globally, consumption of goat meat is lower than consumption of beef *(Madruga and Bressan, 2011)*, but goats undoubtedly serve as a major source of red meat for the people *(Webb et al., 2005)*, particularly in developing countries.

Because of its distinctive taste and desirable chemical composition, goat meat is increasingly consumed in Serbia. As animal foods, it is rich in protein, vitamins and minerals, but contains very little fat, especially cholesterol. This type of meat is no opposing religious and cultural aspects of consumption. On the territory of the Republic of Serbia from 1954 to the nineties of past century, was a ban on the keeping of goats. Goats have not been eliminated as a kind of animal, but their production was not controlled (statistics on their numbers, selection, manner of keeping and slaughtering, meat quality) *(Ivanović and Pavlović, 2015)*.

Differences in the quality of goat meat are result of age, gender and genetic groups *(Casey and Webb, 2010)*.

In relation to the carcasses of sheep of the same age and sex, goat carcasses are smaller and have less fat on the surface *(Sheridan et al., 2003)*.The carcasses of young goat containing a high percentage of muscle and a low percentage of bone, a lower percentage of intramuscular and subcutaneous fat, compared with the carcasses of sheep *(Santos et al., 2008; Stanisz et al., 2009)*. On the other hand, a lower percentage of fat on the surface of carcasses can lead to cold shortening and significant loss during the post mortem cooling.

The aim of this review paper is to highlight some health benefits, nutritional values and potential use of goat meat.

The chemical composition of goat meat

On the chemical composition of goat meat affect race, gender, productivity and adaptability to stress, environment, management, diet, weight at slaughter and health condition as well as slaughter and procedures with the carcasses after slaughter. Because of these facts it is difficult to compare the results of the chemical composition of goat meat of different authors, who came to them under different conditions. According to research *(Ivanovic et al., 2012a, 2012b, 2014)*, the average chemical composition of lean goat meat of the race Serbian white goat contains about 75.42% water, 3.55% fat, 19.95 % protein and 1.06 % mineral matter, while at the race Balkan goat, water was represented with 74.51 %, fat 3.92%, proteins 20.55% and mineral matter 1.04 %.The energy value was similar and is around 580 kJ per 100 g.

Water has influence on the quality of the meat, especially the juiciness, but also on the so-called technological quality.The muscles contain approximately 75% water, which is distributed within the myofibrils, between themselves, between the cell membrane (sarcolemma) and between the muscle bundles. Water is a bipolar molecule which is attracted by particulate species, such as proteins, and in the muscles may be related, reserved and free.

Genetics and treatment of live animals can greatly affect the future capacity of water in the product. The cooling or freezing mode after slaughter, especially during the rigor, is of great importance for the percentage of water that will remain in the meat. These factors have a significant impact on the pH. Retained water also affects the particular sensory properties *(Ivanović et al., 2012a)*.

Adipose tissue and fat. Adipose tissue is not a passive depot of fat, it conducted a very extensive biochemical processes. In fat cells, glycerol is synthesizing, the fatty acids are linking into glycerides, the glycerides are converting to each other, the grease is synthesizing from glucose, fat mobilization is performing, whereby the fatty acids and glycerides are releasing which cause hyper lipemia. According to their chemical composition, the fats of adipose tissue are mainly triglycerides and are located in the cells, while the water, proteins and mineral matter are ingredients of connective tissue stroma. Adipose tissue of slaughtered animals contains 50-95% fat, 3-35% water, 2-15% protein and 0.1-0.6% mineral matter. The composition of fat in adipose tissue is highly variable and depends on nutrition, breeding, age, type of animal.

In water, fats are insoluble biomolecules. They are present in the muscles as a structural component of muscle membrane, between the muscle fibers as a droplets depot of triacylglycerol, and as adipose tissue, as to fat that gives the meat marbling. Fats represent about 5% of the cells organic matter. In the cell, there is 40-50 different types of fats. The cells of the brain and nervous tissue, are extremely rich in fats.

For cattle and sheep, diet has a great effect on the deposition of intramuscular fat *(De Smet et al., 2004; Grubić et al., 2005)*, as well as on the concentration of saturated fatty acids (SFA) and polyunsaturated fatty acids (PUFA).

Lipids from meals are hydrolyzed in the rumen of ruminants. Unsaturated fatty acids from foods pass through the process of biohydrogenation by acting of microorganisms of the rumen. The result is that the ruminants predominantly absorb saturated fatty acids, so that the food that comes from ruminants contains a higher percentage of saturated fatty acids. When the biohydrogenation in the rumen is not complete, part of the conjugated linoleic acid (CLA) managed to avoid it and the animals absorb it in that form, so that the tissues and their products are supplied by isomers of CLA (mixture of isomers of conjugated linoleic acid).

Mainly, meat from ruminants fed with grass containing more PUFA, n-3 PUFA, CLA, vitamin E, beta-carotene and vitamin A compared to meat from ruminants fed with grains *(De Smet et al., 2004; Bressan et al., 2014)*. Several studies are conducted with the aim to determine the fatty acid profile in goat meat *(Sheridan et al., 2003; Madruga et al., 2009)*. However, biohydrogenation, transition of unsaturated into saturated fatty acids, elongation of fatty acid chain, as well as the metabolism and deposition rate, are not clear. After all, the composition of the fat in goats meat compared to monogastrics animals (e.g. swine.), is similar to other ruminants: large quantities of SFA, lower amounts of the PUFA, the presence of C18:1 and C18:2 trans and cis isomers of FA.

In animals, the main PUFA (C18:2n-6 and C18:3n-3) are obtained from the diet, but in ruminants, are biohydrogenized by ruminal bacteria into the intermediate FA and C18:0. The intermediate biohydrogenation includes cis and trans C18:1 isomers and C18:2 trans isomers, conjugated or unconjugated. Their concentration in the meat is related to reducing of C18 PUFA *(Bessa et al., 2000)*. The grain feeds are considered as good source of C18:2n-6, while a green grass on pasture is rich in C18:3n-3 *(Goffman and Böhme, 2001; Boufaied et al., 2003)*.More grazing in ruminant nutrition leads to higher percentage of omega-3 fatty acid, which is highly desirable.

C18:2 cis-9, trans-11 is quantitatively the largest isomer of CLA, and is more presents in the meat of ruminants fed on pasture compared to the meat of ruminants fed with grain feeds. Even it is thought, that this FA occurs in the rumen, about 70-80% of the acid is accumulated in the tissues as a result of endogenous transition into unsaturated C18:1 trans-11, catalyzed by the enzyme Δ9 desaturase *(Palmquist et al., 2004)*. As a consequence of the difference in the concentration of CLA is a consequence of the difference in the quantities of C18:1 trans-11 absorbed in the rumen. The meat of ruminants is a natural source of conjugated linoleic acid (CLA), since CLA is a product of the rumen. Of all ruminant meat, the lamb meat is the richest source of CLA, when in question is the meat as a source.

Ivanovic et al. (2014) are examined the impact of race (Serbian white goat, Balkan goat and Bunte Deutsche Edelziege) on the fatty acid composition of goat meat and found that there was a statistically significant difference between the individual fatty acids in samples. According to the findings of these authors, the ratio of unsaturated to saturated fatty acids (UFA / SFA) in the meat was for Serbian white goat 0.96, for Balkan goat 0.92 and for German Spotted breed (Bunte Deutsche Edelziege) 0.46.

Genetic groups of ruminants, and therefore the goat, show a significant difference in the activity of Δ9 desaturase, which converts SFA to cis-9 monounsaturated fatty acids (MUFA), and elongase which converts C16:0 to C18:0. In these biotransformations participate enzymes desaturase and elongase and of their activity, as well as the amount of a substrate depends on the intensity and efficiency of these reactions. Desaturases are enzymes that are responsible for

the introduction of a new double bond in the fatty acid chain. Between fatty acids of n-3 and n-6 series there is a competition for these enzymes. Elongase are enzymes that are responsible for the chain extension of the fatty acid by two carbon atoms, i.e. for the introduction of two new methylene groups.

Proteins. After the water, the proteins are the most represented in the body. In the organisms of the animals and humans are entering through food. Each species of living organisms contains specific types of proteins. The proteins of the one species are chemically different from the proteins present in the other species. Therefore, it is right to say that specificity of some kinds of living beings comes from the specificity of the protein of which are built. The proteins are built from 20 correct building units - amino acids - that are called the building units of proteins.

There is not much data for the composition of amino acids in the goat meat that are bred in Serbia. *Ivanovic et al. (2014)* have examined the composition of amino acids in the meat of different races. They used as samples the meat (*m. longissimus dorsi*) which was from the two goat races (Balkan and Serbian white goat).The goats whose samples were tested are grown in the area of Stara Planina, and were four years old. In winter, the goats are fed combined by: hay and concentrate, and in summer were taken to pasture. The content of individual amino acids is shown in Table 1.

Table 1.The composition of amino acids (g/100 g) in protein of Serbian white and Balkan goats

Serbian white goat				Balkan goat			
Amino acid	**Content**	**Amino acid**	**Content**	**Amino acid**	**Content**	**Amino acid**	**Content**
Alanine	4.93	Lysine	8.36	Alanine	4.98	Lysine	8.11
Arginine	5.44	Methionine	3.20	Arginine	5.54	Methionine	3.51
Aspartic acid	8.66	Phenylalanine	4.22	Aspartic acid	8.74	Phenylalanine	4.55
Cysteine	1.02	Proline	3.45	Cysteine	1.04	Proline	3.37
Glutamic acid	14.41	Serine	3.92	Glutamic acid	13.95	Serine	3.89
Glycine	3.97	Threonine	4.84	Glycine	3.91	Threonine	4.97
Histidine	3.62	Tryptophan	1.19	Histidine	3.84	Tryptophan	1.27
Isoleucine	4.63	Tyrosine	4.17	Isoleucine	4.71	Tyrosine	4.44
Leucine	8.13^{a}	Valine	4.97	Leucine	8.38^{b}	Valine	5.05

Legend:^{a,b} - Mean values within a row with superscript differ significantly ($P<0.05$)

According to the results shown in Table 1, just between leucine amino acids were statistically significant difference between the samples. The absence of differences in the composition of amino acids in meat samples, confirms that proteins are typical for the species. The results obtained in research by *Brzostowski et al. (2008), Webb et al. (2005),* also indicate that the proteins, or amino acid

composition are typical for the species. Regarding to the essential amino acid composition, the goat meat closely looks like beef and lamb *(Correa, 2011)*.

Vitamins and minerals. The meat and therefore goat meat is a good source of B vitamins (B1, B2, PP), minerals (P, Mg) and microelements.

Vitamins.In the nature, there is13 vitamins and all are essential, without exception.The vitamins are not food, nor a substitute for food.The vitamins do not provide calories and energy directly, but are essential to body, especially vitamin B - to convert food into the energy. The only way to enter in the body is through food, both plant and animal origin.The meat can be one of the sources of vitamins, especially vitamins of B group.The confirmation of this are gave *Lawrie (1981)*, and *Holland et al. (1995)*.

Minerals.The minerals are inorganic chemical elements which in very small quantities are entered through food in the human and animals' body. They participate in metabolism, synthesis of many hormones and enzymes that ensure the normal growth of the organism and maintain it healthy. As well as vitamins and minerals must be constantly import with food and in a certain amount. In the food that is a source of minerals is includes the meat of different animal species *(Holland et al., 1995)*. *Ivanovic et al. (2014)* have examined the content of microelements (mg/kg) in the meat of Serbian white goat and Balkan goat (4 years old).The obtained results are shown in Table 2.

Table 2. The content of microelements (mg/kg) in the kidneys of Serbian white and Balkan goats

Serbian white goat		Balkan goat	
Element	**Content**	**Element**	**Content**
Copper	0.73	Copper	0.58
Iron	7.25	Iron	6.51
Manganese	0.06	Manganese	0.07
Zinc	102.00	Zinc	114.00

According to *(Correa, 2011)*, goat meat has higher levels of iron (3.2 mg) when compared to a similar serving size of beef (2.9 mg), pork (2.7 mg), lamb (1.4 mg), and chicken (1.5 mg). Comparatively, goat meat also contains higher potassium content with lower sodium levels.

Carbohydrates. The carbohydrates are derived from the muscle and connective tissues. In the muscle tissue, there is a polysaccharide - glycogen, wherein the D-glucose molecules are linked with 1,4- glucosidic bond, while at the branching sites of the backbone with 1,6- glucosidic bond.The inclusion of glycogen are suspended in sarcoplasm. The content of carbohydrates in the muscles of animals for slaughter is relatively low and ranges between 0.5% and 1.5%.The red muscles contain more glycogen than the white muscles.In the muscles, where is occurred post-mortem glycolysisis a very small amount of glycogen, but the meat

containing intermediate products of metabolism:hexose-phosphates, triose-phosphates, pyruvic and citric acid and a significant amount of lactic acid (about 1%).The carbohydrates are also found in the glycoproteins and the mucopolysaccharides of the connective tissue *(Ivanović and Pavlović, 2015)*.

The nutritional value and the impact on human health

The goat meat has about the same nutritional value as the sheep (more precisely, more protein and less fat compared to the sheep meat). *Anaeto et al. (2010)* state that, because of the molecular structure, the goat meat is more easily digested. Due to low content of saturated fatty acids and cholesterol, the goat meat in the human diet is healthier alternative compared to other types of red meat. According to the same author, polyunsaturated fatty acids prevalent in goat meat, and the diet rich in unsaturated fatty acids is correlated with a reduced risk of stroke and coronary disease. In addition, in goat meat are present the essential amino acids such as lysine, threonine and tryptophan.

The nutritional value of goat meat affects human health, because it is not only contains less total fat and cholesterol, but also content of saturated fatty acids are lower than in the traditional types of meat (Table 3).

Table 3. The nutrient composition of goat and other types of meat

Nutrient	Goat	Chicken	Beef	Pork	Lamb
Calories (kcal)	122	162	179	180	175
Fat (g)	2.6	6.3	7.9	8.2	8.1
Saturated Fat(g)	0.79	1.7	3.0	2.9	2.9
Protein (g)	23	25	25	25	24
Cholesterol (mg)	63.8	76.0	73.1	73.1	78.2

[1] Per 3 oz. of cooked meat
[2] USDA Nutrient Database for Standard Reference, Release 14 (2001)

Less saturated fats and a relatively high percentage of total unsaturated fats seems that the goat meat is very healthy.

The saturated fats are fats or fatty acids that do not include double bonds between carbon atoms in the fatty acid chain. They form a solid or semi-solid fat at room temperature, and are the cause of the increase in cholesterol levels. The amount of cholesterol in the food has only a moderate effect on the amount of cholesterol in the bloodstream.

The unsaturated fats are fats or fatty acids that contain one or more double bonds between the carbon atoms in the fatty acid chain. Where double bonds are formed, hydrogen atoms are eliminated. The fatty acids are monounsaturated when containing one double bond, and polyunsaturated if they contain more than one

double bond. Monounsaturated and polyunsaturated fats are in liquid form at room temperature. It is known that they reduce the risk of heart disease and stroke.

According to *the Harvard School of Public Health (2008)*, saturated fats (the bad fats) increase the risk of cardiovascular disease and other chronic diseases, while unsaturated fats (good fats) can improve cholesterol level in blood, alleviate inflammation, stabilize heart rhythm, and have numerous other useful effects.

When we talk about the effect of saturated and unsaturated fats on blood cholesterol levels and risk for heart disease, it is necessary to clearly understand the lipoproteins. The lipoproteins are complex particles consisting of a core of hydrophobic lipids that are surrounding by a layer of phospholipid and protein (lipid-binding proteins), that make up the particles are soluble in water. Due to the hydrophobic (water-repellent) nature of lipids, lipoproteins are the forms in which lipids as cholesterol, are transporting in the blood. The two main types of lipoprotein particles in the human blood are low density lipoproteins (LDL) and high density lipoproteins (HDL).Of these two lipoprotein holders of cholesterol, HDL contains relatively high concentration of protein and a small amount of cholesterol. Opposite, LDL contains a relatively low concentration of protein, and a large amount of cholesterol as a primary lipid. Usually, LDL transport cholesterol from the liver into cells throughout the body. The body is using cholesterol for the formation of cell membranes and the synthesis of vitamin D, estrogen, testosterone, and other steroid hormones. If is not used, LDL continues to bear the cholesterol through the blood. When too much LDL cholesterol circulates in the blood, these particles can attach themselves to the walls of arteries and form plaque that narrows arteries, restrict or block the flow of blood and thus cause heart attack or stroke. So, LDL cholesterol is often called "bad" cholesterol. Since HDL transports cholesterol from the cells, from the walls of the arteries and blood back to the liver for processing, HDL cholesterol is often called "good" cholesterol.

The clinical studies show that saturated fats originating from foods increase levels of LDL cholesterol, while monounsaturated and polyunsaturated fats can help in reduce LDL cholesterol and increase levels of HDL cholesterol in the blood. Based on these findings, it can be argue that the goat meat helps reduce blood cholesterol levels and thereby reduce the risk of atherosclerosis and coronary disease *(Correa, 2011)*.

Regardless to the nutritional value, the goat meat is still less appreciated due to their specific smell and taste, the more if the animal is older *(Ivanović et al., 2011)*.

Conclusion

The world's production of goat meat in the past ten years is increased by 30%.Compared to other types of meat (beef, lamb, chicken), goat meat has less acceptable taste and odor, but it is very similar nutritional value.The goat meat has

about the same nutritional and digestible value, as well as sheep. The nutritional value of goat meat affects human health, because it is not only contains less total fat and cholesterol, but also content of saturated fatty acids are lower than in the traditional types of meat. It is accepted that increasing levels of n-3 fatty acids (FA) in the human diet reduces the risk of heart problems and arteriosclerosis, and isomers of conjugated linoleic acids (CLA) have anticarcinogenic and antiarterogenic properties.

Due to the high nutritional value, the goat meat should be more promote in Serbia and thus improve his sale on the market.

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Kvalitet mesa koza i njegov uticaj na zdravlje ljudi

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Rezime

Danas su koze rasprostranjene u celom svetu. Žive u malim ili velikim stadima i to u različitim oblastima i okruženjima. Zbog svojeg karakterističnog ukusa i poželjnog hemijskog sastava, kozje meso se sve više konzumira u Srbiji. Kao namirnica životinjskog porekla bogata je proteinima, vitaminima i mineralima, sadrži vrlo malo masti, a posebno holesterola. Cilj ovog preglednog rada je da se istaknu neke zdravstvene prednosti, nutritivne vrednosti i potencijalna upotreba kozjeg mesa. Na hemijski sastav mesa koza utiču rasa, pol, proizvodnost i adaptiranost na stres, okolina, menadžment, ishrana, telesna masa prilikom klanja i zdravstveno stanje ali i klanje i postupci sa trupom posle klanja. Prosečan hemijski sastav krtog mesa koza sadrži oko 75.42 % vode, 3.55 % masti, 19.95 % proteina i 1.06 % mineralnih materija. Energetska vrednost je oko 580 kJ na 100 grama. Kozje meso ima otprilike istu hranljivu vrednost kao i ovčije. Zbog niske zastupljenosti zasićenih masnih kiselina i holesterola, kozje meso u ishrani ljudi, je zdravija alternativa u poređenju sa drugim vrstama crvenog mesa. Polinezasićene masne kiseline preovlađuju u mesu koza, a ishrana bogata sa nezasićenim masnim kiselinama je u korelaciji sa smanjenim rizikom od moždanog udara i koronarnim bolestima. Pored toga, u mesu koza zastupljene su esencijalne amino kiseline kao

što su lizin, treoninitriptofan.Bez obzira na nutritivnu vrednost, meso koza je ipak manje cenjeno zbog specifičnog mirisa i ukusa, tim više ukoliko je životinja starija.

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