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Studies on hydrolysis of vegetable oil for the synthesis of fatty acids

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ABSTRACT: *Free fatty acids (FFAs) play a vital role as raw materials in the production of food and soap products across various industries. This project investigates the hydrolysis of vegetable oil for the synthesis of fatty acids and examines the extraction of FFAs using different solvents, including water, methanolic KOH, ethanolic KOH, and isopropyl alcohol-KOH. The study demonstrates that under optimal processing conditions, a maximum FFA yield of 57.68 and an acid value of 28.84 were achieved within one hour using ethanolic KOH (E-KOH) as the solvent. These findings highlight the potential of solvent-assisted hydrolysis in efficiently producing FFAs for industrial applications.*

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I. INTRODUCTION

The hydrolysis of oils and fats is crucial in various industrial applications, highlighting its versatility and significance. This process is essential for producing fatty acids used in food, pharmaceuticals, biodiesel, and chemical manufacturing. Fatty acids, derived from triglycerides in oils and fats, are vital components in numerous products. Their production primarily occurs through the hydrolysis of triglycerides or via chemical synthesis.

Hydrolysis involves breaking down triglycerides into fatty acids and glycerol by adding water, often with catalysts like acids, bases, or enzymes. This adaptable method supports diverse industries, underpinning the development of many key compounds. Exploring fatty acid production reveals a complex intersection of science and industry, underscoring its importance in modern advancements.In fatty acid production, the hydrolysis of triglycerides is catalyzed according to industrial needs. Post-hydrolysis, the mixture is separated to isolate fatty acids for further processing and purification. Additionally, fatty acids can be synthesized through oxidation, esterification, or hydroformylation of olefins, typically for specialized or industrial-grade products.

Several studies have focused on producing free fatty acids (FFAs) from plant-based oils via hydrolysis. For instance, Machado et al. (2021) examined enzymatic hydrolysis of soybean, palm, and sunflower oils using lipase enzymes, optimizing conditions for high FFA yields. Similarly, Mustafa (2021) compared acid and enzymatic catalysis for hydrolyzing waste cooking oil into FFAs, evaluating efficiency and sustainability in recycling waste. Baena et al. (2022) reviewed various FFA production techniques, including conventional hydrolysis and microbial fermentation, highlighting the importance of optimizing process parameters to maximize yields while minimizing costs and environmental impacts. Thus, this study aims to synthesize FFAs through solvent-assisted hydrolysis of crude sunflower oil, investigating how process parameters (pH, temperature, solvent-to-oil ratio, and time) affect fatty acid synthesis.

II. MATERIALS AND METHODS

2.1 Materials:

Crude sunflower oil was sourced from a local industry in Salalah, Oman. Methanol, ethanol, isopropanol, andpotassium hydroxide (KOH) were of analytical grade, obtained from VWR International, USA. Double-distilled water was used throughout the experiment unless otherwise noted.

2.2 Methods:

2.2.1 Hydrolysis of Crude Sunflower Oil:

A 1 M ethanolic KOH solution was prepared by dissolving 1 M KOH in ethanol in a 1:1 volume ratio. The same procedure was followed for methanolic- and isopropanolic-KOH solutions. The hydrolysis was then performed by mixing crude sunflower oil with various solvents, including water, ethanolic KOH (1 M), methanolic KOH (1 M), and isopropanolic KOH (1 M). In a 500 mL beaker, 50 g of crude sunflower oil was combined with 300 mL of solvent. The reaction was carried out in a temperature-controlled reactor at 60°C, with reaction times of 30, 45, and 60 minutes. After hydrolysis, 200 mL of water was added to the mixture. The residue was extracted using 100 mL of hexane, and the aqueous alcohol phase was acidified to pH 1 using 6 N HCl. The extract was washed with distilled water until it reached a neutral pH. The lower layer was separated and discarded using a separating funnel, while the free fatty acids (FFAs) were extracted and recovered.

2.2.2 Acid Value determination:

One gram of crude sunflower oil sample was mixed with 10 ml of isopropyl alcohol (IPA) in a conical flask. Then, 2 drops of phenolphthalein indicator was added to titrate the solution against 0.1 N KOH to calculate the FFA. The same procedure was repeated for blank without oil. The FFA% was calculated by the Equation (1).

(1)

where m is mass of sample, E is equivalent weight of KOH, B is titre value without sample (blank), V is titre value with sample, and N is normality of KOH [18].

2.2.3 Free Fatty Acid (FFA) determination:

The determination of free fatty acids (FFAs) from the acid value is a common method in oil and fat analysis. The acid value refers to the amount of potassium hydroxide (KOH) in milligrams needed to neutralize the free fatty acids in one gram of fat or oil. It serves as an indicator of the amount of FFAs present in the sample, as FFAs contribute to the acidity of oils.

III. RESULTS AND DISCUSSION

4.1. Effect of FFA and Acid Value on Methanolic KOH (M-KOH)

The impact of time on FFA content and acid value is evident from Table 4.1. As shown in Figure 1 the bar chart, the FFA concentration increased from 1.96 to 3.08 as the reaction time was extended from 30 minutes to 60 minutes. Similarly, the acid value rose from 3.39 to 6.16 over the same time period, using methanolic KOH (M-KOH) as the solvent.

Table 4.1 Estimation of Acid Value and FFA with respect to time

Solvents	30 min		60 min	
	Acid Value	FFA	Acid Value	FFA
H_2O	3.93	1.96	4.48	2.24
E-KoH	50.96	25.48	57.68	28.84
M-KoH	3.93	1.96	6.16	3.08
IPA-KoH	16.8	8.4	26.32	13.16

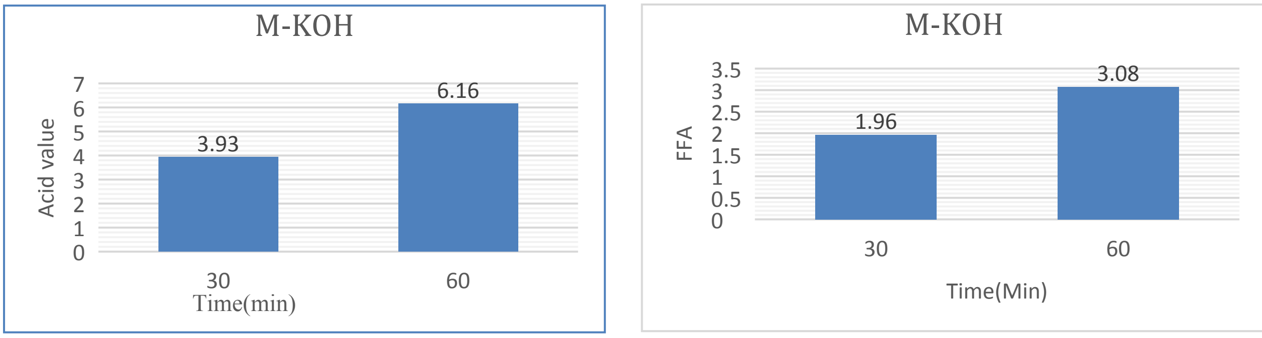

Figure1. FFA and Acid value with M-KOH solvent

4.2 Effect of FFA and Acid Value on Ethanolic KOH (E-KOH)

The effect of time on FFA and Acid value is clear as shown in the bar chart in Figure 2, the amount of FFA increasing from 25.48 to 28.84 when we increase the time from 30 min to 60 min also acid value increasing from 50.96 to 57.68 in the same time by using E-KoH solvent.

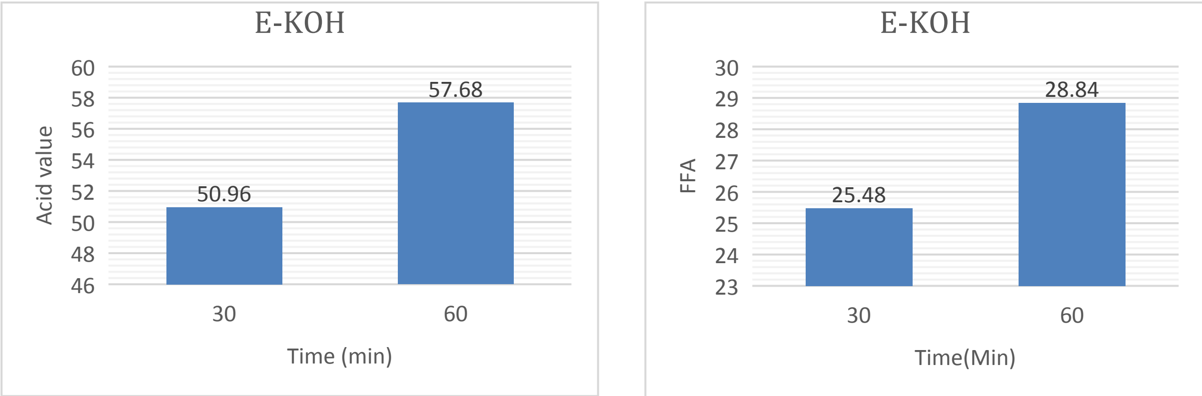

Figure 2. FFA and Acid value with E-KOH solvent

4.3 Effect of FFA and Acid Value on Water

The impact of time on FFA content and acid value is evident in Figure 3. As illustrated in the bar chart, the FFA content increased from 1.96 to 2.24 when the reaction time was extended from 30 to 60 minutes. Concurrently, the acid value rose from 3.93 to 4.48 during the same period, using water as the solvent as shown in Figure 3.

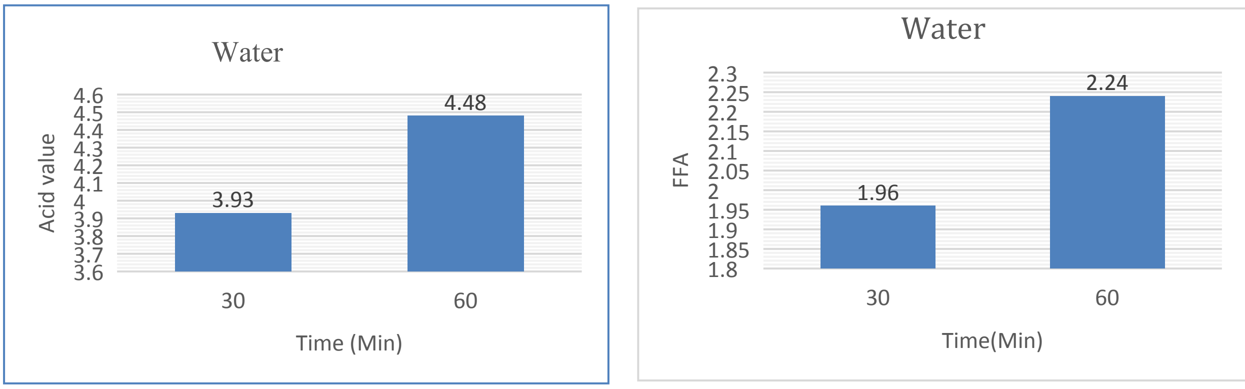

Figure3. FFA and Acid value with water

4.4 Effect of FFA and Acid Value on Iso Propyl Alcohol-KOH

Figure 4 illustrates the FFA amount and acid value with isopropanol KOH (IPA-KOH) as the solvent. The influence of time on FFA content and acid value is clearly depicted in the bar chart. The FFA amount increased from 8.4 to 13.16 as the reaction time was extended from 30 to 60 minutes. Similarly, the acid value rose from 16.8 to 26.32 during the same period when using water as the solvent.

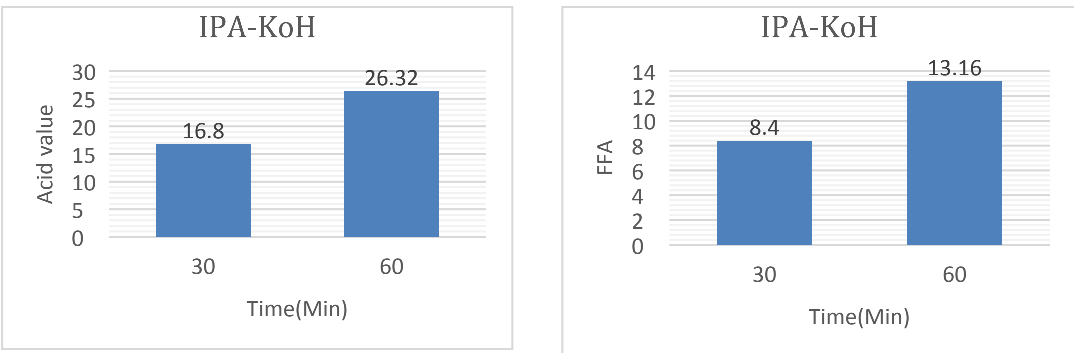

Figure4. FFA and Acid value with Iso Propyl Alcohol

IV. CONCLUSION

Free fatty acids (FFAs) are crucial compounds utilized as raw materials in the manufacturing of food and soap products across various industries. This project aims to investigate the hydrolysis of vegetable oil for the synthesis of fatty acids and to examine how FFAs can be extracted using different solvents, including water, methanolic KOH, ethanolic KOH, and isopropyl alcohol-KOH. Under optimal processing conditions, the maximum FFA yield and acid value were found to be 57.68 and 28.84, respectively, after one hour of using ethanolic KOH (E-KOH) as the solvent.

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