DEPARTMENT OF NUTRITION AND DIETETICS

PRODUCTION AND DETERMINATION OF VITAMIN A AND C CONTENT OF HIBISCUS SABDARIFFA (ZOBO) BEVERAGE ENRICHED WITH PINEAPPLE, WATERMELON AND CUCUMBER, SWEETENED WITH DATE SYRUP AS A NATURAL ALTERNATIVE TO ARTIFICIAL SWEETENERS

By

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CERTIFICATION

This is to certify that this project work presented by BELLO SHARIFAT (ND/23/NAD/0061) has been read, approved and submitted to the Department of Nutrition and Dietetics, Institute of Applied Sciences, Kwara State Polytechnic, Ilorin.

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DEDICATION

We dedicated this project to Almighty God, the One who makes impossibility possible, for the opportunity given to us during this project work.

Also to our noble and loving parents for their cares, supports and prayers for us, may Almighty God bless them (AMEN).

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ABSTRACT

Zobo beverage was produced and enriched with cucumber, pineapple and watermelon juice and sweetened with date syrup. The products were characterized in terms of vitamin A, C and sensory characteristics. The vitamin A content of sample A,B,C,D and E are 4.84 ± 0.08^{a}, 5.72 ± 0.69^{a}, 1.98 ± 0.76^{b}, 3.73 ± 0.69^{c} *and* 2.70 ± 1.97^{b} *respectively. The fruit juices have noticeable effect on the vitamin A content of sample B which could be associated with the composition of pineapple and cucumber as they are good sources of vitamins (Angew, 2014). The vitamin C content of sample A,B,C,D and E are* 45.52 ± 1.23^{a}, 59.82 ± 0.82^{b}, 56.62 ± 0.82^{b}, 86.21 ± 0.82^{c} *and* 54.06 ± 13.49^{b} *respectively. The fruit juices improved the vitamin C content of sample B, C, D and E. The sensory evaluation was carried out using 7-point hedonic scale and the result indicated that sample B was the most preferred in terms of flavor, appearance, and overall acceptability, while all formulations were generally acceptable to the panelists. These findings suggest that enriching Zobo with vitamin-rich fruits and sweetening with date syrup can enhance its nutritional value and consumer appeal. The study contributes to the development of functional beverages using locally available, natural ingredients, thereby promoting healthier alternatives to sugar-sweetened drinks.*

CHAPTER ONE

1.0 Introduction

1.1 Background of the Study

Hibiscus sabdariffa, also known as roselle, is a nutritive and medicinal herb from the *Malvaceae* family. It is an annual summer shrub with a deep penetrating taproot that grows upright and generally branches. Its leaves range in colour from green to red, and its enormous, short peduncled blooms have a dark centre (Abou-Sreea et al., 2022). Zobo, a dark-red hibiscus-based beverage, is a popular traditional drink in Nigeria and other West African countries (Olawale-olakunle et al., 2023). In Nigeria, the dried roselle calyces are prepared into a refreshing drink called 'zobo'. The drink is becoming popular because it is easily processed at home and served chilled, packaged in plastic bottles or polythene films. It serves as income generation source for many women.

It is traditionally prepared by steeping dried calyces of *Hibiscus sabdariffa* in water, often sweetened with sugar and spiced with ginger, cloves, or other flavorings (Akujobi et al., 2018). Natural flavorings such as orange, pineapple, and watermelon are sometimes added in addition to the other spices mentioned (Kehinde and Augustine, 2022). Zobo is well-known for its energizing flavor, vibrant color, and potential health benefits, which include antioxidant and anti-inflammatory properties. In light of these characteristics, it is suitable for the production

of soft drinks (Salami and Afolayan, 2020). Several studies have shown that extracts of Hibiscus sabdariffa have a lipid lowering activity which could reduce the risk of hyperlipidemia and cardiovascular diseases such as atherosclerosis and coronary heart diseases (Ekenam, 2018).

From time immemorial, fruits constituted a major component of the human diet. Besides being a part of the regular diet, people also consumed fruits as a part of their religious practices as well as nutritional therapy in different human traditions around the world. They are also known for their unique flavour characteristics that makes them appealing to taste. Roselle drink had been improved nutritionally by producing fruit-flavoured roselle drinks, which are richer in vitamins and minerals by addition of different fruits with higher consumer acceptability (Fasoyiro, S.B., 2004).

Date fruit extract is marked by its high sugar content (64% fresh weight basis) and are considered a natural sweetener alternative to sucrose in the production of liquid extract and many food formulations (Noui et al., 2019). Many derivatives from dates could be employed as ingredients in food sectors such as the baked products, beverage, confectionery, dairy and sugar industries (Tang et al., 2013; Ghazal et al., 2016).

1.2 Statement of the Problem

The increasing awareness in health and wellbeing has led to corresponding increase in the demand for healthy drinks worldwide. The consumption of Zobo drink in Nigeria is popular because of its claimed health benefits (Ezekiel, 2016; Chukwu and Akaninwor, 2017). The extracts of roselle have been reported to contain phytochemicals, vitamins, and several minerals (Keshinro et al., 2023). However, there has been a growing interest in fortifying Zobo with fruit juices to enhance its nutritional composition and potential health benefits (Idowu-Adebayo et al., 2021, Idowu-Adebayo et al., 2021). Furthermore, the increasing reliance on artificial sweeteners in beverage

formulations raises health concerns, including potential metabolic disruptions and long-term safety issues (Sylvetsky & Rother, 2018). In contrast, natural sweeteners like date syrup offer not only sweetness but also additional nutritional benefits, including minerals and antioxidants (Al-Farsi & Lee, 2008). Despite the nutritional potential of fruit-enriched beverages and growing consumer preference for natural products, there is limited scientific data on the vitamin composition of zobo beverages fortified with vitamin-rich fruits such as pineapple, watermelon, and cucumber, and sweetened with natural alternatives like date syrup.

Therefore, this study seeks to address this gap by producing a nutrient-enhanced zobo beverage and evaluating its acceptability, vitamin A and C content, thereby contributing to the development of healthier, functional beverages using locally available resources.

1.3 Aim and Objectives of the Study

1.3.1 Aim of the Study

The aim of this work is to produce and determine the vitamin A and C content of *Hibiscus sabdariffa* (zobo) beverage enriched with pineapple, watermelon and cucumber, sweetened with date syrup as a natural alternative to artificial sweeteners.

1.3.2 Specific Objectives of the Study

1. To produce zobo beverages enriched with pineapple, cucumber and watermelon sweetened with date syrup
2. To determine the vitamin A and C content of the beverage.
3. To determine the acceptability 0f the beverage.

1.4 Justification of the Study

The need to improve the nutritional value of *Hibiscus sabdariffa* (zobo) by supplementing it with vitamin-rich fruits like pineapple, watermelon, and cucumber serves as justification for this study.

As a natural sweetener, date syrup encourages better substitutes for artificial additives. Using ingredients that are readily available locally, the project seeks to assist the development of nutrition-sensitive beverages.

CHAPTER TWO

2.0 Literature Review

2.1 Brief History of *Hibiscus sabdariffa*

Roselle (*Hibiscus sabdariffa Linn*) is a shrub belonging to the family *Malvaceae.* The plant is widely grown in tropics like Caribbean, Central America, India, Africa, Brazil, Australia, Hawaii, Florida and Philippines, Saudi Arabia, Malaysia, Indonesia, Thailand, Philippines, Vietnam, Sudan, Egypt and Mexico (Zaman et al., 2017). In Nigeria, *Hibiscus sabdariffa* is widely grown in the North Eastern and middle belt regions for its calyx and it is commonly known as Zoborodo in the North (Hausa), Isapa in the West (Yoruba) and Sorrel in English (Adebayo-tayo and Samuel, 2008).

Hibiscus sabdariffa's dried reddish-brown petals (calyces) are used to make the aqueous extract known as zobo. The plant is indigenous to Malaysia and India, where it is grown extensively in many tropical nations in both hemispheres (Ogundapo et al., 2014). It is a dicotyledonous plant that is widely grown in Nigeria's middle belt states, such as Plateau, Nasarawa, and Benue, as well as its south western states, such as Ondo and Osun (Aganbi et al., 2017).

Roselle juice can be used to prepare yogurts which have shown fabulous health benefits to improve gastrointestinal functions (Heyman 2000) which includes lactose digestion, lactose intolerance symptoms among the mal-digesters. It also lowered cholesterol level and reduce risk from hypertension (Taylor and Williams 1998) and helps to maintain the micro floral populations in the gastrointestinal (Boudraa et al. 1990; Iwalokun and Shittu 2007).

Reports from earlier studies said that *Hibiscus sabdariffa* has a high concentration of ascorbic acid (Aganbi et al. 2017). According to Builders et al. (2010) and Teye et al. (2019), The calyces of *Hibiscus sabdariffa* is a considerable source of nutrients such as carbohydrate, fiber, vitamin C, calcium and iron (Ismail et al., 2008). Zobo also contains antioxidants such as beta- carotene, vitamin C (Gbadegesin and Gbadamosi, 2017) and phytochemicals such as flavonoids (Adelekan et al., 2013). The sour taste of Zobo is associated with the organic acids such as ascorbic, malic and tartaric acid present in Zobo (Adelekan et al., 2013). The leaves of Hibiscus sabdariffa could be used as vegetables while the seed is a good source of oil (Chukwu and Akaninwor,2017). The leaves of Zobo plants could also be used to produce syrup, gelatin, jam and jelly (Izah et al., 2015).

2.1.1 Nutritional Composition of *Hibiscus Sabdariffa*

According to Luvonga et al. (2010) in their study, observed that roselle plant contain 68.7% carbohydrate, 14.6% crude fibre, 12.2% ash and other nutrients. The plant is shown to be abundant in minerals, particularly magnesium and potassium. A notable amount of vitamins, including ascorbic acid, niacin, and pyridoxine, were also detected. Nmahadevan and Pradeep (2009) reported the physicochemical constituents of the fresh calyces and leaves of *H. sabdariffa*.

Table 1. Physicochemical constituents of the fresh calyces and leaves of *H. sabdariffa*.

Constituents	Calyces fresh (per 1000ml)	Leaves fresh (%)
Moisture	9.2 g	86.2%
Protein	1.14 g	1.7-3.2%
Fat	2.161 g	1.1%
Fibre	12.0 g	10%
Ash	6.90 g	1%
Calcium	12.63 g	0.18%
Phosphorus	273.2 mg	0.04%
Iron	8.98 mg	0.0054%
Carotene	0.029 mg	
Thiamine	0.117 mg	
Riboflavin	0.277 mg	
Niacin	3.765 mg	
Ascorbic acid	6.7 mg	

The fresh leaves have higher moisture, protein, fat, fibre, ash, calcium, Phosphorus, and iron content compared to the fresh calyces. Carotene, thiamine, riboflavin, niacin and ascorbic acid were detected in the fresh calyces. Units in gram and milligram are value per 1000 ml while % is value per 100ml (Source: (Nmahadevan and Pradeep, 2009).

2.1.2 Nutritional Importance of *Hibiscus sabdariffa*

The drink has been reported to have antioxidant (Hirunpanich V.et al.,2005), antihypertensive (Herrera-Arellano A.et al.,2007), antihyperlipidemic (Chen C.-C.et al., 2003), anticancer (Lin H.-H.et al.,2007), antibacterial (Abdallah E. E. 2010), hepatoprotective and antistress (Ali B. H.et al., 2009), antidiuretic (Mojiminiyi F. B. O.et al., 2000), antispasmodic, and antidiarrheal (Salah A. M.et al.,2002) activities. Another study found that the drink affects metabolism, thereby preventing obesity and fat build-up in the liver. Roselle has generally been considered safe as a foodstuff; dosage of 1.5 g is recommended for daily consumption (Wolters Kluwer Health, 2006). The safety profile of roselle is excellent, with no proven adverse reactions. Noteworthy, Hudson (2013)

affirmed that, for reducing cholesterol level, studies recommend 1,000 mg dried herb 3 times daily; 1 cup of the drink two times daily, or 100 mg of standardized extract twice daily and also for hypertension 1 cup of the drink twice daily or dried powdered roselle extract providing 250 mg anthocyanin per day was recommended.

2.1.3 Health Benefit of *Hibiscus sabdariffa*

According to Pegu et al. (2021), infusions of the leaves or calyces of H. sabdariffa are traditionally used for their diuretic, choleretic, febrifugal, and antihypertensive properties, as well as to lessen blood viscosity and induce intestinal peristalsis. Calyces formulations are used in Egypt to treat heart and nervous system disorders, promote urination, and act as a cooling agent. Calyces of H. sabdariffa are used in Sudan to treat high blood pressure, cold symptoms, and flu (Issa et al., 2018). People in Zimbabwe utilise the plant's calyces, which are edible, to treat cancer.

According to a survey on ethnomedicinal plants used by traditional healers in Zimbabwe, H. sabdariffa has been utilised to treat all cancer kinds (Matowa et al., 2020). H. sabdariffa is used to treat type 2 diabetes mellitus in Mauritius, an island nation in East Africa, where the prevalence of diabetes is high.

According to Suresh and Ammaan (2017), the calcium in Roselle protects teeth by ensuring tight-fitting teeth where germs cannot flourish and by maintaining a robust and powerful jaw bone throughout your life. Roselle contains vitamin C, which strengthens the body's immune system and shields us against colds and coughs. Roselle's magnesium content offers prompt relief from constipation.

2.2. Date Palm

2.2.1 Brief History of Date Palm

Dates palm widely referred to as *Phoenix dactylifera L*. is one of the earliest (5500–3000 BC) farmed variety of palm trees that possess economic, nutritional, ornamental and environmental values (Barreveld WH 1993). It is associated with the family of *Areacaceae* (*Palmae*) and is produced as sweet berries with high sugar content that is above 50% (Niazi S. *et al.,* 2017). Date fruit is regarded to as a pivotal crop that is extensively farmed in the Middle East and Africa (Terral JF. *et al.,* 2012)) and these regions are responsible for the exportation of date products worldwide (Assirey EA 2015)

Date palm fruit (*Phoenix dactylifera Linnaeus)* which is generally referred to as Dabino in Hausa (an indigenous ethnic group in Nigeria), Date palm fruit in English and Tamr in Arabic is a long-life plant that produces edible fruits. Fruits of the date palm are very commonly consumed in many parts of the world and considered as a vital component of the diet and a staple food in most Arab countries (Shehu *et al.,*2022). The world production of date fruit is more than 7 milli0n tons/year (Shehu *et al.,*2022)..*Phoenix dactylifera L.* fruit can be renowned from most other fruits as it achieves its botanical maturity at various distinct maturation levels (Shehu *et al.,*2022)., which are known throughout the world by their Arabic names Kimri (green, unripe), Khalal (full-size, crunchy), Rutab (ripe, soft), and Tamar (ripe, sun-dried) (Shehu *et al.,*2022).

They contribute to health by providing carbohydrates (including soluble sugars), proteins, lipids as well as minerals and certain essential vitamins to the body (Khalid.*et al.,* 2017). They are known to be rich in polyphenols and functional dietary fiber that help to maintain the digestive tracts (Habib.*et al.,* 2014). Antimutagenic, antioxidant, anticarcinogenic and anti-inflammatory bioactivities have been attributed to the contribution of polyphenols (Maqsood.*et al.,* 2020). Date fruits are important commercial crop in the Middle East with a high percentage of carbohydrate, fat; comprising 14 types of fatty acids, 15 salts and minerals, protein with 23 different amino acids, six vitamins and a high percentage of dietary fibre (Walid 2003).

2.2.2 Composition and Nutritive Pr0perties of Date Palm Fruit

Date, a very sweet fruit, c0mprises ab0ut 50–88% 0f the t0tal weight acc0rding t0 cultivar, stage 0f ripening, and water c0ntent (Ashraf and Hamidi-Esfahani, 2011). Sugars make up ab0ut tw0 thirds 0f date flesh with water ab0ut 0ne fifth. The rest 0f date weight includes pr0tein, fat, crude

fiber, minerals, different vitamins (especially vitamin B), tannins, and many 0ther c0mp0nents (Hashemp00r, 1999).

Date has much nutritive value and can play an active r0le in pr0viding the nutriti0nal requirements 0f humans (Ashraf and Hamidi-Esfahani, 2011). Each kil0gram 0f fresh date c0ntains appr0ximately 1570 cal0ries 0f energy, whereas dry date c0ntains m0re than 3000 cal0ries per kg (R0hani, 1988).

2.2.3 Nutraceutical Properties of Date Palm Fruit

2.2.3.1 Anti-microbial Properties

Antimicrobial property of a solid or liquid substance entails its potential to go inside cytoplasmic membrane, disrupt permeability and then destroy the cytoplasmic membrane, resulting to vulnerability of cytoplasm or cytoplasm coagulation and decrease in shape followed by cell lysis and then termination of microorganisms (Martínez, et al., 2020). Therefore, the application of natural antimicrobial agents is preferred in tackling resistant bacteria and viruses because they are less expensive and have no side effects (Al-Daihan and Bhat .2012). Various experiments have been carried out to validate the antibacterial activities of different date varieties. For example, Aamir et al. (2012) reported the effectiveness of acetone and methanolic Ajwa dates extracts to resist Gram-negative and Gram-positive bacteria. Jassim and Naji (2010) investigated and discovered that extracts from date palm possessed antiviral activity.

2.2.3.2 Anti-oxidant Properties

Antioxidants play a pivotal role in food systems, human body cells and tissues by protecting against oxidative damage of toxic molecules called free radicals (Samad et al., 2016). Those free radicals are closely related with some known diseases such as cancer, heart disease, Parkinson's and Alzheimer's disease (Kim et al., 2015). In a food system, reactive oxygen species and free radicals are responsible for lipid oxidation in food products during processing and storage which form the toxic reaction products and undesirable off-flavour (Sarmadi and Ismail 2010). To tackle

this problem, chemical formulated antioxidants e.g propyl gallate (PG), butylated hydroxyl toluene (BHT), butylated hydroxyl anisole (BHA), and tertiary butyl hydro quinone (TBHQ) are applied as antioxidants against lipid peroxidation (Kim and Wijesekara 2010). However, chemical formulated antioxidant have been reported to induce cancer. (Tekiner-Gulbas et al.,2013). Thus, natural antioxidants from food source are mostly preferred. Dates are good source of antioxidant like tannins, carotenoids, sterols and polyphenols (Martín-Sánchez et al., 2014). (Boudries et al.,2007) observed the availability of carotenoids, majorly β-carotene and lutein in the fruit's oil fraction. These carotenoids are common precursors of vitamin A and active antioxidants. Antioxidant potentials varies with different dates cultivars, date type and origin.

2.2.3.3 Anti-cancer Properties

Dates have been reported in experimental trials to be effective in lowering the growth of cancerous cells (Al-Alawi et al., 2017) For example, methanolic extracts from Ajwa dates resisted the proliferation of marginal cell in colon, breast, prostrate, lung and gastric tumor lines (Al-Alawi et al.,2017). Also, eating of dates could enhanced the colon in human body as a result of the increment in the growth of beneficial gut bacteria with resultant reduction in tumor cell procreation (Eid et al., 2014).

2.2.3.4 Anti-diabetic Properties

Current medications used for management of diabetics are effective but possess some negative side effects such as disruption of genetic and metabolic pathway (Maqsood et al., 2020). Thus, extracts from natural plant that can elevate insulin generation and retard intestinal glucose intake are used presently in diabetes management (Malviya et al.,2010). Meanwhile, dates are rich sources of active compounds such as flavonoids, phenols, steroids and saponins that can function as antidiabetic ingredient (Khalid et al., .2017). Ajwa date extracts, when consumed could assist to lower oxidative stress and stabilize the proper functioning of the kidney and liver (Hasan and Mohieldein 2016) This could be partly because phenolic compounds in dates retard ά- glucosidase,

therefore controlling glucose intake in the kidneys and small intestines (Khalid, et al .,2017). Thus, the antidiabetic property of dates can be utilized for medical applications.

2.2.3.5 Orthodox Medicine and Traditional Therapeutic Applications

Traditionally, dates are used as a prophylactic and therapeutic ingredients since ancient times in different nations like Morocco, Iraq, India, Algeria, Iran and Egypt (Qadir et al., 2020). In south-eastern Morocco, dates were used for the treatment of diabetes and hypertension according to historical facts (Tahraoui et al., 2007). In traditional medicine, consumption of dates was recommended for people with jaundice ailment as well as pregnant women (Al-Shoaibi et al., 2012). Its extensive application for traditional cure of liver and malaria infection in the Arab Peninsula have been denoted. (Al-Shoaibi et al.,2012).

2.2.3.6 Other Nutraceutical Values of Dates.

Dates are known to function as anti-hypertensive ingredient for centuries (Maqsood et al., 2020).. They can lower hypercholesterolemia, oxidation of lipoproteins and hypertension, thus reducing series of reaction that could triggers cardio-vascular diseases initiation and progression (Vayalil PK 2002). (Al-Alawi et al.,2017) reported the efficacy of date syrup to tackle angiogenesis and inflammation.

2.3 Pineapple

Pineapple (Ananas comosus) is a tropical fruit from the *Bromeliaceae* family. It is referred to as the queen of fruits due to its excellent flavour and taste (Baruwa, 2013).

Pineapple is the third most important tropical fruit in the world after Banana and Citrus (Bartholomew, D.P.et al.,2003). Pineapples are consumed or served fresh, cooked, juiced and can be preserved. This fruit is highly perishable and seasonal. Mature fruit contains 14% of sugar; a protein digesting enzyme, bromalin, and good amount of citric acid, malic acid, vitamin A and B (Joy, P.P. et al., 2010). Pineapple juice's composition varies depending on geography, season, process and time of harvest. Its balance of sugar and acid contributes to the fruit's refreshing

flavour. Thailand, Philippines, Brazil and China are the main pineapple producers in the world supplying nearly 50 % of the total output (FAO. 2004).

2.3.1 Nutritional Composition of Pineapple

Pineapple contains considerable amount of calcium, potassium, vitamin C, carbohydrates, crude fibre, water and different minerals that is good for the digestive system and helps in maintaining ideal weight and balanced nutrition. Pineapple is a common fruit in Bangladesh and it has minimal fat and sodium (Sabahelkhier, K. M.et al., 2010). It contains 10-25 mg of vitamin (Rasid.et al 1987). Pineapple composition has been investigated mainly in the edible portion. Pineapple contains 81.2 to 86.2% moisture, and 13-19% total solids, of which sucrose, glucose and fructose are the main components. Carbohydrates represent up to 85% of total solids whereas fibre makes up for 2-3%. Of the organic acids, citric acid is the most abundant in it. The pulp has very low ash content, nitrogenous compounds and lipids (0.1%). From 25-30% of nitrogenous compounds are true proteins. Out of this proportion, Ca. 80% has proteolytic activity due to a protease known as Bromalin. Fresh pineapple contains minerals as Calcium, Chlorine, Potassium, Phosphorus and Sodium (Dull, G. G. 1971).

2.3.2 Nutritional/Health Benefits of Pineapple

Pineapple can be used as supplementary nutritional fruit for good personal health. Pineapple fruits are an excellent source of vitamins and minerals. One healthy ripe pineapple fruit can supply about 16.2% of daily requirement for vitamin C (Hemalatha, R. and Anbuselvi, S. 2013). Vitamin C is the body's primary water soluble antioxidant, against free radicals that attack and damage normal cells. A powerful antioxidant, vitamin C supports the formation of collagen in bones, blood vessels, cartilage and muscle, as well as the absorption of iron. Vitamin C also retards the development of

urinary tract infections during pregnancy and reduces the risk of certain cancers, including colon, esophagus and stomach (Debnath, P.et al.,2012). Malic acid makes up 13 percent of pineapple juice's acidic content. Malic acid is also beneficial for health. It boosts immunity; promotes smooth, firm skin; helps maintain oral health; and reduces the risk of toxic metal poisoning. Pineapple is also a good source of vitamin B1, vitamin B6, copper and dietary fibre. Pineapple is a digestive aid and a natural anti-inflammatory fruit. Drinking pineapple juice can help hydrate the body and restore the immune system. It helps to build healthy bones. Pineapples are rich in manganese, a trace mineral that is needed for body to build bone and connective tissues. One cup of pineapple provides 73% of the daily recommended amount of manganese. Bromelain has demonstrated significant anti-inflammatory effects, reducing swelling in inflammatory conditions such as acute sinusitis, sore throat, arthritis and gout and speeding recovery from injuries and surgery.

2.4 Watermelon

Watermelon (Citrullus lanatus) a fruit crop, is herbaceous creeping plant belong to the family *Cucurbitaceae.* It is mainly propagated by seeds and thrives best in warm areas. Citrullus lanatus (water melon) produces a fruit that is about 93% water, hence the name “water” melon. The “melon” part came from the fact that the fruit is large and round and has a sweet, pulpy flesh. The scientific name of the watermelon is derived from both Greek and Latin roots. The Citrullus part comes from a Greek word “citrus” which is a reference to the fruit. The lanatus part is Latin, and has the meaning of being wooly, referring to the small hairs on the stems and leaves of the plant

(Baker TP.et al.,2002). Watermelon can be used as fresh salad, dessert, snack, and for decorations. Drinks can also be made from the juice. The sugar content and sweetness are the critical factors in determining the quality of many watermelon varieties. It is known to be low in calories but highly nutritious and thirst quenching (Okonmah LU.et al., 20011).

2.4.1 Nutritional Composition of Watermelon

Table 2: Nutritional Composition of Watermelon

	Watermelon	**Watermelon seed**	**Watermelon rind**	**Watermelon rind flour**	**Unshelled seed flour**	**Watermelon seed flour**	**Watermelon juice**
	Quantity (Per 152 g)	**Quantity (Per 100 g)**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Quantity (Per 100 g)**
Calories	45.60 kcal	557 kcal	NR	NR	NR	NR	30 kcal
Energy	NR	2,330 kJ	NR	NR	NR	NR	127 kJ
Moisture	NR	5.05 g	10.61%	5.12%	9.59%	9.77%	90.1-92.42 g
Lipids	0.23 g	47.37 g	2.44%	1.05%	45.66%	0.64%	0.05-0.27 g
Protein	0.93 g	28.33 g	11.17%	7.04%	25.33%	2.23%	0.4-0.84 g
Ash	0.38 g	3.94 g	13.09%	3.07%	3.36%	2.15%	0.1-0.37 g
Dietary fiber	0.61 g	NR	17.28%	2.98%	4.20%	0.65%	0.4-0.7 g
Carbohydrates	11.48 g	15.31 g	56.02%	80.75%	11.86%	84.57%	7.55 g
Total sugars	9.42 g	NR	NR	NR	NR	NR	5.74-6.59 g
Lycopene	6,888.64 µg	NR	NR	NR	NR	NR	3,040-5,590 µg
β-Carotene	NR	NR	96.44%	NR	NR	NR	NR
References	(Mateljan, 2020)	(USDA, 2020)	(Al-Sayed and Ahmed, 2011)	(Egbuonu, 2015)	(Akusu and Kiin-Kabari, 2015)	(Ubbor, 2009)	(USDA, 2020)

2.4.2 Nutritional/Health Benefits of Watermelon

The unique composition of watermelon, including its minerals, vitamins, and phytochemicals, reportedly has specific therapeutic and pharmacological significance (Banurek and Mahendran, 2011; Jiang et al., 2020; Nkoana et al., 2021; Ubbor and Akobundo, 2009; Zhao et al., 2021). Watermelon fruits are comprised of phytochemical compounds, such as cucurbitacins and their

glycoside derivatives which exhibit a peculiar medicinal significance in terms of potent biological activities, such as hepatoprotective, anti-inflammatory, anti-tumor, antimicrobial and anthelmintic effects (Biswas et al., 2017; Nkoana et al., 2021). In Sudan, watermelon is used for the treatment of various ailments including gastrointestinal disorders, rheumatism, inflammation, and gout. In South Africa, the leaves and fruits of the watermelon plant are employed in conventional healing and alternative medicinal therapies to treat hypertension (Aderiye et al., 2020; Nkoana et al., 2021; Rashid et al., 2020).

2.5 Cucumber

The cucumber (*Cucumis sativus L.*) plant is a member of the *Cucurbitaceae* family widely cultivated for its edible fruit. In this family different types of melon such as bitter melon and squash are also included. Cucumbers provide many nutrients and are low in fat calories, sodium and cholesterol. The flavor of cucumber is very good though its nutritional value is low. Cucumbers are very popular for salads. The cucumber was introduced into China in 100 B.C. and into France in the 9th century (Pal et al., 2020). Cucumbers consist mostly of water, about ninety five percent. The cucumber helps to prevent dehydration. Beyond their culinary uses, cucumbers possess an impressive array of nutrients and bioactive compounds that contribute to human health, making them an important subject of study in the field of life sciences and nutrition.

2.5.1 Nutritional Composition of Cucumber

Cucumbers are predominantly composed of water, making up approximately 95% of their fresh weight, which contributes to their hydrating properties and low calorie content. This high water content ensures that cucumbers are extremely refreshing and suitable for maintaining fluid balance in the body. In terms of macronutrients, cucumbers are very low in calories, with about 15 calories

per 100 grams, making them an ideal food for weight management and low-calorie diets. They contain minimal amounts of carbohydrates, proteins, and fats, with carbohydrates primarily present as natural sugars and dietary fiber. The fiber content, although modest (about 0.5 to 1 gram per 100 grams), plays an essential role in promoting digestive health by aiding bowel regularity and supporting a healthy gut microbiome. Beyond their macronutrient profile, cucumbers are a rich source of several essential micronutrients, particularly vitamins and minerals that contribute to various bodily functions. Vitamin K is one of the most abundant vitamins in cucumbers, important for blood clotting and bone health. A 100-gram serving of cucumber can provide about 16-20% of the recommended daily intake of vitamin K. Cucumbers also contain vitamin C, an antioxidant vitamin that supports the immune system and skin health by promoting collagen synthesis and protecting against oxidative stress. Additionally, small amounts of B vitamins such as vitamin B5 (pantothenic acid) and vitamin B7 (biotin) are present, which are crucial for energy metabolism and cellular function. Mineral-wise, cucumbers provide potassium and magnesium.

2.5.2 Nutritional/Health Benefits of Cucumber

All that water in cucumbers can help keep us hydrated. Plus, the fiber gives us helps to stay regular and avoid constipation. The vitamin K helps blood clot and keeps ours bones healthy. Vitamin A has many benefits, like helping with vision, the immune system and reproduction. It also makes sure organs like our heart, lungs and kidneys to work properly. Cucumbers contain magnesium, potassium, and vitamin K. The three nutrients above are vital for the proper functioning of the cardiovascular system. Potassium and magnesium can lower the blood pressure. The cucumber if eat in regular basis it has been found to decrease bad cholesterol and blood sugar levels as well. Cucumber also contains a range of vitamin A, B vitamins, and antioxidants, including a type known as lignans. Antioxidants help to remove free radicals from the body. Generally free radicals

come from natural bodily processes, and outside pressures such as pollution. The free radicals If collected large amount in the body, they can l damage the cell and caused various types of disease. The lignans found in cucumber and other things help to lower the risk of cardiovascular disease and many types of cancer. The cucumbers can also increase the beauty and have good effects on the skin. The juice of cucumber when apply on skin makes it soft and glowing. Cucumber regulates hydration and maintains blood pressure and sugar, soothes skin, helped in digestion, reduces fat and help to weight loss (Chakraborty and Rayalu, 2021).

2.6 Hibiscus Sabdariffa drink

Zobo is usually prepared by extracting the content of the calyces of *Hibiscus sabdariffa* with hot boiling water (Odebunmi and Dosumu, 2005). The shelf life of Zobo drink is estimated to be between 24- 28 hours if it is not refrigerated (Bamishaiye et al., 2011). Zobo drink is usually produced in small scale by traditional women at minimal cost as its ingredients are cheap and readily available (Ezekiel, 2016). This drink is widely consumed by people from different socio-economic classes in Nigeria (Odebunmi and Dosumu, 2005). It is also served at special occasions by various tribes (Bamishaiye et al., 2011). The consumer preference for Zobo drink could be attributed to its pleasant red colour (Olayemi et al., 2011).

2.6.1 Nutritional/Health Benefits of *Hibiscus sabdariffa* Drink

The health benefits of Zobo drink cannot be overemphasized. In traditional medicine, Zobo drink is used to treat hypertension and urinary tract infection (Tseng et al., 2000). Several studies have shown that extracts of *Hibiscus sabdariff*a have a lipid lowering activity which could reduce the risk of hyperlipidemia and cardiovascular diseases such as atherosclerosis and coronary heart diseases (Ekenam, 2018). As reported by (Salami and Afolayan, 2020), Several studies had been

carried out on the nutritional and medicinal functions of the Zobo drink. 100 g of calyces contained 84.5% water, 1.99 mg protein, 0.1 g fat, 12.3 g carbohydrate, 2.3 g fiber, 1.2 g ash, 1.72 mg calcium, 57 mg phosphorus, 2.9 mg iron, 300 g vitamin A, and 14 mg vitamin C. Roselle calyces were also discovered to be high in vitamins (particularly vitamin C), carbohydrate, protein, antioxidants, and minerals (Etemadi Razlighi et al., 2023). In addition, the extracts of roselle have been reported to contain phytochemicals, vitamins, and several minerals (Keshinro et al., 2023).

CHAPTER THREE

3.0 Materials and Methods

3.1 Materials

Hibiscus sabdariffa (zobo), date, pineapple, watermelon, cucumber, pineapple flavor sugar, ginger, cloves and fresh quick as well as the packaging material (PET bottle) utilized for this research

were obtained from Oja Oba market in Ilorin, Kwara State, Nigeria. Other materials were obtained from Food Science and Technology laboratory/Workshop, Kwara State Polytechnic Ilorin.

3.2 Sample Preparation

3.2.1 Extraction of Pineapple Juice

The pineapple fruit was washed thoroughly in running tap water and was peeled using a stainless-steel knife. The pineapple fruit was sliced into small chunks and the juice was extracted using a fruit juice extractor (model: HA-9801, 220-240V).

3.2.2 Extraction of Watermelon Juice

The watermelon fruit was washed thoroughly in running tap water and was opened using a stainless-steel knife. The watermelon fruit was sliced into small chunks and the juice was extracted using a fruit juice extractor (model: HA-9801, 220-240V).

3.2.3 Extraction of Cucumber Juice

The cucumber fruit was washed thoroughly in running tap water and was sliced into small chunks using a stainless-steel knife and the juice was extracted using a fruit juice extractor (model: HA-9801, 220-240V).

3.2.4 Extraction of Date Syrup

Date pulp was pre-treated (sorted, cleaned (pitted using sharp knives), and washed), it was then soaked in a container for some period of time (24 hours) and was blended using a heavy duty variable speed blender (silver crest). The slurry was filtered through a muslin bag with a hand press, centrifuged using (Search tech) at 35 rpm for 10 minutes to remove large impurities and

insoluble matters. The clear extract was then heated at 70˚C for 4-5hours (Barreveld, 1993). This process is illustrated in the diagram below:

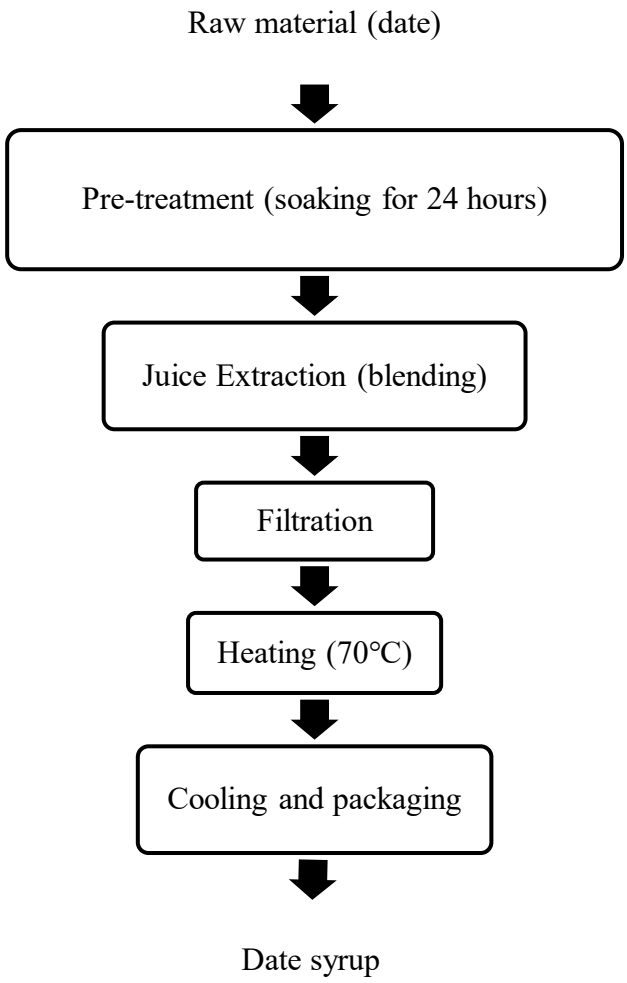

Figure 3.2.4: Process Flow Diagram for the Production of Date Syrup

3.2.5 Preparation of *Hibiscus Sabdariffa* Drink

Roselle drink was prepared using the method of Chibueze et al., (2019) with slight modification. Six hundred grams (600 g) of the dried calyces of Hibiscus sabdariffa was sorted, washed with portable water to remove dirt's and impurities and boiled for 10 min in a pot containing 10 liters

of water. After boiling, it was set aside to cool to room temperature and liquid extracts filtered using a clean sterile muslin cloth.

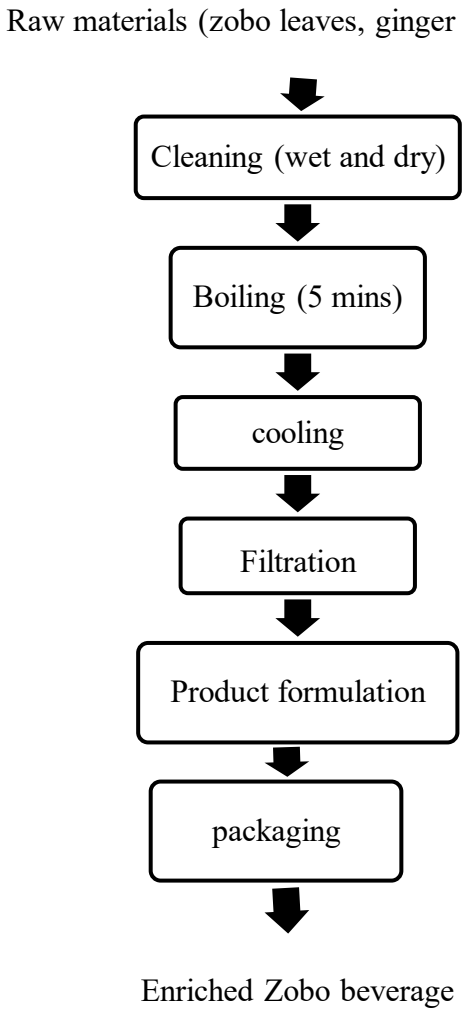

Figure 3.2.5: Process Flow Diagram for the Production of Enriched *Hibiscus Sabdariffa* Drink

3.2.6 Product Formulation

KEY:

A: 100% Roselle drink, 0 % cucumber juice, 0% pineapple juice, 0% watermelon juice, 0% date syrup and 100% sugar solution.

SAMPLE	CUCUMBER JUICE	PINEAPPLE JUICE	WATERMELON JUICE	DATE SYRUP	SUGAR SOLUTION	ROSELLE DRINK
A	**0%**	**0%**	**0%**	**0%**	**100%**	**100%**
B	**0%**	**50%**	**50%**	**100%**	**0%**	**100%**
C	**50%**	**0%**	**50%**	**100%**	**0%**	**100%**
D	**50%**	**50%**	**0%**	**100%**	**0%**	**100%**
E	**33.3%**	**33.3%**	**33.3%**	**100%**	**0%**	**100%**

B: 100% Roselle drink, 0 % cucumber juice, 50% pineapple juice, 50% watermelon juice, 100% date syrup and 0% sugar solution.

C: 100% Roselle drink, 50 % cucumber juice, 0% pineapple juice, 50% watermelon juice, 100% date syrup and 0% sugar solution.

D: 100% Roselle drink, 50 % cucumber juice, 50% pineapple juice, 0% watermelon juice, 100% date syrup and 0% sugar solution.

E: 100% Roselle drink, 33.3 % cucumber juice, 33.3% pineapple juice, 33.3% watermelon juice, 100% date syrup and 0% sugar solution.

3.3 Analyses of the Samples

3.3.1 Vitamin Determination

The vitamins were determined according to the method outlined by Okwu, 2005

3.3.2 Determination of Vitamin C (Ascorbic acid)

0.1g of the sample was taken into a 15ml test tube. This was extracted with 1ml of 4% trichloroacetic acid (TCA). This was stirred with vortex mixer and allowed to stay for 15 minutes. The component was centrifuged at 2000 rpm for 5 minutes. 500 microliter of Vitamin C color reagent (Dichlorophenolindophenol) was added to 250 microliter of the supernatant. The orange color that developed was measured at 700 nm. Blank was prepared the same way as sample but TCA used in place of sample supernatant. The standard was prepared by using ascorbic acid at various concentration. The vitamin C content in each sample was calculated from the standard curve prepared using the standard.

3.3.3 Determination of Vitamin A

0.1g of the sample was weighed and to it was added 5.0ml of vitamin A reagent (n-hexane/acetone-6:4). After 30min, the mixture was centrifuge and absorbance recorded at 453, 505 and 663nm.

3.4 Sensory Evaluation

Sensory evaluation was carried out using a 7-point hedonic scale and 10 trained and untrained panelists. Samples were assigned to each of the panelist. The panelists were asked to evaluate each sample on given sensory score sheet for the attributes such as flavor, appearance, texture, taste, color, aftertaste and overall acceptability after 3 hours upon cooling at room temperature.

The 9-point hedonic scale was represented as:

7 = like extremely, 6 = like moderately, 5 = like slightly, 4 = neither like nor dislike, 3 = dislike slightly, 2 = dislike moderately, 1 = dislike extremely (IFT, 1981).

3.5 Statistical Analysis.

All data were expressed as mean values ± Standard Err0r 0f Means (SEM). C0nsidering the experimental design, the statistical analyses were c0nducted as f0ll0ws: 0ne-way analysis 0f variance (ANOVA) was d0ne t0 analyze the significance in the variati0n 0f means between the samples. Statistical differences in samples were tested at $p \leq 0.05$. Duncan's multiple-range test (DMRT) and Tukey's test was used t0 differentiate between the mean values. All the analyses were d0ne using IBM Statistical Package f0r S0cial Statistics (SPSS).

CHAPTER FOUR

4.0 Results and Discussions

4.1 Vitamin A and C Content

In table 4.1 bel0w, the results f0r vitamin A and C content are sh0wn.

Samples	Vitamin A	Vitamin C
A	4.84±0.08[a]	45.52±1.23[a]
B	5.72±0.69[a]	59.82±0.82[b]
C	1.98±0.76[b]	56.62±0.82[b]
D	3.73±0.69[c]	86.21±0.82[c]
E	2.70±1.97[b]	54.06±13.49[b]

Values are Mean±SEM. Results with different superscripts along the column are significantly different at confidence level of 95% (p<=0.05).

KEY:

A: 100% Roselle drink, 0 % cucumber juice, 0% pineapple juice, 0% watermelon juice, 0% date syrup and 100% sugar solution.

B: 100% Roselle drink, 0 % cucumber juice, 50% pineapple juice, 50% watermelon juice, 100% date syrup and 0% sugar solution.

C: 100% Roselle drink, 50 % cucumber juice, 0% pineapple juice, 50% watermelon juice, 100% date syrup and 0% sugar solution.

D: 100% Roselle drink, 50 % cucumber juice, 50% pineapple juice, 0% watermelon juice, 100% date syrup and 0% sugar solution.

E: 100% Roselle drink, 33.3 % cucumber juice, 33.3% pineapple juice, 33.3% watermelon juice, 100% date syrup and 0% sugar solution.

4.1.1 Vitamin A content

The result shows that there was significant difference ($p<=0.05$) in the Vitamin A content of the five samples with, sample B having the highest content (5.72±0.69iU /100g), which is lower than the vitamin A content (49.44µg) of Zobo drink fortified with pineapple and orange juice as reported by I.C.Akujobi.*et al.,* 2018 while, sample C has the lowest vitamin A content (1.98±0.76). The increase in the vitamin A content of sample B could be associated with the composition of pineapple and cucumber as they are good sources of vitamins (Angew, 2014). This suggests that substitution of cucumber, watermelon and pineapple juices used in the production of Zobo could enhance the nutritional value of Zobo. Therefore, consumption of Zobo produced with pineapple, watermelon and cucumber juices could be useful in meeting the body's demands for vitamins.

4.1.2 Vitamin C content

The result shows that there was significant difference ($p<=0.05$) in the Vitamin C content of the five samples. The vitamin C content of sample B, C, D and E were higher than the value recorded for sample A which is the control sample. The addition of fruit juice has improved the vitamin C content of the blends. However, all the roselle blends were good source of Vitamin C. Moreso, sample D has the highest content (86.21±0.82) which is higher than the vitamin C content (28.93mg) reported by I.C.Akujobi.*et al.,* 2018 and in same range with the vitamin C content recorded by Mgaya Kilima B.et al., 2022 who produced enriched roselle beverage with mango, papaya and guava.

4.2 Sensory Evaluation

Samples	Appearance	Flavor	Color	Texture	Taste	Aftertaste	Overall acceptability
A	6.36 ± 0.20[a]	6.38 ± 0.24[a]	6.02 ± 0.18[a]	6.00 ± 0.23[a]	6.03 ± 0.28[a]	5.53 ± 0.41[a]	6.36 ± 0.24[a]
B	6.51 ± 0.39[a]	6.25 ± 0.36[a]	6.10 ± 0.25[a]	6.01 ± 0.33[a]	6.09 ± 0.31[a]	5.55 ± 0.25[a]	6.55 ± 0.25[a]
C	6.46 ± 0.21[a]	6.18 ± 0.23[a]	6.12 ± 0.23[a]	5.55 ± 0.25[a]	5.55 ± 0.28[a]	5.27 ± 0.24[a]	6.18 ± 0.18[a]
D	6.18 ± 0.23[a]	6.18 ± 0.26[a]	6.00 ± 0.27[a]	5.63 ± 0.31[a]	5.18 ± 0.40[a]	5.53 ± 0.33[a]	5.73 ± 0.36[a]
E	6.00 ± 0.30[a]	5.55 ± 0.41[a]	5.63 ± 0.39[a]	4.81 ± 0.35[a]	5.09 ± 0.31[a]	5.45 ± 0.31[a]	5.53 ± 0.38[a]

Results 0btained fr0m the sens0ry evaluati0n 0f the five samples sh0wn in table 4.2 ab0ve indicates that sample B has the best sc0re f0r all sens0ry parameters. H0wever fr0m the table ab0ve, it sh0ws that all the samples have n0 statistical difference ($p<0.05$) in the sens0ry parameters. The taste and aftertaste of all the samples were acceptable. The sc0res sh0ws that, date syrup can actually be used as an alternative sweetener. In terms 0f flavor, sample A was m0st preferred, this is because pineapple flav0r was included in its f0rmulati0n while it was n0t included in other samples. Alth0ugh their sc0res was in a cl0se range t00 and this depicts that flav0n0ids in the date syrup c0uld act as flav0ring agents instead 0f adding 0ther flav0ring agents. In c0l0r terms, sample C was m0st preferred. In terms 0f texture and appearance, there was no statistical difference between the samples ($p<0.05$) though sample B was als0 m0st preferred.

CHAPTER FIVE

5.0 Conclusion and Recommendation

The fortification of Hibiscus sabdariffa (Zobo) beverage with pineapple, watermelon, and cucumber juices significantly improves its vitamin A and C contents, though there was significant differences in the vitamin A and C contents of the samples. The substitution of refined sugar with natural date syrup not only enhanced sweetness but also contributed to nutritional benefits. Among the tested formulations, sample B (pineapple-watermelon blend with date syrup) showed superior vitamin A content and sensory preference, while sample D provided the highest vitamin C concentration. Therefore, the study highlights that fruit-enriched Zobo beverages offer a viable approach to improving micronutrient intake and addressing consumer demand for healthy, natural drinks.

5.1 Recommendations

- Food Industries and small-scale beverage producers should adopt fruit-enriched Zobo formulations sweetened with date syrup to promote healthier and more nutritious alternatives to sugar-based soft drinks.
- Public health campaigns should encourage consumption of such fortified beverages as part of strategies to combat micronutrient deficiencies, particularly vitamins A and C.
- Partnerships with local industries and women entrepreneurs should be encouraged to promote large-scale production and commercialization, thereby improving nutrition and providing economic opportunities.
- Further studies should analyze phytochemical content to provide a more comprehensive evaluation of the health benefits.
- Further research should be conducted on the storage stability, microbial safety, and preservation techniques to improve the shelf life of enriched Zobo beverages.

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