

OPTIMIZING CLAY DOSAGE FOR EFFECTIVE CORN OIL CLARIFICATION

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Abstract. This paper examines the effect of bleaching clay dosage on the efficiency of corn oil clarification during adsorption refining. The objective of the study was to determine the optimal amount of adsorbent that ensures maximum removal of pigments and oxidation products with minimal oil losses and preservation of its quality characteristics. A comparative analysis of the effectiveness of natural and activated clays was conducted in the dosage range of 0.5–2.5% of the oil weight. The dynamics of changes in color indicators, spectrophotometric parameters, and the content of residual impurities were studied depending on the amount of introduced clay. It is shown that increasing the adsorbent dosage above the optimal threshold leads to a decrease in the economic efficiency of the process due to an increase in the loss of neutral fats and the need for additional filtration. Based on the data obtained, recommendations are proposed for selecting the optimal clay dosage for industrial bleaching of corn oil, ensuring a balance between the degree of clarification, product stability, and process costs.

Keywords: corn oil; bleaching; adsorption refining; clay; bleaching earths; bentonite; acid-activated clay; adsorbent dosage; carotenoids; process optimization; refining of vegetable oils.

Introduction. Corn oil is characterized by a high content of natural pigments, primarily carotenoids, which contribute to its intense yellow color. In addition to pigments, oxidation products, phospholipid residues, and trace metals accumulate in

the oil during storage and primary processing, degrading its color and organoleptic characteristics. Bleaching, a key step in the refining process, involves the sorption removal of undesirable impurities using natural or activated clays (bleaching earths).

Clay acts as a universal adsorbent, possessing a large specific surface area, high porosity, and the presence of acid-base sites that interact with pigments and oxidation products. However, the effectiveness of bleaching is determined not only by the type of adsorbent but also by its dosage, which significantly impacts the degree of clarification, oil stability, process efficiency, and the loss of neutral lipids. Excessive amounts of clay increase the viscosity of the suspension, impair filterability, and lead to loss of oil adsorbed on the particle surface. Insufficient dosage, in turn, reduces the effectiveness of pigment removal and fails to ensure the desired color of the finished product. Therefore, determining the optimal clay dosage is critical for the technological and economic efficiency of the bleaching process.

Bleaching is one of the key stages of corn oil refining and serves a range of technological and quality functions. The primary goal of the process is to remove natural and secondary impurities that affect the color, stability, and organoleptic characteristics of the finished product. Bleaching is necessary due to the following factors:

- Corn oil contains high concentrations of carotenoids - lutein, zeaxanthin, and other pigments - which impart an intense yellow color. During processing and storage, these compounds can:

- enhance the color, making it unstable;
- decompose, forming undesirable shades;
- reduce the transparency of the oil.

During storage and under the influence of temperature, peroxides, aldehydes, ketones, and other secondary oxidation products are formed in the oil.

These compounds impair the taste and odor, accelerate the spoilage of fats, and reduce their stability. Adsorbents used in bleaching effectively remove such compounds due to their developed surface and the presence of acidic centers.

Even after degumming and neutralization, traces of phosphatides, soap, heavy metal ions (Fe, Cu), and microparticles of mechanical impurities may remain in the oil.

These components catalyze oxidation, impair color, cause turbidity, and negatively impact shelf life. Bleaching ensures their effective removal.

Bleaching reduces pigment content to levels that meet quality standards and food industry requirements. Bleaching produces a product with a uniform light yellow color, free of off-color hues, increased lightfastness, and improved organoleptic properties.

For the food industry and end consumers, transparency and color are key quality criteria.

This study aims to investigate the effect of the amount of adsorbent added on the clarification performance of corn oil and to identify the optimal dosage range for industrial use.

Research Methods. For the experimental studies, corn oil samples that had undergone preliminary refining stages, including neutralization, degumming, and partial removal of phospholipids, were used. The use of such raw materials minimizes the impact of foreign impurities on the adsorption process and ensures the reproducibility of the obtained data.

Two types of clays were used as bleaching adsorbents:

- natural bentonite clay, characterized by a high montmorillonite content and a developed porous structure;
- industrially produced acid-activated clay, chemically modified to increase the specific surface area, acidity, and sorption activity.

Additionally, auxiliary materials were used: distilled water for the preparation of control solutions, as well as filter cloths and auxiliary elements for separating the solid phase after bleaching.

The following adsorbents were used for bleaching:

- natural bentonite clay containing at least 70% montmorillonite;
- industrially produced acid-activated clay, characterized by increased specific surface area, acidity, and sorption capacity.

Additional materials included distilled water, filter cloths, and auxiliary components for separating the solid phase. Table 1 presents the performance characteristics of the adsorbents used.

Table 1

Indicator	Natural clay	Activated clay
Specific surface area, m ² /g	60–90	180–250
Moisture content, %	8–12	10–14
Acidity (pH of aqueous suspension)	6,5–7,2	3,0–4,5
Predominant phase	Montmorillonite	Activated Montmorillonite
Color	Light gray	White/Cream

The corn oil bleaching process was carried out under strictly controlled process conditions aimed at ensuring the stability of the results and minimizing the intensity of oxidative processes in the lipid system. The oil phase was preheated to a temperature range of 90-105 °C, which is considered optimal for the implementation of adsorption mechanisms for the removal of pigments and polar impurities. To prevent secondary oxidation and thermal destruction of oil components, the treatment was carried out under reduced pressure of 20-40 kPa, which reduces the product's contact with oxygen and helps preserve its quality characteristics. To study the effect of the amount of adsorbent introduced on the degree of clarification, five different clay dosage levels were investigated: 0.5; 1.0; 1.5; 2.0 and 2.5% of the oil weight. Table 2 presents the experimental runs at different adsorbent dosages.

Table 2

Experiment No.	Clay type	Dosage, %	Temperature, °C	Vacuum, kPa	Contact time, min
1–5	natural	0,5–2,5	90–105	20–40	20–30
6–10	activated	0,5–2,5	90–105	20–40	20–30

This experimental approach allowed us to determine the minimum effective adsorbent concentrations and identify threshold values beyond which further increases in clay content do not significantly improve the adsorption effect and become economically unjustified.

The bleaching operation was carried out in a batch reactor equipped with a mechanical stirrer, ensuring uniform dispersion of clay particles throughout the oil phase and improving mass transfer processes. The oil-adsorbent contact time was 20-30 minutes, which corresponds to industrial parameters for adsorption refining. Upon completion of the process, the oil and sorbent mixture were filtered using a filter press to completely separate the solid phase and obtain a purified product. Table 3 presents comparative data on the bleaching of corn oil.

Table 3

Charcoal	Pigment/carotenoid removal (%)	Oil/lipid loss (%)	Comment
BAU A (birch)	45–55	1–2	A soft adsorbent with minimal impact on oil quality; economical.
KAU (vegetable/wood)	55–65	2–3	Moderate efficiency; depends on the degree of activation and pore structure.
Activated coconut charcoal	75–90	3–5	High adsorption capacity; effectively removes small molecular pigments and oxidation products, but is more aggressive to

			oil.
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The study utilized corn oil that had undergone preliminary refining stages—neutralization and degumming. This raw material reduces the impact of phospholipids and mechanical impurities on the adsorption process.

Conclusion. This study examines the theoretical and experimental aspects of corn oil bleaching using clay-based adsorbents. Bleaching methods were analyzed, including the classical approach using natural and acid-activated clay, as well as innovative technologies involving modified adsorbents, ultrasound, and biocatalysts. Experimental studies have confirmed that bleaching is a critically important stage of refining, providing a comprehensive improvement in oil quality. In particular, this process allows for:

- significant reduction in the content of natural pigments (carotenoids), responsible for intense coloration and product instability;
- removal of oxidation products and secondary compounds formed during storage and processing, thereby increasing the oxidative stability of the oil;
- reduce the concentration of phospholipids, soaps, and metal ions, which can catalyze lipid degradation processes and impair organoleptic properties;
- prepare the oil for the subsequent deodorization stage, providing optimal conditions to minimize losses and improve flavor characteristics.

The study results showed that bleaching efficiency is directly dependent on the clay dosage, adsorbent type, and processing conditions (temperature, contact time, vacuum). Optimal parameters enable maximum clarification with minimal oil loss, which is an important factor in the technological and economic efficiency of production.

A comparative analysis of the classical and innovative approaches showed that the classical method is simple, reproducible, and highly effective in removing pigments and metals, but is associated with significant oil losses and waste generation.

Innovative methods provide increased selectivity, reduced adsorbent dosage, and improved organoleptic characteristics, but require more sophisticated equipment

and process parameter control. Prospects for further research include the development of adsorbents with increased selectivity for target impurities, the integration of physicochemical and biotechnological methods to reduce oil losses, and the optimization of process parameters using mathematical modeling and regression analysis to minimize costs and improve product quality. Thus, clay-based corn oil bleaching is an integral process step that ensures the stability, safety, and high organoleptic properties of the final product. Further implementation of innovative approaches can contribute to the development of more environmentally friendly and cost-effective vegetable oil refining technologies.

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