THE IMPACT OF TECHNOLOGICAL FACTORS ON REDUCING PHENOLIC COMPOUNDS IN SUNFLOWER SEED KERNELS

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Abstract: *The study revealed to a technological factors which are responding to reduced phenolic compounds and Chlorogenic acid, in whole-grain or broken sunflower seeds during its hydrothermal treatment. It is important to point out that, the sensory analysis of organoleptic properties was obtained in the hydrothermal treated samples.*

Keywords: *sunflower seed kernels, phenolic compounds, Chlorogenic acid, hydrothermal processing, organoleptic properties*

INTRODUCTION

In recent years, the production of food and semi finished products from Sour milk cheese are increasing. In accordance with the current global financial crisis on the dairy industry in Ukraine, and deficit of raw materials, particularly Sour milk cheese [1, 2], of course, changes in dietary consumption pattern in Ukrainian and essential nutrients deficiency [3, 4] updated searching alternative sources of raw materials and diversification by finding and developing new products, one with higher quality, new features, and higher value in use In all to create successful new products [1].

The special role, plans for new products of the plant as row that contain the essential nutrients in their bodies, as oilseeds [5]. Compares oilseeds, Sunflower seeds are important source of the functional components (protein and oil) and rich chemical composition, particularly confectionery sunflower varieties, is the basic form in Ukraine and traditionally are used both whole and in the powdered form in many food technologies [6]. Market analysis of culinary products based on Sour milk cheese showed that sunflower seed no use in it at all. The major problem is the lack of scientific basis.

The product of the invention is an improved a type of disperse systems, emulsion (hereinafter – the emulsion) based on the sunflower seed kernels [7] with the low-fat Sour milk cheese, create semi-product of cheese composition [8], which will be used in the cooking products with the possibility of further inclusion the required prescription ingredients (flour, sugar, egg, vegetable fillers, flavoring agents, etc.).

It should be noted that one of the major problems that limit the use of the sunflower seed kernels in the products based on Sour milk cheese, is the presence of phenolic compounds (70% of the total content of phenolic compounds is Chlorogenic acid) [9-10]. Under heat treatment, phenolic compounds has led to decrease biological value of the proteins and browning [9-10].

This problem is one the most specific object of the scientific research [10, 11]. It should be emphasized that, one of the important tasks of a new culinary products based on Sore milk cheese involving sunflower seed kernels is to provide high organoleptic characteristics, such as bright color. In order to this problem, remove or substantial reduce the phenolic compounds in the sunflower seed kernels is too nessasery.

Famous research, [10] ensure that phenolic compounds due to small size of their molecules, are soluble in acidic solution of Capillary-Porous Structures in backing fabric sunflower seed kernels, give them possibility passing through the semipermeable cell membrane in difference with protein and oil molecules in aqueous acid solution. In accordance with the present knowledge, hydrothermal processing sunflower seed kernels reduce content of the phenolic compounds. This large molecules (protein and oil) will not be passed through of the cell membranes and remain in the cells.

As we know, among the organic acids, Citric acid which is the prevalence and accessibility in cooking products, As the known requirements for solvents [12] the use of an aqueous solution of citric acid should be preferred: this solution is characterized phenolic compounds, specially acid

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chlorogenic, and in difference with the basic nutrients – protein (globular fractions in protein complex) and lipids.

EXPERIMENTAL PART

The objectives of this experiment are:

- determining the influence of technological factors on the reduction of phenolic compounds in the sunflower seed kernels during its hydrothermal treatment;
- the sensory analysis of organoleptic properties in the hydrothermal treatment sunflower seed kernels;
- scientific substantiation of hydrothermal processing on sunflower seed kernels.

The experimental conditions

In the preferred embodiment of the present invention, the seed coat of seed kernels are removed. In view of the known factors that affect the extraction process [12], was selected the dispersion prepared – whole or broken sunflower seed kernels particle size in the range (3-4) × 10^{-3}, (2-3) × 10^{-3}, and (1-2) × 10^{-3} m, which were obtained by fractionation of seed kernels after removing the seed coat.

Hydrothermal treatment of fractional seed kernels performed by steeping it in a solution of citric acid at pH 4,0 ± 0,1 at 20 ± 2, 40 ± 2, 60 ± 2, 80 ± 2 °C. Based on famous scientific observations [13] in order to remove phenolic compounds, rational ratio solid: extragent should be as (1 : 10-15). In view of this, hydromodel of hydrothermal treatment (ratio sunflower seed kernels : acid solvent) in the first stage of research selected 1 : 10 with an opportunity to further refine.

Should note that, to determine total amount of phenolic compounds with chlorogenic acid, used colorimetric method with Folin-Denis reagent. [14] Chopped seed kernel samples are weighed (8-10) × 10^{-3} kg, an accuracy of 1 × 10^{-5} kg, filled with 96% alcohol. Designate its final concentration 80% vol., boiled on a water bath under reflux for 10 × 60 s, cooled and closed stopper. After that, obtained alcohol extract was poured and samples triturated, by repeated washing with an aqueous solution of 80 % ethyl alcohol, on a Buchner funnel and filtered.

Focus on the completeness of the extraction phenolic compounds, checked by reaction with a solution of 15 % NaOH , should notice that when heating the solution, it should not turn yellow. In order to accurately determine the concentration of phenolic compounds in the working solutions should be in the range of 0,01 to 0,15 mg/cm^3, while the concentration of ethanol is 50 % vol. In the case where the content phenolic compounds in solution was above the specified, it was separated to several times. To 1 cm^3 ready extract was added 0,3 cm^3 reagent Folin-Denis, mixed well, exactly after 20 s, added 5 cm^3, 20 % Na_2CO_3 and after 30 s with the optical density was measured at a wavelength 725-730 nm photocolorimeters in a 5 × 10^{-3} m cuvette.

The control was water with the addition of all specified reagents. Simultaneously determine the moisture contents in the samples seed kernels. To calculate the amount of phenolic compounds was found from calibration curve for chlorogenic acid.

Determine the total number of phenolic compounds with chlorogenic acid in terms of the dry matter content shown in the formula:

$$x = \frac{a \times V \times p \times 100 \times 100}{h \times (100 - W)},$$

Where x – the total amount of phenolic compounds in terms of the dry matter, mg/100 g of dry matter;

a – the content of chlorogenic acid, derived from a calibration graph mg/cm^3;

V – Volume of alcoholic extract, cm^3;
p – The dilution;
h – Mass of sample, g;
W – Moisture of the sample %

RESULTS AND DISCUSSION

In terms of the reported mechanism, release phenolic compounds by hydrothermal treatment from the seed kernel tissues is similarly complex mass transfer, involving dialysis, dilution and diffusion. Generally, based on the laws of mass transfer [12], Influence of factors on this process described. According to the theory of mass transfer, the diffusion of phenolic compounds is accelerated with increasing temperature, dispersion seed kernel particles, difference in concentrations between the particles of plant tissue and extragent and decreasing the viscosity of the extragent and size of the molecules that extracted.At the beginning stage of the extraction process, acidic solution of the extragent penetrating into plant tissues sunflower seed kernels.

At first on the macro, micro-cracks, and then on intercellular pores, extragent reaches the cells and diffuses through the cell walls. During the penetration of the extragent into the cell, its contents begin hydrate and dissolve into solution.

Due to difference concentration dissolved substances in and out the cell, begins the dialysis – transfer low molecular weight compounds in the other direction through the cell wall, First in the extragent, which is located in the intercellular pores, and then in extragent, which fills the micro-and macro-cracks and, in the end, the extragent that removes the particles of plant tissue sunflower seed kernels. Thus the speed of penetration solvent and solute is usually much higher than internal diffusion.

Figure 1 shows that decrease the residual content of phenolic compounds occurs with increasing extraction temperature and reducing the particle size of sunflower seed kernels. As seen at 60 ± 2 ° C and 80 ± 2 ° C remove of phenolic compounds is intensively than at 20 ± 2 ° C and 40 ± 2 ° C.

Obviously, due to the integrity of the cell structure and a complication the diffusion process, the longest extraction of phenolic compounds is from whole sunflower seed kernels. Comparison of efficiency in removing phenol compounds was estimated by organoleptic characteristics hydrothermal sunflower seed kernels. As a result, various freed from phenolic compounds, acquired different color, taste and smell.

It should be mentioned that the formation of organoleptic characteristics, affected by the temperature, duration of the hydrothermal treatment and the particle size of sunflower seed kernels. To determine the reasonable range of these parameters was performed organoleptic evaluation of the milled samples after the hydrothermal treatment. Sensory analysis techniques have developed by using a well-defined 5-point scale (Table 1

Table 1 – Sensory evaluation on a 5-point scale for the sample of sunflower seed kernels after hydrothermal treatment

Quality indicators	Weight-coefficients	Quality level				
		5	4	3	2	1
Color (at a residual content of phenolic compounds,%)	0,6	White with slight light gray tint (less than 1,0)	Light gray (1,0 to 1,3)	gray (1,3 to 1,7)	Taupe (1,7 to 2,2)	Clearly pronounced dark gray (more than 2,2)
Taste	0,3	Impersonal, pure flavors no sunflower oil	Impersonal with a slight flavor and sunflower oil	No strong taste of sunflower with a taste of oil	Taste of sunflower with signs of damage	Clearly pronounced taste of sunflower and a significant flavor of oil with signs of spoilage
Odor	0,1	Impersonal, odorless oil and sunflower	Impersonal, with a slight smell of oil and sunflower	No distinct smell of sunflower and oil	Taste of sunflower with little taste of oil with signs spoilage	Explicitly smell of sunflower and oil with signs of spoilage

Following the results, establishing a connection between residual content of phenolic compounds, color hydrothermally treated sunflower seed kernels and scoping. So, when the content of phenolic compounds is less than 1,0 % after hydrothermal treatment samples were characterized in white with light gray tint, when the content of phenolic compounds in the range of 1,0-1,3 % – light gray, with 1,3-1,7 % – gray, with 1,7-2,2 % – dark gray, and when the content of these compounds more than 2,2 % of the samples had dark gray. In view of these data was established reasonable selectivity to phenolic compounds (Fig. 1, I), which allows to achievement crushed fractionated sunflower seed kernels and defines the duration and temperature of the process. View to the scale based sensory evaluation considering the weight coefficients of the samples (Table 1), conduct different sensory evaluation tests on the samples of sunflower seed kernels during hydrothermal treatment. In the course of this study, have found that the color and the taste, based the forming of organoleptic properties sunflower seed kernels samples. Data in table 2 shows the technological modes of hydrothermal treatment, in which the samples have highest scored.

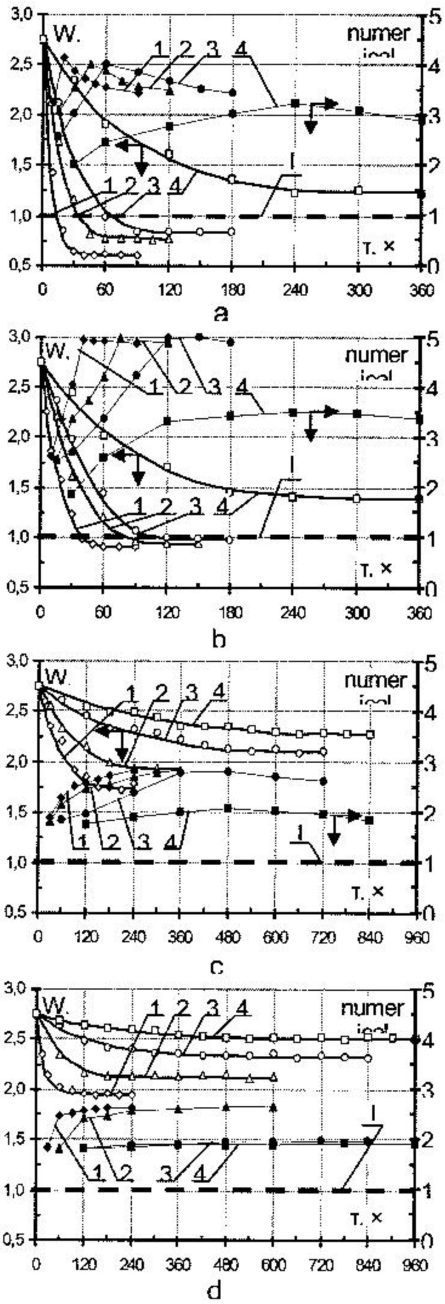

Fig. 1. *Dynamics of the residual content phenolic compounds (W, %) in sunflower seed kernels with different size,* × 10^{-3} *m: 1 – (1-2), 2 – (2-3), 3 – (3-4), 4 – whole, temperatures,* °*C: a – 80 ± 2, b – 60 ± 2, c – 40 ± 2, d – 20 ± 2 and sensory evaluation of organoleptic characteristics of the samples, respectively – 1a, 2a, 3a, 4a. I – reasonable range of phenolic compounds.*

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Table 2 – Study organoleptic properties of sunflower seed kernels during hydrothermal treatment

Temperature hydrothermal treatment of, ° C	Scoping organoleptic properties (b) and duration of hydrothermal treatment of (τ) × 60 s with particle sizes of sunflower seed kernels (d), × 10^{-3} m							
	d (1-2)		d (2-3)		d (3-4)		d (whole)	
	b	τ	b	τ	b	τ	b	τ
80 ± 2	4,15	20,0 ± 0,5	4,02	45,0 ± 1,0	4,00	60,0 ± 1,5	3,23	240 ± 5
60 ± 2	4,95	40,0 ± 1,0	4,97	75,0 ± 1,5	4,97	120,0 ± 2,0	3,51	240 ± 5
40 ± 2	2,86	240 ± 5	2,84	360 ± 5	2,81	480 ± 10	2,09	480 ± 10
20 ± 2	2,64	180 ± 3	2,65	480 ± 10	1,99	720 ± 12	1,94	960 ± 15

It must be emphasized that the scoring curves were extreme at 60 ± 2 ° C and 80 ± 2 ° C (Fig. 1, a, b – curves 1a-4a) and 40 ± 2 ° C (Fig. 1, c – curves 3a, 4a), due to the deterioration of taste and smell under hydrothermal treatment above the specified duration (Table 2). For the samples of sunflower seed kernels, hydrothermally treated are at 20 ± 2 ° C and 40 ± 2 ° C (Fig. 1, c – curves 1a, 2a, d – curves 1a-4a), scoping reached a maximum at the maximum duration of the hydrothermal treatment. The results showed (Fig. 1, b) reasonably achieving range of phenolic compounds is possible at temperatures of 60 ± 2 ° C and 80 ± 2 ° C. In this case, highest numerical score (4,00-4,97) during hydrothermal treatment of the samples occur at the particle size (1-2), (2-3) and (3-4) × 10^{-3} m (Table 2). It should be noted that the hydrothermal treatment at a temperature 80 ± 2 ° C and the specified duration (Table 2) gave the samples of sunflower seed kernels specific taste and smell with the signs of rancid butter, which is obviously due to the hydrolytic oxidative rancidity of the fats [15]. Hydrothermally treated of sunflower seed kernels at 60 ± 2 ° C were characterized by white color light gray shade with an impersonal taste and smell without taste and smell of rancid butter

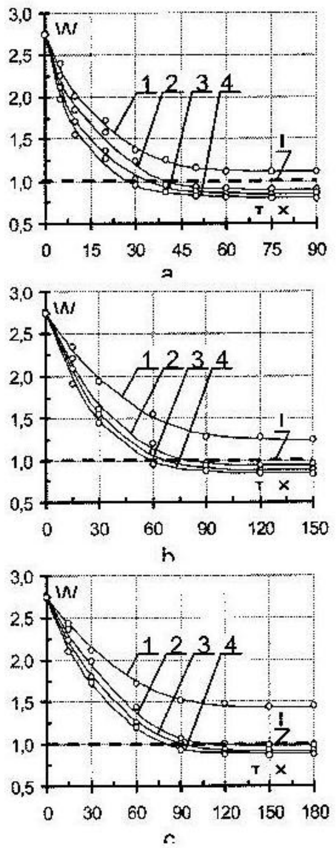

Fig. 2. *Dynamics of residual phenolic compounds in fractionated crushed sunflower kernel with particles, × 10^{-3} m: a – (1-2), b – (2-3), c – (3-4) after hydrothermal treatment at hydromodel: 1 – 1 : 5, 2 – 1 : 10, 3 – 1 : 15, 4 – 1 : 20 at 60 ± 2°C. I – reasonable range of phenolic compounds*

The residual amount of phenolic compounds in them was 33-36 % of the total content that means 0,99-0,92 % of dry matter of sunflower seed kernels. It is interesting to point out that, the hydrothermal treatment with extreme temperature and duration (Fig. 1, a – curve 1) 78,2 % of phenolic compounds can remove up. The finding data of the current study are consistent with the literature [10], approximately 21 % of these compounds are associated with a protein complex in sunflower seed kernels, so they can't be fully separated with acid extraction.

In the next stage of the research, was studied effect of hydraulic module of the hydrothermal treatment on residual content of phenolic compounds in sunflower seed kernels with specific range of the temperature and particle size. For this purpose was determined the residual content of phenolic compounds in the crushed sunflower seed kernels with particle size (1-2) × 10^{-3} m, (2-3) × 10^{-3} m, (3-4) × 10^{-3} m at a temperature of 60 ± 2 ° C and hydraulic module 1 : 5, 1 : 10, 1 : 15 and 1 : 20.

According to the data, (Fig. 2) there is a general tendency to increase the intensity of removal phenolic compounds and the reduction of their content with increasing hydraulic module. The obtained results suggest that the hydrothermal treatment with hydraulic module 1 : 5 (Fig. 2, 1, 2, 3, curve 1) does not allow achieve a certain reasonable range of phenolic compounds (Fig. 1, 2, I – the rational limits for phenolic compounds), which, according to previous studies should not be higher than 1,0 % (Table 1). The residual content of phenolic compounds in the samples with particle sizes (1-2) × 10^{-3} m, (2-3) × 10^{-3} m and (3-4) × 10^{-3} m, with hydraulic module, are respectively 1,11-1,12, 1,25-1,28 and 1,43-1,45 %.

Hydrothermal treatment with hydraulic module from 1 : 10 and above offers the possibility of obtaining hydrothermally treated sunflower seed kernels with a 1,0 % residual content of phenolic compounds In this case, with increasing hydraulic module ratio 1 : 10, 1 : 15, 1 : 20, time to reach a reasonable range of phenolic compounds decreases: for the samples with the particle size (1-2) × 10^{-3} m respectively (40 ± 1), (34 ± 1), (30 ± 1) × 60 s, with a particle size (2-3) × 10^{-3} m – (75,0 ± 1,5), (65 ± 1) and (60 ± 1) × 60 s, and with a particle size (3-4) × 10^{-3} m – (100 ± 2), (90 ± 1) and (85 ± 1) × 60 s. Analyzing data show that increasing the ratio of hydraulic module 1 : 10, 1,5 and 2 times (hydromodel 1 : 15 and 1 : 20) a time for limit phenolic compounds is reduced slightly: 1,18 and 1,50 times for samples with particle sizes (1-2) × 10^{-3} m, 1,15 and 1,25 times for the samples with particle sizes (2-3) × 10^{-3} m, 1,11 and 1,18 times for samples with particle sizes (3-4) × 10^{-3} m.

CONCLUSIONS

Summarize the results of research, can be stated on the hydrothermal treatment of crushed sunflower seed kernels with particle size (1-2) × 10^{-3}, (2-3) × 10^{-3} and (3-4) × 10^{-3} m at a temperature of 60 ± 2 ° C and duration no more than (40 ± 1) × 60 s, (75,0 ± 1,5) × 60 s and (100 ± 2) × 60 s. Thus, in our opinion from rational use of water resources point of view, hydrothermal treatment adjustable with hydromodel at 1 : 10. Specified process allows to get sunflower seed kernels with low phenolic compounds, high organoleptic characteristics and a light color, which satisfies each of the requirements for emulsion and in composition, curds.

In such a way, following the development of science-based emulsion technology on the basis of sunflower seed kernels with reduction phenolic compounds will provide new opportunities for using plant material in the culinary products based on the compositional curd products using the developed emulsions creating a new class of food products with regulate nutritional value, amino acid and fatty acid composition.

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