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Investigating Alcoholic Characteristics of Bush Cane (*Costus Afer*) Leaf Extract

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ABSTRACT

Ethanol was extracted from the juice of leaf, stem and root of *Costus afer* (monkey sugarcane) to determine their respective and comparative yield and also to determine its fuel composite qualities. Samples were selected from farmland in Bori, Khana Local Government Area of Rivers State. They were cut into bits, measuring 1 cm length and were pounded to pulp and transferred into 30 L bow, where it was allowed to ferment. Fermentation was completed in four days and the filtrations of the various samples subjected to distillation to yield ethanol. Redistillation of ethanol was carried out using a reflux condenser to yield a very pure ethanol. Ethanol yield of the three samples was found to be 10 L of leaf, stem and root of *costus afer* respectively. Percentage purity of the ethanol was found to be 95 %, specific gravity (S.G) was 0.7620 Kg/L and the boiling point range was 78°C-88°C. Finally, juice from the leaf, stem and root of *Costus afer* can be used for ethanol production.

Keywords: Alcohol, alcoholic characteristic, bush cane, leaf, leaf extract

INTRODUCTION

Alcohol production from plant materials has gained increasing attention due to the need for alternative energy sources and the growing interest in bio-based products. Plants contain various biochemical compounds that can undergo fermentation to produce ethanol, which has applications in fuel, industry, and beverages. In this study, the alcoholic characteristics of bush cane (*Costus afer*) leaf extract are investigated to determine its potential for ethanol production through fermentation and distillation processes. The research also evaluates key physiochemical properties of the produced alcohol to assess its suitability for practical applications.

LITERATURE REVIEW

Since ancient times, medicinal plants and herbal teas have been used in everyday human life as traditional medicines due to their healing and therapeutic properties [1],[2]. Medicinal plants are the source of many phytochemicals which are secondary metabolites responsible for herbs' beneficial properties [3]. Plant secondary metabolism could be bio-synthetic source of several compounds which are attractive to utilize in the food industry and the pharmaceutical, chemical, cosmetic, and agronomic industries. The fundamental aim of plants is to create secondary metabolites as a defense mechanism against microorganisms, insects, and consumers such as herbivores [4]. Numerous physiologically active compounds, including alkaloids, essential oils, flavonoids, bitters, coumarins, tannins, glycosides, and saponins, are examples of these secondary metabolites. The locations of target phenolic compounds in various plant sections are depicted in Figure 1.

Many studies have discussed biologically active compounds as they have antioxidant, antibacterial, antifungal, anti-

inflammatory, and anti-tumor effects [5-7]. In recent years, plants and their extracts containing high content of bioactive or aromatic compounds have found use in numerous applications in the food industry as flavors, colorings, antioxidants and antimicrobial agents (preservatives), nutrient enhancers, enzymes, and packaging additives [1],[8]. Their application in food increases the shelf life of products by preventing undesirable changes in nutritional and sensory properties, such as the formation of flavors in lipid-rich food [9].

Alcohol has existed since the beginning of recorded history. The ancient Egyptians produced alcohol by naturally fermenting vegetative materials [10]. Also, in ancient times, the Chinese discovered the art of distillation, which increases the concentration of alcohol in fermented solutions. Ethanol was first prepared synthetically in 1826, through the independent effort of Henry Hennel in Britain and S.G in France. In 1828, Michael Faraday produced ethanol using the acid-catalyzed hydration of ethylene, a method akin to the current industrial production of ethanol. The most common substrate used for nearly 99% of ethanol production in the United States today is starch from agricultural crops, primarily corn [11]. The evolution of new biofuel production technologies could help alleviate some of the concerns regarding the use of food for fuel by facilitating the use of non-food feedstocks and could alleviate some of the environmental concerns associated with grain ethanol production [10].

Some of the starch-rich plants such as potato and corn have been used for alcohol production and as well food for human. This results in a mismatch between the usage of energy resources and food consumption, which drives up the alcohol feedstock cost, and also causing

competition between the use of edible plants and vegetable oils as source materials for energy generation and food, hence discouraging some minds to the idea of alcohol due to the high cost of living involved in our present dispensation. Hence, it is advisable to use a plant which is not grown for the purpose of food production but rather seen as a weed, so that, its application in alcohol production can also be used as a form of weed control in the farm environment. Therefore, a very viable plant that can be used as an alternative for this purpose is the bush cane (*Costus afer*).

Costus afer, commonly known as bush cane or ginger lily, is a tropical plant used in traditional medicine across Africa. The plant has been widely studied for its various pharmacological properties, including anti-inflammatory, antimicrobial, and antioxidant effects. However, limited research exists on the potential alcoholic properties of *Costus afer* leaf extract, and understanding these could open up new avenues for its application, particularly in alcoholic beverages or as a potential source of bioethanol. The aim of this investigation is to explore the potential alcoholic characteristics of *Costus afer* leaf extract, particularly in the context of fermentation, ethanol yield, and its possible role in alcoholic beverages or bioethanol production.

METHODOLOGY

Sample Collection

Samples of *costus afer* (bush cane) were collected from a farmland in Rivers State University, Port Harcourt, Nigeria.

Experimental Procedure Fermentation procedure

The samples (leaves) were cut into bits and crushed in a mortar to form pulp. The pulps were transferred into three separate transparent 20 L buckets. Water was

added to the pulp until it covered the entire pulp in the bucket. This was done at five different pulp/water ratios (40:60, 45:55, 50:50; 55:45, and 60:40). The water served as a solvent front that will aid in properly exposing the juice extract of the sample to yeast attack and effective fermentation. The buckets were properly opened so as to maximize attack by wild yeast on the juice extracts which could yield speedy reactions and desirable products for a period of seven days.

Production of Alcohol

The continuous distillation unit was used to distill the alcohol. The alcohol was collected from the distillation flasks at boiling point of 83.40°C during the distillation.

Determination of Other Parameters

1. Refractive Index

The **Refractometer** method was used to determine refractive index of alcohol using handheld refractor. A drop of the alcohol sample was placed on the refractometer's glass surface. The cover was closed, then read the refractive index value directly from the instrument's scale.

2. Viscosity

Method: Viscometer (Ostwald or Brookfield type) Procedure:

- Clean and dry the viscometer.
- Fill the viscometer with the alcohol sample.
- Measure the time it takes for the alcohol to flow through the capillary (Ostwald) or the torque required to rotate a spindle (Brookfield).
- Calculate the viscosity using the appropriate formula for the device used.

Equipment: Ostwald or Brookfield viscometer.

3. Density

Method: Hydrometer or Pycnometer Procedure:

- For a hydrometer, place the

alcohol in a graduated cylinder and insert the hydrometer. Read the density directly from the hydrometer.

- For a pycnometer, fill it with the alcohol sample, weigh it, and calculate the density using the known volume of the pycnometer and the mass of the sample.

Equipment: Hydrometer, Pycnometer.

4. Alcohol Content

Method: Distillation followed by Hydrometer or Alcoholmeter
Procedure:

- Distill a known volume of the alcohol sample.
- Measure the alcohol content in the distillate using a calibrated alcoholmeter.

Equipment: Distillation apparatus, Alcoholmeter.

5. Volatility

Method: Gravimetric Analysis
Procedure:

- Weigh a known amount of alcohol sample.
- Heat the sample in a closed system and measure the weight loss over time.
- Calculate the rate of evaporation to determine volatility.

Equipment: Analytical balance, Oven or evaporator.

6. Sugar Content

Method: Fehling's Test or HPLC
Procedure:

- For Fehling's test, mix the alcohol with Fehling's solution and heat. The appearance of a brick-red precipitate indicates reducing sugars.
- Alternatively, use High-Performance Liquid Chromatography (HPLC) for accurate quantification of sugars.

Equipment: Fehling's solution, HPLC.

7. Colour

Method: Visual or Spectrophotometer
Procedure:

- Visually inspect the color of the alcohol sample.
- For quantitative analysis, use a spectrophotometer to measure absorbance at specific wavelengths.

Equipment: Spectrophotometer.

8. Melting Point

Method: Melting Point Apparatus

Procedure: For solid alcohols (e.g., certain alcohol derivatives), place a small amount in a melting point capillary tube and insert it into the apparatus to determine the melting point range.

Equipment: Melting point apparatus.

9. Solubility

Method: Solubility Test Procedure:

- Add a small amount of alcohol to different solvents (e.g., water, ether, chloroform) and observe whether it dissolves or forms a distinct layer.
- Document the solvent ratios for complete solubility.

Equipment: Various solvents, test tubes.

10. Odour

Method: Sensory Evaluation (Sniff Test)

Procedure: Carefully waft the alcohol sample toward your nose and describe the odor.

Safety: Use fume hoods when necessary to avoid inhaling harmful fumes.

11. Flash Point

Method: Pensky-Martens Closed Cup Tester
Procedure:

- Fill the tester with the alcohol sample.
- Heat the sample at a controlled rate.
- Introduce a small flame periodically until the sample ignites, determining the flash point.

Equipment: Pensky-Martens closed cup tester.

12. Water Content

Method: Karl Fischer Titration

Procedure:

- Add the alcohol sample to the titration cell.
- Titrate with Karl Fischer reagent until the endpoint is reached.

- Calculate the water content from the volume of reagent used.

Equipment: Karl Fischer titrator.

The alcohol characteristics of Bush Cane (*Costus afer*) Leaf Extract is shown in Table 1 below.

RESULTS AND DISCUSSION

Table 1: Alcohol Characteristics of Bush Cane (*Costus afer*) Leaf Extract.

Parameter	C1	C2	C3	C4	C5	Standard
Boiling point (°C)	83.4	83.4	83.4	83.4	83.4	79.2
Refractive index	1.34527	1.345498	1.34588	1.34689	1.3479	1.34926
Viscosity (N.s/m ²)	2.46	2.46	2.46	2.46	2.46	1.13
Density (g/cc)	0.901	0.893	0.883	0.862	0.834	0.79
Alcohol; content (%)	43.088	46.974	48.86	53.746	58.632	98
Volatility	Low	Low	Low	Low	Low	High
Sugar content (%)	37.12	41.76	46.4	47.04	48.68	54
Colour	Light	Light	Light	Light	Light	Light
Solubility	92% miscible	93% miscible	94% miscible	95% miscible	96% miscible	Miscible
Melting point (oC)	-76.8	-86.4	-96	-98.6	-105.2	-114.5
Odour	Slightly alcohol	Slightly alcohol	Slightly alcohol	Moderate alcohol	Moderate alcohol	Alcohol
Slash point (°C)	83.6	83.5	83.4	83.3	83.2	<83
Water content (%)	24.4	24.3	24.2	24.15	24.1	20 - 24

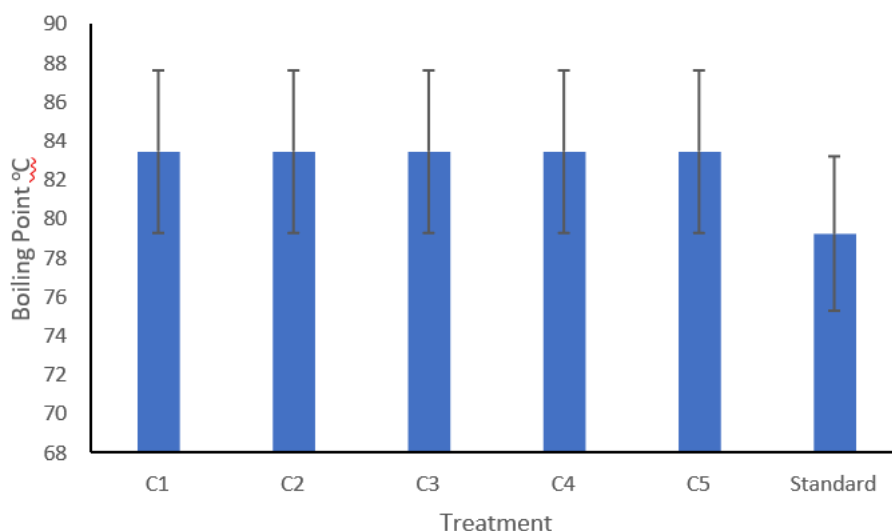


Fig. 1: Alcohol Boiling Point.

The boiling point of the alcohol samples remained constant at 83.4°C across all concentrations (C1-C5). This value is slightly higher than the standard boiling point of pure ethanol (79°C).

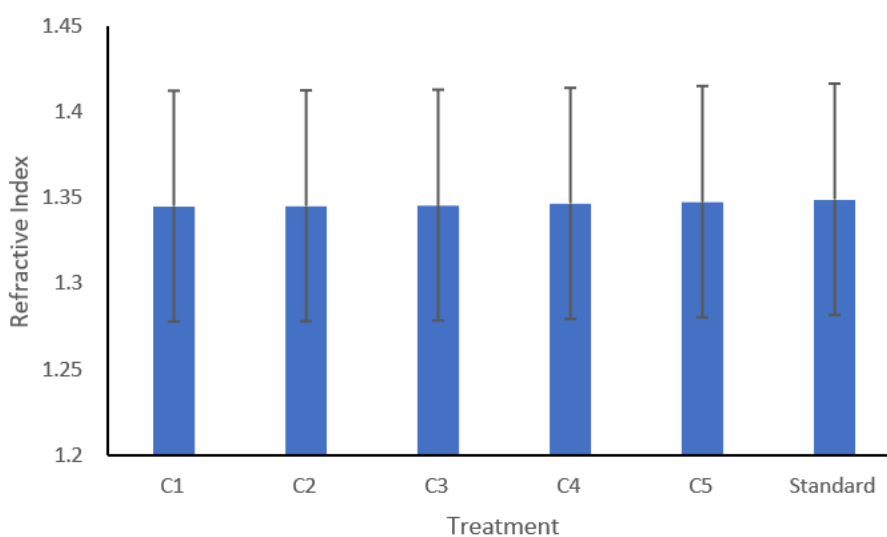


Fig. 2: Alcohol Refractive Index.

The refractive index increased gradually from 1.34527 to 1.3479 as the concentration changed from C1 to C5 [Figure 2]. Although these values are slightly lower than the standard ethanol value of 1.34926.

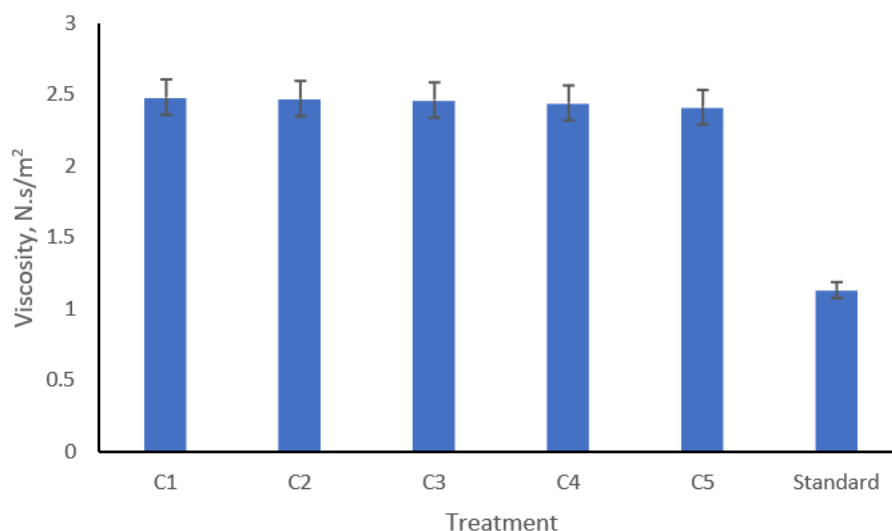


Fig. 3: Alcohol Viscosity.

The viscosity remained constant at 2.46Ns/m² for all samples [Figure 3]. This value is higher than the standard viscosity of ethanol (1.13 Ns/m²), suggesting the presence of dissolved solids or other compounds from the bush cane extract.

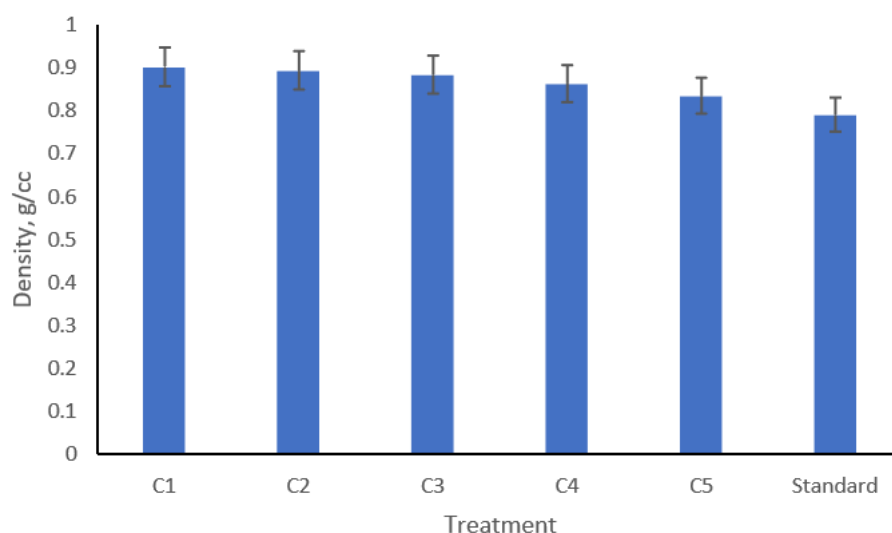


Fig. 4: Density.

The density decreased gradually from 0.901g/cc(C1) to 0.84g/cc(C5). This trend indicates that the alcohol concentration increased across the samples since ethanol generally has a lower density compared to water as shown in Figure 4.

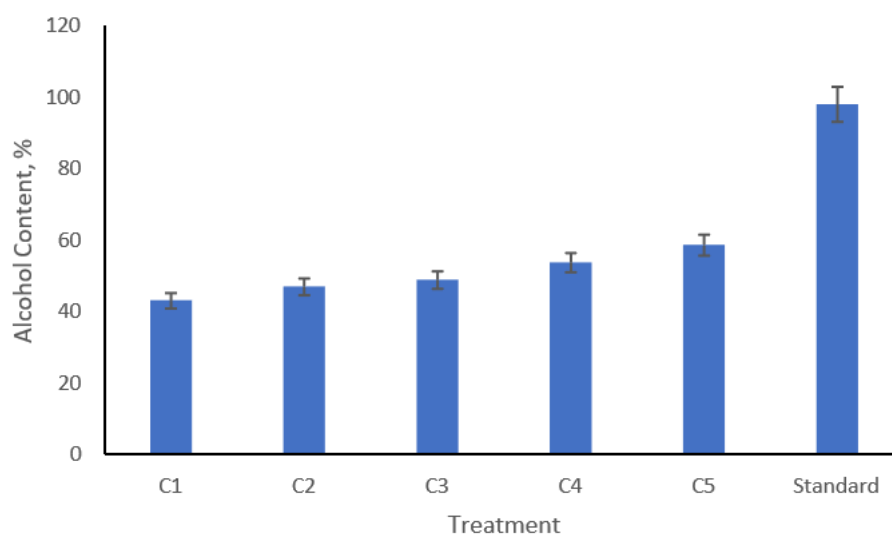


Fig. 5: Alcohol Content.

Alcohol content increased from 43.09%(C1) to 58.63%(C5). This shows that higher pulp-to-water ratios favoured greater ethanol production during fermentation. However, the values are still lower than standard 98% ethanol as shown in Figure 5.

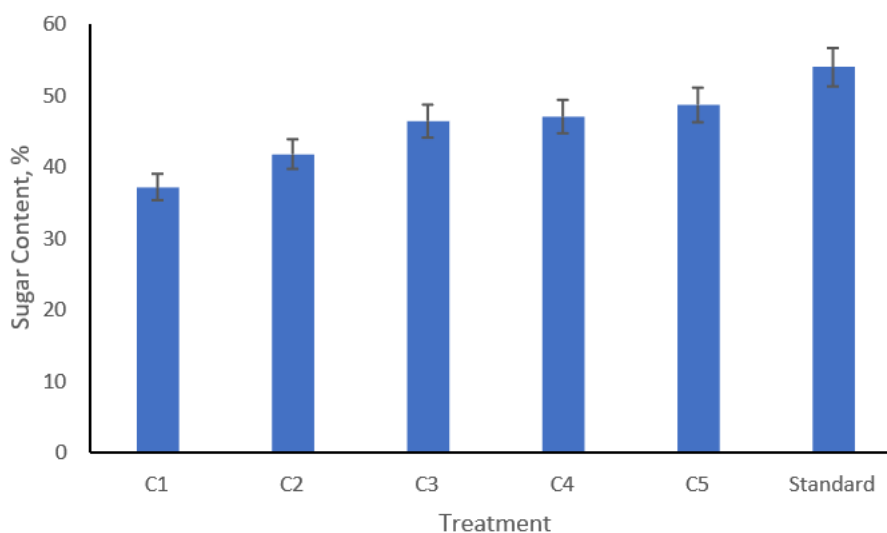


Fig. 6: Alcohol Sugar Content.

The sugar content increased from 37.12% to 48.68% across the samples. This suggests that the bush cane extract contains a significant number of fermentable sugars, which are essential for ethanol production as shown in Figure 6.

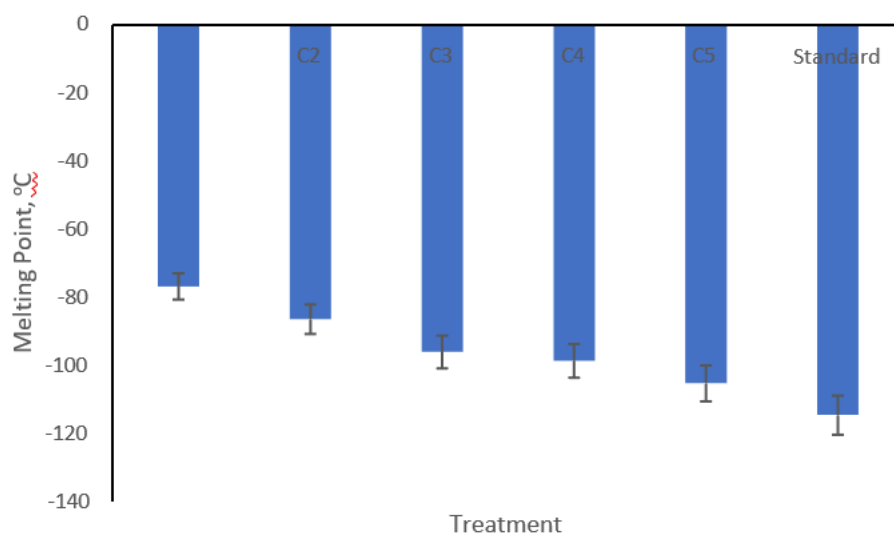


Fig. 7: Alcohol Melting Point.

The melting point values decreased from -76.8°C to -105.2°C across the samples as shown in Figure 7. Although these values differ from the standard ethanol melting point (-114.5°C), the decreasing trend indicates increasing ethanol purity.

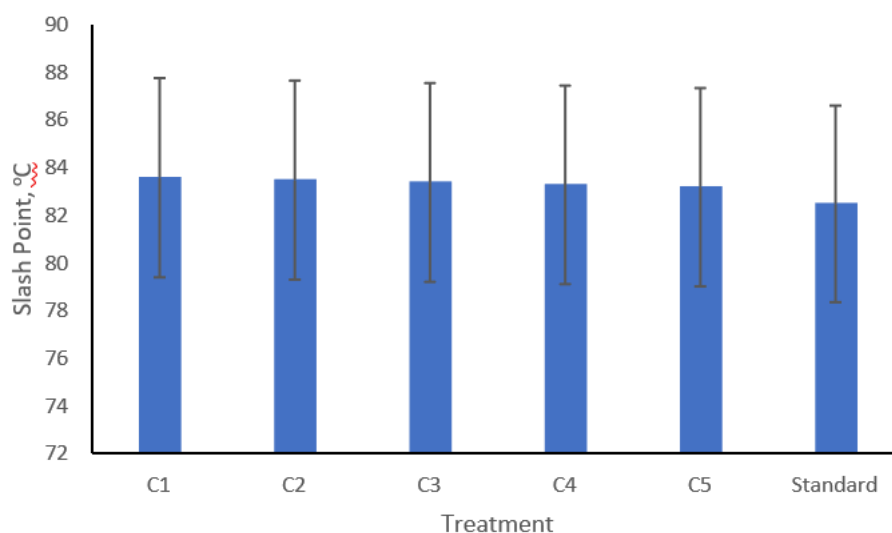


Fig. 8: Alcohol Flash Point.

The flash point [Figure 8] ranged from 83.6°C to 83.2°C , which is slightly higher than the standard value of $<83^{\circ}\text{C}$. The slight decrease across the samples suggests improved alcohol concentration.

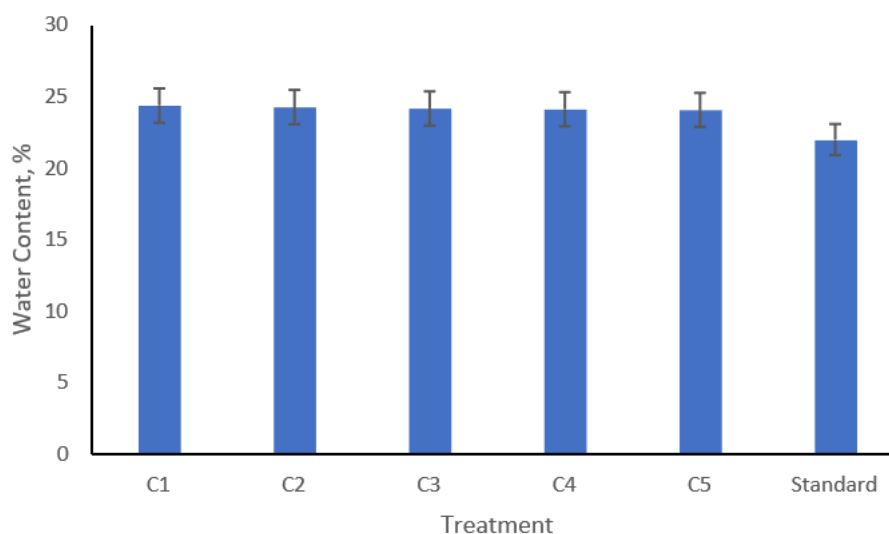


Fig. 9: Alcohol Water Content.

Water content decreased slightly from 24.4% to 24.1% across the samples [Figure 9]. This small reduction indicates gradual removal of water during distillation. However, that values remain close to the upper range of the standard 20-24%.

CONCLUSION

The boiling ranges for the samples were 78 – 88 with coefficient of regression (R^2) of 0.973 as good relationship between the volume of ethanol produce and the boiling temperature range. The temperature for the double distillation column was 200°C. The boiling ranged from 35°C to 200°C. The specific gravity (S.G) of the ethanol extract measured at 25°C was 0.7620 Kg/L. The S.G of pure ethanol is 0.7951 Kg/L. The percentage purity of the ethanol extracted after reflux distillations was found to be 95.8%. The refractive index of ethanol was 1.3449 at 88°C. 20 liters of money sugarcane stem (*costus afer*) yielded 10 liters of ethanol. From the results distillation data result showed an initial boiling point (IBP) of the distillate to be 78°C. For 2 L, 4 L, to 10 L, as the temperature increased uniformly. Also, results showed the octane number to be 90.3, the Reid vapour pressure to be 0.52 psi and the specific gravity to be 0.7468

Kg/L. Conclusively, *Costus afer* juice gotten from the leaf, stem and root produced 95 % ethanol and there were no significant different from the ethanol produced from the leaf, stem and root juice of *Costus afer*.

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