

STUDYING BIOAVAILABILITY OF PROTEIN FILLING FOR EXTRUDED CEREAL CROPS

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Abstract

Currently, the main category of people who use extruded products in their diets are active people with a lack of free time to prepare traditional dishes. It also highlights the category of population groups leading a healthy way of nutrition, strictly following components nutritional value of their daily diet, as extruded products have a low calorie content. At the same time, the improvement of extrusion technologies allowed producing combined products, i.e. products consisting of a base - grain shell, inside which there are various combinations of fillings. In this regard, in our work a protein filling was developed for starting extruded cereal products. The aim of this research was to study the amino acid composition of protein filling for production of extruded cereal products.

The sample preparation method used in this study was based on the AOAC official method 994.12.(25). Studied the amino acid composition of protein filling.

According to the research results, a high content of essential amino acids in protein filling was observed. In proteins of protein filling, the content of such essential amino acids as: valine, isoleucine, leucine, threonine, and phenylalanine + tyrosine exceeded that recommended by FAO/WHO for humans respectively by: 1.078; 1.0; 3.66 and 4.38. The total content of non-essential amino acids was -60.267 mg/g, and essential - 38.749 mg/g. The total amino acid content is 99.016 mg/g. According to research data, essential amino acids make up more than 1/3 of all amino acids, and this means high quality protein of protein filling.

Based on laboratory studies, the protein filling contains a rich amino acid composition, and allows to get extruded cereal products with a long shelf life.

Key words: *Amino acids, Protein filling, Daily need, Bio-availability, Extruded cereal products, Extruded products.*

1. Introduction

In recent year's extrusion technology dry products have occupied a large market share of ready-to-eat products. Main reason is that the extrusion processing of starch-containing raw materials is an environmentally safe, resource-saving and versatile process, which allows to obtain well-digestible, heat-sterilized foods with improved flavor properties.

Cereal extrudates are all kinds of cereal flakes, balls, sticks, and other forms of products. Cereal products obtained by extrusion technology, have all the nutritional properties of cereals. Food components, primarily vitamins, are well preserved during extrusion technology due to the short-term production cycle of exposure [1]. Production feature of extruded cereal products is the short exposure to high temperatures, which is very valuable when product is enriched with micronutrients. Reducing thermal effect contributes to the preservation of as many food components as possible. Thus, extrusion is a perspective method of producing high quality food products, the advantages of which are powerful performance, variability of technological parameters, preservation of nutrients, opportunities for effective enrichment, production of products with desired consumer properties, and reduction in cost of product [1].

Growth tendency for production and consumption of products with porous macrostructure is due to several reasons. Firstly, because of the reduction of time for cooking, and secondly, because of high flavor and

nutritional value, which fully satisfies the needs of consumers. Thirdly, because of the increase in demand, especially among young people, for ready-to-eat products with the addition of sweet ingredients. These types of products have become a regular acquisition among residents of many countries, also because the speed of preparation or the lack of it due to the change in pace of life for most people. However, ready-to-eat products must comply with the needs of safe and healthy eating [1].

Due to the relatively low cost of raw materials, simplicity and low cost of extruded food products production, the final product - extruded cereal products with filling will have a retail price slightly higher than the cost of crackers (chips), but much lower than a natural product of animal origin, having flavor characteristics natural product and long shelf life. Use of filling is to give a unique flavor to the final product. That way, the product can have beneficial properties of cereals and protein filling of animal origin [2].

In our work, we developed a protein filling for extruded cereal products. The main raw materials for filling used is cottage cheese.

When developing fillings, a combination of components, organoleptic characteristics (flavor, smell, appearance), and safety of nutrients were taken into account [2].



Figure 1. Extruded cereal products with protein filling

Due to the content of vitamins, minerals, amino acids in protein filling, authors have developed extruded cereal products with protein filling, which increase nutritional value and bioavailability of these products. The use of protein additives in production of extruded cereal products is a current trend. In this regard, authors evaluated the bioavailability of protein filling.

2. Materials and Methods

Object of study were protein fillings for starting in extruded cereal products. Experimental studies for determination of amino acids in protein fillings were carried out at Kenbugh National University in Degu, South Korea.

Content of amino acids was determined by use of amino acid analyzer "Hitachi High - Technologies Corporation" (Japan), and amino acid score was determined by calculation.

To obtain data on qualitative composition and quantitative content of amino acids in ducklings, Hitachi amino acid analyzer (Japan) was used on a 0.26 x 15 cm column. The instrument was calibrated using a standard mixture containing 3nM for each amino acid. Analysis was carried out on a column with a sulfonated copolymer of styrene mixed with 8% divinylbenzene at a constant temperature of 53 °C during the experiment. A step gradient from buffer solutions with different pH values (3.3 - 4.9) was used for elution of amino acids. The elution sequence of amino acids depended on the charge of amino acid molecules in acidic buffer medium, degree of hydration, molecular weight and hydrophobicity. Detection was carried out after the interaction of eluates with the ninhydrin reagent photometrically at a wavelength of 570 nm for all amino acids, the quantitative content was determined by detection at a wavelength of 440 nm.

3. Results and Discussions

Nutritional value of a food product is a set of properties of food product at which presence physiological satisfied human needs in necessary substances and energy. In other words, the nutritional value of a food product is a concept that integrally reflects the fullness of the useful properties of the product, including the degree to which this product provides the physiological needs of a human in basic nutrients and energy. The nutritional value of a food product is characterized by the chemical composition of the food product taking into account its consumption in generally accepted quantities and its energy value. In addition, to characterize the nutritional value of a food product, the concepts of the biological value of food protein and the biological efficiency of food lipids that are part of the product are used [3].

As a result of protein deficiency in organism, its normal work is disrupted, and as a result there can be loss of memory and weakening of mental abilities, as well as decrease in body resistance. At the same time, an excess of protein in organism leads to an overload of organs work, which primarily refers to liver and kidneys functioning. Minimum daily need of an adult for complete protein is 30 - 40 g per day.

The value of protein for human body is determined by two main parameters: its balance in the content of essential amino acids and in relation to the protein standard, and in addition by the exchange efficiency and utilization of protein in human body. In the works of other scientists it is noted that the achievement of

a balance level in the food products composition is possible only due to their complexity [4, 5]. Creation of multicomponent products is dictated by the possibility of regulating products chemical composition in accordance with the time needs of science of nutrition. Modeled multicomponent dairy products should be characterized by a maximum approximation to the standard nutrient composition.

A common method of evaluating amino acid composition should include a method of comparing the balance of amino acid scales, the test and reference proteins.

The aim of our research was to study the amino acid composition of protein filling for production of extruded cereal products. As a protein filling for extruded cereal products, we used: cottage cheese, crushed sprouted triticale, strawberry jam as a sweetening component, and vanillin for flavor. When developing fillings, the combination of components, organoleptic characteristics (flavor, smell, appearance) and the safety of nutrients were taken into account.

To express bioavailability of protein filling, used methods were based on comparing the results from determining amino acid composition of proteins of studied product with the "ideal" protein, for example, and the method of amino acid score. The content of essential amino acids of protein filling is displayed in Table 1.

Table 1. The content of essential amino acid protein filling

Essential amino acids	Content, mg/1 g protein	
	FAO/WHO standard	Test standard
Valine	5	6.078
Isoleucine	4	5
Leucine	7	10.657
Lysine	5.5	5.413
Methionine + Cysteine	3.5	3.633
Threonine	4	3.631
Phenylalanine + Tyrosine	6	10.337
Tryptophan	1	2.223
Total content of essential amino acids	36	46.972

When speaking about bioavailability of protein filling, we primarily talk about proteins that are contained in it, and a well-balanced composition of amino acids. From Table 1 can be seen that protein filling have a high content of essential amino acids, or more precisely this protein filling contains following essential amino acids: valine, isoleucine, leucine, threonine, and phenylalanine + tyrosine, which exceeded the recommended ones by FAO/WHO for human consumption.

Bioavailability of proteins depends not only on the content of essential amino acids, but also on their ratios - the greater the difference of these ratios in comparison

with the reference protein, the lower the biological value. Therefore, a very important indicator is amino acid score. Amino acid score - an indicator of protein bioavailability, which is the percentage of certain essential amino acid proportion in the total content of such amino acids in the studied protein to standard value of this proportion. The amino acid that determines bioavailability of given protein is considered to be the one that quickly has a minimum value. Amino acid score of protein filling shown in Table 2.

Table 2. Amino acid score, % of protein filling

Essential amino acids	Amino acid score, %
Valine	121.6
Isoleucine	125
Leucine	152.2
Lysine	98.4
Methionine + Cysteine	103.8
Threonine	91
Phenylalanine + Tyrosine	172.3
Tryptophan	222.3

Analysis of amino acid score showed that the protein of protein filling has a limiting acid, threonine. Amino acid lysine is very important for the immune system (Table 2). Leucine is a source of energy, and also contributes to restoration of bones, skin, and muscles. The bioavailability of this amino acid is higher in protein fillings by 52.2%. Isoleucine is one of the most essential amino acids necessary for the synthesis of hemoglobin. Amino acid isoleucine score is higher by 25% compared to the reference protein. The presence of valine is necessary for muscle metabolism, it repairs damaged tissues and it is important for the maintenance of normal nitrogen metabolism in organism. The decisive value of the score was 121.6%. Score of methionine and cysteine is 3.8% higher than that of the reference protein. Amino acid phenylalanine is essential for the human body and multifunctional. The difference in score of this amino acid with the reference protein was increased and amounted to 172.3% in protein filling. As for the amino acid score of tryptophan, it was 222.3%. This can be explained by the fact that in milk proteins the content of tryptophan is always at a high level. It is the main essential amino acid protein additive, which serves to determine the protein quality indicator.

When comparing amino acid score of the protein filling with the reference protein, it can be seen that almost all amino acid scores are increased, except for threonine (9% less) and lysine (1.6% less). In general, no significant differences were found.

For human, both types of amino acids are equally important: both essential and non-essential. Table 3 shows the content of non-essential amino acids in protein filling, %.

Table 3. The content of non-essential amino acids in protein filling

Non-essential amino acids	Content, mg/1 g protein
Aspartic acid	6,989
Serine	3,648
Glutamic acid	19,297
Glycine	1,023
Alanine	4,380
Cystine	1,173
Histidine	2,748
Arginine	3,771
Proline	12,411
Tyrosine	4,827
Total content of non-essential amino acids	60,267

Non-essential amino acids can be synthesized in organism. However, due to endogenous synthesis, only minimal needs of organism are provided. Satisfying the body need for non-essential amino acids should be mainly carried out due to their release in food as part of proteins. Non-essential amino acids include: alanine, aspartic acid, serine, glutamic acid, glycine, cysteine, histidine, arginine, proline, and tyrosine. They perform very important functions in the body, and some of them play a physiological one. A role not less, than essential amino acids. These include glutamic acid, cysteine and tyrosine.

The total content of non-essential amino acids was 60.267 mg/g, and essential - 38.749 mg/g. The total amino acid content is 99.016 mg/g. It is noted that the daily human need for protein depends on its quality: the more deficient the protein consumed is, the higher daily norm should be, and vice versa, the closer in composition the consumed proteins are to the "ideal" protein, the lower norm is (theoretically 56 - 53 g). In high quality proteins, essential amino acids make up about 1/3 of the mass of all amino acids. According to our research, essential amino acids make up more than 1/3 of all amino acids, and this means high quality protein of protein filling.

We were considering how much of our protein filling covers the daily dosage of amino acids per day. Table 4 shows the norm of essential and non-essential amino acids consumption per day [6].

As can be seen from Table 4, the daily human need is more than normal in essential amino acids: valine, isoleucine, leucine, lysine, methionine, tyrosine, threonine, tryptophan, phenylalanine, or respectively, at: 143; 150; 132; 32; 36; 10; 51; 178; and 25%. Cysteine covers the daily need only 35% of the 100% consumption norm.

When speaking about non-essential amino acids, following amino acids cover daily need above the norm: histidine, glutamic acid, proline, respectively, by 31; 42, and 76%.

Table 4. Consumption norm of amino acids per day

Amino acid name	Norm per day (g)	Test protein
Essential amino acids		
Valine	2.5	6.078
Isoleucine	2	5
Leucine	4.6	10.657
Lysine	4.1	5.413
Methionine	1.8	2.460
Threonine	2.4	3.631
Tryptophan	0.8	2.223
Phenylalanine	4.4	5.51
Non-essential amino acids		
Alanine	6.6	4.38
Arginine	6.1	3.771
Aspartic acid	12.2	6.989
Histidine	2.1	2.748
Glycine	3.5	1.023
Glutamic acid	13.6	19.297
Proline	4.5	12.411
Serine	8.3	3.648
Cysteine	1.8	1.173
Tyrosine	4.4	4.827

It is believed that an acceptable level of amino acid balance can be ensured if at least 55 - 65% of animal proteins are included in the diet. Special attention should be paid to the essential branched chain amino acids - valine, isoleucine and leucine. According to the research, it is clear that the content of valine, isoleucine and leucine in the test protein is almost 2 - 3 times higher than the norm, which indicates the stimulation of energy processes and contributes to the provision of muscle contractions.

4. Conclusions

- It was found that there is a high content of essential amino acids in protein filling. The content of such essential amino acids as: valine, isoleucine, leucine, threonine, and phenylalanine + tyrosine which exceeded the recommended ones by FAO/WHO for human consumption.

- Analysis of the amino acid score showed that the protein of protein filling has a limiting acid, threonine. It is established that the amino acid score of isoleucine is higher by 25% compared with the reference protein. The decisive value of valine score was 121.6%. Score of methionine and cysteine is 3.8% higher than that of the reference protein. Amino acid phenylalanine is essential for the human body and multifunctional. The difference in the score of this amino acid with the reference protein was increased and amounted to 172.3% in protein filling.

- As for the amino acid level of tryptophan, it was 222.3%. When comparing amino acid score of the

protein filling with the reference protein, it can be seen that almost all amino acid scores are increased, except for threonine (9% less) and lysine (1.6% less). In general, no significant differences were found.

- For human, both types of amino acids are equally important: both essential and non-essential. The total content of non-essential amino acids was 60.267 mg/g, and essential - 38.749 mg/g. Total amino acid content is 99.016 mg/g. It is noted that essential amino acids make up more than 1/3 of all amino acids, and this means high quality protein content in protein filling.

- The coverage of daily need of amino acids of organism with protein filling is considered. Daily human need covers more than the norm for essential amino acids: valine, isoleucine, leucine, lysine, methionine, tyrosine, threonine, tryptophan, phenylalanine, or respectively, by: 143; 150; 132; 1324 1374 104 51% 78; and 25%. Cysteine covers the daily need only 35% of the 100% consumption norm.

- It has been revealed that the following non-essential amino acids are covering the daily need of the organism above the norm: histidine, glutamic acid, and proline, or respectively: 31; 42 and 76%.

- According to the research, it is clear that the content of valine, isoleucine and leucine in the test protein is almost 2 - 3 times higher than the norm, which indicates the stimulation of energy processes and contributes to the provision of muscle contractions.

- Based on laboratory studies, the protein filling contains a rich amino acid composition, and allows production of extruded cereal products with a long shelf life.

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