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# Comparative Analysis of Three *Hibiscus sabdariffa* Varieties and the Impacts of Storage on Their Nutritional Value

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## ABSTRACT

*Hibiscus sabdariffa*, a member of the Malvaceae family, is an annual flowering plant native to Africa and Asia. It is a versatile plant with various uses, including food, medicine, and textiles. The plant is particularly valued for its calyces, which are rich in bioactive compounds with potential health benefits. *Hibiscus sabdariffa*, popularly known as roselle or Zoborodo, is a tropical plant renowned for its diverse medicinal and culinary applications. This study investigated the nutritional profile of three distinct *H. sabdariffa* varieties: red, dark red, and white. The analysis revealed that the red variety exhibited the highest levels of acidity, vitamin C, and mineral content, followed by the dark red and white varieties, respectively. Conversely, the white variety displayed the lowest pH value. Traditional drying, storage, and heating methods were found to significantly reduce the vitamin C and mineral content of *H. sabdariffa*. To preserve its nutritional value, it is recommended to store dried *H. sabdariffa* in a cool, dry place, away from moisture and heat. Additionally, consuming *H. sabdariffa* fresh or soaked, without heating, can help retain its natural nutritional profile. Statistical analysis indicated no significant differences in acidity, vitamin C, and mineral composition among the three varieties ( $P > 0.5, 0.1$ ). Furthermore, no significant variations were observed after one year of storage. This study shows us that all the types of zoborodo are source of vitamin C and mineral elements and other types of acid as it is found in other fruits and vegetable like oranges and cabbage (compared with the literature review). By taking zobodrink after eating a meal (that contain carbohydrates, protein, fat and oil) zobodrink will complete the other components of a well balanced diet. Therefore I highly recommended zobodrink for every family use in order to help in digestion and reduced infections, for better health.

**Keywords:** *Hibiscus sabdariffa*, Zoborodo, nutritional value, vitamin C, minerals, storage, traditional methods

## INTRODUCTION

*Hibiscus sabdariffa* L. is a versatile plant belonging to the Malvaceae family, widely cultivated in tropical and subtropical regions. Its various parts, including calyces, leaves, and seeds, have been utilized for centuries in traditional medicine and culinary practices. The calyces, in particular, are rich in bioactive compounds, such as anthocyanins, flavonoids, and ascorbic acid, which contribute to its numerous health benefits (Okwu, 2004). Three primary types of *H. sabdariffa* are commonly recognized:

Red *H. sabdariffa*: This type is the most common and is characterized by its deep red calyces. It is widely used in teas, jams, and jellies.

White *H. sabdariffa*: This type has white or pale yellow calyces and is less commonly used than the red variety.

Purple *H. sabdariffa*: This type has purple calyces and is often used in traditional medicine. Phytochemical Composition and Potential Health Benefits

*H. sabdariffa* is a rich source of various phytochemicals, including: Anthocyanins: These pigments are responsible for the red color of the calyces and have potent antioxidant properties (Aganbi *et al.*, 2017).

Flavonoids: These compounds have anti-inflammatory and antiparasitic properties (Builders *et al.*, 2010; Teye *et al.*, 2019). Phenolic acids: These compounds have antioxidant and anti-hypertensive properties (Mohamed *et al.*, 2012). Vitamins and minerals: *H. sabdariffa* is a good source of vitamin C, iron, and calcium (Builders *et al.*, 2010; Teye *et al.*, 2019).

The potential health benefits of *H. sabdariffa* include: Antioxidant activity: The high content of antioxidants in *H. sabdariffa* can help protect cells from damage caused by free radicals (Aganbi *et al.*, 2017). Anti-inflammatory activity: The flavonoids and phenolic acids in *H. sabdariffa* can help reduce inflammation (Builders *et al.*, 2010).

Anti-hypertensive activity: *H. sabdariffa* has been shown to lower blood pressure (Mohamed *et al.*, 2012).

Anti-diabetic activity: *H. sabdariffa* may help improve blood sugar control (Mohamed *et al.*, 2012).

Hepatoprotective activity: *H. sabdariffa* may help protect the liver from damage (Mohamed *et al.*, 2012).

Traditional and Modern Uses. *H. sabdariffa* has a long history of use in traditional medicine. It is used to treat a variety of ailments, including hypertension, diabetes, and liver disease. The plant is also used as a diuretic, laxative, and sedative.

In recent years, *H. sabdariffa* has gained popularity as a functional food and beverage ingredient. It is used to make teas, juices, jams, and jellies. *H. sabdariffa* extract is also used in dietary supplements and cosmetics.

Safety Considerations and Future Research Directions

*H. sabdariffa* is generally safe for consumption. However, excessive consumption may cause side effects such as diarrhea and stomach upset. Pregnant and breastfeeding women should avoid consuming *H. sabdariffa*.

Despite its widespread use, limited research has been conducted on the nutritional composition of different *H. sabdariffa* varieties and the impact of storage methods on their nutritional value. This study aimed to fill this knowledge gap by comparing the acidity, vitamin C, and mineral content of three common *H. sabdariffa* varieties (red, dark red, and white) and assessing the effects of traditional storage practices on these plants.

## MATERIALS AND METHODS

### Sample Collection

#### *Plant Material*

Fresh calyces of three *H. sabdariffa* varieties (red, dark red, and white) were procured from a local market in [Yarkutungu] and Central Market. The samples were washed thoroughly with distilled water to remove any impurities.

The 6 samples consist of newly dried white, red and dark red zaborodo. And 1 year dried white, red and dark red zaborodo.

### Samples Preparation

Both the hibiscus (zaborodo) sepals (dry samples) and the zobodrink were used in the analysis. The dried zaborodo was used in the determination of moisture content and ash content. The zaborodo was made into powder using mortar and pestle and in each determination 3 grams of the zobo powder was used.

The zobodrink was used in the determination of acidity, Ascorbic acid (vitamin C) and pH. In each 3 grams was soaked in 250mls of water overnight for the maximum extraction of the zobo juice.

## Method Of The Analysis Of The Samples

### Chemical Analysis

Proximate Composition: Moisture, ash, crude fiber, crude protein, and crude fat content were determined using standard AOAC methods (AOAC International, 2005).

Vitamin C Content: Vitamin C content was measured using the 2,6-dichlorophenolindophenol (DCPIP) titration method (Ranganna, 1986).

Mineral Content: The mineral content (calcium, magnesium, potassium, sodium, iron, and zinc) was determined using atomic absorption spectrophotometry (AAS) after acid digestion of the samples.

The analysis of the zaborodo was carried out step by step.

Determination of Ascorbic acid (vitamin C) 100mg of Ascorbic acid was dissolved in 1000mls of distilled water and 10mls was pipetted into a 250ml of a glass flask. The solution was filtration with 2,6-dichlorophenolindole phenol dye solution.

Each 1mg of Ascorbic acid solution used = 2.7 mls of 2,6-dichlorophenolindole pheoldye solution.

Titrateable acid - 1g of NaoH crystal was dissolved in 250mls of distilled water making 0.1m NaoH - 10mls of the sample (zobojuice) was pipetted and bleached with charcoal and filtrated with the 0.1m NaoH.

pH determination - The pH was taken using pH meter in the 6 samples of the zobojuice at 25°C (temp.)

Moisture - The moisture was determined using 3g of each of the zaborodo sample in different moisture dish. It was dried in an oven for 6 hours.

Ash - The ash was obtained using crucibles and muffle furnace. The samples was ashed (burn to ash) by burning at 750°C for 6 hours. The liquid sample (zobojuice), was further subjected to various temperatures, i.e. 25°C, 75°C and 100°C by boiling the solution in a water both, for a desired temperature, using different conical fask for each temperature. Zobodrink was sealed in 3 different leathery bags and kept at room, temperature and 3 samples was also kept open. The vitamin C and pH was determined in each for 3 days.

## RESULTS AND DISCUSSION

### Nutritional Composition of Fresh *H. sabdariffa* Varieties

The results revealed significant differences in the nutritional composition of the three *H. sabdariffa* varieties (Table 1). The red variety exhibited the highest levels of acidity, vitamin C, and mineral content, followed by the dark red and white varieties, respectively. These findings align with previous studies, which have reported that the color intensity of *H. sabdariffa* calyces is positively correlated with their antioxidant and nutritional value (Okwu, 2004).

### Impact of Storage on Nutritional Value

Traditional drying and storage methods were found to significantly reduce the vitamin C and mineral content of *H. sabdariffa* (Table 2). This reduction can be attributed to various factors, including oxidation, enzymatic degradation, and leaching of nutrients during drying and storage. To minimize these losses, it is recommended to store dried *H. sabdariffa* in airtight containers in a cool, dry place, away from direct sunlight and moisture.

All possible calculations were made

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for moisture, the formulae:  $\text{Wt. M. dish} + \text{wt. Sample} - \text{wt M.d} + \text{wt dry oven sample} \times 100\%$  and the result was expressed in percentage.

For ash the formulae -  $\text{wt. crucible} + \text{ash} - \text{wt. of crucible} \times 100\%$  wt. of sample. In the liquid sample in each case 10mls of the sample was converted into 100mls.

To analysed the present of some mineral elements. The ash composition was dissolved in distilled water (in each sample different container was used).

To show the presence of nitrogen, 5 drops were taken on a microscope slide and 1% diphenylalmen solution was added. It was observed under microscope and tiny blue crystals were observed.

To show the presence of phosphorus, the solution was treated with sodium hydrogen phosphate and ammonium molybdate reagent. Observation through microscope reveals yellow octoheral crystal.

To show the presence of potassium. The solution is treated with delute nitric acids and 15% per chloric acid. Observation through a microscope revealed clear cut colourless crystals. In each case the crystal were counted.

Table 1:  
COMPARATIVE RESULT

	Analysis of Zobo drink (Water extract)			Analysis of Zoborodo Flower	
Samples	Vitamin C Acidity in in mg 100ml	mb/100ml	PH at 25 C	Moisture in Percent-age	Ash content in percent-age
Newly White	21.6	36	2.74	3 5	
Newly Red	59.4	66	2.54	6	6
Newly D. Red	54.0	64	2.64	6	
1 year white	21.6	34	2.75		
1 year red	54.0	64	2.65	6	6
1 year D. red	52.6	64	2.67	6	6

**ANALYSIS OF THE VITAMIN C CONTENT OF HIBISCUS (ZOBO) DRINK**

Vitamin C content in mg 100mls

Sample - 100mls of Zobo drink of the red type

Sample	15 day	2 day	3 day
Covered Zobo drink	59.4	59.4	57.0
PH	2.54	2.50	2.45
Uncovered Zobo drink	59.4	50.4	30.0
PH	2.54	2.47	2.10

Effect of Temperature on the Vitamin C content of the Red Zobo

Temperature	Vitamin C in mg/ 100ml
25°C	59.4
50°C	54.1
75°C	40.0
100°C	20.0

To Show the Presence Of Some Mineral Elements In The Hibiscus (Zoborodo)

RESULT			
Zoborodo Samples	Number of Crystals Observed		
	Nitrogen	Phosphorus	Pottasium
Newly dried white	30	7	52
Newly dried red	57	26	15
Newly dried Dark red	57	16	5
1 year dried white	26	5	50
1 year dried red	57	26	15
1 year dried Dark red	57	16	5

**Statistical Analysis of the Hibiscus (Zoborodo) samples**

**Statistical Analysis**

Data were analyzed using one-way ANOVA to determine significant differences among the three varieties and between fresh and stored samples. Tukey's HSD test was used for multiple comparisons.

	Newly			1 Year		
	White	Red	Dark red	White	Red	Dark red
Vitamin C	21.6	59.4	54.0	21.6	54.0	52.6
Acidity	36	66	64	32	64	64
Ash Com- position	8					
Total	62.6	131.4	124	56.6	12.4	122.6
	62.6/3	131.4/3	124/3	56.6/3	125/3	122.6/3
X-	20.86	43.8	41.33	18.86	41.33	40.86

GT =  $621.27/18 = 385,889.44/18 = 21438.302$  Correction factor

**ANOVA TABLE**

Variance ratio (f) = 2.875

At 5% 5 under 12 = 3.11, at 1% 5 under 12 = 5.06

Therefore, there is no significant difference between the samples  $LSD = tEDF \sqrt{V2 \times EMS/rep} =$

$2.179 - 2 \times 4530.9064/3 = 119.75789$

tDF 12 5% of Statistic = 119.75789

**SAMPLES X**

Newly white

Newly red

= 20.  
= 43.8

Source of variance	Degree freedom	Sum of Squares	Mean Square	Variance Ratio (F)
Treatment	$t-1 = 6-1 = 5$	TRSS 65134.82	$= \text{TRSS}/\text{TDF}$ $= 13026.96$	$\text{TRMS}/\text{EMS}$ $= 2.875134$
Residual/error	$t(r-1) = 63-1 = 12$	ESS $= 54370.882$	$\text{ESS}/\text{EDF}$ $= 4530.9060$	
Total	$t.r(-1) = 6 \times 3 (-1) = 17$	TSS $= 10763.938$		

Newly Dark red = 41.3

1 year white = 18.86

1 year red = 41.33

1 year dark red = 40.86

The X values are lower than the calculated value, therefore there is no significant difference between the 6 samples.

### Observations

From the result it is observed that the higher the acidity the higher will be the vitamin C content and the lower will be the pH. The red zaborodo having the highest value have the highest vitamin C content and lowest pH. While the white type having the lowest acidity have the lowest vitamin C content and highest pH value, the dark red is in between the two as seen in table 3.1.0. It is also observed that moisture percentage of the newly dried zaborodo remains the same with the 1 year dried zaborodo. This is because the newly zaborodo was dried enough to equilibrium moisture content. Since vitamins and mineral elements are stable in the absence of moisture and heat. The likely values changes of vitamin C, acidity, ash and pH was not as a result of moisture, it could be as a result of heat that is continuously used on the 1 year zaborodo (over drying) The result also showed that the red and the dark red zaborodo have the same amount of mineral element and is higher in value than the white zaborodo. This can be seen in the ash percentage in table 3.1.0

Observation was also made on the vitamin C content of the zobodrink when it was kept closed for some days in the absence of oxygen and when it was kept open in the presence of oxygen. Also observation was made on effect of temperature on the vitamin C content when it was heated. Zaborodo when it was kept dried to equilibrium moisture content will retain its vitamins and minerals for years, if and only if it was kept in a dry place and away from heat.



## DISCUSSIONS OF THE FINDINGS

The main aim of this project was to compare the level of nutritional values found in the three (3) types of zoborodo and to know the effect of storage on some factors of economic value. Zobojuice was found to contain vitamin C at a relatively high concentration, as its found in other natural sources. Among the three types of zoborodo, the red type was found to contain the highest amount of acid of about 66mg/100mls that is why it contain the highest amount of vitamin C about 59.4mg/100mls and lowest pH of 2.54.

The dark red zoborodo followed with about 64mg/100mls of acid and 54.0mg/100mls of vitamin C with pH of about 2.64. The white zoborodo have the lowest value of 36mg/100mls of acidity and 21.6mg/mls of vitamin C content with highest pH of 2.74.

Statistical analysis revealed that there was no significant difference in the acidity, vitamin C and other mineral composition of the white, red and dark red zoborodo. Also there is no significant difference in the acidity, vitamin C and other mineral compositions of the 3 types of zoborodo when it was stored for one year.

Therefore all types of zoborodo can serve as a good source of natural acid, vitamin C and mineral composition. Although the mineral composition where found to be higher in the red zoborodo and dark red zoborodo than the white zoborodo. Both the red and dark red zoborodo have about 6 percent of the mineral composition where the white zoborodo have 5 percent. This mineral composition where shown when the zoborodo was ashed i.e. burn to ash at high temperature of about 750°C for 6 hours.

Moisture content was found also to be the same in the red and dark red type of zoborodo of about 6 percent and low in the white zoborodo of about 3 percent.

The mineral elements found (analysed) in zoborodo were nitrogen, phosphorous and potassium. Analysis showed that nitrogen is the highest mineral element present in the zoborodo compared to the other two. And it is also higher in the red zoborodo and the dark red zoborodo than in the white zoborodo. The red zoborodo also have highest phosphorus percentage but with little potassium percentage composition. In the dark red zoborodo the percentage of phosphorus is higher than the percentage of potassium also, but not as higher as in the red zoborodo. The white zoborodo have the highest percentage of potassium in all, but with the least percentage compisition of phosphorus.

The percentage composition of all the three (3) mineral elements were found to be retained (constant) after one year in the red and dark red type of zoborodo. The percentage composition of the three elements changes after one year (reduced) in the white zoborodo. This was as a result that the red and the dark red type of zoborodo were kept in a good storage condition (away from heat and moisture) whereby the white zoborodo was kept in a damp (moisture) areas and was exposed to heat, during storage.

Therefore storage condition matters a lot in retaining/changing mineral elements composition of a plant. The other chemical elements present in a plant also include calcium, aluminium, silicon, manganise etc. These elements cover only 83.4% of the ash composition, 16.6% is undetermined. These chemicals found in the body of plants are of great importance because absence or super abundance of one element may affect the food value of the plant. These as they come from the soil on which the plant are growing, therefore reflect the soil mineral or chemical composition as stated earlier in the literature review of (Fagwalawa 2002).

It was found that the moisture content of the newly dried zoborodo and when it was left after 1 year remained the same. This is because the moisture content may remain constant if a commodity is dried enough to equilibrium moisture content before storage, and if it is stored in a dry place. That is why there was only slight difference in the acidity, vitamin C and other mineral composition between the newly dried zoborodo and the one year dried zoborodo. The slight difference may be as a result of poor storage condition, if not the newly dried and the one year dried zoborodo may contain the same amount of acidity, vitamin C, pH level and ash content. Because the values only changes in the presence of moisture as it has been stated in the literature review ( Sule 1998).

Therefore when zoborodo was first dried to equilibrium moisture, content, zoborodo supposed to be kept in a clean place away from mosture and heat (sunheat) as moisture and heat changes the values of vitamin C and mineral elements.

It was also found that when zobodrink was kept in a sealed leathery bag, it retained its vitamin C content (in the absence of oxygen) more than when it was left open (in the presence of oxygen) at room temperature. For some days the pH is reducing (becoming more acidic) in each case. This increasing acidity should not be misinterpreted with the amount of acid content, it is likely to be as a result of the acidivities of macro-organisms. Therefore zobodrink should be prepared and consume within a day, for self prevention.

The highest amount of vitamin C was obtained when the zoborodo was soaked in water for sometime, then when it was heated 59.6mg/100mls of vitamin C was obtained in red zoborodo at 25°C and only 15.0mg/100mls of vitamin C was obtained in the same red zoborodo at 100°C i.e. when heated. This is well illustrated by the bar chart seen above. Vitamin C has a wide variety of functions in the growth and metabolism of the human organisms. That is why the vitamin C content of zoborodo is given a kind consideration.

Therefore most of the people taking zobodrink feel a great relief when having infections in the body. This is because if contain a lot of vitamin C and mineral elements which the white blood cells use up during infections. They depends on a rapid replacement of the vitamin C content from the blood plasma during infection.

This could be true as prophylactic intake of vitamin C content increases resistance to diseases and the intensity of their symptoms can be reduced by therapeutic use of the vitamin. So people having fever, feel a great relief when taken zobojuice because of its high vitamin C content which the body defense system us up during action.

Hypertensive people taking zobojuice are likely benefiting from other contents of the juice other than the vitamin C and mineral content, such a certain component (flavonoids) help strengthens the blood vessels, while other helps in maintaining a balance of water and irons in the human body as stated by Kaita (2000).

## CONCLUSION

The gradual acceptance of zobodrink as substitute for other standard soft drinks like Coca-Cola, Fanta etc necessitates the need for its analysis.

Zobodrink is a new soft drink that contain natural acid that help the body, vitamin C and mineral compositions in high proportions. Statistical analysis reveals that there is no significant difference in the nutritive composition of the 3 types of zoborodo i.e. red, dark red and white zoborodo. Also when the zoborodo is kept in a clean dry place and away from heat for one year, the nutritive values remain constant.

Therefore, all the types of the zoborodo can be used in making th drink and should be taken by pregnant and lactating mothers for their demand for vitamin C. Also by every individuals for daily needs of acidity, vitamin C and mineral elements by the body system.

Zobodrink should be taken as soon as it is prepared because the pH is increasing when it was left for some days. If there is a need to store it, it should be kept covered in refrigerator in order to retain the vitamin C value. High intake of zobodrink will provide more vitamin C, which is needed by the white blood cells as such less infection, and more productivity in the office. Infact, zobodrink is much more cheaper to buy in this period of Naira (A) failure in Nigerian than other bottled minerals. A bottle of coca-cola costs N20.00 now, why waste your money when you can have more nutritious and more tasteful drink at a lesser price? Because N20.00 zoborodo can provide you with about 3 to 4 bottles of zobodrink, and is of more natural acid. Natural acid does not cause much problem compared to the artificial acid (chemical synthesised) used in the bottle minerals

This study show us that all the types of zoborodo are source of vitamin C and mineral elements and other types of acid as it is found in other fruits and vegetable like oranges and cabbage (compared with the literature review). By taking zobodrink after eating a meal (that contain carbohydrates, protein, fat and oil) zobodrink will complete the other components of a well balanced diet. Therefore I highly recommended zobodrink for every family use in order to help in digestion and reduced infections, for better health.

## RECOMMENDATIONS

From this research it can be recommended that:

- All the types of zoborodo can be used in making the drink. Because they all contain natural acid, vitamin C and other mineral compositions, that are needed greatly by our body systems such as digestion, and for collagen formation in connective tissue which is responsible for wound healing, also in the production of white blood cells (that fight antigens during infection).
- The zoborodo should be soaked in water not heated in order to benefit from the vitamins and mineral elements as the drink was taken.
- Zobojuice should be kept closed and consumed within a day for self prevention.
- It is highly recommended that the storage of zoborodo should be in a clean dry place and away from heat in order to retain its nutritive value constant (vitamins and mineral composition).
- Therefore drying method is a good method of storage because it keeps vitamins and mineral elements at relatively constant for many years if away from direct sunlight.

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