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SUSTAINABLE PROCESSING OF SUNFLOWER MEAL. DEVELOPMENT OF THE PROCESS OF ADSORPTION BLEACHING OF SUNFLOWER PROTEIN EXTRACTS.

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Abstract

A new process for producing light sunflower protein concentrates combining weakly acidic extraction of NaCl protein with adsorption removal of phenolic compounds has been developed. Three commercial food adsorbents were tested for their affinity for polyphenols.

Benteco F 205 S,Benteco F 300 S demonstrated optimal bleaching of raw sunflower extracts. In contrast, Benteco F 620 provided maximum binding of monomeric phenolic compounds, but was less effective in removing colored compounds. The adsorption behavior of individual adsorbents was evaluated by adding them to protein extracts, varying the amount of adsorbent, protein concentration in solutions, and temperature. Optimal conditions were derived from experiments at various temperatures, flow rates, and extract concentrations.

To produce light sunflower protein on a pilot scale under conditions optimized during laboratory experiments, which showed that this technology can be easily integrated into existing production lines. Industrial importance: The growing demand for human food products makes it imperative to develop new protein sources. Sunflower oil production waste is rich in protein and can serve as a source of vegetable proteins, which are still not widely used. This is due to the high content of phenolic compounds in them, which can affect proteins, reducing their nutritional value and impairing their organoleptic properties. In this regard, the present study developed a weakly acidic protein extraction process that combines adsorption and ultrafiltration technology to remove polyphenols from crude sunflower extracts.

Keywords: technology, nutritional, production, organoleptic

Introduction:

Sunflower is the most important oilseed crop.Two products derived from sunflower seeds are vegetable oil, which is mainly used for human consumption, and meal, which is mainly used for livestock feed, but not enough for food purposes. Sunflower meal is characterized by a high protein content from 30 to 50 %, which makes it a possible potential source of inexpensive proteins alternative to soy protein [1-3].The techno-functional properties of sunflower proteins are comparable tosoy or other legume proteins, while they are characterized by a high content of sulfur-containing amino acids.Sunflower proteins are deficient in the amino acid lysine, which is a nutritional disadvantage; however, they are considered a valuable source of protein, since they are devoid of any toxic components [4,5].

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The main problem of sunflower meal is the high content of polyphenolic compounds from 1 to 4 %. These polyphenols are oxidized both by polyphenol oxidaseand in an alkaline medium used for protein extraction [6,7]. Oxidation leads to the transformation of phenoliccompounds into chlorogenic derivatives. Polyphenols give sunflower meal a dark color and tartness. These highly reactive compounds are covalently bound to the thiol (-SH) and amino (-NH2) groups of proteins at high pH, or non-covalently by hydrogen bonds at low pH. The complexes formed in this way give the meal and protein isolates a dark green or brown color. The removal of these compounds during protein extraction will make it possible to make greater use of meal in the food industry and provide an alternative to expensive protein sources such as soy protein [8,9]. However, at the moment, the use of sunflower meal is mainly limited to animal feed with low added value.

Traditional alkaline protein extraction results in dark-colored products with reduced nutritional and functional value. This is mainly due to the covalent binding of quinone structures formed from phenolic acids during alkaline treatment with aminoand thiol groups of amino acids, such as lysine and cysteine. For this reason, the meal obtained in the production of sunflower oil is still used mainly as feed for ruminants.

Sunflower proteins show a minimum solubility of about 10-20% at pH values close to the isoelectric point (pH 4-5). Therefore, proteins are usually extracted under alkaline conditions. However, co-extractable phenolic compounds are easily oxidized and, therefore, are prone to irreversible binding to proteins, which leads to the formation of dark-colored products with altered functional properties. In contrast, protein extraction in the acidic pH range prevents irreversible binding of phenolic acids to proteins, but provides a low extraction rate.

Over the past four decades, several attempts have been made to remove polyphenols from sunflower proteins, but none of them has yet been implemented on an industrial scale. Among these approaches, the possibility of removing polyphenols with water-organic solvents before alkaline protein extraction was studied. In addition, pre-extraction of polyphenols using acidic or saline media before alkaline separation and separationof phenolic compounds by membrane filtration after the main protein extraction in an inert gas atmosphere have been proposed [10-12]. Due to the main disadvantages of these solutions, a method of weakly acidic extraction of sunflower seed proteins using sodium chloride is proposed to increase the solubility of proteins, both globulins - the main fraction of sunflower proteins, and the albumin fraction, as well as to facilitate the removal of unbound phenolic compounds from extracts, which is a necessary condition for obtaining colorless protein products.

Since the high phenol content is the main limitation of sunflower protein use, it must be reduced in protein-rich extracts to produce protein concentrates with high nutritional value and sensory properties. Therefore, the aim of this study was to develop an innovative process for removing polyphenols from sunflower protein extracts using ultrafiltration adsorption processes [13-15].

1. Materials and methods:

1.1. Sunflower meal produced by EFKO Group of Companies was used for laboratory experiments

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Sunflower seed proteins were extracted using a slightly acidic (pH in the range of 5.2-5.6) NaCl solution (1.3 mol / l). Laboratory experiments on extraction were carried out in a beaker using a magnetic stirrer. Sunflower meal and NaCl solution were mixed in the ratio of meal to solvent from 0.05 g / ml to 0.13 g / ml, and pH was adjusted first with dilute acetic acid, and then after 15 minutes of mixing with dilute acetic acid and NaOH, respectively [16]. After 1 hour, the suspension was centrifuged for 10 minutes at 3300 g. The precipitate was discarded, and надосадочнуюthe supernatant was used for adsorption experiments [17].

1.2. Periodic adsorption experiments

Periodic adsorption experiments were performed in screw-cap flasks with a volume of 150 ml, varying the concentration, temperature, type and amount of adsorbent in accordance with Table 1.

Table 1. Characteristics of the studied samples

Sample	pH	Dilution	Salt / NaOH / other	Additional components	Notes
1	5.2	1: 10	$CaCl_2$ 5%	Vinegar. k-ta 10%, 50 ml	-
2	5.6	2: 8	NaCl 5%	Vinegar. k-ta 10%, 50 ml	Benteco F 205 S, filter
3	5.2	1: 10	$CaCl_2$5%	Vinegar. k-ta 10%, 80 ml	Benteco F 300 S2
4	8.0	1: 10	NaOH 10%	--	—
5	5.8	2: 8	$CaCl_2$5% (20 g)	—	Benteco F 620, 10 g PER FILTER
6	8.0	1:10	NaOH 10%	-	Benteco F 620, 10 g per filter

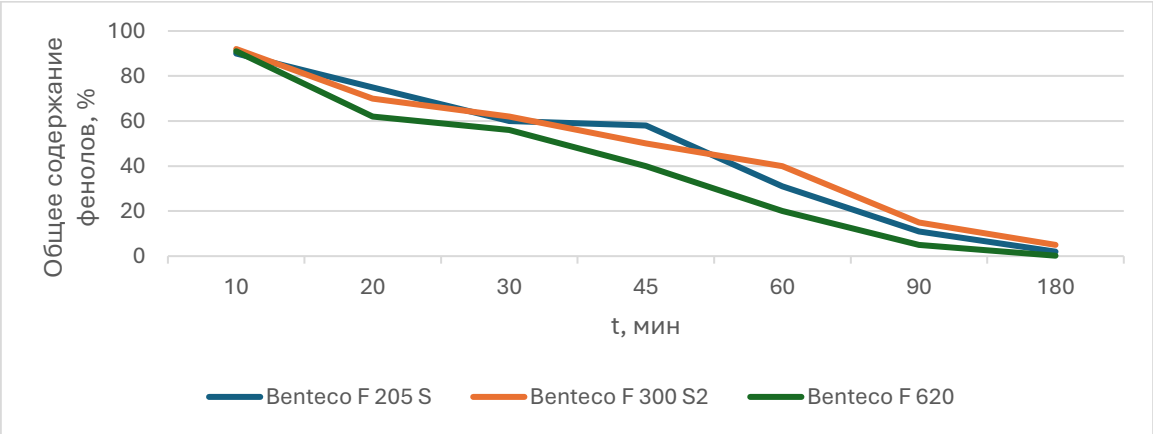

Figure 1 Dynamics of decrease in the content of phenolic compounds during adsorption on various Benteco sorbents

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For each experiment, 100 ml of the extract was previously combined with an adsorbent, and the flask was purged with nitrogen to prevent oxidation of polyphenols. The suspensions were stirred using a magnetic stirrer at a speed of 150 rpm in термостатируемойа temperature-controlled water bath. Via 0, 10, 20, 30, 45, 60, 90, 180 aliquots of 2 ml were taken for analysis of polyphenols and proteins for 240 min. The amount of adsorbed phenolic compounds was calculated from the difference in the content of phenolic compounds obtained by summing individual compounds between the starting point and the sample collection [18, 19].

Figure 1 shows the dynamics of reducing the phenol content when using different types of adsorbents.

Benteco F205 S showed a gradual decrease in the phenol content, which indicates a gradual saturation of the active centers and a uniform flow of the process.

Benteco F300 S2 was characterized by high sorption activity at the initial stage (up to 60 min), which is due to the presence of a large number of available active surfaces. However, as the adsorption centers were filled, the rate of phenol removal decreased.

Benteco F620 demonstrated the greatest efficiency, providing almost complete removal of phenolic compounds by the 180th minute. This indicates a high specific surface area and significant sorption capacity of this material.

1.3. Determination of the concentration of chlorogenic acid. The concentration of chlorogenic acid (CHA) was determined by UV spectrophotometry based on the Bouguer-Lambert-Baer law [14, 20]. The analysis is based on measuring the optical density (A) at a wavelength of 325 nm, which corresponds to the maximum absorption of HCG in the UV region of the spectrum. The calculation was performed according to a calibration graph constructed using standard solutions of HCG [17].

Analysis methodology

The study was carried out in accordance with the method of spectrophotometric determination of chlorogenic acid (CHA) at **a wavelength of 325 nm**, where CHA shows the maximum absorption in the UV region. The method is based on the Bouguer-Lambert-Baer law, validated by linearity criteria ($R2 \geq 0.998$) and detection limit (LOD = 0.5 μg / ml).

Measurement results

The spectra of eight bentonite samples studied were recorded in the range of 200-1100 nm. Figure 1 shows a graph of the absorption spectra of the studied samples, as well as pure chlorogenic acid (ChA, standard). In sample No. 3, a pronounced peak is observed at 325 nm, corresponding to the content of chlorogenic acid of ~ 1.9 %.

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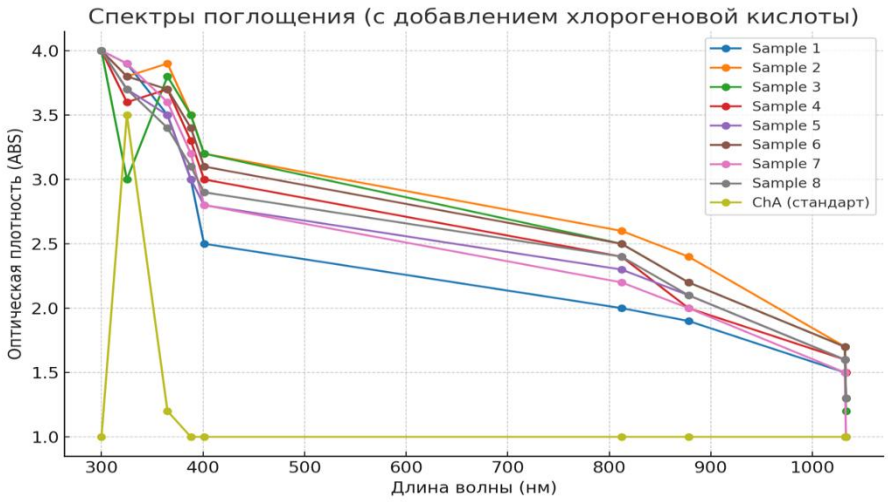

Figure 2. Absorption spectra of eight bentonite samples and a chlorogenic acid standard.

The results are summarized in table 2:

Sample number	**Wavelength Sample number (nm)**	**Absorption (ABS)**
Chlorogenic acid (standard)	325	3.500
1	878, 812	1.994, 2.028
2	1033, 388	1.386, 4.000
3	1033, 325, 365	1.207, 3.000, 4.000
4	1033, 401	1.504, 4.000
5	1033	1.322
6	1033, 390	1.778, 4.000
7	1033, 365, 297	0.905, 4.000, 4.000
8	1032	1.313

In sample № 3, absorption was recorded at 325 nm — this is the key range specific for CGA. In other samples obtained with the use of adsorbents, no shoulders or secondary maxima were observed in the range of 323-327 nm, which indicates the absence of chlorogenic acid in the samples studied with protein extracts.

Interpretation of results

1. **Lack of chlorogenic acid (HCG):**

- In the spectrophotometric analysis at λ = 325 nm, none of the eight samples showed significant maxima.

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- The absence of CGA is confirmed both by the absolute values of absorption and by the spectral profile.
- The specificity of the method excludes the influence of compounds that are similar in structure, since the spectral region was controlled in the range of 200-400 nm.

2. **Positive impact on product quality:**

- HCG is a representative of phenolic acids with moderate oxidative properties. If the bentonite content is high (for example, if it is contaminated with plant residues), it can affect the chemical stability and sensory properties of the product.
- In this situation, **the absence of HCG is regarded as a positive indicator**, indicating the purity of the feedstock, the absence of contamination with organic substances and the suitability of bentonite for sensitive applications — for example, in the pharmaceutical or food industry.

Conclusion

Analysis of eight bentonite samples by UV spectrophotometry showed **the complete absence of chlorogenic acid**, which:

- Indicates the **high purity of the mineral matrix**.
- Confirms the absence of vegetable impurities.
- **It has a positive effect on the final product quality**, especially in the context of its use in environments sensitive to antioxidant and phenolic compounds.

The introduction of the adsorption stage in the sunflower protein extraction process made it possible to obtain high-quality protein concentrates, thanks to the almost complete removal of polyphenols and significant color lightening. Since the brownish color of sunflower protein preparations limits their use in food products, the present study showed the high potential of this new approach.

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