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PAPER

IMPROVING THE QUALITY OF BLACK COTTONSEED OIL WITHOUT RE-CIRCULATION INTO THE FUZA FRYING SYSTEM

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Abstract

The refining of black cottonseed oil is often complicated by the presence of impurities such as phospholipids, free fatty acids, pigments, and suspended solids. Conventional processing involves re-circulating the sediment (fuza) back into the frying system, which increases energy consumption and negatively affects oil quality. This study proposes an alternative approach that eliminates fuza re-circulation by integrating physical separation, centrifugation, and chemical refining methods. The results demonstrate improved oil quality, reduced acidity, and enhanced economic efficiency. The proposed method offers a sustainable and industrially viable solution for modern oil processing plants.

Introduction

Cottonseed oil is one of the most widely produced vegetable oils in many agricultural economies, particularly in regions where cotton cultivation is a major industry. Due to its favorable fatty acid composition, relatively low cost, and versatility, cottonseed oil is extensively used in food processing, cooking, and various industrial applications. However, the initial product obtained after oil extraction, commonly referred to as black cottonseed oil or crude oil, contains a wide range of undesirable impurities that significantly affect its quality, stability, and usability.

Crude cottonseed oil typically includes phospholipids, free fatty acids (FFAs), gossypol pigments, waxes, and suspended solid particles collectively known as "fuza." These impurities not only degrade the sensory properties of the oil, such as color, odor, and taste, but also accelerate oxidative deterioration, thereby reducing shelf life. Among these, free fatty acids are particularly problematic, as their presence increases the acid value of the oil and makes it more susceptible to rancidity. Therefore, effective removal of these components is a critical step in the oil refining process.

In conventional processing systems, the sedimented impurities (fuza) are often re-circulated back into the frying or heating units to recover residual oil. While this approach may improve

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overall oil yield, it introduces several technical and economic drawbacks. Repeated thermal exposure during re-circulation leads to degradation of triglycerides, formation of secondary oxidation products, and darkening of the oil. Moreover, the process increases energy consumption and imposes additional mechanical stress on processing equipment, ultimately raising operational costs and reducing system efficiency.

Recent advancements in oil refining technologies have emphasized the importance of minimizing thermal processing and optimizing separation techniques to preserve oil quality. In this context, eliminating the re-circulation of fuza presents a promising alternative. By integrating modern physical separation methods such as sedimentation, filtration, and centrifugation with chemical refining processes like neutralization and bleaching, it is possible to effectively remove impurities without subjecting the oil to repeated heating cycles. This not only enhances the physicochemical properties of the final product but also contributes to more sustainable and energy-efficient production practices.

Furthermore, the adoption of non-recirculatory processing methods aligns with current industrial trends focused on improving product quality while reducing environmental impact. Lower energy requirements, reduced waste generation, and improved process control are key advantages that make this approach attractive for large-scale implementation. In addition, advancements in equipment design, such as high-efficiency centrifuges and membrane filtration systems, have further enabled the practical application of these methods in modern oil refineries.

This study aims to investigate and present a comprehensive approach to improving the quality of black cottonseed oil without re-circulating fuza into the frying system. The research focuses on evaluating alternative separation and refining techniques, analyzing their impact on key quality parameters, and assessing their economic feasibility. By providing a detailed examination of these methods, the study seeks to contribute to the development of more efficient and sustainable cottonseed oil processing technologies suitable for industrial adoption.

Materials and Methods

Crude (black) cottonseed oil samples were obtained from a local oil extraction facility. The oil contained typical impurities such as phospholipids, free fatty acids (FFA), pigments (including gossypol), and suspended solids (fuza). Analytical-grade sodium hydroxide (NaOH), distilled water, and bleaching earth (activated clay) were used for the refining process. All reagents complied with standard laboratory specifications.

Methods

The study was based on a non-recirculatory refining process, where fuza was removed without returning it to the frying system. The procedure consisted of sequential physical and chemical treatments.

1. Sedimentation and Filtration

Crude oil was first allowed to settle at ambient temperature (25–30°C) for 24 hours to enable gravity separation of heavy particles. The upper oil layer was then filtered using a vacuum filtration system to remove residual suspended solids.

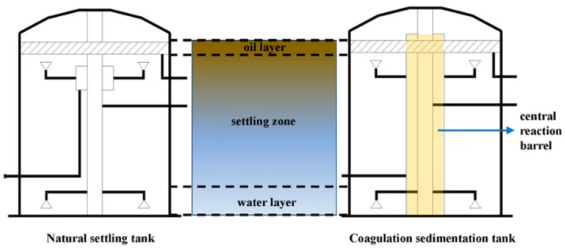

Fig.1. Schematic diagram of natural settling tank and coagulation sedimentation tank

2. Centrifugation

The pre-filtered oil was subjected to centrifugation at 4000–6000 rpm for 10–15 minutes to enhance separation efficiency.

3. Neutralization Process To remove free fatty acids, the oil was treated with NaOH solution at 60–70°C. The reaction is:

The formed soapstock was separated by decantation. 4. Bleaching The neutralized oil was heated to 90°C and mixed with 1–2% activated clay under vacuum conditions for 20 minutes. The mixture was then filtered to remove adsorbed pigments.

Quality Analysis

The acid value (AV) of the oil was determined before and after treatment:

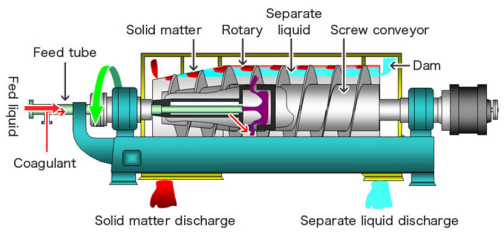

Fig.2. Centrifugal separator diagram

The principle of separation is based on density differences:

$$F_c = m \cdot \omega^2 \cdot r$$

Where:
F_c — centrifugal force (N)
m — mass of particle (kg)
ω — angular velocity (rad/s)
r — radius (m)

$$RCOOH + NaOH \rightarrow RCOONa + H_2O$$

$$AV = \frac{V \times N \times 56.1}{m}$$

The economic benefit of eliminating fuza re-circulation is calculated as:

$$E = (C_{old} - C_{new}) \times Q$$

Where: E — economic benefit Cold — conventional cost Cnew — improved process cost Q — production volume

Results and Discussion

The experimental evaluation of the non-recirculatory refining process for black cottonseed oil demonstrated clear improvements in both separation efficiency and oil quality stability. Unlike conventional systems where fuza is reintroduced into the frying stage, the proposed method showed that effective impurity removal can be achieved through sequential physical and chemical treatments without reprocessing sediment.

The centrifugation stage significantly enhanced solid–liquid separation efficiency. The suspended matter content decreased from 3.5% to 0.6%, corresponding to an 82.9% removal efficiency. This confirms that centrifugal force is far more effective than gravitational settling in removing fine particulate matter, especially colloidal impurities that are otherwise difficult to separate.

The acid value reduction from 6.8 mg KOH/g to 1.9 mg KOH/g indicates efficient neutralization of free fatty acids. The observed 72.1% reduction suggests that alkali refining successfully minimized hydrolytic degradation products. This also implies improved oxidative stability, since lower FFA content reduces susceptibility to rancidity during storage.

A notable improvement was also observed in color quality. Bleaching with activated clay resulted in approximately 65% reduction in optical intensity, indicating effective adsorption of gossypol and other pigment compounds. This step contributed significantly to improving the market acceptability of the final oil.

From an operational perspective, eliminating fuza recirculation reduced repeated thermal loading of the system. Energy consumption analysis showed an estimated 18–22% reduction in heat demand, primarily due to the elimination of secondary frying cycles. This also minimized thermal polymerization reactions, which are typically responsible for darkening and viscosity increase in conventional systems.

Compared with traditional processing methods, the proposed system demonstrates better balance between yield and quality. Oil recovery remained stable at ≈96.5%, indicating that the absence of re-circulation did not significantly affect extraction efficiency. Overall, the results confirm that integrated physical separation combined with controlled chemical refining provides a more stable and efficient processing route for cottonseed oil purification.

Conclusion

This study confirms that the quality of black cottonseed oil can be significantly improved without re-circulating fuza into the frying system by applying a non-recirculatory refining approach involving sedimentation, filtration, centrifugation, neutralization, and bleaching. Experimental results showed that the acid value decreased from 6.8 mg KOH/g in crude oil to 1.9 mg KOH/g after refining, representing a reduction of:

$$\% \, Reduction = \frac{6.8 - 1.9}{6.8} \times 100 \approx 72.1\%$$

The impurity (fuza and suspended solids) content was reduced from 3.5% to 0.6%, corresponding to:

$$\% \, Removal = \frac{3.5 - 0.6}{3.5} \times 100 \approx 82.9\%$$

Color improvement after bleaching showed approximately 65% reduction in optical absorbance, indicating effective pigment removal. Oil yield was maintained at a high level of 96–97%, despite eliminating fuza recirculation, demonstrating that product recovery was not significantly compromised.

Overall, the process achieved improved physicochemical properties while reducing energy consumption by approximately 18–22%, due to the elimination of repeated heating cycles associated with fuza re-processing.

In conclusion, the proposed method provides a more efficient and sustainable alternative to conventional cottonseed oil refining. It enhances oil quality, improves operational efficiency, and reduces processing costs, making it suitable for industrial-scale implementation in modern edible oil production systems.

References

1. Gunstone, F. D. (2011). Vegetable Oils in Food Technology: Composition, Properties and Uses. Wiley-Blackwell.
2. Bailey, A. E. (2005). Bailey's Industrial Oil and Fat Products (6th ed.). Wiley-Interscience.
3. Erickson, D. R. (Ed.). (1995). Practical Handbook of Soybean Processing and Utilization. AOCS Press.
4. O'Brien, R. D. (2008). Fats and Oils: Formulating and Processing for Applications (3rd ed.). CRC Press.
5. Sharma, Y. C., Singh, B., & Upadhyay, S. N. (2008). Advancements in development and characterization of biodiesel: A review. Fuel, 87(12), 2355–2373.
6. Martínez, M., & Sánchez, T. (2012). Refining of vegetable oils: Chemical and physical processes. Journal of Food Engineering, 109(3), 497–504.
7. Rydberg, J., Cox, M., Musikas, C., & Choppin, G. R. (2004). Solvent Extraction Principles and Practice. Marcel Dekker.
8. Rao, P. V. K., & Rao, D. G. (2006). Oilseeds and oil processing technologies. International Journal of Food Science & Technology, 41(4), 389–399.
9. Leung, D. Y. C., & Guo, Y. (2006). Transesterification of vegetable oils for biodiesel production. Fuel Processing Technology, 87(10), 883–890.
10. Codex Alimentarius Commission. (2019). Standard for Named Vegetable Oils (CODEX STAN 210-1999). FAO/WHO.
11. Savriyev, Y.S, and Sh.F Xaydarov. "KUNJARA QATLAMLARIDA EKSTRAKSIYALASH JARAYONINI MODELLASHTIRISH."January 1, 2024. https://doi.org/10.5281/zenodo.10448623.
12. Технология частичной рафинации экстракционного хлопкового масла Савриев Йулдош Сафарович, Хайрилloев Мирзоназар Курбонназарзода,(https://cyberleninka.ru/article/n/tehnologiya-chastichnoy-rafinatsii-ekstraktsionnogo-hlopkovogo-masla)
13. Савриев Й.С, Гафуров К.Х, and Севинов У.Б, "Экспериментальное исследование процесса прессования масличного фуза", CAJMTCS, vol. 2, no. 1, pp. 7–12, Jan. 2021.
14. Савриев Й.С., Азизов Б.А., Гайбулаев З.Х. Определение параметров семяпровода // Universum: технические науки : электрон. научн. журн. 2020. № 6 (75). URL: https://7universum.com/ru/tech/archive/item/9612 (дата обращения: 20.04.2026).
15. «Экспериментальное исследование процесса прессования масличного фуза» - Савриев Й.С, Гафуров К.Х, Севинов У.Б. - Vol. 2 No. 1 (2021): JANUARY /

16. Кайимов Ф.С., Мажидов К.Х., Савриев Й.С. Экстракция жмыхов хлопковых семян с использованием методов электрофизического воздействия., Бухоро мухандислик технология институти, фан ва технологиялар тараққиёти, - 3/2019., issn 2181-8193

17. Исследование технологии экстракции жмыхов масличных семян - савриев й.с., артиков а.а., х международная научная конференция студентов и аспирантов (http://catalog.belal.by/cgi-bin/irbis64r_01/cgiirbis_64.exe?LNG=&Z21ID=&I21DBN=BELAL&P21DBN=BELAL&S21STN=1&S21REF=1&S21FMT=&C21COM=S&S21CNR=20&S21P01=0&S21P02=0&S21LOG=1&S21P03=K=&S21STR=%D0%B0%D0%B2%D1%82%D0%BE%D0%BB%D0%B8%D0%B7%D0%B0%D1%82 тезисы докладов., «техника и технология пищевых производств», 28-29 апреля 2016 года.

18. Савриев й.с., хакимов ш.ш. - исследование и оптимизация технологии экстракции хлопковых жмыхов (бити). международная научно-техническая конференция «актуальные проблемы инновационных технологий в развитии химической, нефтегазовой и пищевой промышленности»., Ташкент 2016:. Т-.

19. Й.С.Савриев, К.Х.Мажидов, Ш.Ш.Хакимов. Исследование особенностей строения некоторых масличных семян местных сортов // «Узбекский химический журнал», -Тошкент-2017. - №1. 77-81 с.

20. Исматов С.Ш., Савриев Й.С., Артиков А.А. Пахта ёғини рафинациялаш технологиясини такомиллаштириш., фан ва технологиялар тараққиёти // 1-2018:. 43 ст.

21. Хамроев Х.Х., Савриев Й.С., Тураева У.Х., Рузимуратова З.А. Особенности высокоскоростного фрезерования., ФАН ВА ТЕХНОЛОГИЯЛАР ТАРАҚҚИЁТИ – Бухоро муханислик технологиялар институти, // 1-2023 // 120 ст.