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Research Article

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Lysine - an Absolutely Essential Amino Acid in Soybean Proteins from the Russian Selection

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ABSTRACT

The study aims to evaluate the content of lysine, a valuable and important amino acid for food and feed purposes in the protein composition of soybean grain in varieties bred in the Federal Scientific Centre of All-Russian Scientific Research Institute of Soybean (Russian Federation) from 2003 to 2021. Lysine is the first limiting amino acid which is essential for normal metabolism of proteins from food and feed. If this amino acid is not sufficient, no matter how much protein is ingested in humans and animals, it will not be properly metabolized. Its high requirement (3-5 g per day in humans) makes it one of the most important essential amino acids. A high content of this amino acid is found in soybeans. A laboratory study of the amino acid composition of soybean protein was carried out in 2018 -2020 by diffuse light reflection in the infrared region of the spectrum on a FOSS NIR Systems 5000 model IR scanner. It was found that the lysine content in the protein of soybean grain of Amur varieties, ranged from 6.0 to 6.3% of total protein, which is significantly higher than varieties of European breeding. In all of the studied varieties, the Institute's selection has an amino acid index of lysine ranging from 109 to 113%, which significantly exceeds the FAO/WHO standard. The highest lysine indices were observed for the variety Kruzhevnitsa (6.3%).

Key words: *Soybean, Varieties, Protein, Lysine, Amino acid index*

INTRODUCTION

Lysine is an aliphatic amino acid with selected bases (2,6-diaminohexanoic acid). Lysine belongs to the group of diamino, or double-base amino acids, which contain two amino groups [1]. According to the degree of hydrophobicity, lysine belongs to the group of highly hydrophilic amino acids [2]. Like other aliphatic amino acids, it is not synthesized in animals and humans and is an essential amino acid [3]. Lysine is the first of the limiting amino acids that are essential for the normal metabolism of dietary proteins [4]. If this amino acid is deficient, no matter how much protein is ingested, it will not be absorbed normally, leading to fatigue, fatigue and weakness, poor appetite, stunted growth and weight loss, inability to concentrate, irritability, ocular hemorrhages, hair loss, anemia and reproductive problems [5]. Lysine is involved in the absorption of calcium, which is essential for the growth of muscle tissue and is an important element for maintaining the immune system [6]. Its relatively high daily requirement (3-5 g) for humans makes it one of the most important essential amino acids. Its deficiency in the diet leads to a decrease in the number of red blood cells and hemoglobin, dystrophic changes in muscles,

liver, and lungs, impaired calcification of bones [7]. Feed additives with lysine are widely used in animal husbandry, which can increase the weight gain of animals and poultry by 10-30%, increase milk yield by 12%, increase the egg production of chickens by 10% [8, 9]. It should be noted that lysine is a deficient amino acid for cereal proteins, so its deficiency is the main reason for the reduced value of plant feeds [10]. High levels of this amino acid are found in amaranth and legumes, especially soybean [11]. Consumption of only 150-250 g of seeds of this crop can fully meet the daily requirement of many farm animals in this amino acid in the absence of other sources of protein in the diet, while the seeds of grain crops would require 5-7 times more [12]. This fact makes it relevant to research the identification of soybean varieties with increased lysine content in the amino acid composition of protein. Accordingly, the purpose of the research in this scientific work was to evaluate the protein of soybean grain of different varieties of Amur breeding, bred in All-Russian Scientific Research Institute of Soybean in 2003 - 2020 by their lysine content. The study aimed to identify the most suitable varieties suitable for high lysine products and feed additives with an increased nutritional and fodder value.

MATERIALS AND METHODS

The soybean varieties were tested at the Federal Scientific Center All-Russian Scientific Research Institute of Soybean in the period from 2003 to 2021. Throughout this period, the institute's testing laboratory performed analyses and determined the protein content and amino acid composition of soybean grain of the varieties transferred for production (listed in the State Register of Breeding Achievements of the Russian Federation as of 2021). The results of at least 3-year trials are taken as a basis. For example, the 3-year data were taken into account only for varieties released in 2019 (Topaz, Sentyabrinka, and Zolushka). Data for a longer period are taken into account for the oal varieties.

In the year when the analysis was conducted, seed samples were taken from the collection nurseries of the Soybean Breeding Laboratory of the All-Russian Research Institute of Soybean Breeding (Sadovoye village, Tambovsky district, Amur region, RF) after harvesting. Grain protein content and amino acid composition were determined by diffuse reflectance of light in the infrared region of the spectrum using a FOSS NIRSystems 5000 infrared scanner (Denmark). Standard calibration equations of FOSS Analytical A/S were used for protein determination. Calibration equations for the determination of amino acid composition were developed in 2009 - 2010 by the Analytical Group of the All-Russian Research Institute of Soybean [13]. In this case, samples of soybean grain, whose amino acid composition had been previously studied by liquid chromatography using an automatic amino acid analyzer LKB 01 (Sweden), were used as standards [14]. Analyses were generally performed in 3 analytical repetitions. Mathematical data processing was performed using Statistica 6.0 software.

RESULTS AND DISCUSSION

The Food and Agriculture Organization of the United Nations and the World Health Organization have developed the Ideal Protein Standard (FAO/WHO standard) for assessing the nutritional and biological value of proteins in food and feed products [5, 15]. To evaluate the protein quality of a product, it is necessary to compare its amino acid content with the amino acid composition of the "ideal protein" and calculate the amino acid index (Scor), which is the ratio of the amount of amino acid in the product protein to the amount of the same amino acid in the "ideal protein", expressed as a percentage. For lysine, the amino acid index is established as 5.5 g per 100 g of protein (5.5%). The table shows the data on protein and lysine content in the amino acid spectrum of soybean grain obtained by the Analytical Group of All-Russian Scientific Research Institute of Soybean in the study of the biochemical composition of new and promising soybeans varieties.

Table 1. Protein content (% of dry matter), protein lysine (% of amino acid sum), and its amino acid index (% of FAO/WHO standard) in soybean varieties selected by the All-Russian Scientific Research Institute of Soybean breeders

Soybean Variety	Protein	Lysine	Amino Acid Index
Ultra-Early Ripening Soybean Varieties			
Topaz	40.8	6.2	112.7
Early Ripening Soybean Varieties			
Lidiya	40.2	6.1	110.9
Gratsiya	39.3	6.2	112.7

Statnaya	39.3	6.0	109.0
Umka	39.5	6.2	112.7
Kruzhevnitsa	40.1	6.3	114.5
Sentyabrinka	42.3	6.1	110.9
Srednee	39.6	6.2	
Pearson Pair Correlation Coefficient			-0,10
Medium-Ripening Soybean Varieties			
Garmonia	38.6	6.1	110.9
Persona	39.4	6.1	110.9
Dauria	38.8	6.2	112.7
Pepelina	39.1	6.1	110.9
Kuhanna	41.3	6.2	112.7
Layurnaya	40.1	6.2	112.7
MK 100	38.4	6.2	112.7
Evgeniya	38.7	6.0	109.0
Nega 1	39.1	6.2	112.7
Kitrossa	38.9	6.2	112.7
Lebedushka	39.5	6.2	112.7
Zhuravushka	38.5	6.2	112.7
Nevesta	40.1	6.1	110.9
Intriga	39.4	6.1	110.9
Zolushka	39.3	6.1	110.9
Srednee	39.2	6.2	
Pearson Pair Correlation Coefficient			+0,12
Late-Ripening Soybean Varieties			
Alena	38.4	6.1	110.9
Bonus	39.0	6.2	112.7
Srednee	38.7	6.1	
Critical Range of Difference ($CR_{0,95}$)	0.91	0.06	

According to S.V. Bobkov *et al.* [16], the lysine content in the spare proteins of European soybean grain varies from 3.3 to 5.7 % of the total amino acid composition. Only a small number of these varieties have a lysine content following the FAO/WHO standard. The All-Russian Scientific Research Institute of Soybean varieties, according to **Table 1**, significantly exceed the European varieties, as well as the FAO/WHO standard for lysine in general. The lysine content in grain protein of Amur soybean varieties varies from 6.0 to 6.3%. At the same time, the Institute varieties have a good amino acid index for lysine - it is above 100%. It is generally accepted that the lysine content of 6.3% of the total amount of amino acids or 5.9 mg/100 g of protein characterizes proteins as highly lysine products, increasing the value of the crop in feed mixtures for farm animals [17]. The highest lysine content was found for the variety Kruzhevnitsa (6.3%). Such indicators allow us to assign this variable to the category of high lysine and recommend it for the preparation of high-quality food products and feed additives. The Kruzhevnitsa variety belongs to early-ripening varieties (vegetation period 99 - 106 days [10]). This variety is recommended for cultivation in various regions of the Russian Federation.

No differences in lysine content depending on the early ripening of the varieties were found. In general, the data obtained on lysine content in different varieties of the All-Russian Scientific Research Institute of Soybean is highly stable, as evidenced by the index of critical differences, which does not exceed the value of 0.1. For all ripeness groups, the average lysine content is 6.1%. There were no interdependencies between lysine content and protein content of the variety. The Pearson pair correlation coefficient between protein content and lysine content was very low (from - 0,1 to + 0,12).

CONCLUSION

The lysine content in grain protein of soybean varieties of the All-Russian Scientific Research Institute of Soybean breeding ranges from 6.0 to 6.3%, which is significantly higher than in varieties of European breeding. The Amur varieties have a high amino acid index for lysine from 109 to 113%, which significantly exceeds the FAO/WHO standard. The highest lysine indices were found in the early-ripening variety Kruzhevnitsa (6.3%). These values allow this variety to be classified as a high lysine variety and recommend it for the preparation of quality food products and vegetable feed additives.

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