



PURIFICATION OF VEGETABLE OIL USING CLAY ADSORBENTS IN ADSORPTION PROCESSES

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Annotation:

This article demonstrates the potential application of clay adsorbents obtained by acid activation of local bentonites from the Krantov deposit. The optimal amount of adsorbent required to reduce the color intensity of safflower oil from 15 to 6 mg/iodine, the acid value from 2.6 to 1.5 mg KOH/g, and the peroxide value from 4.4 to 3.1 mmol active oxygen/kg has been determined. It has been shown that after bleaching with the proposed adsorbent, the oxidative stability of the oil meets GOST standards for 150 days and is inferior to imported analogs.

Keywords: Safflower oil, adsorption, purification, clay, montmorillonite, bentonite, activation.

Introduction

The oil and fat industry holds a significant position in the food sector due to the diversity and uniqueness of raw materials, as well as the essential role of oils in human diets. Vegetable oils and fats are an indispensable component of nutrition, serving as a source of energy and building materials for the body. Additionally, they supply vital substances involved in metabolism, regulation of blood pressure, and the removal of





excess cholesterol and other compounds from the body. Safflower oil surpasses sunflower and olive oils in terms of nutritional properties and health benefits. It contains up to 80% linoleic acid and other polyunsaturated fatty acids, which help reduce cholesterol levels in the blood and aid in combating various diseases.

The process of removing unwanted substances from oils is called "**refining.**" During refining, it is crucial not only to eliminate unnecessary impurities but also to preserve the beneficial components in the oil and protect them from degradation. The impurities in oils include phosphatides, waxes, resins, free fatty acids, aromatic and flavor compounds, gossypol, mucilaginous substances, and others.

Methods of Oil Purification

Modern methods of purifying oils and fats are divided into three categories:

1. **Physical methods** (sedimentation, centrifugation, filtration).
2. **Chemical methods** (hydration, alkaline refining).
3. **Physicochemical methods** (adsorption refining, deodorization).

The purification method is chosen based on the oil's composition and the volume of impurities, their characteristics, as well as the intended use of the oil. To achieve complete purification, a combination of several methods is often employed. Phosphatides, sterols, and tocopherols enhance the biological value of oils, while waxes, free fatty acids, and gossypol reduce oil quality. At the same time, the presence of phosphatides in oil negatively affects its technological properties, complicating the refining and hydrogenation processes. Therefore, maintaining the quality of preliminary purification plays a crucial role.

Adsorption methods and the use of local clays.

The purification of liquids, particularly vegetable oils, using adsorption methods is widely practiced in many countries. Primarily, locally activated clays are used. Today, the purchase and transportation costs of imported activated clays are expensive for oil and fat enterprises, which increases the production cost of the manufactured products. For this purpose, research has been conducted to develop adsorbents from local bentonite.

Analysis of literature related to the topic.

Vegetable oils and fats are essential in the diet as they serve as a source of energy and building materials for the body. They provide essential substances that participate in metabolism, regulate blood pressure, and aid in the removal of excess cholesterol and other substances from the body [1]. Safflower oil is considered superior to sunflower and olive oil in terms of its nutritional properties and health benefits. It contains up



to 80% linoleic acid, as well as other polyunsaturated fatty acids that help reduce cholesterol levels in the blood and are beneficial in combating various diseases. The process of removing undesirable substances from oils is called "refining." During refining, it is crucial not only to eliminate unnecessary impurities but also to preserve all the beneficial components in the oil and prevent their loss or degradation. Impurities include phosphatides, waxes, resins, free fatty acids, aromatic and flavoring substances, gossypol, mucilaginous substances, and other elements [2]. Modern methods of oil and fat purification are divided into three categories: physical (sedimentation, centrifugation, filtration), chemical (hydration, alkali refining), and physicochemical (adsorption refining, deodorization). The choice of method depends on the composition and volume of impurities, their characteristics, and the purpose of the oil. Often, a combination of various methods is used to achieve complete purification. Phosphatides, sterols, and tocopherols enhance the biological value of oils, whereas waxes, free fatty acids, and gossypol lower their quality. However, the presence of phosphatides in oils also negatively impacts their technological properties, making the refining and hydrogenation processes more difficult. Therefore, preliminary purification of oils plays a crucial role in maintaining their quality. Adsorption purification methods for liquids, particularly vegetable oils, are widely used in many countries, with locally activated clay materials being primarily utilized in these processes. Today, the purchase and transportation of imported activated clays are costly for enterprises in the oil and fat industry, which increases the production cost of the final products. For this purpose, research has been conducted to develop adsorbents for adsorption purification based on local bentonite [3]. Montmorillonite minerals differ from pyrophyllite in structure only by the swelling capacity of their lattice and occur in nature as very fine and imperfect crystals [4]. The structure of montmorillonite, considering the possibility of isomorphic substitutions in its lattice, is similar to the pyrophyllite-talc structure [5]. Natural bentonites, in their raw state, have a relatively small surface area (59-90 m²) [6]. In Uzbekistan, particularly in the regions of Tashkent, Bukhara, Khorezm, Navoi, Fergana, Samarkand, and the Republic of Karakalpakstan, there are more than 100 natural clay deposits with adsorption properties [7]. Bentonite clays are composed of various clay substances, with their main components being montmorillonite and beidellite. The Al₂O₃:SiO₂ ratio in these clays ranges from 1:2 to 1:4 [8-9]. The characteristics of bentonite composition indicate that a series of processes, including enrichment and activation, are necessary to obtain an effective adsorbent. Undoubtedly, achieving a highly active adsorbent requires considering the raw material's condition, as it is often extracted with a high content of iron, titanium, and other color-inducing oxides [10,11]. Under





the optimal conditions for acid activation of clay, micropores are eliminated, the number of hydrogen bonds on the adsorbent surface increases, and the transitional pores (3-20 nm), which are essential for purifying and bleaching oil solutions containing high-molecular substances, significantly increase [12]. For this purpose, research was conducted on adsorption purification using clay-based adsorbents obtained by acid treatment of Krantau bentonite [13].

Experimental Section

Adsorption purification of safflower oil was carried out using the contact method under the following conditions: a temperature of 70°C, a stirring speed of 400-500 rpm, and varying amounts of adsorbents.

Figure 1 shows the variation in the purification level achieved with the obtained adsorbents.

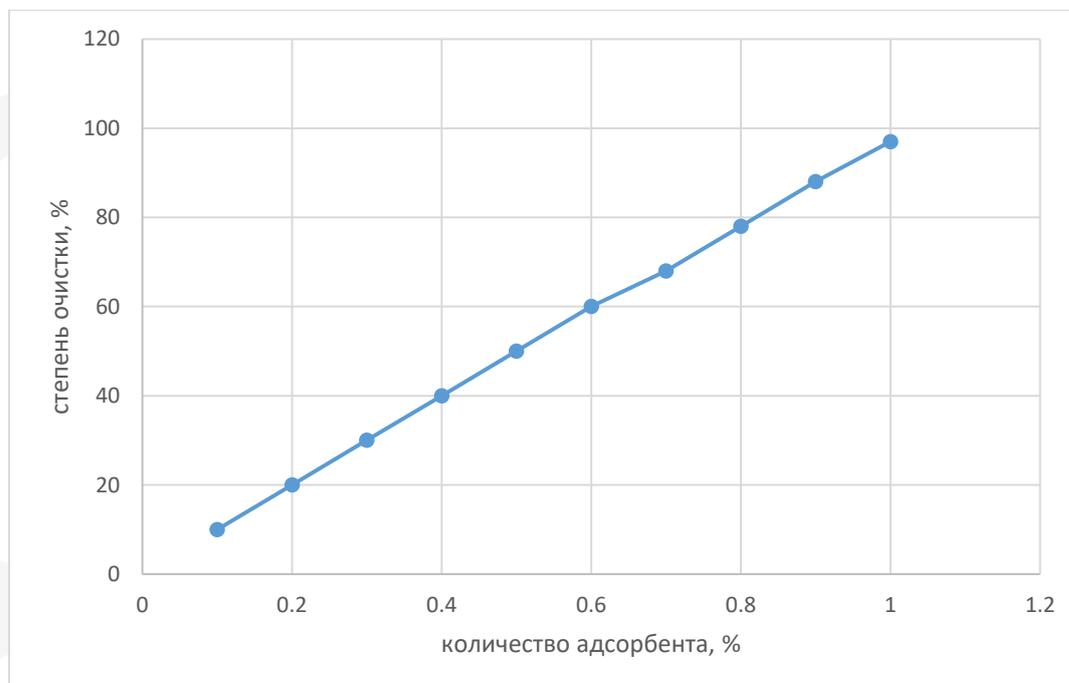


Figure 1. The relationship between the amount of adsorbent and the purification level. As seen in Figure 1, an increase in the amount of adsorbent leads to a higher purification level. However, an increase in the adsorbent amount also reduces oil yield, which impacts the cost of the obtained oil.

Subsequently, the effect of the introduced adsorbent amount on the physicochemical properties was studied.



Research Results and Discussion

Table 1. Results Before and After Bleaching Cottonseed Oil with Clay-Based Adsorbents

"Names of Indicators"	"Initial parameters of safflower vegetable oil"	"Parameters after bleaching of vegetable oil"			
		"Amount of clay adsorbent"			"Pakistani clay adsorbent (control)"
		0,25	0,5	1,0	
"Color index, mg of iodine"	15	10	8	6	7
"Acid value, mg KOH/g"	2,6	2,1	1,8	1,5	1,5
"Peroxide value, mmol of active oxygen/kg"	4,4	4,0	3,4	3,1	3,0
"Oil absorption capacity of the adsorbent, %"	-	45	45	45	42

"As seen from Table 1, with an increase in the amount of adsorbent from 0.25% to 1.0% of the total oil mass, the color index, acid value, and peroxide value decrease accordingly: the color index from 15 to 6 mg iodine, the acid value (A.V.) from 2.6 to 1.5 mg KOH/g, and the peroxide value (P.V.) from 4.4 to 3.1 mmol of active oxygen/kg. Moreover, the parameters obtained with the addition of 1% adsorbent are equal to those of the control sample. This proves that the bentonite from the Krantau deposit, modified through acid treatment, is not inferior to the imported adsorbent.

The oxidative stability of purified safflower oil bleached with the proposed clay adsorbents is a key quality indicator of the oil. The obtained results are presented in Figure 2."

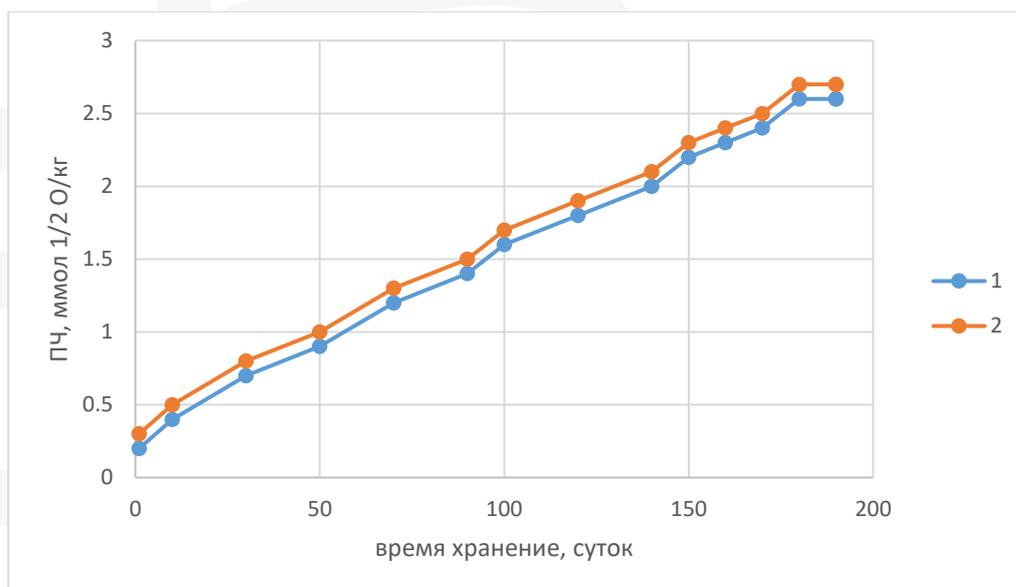


Figure 2. Dependence of peroxide value (P.V.) changes on storage time after bleaching with the developed clay adsorbents.



- 1 - After bleaching with the proposed adsorbents;
- 2 - After bleaching with the imported Pakistani adsorbent.

From Figure 2, it can be seen that the change in the peroxide value kinetics is related to the storage time. Over time, the peroxide value increases, which indicates a deterioration in the quality of the oil. On average, under normal conditions, the oil's shelf life is 1-2 years. However, if the storage conditions outlined in the GOST standards are not followed, the deterioration of oil quality can be accelerated. Over a period of 150 days, the peroxide value changes from 0.3 mmol $\frac{1}{2}$ O/kg to 2.8 mmol $\frac{1}{2}$ O/kg, which is almost a 5-fold increase.

Conclusion

Thus, the use of clay adsorbents obtained from local bentonites can be applied for bleaching safflower oil. When using 1% clay adsorbent for bleaching safflower oil, the color index decreases from 15 mg iodine to 6 mg iodine, the acid value (A.V.) decreases from 2.6 to 1.5 mg KOH/g, and the peroxide value (P.V.) decreases from 4.4 to 3.1 mmol of active oxygen/kg. The oxidative stability after bleaching with the proposed adsorbent shows that, over a period of 150 days, the peroxide value of the oil does not exceed the standards set by GOST, and it is also lower than the values of the imported counterpart.

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