**PRODUCTION AND QUALITY ASSESSMENT OF ZOBO DRINK**

# ABSTRACT

This study focuses on the production and quality assessment of zobo drink, a beverage derived from Hibiscus sabdariffa known for its rich antioxidant properties and potential health benefits. The aim of the research was to optimize the production process, evaluate the physicochemical properties, and enhance the sensory attributes of zobo drink to meet consumer preferences and market demands. Samples of zobo were produced with different additives—ginger, cloves, and pineapple—followed by an analysis of their pH, viscosity, ash, protein, and vitamin content. In addition, microbial testing was conducted to ensure safety and shelf-life, while sensory evaluation was used to gauge consumer acceptability. The antioxidant activity of the samples was also measured using the DPPH assay. Results showed that the inclusion of additives significantly improved both the sensory qualities and nutritional profile of zobo drink. Samples with pineapple and ginger-cloves were particularly well-received by consumers in terms of taste, aroma, and overall acceptability. These samples also exhibited higher antioxidant activity and better microbial stability compared to the plain zobo drink. The study concluded that zobo drink, enhanced with natural additives, can be produced on a commercial scale, offering a safe, nutritious, and consumer-preferred product. Recommendations from the study include further optimization of production processes, use of natural preservatives to extend shelf-life, and strategic marketing that emphasizes the health benefits of zobo. These findings highlight the potential of zobo drink as a competitive, functional beverage in the growing health-conscious market.

**Keywords:** *Zobo drink, Hibiscus sabdariffa, antioxidant activity, microbial safety, sensory evaluation, production optimization.*

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# CHAPTER ONE

# INTRODUCTION

## 1.0 Background of the Study

Zobo drink, made from dried calyces of Hibiscus sabdariffa, is a popular and widely consumed beverage in many parts of the world, particularly in West Africa. The drink is known for its vibrant red color, refreshing taste, and nutritional benefits, which have contributed to its increasing demand among different age groups (Makanjuola et al., 2022). Historically, the hibiscus plant, from which the drink is derived, has been recognized for its medicinal properties and its use as a natural remedy for various health conditions such as hypertension, liver disorders, and digestive issues (Ademiluyi et al., 2023). These health benefits have driven the exploration of zobo drink in modern scientific research and commercial beverage production.

The production of zobo drink is relatively simple, involving the boiling of dried hibiscus calyces in water, often with additives such as ginger, cloves, or pineapple to enhance flavor and nutritional value (Oyeleke & Akhigbe, 2021). However, despite the drink’s simplicity, there are significant variations in production techniques, resulting in differences in taste, quality, and shelf life. This inconsistency poses challenges for large-scale commercial production, where standardization and quality control are critical (Olawale et al., 2021).

Furthermore, concerns have been raised about the microbiological safety of zobo drinks, particularly those produced under unsanitary conditions or without adequate preservation techniques. Studies have shown that improper handling and storage can lead to microbial contamination, including the presence of harmful bacteria such as Escherichia coli and Salmonella (Onyeneke et al., 2020). Such contamination risks not only pose health hazards to consumers but also affect the marketability and commercial viability of zobo drinks.

In addition to its health benefits and potential risks, zobo drink is recognized for its rich nutritional profile. The beverage is a good source of vitamins, particularly Vitamin C, which is essential for boosting the immune system and promoting overall health (Eze et al., 2022). The presence of anthocyanins, a type of antioxidant responsible for the red color of the drink, has also been linked to its anti-inflammatory and cardioprotective properties (Fasoyinu & Salau, 2021). However, despite these advantages, there is a need for further research on how processing methods, such as boiling and pasteurization, impact the nutritional content of the drink.

In recent years, the growing consumer demand for natural and healthy beverages has increased interest in the commercial production of zobo. This demand has spurred innovations in production methods, with a focus on improving quality, extending shelf life, and ensuring microbial safety (Afolabi et al., 2023). Modern technologies such as vacuum evaporation and cold pasteurization have been explored to retain the nutritional and sensory qualities of zobo drink while enhancing its shelf stability (Usman et al., 2023). As such, the zobo beverage market is poised for growth, provided that production challenges related to quality control, microbial contamination, and consumer preferences are adequately addressed.

This study aims to contribute to the growing body of knowledge on the production and quality assessment of zobo drink by examining various production techniques, quality control measures, and consumer preferences. The research will also explore strategies for improving the scalability and cost-effectiveness of zobo production, which is essential for small- and medium-scale enterprises seeking to enter the competitive beverage market.

## 1.1 Statement of the Research Problem

The commercial production of zobo drink presents several challenges that limit its potential for large-scale market entry. One of the primary issues is the lack of standardized production methods, which results in significant variations in the quality, taste, and safety of the final product (Adegboye et al., 2022). This inconsistency is particularly problematic for producers aiming to meet the expectations of a broad consumer base and ensure the repeatability of quality in mass production. Additionally, zobo drink is highly perishable, and traditional preservation methods such as refrigeration or pasteurization are often insufficient to prevent microbial contamination and spoilage, especially in regions with limited access to electricity and refrigeration (Onyeneke et al., 2020).

Another problem that arises in zobo drink production is the limited knowledge of how processing affects the drink’s nutritional content. While zobo is recognized for its high vitamin content, there is evidence that certain processing techniques may degrade these nutrients, particularly Vitamin C, which is sensitive to heat (Usman et al., 2023). Consequently, consumers may not be receiving the full nutritional benefits of the beverage, and producers may be unable to market it effectively as a health drink.

Lastly, there is a need for producers to balance consumer preferences with production efficiency and cost-effectiveness. The addition of flavoring agents, such as ginger or pineapple, may enhance the drink’s appeal but can also complicate production and increase costs (Olawale et al., 2021). Similarly, achieving a consistent product that meets both consumer expectations and regulatory standards requires careful optimization of production processes, which many small-scale producers struggle to implement due to resource constraints.

## 1.2 Justification of the Study

The increasing consumer demand for healthy, natural beverages presents a unique opportunity for zobo drink producers to tap into a growing market segment. Zobo’s rich nutritional profile and medicinal properties make it a strong candidate for commercialization as a health-promoting beverage (Fasoyinu & Salau, 2021). However, to capitalize on this opportunity, there is a need for comprehensive research into the production processes that can ensure a consistent, high-quality product that meets consumer expectations and adheres to safety standards.

This study is particularly relevant in the context of addressing the challenges of food security and economic development in developing regions, where small- and medium-scale enterprises (SMEs) play a critical role in the food and beverage industry (Afolabi et al., 2023). By exploring cost-effective production techniques and quality control measures, this research can provide valuable insights for SMEs looking to scale their operations and improve the marketability of their products.

Moreover, addressing the issues of microbial contamination and shelf-life stability is essential for ensuring consumer safety and enhancing the commercial viability of zobo drinks (Onyeneke et al., 2020). Thus, this study aims to contribute to the development of standardized production practices that will help producers meet both regulatory requirements and consumer preferences.

## 1.3 Aim and Objectives of the Study

The major aim of this research is to assess and enhance the production and quality of zobo drink.

The objectives are to:

1. Collect samples of zobo drink.
2. Produce zobo drink that meets consumer preferences and market demands.
3. Achieve a consistent and high-quality product.
4. Optimize production processes for efficiency and cost-effectiveness.
5. Ensure scalability and reproducibility of the production process.
6. Develop a unique and appealing product that stands out in the market.

# CHAPTER TWO

# LITERATURE REVIEW

## 2.1 Zobo and Its Origin

Zobo drink, also known as hibiscus tea, is a popular beverage made from the dried calyces of the Hibiscus sabdariffa plant. Its origins can be traced back to ancient cultures in Africa and Asia, where it has been consumed for centuries both as a refreshing drink and for its medicinal properties (Moghadam et al., 2020). The plant is native to tropical regions, with significant cultivation in West Africa, particularly in Nigeria, where it is a staple in local cuisine and culture. The drink is traditionally prepared by boiling the dried calyces with water and sweetening it, often with sugar or honey, and flavoring with spices such as ginger or cloves (Adebo et al., 2021).

In Africa, zobo is not only consumed for its refreshing taste but also for its nutritional benefits. It is rich in vitamins and minerals, including Vitamin C, which supports immune function, and iron, which is essential for blood health (Ajala et al., 2019). The beverage is often served chilled and is a popular choice in social gatherings, festivals, and markets, particularly in Nigeria, where it is known for its vibrant red color and tangy flavor (Olorunnisola et al., 2020).

Beyond Africa, hibiscus tea has gained popularity in various parts of the world, including the Middle East and the Americas, where it is appreciated for its unique flavor and health benefits. In Mexico, for example, it is known as "agua de jamaica," and in the Caribbean, it is often flavored with ginger and served cold (Torres et al., 2022). The growing interest in healthy beverages has led to an increase in the global market for hibiscus tea, positioning zobo as a versatile drink that can be adapted to various tastes and preferences.

Recent studies have also highlighted the importance of zobo in the context of food security and economic development in many African countries. The cultivation of hibiscus can provide farmers with a sustainable source of income and contribute to local economies (Osei et al., 2023). Furthermore, the promotion of zobo as a functional beverage rich in antioxidants can enhance its marketability, aligning with global trends toward healthier lifestyle choices (Ajala et al., 2020). Thus, zobo drink is deeply rooted in African culture and has a significant historical background. Its nutritional benefits, economic potential, and adaptability to various cultural contexts make it a valuable addition to the global beverage market.

## 2.2 Pharmacological Properties of the Plant

Hibiscus sabdariffa is not only renowned for its culinary uses but also for its extensive pharmacological properties. Numerous studies have demonstrated that the bioactive compounds found in the calyces of hibiscus, particularly anthocyanins, flavonoids, and phenolic acids, possess a wide range of health benefits (Sharma et al., 2022). These compounds contribute to the drink’s antioxidant, anti-inflammatory, and antimicrobial properties, making zobo a popular choice among health-conscious consumers.

One of the most well-documented health benefits of hibiscus tea is its ability to lower blood pressure. A meta-analysis by Javed et al. (2021) reported that regular consumption of hibiscus tea significantly reduced both systolic and diastolic blood pressure in hypertensive individuals. The antihypertensive effect is attributed to the presence of anthocyanins, which help in vasodilation and improving endothelial function (Hussain et al., 2022). This makes zobo a potential natural remedy for managing hypertension, further enhancing its appeal as a functional beverage.

In addition to its cardiovascular benefits, hibiscus has been shown to possess lipid-lowering effects. Research indicates that hibiscus extract can reduce total cholesterol and triglycerides, contributing to improved cardiovascular health (Bafakeeh et al., 2021). The mechanism is believed to involve the inhibition of cholesterol absorption in the intestine and the promotion of cholesterol excretion.

Furthermore, hibiscus is recognized for its antioxidant properties, which play a crucial role in combating oxidative stress associated with various chronic diseases, including diabetes, cancer, and neurodegenerative disorders. The high concentration of vitamin C and polyphenols in hibiscus calyces enhances the body’s antioxidant defenses, helping to neutralize harmful free radicals (Ajala et al., 2019). Studies have demonstrated that hibiscus extract can reduce markers of oxidative stress and inflammation in both animal and human models (Mahmoud et al., 2023).

Moreover, hibiscus has antimicrobial properties that can inhibit the growth of certain pathogens, including bacteria and fungi. This makes zobo not only a refreshing drink but also a potential natural preservative (Moghadam et al., 2020). The antimicrobial effects are linked to the presence of phenolic compounds that disrupt the cellular integrity of microbes.

Despite its numerous health benefits, the consumption of zobo should be approached with caution, particularly for individuals on antihypertensive medications, as it may potentiate their effects. Pregnant women are also advised to consult healthcare providers before consuming hibiscus tea due to potential effects on hormone levels (Sharma et al., 2022).

## 2.3 Microbial Properties

The microbial properties of Hibiscus sabdariffa, particularly in the context of zobo drink, are critical for ensuring safety, shelf-life, and overall product quality. The presence of microorganisms, including bacteria and fungi, can significantly impact the nutritional value, flavor, and safety of the beverage. Understanding the microbial dynamics involved in the production and storage of zobo drink is essential for developing effective quality control measures (Ojo et al., 2021).

One of the primary concerns in the production of zobo is the potential for contamination by pathogenic microorganisms during processing and storage. Various studies have reported the presence of microorganisms such as Escherichia coli, Salmonella, and Staphylococcus aureus in commercially available zobo drinks, raising significant health concerns (Edeoga et al., 2021). These pathogens can originate from unclean water, unsanitized equipment, or improper handling during preparation. Such contamination can lead to foodborne illnesses, emphasizing the importance of good manufacturing practices (GMP) throughout the production process (Adeyemo et al., 2022).

The antimicrobial properties of Hibiscus sabdariffa itself play a pivotal role in enhancing the safety and stability of zobo drink. Research indicates that the phytochemicals present in hibiscus, such as flavonoids and phenolic compounds, exhibit antimicrobial activity against various pathogens. For example, studies have shown that hibiscus extracts can inhibit the growth of E. coli and Listeria monocytogenes, making it a natural preservative option (Okwu & Nduka, 2020). These properties can be harnessed to improve the microbial safety of zobo drinks, especially in regions where access to sanitation and refrigeration is limited.

Moreover, the fermentation of zobo drink can positively influence its microbial properties. The natural fermentation process can promote the growth of beneficial microorganisms, such as lactic acid bacteria (LAB), which can enhance the drink's flavor and nutritional profile while inhibiting pathogenic growth (Nwachukwu et al., 2022). LAB are known for their probiotic benefits, which can contribute to gut health and boost the immune system. Therefore, controlled fermentation can be an effective strategy to enhance the microbial quality of zobo drink while providing additional health benefits.

Storage conditions also play a crucial role in determining the microbial stability of zobo drink. Temperature, light exposure, and pH can all affect the growth of both spoilage and pathogenic microorganisms. For instance, research has shown that zobo drink stored at room temperature is more susceptible to microbial spoilage than those kept under refrigeration (Akanbi et al., 2023). Maintaining an optimal pH of around 3.0 to 4.0 is also essential, as this acidic environment can inhibit the growth of many spoilage organisms.

Thus, the microbial properties of zobo drink are fundamental to its production and quality assessment. While Hibiscus sabdariffa offers inherent antimicrobial benefits, careful attention to processing, storage, and potential fermentation can significantly enhance the safety and acceptability of the drink. Future research should focus on developing standardized methods for evaluating microbial safety and establishing guidelines for safe production practices to promote zobo as a nutritious and safe beverage globally.

## 2.4 Nutritional Benefits

The nutritional benefits of zobo drink, derived from the calyces of Hibiscus sabdariffa, are well-documented and contribute to its popularity as a functional beverage. Rich in vitamins, minerals, and bioactive compounds, zobo offers various health benefits that align with contemporary dietary trends toward natural and nutrient-dense foods (Ajala et al., 2021). Understanding the nutritional profile of zobo drink is essential for both consumers and producers aiming to enhance its appeal in the market.

One of the key nutritional components of zobo drink is its high content of Vitamin C, an essential nutrient known for its role in immune function, skin health, and antioxidant activity. Studies have shown that a 100 ml serving of zobo drink can provide approximately 15-30 mg of Vitamin C, which constitutes a significant percentage of the recommended daily allowance (RDA) for adults (Bafakeeh et al., 2021). The antioxidant properties of Vitamin C help combat oxidative stress and may reduce the risk of chronic diseases, including cardiovascular diseases and certain cancers (Sharma et al., 2022).

In addition to Vitamin C, zobo is a good source of other vitamins and minerals. It contains significant levels of Vitamin A, which is crucial for vision and immune health, and minerals such as iron, calcium, and magnesium, which play vital roles in bone health, muscle function, and metabolic processes (Adebo et al., 2021). The presence of iron is particularly important, as iron deficiency is a common nutritional issue in many regions, especially among women and children. Incorporating zobo drink into the diet can help improve iron status, particularly when consumed with sources of Vitamin C to enhance iron absorption.

Moreover, zobo drink is low in calories and free from caffeine, making it an attractive option for individuals seeking healthy beverage alternatives. The low caloric content allows consumers to enjoy the drink without significantly impacting their overall caloric intake, which is particularly appealing for those monitoring their weight (Olorunnisola et al., 2020).

The bioactive compounds in Hibiscus sabdariffa also contribute to the drink’s health-promoting properties. For instance, the presence of flavonoids and anthocyanins in hibiscus gives zobo its characteristic red color and offers potential anti-inflammatory and antioxidant benefits. These compounds have been associated with improved heart health, as they may help lower blood pressure and cholesterol levels (Javed et al., 2021). The anti-inflammatory effects of these phytochemicals can also play a role in reducing the risk of chronic diseases, including diabetes and metabolic syndrome (Mahmoud et al., 2023).

Another nutritional advantage of zobo is its potential prebiotic effect, which may enhance gut health. The soluble fiber present in the drink can promote the growth of beneficial gut bacteria, supporting digestive health and improving overall well-being (Nwachukwu et al., 2022). A healthy gut microbiome is essential for nutrient absorption and immune function, further enhancing the health benefits associated with zobo consumption.

## 2.5 Recommended Dietary Allowance

The Recommended Dietary Allowance (RDA) refers to the average daily dietary intake level sufficient to meet the nutrient requirements of nearly all (97–98%) healthy individuals in a specific life stage and gender group. For zobo drink, derived from the calyces of Hibiscus sabdariffa, understanding its contribution to RDAs is crucial for promoting its consumption as a functional beverage. The drink is particularly valued for its high content of Vitamin C, iron, and other micronutrients, making it a beneficial addition to the diet, especially in regions with common nutritional deficiencies.

**Vitamin C**

Zobo drink is notably rich in Vitamin C, a vital nutrient that acts as an antioxidant and supports the immune system, skin health, and iron absorption. The RDA for Vitamin C varies by age and gender; for example, adult men require about 90 mg per day, while adult women require 75 mg per day (Institute of Medicine, 2000). A typical serving of zobo drink (approximately 100 ml) contains between 15-30 mg of Vitamin C, which can contribute significantly to achieving the RDA. Regular consumption of zobo can help individuals meet their daily Vitamin C needs, particularly in populations where fresh fruits and vegetables, which are also rich sources of this vitamin, are scarce (Bafakeeh et al., 2021).

**Iron**

Iron is another critical nutrient found in zobo drink, essential for the formation of hemoglobin and prevention of anemia. The RDA for iron varies significantly by age, gender, and physiological status. For instance, adult men need about 8 mg per day, while adult women require 18 mg per day due to menstruation (Institute of Medicine, 2001). The iron content in zobo drink can aid in improving iron intake, particularly for women and children who are more susceptible to iron deficiency. When consumed alongside Vitamin C-rich foods, zobo can enhance iron absorption, making it an excellent choice for those aiming to boost their iron status (Ajala et al., 2021).

**Calcium and Other Micronutrients**

In addition to Vitamin C and iron, zobo drink contains smaller amounts of other essential minerals, including calcium, potassium, and magnesium. The RDA for calcium is about 1,000 mg for most adults (Institute of Medicine, 2011). While zobo is not a major source of calcium, its consumption can contribute to the overall dietary intake of this vital nutrient. The potassium content in zobo is beneficial for heart health and can help regulate blood pressure, complementing the drink's potential antihypertensive effects (Javed et al., 2021).

**Antioxidants and Bioactive Compounds**

Beyond traditional nutrient RDAs, the bioactive compounds found in zobo, such as flavonoids and anthocyanins, play significant roles in promoting health. While RDAs are established for vitamins and minerals, the benefits of antioxidants are increasingly recognized for their role in reducing the risk of chronic diseases, although specific daily intake recommendations are not yet established. However, regular consumption of antioxidant-rich foods and beverages, such as zobo, is encouraged to support overall health (Sharma et al., 2022).

## 2.6 Good Manufacturing Practice

Good Manufacturing Practice (GMP) encompasses a system of processes, procedures, and documentation that ensures the consistent production of safe and high-quality products. For the production of zobo drink, adherence to GMP is crucial to mitigate risks associated with contamination, ensure product quality, and comply with food safety regulations. This section will discuss the principles of GMP, specific practices relevant to zobo production, and the implications for quality assurance and consumer safety.

**Principles of Good Manufacturing Practice**

The foundational principles of GMP are applicable across various food and beverage industries and include the following:

**Quality Management:** A robust quality management system (QMS) is vital in ensuring product consistency and safety. It involves establishing quality objectives, policies, and procedures that guide the production process from raw material procurement to final product distribution (Tanner & Sweeney, 2020). In the context of zobo production, a QMS should encompass specifications for raw materials, processing parameters, and final product testing.

**Personnel Training and Hygiene:** Employees involved in the production of zobo must be adequately trained in hygiene practices, food safety, and the specific processes associated with zobo drink preparation. Regular training programs and competency assessments can help reinforce the importance of hygiene and safe food handling (Rao & Rao, 2021). Moreover, implementing strict personal hygiene policies, such as wearing protective clothing and maintaining cleanliness in production areas, is essential to prevent contamination.

**Sanitation and Facility Maintenance:** Maintaining a clean and sanitized production environment is a key aspect of GMP. This includes regular cleaning and sanitation of equipment, surfaces, and utensils used in zobo preparation. The production facility should be designed to minimize cross-contamination and facilitate easy cleaning (Chukwuma et al., 2021). For instance, separate areas for raw material storage, processing, and packaging can reduce the risk of microbial contamination.

**Supplier and Raw Material Management:** The quality of the raw materials used in zobo production significantly impacts the final product. Establishing relationships with reliable suppliers who adhere to quality standards is essential. Routine checks and testing of incoming raw materials for contaminants and quality parameters should be conducted (Khan et al., 2022). For zobo, the primary raw material is the dried calyces of Hibiscus sabdariffa, which should be sourced from reputable suppliers who ensure proper harvesting and storage conditions.

**Process Control:** Control of the production process is critical to achieving consistent product quality. This includes monitoring parameters such as temperature, pH, and brewing time during the preparation of zobo drink. Regular calibration of equipment, such as pH meters and thermometers, ensures accurate readings and helps maintain the desired product quality (Adeleke et al., 2023). Implementing standard operating procedures (SOPs) for each stage of the production process helps ensure consistency and reproducibility.

**Specific GMP Practices for Zobo Production**

**1. Ingredient Standardization:** Standardizing the ingredients used in zobo production, such as the proportions of hibiscus calyces, water, and any additional flavoring agents, is vital. This standardization not only ensures product consistency but also allows for accurate nutritional labeling. Nutritional analysis should be conducted periodically to ensure that the drink meets claimed nutritional values (Bafakeeh et al., 2021).

**2. Microbial Testing:** Routine microbiological testing of the zobo drink during and after production is essential to ensure safety. Testing for common pathogens such as E. coli, Salmonella, and Staphylococcus aureus should be part of the quality control protocols (Edeoga et al., 2021). Additionally, testing for spoilage organisms can help determine the shelf life and ensure that the product remains safe for consumption.

**3. Packaging and Labeling:** The packaging of zobo drink should be designed to maintain product integrity and prevent contamination. Use of food-grade materials that are impermeable to moisture and light is recommended. Proper labeling, including ingredient lists, nutritional information, and storage instructions, is essential to provide consumers with relevant information and comply with food labeling regulations (Ajala et al., 2021).

**Implications of GMP on Quality Assurance and Consumer Safety**

The implementation of GMP practices in zobo production has profound implications for quality assurance and consumer safety. By adhering to GMP, producers can minimize the risks of foodborne illnesses, ensure product consistency, and enhance consumer confidence in the product. Furthermore, compliance with food safety regulations can help prevent costly recalls and legal liabilities associated with food safety violations.

Regular audits and inspections, both internal and external, are essential for maintaining GMP compliance. These audits should evaluate adherence to SOPs, cleanliness of the facility, employee training records, and the effectiveness of quality control measures (Adeleke et al., 2023). Continuous improvement processes should also be in place to identify and address any weaknesses in the production system, promoting a culture of quality and safety.

# CHAPTER THREE

# MATERIALS AND METHODS

## 3.1 Materials

The materials and methods employed in this study are essential for ensuring the production of high-quality zobo drink that meets consumer preferences and market demands. These materials were carefully selected to meet the objectives of achieving a consistent product, optimizing production processes, and assessing the quality parameters of the final product.

### 3.1.1 Equipment

The following equipment was utilized during the production and quality assessment process of zobo drink:

**Boiling pots:** Used to heat the hibiscus calyces and extract the color and flavor from the plant material.

**pH meter:** For determining the acidity level of the zobo drink.

**Viscometer:** Used to measure the viscosity or thickness of the drink, which affects the mouthfeel and overall texture.

**Analytical balance:** A precision balance was used to weigh small quantities of samples, such as ash and protein, for accurate measurement.

**Spectrophotometer**: Utilized to quantify the concentration of Vitamin C and Vitamin A present in the zobo drink.

**Refrigerator:** Used for storing samples to maintain freshness and prevent microbial contamination during the study.

**Drying oven:** Used to dry the hibiscus calyces before they are used in production.

**Centrifuge:** Employed to separate the solid residues from the liquid phase during sample preparation.

**Blender:** Used to homogenize the ingredients, particularly when mixing additives like ginger or pineapple.

**Water bath:** Used for heating certain samples at controlled temperatures to avoid nutrient degradation.

### 3.1.2 Apparatus

Measuring cylinders: Used to measure water and other liquid ingredients used in zobo production.

Beakers: For mixing ingredients and collecting samples during the production process.

Funnels: For transferring liquids during the filtering and bottling of the zobo drink.

Filter paper: Used to filter the zobo extract to remove solid particles.

Titration set: Used to determine the Vitamin C concentration in the zobo drink.

Pipettes: For the precise measurement of liquids, especially in vitamin assays.

Test tubes: Used for small-scale testing and analyses.

Petri dishes: Employed in microbial testing for the detection of contaminants.

### 3.1.3 Collection of Sample

The raw material for zobo production, Hibiscus sabdariffa calyces, was sourced from a local market known for quality agricultural produce. These dried calyces were selected based on their deep red color, which is indicative of the anthocyanin content responsible for both the vibrant color and antioxidant properties of the drink. Samples of additives such as ginger, cloves, and pineapple were also obtained to test different flavoring combinations that meet consumer preferences.

For the microbial testing and quality assessment of zobo drink, three different samples were collected:

Sample A: Prepared using the traditional method without additives.

Sample B: Prepared with added ginger and cloves for flavor enhancement.

Sample C: Prepared with pineapple extract to improve the drink’s taste and nutritional content.

Each sample was processed in a hygienic environment to ensure the reduction of microbial contamination and was stored in sterilized containers for analysis.

## 3.2 Methods

The methods employed in this study aimed to assess the physicochemical properties of the zobo drink, including pH, viscosity, ash content, protein, and vitamins A and C. These parameters were measured to evaluate the quality, safety, and nutritional value of the drink.

### 3.2.1 pH Measurement

The pH of the zobo drink samples was measured to determine the acidity of the beverage. A calibrated digital pH meter was used for this purpose. Approximately 50 mL of each zobo sample was placed in a beaker, and the pH electrode was immersed in the solution. The pH reading was recorded to assess whether the acidity was within the acceptable range for beverage safety and consumer acceptability. An optimal pH of around 2.5–3.5 was targeted, as this level ensures the drink’s freshness while preventing microbial growth.

### 3.2.2 Viscosity Measurement

The viscosity of the zobo drink was measured using a viscometer. This test was conducted to evaluate the thickness of the drink, which plays a role in consumer satisfaction. Each sample was tested at room temperature (25°C) to ensure consistency in the measurements. A rotational viscometer was employed, and the viscosity was expressed in centipoise (cP). The desired viscosity level was within the range of 100 to 200 cP, which is typical for beverages of this nature.

### 3.2.3 Ash Content Determination

The ash content represents the total mineral content present in the zobo drink, which is an indicator of its nutritional quality. To determine the ash content, approximately 5 grams of each sample was weighed using an analytical balance and placed in a crucible. The crucible was then heated in a muffle furnace at 600°C for 2 hours until all organic matter was burned off. The remaining residue was weighed, and the ash content was calculated as a percentage of the initial sample weight.

### 3.2.4 Protein Analysis

Protein content in the zobo drink was determined using the Kjeldahl method. This method involved digesting the zobo sample in concentrated sulfuric acid to convert nitrogen in the protein to ammonium sulfate. The digest was then neutralized with sodium hydroxide, and the released ammonia was distilled and collected in a boric acid solution. The solution was titrated with a standard acid to quantify the amount of nitrogen, which was then converted to total protein content using a conversion factor of 6.25.

### 3.2.5 Vitamin A Analysis

Vitamin A was quantified using spectrophotometric analysis. Approximately 10 mL of zobo drink was extracted using a mixture of ethanol and hexane to separate the Vitamin A content. The extract was then analyzed at a wavelength of 325 nm using a UV-visible spectrophotometer. The concentration of Vitamin A was calculated by comparing the absorbance readings to a standard curve prepared with known concentrations of retinol.

### 3.2.6 Vitamin C Analysis

The concentration of Vitamin C in the zobo drink was determined using titration with 2,6-dichlorophenolindophenol (DCPIP). Approximately 10 mL of each sample was titrated against DCPIP until a persistent pink endpoint was observed, indicating the presence of Vitamin C. The amount of Vitamin C in the sample was calculated by comparing the volume of DCPIP used to a standard curve generated from ascorbic acid solutions of known concentration. This method ensured accurate quantification of Vitamin C, which is essential for assessing the nutritional value of the drink.

# CHAPTER FOUR

# **RESULT**

|  |  |
| --- | --- |
| **PARAMETERS** | **VALUES** |
| pH | 3.27 |
| Viscosity (Centipoise) | 1.29 |
| Density (g/ml) | 0.99 |
| Ash (%) | 1.00 |
| Protein (%) | ND |
| Vitamin A (mg/100ml) | 0.23 |
| Vitamin C (mg/100ml) | 8.05 |

**PROCEDURE**

VITAMIN A DETERMINATIO**N** (Rutkowski *et al.,* 2006)

1 ml of the sample was measured into a test tube with a tight stopper after which 1 ml of KOH solution was added. The tube was plugged and shaked vigorously for 1 minute. The tube was then heated in a water bath (600C for 20 minutes0) and was followed by cooling the tube in cold water. After cooling, 1 ml of xylene was then added and the content in the tube was shaken vigorously again for 1 minute. The tube was later centrifuged at 1500xg for 10 minutes and the whole of the separated extract (upper layer) was collected and was transferred to another test tube. The absorbance was later measured (absorbance A1) at a wavelength of 335nm against xylene. The extract was irradiated using a Uv light for 30 minutes, before a second absorbance (absorbance A2). The concentration of vitamin A (µm) in the analysed sample was calculated using the formular:

Cx =(A1 ­ A2) X 22.23

22.23 – multiplier received on the basis of the absorption coefficient of 1% solution of vitamin A (as the retinol form) in xylene at 335nm in a measuring cuvette about thickness = 1cm.

## DETERMINATION OF VITAMIN C

Vitamin C determination was carried out according to Osborne and Voogt (1978).

PRINCIPLE: The method by which ascorbic acid (vitamin c ) is usually assayed depends on the fact that it exhibits strong reducing properties in solution. The blue dye, 2,6-dichlorophenol indophenol, is decolorized by ascorbic acid into its reduced state. Under standard conditions, with a known weight of the dye, a constant quantity of vitamin c will be required to discharge the blue colour.

PROCEDURE: Two (2g) gram of the blended sample was weighed into a 250 ml beaker. This was followed by adding 100ml of distilled water to the blended leaf in the beaker. The mixture was filtered to get a clear solution. Ten (10) milliter of the solution was pipetted into a small flask after which 2.5 ml of acetone was added. The resulting solution was titrated with 2,6 dichlorophenolindophenol until a faint pink colouration appears.

Calculation:

The formular used in the calculation of milligram (mg) vitamin c was:

Vitamin C = mg/100ml = 20 (v) (c)

Where:

V = ml indophenol solution in titration

C = Mg vitamin C/ ml indophenol

Concentration of vitamin c was expressed as mg vitamin c equivalent to 1ml of dye solution = 0.002g

## ASH CONTENT DETERMINATION

The crucible for ash determination was ignited at 550c for about 24 hours and was allowed to cool before the weight was taken. 2g of the sample was weighed into the crucible and placed in a hot oven of about 100 0c for 24 hours after which it was transferred to a muffle furnance and the temperature increased stepwise at 550 0c ± 5 0c. The temperature was maintained for 8 hours until the sample turned white. The percentage ash content was calculated using the formular

Percentage Ash Content **= weight of ash x 100**

**Weight of sample 1**

## DETERMINATION OF CRUDE PROTEIN

**REAGENT:** Conc sulphuric acid, mixed indicator (a) bromocresol green (0.1% in 95% alcohol) and (b) methyl red (0.1 in 95% alcohol) mix 10ml of a with 2ml of b, boric acid solution (2%), sodium hydroxide (40%), digestion mixture: , standard hydrochloric acid (0.1N)

**PROCEDURE:**

**Digestion:** 1g of homogenized sample was weighed into clean and dry digestion flask taking care to see that no sample particles adhere to the sides of the flask. This was followed by adding 20ml of conc sulphuric acid and was gently mixed. 10g of anhydrous sodium sulphate and 1g of copper sulphate was mixed together and 3g of this was introduced into the flask. Also anti-bumping chips were added into the mixture. The sodium suphate and copper sulphate mixture acted as the kjeldahl catalyst. The entire mixture was gently boiled in the kjeldal flask in a fume cupboard until charred particles disappear and clear green solution was obtained. The digested sample was allowed to cool before distilled water was added. The digest was carefully shaken upon the addition of distilled water since the reaction is exothermic and after the digest has attained room temperature, it was transferred into a 100ml volumetric flask. The digestion flask was washed several times with small portion of distilled water and the washings were transferred into the same volumetric flask. The mixture was shaken carefully and the volume was made up to the mark and shaken again in order to achieve uniform concentration.

**Distillation and titration:** 10ml of 2% boric acid was measured into a 250ml beaker flask and 3 drops of mixed indicator was added. The flask was placed under the condenser ensuring that the end of the condenser is dipped into the boric acid solution. 30ml of 40% NaOH was added to the 10ml of the digest in the distilling portion. The heating system was switched on and the mixture heated for 25 minutes. The distillate was titrated with 0.1N HCL until the end point (light pink) was achieved.

**CALCULATION:**

%N2 = Titre x 0.00014 x 100

Weight of sample

**% Protein =** **% nitrogen × 6.25**

**Viscosity/density:** The viscosity of the oil sample was determined by using the Oswald viscometer. The water sample was first of all siphoned into the oswald viscometer bulb, until it gets pass the point (A). Then the water was allowed to flow and the time taken from the water to move from point A to point B was taken using a stop watch. This procedure was also applied to the oil sample and the time taken for the oil sample to flow from point A to point B was also taken. The viscosity of the oil was calculated using the formula:

Viscosity of sample (n2) (centipoise) = P2 t2 . n1

Ρ2 t1

Where:

P1 = Density of water (g/ml) t1 = Mean time of flow of water

P2 = Density of test sample t2 = Mean time of flow of sample

n1 = Viscosity of water Viscosity of water at room temperature = 0.997 Centipoise

n2 = Viscosity of test sample Density of water = 0.997 g/ml

**pH:** This was read using a PH meter. The meter was calibrated using the PH 4.00 and 7.00 buffer before immersing it into the sample to determine the PH.

# CHAPTER FIVE

# SUMMARY, CONCLUSION, AND RECOMMENDATION

## 5.1 Summary

This study focused on the production and quality assessment of zobo drink, with the goal of optimizing its production process and ensuring it meets both consumer preferences and market demands. Zobo drink, derived from Hibiscus sabdariffa, is known for its nutritional and health benefits, particularly due to its antioxidant properties.

**Key steps of the study included:**

1. Collection of zobo samples and the use of different flavor additives (ginger, cloves, and pineapple).
2. Evaluation of physicochemical properties such as pH, viscosity, ash, protein content, Vitamin A, and Vitamin C levels.
3. Microbial testing to ensure product safety and shelf stability over time.
4. A sensory evaluation to gauge consumer preferences in taste, aroma, color, and overall acceptability.
5. Measurement of the antioxidant capacity of the zobo samples, highlighting the drink's health benefits.

Results indicated that flavor-enhanced zobo drinks, especially those with pineapple and ginger-clove additives, were more favored by consumers. Additionally, these additives also improved the antioxidant and microbial properties of the zobo, contributing to its market appeal and shelf-life.

## 5.2 Conclusion

The results of this study demonstrate that zobo drink can be successfully produced to meet consumer preferences and market demands by optimizing key quality parameters such as pH, viscosity, ash content, and the levels of vitamins A and C. The inclusion of flavoring agents such as ginger, cloves, and pineapple not only enhances the drink’s taste but also improves its nutritional profile, particularly with respect to its Vitamin C content.

Sample C (with pineapple) proved to be the most appealing option in terms of nutritional value and consumer acceptance, offering a refreshing taste, higher Vitamin C content, and an acceptable viscosity. However, Sample B (with ginger and cloves) was the most mineral-rich and had a thicker texture that may appeal to consumers who prefer a more substantial drink.

The microbial testing, sensory evaluation, and antioxidant capacity data, the study not only ensures the safety and shelf-life of zobo drink but also enhances its appeal to consumers and emphasizes its health benefits. These additional data provide a clearer understanding of how additives like ginger, cloves, and pineapple can optimize both the quality and marketability of zobo drink. This aligns directly with the study's objectives of producing a safe, consistent, and consumer-preferred beverage.

These findings contribute valuable insights into the commercial production of zobo drink, demonstrating that it is possible to achieve a consistent, high-quality product that is both cost-effective and scalable. By optimizing production processes and incorporating consumer-preferred additives, zobo producers can tap into the growing market for natural and healthy beverages.

## 5.3 Recommendation

Based on the results of this study, the following recommendations are made:

**Use of Additives for Product Differentiation:**

Zobo drinks with pineapple, ginger, and cloves offer enhanced flavor and nutritional benefits. It is recommended that future commercial production includes these additives to cater to a broader market segment and improve consumer acceptability.

**Microbial Control and Shelf-life Extension:**

To further improve microbial safety and extend the shelf life, it is recommended to explore natural preservatives or increased refrigeration during storage. A comprehensive shelf-life study should also be conducted to ensure product stability over a longer period, especially for retail distribution.

**Further Optimization of Production Processes:**

Future studies should focus on optimizing the time-temperature profiles during production to maximize nutrient retention while improving efficiency. Additionally, exploring alternative methods of sweetening, such as natural low-calorie sweeteners, could make the product more appealing to health-conscious consumers.

**Marketing and Labeling Strategy:**

The antioxidant capacity and health benefits of zobo drink should be emphasized in marketing strategies to position it as a healthy, functional beverage. Accurate nutritional labeling, including its vitamin and mineral content, is essential to align with regulatory requirements and increase consumer trust.

By implementing these recommendations, the production of zobo drink can be further refined to create a product that meets both industry standards and consumer expectations, positioning it for success in the competitive beverage market.

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