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PURIFYING USED CANOLA OIL USING *Zingiber Officinale* (GINGER) AS ADSORBENT

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Abstract:

Enormous waste of cooking oil is produced daily in households and food service industries. It can harm the consumer's or the environment's health if not handled and disposed of properly. To help lessen the disposal and over-reused consumption of used cooking oil, the researchers devised purifying used cooking oil using *Zingiber officinale* (Ginger) as an adsorbent. The selected cooking oil employed in this study is Canola oil, a low-cost vegetable oil widely known for its healthy content. The researcher utilized a quantitative research design to obtain the desired data. Two experiments were conducted: first, purifying the used Canola oil using Ginger, and second, testing the free fatty acid content of the unused, used, and used Canola oil. The results revealed that the FFA content of the used Canola oil is 19.18% in 5g and 16.92% in 3g. As for the purified Canola oil, the percentage in 5g is 12.41%, while it is 16.92% in 3g. The FFA content of the samples was compared using the one-way ANOVA test and paired t-test. Based on the gathered data, the results indicate a low significant difference between the free fatty acid content of the

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used Canola oil and purified used Canola oil is relatively low. Thus, using Ginger as an adsorbent does not significantly affect the purification process. Further research is recommended in this study as alterations, measurements, and proportions during the experimentations may affect the data results.

Keywords:

Zingiber Officinale (Ginger), Free Fatty Acids (FFA), Canola Oil, Waste Cooking Oil (WCO)

Introduction

Cooking oil is a staple ingredient for food preparation. It is a product that society needs and purchases to fulfill daily needs concerning oil-quality-based products (Botahala et al., 2019). According to Bouchon (2009), kitchens and cooking industries commonly use oil to fry food to enhance customer satisfaction with the color, texture, and taste. Therefore, the demand for cooking oil is constantly high since preparing and cooking food is essential in sustaining life.

With the continuous demand for cooking oil, the amount of cooking oil used is also increasing. Most kitchens discard used cooking oil instead of recycling (Cooper, 2020). On the other hand, some consumers prefer to reuse oil to save money. Cooking oil should only be utilized two or three times before it is regarded as a hazard to human health (Susiwolati, 2021). The underlying reason is that cooking oil undergoes chemical reactions as a result of exposure to heat, including hydrolysis, oxidation, and polymerization Ghobadi et al. (2017), which increase the free fatty acids, hydroperoxides, polar compounds, and aldehyde content of oil Chloe and Min (2007). These changes are not healthy for human consumption.

Previous studies indicated that the continuous consumption of used cooking oil could cause deposition of blood vessels, decreased fat digestibility, increased adiposity, hypertension, cardiac damage, diabetes and possibly diminished intellectual abilities for the next generations (Rukmini Ambar, 2007; Evika, 2011 as cited by Botahala et al., 2019) According to Ali et al., (2015) (as cited by Oprea et al., 2007; Oprea et al., 2008; Ampaitepin & Tetsuo, 2010), if used cooking oil is not handled and disposed of properly, this will lead to significant negative consequences on the environment. On the other hand, if it is used beyond what is advised, it may have negative health impacts on the user. Therefore, purifying used cooking oil before consumption or disposal is necessary to prevent such risks and hazards.

Zingiber officinale (Ginger) is a spice widely employed to enhance the flavor of various foods and beverages (Zhang et al., 2019). Ginger is a plant grown throughout the humid tropics, with India being the most significant producer. It is thought that Indians and Chinese have been using ginger as a tonic root for over 5000 years to treat various diseases (Anaedu, 2020). Zingiber officinale (Ginger) contains abundant chemical elements such as terpenes, polysaccharides, lipids, organic acids, and raw fibers. Additionally, Ginger has porous carbons with high capacity and high adsorption rate. This has led the researchers to be interested in utilizing Ginger in the study. To lessen the disposal of used cooking oil, the researchers devised adsorption to purify used cooking oil using Zingiber officinale (Ginger) as an alternative adsorbent.

The researchers used Canola oil for the study since it is widely used in the Philippines. According to Grain Central (2019), Rapeseed or Canola oil usage has been rising globally, with

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an estimated 31 million tons consumed in 2017. Consumers are becoming more health conscious. Therefore, the industry anticipates a demand for healthier oils like canola (Ken Research, 2020). Canola oil helps reduce cholesterol levels and the risk of heart disease (Lin et al., 2013). Thus, many consumers who practice healthy living prefer Canola oil as their cooking oil since it is considered the cheapest, healthiest, and most readily available oil in the market. Purifying the used canola oil helps prevent such risks and hazards before consumption and disposal. Moreover, it reduces the risk of sewage issues caused by blocked or damaged drains, which promotes a healthier and safer environment. Consumers, especially restaurants that use cooking oil, will have an impact on their consumption of cooking oil, according to the results of this study.

In a previous study, the effectiveness of Zingiber officinale (Ginger) as an adsorbent for purifying used cooking oil was successfully proven by the students of Madrid National High School in Madrid, Surigao del Sur (Dua et al., 2019). However, the researchers did not test the free fatty acid content difference between purified and used cooking oil. This gap will be employed in the study in order to provide additional evidence to the study. An essential part of the study experiment is testing the free fatty acid content since it shows the quality of the oil samples. Consumers will utilize the suggested purification methods based on the quality of the used cooking oil before and after the purification process.

Literature Review

Oil goes to waste once used (Dua et al. 2019, as cited by Regina, 2014). As a result, consumers must buy new cooking oil once every while. To address this issue, the researchers used ginger as an adsorbent to purify Canola oil because ginger is affordable and accessible. It contains protease ions used for purification procedures by breaking down peptide bonds of proteins. The ginger will soak up most of the smell and flavor of the ingredients cooked in the oil.

Zingiber officinale (Ginger) has several significant health benefits. Aside from its medicinal properties, one of the most popular uses of Ginger rhizomes is its detoxifying action. The researchers hypothesized that Ginger could scale back the free fatty acid content in used oil, making it safer to reuse (Acut, 2019).

According to Hamdi et al. (2022), cooking oil can be broken down by microorganisms such as fungi, actinomycetes, and bacteria because it primarily consists of fatty acids or triacylglycerols. This means that cooking oil needs to be purified before it will be reused and disposed because its high usage due to rising global demand may result in some industries managing waste cooking oil (WCO) improperly, which poses a serious threat to the environment. When waste cooking oil (WCO) is disposed of incorrectly, it leaves an oil film on the water's surface, which suffocates aquatic life by depriving it of oxygen. This can also result in problems if WCO is disposed of in the plumbing system. Solidified WCO can clog treatment filters and produce blockages, which can cause a variety of problems, including odor. For this reason, cooking oil can also be purified using ginger. Because gingerol, paradol, shogaols, and zingerone have antibacterial and other biological properties, *Zingiber Officinale* (ginger), is used to purify old canola oil. It was reported an interesting discovery indicating that 10% ethanolic ginger extract exhibited antibacterial activity against infections (Al Shabrmi et al. 2014).

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Canola oil is considered an utterly healthful oil due to its fatty acid composition. It averages approximately 60% oleic acid, 20% linoleic acid, and 10% ALA. This makes canola oil an excellent supply of alpha-linolenic acid (ALA) with the perfect ratio (2:1) of omega-6 (ω-6) to omega-3 (ω-3). Compared to alternative vegetable oils such as Sunflower (12%), Canola oil has the lowest quantity of saturated fatty acid (7% or less). Lower free fatty acid (FFA) present in oil indicates that the oil is high-quality and refined. On the other hand, the higher free fatty acid in oil indicates that the oil has degraded quality due to hydrolysis and oxidation. Regarding the free fatty acid composition, vegetable oil is recognized for its heart-healthy properties; this has allowed it to penetrate several markets, notably, the United States, which is dominated by soybean oil (Eskin & Przybylski, 2011).

Canola oil and sunflower oil are both high in unsaturated fats, which can be either polyunsaturated or monounsaturated, and low in saturated fat (*Canola Vs. Sunflower Oil: Which Better Supports Heart Health*, n.d.). Both oils support the heart's regular operation. FFA, PV, CD, and TBA levels in sunflower oil decrease in proportion to the content of Zingiber Officinale (ginger) extract (Elgindy & Elsorady, n.d.). Since canola oil and sunflower oil are similar in terms of their fat components, canola oil will decrease in proportion to the content of zingiber officiinale (ginger) extract.

According to Xylem Analytics (n.d.), free fatty acids (FFA) in plant oils and fats (e.g., consumable oils and fats) are high quality for these fats. Fats with high levels of FFA are obligated to oxidative maturing; they rank more rapidly. In this manner, the gathering of free fatty acids is caused by warm debasement and the chemical response of fatty acids (Guntiñas et al., 2022). According to Guntiñas et al. (2022, as cited in Mahesar et al., 2014), it is confirmed that FFA impacts the standard of nourishment; for this case, physical characteristics will essentially influence and be biased toward human well-being.

The sum of FFA depends on the substance's time, temperature, and wetness due to fats and oils uncovered to diverse natural variables. FFA is less steady than unbiased oil; it is extra inclined to oxidation and rancidity. Much obliged to this, free fatty acids are a critical thing, almost determinative of the standard and mechanical cost of oils and fats. Free fatty acids form during frying due to moisture in the foods exposed to oil (Erikson, 2007).

Methodology

Research Design

The researchers utilized a quantitative method for the study. According to Brown and Meissel (2022), quantitative research methods are designed to develop and test hypotheses for scientific and statistical methods. A true-experimental design is a quantitative method researchers use as a statistical approach to the study. This design is efficient for testing the relationships between an independent and dependent variable. Specifically, it enabled the researchers to test the hypothesis of whether Ginger is an effective adsorbent for purifying used Canola oil using a set of experimental procedures. According to Hanrahan et al. (2005), using a statistical approach, the experimental method allows the researcher to understand and evaluate the factors that influence a particular system. One variable is controlled to measure its effect on the other variable.

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Materials and Method

Materials

The materials necessary to purify used Canola Oil are 50g ginger slices per 120ml used oil sample, Canola oil, a cooking pan, specifically a saucepan, a paper towel, a strainer, and a food thermometer. The materials for testing the Free Fatty Acid (FFA) content include sodium hydroxide titrant, phenolphthalein indicator, 95% ethanol, hot plate, conical flask, measuring cylinder, burette, and balance machine.

The Procedure of the Experiment

In testing whether Zingiber officinale (Ginger) is an effective adsorbent in purifying used Canola oil, the researchers adapted the procedure from the study of the students of Madrid National High School in Madrid, Surigao del Sur (Dua et al., 2019) and implored the following steps: First, the researchers filtered the used Canola oil to remove any large particles using a strainer as a filter. Second, the filtered oil was put into the burner for around 2-3 minutes with a temperature of 170-200 degrees as the sliced ginger was added and waited to cool down the mixture naturally. Third, the oil was filtered with a strainer and paper towel as it cooled to around 120 degrees Fahrenheit (48.89 Celsius). Fourth, the purified Canola oil was put into a container and filtered by a cloth. It takes at least 5 minutes for the 60 ml of oil to pour thoroughly. Lastly, the purified Canola oil was transferred into a jar and warmed to room temperature (Dua et al., 2019).

In testing the free fatty acid (FFA) content, the researchers adapted the procedure of Mircochem Experiments (2020). The procedure follows: 1) Phenolphthalein Indicator Solution Preparation: Mix one drop of Phenolphthalein Indicator into 100 ml of Ethanol. 0.1N 2) Sample Preparation: Samples 1 and 3 (purified oil) - 3g of oil sample and samples 2 and 4 (used oil) - 5 g of, measure 50mL Ethanol (95%) and pour into a 50mL conical flask, added three drops of Phenolphthalein Indicator Solution and shake, add 0.1N NaOH dropwise until the light pink color solution is formed (this is done to neutralize the ethanol), and stopped the addition of 0.1N NaOH as the solution is turned into pink. Now the neutralized ethanol is added to the flask containing the sample, shake the flask to mix the solution, boiled the mixture by placing the flask on a hot plate with a temperature of 350 degrees; after 10 minutes, continue the boiling until the sample is dissolved completely, shaken with hand should continue periodically, and continued the boiling until the sample is dissolved completely. 3) Titration: Take 0.1 NaOH (standardized) in a burette, and start titration by adding a few drops of Phenolphthalein Indicator in the sample until the pink color solution occurs, indicating the titration's end-point. 4) Calculation: In calculating the Free Fatty Acids (FFA), we used the formula FFA (as oleic acid) = 28.2×Volume of NaOH×Normality of NaOH / Weight.

Data Analysis

In analyzing the data, the researchers used the Free Fatty Acids (FFA) formula.

Free Fatty Acids (as an oleic acid) = $\mathbf{28.2 \times V \times NW}$

Where:

V= volume of the titrant
N= normality of titrant (NaoH)
W= weight of the sample

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Two oil samples were tested for their free fatty acid content: the used Canola oil (control group) and purified Canola oil (experimental group). The result of the oil sample was compared using the percentage generated using the formula of the FFA stated above. If the free fatty acid percentage of the first type of oil is low, then the quality of the oil is high. On the other hand, if the percentage of the second type of oil is high, then the quality of oil is low (Eskin & Przybylski, 2011).

Furthermore, after computing the FFA percentage using the FFA formula, the researchers analyzed the data further using paired t-test and ANOVA. Paired t-tests and ANOVA are statistical tools used to assess the significance of the experiment's findings. The researchers utilized the following tools to check the differences between the data sets. From the gathered data, the means of Canola oil samples are compared using the ANOVA approach based on their free fatty acid composition before, after, and after usage. This helped the researchers identify the significance between the three variables - unused and used, unused and purified, and finally, purified and used oil. Below is the formula for the paired t-test and one-way ANOVA:

Paired t-test Formula

$$t = \frac{\bar{x}_d - \bar{\mu}_d}{\left(\frac{S_d}{\sqrt{n}}\right)}$$ **, df= n-1**

Where:
'X' bar = mean of the sample
μ = assumed mean
Sd = standard deviation
n = number of observations

One-way ANOVA Formula

$$F = \frac{MST}{MSE}$$

$$MST = \frac{\sum_{i=1}^{k}(T_i^2/n_i) - G^2/n}{k-1}$$

$$MSE = \frac{\sum_{i=1}^{k}\sum_{j=1}^{n_i} Y_{ij}^2 - \sum_{i=1}^{k}(T_i^2/n_i)}{n-k}$$

Where:
F = coefficient of ANOVA
MST = mean sum of squares between the groups
MSE = mean sum of squares within groups

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Results and Discussion

Table 1: Free Fatty Acids (FFA) Values (in oleic acid) Of Used, Purified, And Unused Canola Oil.

No. of Grams	Unused	Used	Purified
5	60	19.18	12.41
3	60	16.92	16.92

The data was obtained by conducting two sets of samples: First, the Free Fatty Acid of the two variables was tested with a sample of 5g of oil. The used Canola oil resulted in 19.18, and the purified used Canola oil resulted in 12.41, using a 5g sample. Second, the two variables were tested with a sample of 3g of oil. The used and purified Canola oil resulted in 16.92 with a 3g sample.

Table 2: Summary of Table 1

Groups	Count	Sum	Average	Variance
Column 1	2	120	60	0
Column 2	2	36.1	18.05	2.5538
Column 3	2	29.33	14.665	10.17

Table 2 shows the summary of the one-way ANOVA results of the free fatty acid content between column 1 (unused), column 2 (used), and column 3 (purified). The table above shows that column 1 has a FFA mean of 60, which is the average FFA content of Canola oil. Next, column 2 has an FFA mean of 18.05, which is lower than the average FFA content of Canola Oil. Column 3 has a 14.665 FFA mean, which is also significantly lower than the average FFA content of Canola Oil. The table also shows the variance of the three variables, wherein the unused variable has a variance of 0, which indicates that all the data are identical. On the other hand, the used has a variance of 2.5538 and 10.1701 for purified used Canola oil.

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Table 3: ANOVA: Single Factor on the Free Fatty Acid content of Unused, Used, and Purified Canola Oil in two sets.

Source of Variation	SS	df	MS	F	P - value	F - critical
Between Groups	2551	2	1275.5	300.7	0.0003	9.5521
Within Groups	12.724	3	4.2413			
Total	2563.7	5				

Table 3 shows that upon performing one-way ANOVA, the F-value of the data set is 300.7, and the corresponding P-value is 0.0003. Since the P-value is less than .05, the null hypothesis is rejected. Therefore, there is a significant difference in the Free fatty acids of unused, used, and purified Canola oil. However, there is no related research that can support this data.

Table 4: Unused and Used Canola Oil t-Test: Paired Two Samples for Means

	Variable 1	Variable 2
Mean	60	18. 05
Variance	0	2.5538
Observations	2	2
Pearson Correlation	#DIV/0!	
Hypothesized Mean Difference	0	
df	1	

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t Stat	37.1239
P(T<=t) one-tail	0. 008572
t Critical one-tail	6.313752
P(T<=t) two-tail	0. 017144
t Critical two-tail	12.7062

Table 4 shows the t-test result of unused and used Canola oil. The table shows that the P-value of unused and purified Canola oil is 0.017144. The critical value is 12.7062, with a t-stat value of 37.1239. Since the P-value is less than .05, it concludes that the set of unused and used Canola oil significantly differs in their Free fatty acid content. However, there is no related research that can support this data.

Table 5: Unused and Purified Used Canola Oil t-Test: Paired Two Sample for Means.

	Variable 1	Variable 2
Mean	60	14.665
Variance	0	10.17005
Observations	2	2
Pearson Correlation	#DIV/0!	
Hypothesized Mean Difference	0	
df	1	

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t Stat	20.1042
P(T<=t) one-tail	0. 01582
t Critical one-tail	6.313752
P(T<=t) two-tail	0. 03164
t Critical two-tail	12.7062

Table 5 shows the t-test result of unused and purified canola oil. The table shows that the P-value of unused and purified used canola oil is 0.03164. The critical value is 12.7062, with a t-stat value of 20.1042. Since the P-value is less than .05, it concludes that the set of unused and purified canola oil significantly differs in their Free fatty acid content. However, there is no related research that can support this data.

Table 6: Used and Purified Used Canola Oil t-Test: Paired Two Samples for Means

	Variable 1	**Variable 2**
Mean	18.05	14.665
Variance	2.5538	10.17005
Observations	2	2
Pearson Correlation	-1	

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Hypothesized Mean Difference	0
df	1
t Stat	1
P(T<=t) one-tail	0.25
t Critical one-tail	6.313752
P(T<=t) two-tail	0.5
t Critical two-tail	12.7062

Table 6 shows the t-test result of used and purified canola oil. The table shows that the critical value is 12.7062, with a t-stat value 1. This set of variables has a P-value of 0.5. In contrast, it is more significant than .05. Thus, the free fatty acid content of used and purified canola oil has no significant difference since the null hypothesis of this set is accepted. However, there is no related research that can support this data.

Conclusion

Based on the gathered data, the following conclusions and recommendations are drawn: There is a significant difference between the free fatty acids of unused, used, and purified Canola oil. However, the difference between the free fatty acid content of the used Canola oil and purified used Canola oil is relatively low. Thus, ginger as an adsorbent does not significantly affect Canola oil purification. In addition, the ginger failed to reduce the high FFA content of the used Canola oil. According to Dunford (2016), cooking oil with high FFA content is not recommended for human consumption due to its degraded quality. Since the FFA content of the purified used Canola oil did not scale back and reach the recommended FFA content for cooking oil consumption, the purified oil sample remains hazardous, possibly retaining the health risks of the used Canola oil before the purification process.

Based on the results, the following studies are suggested for future researchers: A retest on the study "Purifying used Canola oil using Zingiber officinale (Ginger) as an Adsorbent." A study on recycling used Canola oil for biodiesel production. A study on the effectiveness of Zingiber officinale (Ginger) as an Adsorbent by testing both the physical and chemical properties of the

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used Canola oil. A study on the effectiveness of Zingiber officinale (Ginger) as an Adsorbent in Purifying Used Canola Oil (animal-based).

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