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REFINING OF COTTONSEED OIL USING AN ALKALINE EXTRACT SOLUTION DERIVED FROM COTTON STALK ASH AND EVALUATION OF THE PHYSICOCHEMICAL PROPERTIES OF THE REFINED OIL

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Annotatsiya. Ushbu tadqiqotda paxta poyasi kulidan olingan ishqoriy ekstraktni paxta moyini rafinatsiya qilish jarayonida an’anaviy ishqoriy reagentlarga muqobil sifatida qo‘llash imkoniyati o‘rganilgan. Paxta poyasi kuli — bu maishiy va xizmat ko‘rsatish obyektlarida paxta poyalarini yoqish natijasida hosil bo‘ladigan qishloq xo‘jaligi chiqindisi bo‘lib, undan samarali foydalanish dolzarb masalalardan biridir. Tajriba jarayonida kul va distillangan suv 1:5 massa nisbatda qaynatilib, ishqoriy ekstrakt olingan va u paxta moyini rafinatsiya qilishning neytrallash bosqichida qo‘llanilgan. Rafinatsiyadan so‘ng moyning fizik-kimyoviy ko‘rsatkichlari sezilarli darajada yaxshilangani kuzatildi: kislotalilik soni 5 mg KOH/g dan 0,15 mg KOH/g gacha kamaydi, peroksid soni 7 dan 2 meq O_2/kg gacha pasaydi, rang ko‘rsatkichlari yaxshilanib, Lovibond bo‘yicha qizil birliklar 50 dan 7 gacha kamaydi. Bundan tashqari, moyning tiniqligi oshdi, unda sovun va cho‘kma aniqlanmadi. UV–Vis spektrofotometrik tahlil natijalari 420–430 nm diapazonda maksimal yutilishni ko‘rsatib, karotinoid pigmentlar mavjudligini tasdiqladi, uzoq to‘lqinli sohada esa yutilish qiymatlarining nolga yaqinlashishi moyning optik tozaligini ko‘rsatdi. Olingan natijalar paxta poyasi kulidan olingan ishqoriy ekstrakt paxta moyini rafinatsiya qilishda samarali, iqtisodiy jihatdan maqbul va ekologik barqaror muqobil reagent ekanligini ko‘rsatadi.

Kalit so‘zlar: paxta poyasi kuli ekstrakti, optimal konsentratsiya, neytrallash, rang ko‘rsatkichi, kislotalilik soni, peroksid soni.

Аннотация. В данном исследовании рассматривается возможность использования щелочного экстракта, полученного из золы стеблей хлопчатника, в качестве альтернативы традиционным щелочным реагентам при рафинации хлопкового масла. Зола стеблей хлопчатника является побочным продуктом сельского хозяйства, образующимся при сжигании стеблей в бытовых и сервисных условиях, и её эффективное использование остаётся актуальной задачей. В эксперименте зола и дистиллированная вода кипятились в массовом соотношении 1:5 с целью получения щелочного экстракта, который затем применялся на стадии нейтрализации при рафинации хлопкового масла. После проведения процесса рафинации были зафиксированы значительные улучшения физико-химических показателей масла: кислотное число снизилось с 5 мг KOH/г до 0,15 мг KOH/г, перекисное число уменьшилось с 7 до 2 мэкв O_2/кг, улучшились цветовые характеристики — показатель красных единиц по Ловибонду снизился с 50 до 7. Кроме того, масло стало более прозрачным, в нём не обнаружено мыла и осадка. Спектрофотометрический анализ в УФ–видимой области показал максимум поглощения в диапазоне 420–430 нм, что подтверждает наличие каротиноидных пигментов, тогда как в области длинных волн значения поглощения стремятся к нулю, что свидетельствует об оптической чистоте масла. Полученные результаты показывают, что щелочной экстракт из золы стеблей хлопчатника является эффективным, экономически целесообразным и экологически устойчивым альтернативным реагентом для рафинации хлопкового масла.

Ключевые слова: экстракт золы стеблей хлопчатника, оптимальная концентрация, нейтрализация, цветовой показатель, кислотное число, перекисное число.

Abstract. This study investigates the feasibility of using an alkaline extract obtained from cotton stalk ash as an alternative to conventional alkaline reagents in the refining of cottonseed oil. Cotton stalk ash is an agricultural by-product formed as a residue from the combustion of cotton stalks in household and service facilities, and its effective utilization remains an important issue. In the experimental procedure, ash and distilled water were boiled at a mass ratio of 1:5 to obtain an alkaline extract, which was subsequently applied during the neutralization stage of cottonseed oil refining. Following the refining process, significant improvements in the physicochemical properties of the oil were observed: the acid value decreased from 5 mg KOH/g to 0.15 mg KOH/g, the peroxide value declined from 7 to 2 meq O_2/kg, and the color characteristics improved, with the Lovibond red units reduced from 50 to 7. In addition, the oil exhibited increased clarity, with no detectable soap or sediment. UV–Vis

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spectrophotometric analysis revealed a maximum absorbance in the 420–430 nm range, confirming the presence of carotenoid pigments, while the absorbance values in the longer wavelength region approached zero, indicating the optical purity of the oil.The results demonstrate that the alkaline extract derived from cotton stalk ash is an effective, economically viable, and environmentally sustainable alternative reagent for the refining of cottonseed oil.

Keywords: cotton stalk ash extract, optimal concentration, neutralization, color index, acid value, peroxide value

INTRODUCTION.

Vegetable oils play an important role in human nutrition, and their quality is determined by physicochemical and organoleptic parameters. Although oils mainly consist of triacylglycerols, they also contain minor components such as phospholipids, sterols, tocopherols, and pigments, which directly affect their quality and stability [1]. Therefore, controlling these components during processing is essential.

Crude vegetable oils contain coloring substances primarily composed of carotenoids and chlorophylls, which impart yellow, reddish, or green hues to the oil. In addition to influencing the appearance, these pigments also affect oil quality; thus, their reduction during the refining process is necessary [2]. Furthermore, pigments formed as a result of oxidation and other reactions during technological processes also contribute to color changes [2].

Changes in the color of refined oils are often explained by the “color reversion” phenomenon. This process is mainly associated with oxidation reactions, particularly involving oxidation products of γ-tocopherol and other minor components [2]. Therefore, optimizing the refining process is crucial to maintaining color stability and improving oil quality.

Vegetable oil refining consists of several stages, including degumming, neutralization, bleaching, and deodorization. These stages aim to reduce free fatty acids, phospholipids, pigments, and other undesirable components present in the oil [1]. In particular, alkaline reagents are used during the neutralization stage to remove free fatty acids in the form of soap.

One of the key indicators for evaluating oil quality is its color. Vegetable oils are typically yellow or light-colored, and their color is determined using the Lovibond colorimetric method [3]. The color depends on the concentration of pigments in the oil, and its reduction during refining indicates an improvement in oil quality [3].

In recent years, studies have focused on using alkaline solutions derived from biomass waste as alternatives to conventional alkaline reagents. For instance, research on obtaining alkaline solutions from cocoa shell ash has shown

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that potassium carbonate is the main component in the ash, and when extracted with water, it forms an alkaline solution [4]. During combustion, minerals in the ash convert into carbonates, which subsequently react with water to produce an alkaline medium.

Ash derived from agricultural waste is considered a valuable source of alkaline reagents. Studies investigating the chemical composition of ash obtained from cocoa husks, palm bunch waste, maize residues, and peanut shells revealed the presence of potassium and sodium compounds in their liquid extracts. Based on chemical analyses, potassium carbonate was identified as the main alkaline component, particularly abundant in cocoa husk and palm waste ash, making these materials suitable as practical sources of alkali [5]. Additionally, all studied ash samples were found to be water-soluble and capable of producing an alkaline medium, indicating their potential as alternatives to conventional alkaline reagents.

These findings also demonstrate that potassium and sodium compounds can be economically extracted from agricultural waste ash. Due to the higher content of alkaline compounds in cocoa husk and palm waste ash, these materials are considered particularly suitable for traditional black soap production. Experimental results showed that the produced soap samples had good solubility, consistency, cleansing ability, and foaming properties [5]. This suggests that ash-based solutions can be effectively used as alternative reagents in oil refining processes.

The effectiveness of ash materials derived from plant waste in oil purification has also been demonstrated. For example, a study using banana peel ash showed that this material is highly effective in reducing free fatty acids, achieving up to 97% reduction under optimal conditions [6]. In addition, ash-based materials also exhibit a certain degree of effectiveness in reducing pigments.

These studies indicate that parameters such as temperature, time, and reagent dosage play a crucial role in the refining process, and their optimization significantly improves oil quality [6]. This highlights the importance of scientifically controlling refining processes based on ash extracts.

In general, the literature review shows that color, free fatty acids, and other physicochemical parameters are the main quality indicators in vegetable oil refining. Modern studies confirm that ash extracts derived from biomass waste can serve as effective, economical, and environmentally friendly alternatives to conventional alkaline reagents. Moreover, colorimetric and spectrophotometric methods play an important role in evaluating oil quality.

MATERIALS AND METHODS.

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Materials. A crude cottonseed oil sample with an acid value of 5 mg KOH/g was used as the research object. An alkaline extract obtained from cotton stalk ash, considered a household waste material, was applied as the alkaline reagent. Distilled water was used in the preparation of the extract. After the neutralization stage, the resulting refined cottonseed oil was analyzed under laboratory conditions.

Preparation of Ash Extract. The alkaline solution was obtained from cotton stalk ash using an aqueous extraction method. For this purpose, ash and distilled water were mixed at a mass ratio of 1:5 and boiled. During boiling, the alkaline components of the ash (mainly carbonates) were transferred into the solution. After cooling, the solution was filtered to remove solid residues and then concentrated by evaporation up to 75%. The obtained extract was subsequently used as an alkaline reagent in the refining process. This method is based on existing scientific studies on obtaining alkaline solutions from biomass ash, as well as the author's previous research (4, 7–14).

Refining of Cottonseed Oil. The refining of cottonseed oil was carried out under laboratory conditions using the alkaline neutralization method. During the process, the prepared ash extract was added to the oil in a specific amount and thoroughly mixed.

The refining process was conducted under the following conditions:

- Temperature: 50–55°C
- Time: 30 minutes
- Continuous stirring

During the process, the alkaline solution reacted with free fatty acids present in the oil, forming soap. The resulting soapstock was separated using a separator, and the purified oil was collected for further analysis. This process follows the principles of a continuous refining mechanism.

To evaluate the quality parameters of the refined oil samples, UV–Vis spectrophotometric analysis was performed in the wavelength range of 200–800 nm.

The color characteristics of both crude and refined oil samples were initially determined using a Lovibond colorimeter. In addition, the color of the refined oil was also evaluated based on UV–Vis spectral data. The results obtained from the Lovibond measurements were compared with those derived from the UV–Vis spectrogram. Based on the absorbance values, the color intensity and quality level of the oil were determined, and their changes after the refining process were analyzed.

RESULTS AND DISCUSSION.

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Refining Results Using Ash Extract: The physicochemical properties of the cottonseed oil used for refining are presented in Table 1.

Table 1.

Physicochemical properties of the received cottonseed oil

Acid Value	Color Index. Red units at 35 yellow units (Lovibond)	Non-oil impurities (sediment)	Moisture and volatile matter
5 mg KOH/g	50	0,1 %	0,2 %

The refining of cottonseed oil was carried out under laboratory conditions using a concentrated alkaline extract solution obtained from cotton stalk ash by evaporation to 75% (density 1.2 g/mL, normality 3.41). This concentrate was selected in accordance with Table 2, which was developed on the basis of the values determined as optimal in previous studies.

Table 2.

Dependence of solution density and pH on solution concentration

Evaporation Degree (%)	Density (g/mL)	pH	Normality (N)
0	1.04	11.0	0.20
5	1.05	11.2	0.30
10	1.07	11.4	0.45
15	1.08	11.6	0.60
25	1.10	12.0	1.00
30	1.12	12.2	1.30
35	1.13	12.4	1.60
40	1.14	12.6	1.90
45	1.15	12.8	2.20
50	1.16	13.0	2.50
55	1.17	13.2	2.80
60	1.18	13.4	3.00
65	1.19	13.6	3.20
70	1.195	13.8	3.30
75	1.20	14.0	**3.41**
80	1.21	14.0	**0.856**
85	1.215	14.0	0.70

During the process, the alkaline solution reacted with the free fatty acids present in the oil, forming a soap fraction, which was then separated from the oil through phase separation. In the course of the study, the physicochemical

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properties of the oil before and after refining were determined and compared with each other (Table 3). In particular, the color parameters were also measured using a Lovibond optical instrument. According to the results, the color of the oil was found to be 7 red units at 35 yellow units. The results obtained from the UV–Vis analysis were also consistent with this value.

Table 2.

Rafinatsiya natijasida olingan paxta moyining fizik-kimyoviy ko‘rsatkichlari

Parameters	Initial	After Refining
Red units at 35 yellow units (Lovibond)	50	7
Acid value (mg KOH/g)	5	0.15
Soap content (%)	Not determined	Not detected
Sediment (%)	0.1	Not detected
Clarity	Not clear	Clear
Peroxide value (meq O_2/kg)	7	2
Moisture and volatile matter (%)	0.2	0.08

According to the data presented in Table 3, the refining process carried out using the ash extract led to a significant improvement in the main quality indicators of cottonseed oil. In particular, the Lovibond color index (red units at 35 yellow units) decreased from an initial value of 50 to 7, indicating an effective reduction of color-forming pigments in the oil.

The decrease in acid value from 5 mg KOH/g to 0.15 mg KOH/g confirms that free fatty acids were almost completely neutralized. In addition, the absence of soap content and sediment after refining indicates that the process was properly conducted and that undesirable components were effectively removed.

The change in oil clarity from “not clear” to “clear” confirms an improvement in its optical properties. The reduction in peroxide value from 7 to 2 meq O_2/kg indicates a decrease in oxidation products. Furthermore, the decrease in moisture and volatile matter content from 0.2% to 0.08% reflects an overall improvement in oil quality parameters.

Overall, the obtained results demonstrate that the alkaline extract derived from plant ash is an effective reagent for refining cottonseed oil and that its

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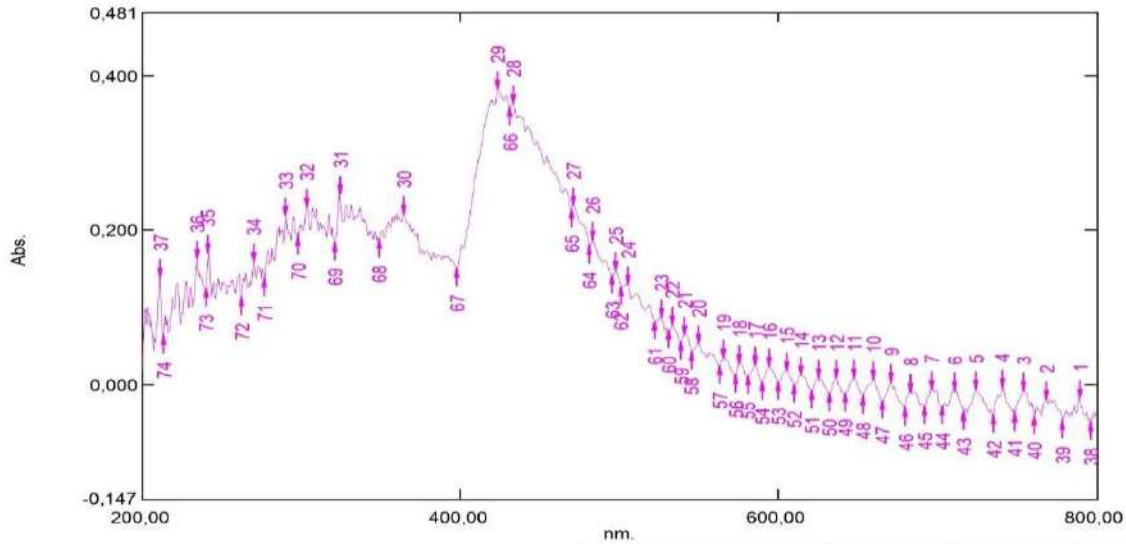
application significantly improves the physicochemical and organoleptic properties of the oil.

In the next stage of the study, the refined oil (previously analyzed using a Lovibond instrument) was also examined using UV–Vis spectrophotometry. The UV–Vis spectrum of the refined oil samples was studied in the wavelength range of 200–800 nm.

Spectrum Peak Pick Report

13.04.2026 10:32:29

Data Set: File_260413_102944 - RawData



[Measurement Properties]
Wavelength Range (nm.): 200.00 to 800.00
Scan Speed: Fast
Sampling Interval: 0,5
Auto Sampling Interval: Enabled
Scan Mode: Single

[Instrument Properties]
Instrument Type: UV-2600 Series
Measuring Mode: Absorbance
Slit Width: 2,0
Accumulation time: 0,1 sec.
Light Source Change Wavelength: 323,0 nm
Detector Unit: External(2Detector)
Detector Change Wavelength: 830,0 nm
S/R Exchange: Normal
Stair Correction: OFF

[Attachment Properties]
Attachment: None

[Operation]
Threshold: 0,0010000
Points: 4
InterPolate: Disabled
Average: Disabled

[Sample Preparation Properties]
Weight:
Volume:
Dilution:
Path Length:

No.	P/V	Wavelength	Abs.	Description
1	↑	789.50	-0.017	
2	↑	768.50	-0.018	
3	↑	754.00	-0.007	
4	↑	741.50	-0.003	
5	↑	724.50	-0.005	
6	↑	711.50	-0.007	
7	↑	696.50	-0.005	
8	↑	683.00	-0.008	
9	↑	671.00	0.003	
10	↑	660.50	0.007	
11	↑	648.00	0.009	
12	↑	636.50	0.009	
13	↑	625.00	0.009	
14	↑	614.50	0.012	
15	↑	605.50	0.018	
16	↑	594.00	0.024	
17	↑	585.50	0.026	
18	↑	575.50	0.029	
19	↑	566.00	0.036	
20	↑	550.00	0.054	
21	↑	541.50	0.065	
22	↑	533.50	0.077	
23	↑	526.50	0.088	
24	↑	505.50	0.131	

Figure 1. UV–Vis spectrum of refined cottonseed oil (in the 505–800 nm range) and the decreasing trend of absorbance in the long-wavelength region

Measurements were carried out using a spectrophotometer in absorbance mode. In the 505–550 nm range, a consistent decrease in absorbance values from 0.131 to 0.054 was observed, indicating a gradual reduction of color-forming

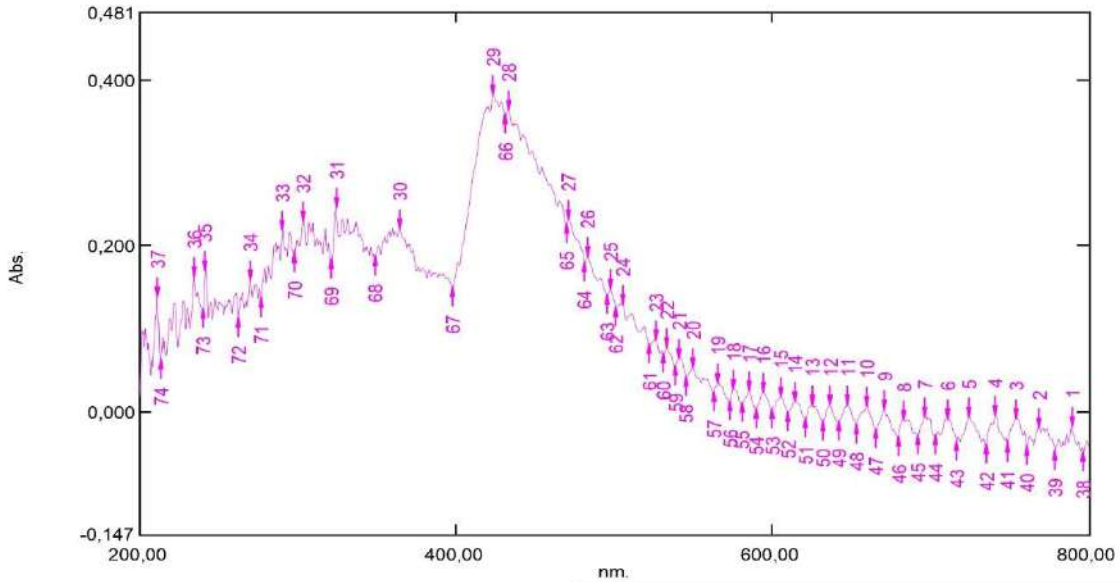
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components in this region. At wavelengths above 550 nm, a sharp decline in absorbance values was recorded; beyond 650 nm, the values approached zero, and in some cases, small negative values (due to instrumental noise) were observed. This indicates the absence of pigments absorbing in the long-wavelength region, particularly dark-colored compounds, and confirms a high degree of optical clarity in the sample (Figure 1).

Spectrum Peak Pick Report

13.04.2026 10:32:29

Data Set: File_260413_102944 - RawData



[Measurement Properties]
Wavelength Range (nm.): 200.00 to 800.00
Scan Speed: Fast
Sampling Interval: 0,5
Auto Sampling Interval: Enabled
Scan Mode: Single

[Instrument Properties]
Instrument Type: UV-2600 Series
Measuring Mode: Absorbance
Slit Width: 2,0
Accumulation time: 0,1 sec.
Light Source Change Wavelength: 323,0 nm
Detector Unit: External(2Detector)
Detector Change Wavelength: 830,0 nm
S/R Exchange: Normal
Stair Correction: OFF

[Attachment Properties]
Attachment: None

[Operation]
Threshold: 0,0010000
Points: 4
InterPolate: Disabled
Average: Disabled

[Sample Preparation Properties]
Weight:
Volume:
Dilution:
Path Length:
.....

No.	P/V	Wavelength	Abs.	Description
25	↑	498.00	0.148	
26	↑	483.50	0.187	
27	↑	471.50	0.233	
28	↑	433.50	0.364	
29	↑	423.50	0.383	
30	↑	364.50	0.221	
31	↑	324.00	0.248	
32	↑	303.00	0.231	
33	↑	290.50	0.219	
34	↑	270.00	0.161	
35	↑	241.50	0.171	
36	↑	234.50	0.163	
37	↑	211.00	0.139	
38	↓	797.00	-0.049	
39	↓	779.00	-0.047	
40	↓	761.00	-0.041	
41	↓	749.00	-0.036	
42	↓	735.00	-0.039	
43	↓	717.00	-0.036	
44	↓	703.50	-0.028	
45	↓	692.50	-0.027	
46	↓	679.50	-0.030	
47	↓	666.00	-0.021	
48	↓	653.00	-0.014	

Figure 2. UV–Vis spectrum of refined cottonseed oil (in the 230–500 nm range) and the maximum absorption observed at 423.5 nm

In the 400–500 nm range, a significant increase in absorbance values was observed, with a maximum absorption peak at 423.5 nm (Abs = 0.383), indicating

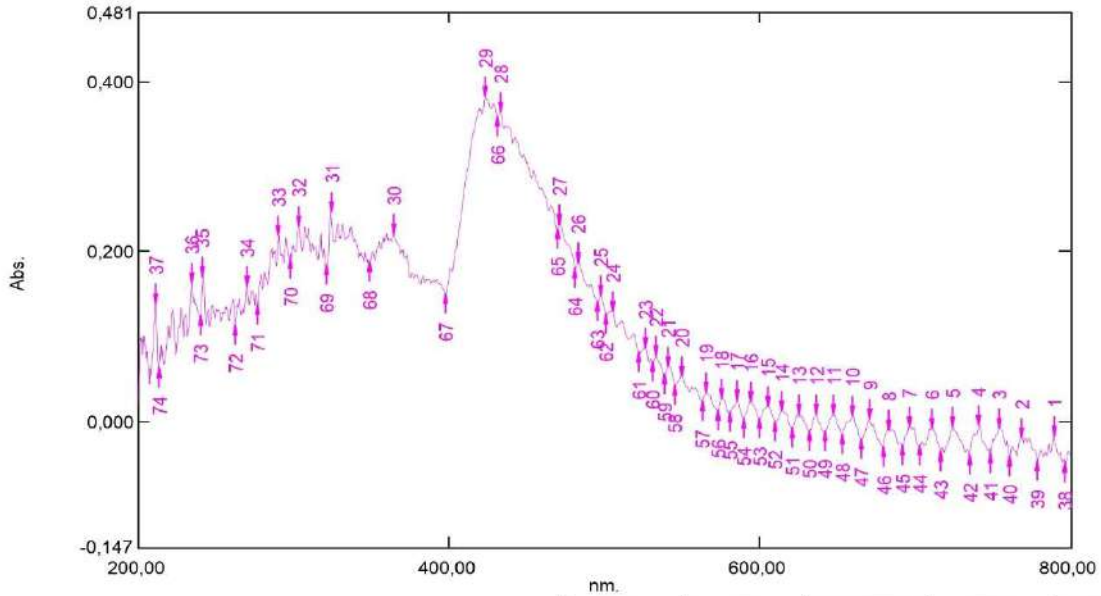
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the presence of carotenoid pigments in the oil. In the 450–500 nm interval, the decrease in absorbance values from 0.233 to 0.148 reflects a reduction in color intensity. The absorption observed in the 300–370 nm range (Abs ≈ 0.22–0.25) can be attributed to the presence of organic compounds. The absorption recorded in the 230–270 nm region (Abs ≈ 0.16–0.17) is characteristic of conjugated systems, which are typical for vegetable oils. The approach of absorbance values to zero above 650 nm further confirms the optical purity of the sample (Figure 2).

Spectrum Peak Pick Report

13.04.2026 10:32:29

Data Set: File_260413_102944 - RawData



[Measurement Properties]
Wavelength Range (nm.): 200.00 to 800.00
Scan Speed: Fast
Sampling Interval: 0,5
Auto Sampling Interval: Enabled
Scan Mode: Single

[Instrument Properties]
Instrument Type: UV-2600 Series
Measuring Mode: Absorbance
Slit Width: 2,0
Accumulation time: 0,1 sec.
Light Source Change Wavelength: 323,0 nm
Detector Unit: External(2Detector)
Detector Change Wavelength: 830,0 nm
S/R Exchange: Normal
Stair Correction: OFF

[Attachment Properties]
Attachment: None

[Operation]
Threshold: 0,0010000
Points: 4
InterPolate: Disabled
Average: Disabled

[Sample Preparation Properties]
Weight:
Volume:
Dilution:
Path Length:
.....

No.	P/V	Wavelength	Abs.	Description
49		642.00	-0.011	
50		632.00	-0.011	
51		621.50	-0.008	
52		610.00	0.000	
53		599.50	0.003	
54		589.50	0.004	
55		581.00	0.011	
56		573.00	0.013	
57		563.00	0.025	
58		546.00	0.043	
59		538.50	0.055	
60		531.50	0.070	
61		522.50	0.081	
62		501.50	0.126	
63		496.00	0.141	
64		481.50	0.180	
65		469.50	0.227	
66		431.50	0.359	
67		398.00	0.151	
68		348.50	0.187	
69		321.00	0.183	
70		297.50	0.192	
71		277.00	0.137	
72		262.00	0.113	

Figure 3. UV–Vis spectrum of refined cottonseed oil (in the 260–650 nm range) and the gradual decrease in absorbance values

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A sharp increase in absorbance values was observed in the 400–450 nm range, with a pronounced absorption peak at 431.5 nm (Abs = 0.359), further confirming the presence of carotenoid pigments in the oil. In the 450–550 nm interval, the decrease in absorbance values from 0.227 to 0.070 indicates a reduction in color intensity and suggests that the oil has a light yellow color.

In the 550–600 nm range, the absorbance values decreased from 0.043 to 0.003, indicating that absorption is nearly negligible. At wavelengths above 600 nm, the absorbance values approached zero, and in some cases, small negative values were observed, confirming the optical clarity of the sample and the absence of pigments absorbing in the long-wavelength region (Figure 3).

At the same time, the absorption recorded in the 260–320 nm range (Abs ≈ 0.11–0.19) indicates the presence of conjugated organic systems in the oil.

CONCLUSION.

The results of the conducted study demonstrate that cottonseed oil can be effectively refined using an alkaline extract derived from plant ash. The neutralization process based on the ash extract led to a significant reduction in free fatty acids, color-forming pigments, and other undesirable components present in the oil.

Physicochemical analysis showed that the acid value decreased from 5 mg KOH/g to 0.15 mg KOH/g, the peroxide value declined from 7 to 2 meq O_2/kg, and the content of moisture and volatile matter was reduced from 0.2% to 0.08%. In addition, the absence of soap and sediment after refining, along with improved clarity, was confirmed. The color index (according to Lovibond) improved significantly, with red units decreasing from 50 to 7, indicating the effective removal of pigments.

The results of UV–Vis spectrophotometric analysis also confirmed the efficiency of the refining process. A maximum absorption was observed in the 420–430 nm range (Abs ≈ 0.383 at 423.5 nm), indicating the presence of carotenoid pigments in the oil. After refining, the absorbance values in the long-wavelength region (above 600 nm) approached zero, confirming the optical clarity of the oil and the absence of dark-colored pigments.

Overall, the alkaline extract obtained from cotton stalk ash can be considered an economically and environmentally viable alternative to conventional alkaline reagents. The obtained results indicate that this method is a promising approach for the refining of cottonseed oil.

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