International Food Research Journal 23(6): 2540-2544 (December 2016)

Journal homepage: *http://www.ifrj.upm.edu.my*

The value of the lamb meat in human nutrition

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Article history

Received: 18 December 2015
Received in revised form: 24 February 2016
Accepted: 7 March 2016

Keywords

Lamb meat
Breed
Protein
Amino acids
Nutrition
Biological value

Abstract

The samples of lean tissue of 6 and 8 months old lambs of various breeds have been chosen as data for meat nutrition value study. We have found out that meat of purebred and cross-bred sheep (both 6 and 8 month old) has high biological value. However, it should be noted that lamb meat of animals from the first group (Bakur pure breed (B) and Bakur-Edilbaev crossbreed (BxE)) contains slightly more proteins than lamb meat of animals from the second group (Stavropol pure breed (S) and Stavropol-Edilbaev crossbreed (SxE)), and that meat of crossbreeds of both studied group also contains more proteins that meat of purebred animals. We have not found any significant impact of breed and age of animals on content of most amino acids excluding lysine as lamb meat of animals from S and SxE group contains more lysine compared to meat of animals from B and BxE group (both 6 and 8 months old). According to test results, 100 g of lamb meat produced from 6 months old animals of group B provides 18.3 – 33.6 % of the required amounts of essential amino acids, lamb meat produced from the similar animals of group BxE provides 20.3 – 35.8%; group S – 13.6 – 48.3%; group SxE – 14.2 – 50.3%. We also found out that limiting amino acids of the protein of lamb meat from two studied animal groups (B and BxE; both 6 and 8 months old) are valine, phenylalanine and tyrosine. We have not found any limiting amino acids in the protein of lamb meat of animals from groups S and SxE (both 6 and 8 months old). Amino balance/imbalance coefficient indicates that amino acid content of lamb meat protein for all studied animal breeds (B, BxE, S and SxE) and ages (6 and 8 months old) is rather balanced compared to ideal reference protein.

Introduction

Human nutrition plays an integral role in normal operation of all body systems. This process depends rather closely on nutrition value of food products. Insufficient amount or lack of any particular essential biologically active substances in food leads to disruption of biochemical processes and body systems operation. The composition of food products has a big impact on human body functioning. The quality and safety of food determines the human health as it may cause and treat diseases as any substance introduced into the human body affects its systems in some particular way (Bazarkova *et al*., 2004; Baturin *et al*., 2005).

The primary sources of native protein are products of animal origin. Among such products, the meat of slaughter animals is especially significant. According to various contemporary conceptual ideas regarding human nutrition, meat is a source of specific vital nutrients (first and foremost, native animal protein) which are either absent in other food products or their content is insignificant and the form is hard to digest. The presence of such nutrients is what makes meat such a high-value product in terms of nutrition and physiology (Kreiger-Metbach, 2007).

During the last decade, production of cattle meat in Russia decreased while pork and especially poultry meat production increased. Sheep breeding is a much less labor- and capital-intensive sector of animal breeding compared to others. Therefore, the study of lamb meat of cross-bred animals becomes especially necessary.

According to studies (Lushnikov *et al*., 2008;

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Krishtafovich *et al*., 2011), meat of young cross-bred sheep (produced by breeding Bakur and Stavropol ewes to Edilbaev rams) is a product with nutritional value with a balanced composition of such important nutrients as proteins and fats. Amino acid composition study has shown that meat protein of both studied animal groups contain very high amount of essential amino acids. The authors also established that the quality of lamb meat depends on lamb age and breed and that 6-8 months old cross-bred animals' carcasses are the most suited for lamb meat production.

Analysis of fat tissue (both internal and tail) quality has shown the impact of animal age and type of fat tissue on its qualitative characteristics. For example, it has been established that tail fat tissue contains a higher amount of polyunsaturated fatty acids compared to internal fat tissue. This trend is especially evident for fat tissue of 6-8 months old lambs (Lushnikov *et al*., 2009; Krishtafovich *et al*., 2013). In this paper, we would like to establish whether meat produced from 6-8 months old lamb provides the amount of vital nutrients required by physiological consumption standards.

Materials and Methods

The subjects of meat nutrition value study are samples of lean tissue of 6 and 8 months old lambs. According to GOST (State Standard) no. P 52843-2007 (Slaughter Animals: Sheep and Goats. Mutton, Lamb and Goat Meat Carcasses. Technical Specifications), sheep up to 12 months old are considered lambs. Lamb meat can be classified as extra-, first-, second- and third-class depending on the mass of carcass. For the purpose of this study, we used extra- (more than 23 kg) and first-class (20 – 23 kg) carcasses of 6 and 8 months old cross-bred lambs (Surzhanskaya *et al*., 2011).

The studied animals have been divided into two groups: the first group included 6 and 8 months old purebred Bakur (B) and cross-bred Bakur-Edilbaev lambs (BxE); the second group included 6 and 8 months old purebred Stavropol (S) and cross-bred Stavropol-Edilbaev lambs (SxE). Purebred Bakur (B) and Stavropol (C) lambs have been used as control group. The lambs were bred by various agricultural enterprises of Saratov Region.

Total lean tissue protein content has been established by Kjeldahl method. Amino acid composition of lamb lean tissue protein has been established by standard methods using amino acid analyzer.

Amino acid score has been calculated as follows (Lipatov *et al*., 2001):

$$C = \frac{A_i \times 100}{A_{cmi}},$$

where C is amino acid score, %;

A_i is essential amino acid content in the studied protein, g/100 g of protein;

A_{cmi} is the aforementioned acid content in the "ideal" protein as established by FAO/WHO standards, g/100 g of protein.

Biological value of protein has been defined by utility coefficient, indexes of "excessive content" and "collatable excessiveness" of protein amino acid composition as well as amino balance/imbalance coefficient.

The utility coefficient has been calculated as follows (Lipatov *et al*., 2001):

$$U = \frac{\sum_{I=1}^{K} (A_i \times \alpha_i)}{\sum_{I=1}^{K} A_i},$$

where U is the amino acid composition utility coefficient which serves as an indicator of balanced essential amino acid composition compared to reference protein;

A_i is the content of a particular amino acid in product protein, g/100 g of protein;

α_i is the utility coefficient of a particular amino acid.

The "collatable excessiveness" index shows the total amount of essential amino acids in studied product protein which cannot be processed by human body due to amino acid imbalance compared to reference protein. This index has been calculated as follows (Lipatov *et al*., 2001):

$$G_c = \frac{G_n}{G_{min}}$$

where G_c is the "collatable excessiveness" index;

G_n is the essential amino acid "excessive content" index;

G_{min} is the minimal score of essential amino acid of studied protein compared to ideal reference protein, %.

In turn, the "excessive content" index is calculated as follows (Lipatov *et al*., 2001):

$$G_n = \sum_{I=1}^{K} (A_i - G_{min} \times A_{cmi})$$

Amino balance coefficient (ABC) U is a numerical characteristic of balanced composition of essential amino acids compared to physiological standard (reference protein). It is calculated as follows (Lipatov *et al*., 2001):

$$U = C \min \sum_{j=1}^{n} Aaj \; / \sum_{j-1}^{n} Aj \;,$$

where Aj is the weight ratio of essential amino acid no. *j* in the product, g/100 g of protein;

Aaj is the weight ratio of essential amino acid no. *j* in accordance with requirements of physiological standard (in reference protein), g/100 g of protein

Amino imbalance coefficient (AIC) R is a numerical characteristic of imbalanced composition of essential amino acids compared to physiological standard (reference protein). It is calculated as follows (Lipatov *et al*., 2001):

$$R = (\sum_{j=1}^{n} Aj - C \min \sum_{j=1}^{n} Aaj) / \sum_{j=1}^{n} Aj \;,$$

where R is the parameter characterizing the total mass of essential amino acids unused by anabolic processes.

Results and Discussion

Meat biological value is a very important characteristic of human nutrition balance. Proteins are, first and foremost, plastic and energy-yielding material for human body cells which is an important criterion for assessing nutritional value of food product. The amount of protein received by the human body must correspond with its average daily physiological needs.

For adults, the physiologically required daily amount of protein varies from 65 to 117 g for men and 58 to 87 g for women, with recommended share of animal protein in the daily diet being equal to 50% from the total amount of consumed proteins. For the purpose of our study, we have chosen the physiologically required amount of protein for men equal to 91 g, i.e. 45.5 g of animal protein (The Russian Federation Standard, 2008). Amino acid composition of lean tissue of purebred and cross-bred 6 and 8 month old lambs' carcasses is provided in Tables 1 and 2. According to these Tables, the studied lamb meat is a rather balanced protein product.

Consumption of 100 g of studied lamb meat produced from 6 months old Bakur (B) and Bakur-Edilbaev (BxE) cross-bred sheep provides 44.7 and 47.9% of required amount of animal protein, while consumption of the same amount of meat produced from sheep of the second group (Stavropol (S) and Stavropol-Edilbaev (SxE) breeds) provides 42.7 and 43.7%, respectively. Such discrepancies can be explained by various meat production characteristics of studied breeds (Stavropol is a wool-bearing sheep breed, Bakur is a lamb and mutton sheep breed, while Edilbaev is a fat-tailed mutton sheep breed). That is why meat produced from the animals of the first groups contains slightly more protein. However, it should be noted that meat produced from cross-bred lambs of both groups contains more protein than meat produced from purebred animals.

The similar results have been observed for meat produced from 8 months old lambs of both groups. We have also established that protein content of that meat is 1.9 – 6.4% higher than that of meat produced from 6 months old lambs. The studied lamb meat contains all essential and nonessential amino acids required by the human body for production of its own tissues. Lamb meat proteins consist of amino acids that determine nutritional value of meat. For example, valine is capable of restoring damaged tissues. Lysine is the primary amino acid involved in protein digestion. Threonine participates in fat metabolism and prevents hepatic fat deposition. Phenylalanine affects psychological state of the person, namely, it enhances brain activity, improves memory and stimulates learning process.

According to test results, 100 g of lamb meat produced from 6 months old animals of group B provides 18.3 – 33.6 % of the required amounts of certain essential amino acids, lamb meat produced from the similar animals of group BxE provides 20.3 – 35.8%; group S – 13.6 – 48.3%; group SxE – 13.6 – 49.5%. Analysis of test results also shows that consumption of 100 g of lamb meat produced from animals of groups S and SxE provides up to 48.5 and 49.5% (respectively) of required maximal lysine amount as well as up to 13.6% of minimal methionine and cystine amount, while lamb meat produced from animals of groups B and BxE provides up to 32.7 and 35.8% of lysine and 22.3 and 23.8% of methionine and cystine, respectively. We have not found any significant discrepancies between other amino acids contents in lamb meat produced from animals of different studied breeds.

We also established that consumption of 100 g of lamb meat produced from 8 months old animals of B group provides 18.5 – 37.0% of required amount of certain essential amino acids; lamb meat produced from the similar animals of group BxE provides 21.4 – 45.0%; group S – 14.0 – 48.5%; group SxE – 14.2 – 50.3%. According to test results, lamb meat produced from 8 months old animals of various breeds contains the same amount of lysine, methionine and cystine as lamb meat produced from 6 months old animals of the same breed.

We also have not found any significant discrepancies between other amino acids contents in lamb meat produced from 8 months old animals compared to meat produced from 6 months old lambs as well as between meat produced from different breeds. Nonessential amino acids also play a vital physiological role in human body operation with some of them (arginine, tyrosine, glutamic acid) being as important as essential amino acids.

According to test results, 100 g of lamb meat produced from 6 months old animals of group B provides 7.0 – 46.6% of the required amounts of nonessential amino acids, lamb meat produced from the similar animals of group BxE provides 4.4 – 50.0%; group S – 16.2 – 39.4%; group SxE – 18.8 – 42.3%. We have also established that consumption of 100 g of lamb meat produced from animals of groups B and BxE provides up to 46.6 and 50.6% (respectively) of required maximal histidine amount as well as up to 39.0 and 43.0% of required glycine amount, while lamb meat produced from animals of the other test group (S and SxE) provides up to 39.47 and 42.3% of glycine, respectively. Praline content in studied meat is the smallest among other amino acids: meat produced from 6 months old lambs of groups B and BxE contain only 7.0 and 4.4% while meat produced from similar animals of groups S and SxE contain only 16.2 and 17.0% of required daily amount of proline, respectively. We also have not found any significant discrepancies between other amino acids contents.

Thus it should be noted that 100 g of lamb meat produced from 8 months old animals of group B provides 7.0 – 50.6% of the required amounts of nonessential amino acids, lamb meat produced from the similar animals of group BxE provides 6.4 – 48.8%; group S – 17.0 – 39.4%; group SxE – 16.6 – 42.9%. According to test results, lamb meat produced from 8 months old animals of various breeds contains the same amount of histidine, glycine, serine and proline as lamb meat produced from 6 months old animals of the both studied groups.

In order to assess biological value of protein components we used method proposed by A.A. Lipatov and I.A. Rogov (Lipatov *et al.*, 2001), Members of the Academy of Science. Parameters provided in Tables 3 and 4 can be used to establish whether the protein composition is balanced. Biological value of studied protein have been assessed on the basis of limiting amino acid score. In this case, limiting amino acid is the one whose score is less 100%, thus limiting biological value of the protein.

According to our data, valine is the limiting amino acid for lamb meat produced from animals of two studied groups (B and BxE) as its score value is 87.4% in the case of lamb meat produced from 6 months old animal of group B (and 88.4% in the case of group BxE) as well as phenylalanine and tyrosine for group B (their score is 97.8%). This value of valine score indicates that nitrogen contained in the meat can be used to produce only 87-88% of human body tissues.

In the case of meat produced from 8 months old lambs of groups B and BxE, the limiting amino acids remain the same (valine, phenylalanine and tyrosine). However, in the case of group B there is another limiting amino acid – threonine (its score is 99.2%). Protein of the meat produced from both 6 and 8 months old lambs of groups S and SxE do not have any limiting amino acids. Maximal score for both studied groups is observed for tryptophan, lysine, methionine and cystine. These amino acids are sources of non specific nitrogen used to “fuel” metabolic processes of human body.

Amino acid composition utility coefficient of meat produced from the animals of control group (B and S) varies from 0.7 to 0.9, while the same coefficient of meat produced from animals of test group (BxE and SxE) varies from 0.7 to 0.8. Utility coefficient is a function of “excessive content” index. This parameter indicates that out of 100 g of protein consumed with lamb meat produced from Bakur sheep and their cross-breeds (Bakur-Edilbaev) 10.2-10.8 g of protein are not digested by the human body, while in the case of Stavropol sheep and their cross-breeds (Stavropol-Edilbaev) 14.0-14.1 g of protein are not digested. This is valid for meat produced from both 6 and 8 months old lambs.

“Collatable excessiveness” index shows the total amount of non-essential amino acids in studied meat protein which can not be digested and utilized by the human body due its imbalanced composition compared to reference protein (Nechaev *et al.*, 2003). Thus, “collatable excessiveness” index for control group meat varies from 12.6 to 13.7 g while the same index for test group meat varies from 13.0 to 14.0 g, respectively.

Estimation of amino balance and imbalance coefficients has shown that amino acid composition of studied protein is rather well-balanced compared to ideal reference protein; amino balance coefficient varies from 0.32 to 0.68 and is directly proportional to amino imbalance coefficient which varies from 0.34 to 0.40. These values are not affected by either age or breed characteristics of studied animals.

Conclusions

Thus, we have found out that meat of purebred and cross-bred sheep (both 6 and 8 month old) has high biological value. However, it should be noted that lamb meat of animals from the first group (Bakur pure breed (B) and Bakur-Edilbaev crossbreed (BxE)) contains slightly more proteins than lamb meat of animals from the second group (Stavropol pure breed (S) and Stavropol-Edilbaev crossbreed (SxE)), and that meat of crossbreeds of both studied group also contains more proteins that meat of purebred animals. We have not found any significant impact of breed and age of animals on content of most amino acids excluding lysine as lamb meat of animals from S and SxE group contains more lysine compared to meat of animals from B and BxE group (both 6 and 8 months old).

According to test results, 100 g of lamb meat produced from 6 months old animals of group B provides 18.3 – 33.6% of the required amounts of essential amino acids, lamb meat produced from the similar animals of group BxE provides 20.3 – 35.8%; group S – 13.6 – 48.3%; group SxE – 14.2 – 50.3%. We also found out that limiting amino acids of the protein of lamb meat from two studied animal groups (B and BxE; both 6 and 8 months old) are valine, phenylalanine and tyrosine. We have not found any limiting amino acids in the protein of lamb meat of animals from groups S and SxE (both 6 and 8 months old). Amino balance/imbalance coefficient indicates that amino acid content of lamb meat protein for all studied animal breeds (B, BxE, S and SxE) and ages (6 and 8 months old) is rather balanced compared to ideal reference protein.

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