Introduction

Providing the population with ecologically pure protein products of plant origin is an important task of national importance in any country [1]. However, the native use of soybeans today is limited due to the presence of antinutritional substances in them, namely the content of phytic acid. It stops the fermentation of the oligosaccharides of raffinose and stachyose, which, getting into the intestine, are absorbed with the release of gases [2]. In a healthy adult, the stomach and intestines contain about 1 liter of gas, while consuming legumes, the volume of gas removed can reach three or more liters. The accumulation of gas, while consuming legumes, the volume of gas reduces the phytic acid content in legumes during germination [3]. Plant protein, which is the main component of legumes, has the ability to accumulate inorganic trace elements, transforming them into organic forms during soaking during germination [6, 7]. The aforementioned question is of particular relevance given the prevalence of iodine deficiency states [8]. A method of producing germinated soybean grain in an aqueous extract of kelp Laminaria japonica or Laminaria saccharina is well-known, which includes hydromechanical processing of grain and grinding [9]. The proposed method allows to obtain a product with iodine content, but the disadvantage of this method is the low iodine content. Also, scientists have not studied how the process of germination affects the change in the amino acid composition of grain. Therefore, the aim of this work is to study the effect of various conditions of soybean germination on the change in amino acid composition, and the content of phytic acid. This is relevant and timely, and will solve the problem of iodine deficiency diseases and chronic colitis. This study is of particular importance given the possible use of these raw materials in the technology of meat products.
So, the object of research is selected «Diamond» early ripe soybean variety with a protein content of 43.88 %, 2018 harvest from the Agrotek collection nursery (Kyiv, Ukraine).

2. Methods of research

The characteristics of the soaking solutions are as follows: the concentration of potassium iodide in the soaking solution is 38 g/1000 cm³ H₂O, which corresponds to the iodine content in the solutions of 41 μg/g and satisfies 1/3 % of the daily iodine requirement. The grain is soaked for 48 hours. Analysis of the amino acid composition of the studied samples is carried out by ion exchange chromatography on an AAA T-339m amino acid analyzer (Czech Republic) and a Shimadzu LC-20 chromatograph (Japan). Samples weighing 0.3 g are poured into 10 cm³ of distilled water and 10 cm³ of concentrated hydrochloric acid. Samples are placed in a dry oven with a temperature of 130 °C for 8 hours. After that, they are filtered through a filter and washed with distilled water. The resulting solution is transferred to a porcelain cup and evaporated in a filter and washed with distilled water. The resulting sample is passed through a 0.45 μm diameter membrane filter. They are introduced into the chromatographic ion-exchange column of the AAA T-339m analyzer. Further, the analysis is carried out automatically and lasted 115 minutes. After the analysis is completed, the obtained chromatograms are decrypted and the peak areas of each amino acid are calculated. Tryptophan during acid hydrolysis of the protein almost completely decomposes, therefore, its determination is carried out on a Shimadzu LC-20 chromatograph. The sample is subjected to alkaline hydrolysis (NaOH) at 100 °C, 16–18 hours in the presence of 5 % tin chloride. The hydrolyzate after neutralization with a mixture of citric and hydrochloric acids (for the prevention of drag) is analyzed on an amino acid analyzer. The phytic acid content is determined by the Lott method, which is based on the discoloration of phytic acid with a solution of the complex anion of iron disulfosaliclylate to brown [10].

3. Research results and discussion

The influence of various conditions of germination on the change in the amino acid composition of soybean is investigated. The research results are shown in Table 1.

From the experiment it is possible to conclude that the process of germination affects the change in amino acid composition in the direction of its increase. The total content of essential amino acids, such as valine, isoleucine, tyrosine+phenylalanine, lysine, methionine, threonine tryptophan, arginine, histidine increases from 148 (in native grain) to 238.7 (in sprouted in aqueous solutions) and to 289.7 (sprouted in a solution with KI content) μg/g dry matter, respectively. The total amino acid content increases from 288.8 to 443.6 and to 562.6 μg/g of dry matter, respectively. Obviously, the process of soybean germination in KI solutions affects the increase in amino acid content by almost 50 %. Due to the high hydrophilicity of the protein, the mass of germinated grains increases by 2 times, which is an important factor in the manufacture of sausages.

Table 1

| No. | Amino acids | The content in grains of soybeans, μg/g of dry matter |
|-----|-------------|-----------------------------------------------------|
| Essential amino acids: Native grain | Germinated in aqueous solution | Germinated in KI solution |
| 1 | valine | 15.7 | 26.2 | 31.9 |
| 2 | isoleucine | 13.6 | 21.6 | 26.4 |
| 3 | leucine | 22.3 | 38.1 | 42.0 |
| 4 | tyrosine+phenylalanine | 24.7 | 45.9 | 47.1 |
| 5 | lysine | 26.3 | 37.3 | 52.8 |
| 6 | methionine | 3.4 | 5.0 | 6.8 |
| 7 | threonine | 9.1 | 14.7 | 18.4 |
| 8 | tryptophan | 4.3 | 6.6 | 8.2 |
| 9 | arginine | 21.1 | 29.5 | 41.0 |
| 10 | histidine | 7.9 | 13.8 | 15.1 |
| Essential amino acids content | 149.4 | 238.7 | 289.7 |
| Nonessential amino acid: | | | |
| 11 | cystine | 2.1 | 3.1 | 4.1 |
| 12 | alanine | 12.9 | 18.0 | 22.2 |
| 13 | aspartic acid+asparagine | 33.3 | 59.1 | 67.6 |
| 14 | glycine | 10.8 | 13.2 | 20.0 |
| 15 | glutamic acid+glutamine | 63.0 | 90.9 | 122.1 |
| 16 | serine | 18.1 | 20.6 | 36.9 |
| Total amino acids content | 288.8 | 443.6 | 562.6 |

The content of phytic acid in native soybean grain was studied, which amounted to 29.3 g/kg. In the sprouted in aqueous solution – 8.6 g/kg. In the sprouted in KI solution – 3.2 g/kg. Let’s assume that the process of soybean germination affects the reduction of phytic acid due to the launch of enzymatic processes that occur during shoot germination, and KI solutions are synergists of this process.

4. Conclusions

Having studied the effect of various conditions of soybean germination on the change in amino acid composition, it is found that the total content of essential amino acids increases from 148 (in native grain) to 238.7 (in sprouted in aqueous solutions) and to 289.7 (sprouted in a solution with KI content) μg/g of dry matters. The total amino acid content increases from 288.8 to 443.6 and to 562.6 μg/g of dry matter, respectively. Having studied the influence of various conditions of germination on the phytic acid content, it is found that native soybean grain contains 29.3 g/kg, 8.6 g/kg germinated in aqueous solutions, and 3.2 g/kg germinated in a KI solution.

References
1. Ulliams, K., Senders, T. (2000). Sviaz mezhdu zdorovem i potre­bieniem belka, uglevodov i zhira. Voprosy pitanii, 7, 54–57.
2. Arsenieva, L. Yu., Bondar, N. P., Uatsuik, S. I. (2017). Dosli­dzhennia zmizhi kimichnho skladu nasinnya bobovykhd pid chas proroshchuvannia ta ekstruduvannia. Khorennye y pere­rabotka zeron nauchno praktycheskyj portal. Available at: http:// hipzmag.com/tehnologij/phererabotka/doslidzhennya-zmini­himichnogo-skладу-nasinnya-bobovikh-pid-chas-proroshchuv­annya-ta-ekstruduvannya/
3. Bohdanov, H. O., Holovchenko, O. V., Arsenieva, L. Yu., Bondar, N. P. (2004). Perspektivy ta bezpechnist vykorystannia nasinnia biloho lupynu dla vyrobnystva kharchovykh produktiv. V'yanok ahrarnoi nauky, 4, 57–61.

4. Abramova, E. P., Chernikov, M. P. (1964). Soderzhanie inhibitorov proteinaz v semenakh nekotoryh bobovykh. Voprosy pitaniia, 4, 13–14.

5. Obertiukh, Yu. V. (2012). Antypozyvni rechovyny soi, yikh inaktyvatsiia ta tekhnomolohy pererobky soi, prihoden do promyslovii osnovi v umovakh hospodarstva. Kormy i kormo vyrobnytstvo, 71, 62–72. Available at: http://www.irbis-nbu.gov.ua/cgi-bin/irbis_nbu/vip/janis_64.exe?C21COM=2&I21DBN=UJRN&P21DBN=UJRN&IMAGE_FILE_DOWNLOAD=1&Image_file_name=PDF/kik_2012_71_10.pdf

6. Biletska, Y., Plotnikova, R., Danko, N., Bakirov, M., Chuniko, M., Perepelytsia, A. (2019). substantiation of the expediency to use iodine-enriched soya flour in the production of bread for special dietary consumption. Eastern-European Journal of Enterprise Technologies, 5 (11 (101)), 48–55. doi: http://doi.org/10.15587/1729-4061.2019.179809

7. Biletska, Y., Plotnikova, R., Skyryda, O., Bakirov, M., Iurchenko, S., Botshtein, B. (2020). Devising a technology for making flour from chickpea enriched with selenium. Eastern-European Journal of Enterprise Technologies, 1 (11 (103)), 50–58. Available at: https://doi.org/10.15587/1729-4061.2020.193515

8. Ryzhkova, T., Bondarenko, T., Dyukareva, G., Biletskaya, Y. (2017). Development of a technology with an iodine-containing additive to produce kefir from goat milk. Eastern-European Journal of Enterprise Technologies, 3 (11 (87)), 37–44. doi: http://doi.org/10.15587/1729-4061.2017.103824

9. Kravchenko, M. F., Kryvoruchko, M. F., Pop, T. M. (2012). Pat. No. 60515. UA. Spozh cistomannia boroshna z soi, prinadlennoho u vodnomu ekstraktu laminarii laminaria japonica abo laminaria saccharina. MPK A23 L 1/325. No. 2011114882. declared: 30.11.11.; published: 25.04.2012. Bul. No. 8.

10. Titok, V. V., Bakula, S. I., Leontiev, V. N. (2015). Analiz strukturnikh kachestvenykh osobenostei deponirovaniia fitina v zrelykh semenakh lina maslichnogo. Tsitoloiia i genetika, 49 (1), 40–45.

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