New technology for primary purification of sunflower and soybean oils

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Abstract. This article presents the results of the return of a high-oil fuse for frying, and its further pressing; the acidity of the resulting oil reached 5-6 mg KOH, which is 2-3 units higher than the technological norm. To reduce the acidity of black oil to normal, additional costs are required for refining. According to the proposed method, after 5 hours of operation of the production line, the acidity of the black oil decreased to 1.2 mg KOH, which contributed to an increase in the yield of refined oil by 2.5%.

1 Introduction

Sunflower oil is the best source of lecithin. This substance helps the formation of the child's nervous system and, at an older age, maintains the activity and clarity of the mind. Also, lecithin helps restore strength in anemia and stress. Soybean sown areas in Uzbekistan are growing from year to year. In 2023, it is planned to sow 156.5 thousand hectares of soybeans, including 82.5 thousand hectares in open fields and 74.0 thousand hectares in cotton inter-rows. In particular, soybeans were grown on 18.5 thousand hectares in 2018, 19.8 thousand hectares in 2019, and 17.314 thousand hectares in 2020. By the end of this year, the country is expected to produce 165.0 thousand tons of soybeans. It will produce 34 thousand tons of vegetable oil and 128 thousand tons of soybean meal [1]. Soybean meal will be sent to 38 million industrial birds. During the production of vegetable oils, the purification process is carried out by straining, centrifugation, and filtration to remove coarse and mechanical additives. Also, after the refining process of vegetable oils, it is required to retain the residual particles and separate the whitening reagent particles after the whitening process [2-3].

One of the problems in the filtration process is the reduction of filtration efficiency due to small particles in the oil clogging the filter surface. The time and labor required to clean the filter is a factor that reduces production efficiency.

Non-oil mucilage in the primary refining process of vegetable oils, small particles that do not settle in the filtration of refined oil, and grinding of bleaching earth to very small sizes to form micropores in the bleaching process lead to rapid clogging of the filtering surface [4-5].

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In the filtration process, the possibility of using different agents that prevent the filter surface from clogging to increase the filter's working period until the next cleaning and the filtration efficiency determines the relevance of researching this topic.

Vegetable oils obtained by pressing and extraction methods contain mechanical compounds, non-oily substances, toxic substances, and toxic substances in addition to glyceride. Also, when the presslab oil is extracted, the particles of fry and kunjara may fall into the forpress oil. Over time, the filtered oils become cloudy and precipitate. Fuza oil sinks to the bottom of storage tanks during storage. Their amount is 20-25%. It consists of fusa-phosphatides, proteins, and mucilaginous substances. When heated, fuza dissolves in oil, and when cooled, it separates from oil again.

Impurities that form a real solution or colloidal solution with vegetable oil include sterols, waxes and waxy substances, phosphatides, color and odorants, carbohydrates, proteins, and vitamins.

In addition to oil, almost all oilseeds contain several other fatty substances. These substances are collectively called lipids. Lipids are in the gel part of the kernel as complex compounds with pure carboxylic acids, sugars, sterols, pigment, alkaloids, phosphatides, and several other proteins, and their transfer to the fat part depends on the progress of the technological process of fat extraction [5-7].

According to the classification of V.G. Shcherbakov [8], oil plants are divided into several groups depending on their use: oil plants are grown to produce oil, while other products are secondary [9].

According to the classification of Professor V.V. Beloborodov [10], the technological processes of modern production of vegetable oils are divided into: mechanical - seed cleaning, seed hulling, separation of fruit and seed coats from the kernels, grinding of the kernel and cake; diffusion and diffusion-thermal methods - seed conditioning by moisture, roasting of mint, oil extraction, distillation of the solvent from miscella and meal; hydromechanical - pressing the pulp, settling and filtering the oil; chemical and biochemical processes - lipid hydrolysis and oxidation, protein denaturation, formation of lipid-protein complexes.

The choice of the scheme for processing oilseeds and the composition of the technological equipment is determined by the physical and mechanical properties of the seeds, their nature, and the purpose of the extracted oil [9].

On a technological basis, technological processes are divided into six groups [11]: preparation for storage and storage of oilseeds; seed preparation for oil extraction; actual oil extraction; refining of the obtained oil; bottling; packaging and labeling.

Oil from oilseeds is extracted by two main methods [12-16]: mechanical, which is based on the pressing of crushed raw materials; used in oil mills or oil churns of agricultural enterprises; chemical (extraction), in which specially prepared oilseeds are treated with organic solvents; used in oil extraction plants.

Oil extraction by pressing [16-18]. The mechanical method of obtaining oil by pressing oilseed material that has undergone preliminary preparation is widespread almost everywhere, not only at pressing oil plants but also at oil extraction plants, where the main technological scheme is pre-pressing - extraction.

Apply only a continuous method of pressing on screw presses. There are screw presses for preliminary oil removal (forpresses) and final oil removal (expellers). The original pulp is a loose porous material. With all-round compression under the influence of the applied pressure, two closely related processes occur: separation of the liquid part - oil; connection (fusion) of solid particles of the material with forming a briquette - cake. Screw presses have the same type of working bodies and a common scheme of design and operation. The main working parts of the screw press are the screw shaft and the grinding cylinder.

Forpressing - extraction is used for the final extraction of oil from the forpress shell (cake).

In the oil extraction plants of Uzbekistan, there is a technological scheme that includes preliminary moisture-thermal treatment and preliminary degreasing of the oil by forpressing, followed by its extraction by extraction with gasoline [19].

The crushed material - mint from the preparatory section is fed by elevator into the screw devices and distributed into the steaming and moistening screws above the braziers. Here, the enzyme system is inactivated by briefly heating the mint (30-40 s) with live steam to an 80-85°C temperature and moistening the mint to 8-9%.

2 Methods

The article uses modern chemical, physical-chemical, standardized physical-mechanical, technological, and operational test methods.

The essence of the method. For analysis, the sample is extracted in an extractor with technical hexane or, in its absence, with light petroleum ether. The solvent is distilled off, and the resulting residue is weighed.

The mass fraction of crude fat, w,%, is calculated by the formula [20]:

$$W = 100 \cdot \frac{m_1}{m_0} \tag{1}$$

where m_0 is the mass of the sample for analysis, g; weigh, to the nearest 0.001 g, approximately 10 g of the laboratory sample; m_1 is the mass of raw fat after drying, g; remove most of the solvent from the flask by distillation on an electric heating bath or hot plate. Remove the last traces of solvent by heating the flask for approximately 20 minutes in an incubator at 103°C.

Express the result to the first decimal place 1.2. Method for determining the moisture content of the fuse.

Humidity fuse without prior drying W_1,%, calculated by the formula [21]:

$$W_1 = \frac{(m - m_1) \cdot 100}{m - m_2} \tag{2}$$

where m is the weight of the bottle with seeds before drying, g; m_1 is weight of the bottle with seeds after drying, g; m_2 is the mass of an empty bottle, g.

The allowable discrepancy between the results of two parallel determinations with a confidence level p=0.95 should not exceed 0.25% abs. If the allowable discrepancy between the results of two parallel determinations is exceeded, the analysis is repeated.

The arithmetic mean value is taken as the final result of the analysis.

3 Results and Discussion

The results of the experiments are shown in Table 1. As an output, we consider the residual oil content of the cake after pressing y, %.

Table 1. Results of the experiments carried out according to scheme 2^2

Experiment number	Factors		Interaction effects of factors	Experimental results			Average result, $s\bar{y}_u$, %
	x_1	x_2	x_1x_2	y_1	y_2	y_3	
1	-	-	+	12.7	13.2	14.1	13.333
2	-	+	-	10.5	12.2	11.7	11.466
3	+	-	-	8.4	7.54	8.2	8.0466
4	+	+	+	18.3	18.7	17.5	18.166

Based on the results of a two-factor experiment, we will compose an equation in which, in addition to linear terms, there will be a term that considers the effect of pairwise interfactorial interaction.

The regression equation, in this case, has the following form:

$$y = b_0 + b_1x_1 + b_2x_2 + b_{12}x_1x_2 \quad (3)$$

Regression coefficients are calculated using the formulas:

$$b_0 = \frac{\sum_{i=0}^{N} \overline{y_M}}{N}$$
$$b_i = \frac{\sum_{i=1}^{N} \overline{X_{\iota M} y_M}}{N}$$
$$b_{12} = \frac{\sum_{i=1}^{N} \overline{X_{1M}X_{2M}y_M}}{N} \quad (4)$$

The calculation results are given in Table 2.

Table 2. Results of calculating values of regression coefficients

Odds	b0	b1	b2	b12
Values	12.75	0.35	2.06	2.99

We determine the significance of these coefficients according to the formula [22]:

$$S_{\{y\}}^2 = \frac{\sum_1^N \sum_1^N (y_{ni} - \overline{y_n})}{N(n-1)} \quad (5)$$

where N is the number of experiments in the experiment; n is the number of repeated observations in each experiment.

In our case: S_({y})^2=0.4606. The calculation results are shown in Table 3.

Table 3. Calculation of dispersion of reproducibility

j	y_1	y_2	y_3	y_j	$(y_{j1} - yj)^2$	$(y_{j2} - yj)^2$	$(y_{j3} - yj)^2$	$S^2 prepr.$
1	12.70	13.20	14.10	13.333	0.4011	0.0178	0.5878	0,5033
2	10.50	12.20	11.70	11.467	0.9344	0.5378	0.0544	0,7633
3	8.400	7.540	8.200	8.047	0.1248	0.2567	0.0235	0,2025
4	18.30	18.70	17.50	18.167	0.0178	0.2844	0.4444	0,3733
							Sum:	1,8425

The standard deviation of coefficients:

$$S_{\text{coeff}} = \frac{S_{prepr.}}{\sqrt{N}} \qquad (5)$$

In our case: $S_{S_{\text{coeff}}}$ =0.24

The calculated value of the Student's criterion is determined by the formula:

$$t_{kr} = \frac{|b_j|}{S_{\text{coeff}}} \qquad (6)$$

From the Student distribution tables [22], according to the number of degrees of freedom n(m-1)=4 2=8 at the significance level α = 0.05, we find $t_{kr.}$= 1.44.

The calculated value of the Student's criterion is determined by the formula (6) $|b_j|= t_{kr.}\cdot S_{coeff}$= 1.44·0.2400=0.346.

Comparing the obtained value of 0.346 with the coefficients of the regression equation, we find that all coefficients are greater in absolute value |bj |. Therefore, all coefficients are significant.

Then the regression equation (3) has the form:

$$y = 12{,}75 + 0{,}35x_1 + 2{,}06x_2 + 3{,}0x_1x_2 \qquad (7)$$

The adequacy of the obtained regression equation was checked using the Fisher criterion [22].

$$F = \frac{S^2_{rem.}}{S^2_{repr.}} \qquad (8)$$

where the residual variance is calculated by the formula:

$$S^2_{rem.} = \frac{\sum_{i=1}^{N}(y_i - yr_i)^2}{N-L} \qquad (9)$$

where L is the number of significant coefficients in the regression equation.

If the calculated value of the Fisher criterion is less than the tabular value, then the resulting regression equation adequately describes the experiment.

For our case $S^2_{rem} = 1.49813$.

At a significance level of α = 0.05 and degrees of freedom $k_1=n-r$=4-3=1 i $k_2=n(m-1)$=8 F_{tabl}=5.32.

The calculated value of the Fisher criterion according to the formula F_{calc}=3.25.

Hence, F_{calc}=3.25 < F_{tabl} =5 m. Based on this, we can conclude that the resulting model adequately describes the process.

By converting the values of the factors into natural dimensions according to formula (7) on MatCAD program, we plotted the dependence of the process yield on the percentage ratio of the fuse in the mixture and the duration of mixing (drawing 1).

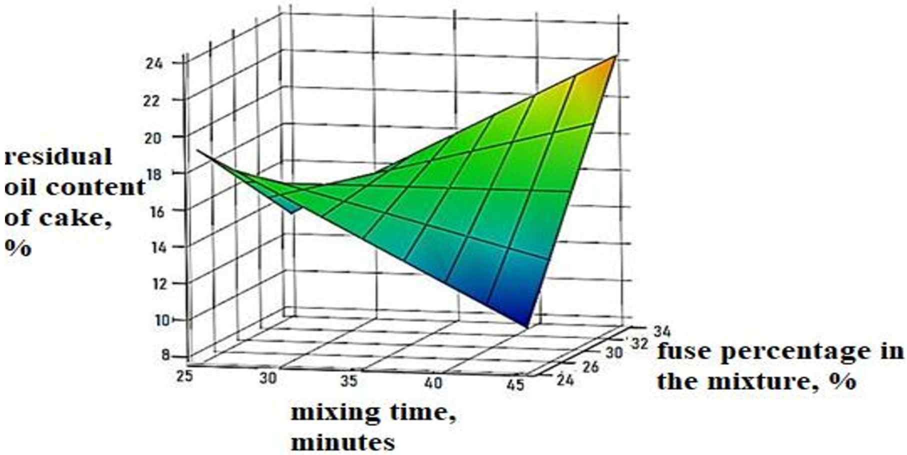

Fig. 1. Dependence of oil cake residual oil content on influencing factors.

It can be seen from the graph that with the values of the influencing factors (the percentage of fuse in the composition of the mixture x1=33% and the mixing time x2=40 min), the residual oil content of the cake will be the lowest (8.0%).

In the proposed technological scheme for processing the separated high-oily fuse on the separator, the latter is not returned to frying, which leads to a decrease in the acid number of the black oil. Therefore, we have determined the change in the acid number of the oil coming from the presses to the separator. At the same time, each oil sample was subjected to laboratory analysis under production conditions according to certain methods, where the acid number of black oil, oil color, oil moisture content, and oil temperature were determined. The results of the experiments are shown in Table 4.

Based on the experimental data obtained, a graph was constructed of the change in the acid number of black oil depending on the time when the high-oil fuse is not returned to frying, where it is further pressed and oils and oil cake are obtained (Figure 2).

Table 4. Dependence of indicators of black sunflower oil on time of non-return of fuse to fryer

Fuse non-return time to brazier (hour)	Acid number of black oil, mg KOH	Oil color (red unit)	Oil moisture content, %	Oil temperature, 0C
0	4	25	0.29	85-90
1.5	2	24	0.28	85-90
2	1.4	18	0.24	85-91
2.5	1.2	14	0.22	85-92
3	0.6	8	0.2	85-93
3.5	0.2	6	0.2	85-94
4	0.2	4	0.2	85-95
5	0.2	4	0.2	85-96

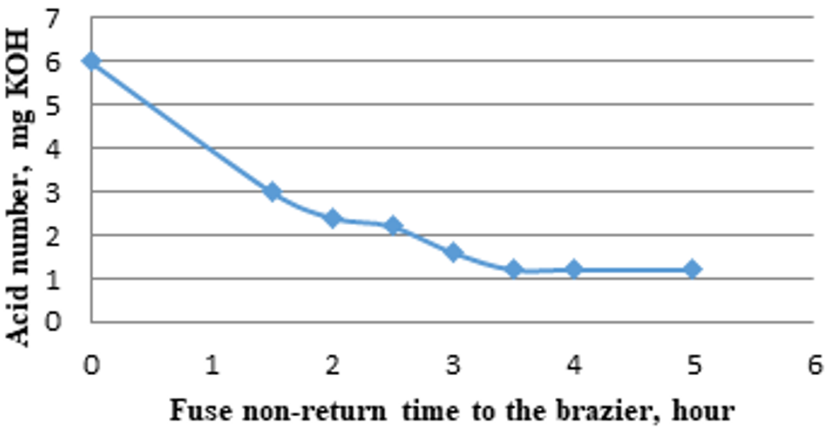

Fig. 2. Plot of black oil acid number vs fuse non-return time to fryer

It can be seen from the graph that when the high-oil fuse was returned to frying and further pressed, the acidity of the resulting oil reached 5-6 mg KOH, which is 2-3 units higher than the technological norm. To reduce the acidity of black oil to normal, additional costs are required for refining. According to the proposed method, after 5 hours of operation of the production line, the acidity of the black oil decreased to 1.2 mg KOH, which contributed to an increase in the yield of refined oil by 2.5%.

The proposed technological scheme consists of the following main processes **(**draw.3):

- mixing oil fuse; - resting the mixture on the mixer; -pressing the mixture to obtain black oil and cake; -direction of black oil to the fuzo separator; - the direction of oilseed cake for extraction.

The proposed technological scheme consists of the following main devices: a husk separator 1, a channel for pressing black oil from presses 2, a redler for unloading the separated sludge 3, a mixer for mixing the separated sludge with husk 4, blades for mixing husk and sludge 5, a screw conveyor for feeding husks to the mixer 6, a chute for the exit of the mixture of husks and sludge from the mixer 7, a mini oil press 8, a channel for the exit of black oil from the mini press 9, a mini press head for the exit of oil cake 10, a screw conveyor for oil cake coming out of the mini press 11, branch pipe for sampling black oil from the separator 12. The proposed technological scheme works according to the following sequence and interconnection of devices.

The separated fuse with an oil content of about 50% from the fuse separator is directed to a container with a mixer with a volume of 3 m /67, i.e., 33% fuse mixture, 67% husks, husks are supplied by a screw conveyor with a capacity of 0.038 kg/s. The mixer at the bottom has a chute to exit the mixture. In the mixer, the processes of complete mixing of the husk and oilseed fuse will take place, after which a chute is opened to exit the mixture, and the mixture enters the mini-press plant with a power of 5 kW, a capacity of 0.07 kg / s. From the mini press, black oil is obtained with a low fuse content of 2-3%, which is sent to the separator and oil cake - to the conveyor for the extraction shop.

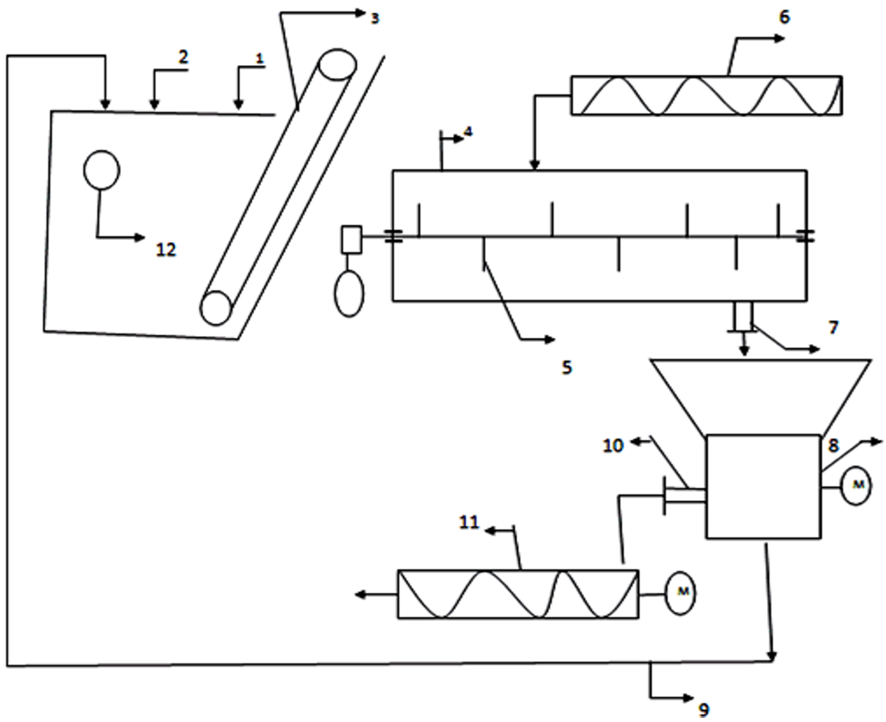

Fig. 3. Technological scheme of process of processing fuse separated on separator

4 Conclusions

During the production of vegetable oils, the purification process is carried out by straining, centrifugation, and filtration to remove coarse and mechanical additives. Fuza oil sinks to the bottom of storage tanks during storage. Their amount is 20-25%. It consists of fusa-phosphatides, proteins, and mucilaginous substances. When heated, fuza dissolves in oil, and when cooled, it separates from oil again.

In the process of refining the oil, at the values of the influencing factors (the percentage of the fuse in the composition of the mixture x1=33% and the duration of mixing x2=40 min), the residual oil content of the cake will be the smallest (8.0%). When the high-oil fuse was returned to frying and further pressing, the acidity of the resulting oil reached 5-6 mg KOH, which is 2-3 units higher than the technological norm. To reduce the acidity of black oil to normal, additional costs are required for refining. According to the proposed method, after 5 hours of operation of the production line, the acidity of the black oil decreased to 1.2 mg KOH, which contributed to an increase in the yield of refined oil by 2.5%.

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