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PRODUCTION OF BIOETHANOL FROM THE MIXTURE OF TANGERINE AND POTATO PEELS

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Abstract
Tangerine peels and potato peels were collected and pretreated, they were then mixed at a tangerine to potato peel ratio of 30:70. Proximate and ultimate analysis were carried out on the peels after pretreatment to check their potential for bioethanol production, the results of the proximate analysis showed that the moisture, crude lipids, ash, protein and carbohydrates content were, 17.90, 8.03, 6.00, 6.12, 61.95 respectively, the carbohydrate content shows the suitability for bioethanol production. The treated peels were then hydrolyzed to extract fermentable sugars, then saccharomyces cerevisiae was used as the fermentation agent to aid the fermentation process to produce bioethanol, the produced bioethanol was then characterized. After 96 hours of fermentation at an average temperature of 34^{o}C the bioethanol yield was 45.7g/L it was observed that the total number of solids reduced significantly. After characterization, the results showed that the flash, pour and cloud point were 19.8^{o}C, 4.63^{o}C, 18.5^{o}C respectively, the viscosity was 1.05mm^2/s and the octane rating was 93.

Keywords
Bioethanol, Tangerine peels, Potato peels, Fermentation

1. INTRODUCTION

The world's increasing need for energy has been a major concern in the human sector. Fossil fuel is one of the primary sources of energy all over the world and it poses a great threat to the environment, threats including pollution, ozone depletion and climate change. Fossil fuels have been depleting in abundance over the years hence, there is a need for an alternative of energy that is ecofriendly and long lasting. The environmental impact of using fossil fuel as a source of energy demand for alternative sources of energy such as solar, wind, biofuel.

Ethanol, also known as ethyl alcohol, is a versatile compound with various industrial, commercial, and recreational applications. This colorless and flammable liquid plays a significant role in the transportation, energy, and chemicals sectors (Hernandez, 2019). Ethanol, chemically represented as C2H5OH, has a simple molecular structure consisting of two carbon atoms, six hydrogen atoms, and one hydroxyl (OH) group (Khan et al., 2020). Its solubility in water and low boiling point makes it suitable for numerous industrial processes and applications (Patel, 2019).

Bioethanol has various potential applications across different industries. As a transportation fuel, bioethanol can be blended with gasoline to power vehicles, reducing greenhouse gas emissions and dependence on fossil fuels (Alvarez et al., 2021). In the industrial sector, bioethanol can be used as a solvent, cleaning agent, and feedstock for chemical synthesis (Santos et al., 2020). Additionally, bioethanol can be employed in the power generation sector as a fuel for electricity production, providing a renewable alternative to fossil fuels (Martinez et al., 2029). In the agricultural sector, bioethanol can be used as a pesticide and fertilizer, promoting sustainable farming practices (Garcia et al., 2018). Furthermore, bioethanol can be utilized in the pharmaceutical industry as a precursor for the production of medicines and vaccines (Wang et al., 2017). Biomass has considerable amounts of starch, which can be utilized in the production of bioethanol, there are many sources of biomass for energy purposes, across large areas. They can be further classified as;

First-generation bioethanol: Feedstocks used for this type of bioethanol are classified as starch-rich materials, which contain considerable amounts of starch that can be utilized in bioethanol production. Second-generation bioethanol: Feedstocks used for this type of bioethanol are classified as lignocellulosic

biomass, which contains lignocellulose that needs to be broken down to release cellulose and hemicellulose into fermentable sugars. Third-generation bioethanol: Feedstocks used for this type of bioethanol are classified as algae-based materials, which contain algae that release lipids and carbohydrates.

Tangerine and potato peels fall under the biomass for first-generation bioethanol, because they contain a significant amount of starch. The production of bioethanol from the mixture of tangerine peels and potato peels opens economic opportunities at various levels, in rural areas most especially, it stimulates local economies, and it reduces the expenses incurred on imported energy sources thereby promoting economic stability and resilience. Searching through the literature, work has not been done on production of bioethanol using a mixture of tangerine peels and potato peels. Hence, in this study, bioethanol was produced from the mixture of tangerine peel and potato peel.

2. MATERIALS AND METHOD

2.1 Sample collection

The tangerine peels and potato peels were collected from local sources and processed to remove any contamination.

2.2 Sample preparation

The substrates were dried up under sunlight for about five days, grinded and stored in controlled conditions to maintain their properties and composition. The grinded substrates were mixed in the ratio of 30% tangerine peel to 70% potato peel.

2.3 Proximate analysis

2.3.1 Determination of the moisture content in the mixture of tangerine and potato peels

The biomass was weighed initially and the mass of the substrate was recorded then it was placed in a drying pan, dried to constant mass in an air-oven at a certain temperature, uniform drying was ensured, the final mass of the substrate was then measured and recorded. The moisture content was calculated using the following equation (Riungu et al., 2014).

$$\text{Moisture content} = \left(\frac{m-M}{m}\right) \times 100 \quad (1)$$

Where:

m = mass in g of the material taken for test
M = mass in g of the material upon drying

2.3.2 Determination of the ash value of the mixture

The ash value in the mixture includes dietary minerals such as sodium, potassium, iron and calcium. To get the ash value in the mixture, a muffled furnace was used for the analysis (Efetobor et al., 2022). It was calculated by;

$$\text{Ash value} = \frac{W_a}{W_s} \times 100 \quad (2)$$

Where: W_a = weight of ash

W_s = weight of sample

2.3.3 Determination the crude lipid contents in the mixture

The lipids were extracted from the mixture and calculated using;

$$\text{Crude lipids contents (\%)} = \frac{Weight\ of\ extracted\ lipids}{weight\ of\ original\ sample} \times 100 \quad (3)$$

This formula is based on the soxhlet extraction method, which is used to extract the lipids from the sample

2.3.4 Determination of the protein contents in the mixture

According to Aguilera and Stanley(1999), proteins contain approximately 16% of nitrogen. The factor 6.25 was used to convert nitrogen content to protein content, as recommended by the Association of Official Analytical Chemists (AOAC).

Protein contents (%) = (Total nitrogen) x 6.25

2.3.5 Determination of the percentage of carbohydrates in the mixture

Total carbohydrates = 100- (% protein + % fat + % moisture + % ash) (4)

2.4 Biomass pretreatment (acid hydrolysis)

The acid hydrolysis process is important to break down the complex carbohydrates in the substrate such as the cellulose, into simpler sugars. This process involved using a dilute acid, (HCL) to catalyze the chemical bonds in the cellulose. A 3% hydrochloric acid of 30mL was mixed with 970mL of water to give 1 litre of diluted hydrochloric acid, The prepared substrate was stored in a conical flask in the laboratory, and dilute HCL was added to it relative to the mass of the substrate in a ratio of 1:10, i.e 100 grams of the substrates with 1L of acid solution, the solution was heated up to 60 ^{o}C and kept at this temperature for 20 minutes for proper effectiveness and breakdown of the cellulose. The mixture was then allowed to cool down for a while, then a base (NaOH) was added to the solution to neutralize the acid and regulate the pH value. The base was prepared in the same way the hydrochloric acid was prepared, 30mL of NaOH was added to 970mL of water. The ph of the solution was monitored until it recorded 6.8.

2.5 Fermentation Process

Fermentation of the substrate was conducted using suitable yeast strains (saccharomyces cerevisiae). After the neutralization the yeast strains were added, 1 gram of yeast was added to 1L this was done whilst monitoring the pH value of the solution, The solution was kept in an air tight container (no form of aeration at all) at room temperature for 5-8 days. After 2 days of fermentation of the treated substrate, the bioethanol was observed to have started separating from the substrate. The substrate settled at the bottom of the broth while the ethanol was suspended in the broth forming a separate layer

2.6 **Ethanol Recovery and characterization**

Ethanol was recovered from the fermentation broth by distillation. The recovered ethanol was purified to remove impurities and ensure compliance with fuel standards and specifications. The produced ethanol was then characterized.

2.6.1 Determination of the pH value

The pH value was determined using a pH meter or pH paper according to ASTM D7795-2019. A sample of the bioethanol was taken and inserted into the pH meter or placed on the pH paper to measure its acidity or basicity level.

2.6.2 Determination of the specific gravity

The specific gravity was determined using a density meter according to ASTM D792-20. A sample of the bioethanol was taken and filled into the density meter to measure its density relative to water.

2.6.3 Determination of the refractive index

The refractive index was determined using a refractometer according to ASTM D1218-20. A sample of the bioethanol was taken and placed on the refractometer prism to measure its ability to bend light.

2.6.4 Determination of the octane rating

The octane rating was determined using a knock test apparatus according to ASTM D2699-20

2.6.5 Determination of the cloud point

The cloud point was determined using a cloud and pour point apparatus according to ASTM D2500-20. A sample of the bioethanol was taken and cooled slowly while being stirred, and the temperature at which wax crystals or haze began to form was observed.

2.6.6 Determination of the flash point

The flash point was determined using a flash point apparatus according to ASTM D93-20. A sample of the bioethanol was taken and heated in a closed cup or open cup apparatus, and the lowest temperature at which its vapors ignite when given an ignition source was observed.

2.6.7 Determination of the pour point

The pour point was determined using a cloud and pour point apparatus according to ASTM D97-20. A sample of the bioethanol was taken and cooled slowly without stirring, and the lowest temperature at which the liquid poured was observed.

2.6.8 Determination of the viscosity

The viscosity was determined using a viscometer according to ASTM D445-20. A sample of the bioethanol was taken and filled into the viscometer, and the time taken for the liquid to flow through a capillary tube was measured to determine its resistance to flow.

2.6.9 Determination of the freeze point

The freeze point was determined using a freeze point apparatus according to ASTM D2386-20. A sample of the bioethanol was taken and cooled slowly while being stirred, and the temperature at which it solidified was observed

3. RESULTS AND DISCUSSION

3.1 Proximate analysis results

The results of the proximate analysis of the mixture are as shown in Table 1.

Table 1 Proximate analysis result

Component	Value (%)
Moisture content	17.90
Ash value	6.00
Crude lipids	8.03
Carbohydrate	61.95
Protein contents	6.12

3.2 Results of the characterized bioethanol

The results of the characterization of the bioethanol are as shown in Table 2.

Table 2: The results of characterization of bioethanol

Component	Experimental results	ASTM standard
Flash point	19.8°C	18.6°C
Pour point	4.63°C	5.20°C
Cloud point	18.5°C	19.3°C
Specific gravity	0.924	0.794-0.87
Refractive index	1.428	1.3568-1.444
Viscosity	1.05 mm^2/s	1.15-1.26 mm^2/s
Ph value	6.2	6.5-9.0
Octane rating	93	92 and above

This result as presented indicated the flash point of the produced bioethanol was 19.8, which is slightly higher compared to the standard of 18.60 according to ASTM, this implies that the bioethanol produced from the mixture of tangerine peels and potato peels is slightly less flammable than the standard bioethanol fuel. This variation in values could be attributed to the nature of the biomass used in production. The pour point was determined according to ASTM D97 -20 and the value obtained was 4.63 which is also seen to be lower when compared to the standard of 5.20 ,this indicates that the bioethanol produced can be used even in polar regions where the atmospheric temperature is not less than at least 4.63°C. The cloud point which is described as the temperature at which a cloud of crystals will first appear in a liquid that is cooled under prescribed conditions is also an important property of bioethanol and it was tested for in this research project. The result concluded that the cloud point of the bioethanol produced was 18.5 as compared to the ASTM standard of 19.30 it is seen that the cloud point of the bioethanol produced from the mixture of tangerine

peels and potato peels is slightly lower. Specific gravity is the ratio of the density of a substance compared to the density of a reference substance. The specific gravity of the bioethanol produced was measured and the result obtained from the measurement was 0.924, this is slightly higher than the standardized value that ranges between 0.794-0.87. The pH value of the bioethanol after fermentation reduced from 6.8 to 6.2. The octane number is a number that is used to measure the antiknock properties of a liquid fuel. In other words, it is a measure of ignition quality of the fuel. The higher the octane number of the produced bioethanol the more suitable it is to be used as a fuel. The result of the octane number of the bioethanol produced was 93, this is in total agreement with the ASTM standard of 92 and above.

4. CONCLUSION

In conclusion, this study demonstrated the potential of using a mixture of tangerine and potato peels as a feedstock for bioethanol production. The results of the proximate analysis revealed the suitability of the mixture for bioethanol production. The characterization results showed the improvement in thermal stability and cold-flow properties of the bioethanol produced compared to previous studies. The bioethanol produced is of good yield and quality. The findings of this study provide a promising foundation for future research and development in the field of bioethanol production from agro-industrial waste biomass.

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