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PROSPECTS FOR THE USE OF EXTRUSION AS A TECHNOLOGICAL METHOD THAT CAN IMPROVE THE BIOAVAILABILITY OF AMINO ACIDS IN FEED

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Introduction. *This paper considered issue of the possibility of increasing the efficiency of the extrusion equipment due to expanding the scope of its application, in particular, the production of liquid and pasty feed mixtures. This is achieved by processing the grain component in an extruder and then mixing it with liquid components using extrusion heat. This heat is not currently used in production. During processing, it accumulates in the particles of the extrudate and is then lost to the environment at the exit from it. It is proposed to use this heat in mixing to achieve sterilization of all components of the mixture. The effectiveness of the proposed method investigated by evaluating: the amino acid composition of the obtained mixtures; urease activity; microbiological indicator. The research conducted according to standard methods.*

According to the results of research, the effectiveness of the proposed method has been proven. In particular, this is confirmed by an increase in the amount of essential amino acids in the paste when compared with granulated extrudate and untreated soy. It was proven that urease activity in the paste decreased to 0.15 ΔpH, which is within the normal range. Data were obtained on a slight increase in the microbiological index in the paste from 2 CFU to 14 CFU during 30 days of storage. The absence of enteropathogenic strains of E. coli, toxin-producing anaerobes and Salmonella in the studied samples also indicates the sterilization of the mixture.

Therefore, the obtained data prove that the amount of heat accumulated during extrusion is sufficient to achieve pasteurization of all components of the mixture. Obtained can be used in the agricultural sector, in technologies for the production of pasty mixture and liquid feed.

Key words: *extruder, mixing, pasteurization, mixture, amino acids.*

Introduction.

The implementation of effective technologies for the production of high-quality feed, which meet modern energy efficiency of requirements, always remains an important direction in the development of this industry. An important step for this is the use of high-temperature extrusion technologies. Because they do not require significant energy consumption and allow obtaining high-quality products of various composition and purpose. However, despite all the listed advantages of extrusion, the

next stage, which involves mixing the extrudate with other components, remains a difficult issue. This is due to the fact that feeds are mostly multi-component mixtures. Each of the components has a different nature, properties and consistency. For example, vegetable and animal fats, dry milk substitutes and vitamins are added to the mixture. It is allowed to add liquid milk products or milk whey [1]. As a result, the complexity of organizing the process of mixing such components can significantly affect the quality of the feed and the duration of its storage. Therefore, an important task is not only the choice of raw materials and processing technology, but also the choice of mixing method. Since it should not have a negative effect on the stability of the product during storage.

In the case when the amount of moisture in the feed is less than 40 %, then technologies of vacuum spraying of components are used. The process is considered effective because the extrudate has a porous structure that retains liquid well. Traditionally, such technological schemes include the following stages: preparation of components, dosing, grinding, conditioning, extrusion, drying, vacuum spraying, cooling. Some stages and their sequence may change. Among the leaders of technology “Buhler AG”, “Amandus Kahl”, “Pegasus Vacuum Coater”, “Rotospray”, “Amandus Kahl”, “Ottevanger”.

Domestic manufacturers prefer technologies of mixing components in mixers. Mostly they are of horizontal or vertical type, periodic or continuous action.

In the case when the concentration of liquid components exceeds 40 %, then equipment such as mixers is used. However, a number of difficulties arise when using them. Among the main ones is the appearance of stagnant zones during the mixing process. Also, the manufacturer is often forced to use heating element systems and complex piping systems to supply each component. All this significantly complicates the production process. However, the main reason remains the need for significant initial investments and the lack of qualified personnel [2]. Despite all these difficulties, the latest data have shown that entrepreneurs are still switching to technologies for the production of liquid feed. The main reason is that liquid feed is closer to the physiological needs of animals and gives higher rates of weight gain than dry food [3].

On the basis of the analysis, the authors proposed to obtain granular, pasty and liquid multicomponent mixtures on the basis of one extruder. The peculiarity of the proposed method is the implementation of the mixing process after the extruder. It involves mixing the components at the exit from the extruder using the heat of extrusion, which accumulates in the extrudate particles to achieve pasteurization of the entire mixture. According to the authors, this approach will solve a number of problems. In particular, on the basis of existing equipment with minimal investment and without the involvement of additional personnel, expand the range of products. It will also improve the quality and extend storage time of the product.

For the research, soybeans were used, which today is the main source of protein in most feed products [4]. The following modes are recommended for heat treatment of soybeans: temperature 135...140 C and moisture content – 12...14 % [5].

However, it is known that there is a negative effect of high temperatures on the protein structure, in particular, on the composition of amino acids. The most

thermolabile amino acid of these is lysine. Therefore, the evaluation parameter was the composition of essential amino acids in the final product. Since the product involves long-term storage, the evaluation parameter was the determination of the dynamics of the microbiological indicator during its storage.

To determine the effectiveness of the proposed method, a number of tasks were formulated. These included studying the effect of the heat used to pasteurize the components on: the composition of essential amino acids; microbiological index; indicator of urease activity. For control, the data obtained were compared with samples of extruded and untreated soybeans.

Materials and methods.

For the experiments, soybeans with an initial moisture content of 5 % were used.

The experiments were carried out on a laboratory bench, the scheme of which is shown in Fig.1. It consisted of a grain humidifier 1, an extruder 2, a specially designed device 3 for mixing components. According to the experimental method, soybeans were pre-moistened to 13...14 % in humidifier 1. Then the moistened soybeans were processed in extruder 2, where they were crushed under conditions of high temperatures. The temperature reached maximum values of 135...140° C in the die zone, i. e. before exiting the extruder. Mixing of hot extrudate particles with liquid components occurred at the outlet of the extruder without contact with the medium in device 3.

The object of research – soybean extrudate; pasty feed mixture (50%), including extruded soybeans, water, liquid phosphate concentrate; control sample of mechanically crushed soybeans

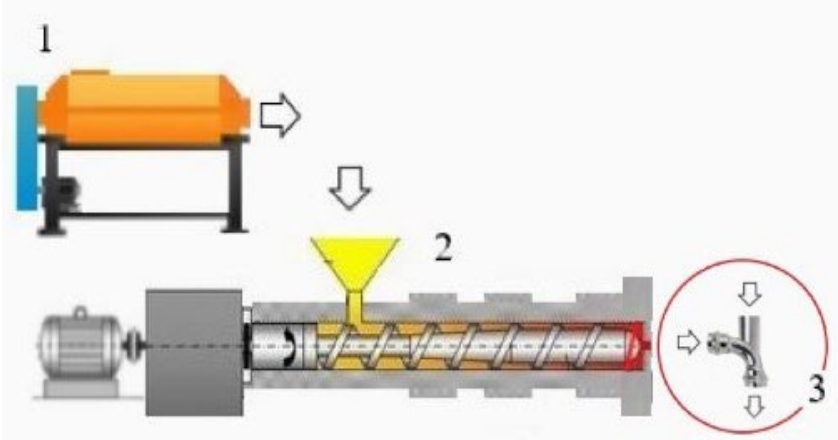

Figure 1 – Experimental stand

***1** – grain moistening device; **2** – extruder; **3** – device for mixing extrudate with liquid components*

The evaluation of the efficiency of soybean processing in the extruder carried out by determining the activity of the urease enzyme accordance with DSTU 8365:2015. The analysis performed for soybean extrudate and pasty feed mixture. The composition of essential amino acids determined by ion-exchange liquid column chromatography using an automatic amino acid analyser. Determination of microbiological parameters carried out according to DSTU EN 12824:2004.

Results.

The urease activity determined in the samples after processing in the extruder

and in the samples of the pasty feed mixture (Table 1). The results showed a decrease in values to normal with a permissible limit of 0.3 pH units. That is, the processing conditions in the extruder ensure the inactivation of anti-nutrients. The proposed mixing method does not create a negative impact.

Table 1 - Physicochemical parameters of soybean and pasty feed mixture

Parameter	Research Result	
	Pasty mixture	Soybean extrudate
Mass fraction of moisture, %	50,87	8,5
Urease activity, Δ pH	0,15	0,12

Analysis of essential amino acids allowed to identify and quantify the composition of 9 amino acids. In particular, lysine, threonine, valine, methionine, leucine, isoleucine, phenylalanine, arginine, histidine, which is illustrated in Figure 2.

Comparison of unprocessed soybeans with samples after extruder processing and paste showed that the composition of essential amino acids is fully preserved. At the same time, some amino acids showed some growth. In particular, the amount of histidine in the paste and extrudate samples increased by 10.3 %, threonine in the paste by 10.0 % and 7.2 % in the extrudate. The amount of lysine also increased by 8.2 % in the paste and by 6.6 % in the extrudate, which is the most thermolabile amino acid. The amount of methionine in the paste increased by 7.3 %, while it remained unchanged for the extrudate. To a lesser extent, the share of isoleucine increased by 6.2 % in the paste and 4.0 % in the extrudate, as well as leucine by 2.7 % in the paste and almost unchanged by 0.9 % in the extrudate.

The data on changes in the amount of arginine, valine, and phenylalanine were analysed. The results indicate that the combined effect of the high temperature in the extruder and the mixing conditions at the outlet do not have a significant impact on the amount of these amino acids.

That is, the obtained results indicate that the complex effect of high temperature in the extruder, as well as the conditions for mixing the components at the exit from the extruder, do not create a noticeable effect on the amount of arginine, valine and phenylalanine, the concentration of which in the paste and extrudate samples has not changed. Their concentration in the paste and extrudate samples did not change.

The analysis of the microbiological indicator showed a slight increase for paste samples from 2 CFU to 5 CFU in the first day and up to 14 CFU within 30 days of storage. Comparison with samples of extruded soybeans also showed insignificant dynamics, in particular, during the first day – 2 CFU and less than 10 CFU during the next 30 days of storage. The analysis revealed the absence of enteropathogenic strains of Escherichia coli, toxin-producing anaerobes and salmonellae in all the samples tested. That is, the presented results indicate the effectiveness of the proposed mixing method. This means that the amount of heat released with the extrudate is sufficient to sterilise all components and thus ensure long-term storage of the product for another 30 days.

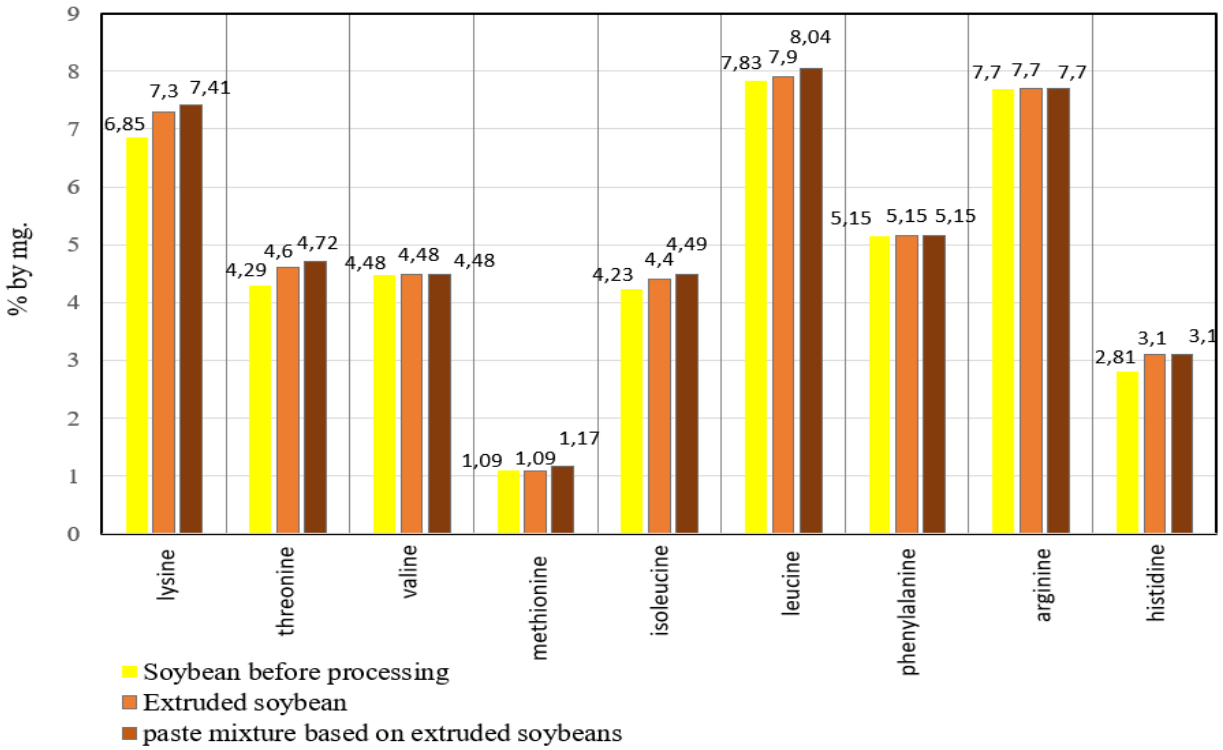

Figure 2 – Content of essential amino acids in soybeans and products of its processing, %

Conclusion.

The effect of extrusion heat used for sterilisation of paste components on its amino acid composition studied. The data obtained allowed us to identify 9 essential amino acids. Their quantitative composition showed a 10.3 % increase of histidine in the paste and extrudate samples, a 10.0 % increase of threonine in the paste and a 7.2 % increase in the extrudate. The amount of lysine increased by 8.2 % in the paste samples and by 6.6 % in the extrudate. The study of the paste samples showed an increase in the amount of methionine by 7.3 %, while this amount remained unchanged for the extrudate. The data obtained showed a lesser increase in the amount of isoleucine - by 6.2 % in the paste and by 4.0 % in the extrudate. The amount of arginine, valine, phenylalanine in the paste and extrudate samples remained unchanged. That is, the proposed method of mixing in combination with extrusion processing allows to preserve, and in some respects improve the composition of essential amino acids.

The study of urease activity in samples of pasty mixture showed a decrease in the index to 0.15 ΔpH, which is within the normal range. For comparison, this indicator determined in the extrudate to be 0.12 ΔpH.

The results of microbiological studies of pasty mixture showed a slight increase from 2 CFU to 5 CFU in 1 day and up to 14 CFU after 30 days of storage. The analysis revealed the absence of enteropathogenic strains of Escherichia coli, toxin-producing anaerobes and salmonellae in all the samples tested.

Therefore, the expediency of using the proposed method of heat utilisation for pasteurisation of all components of pasty mixture is substantiated. The data obtained can be used in the production of pasty and liquid feeds.

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Анотація. *У статті розглянуто можливість підвищення ефективності роботи екструзійного обладнання за рахунок розширення сфери його застосування, зокрема, виробництва рідких і пастоподібних кормових сумішей. Це досягається шляхом обробки зернового компонента в екструдері з наступним змішуванням його з рідкими компонентами при використанні теплоти екструзії. Ця теплота у виробництві зараз не використовується. Вона під час обробки акумулюється в частинках екструдату і на виході з нього потім втрачається в навколишнє середовище. Запропоновано її використовувати при змішуванні для досягнення стерилізації усіх компонентів суміші. Ефективність використання запропонованого способу досліджували шляхом оцінки: складу амінокислот отриманих сумішей; активності уреази; мікробіологічного показника. Дослідження проводились за стандартними методиками. По результатам аналізу доведено ефективність пропонованого способу. Зокрема, підтверджено зростання кількості незамінних амінокислот у пасті порівняно з гранульованим екструдатом та соєю. Доведено зниження активності уреази в пасті до 0,15 ΔpH, що в межах норми. Отримано дані про незначний ріст мікробіологічного показника в пасті з 2 КУО до 14 КУО протягом 30 діб зберігання. Встановлено відсутність ентеропатогенних штамів кишкової палички, токсиноутворюючих анаеробів і сальмонел, що теж свідчить про досягнення стерилізації усіх компонентів суміші. Отже отримані дані доводять, що кількість теплоти акумульованої під час екструзії є достатньою для досягнення пастеризації усіх компонентів суміші. Отримані дані можуть застосовуватись в технологіях виробництва багатокомпонентних кормових сумішей.*

Ключові слова: *екструдер, змішування, пастеризація, суміш, амінокислоти.*

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