

PROXIMATE AND NUTRIENT CONTENT OF JUTE LEAF

BY

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CERTIFICATION

This certify that this project titled: “Proximate and Nutrient Content of Jute Leaf” by Shakira Ibrahim (Adm. No: 2010302126) has been read and approved as meeting part of the requirements for the award of Bachelor of Science (B.Sc. Hons) degree in Biology of the Department of Biology, Faculty of Chemical and Life Sciences, Usmanu Danfodiyo University, Sokoto.

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DEDICATION

I dedicate this project to beloved parents, Alh. Ibrahim Hamza and Haj. Haulatu Ibrahim for their endless support and prayers. Thank you for always being my guiding stars.

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ABSTRACT

This study investigated the proximate and nutrient composition of Jute Leaf (Rama) using three analyzed samples. The proximate analysis focused on moisture, ash, lipid and fibre content, while the nutrient analysis examined nitrogen, protein and carbohydrate levels. Results from the proximate composition showed that ash had the highest mean value (18.17%), indicating a substantial presence of mineral elements. Fibre also recorded a moderately high mean value (11.17%), underscoring the leaf's potential contribution to dietary fibre intake. Moisture content was relatively low (6.10%), while lipid content was the lowest (2.83%), reflecting the naturally low-fat characteristic of leafy vegetables. The nutrient composition revealed that carbohydrate had the highest mean value (55.79%), suggesting that Jute Leaf (Rama) is a significant energy source. Protein content was moderate (6.71%), providing essential nutrients for tissue growth and repair, whereas nitrogen recorded the lowest mean value (1.07%), consistent with its role as a component of protein. The findings indicate that Jute Leaf (Rama) is rich in minerals and carbohydrates, moderately endowed with fibre and protein, and contains very low lipid levels, highlighting its nutritional significance for balanced dietary intake.

CHAPTER ONE

1.0

INTRODUCTION

1.1 Background to the Study

Corchorus olitorius (Linn) is among the edible vegetables commonly consumed in most African countries especially in Nigeria. Vegetables are very important as they possess essential food ingredients which can be used to build up our body system. Vegetables are major sources of both macro and micro nutrients in Africa especially in the rural areas of developing countries where starch based food are mainly consumed for survival (Loumerem & Alercia, 2016). It is commonly called 'Jew mallow', 'bush okro' or 'jute'. It is popularly called Ewedu in Yoruba, Ahihara in Igbo and Rama in Hausa lands. *Corchorus olitorius* had been in existence since about 200 years ago mainly cultivated in the tropics. It is a tall vegetable plant, with a height of between 2- 4m, mainly unbranched stem or with few short branches. The leaves are usually distributed in an alternate manner. *Corchorus olitorius* contain small yellow flowers and the fruit has many seeds enclosed in the form of capsule (Loumeren & Alercia, 2016).

Corchorus olitorius is widely grown in the tropics for the viscosity of its leaves. In the north-western states of Nigeria, particularly Sokoto, *Corchorus olitorius* is one of the major leafy vegetables widely grown and utilized as pot-herb (Akoroda & Akintobi, 1981). The leaves are cooked into thick viscous soup added to stews and eaten with starchy staples, and are rich sources of vitamins and minerals (Tindall, 1983).

Corchorus olitorius are very good sources of proteins, vitamins (A, C, E) and they are also rich in mineral nutrients like calcium and iron (Steyn *et al.*, 2001; Dansi *et al.*, 2008). It is also known to contain high levels of iron and folate which are useful

for the prevention of anemia (Dansi *et al.*, 2008). Literature reports had indicated that different parts of jute have been effectively used in the treatment of cardiac diseases, pains, chronic cystitis, gonorrhea and tumors (Samilova and Lagodich, 1977; Abu-Hadid *et al.*, 1994). *Corchorus olitorius* was also reported to contain series of biological properties such as hypoglycemic, antimicrobial, anti-oxidants and anti-inflammatory (Abo *et al.*, 2008; Semira *et al.*, 2007; Oboh *et al.*, 2009; Nishiumi *et al.*, 2006). Various researches have been conducted on the medicinal and biological values of *Corchorus olitorius*, but little investigations have been carried out on the nutritional and especially the anti-nutritional composition of the vegetable.

Proximate analysis involves the determination of major components such as moisture, crude fiber, carbohydrate, fat, and protein in plant materials (Oboh *et al.*, 2018). Studies conducted on the proximate analysis of jute leaves have revealed variations in their nutrient composition depending on factors such as cultivar, maturity stage, and environmental conditions (Nwosu *et al.*, 2020). For example, research by Oyedele *et al.* (2018) demonstrated that the moisture content of jute leaves ranged from 75% to 85%, while crude fiber content ranged from 10% to 15%, indicating significant variability in these parameters among different samples.

Furthermore, the carbohydrate content of jute leaves, primarily in the form of dietary fiber and sugars, contributes to their nutritional value and dietary fiber intake (Bamigboye *et al.*, 2019). Carbohydrates serve as a major energy source and play a crucial role in maintaining blood glucose levels and promoting digestive health (Nwosu *et al.*, 2020). Understanding the carbohydrate composition of jute leaves is important for assessing their dietary impact and potential applications in functional foods and dietary supplements.

Proximate analysis provides valuable insights into the nutritional composition of jute leaves, allowing researchers to evaluate their dietary significance and potential health benefits. Therefore, examining parameters such as moisture, crude fiber, and carbohydrate content, researchers can better understand the nutritional profile of jute leaves and explore their utilization in various food and pharmaceutical applications. Therefore, this study was aimed at assessing the nutrient compositions, rate of growth and quality of *Corchorus olitorius* as influenced by the application of both organic and inorganic fertilizers with the view to increase sustainable soil productivity and yield of *Corchorus olitorius* under intensive cultivation.

1.2 Statement of the Problem

Although jute leaf is widely consumed and cited as a potentially important source of protein, minerals (notably Ca and Fe) and vitamins, existing reports reveal substantial variation in proximate and micronutrient values across genotypes, growing conditions and post-harvest treatments (e.g., drying, fertilization), and many regions lack up-to-date, locally relevant compositional data (Baiyeri, Adeniji & Alli-Balogun, 2024). This heterogeneity complicates nutritionists' ability to estimate the leaf's true contribution to dietary requirements and limits its targeted use in interventions against protein-energy malnutrition and micronutrient deficiencies. Furthermore, anti-nutrients and processing effects (which alter nutrient retention and bioavailability) are not always measured alongside proximate composition in routine analyses, leaving gaps in understanding of actual nutritive value as consumed. Without systematic proximate and nutrient profiling (including minerals, vitamins and anti-nutrients) of locally available jute leaf accessions, policy makers and extension agents cannot reliably promote jute leaf as a verified nutrition intervention or optimise cultivation and processing practices for maximal nutritional benefit.

1.3 Justification of the Study

Corchorus olitorius (jute leaf) is a popular vegetable in Sokoto State, Nigeria known for its nutritional and medicinal benefits. It is rich in essential nutrients like vitamins, minerals, and proteins, and helps in preventing health issues such as anemia. Despite its importance, there is limited research on how different fertilizers affect its nutritional value and growth. However, soil fertility in many parts of Nigeria is declining, and chemical fertilizers are often expensive and harmful to the environment when overused. Using a combination of organic and inorganic fertilizers has been suggested as a better, more sustainable way to improve soil health and crop yield. However, more research is needed to understand how this approach works specifically for *Corchorus olitorius*. This study is important because it will help farmers know the best type of fertilizer to use for better yield and quality of *Corchorus olitorius*. It will also promote sustainable farming practices that protect the soil and improve food security.

1.4 Objectives of the Study

The aim of this research is to investigate the proximate and nutrients composition of jute leaf (rama). The specific objectives are as follows:

- i. To investigate the proximate composition (moisture, ash, lipid and fibre) of sampled jute leaf (Rama).
- ii. To investigate the nutrient composition (e.g., nitrogen, protein and carbohydrate) in the samples.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Introduction

Jute leaves (*Corchorus olitorius*) are widely cultivated in tropical and subtropical regions for their nutritional and medicinal properties (Bamigboye *et al.*, 2019). As a leafy green vegetable, jute leaves are commonly consumed in various traditional cuisines across Africa and Asia, where they are appreciated for their unique flavor and culinary versatility (Oyedemi *et al.*, 2018). More than 80 compounds, including glycosides, triterpenes, ionones, phenolics, phytosterols, organic acids, lignins, alkaloids have been isolated and identified from jute plant (Islam & Rahman, 2008; Rume, 2010).

2.2 Morphological Characteristics of Jute Leaf (*Corchorus olitorius*)

The plant is an annual herb, growing upright with slender, branched stems that may reach up to 2–4 meters in fibre production fields but remain shorter (0.5–1.5 m) when cultivated as a leafy vegetable (Biswas *et al.*, 2022). Leaves of jute plants are 6–10 cm long and 3.5–5 cm broad. Leaves are alternate and simple; stipules are narrowly triangular with long point; petiole 1–7 cm long; blade narrowly ovate, ovate or elliptical, 4–15 cm × 2–5 cm, cuneate or obtuse and with setaceous appendages up to 2.5 cm long at base. The leaves are acuminate to acute at apex, margin serrate or crenate, almost glabrous, usually shiny dark green, 3–7 veined from the base. Inflorescence is a 1–4 flowered axillary fascicle, bracteates (Ahmed and Sarkar, 2022).

Flowers are bisexual, regular, usually 5 merous and shortly stalked. Sepals are free, narrowly obovate, 5–7 mm long; petals free, obovate, 5–7 mm long, yellow and

caduceus. Stamens are numerous. Ovary is superior, usually 5-celled, style short from a cylindrical capsule up to 7–10 cm long, ribbed, with a short beak, usually dehiscing by 5 valves and many-seeded. Seeds are angular, 1–3 mm long and dark grey. Seedling with epigeal germination; hypocotyl 1–2 cm long; cotyledons foliaceous, broadly elliptical to circular, 3–8 mm long (Kirtikar & Basu, 1975).

Leaves are normally light green colored, and are a bit bitter in taste. When collected, young jute leaves are tasty and tender; older leaves tend to be more woody and fibrous, making them less ideal for consumption. In addition to adding a distinctive flavor to food, jute leaves also have nutritional value, and they act as thickeners in soups, stews, and sauces. Apart from their slightly bitter taste, jute leaves are a good source of nutrients, vitamins and minerals (Ahmed *et al.*, 2001; Islam *et al.*, 2008; Biswas *et al.*, 2020). Apart from food use, it is grown as a commercial crop for jute production in India, Bangladesh and China (Holm, 1979).

2.3 Elemental Analysis of Plant Materials

Different experiments have revealed that plant parts, such as leaves, stems, roots, barks, and seeds, of *C. olitorius* contain polysaccharides, flavonoids, phenolics, cardiac glycosides, sterols, fatty acids, triterpenoids, and ionones (Khan *et al.*, 2006). Ahmed *et al.* (2001) reported that *C. olitorius* leaves are rich sources of Vitamin A (β -carotene), C, E, B1, B2, folic acid and minerals such as iron and calcium in addition to common macromolecules (Islam *et al.*, 2008; Adeniyi *et al.*, 2012; Islam *et al.*, 2013; Ali *et al.*, 2021). Folic acid (folate, B vitamin) substantially higher (0.03 mg/L) than that of other folacin rich vegetables and iron 72 μ g/g. Jute leaves yielded a lot of mucilaginous polysaccharide (acidic polysaccharide) and anthocyanin. Leaf extracts yielded alkaloids, terpenoids, tannins, flavonoids, glycosides (Barku *et al.*, 2013). The extracts also contain two

functional compounds, phytol and monogalactosyldiacylglycerol that protect from free radicals (Elangovan *et al.*, 2012).

Oleanolic acid was isolated from the leaves of *C. olitorius* of Egyptian origin. Four triterpenoid glycosides (chorchorusins A, B, C and D) isolated from aerial parts of *C. acutangulus*. Leaves of *C. olitorius* contain ionone glucosides which are corchoionosides A, B and C, an ionone glucoside (roseoside) and a monoterpeneglucosidebetulabuside A. Leaves of *C. olitorius* gave four higher fatty acids with a trienone system, corchorifatty acids A, B, C, D, an uncanoic acid, corchorifatty acid E and a trihydroxy fatty acid, corchorifatty acid F (Ali *et al.*, 2019).

C. olitorius leaves contain macro and micronutrients as well as polyphenols (Azuma *et al.*, 1999; Handoussa *et al.*, 2013; Zeghichi *et al.*, 2003). Among carbohydrates, acidic polysaccharides are of particular interest because of their notable biological effects including antidiabetic and antioxidant. It is also a good source of a diverse category of phytochemicals including alkaloids, saponins, tannins, terpenes, flavonoids, and phenolics. Different extracts exhibit potent antidiabetic, antioxidant, antiinflammatory, anticancer, antimicrobial, hepatoprotective, cardioprotective, neuroprotective, analgesic, and wound healing effects (Ahmed *et al.*, 2001).

2.4 Organic and Inorganic Fertilizer Application in Jute Leaf (*Corchorus ditorius*) Cultivation

Fertilizer is any organic or inorganic material of natural or synthetic origin that is added to a soil to supply one or more plant nutrients essential to the growth of plants. Conservative estimates report 30 to 50% of crop yields are attributed to natural or synthetic commercial fertilizer (Stewart *et al.*, 2005). Organic fertilizers are fertilizers derived from animal or vegetable matter. Naturally occurring organic

fertilizers include manure, slurry, worm castings, peat, seaweed, humic and poultry guano. The complementary application of organic and inorganic fertilizers as been found to meet the immediate soil nutrient deficits, improve the soil physical properties and enhance yield stability.

Soil fertility and plant nutrition are important aspect of cropping system and these include adequate supply of essential nutrients for soil productivity, plant nutrition and qualitative crop yield. The availability of these nutrients to plant contributes a lot to its growth and yield. Deficiency of mineral elements essential for plant crop is evident in poor yield and yield quality (Osei-Owusu *et al.*, 2023). Adequate supply of mineral elements is of importance in the tropics where the soil is poorly formed and continuous cropping is on the increase. For any sustainable crop production, soil fertility amelioration is essential (Aluko *et al.*, 2014).

Adequate soil fertility is essential for sustainable vegetable production. Tropical soils are inadequate in soil nutrients. Thus, the application of fertilizer or manure for amelioration of soil fertility is an integral part of leafy vegetable production. Leafy vegetables require nitrogen for good vegetative growth. The quality of the harvest and storability are influenced by the availability of essential minerals in balance proportion. Any deviation from the balanced proportion of nutrients is easily noticed on the leaves of vegetable crops as deficiency symptoms (Aluko *et al.*, 2014).

Plant roots require certain conditions to obtain these macro and micro-nutrients from the soil. The soil must be sufficiently moist to allow the plant roots take up and transport the nutrients. The soil moisture content, pH and temperature must fall within an optimum range for the nutrients to be release-able from the soil particles. Sometimes, correcting improper watering strategies will eliminate nutrient

deficiency symptoms. This invariably affects the acceptability and market value of the vegetable (Aluko *et al.*, 2014).

Fertilizer studies in North-Western Nigeria showed positive responses of *Corchorus olitorius* to nitrogen (NIHORT, 1986). Phosphorus is important in root development and helps hasten maturity of the fruit. Tropical soils are often low in available phosphorus and therefore require adequate inputs of phosphorus for optimum plant growth, especially for rapid growing of annual crops such as leafy vegetables (Zapata and Axman, 1995). Leafy vegetables play crucial roles in alleviating hunger and food security. Besides economic potentials, vegetables also have aesthetic value, useful in food preservation, prevent micronutrients deficiencies, enhance nutritional quality of diets and provide little dietary energy (Muller and Krawinkel, 2005). Epidemiological studies have shown that low intake of carotenoids, ascorbic acid, flavonoids and phenolics found in vegetables and fruits increase the risk of cardiovascular diseases and other health challenges (Joshiyura *et al.*, 2001; Liu *et al.*, 2010).

Vegetables contain antioxidants and micro nutrients that possess ability to neutralize (scavenge) free radicals or their actions (Nicoli *et al.*, 1999; Oke and Hamburger, 2002), thereby preventing terrible diseases of man such as cancer, cardiovascular disease, neural disorders, oxidative stress, diabetes and arthritis (Yoshikawa *et al.*, 2000; Devassagayam *et al.*, 2004).

The leafy vegetable of jute is popularly used in soup preparation and folk medicine for the treatment of fever, chronic cystitis, cold and tumours (Obboh *et al.*, 2009). The young shoot tips can be eaten raw or cooked and it contains high levels of protein and vitamin C (Shittu and Ogunmoyela, 2001). Jute is usually recommended for pregnant women and nursing mothers because it is believed to be rich in iron (Oyedele *et al.*, 2006).

AVRDC (1991) and Fayemi (1999) reported that leafy vegetables such as *Corchorus olitorius* and *Celosia argentea* performed best on well-drained alluvial soils with adequate reserve of organic matter and soil moisture. Leafy vegetables have been found to perform well in peat soils, very rich in organic matter (Siemonsma, 1991). They require a lot of nitrogen for protein synthesis in the leaves (Akanbi and Togun, 2002). Thus, cultivation sustainable of leafy vegetables is hinged on availability of soil nutrient adequately.

2.4 Nutritional Significance of Jute Leaves

Jute leaves (*Corchorus olitorius*) are renowned for their nutritional richness and health-promoting properties, making them a valuable addition to diverse diets worldwide. They are a rich source of vitamins, minerals, and dietary fiber, all of which are essential for maintaining optimal health and well-being (Adeyeye *et al.*, 2019). They are particularly high in vitamins A, C, and E, which possess antioxidant properties and play crucial roles in immune function, skin health, and vision (Obboh *et al.*, 2020). The presence of these vitamins in jute leaves underscores their potential to support immune system function and protect against oxidative stress-related diseases.

Furthermore, jute leaves are abundant in essential minerals such as calcium, potassium, and magnesium, which are necessary for bone health, muscle function, and electrolyte balance (Akinola *et al.*, 2019). Adequate intake of these minerals from dietary sources like jute leaves may help prevent osteoporosis, regulate blood pressure, and support overall cardiovascular health (Obboh *et al.*, 2019).

Dietary fiber is another key component of jute leaves that contributes to their nutritional significance (Ademiluyi *et al.*, 2018). Fiber plays a crucial role in digestive health by promoting regular bowel movements, preventing constipation, and reducing the risk of colorectal cancer (Afolabi *et al.*, 2017). Jute leaves contain

both soluble and insoluble fiber, making them an excellent addition to a balanced diet for promoting gastrointestinal health and maintaining healthy cholesterol levels.

Moreover, jute leaves are low in calories and fat, making them an ideal choice for individuals looking to manage their weight and reduce the risk of obesity-related conditions (Oboh *et al.*, 2020). Their high nutrient density and low energy content make them a filling and satisfying option for incorporating into meals without compromising on nutritional quality.

Jute leaves are a nutritional powerhouse rich in vitamins, minerals, and dietary fiber, all of which contribute to their potential health benefits. By incorporating jute leaves into a balanced diet, individuals can enhance their nutrient intake, support overall health, and reduce the risk of chronic diseases.

2.4 Health Benefits of Jute Leaves

Medical science has made a remarkable advancement through the discovery of numerous drugs and medicines-antibiotics, hormones and vaccines-for the treatment of several diseases caused by pathogenic microbes, even though these pharmaceutically formulated medicines are not totally free from side effects. Nevertheless, more studies are still needed to be done to discover cure for many diseases that still remain incurable. This therefore underscores the need to involve herbal medicine in the fight against diseases, because it is cost effective with little or no side effects.

The use of plants in the management and treatment of diseases started with life. Human depends on plants for medicine; both for orthodox and herbal medicine. Through phytochemical screening of plants, it has been revealed that various plants have medicinal values and properties for the treatment of different human diseases.

Jute leaves contain 0.0496 mg of vitamin B6 which is over 30% of the recommended daily value. Most eye diseases are a result of poor diet and nutrient deficiencies. Some of the nutrients that are linked with improving eye health and preventing eye diseases and disorders include Vitamin B6 and folate among other vitamins. Regular consumption of jute leaves can help in slowing the onset of some eye diseases including age-related muscular degeneration (Ahmad & Sarkar, 2022). Patil and Jain (2019) stated that successive solvent extracts of *C. olitorius* contains medicinally important bioactive compounds. Phytochemical analysis revealed the presence of phenols, flavonoids, tannins, saponins, alkaloids, fixed oil and fats which concluded that the crude extract of *C. olitorius* is a potential source of various activates and this justifies its use in folkloric medicine (Patil & Jain, 2019). Vitamin C which is abundant in jute leaves is essential in helping the immune system ward off colds and viruses. In addition to fighting colds, vitamin C can also keep us from suffering further complications like lung infections and pneumonia. Jute leaves are rich in fibre too.

The genus *Corchorus* is rich in bioactive molecules such as glycosides, polysaccharides, triterpenes, ionones, phenolics, sterols, and fatty acids (Kumari *et al.*, 2019). These biomolecules, which are part of a large and varied group of chemical compounds, impart a range of prophylactic and therapeutic applications to the genus. Growing clinical evidence also supports the traditional uses of *Corchorus* as folk medicine. Given the immense genetic diversity, geographical adoptability and biological effects on human health, the genus *Corchorus* can serve as a potential herbal drug-source for enhancing community health standards and livelihood security of the rural population of Asia and Africa (Kumari *et al.*, 2019). A study was carried out by Hassan *et al.* (2019) for the determination of lipid contents (fatty acids, phytosterols and hydrocarbon components) of seeds, roots, leaves and stems of *C. olitorius* which showed that cholesterol was the major

compound. Research has also shown that these copper-rich leaves can help to reduce the levels of bad cholesterol (LDL) and increase beneficial cholesterol. Jute leaves have about 0.222 mg of copper which can dramatically help to reduce chances of cardiovascular diseases as well as promote a healthy weight.

Dietary fibre is one of the major elements that help in regulating the digestive process. By regularly eating jute leaves, you can avoid constipation, bulk up stool and speed up digestion. Having a fibre-rich diet *also* helps to increase the uptake efficiency of nutrients and it reduces symptoms like cramping and gas (Jute Trading Ltd, 2021). Ali *et al.* (2019) reported that jute can be a potential medicinal product for the treatment of many diseases. Its leafy vegetable is popularly used in folk medicine for the treatment of fever, chronic cystitis, cold and tumours.

There are many health benefits of jute leaf, such as-weight loss (due to the presence fatty acids, Omega 3, Vitamins B, magnesium and zinc), prevents aging (due to antioxidant activity and also it prevents the loss of water through the skin), strengthens bone and teeth (due to the presence of calcium and phosphorus), stabilizes blood pressure (due to Omega 3), helps in hormone stabilization in women and improves brain health (due to Omega 3) (Adekanye, 2019).

For people suffering from sleeping disorders like sleep apnea and insomnia, jute leaves might be of help. Jute leaves are rich in magnesium which is the mineral that helps to treat and improve such conditions. Magnesium aids in the release of hormones that relax and soothe the nerves. By increasing the magnesium intake, you can improve your sleep quality for restful and uninterrupted sleeping patterns. The skin and cells require vitamin A which aids in promoting wounds healing and regrowth of skin. Vitamin A is essential in the growth of all epithelial cells both externally and internally and it also helps to prevent skin cancer. Jute leaves have an abundance of Vitamin A. Eating them regularly can help prevent various skin

conditions like poor complexion, acne, lines and wrinkles keeping your skin looking young and healthy.

The Vitamin A contained in jute leaves also helps to promote healthy growth of hair as well. The benefits of eating jute leaves extend to the teeth and gums. They contain calcium which helps in keeping the jaw bone strong and robust. A healthy jaw bone keeps your teeth tightly fit and makes it harder for bad bacteria to grow. To keep your teeth and gums from giving you any trouble, you should maintain a calcium-rich diet which should include daily consumption of jute leaves, especially for young children. Restless leg syndrome is a common condition usually caused by iron deficiency. Because jute leaves are rich in iron, eating them regularly can help to improve the condition. Research shows that the jute plants contain up to 2.73 mg of iron which is more than a third of the daily recommended value. Eating jute leaves can also help to curb muscle spasms which are also considered to be caused by a lack of enough iron.

One of the most celebrated medical benefits of jute leaves is their ability to battle inflammation in the body. Because they contain a variety of antioxidants, eating jute leaves can help to protect against damage caused by inflammation. It is also believed that jute leaves have anti-inflammatory properties. In a study conducted in 2015, it was found that the jute plant to have properties that can treat inflammation. By eating jute leaves regularly, one can prevent inflammation (Jute Trading Ltd, 2021). Jute leaves have a variety of properties that are critical in helping manage body weight. Their high fiber content is essential in improving digestion and keeping people feeling full for longer.

C. olitorius leaves are used in the treatment of fever, tumors, pectoral pains, dysentery, aches, enteritis, cystitis, piles and dysuria (Adegoke & Adebayo-Tayo, 2009). Jute leaves are not only a delicacy in many countries. They are also a super

food with numerous health and medical benefits that promote the general well-being of the body. If you're looking to try new and healthy foods, you should consider adding jute leaves to your diet. They are available fresh and dried and both varieties have the same benefits (Jute Trading Ltd, 2021). Singh *et al.* (2016) conducted a research to evaluate the suitability of *C. olitorius* leaf powder, as a dietary protein source for fish, Labeorohita fingerlings and found that *C. olitorius* leaf powder can be incorporated in the feed of rohu fingerlings up to 20% (significantly $P < 0.05$ higher).

2.5 Potential Health Hazards of Jute Leaves

While jute leaves (*Corchorus olitorius*) offer numerous health benefits, it's important to be aware of potential health hazards associated with their consumption. This section highlights some of the risks and precautions related to jute leaf consumption, as identified in scientific literature.

Jute leaves have been found to accumulate heavy metals from the soil, water, and air, posing a risk of contamination (Afolabi *et al.*, 2017). Heavy metals such as lead, cadmium, and mercury can accumulate in plant tissues and may pose health risks when consumed in high concentrations. Regular monitoring of heavy metal levels in jute leaves and adherence to safety guidelines for cultivation and processing are essential for mitigating this risk.

Pesticides used in jute cultivation can leave residues on leaves, potentially contaminating the plant material (Akinola *et al.*, 2019). Chronic exposure to pesticide residues in food may have adverse effects on human health, including neurotoxicity, endocrine disruption, and carcinogenicity. Organic cultivation practices and proper pesticide management strategies can help minimize pesticide residues in jute leaves.

Individuals with allergies to certain plants or pollens may experience allergic reactions upon consuming jute leaves (Ademiluyi *et al.*, 2018). Allergic reactions to jute leaves may manifest as skin rashes, itching, swelling, or respiratory symptoms such as wheezing and difficulty breathing. It's important for individuals with known allergies to jute or related plants to avoid consuming jute leaves and products derived from them.

Jute leaves contain oxalates, naturally occurring compounds that may contribute to the formation of kidney stones in susceptible individuals (Oboh *et al.*, 2019). High oxalate intake from foods like jute leaves can increase urinary oxalate excretion and promote calcium oxalate crystal formation in the kidneys. Individuals with a history of kidney stones or oxalate-related disorders should moderate their consumption of high-oxalate foods like jute leaves.

Improper handling, storage, or processing of jute leaves can lead to microbial contamination, including bacteria, molds, and yeast (Adeyeye *et al.*, 2019). Consumption of contaminated jute leaves may result in foodborne illnesses such as diarrhea, vomiting, and abdominal pain. Practicing proper hygiene, washing jute leaves thoroughly before consumption, and ensuring adequate food safety measures during processing can reduce the risk of microbial contamination.

While jute leaves offer numerous health benefits, it's important to be aware of potential health hazards associated with their consumption. By addressing factors such as heavy metal contamination, pesticide residues, allergenic potential, oxalate content, and microbial contamination, individuals can enjoy the nutritional benefits of jute leaves while minimizing risks to their health.

CHAPTER THREE

3.0

MATERIALS AND METHODS

3.1 Study Area

The study was conducted at the Mycology Laboratory, Department of Biological Sciences, Usmanu Danfodiyo University, Sokoto. Sokoto State is located in the north-western part of Nigeria. Sokoto lies between latitude 12°00' and 13°58'N and longitude 4°08' and 6°54'E, sharing borders with Zamfara State to the east, Kebbi State to the south and west, and the Republic of Niger to the north. It serves as the seat of the historic Sokoto Caliphate, which has remained a major religious, cultural, and political centre in northern Nigeria (Usman, 2021).

Sokoto State covers a land area of about 25,973 square kilometers and has a population of over 5 million people according to the 2006 census, with more recent estimates suggesting significant growth (National Population Commission [NPC], 2023). The state is predominantly inhabited by Hausa and Fulani ethnic groups, although other groups also reside in urban and rural settlements. The climate is characterized by a long dry season (October–May) and a short rainy season (June–September), with annual rainfall ranging between 500–1300 mm. Average temperatures are high, often exceeding 40°C in the hottest months (March–May). This semi-arid environment influences agricultural practices, which form the backbone of the economy, with crops such as millet, sorghum, rice, and vegetables, including leafy vegetables like jute mallow (*Corchorus* spp.), being widely cultivated (Abubakar & Muhammad, 2022). Sokoto's socio-economic activities revolve around farming, livestock rearing, small-scale trading, and traditional crafts. The presence of Usmanu Danfodiyo University and other higher institutions makes Sokoto an educational hub, while its cultural heritage strengthens its identity as a centre of Islamic scholarship and governance in West Africa.

3.3 Sample Collection and Preparation

Fresh jute leaves will be collected from selected agroforestry demonstration plots of the Department of Forestry, Usmanu Danfodiyo University, Sokoto. The selection of sampling-sites was based on accessibility. The samples will be obtained in the morning, placed in clean polythene bags, and immediately transported to the Mycology Laboratory in the Department of Biological Sciences, Usmanu Danfodiyo University, Sokoto to minimize nutrient loss.

In the laboratory, the leaves will be sorted to remove any diseased or damaged parts and washed thoroughly with clean distilled water to remove dirt and contaminants. The leaves will then be air-dried at ambient temperature (approximately 27-30°C) for several days until constant weight was achieved. Once dried, the leaves will be ground into fine powder using an electric blender and stored in airtight plastic containers at room temperature until analysis.

3.4 Laboratory Analysis

All analyses will be carried out in triplicates to ensure accuracy and reliability. The proximate composition will be determined following standard procedures outlined by the Association of Official Analytical Chemists (AOAC, 2019).

3.5 Proximate Analysis

The following parameters will be analyzed:

3.5.1 Moisture Content: Moisture content will be estimated using the oven-drying method. Freshly homogenized jute leaf samples will be weighed into pre-dried crucibles and placed in a hot-air oven maintained at 105°C. The samples will be dried for several hours and then cooled in a desiccator before re-weighing. Drying and weighing will be repeated until a constant weight is obtained. The

percentage of moisture will be calculated from the difference between the initial and final weights of the samples in relation to the sample weight taken.

3.5.2 Ash Content: Ash content will be determined by incineration in a muffle furnace. A known weight of dried jute leaf sample will be placed in a pre-weighed porcelain crucible and heated in the furnace at 550°C until a light grey or white ash is obtained, signifying complete combustion of organic matter. The crucible will then be cooled in a desiccator and weighed again. The percentage ash content will be expressed as the weight of inorganic residue relative to the initial dry sample weight.

3.5.3 Crude Protein: Crude protein will be determined using the classical Kjeldahl method. In this procedure, a known weight of finely ground sample will be digested with concentrated sulfuric acid in the presence of a catalyst until the solution becomes clear, ensuring complete conversion of nitrogenous compounds into ammonium sulfate. The digest will be neutralized with sodium hydroxide, and the liberated ammonia will be distilled into a boric acid solution. The distillate will then be titrated with standardized hydrochloric acid to determine the nitrogen content. The total nitrogen value will be multiplied by a factor of 6.25 to estimate the crude protein content of the jute leaf.

3.5.4 Crude Fat: Crude fat will be extracted using the Soxhlet extraction method with petroleum ether as solvent. A pre-weighed dried sample will be enclosed in an extraction thimble and placed inside the Soxhlet apparatus. Petroleum ether will be refluxed continuously over the sample for several hours, dissolving the fat and other ether-soluble substances. The solvent will then be evaporated, and the residue containing crude fat will be dried to constant weight. The fat content will be calculated as the difference in weight of the flask before and after extraction in relation to the sample weight.

3.5.5 Crude Fibre: Crude fibre will be determined by sequential acid and alkali digestion. A pre-weighed dried sample will be subjected first to boiling in 1.25% sulfuric acid for about 30 minutes to hydrolyze soluble carbohydrates and proteins, and the residue will be filtered, washed, and further treated with 1.25% sodium hydroxide solution under reflux for another 30 minutes to remove remaining digestible materials. The residue will be washed with hot water, followed by alcohol and ether to remove any soluble materials, then dried in an oven at 105°C to a constant weight. Finally, the dried residue will be incinerated in a muffle furnace at 550°C, and the difference in weight before and after ashing will be taken as the crude fibre content.

3.5.6 Carbohydrate Content: This will be calculated by difference using the formula:

$$\text{Carbohydrate (\%)} = 100 - (\text{Moisture} + \text{Protein} + \text{Fat} + \text{Ash} + \text{Fibre})$$

3.6 Vitamin and Mineral Analysis

Essential vitamins (such as vitamin C and A) and minerals (e.g. calcium, iron, magnesium, potassium, and phosphorus) will be determined using appropriate methods as follows:

3.6.1 Determination of Potassium (K): Potassium (K) in *Corchorus olitorius* will be determined using the flame photometer. 0.5ml of the sample solution will be pipetted and distilled up to 10ml with distilled water.

$$\%K = \frac{T \times V \times R \times 10^{-4}}{W}$$

Where: R=Reading of the flame photometer, W = Weight of ash sample.

3.6.2 Determination of Sodium (Na): Sodium (Na) in *Corchorus olitorius* will be determined using the flame photometer. 0.5ml of the sample will be read on the flame photometer.

$$\% \text{ Na} = \frac{T \times V \times R \times 10^{-R}}{W}$$

Where: R= Reading of the flame photometer. W = Weight of ashed sample.

3.6.3 Determination of Calcium (Ca): Calcium (Ca) in *Corchorus olitorius* will be determined by pipetting 10ml of sample solution into 25ml conical flask (V_2). 5ml of 20% KOH will be added, 10 drops of 2% potassium cyanide KCN and 10 drops of 5% hydroxyl aminehydrochloride ($\text{OH.NH}_2.\text{HCl}$) will be added. Also, a pinch of calcine indicator put in the solution and titrated with 0.01 M EDTA and color is expected to change at titer value T.

$$\% \text{ Ca} = \frac{T \times M \text{ EDTA}}{100} \times \frac{V_1}{V_2} \times \frac{100}{W} \times 40$$

Where: T = Titre value, M = Molarity of EDTA = 0.01M, $V_1 = 50\text{ml}$, $V_2 = 10\text{ml}$, 40 =

Molar mass of calcium, W = Weight of the ash.

3.6.4 Determination of Copper, Zinc, and Iron (Cu, Zn, Fe): Atomic absorption analysis calibration will be determined by the value of copper, zinc and iron. The stock standard of 10ppm will be for each of the metal analyzed. A bulk model 2.00. A flame atomic absorption system will be used. Their individual ppm will be calculated using the expression below:

$$\text{Ppm} = \frac{10\text{ppm}}{\text{Standard reading}} \times \text{Sample reading}$$

The standard reading for each element will be different from one another. Standard reading for Fe = 96.5, Zn = 96.2. Cu = 45.5.

$$\text{Ppm sample} = \frac{R \times V}{W}$$

Where: R= value calculated above, V = Final volume of extract. W = Weight of the sample.

Vitamin C (Ascorbic Acid): This will be determined by titration with 2,6-dichlorophenolindophenol.

Vitamin A (Beta-carotene): This will be extracted with acetone and quantified spectrophotometrically.

3.7 Data Analysis

The data collected from the laboratory analyses will be recorded and statistically analyzed using descriptive statistics such as means and standard deviations. Results will be presented in tables for clarity.

CHAPTER FOUR

4.0

RESULTS

The proximate analysis of the jute leaf (Rama) samples from Filisco revealed variations in the levels of moisture, ash, lipid, fibre, nitrogen, protein and carbohydrate contents. The results are presented in Table 4.1 and Table 4.2.

4.1 Proximate Composition of Jute Leaf (Rama)

The bar chart presents the mean values of four proximate components, namely; moisture, ash, lipid and fibre obtained from the three analyzed samples of Jute Leaf (Rama). Among the components, ash content recorded the highest mean value (18.17%), indicating that Jute Leaf contains a relatively high proportion of mineral elements compared to the other components. The fibre content also showed a moderately high mean value (11.17%), reflecting the leaf's potential contribution to dietary fibre intake, which is important for digestive health. In contrast, the moisture content had a lower mean value (6.10%). The lipid content was the lowest (2.83%), indicating that Jute Leaf contains very little fat, which is typical for leafy vegetables. The chart illustrates that Jute Leaf (Rama) is characterized by high mineral and fibre content but low lipid and moisture levels, highlighting its nutritional significance, especially in diets requiring high fibre and mineral intake with low fat content.

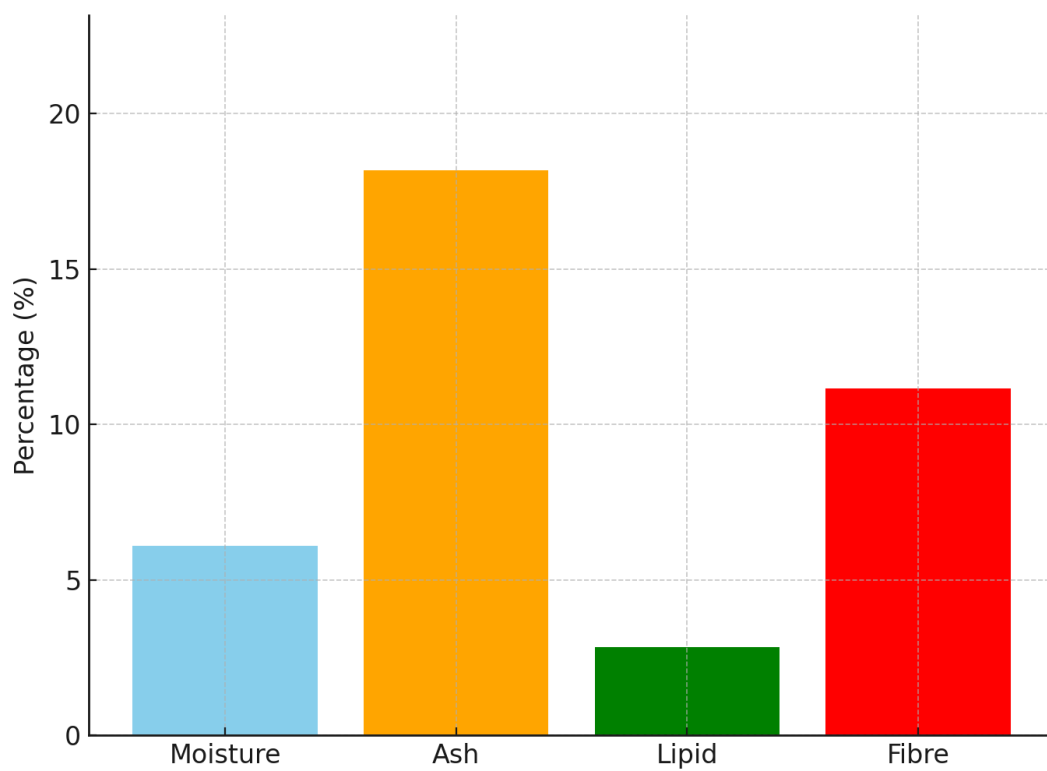


Figure 4.1: Results of Proximate Composition of Jute Leaf (Rama)

4.2 Nutrient Composition of Jute Leaf (Rama)

The bar chart presents the mean values of Nitrogen, Protein, and Carbohydrate in the three analyzed samples. Among these components, Carbohydrate has the highest mean value (55.79%), indicating that the samples are primarily composed of carbohydrates, making them a significant energy source. Protein has a moderate mean value (6.71%), suggesting that the samples provide a reasonable amount of protein, which is essential for growth, repair, and maintenance of body tissues. Nitrogen has the lowest mean value (1.07%), which is consistent with the relatively lower protein content, as nitrogen content is directly related to protein levels in plant materials. Therefore, the samples are carbohydrate-rich with moderate protein content and low nitrogen levels, which provides insight into their nutritional composition.

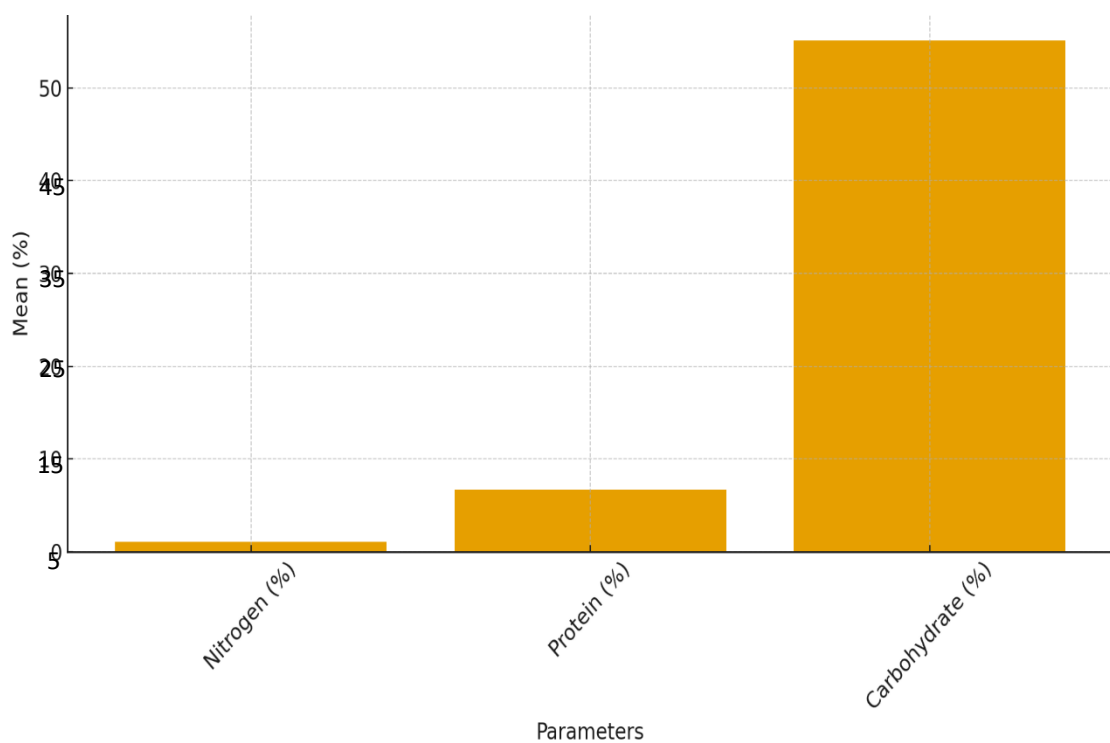


Figure 4.2: Results of Nutrient Composition of Jute Leaf (Rama)

(Note: Protein content was calculated using the conversion factor $6.25 \times$ Nitrogen content.

CHAPTER FIVE

5.0

DISCUSSION

The moisture content had mean of 6.10%, indicating a low level of water in the samples. Low moisture content suggests that the leaves were adequately dried, which enhances their shelf life and minimizes microbial spoilage. According to Oduse, Adeyemi and Olagunju (2019), vegetables with moisture content below 10% are considered stable for storage under dry conditions. Similarly, Adebayo and Omodara (2020) observe that drying leafy vegetables to low moisture levels improves preservation by slowing enzymatic and microbial activities. The result is also in agreement with Onwordi, Anjuwon and Abodunde (2022) report that reduced moisture in vegetables is advantageous for maintaining nutrient quality and preventing deterioration during storage.

The ash content had recorded the highest mean value of 18.17% indicating higher mineral concentration. Ash represents the total amount of inorganic minerals present in a sample. According to Olaiya, Adegoke and Ojo (2021), high ash content signifies the presence of essential minerals such as calcium, potassium, iron and phosphorus, which are important for human nutrition. Similarly, Ezech, Udeh and Nwankwo (2020) reported that jute leaf and other green vegetables are valuable sources of minerals that contribute to bone development and enzymatic functions. Oloye and Agbede (2022) also confirmed that leafy vegetables with high ash content play significant roles in maintaining electrolyte balance and supporting metabolic activities.

The lipid content had the lowest mean (2.83%), confirming that jute leaf is a low-fat food. Low lipid levels make such vegetables suitable for individuals who require diets with minimal cholesterol and saturated fats. According to Adebayo and Omodara (2020), vegetables are typically low in fat and serve mainly as

sources of fibre and micronutrients. Onyeike and Acheru (2019) also found that the low lipid content of leafy vegetables contributes to their health benefits, particularly in weight management. In a similar study, Ezech *et al.* (2020) emphasized that low-fat vegetables help reduce the risk of cardiovascular diseases.

Fibre content showed a moderately high mean value of 11.17%, showing that jute leaf is rich in dietary fibre. High fibre intake aids digestion, prevents constipation and promotes a healthy digestive system. Onwordi *et al.* (2022) highlighted that vegetables with high fibre content support gastrointestinal health and help regulate blood sugar levels. Olaiya *et al.* (2021) also reported that crude fibre contributes to satiety and assists in cholesterol reduction. Similarly, Ezech *et al.* (2020) observed that leafy vegetables containing appreciable fibre are valuable for preventing metabolic disorders such as obesity and diabetes.

The mean nitrogen content of the jute was 1.07%, with variation in nitrogen levels across the samples reflecting differences in the nutritional and physiological composition of the samples. Nitrogen is an essential element in amino acids and proteins, indicating the leaf's potential as a dietary protein source. According to Oduse, Adeyemi and Olagunju (2019), leafy vegetables generally contain appreciable nitrogen content, which contributes to their nutritional significance. Similarly, Olaiya, Adegoke and Ojo (2021) reported that nitrogen values in vegetables serve as an indicator of protein quality and overall nutrient density. In agreement, Onwordi, Anjuwon and Abodunde (2022) noted that nitrogen-rich vegetables are vital for promoting growth and maintaining body tissue functions.

Protein had a moderate mean value of 6.71%. This indicates that jute leaf contains a moderate amount of protein, comparable to other common leafy vegetables. Proteins are essential macronutrients necessary for cell repair, enzyme activity and general body maintenance. According to Ezech, Udeh and Nwankwo (2020), leafy

vegetables supply moderate protein that complements other dietary sources. Adebayo and Omodara (2020) also observed that jute leaf provides sufficient protein to supplement cereal-based diets, thereby contributing to improved nutritional balance. Similarly, Onyeike and Acheru (2019) stated that the moderate protein content of vegetables is significant in rural diets where animal protein sources are limited.

Carbohydrate has the highest mean value of 55.79%. It was the most abundant nutrient in the samples, signifying that jute leaf can serve as a potential energy source. Oloye and Agbede (2022) reported that green leafy vegetables with high carbohydrate content contribute to daily energy requirements and serve as bulk in food. According to Olaiya *et al.* (2021), carbohydrates in vegetables consist mainly of complex polysaccharides, which are essential for proper metabolism. Similarly, Ezeh *et al.* (2020) emphasized that carbohydrate-rich vegetables support body energy needs and aid intestinal health due to the presence of non-starch polysaccharides.

CONCLUSION

Jute leaf is a nutrient-dense food source with low fat and high mineral and energy content. The relatively low moisture content implies that the leaf can be effectively preserved in its dried form without rapid deterioration, thereby extending its shelf life. The high ash content reflects a rich concentration of essential minerals such as calcium, potassium, phosphorus and iron, which are vital for bone development, blood formation and enzymatic activities. The moderate protein level confirms that jute leaf can serve as a supplementary protein source, particularly for low-income populations with limited access to animal protein. The low lipid content further supports its suitability for individuals seeking low-fat diets, while the high fibre content highlights its role in promoting digestive health and preventing

constipation. The high carbohydrate content indicates that the leaf also provides considerable energy, enhancing its dietary value.

Therefore, this study concludes that jute leaf (*Rama*) is a valuable source of nutrients that can contribute significantly to food security, nutrition and health improvement, especially in regions where plant-based diets are predominant. Encouraging the consumption and utilization of jute leaf in various forms (fresh, dried or processed) can help improve nutritional intake, reduce malnutrition and promote sustainable food systems.

RECOMMENDATIONS

The following recommendations are proffered:

1. Consumption of jute leaf (*Rama*) should be promoted as part of a balanced diet to enhance nutritional intake and improve public health, particularly in rural and low-income communities.
2. Food industries and nutrition agencies should explore ways of incorporating jute leaf into processed food products such as soups, sauces and dietary supplements to increase its accessibility and utilization as a low-cost nutrient source.
3. Government and agricultural institutions should support further research on the mineral and vitamin composition, medicinal properties, and large-scale cultivation of jute leaf to maximize its nutritional and economic potential.

REFERENCES

- Abubakar, A. & Muhammad, S. (2022). Climate variability and agricultural productivity in Sokoto State, Nigeria. *Journal of Environmental and Agricultural Studies*, *4*(2), 45–56.
- Adebayo, A. A., & Omodara, M. A. (2020). Nutritional evaluation of selected green leafy vegetables in Southwestern Nigeria. *Journal of Food Science and Nutrition*, *8*(4), 215–223. <https://doi.org/10.1002/fsn3.1345>
- Baiyeri, S. O., Adeniji, O. T., & Alli-Balogun, V. O. (2024). Assessment of the nutritional composition of the fruits of jute mallow (*Corchorus olitorius*). *Journal of Agriculture and Food Environment*, *11*(1), 1–7. Retrieved from https://www.jafedelsu.org/wp-content/uploads/2025/02/22_28-JAFE-11_1-Baiyeri-et-al.-2024-new-format-D.pdf
- Biswas, A., Dey, S., Li, D., Liu, Y., Zhang, J. & Huang, S. (2022). A comprehensive review of *Corchorus capsularis* and *Corchorus olitorius*: A source of nutrition, essential phytoconstituents and pharmacological activities. *Journal of Food Quality*, *1*, 1–12. <https://doi.org/10.1155/2022/8893842>
- Ezeh, C. O., Udeh, F. N., & Nwankwo, C. E. (2020). Comparative proximate and mineral analysis of selected Nigerian vegetables. *African Journal of Food Science*, *14*(3), 45–52. <https://doi.org/10.5897/AJFS2020.1924>
- National Population Commission (NPC). (2023). *Population estimates for Nigeria by states and gender*. Abuja: NPC.
- Oduse, A. O., Adeyemi, T. O., & Olagunju, R. A. (2019). Proximate and mineral composition of commonly consumed vegetables in Nigeria. *Nigerian Journal of Nutritional Sciences*, *40*(1), 56–63.
- Olaiya, C. O., Adegoke, A. A., & Ojo, O. F. (2021). Proximate composition and mineral content of commonly consumed vegetables in Nigeria. *Journal of Applied Sciences and Environmental Management*, *25*(2), 201–207. <https://doi.org/10.4314/jasem.v25i2.5>
- Oloye, D. A., & Agbede, J. O. (2022). Nutritional and phytochemical analysis of selected tropical vegetables. *International Journal of Nutrition and Food Sciences*, *11*(1), 12–20.

- Onwordi, C. T., Anjuwon, O. E., & Abodunde, S. M. (2022). Assessment of proximate composition and nutritional value of selected Nigerian vegetables. *International Journal of Food Research*, **9**(2), 34–42.
- Onyeike, E. N., & Acheru, G. N. (2019). Chemical composition of selected Nigerian leafy vegetables and their functional properties. *Food Chemistry*, **285**, 79–85. <https://doi.org/10.1016/j.foodchem.2019.01.074>
- Osei-Owusu, J., Kokro, K. B., Ofori, A., Apau, J., Dofuor, A. K., Vigbedor, B. Y., Aniagyei, A., Kwakye, R., Edusei, G., Antwi, B. Y., & Okyere, H. (2023). Evaluation of phytochemical, proximate, antioxidant, and anti-nutrient properties of *Corchorus olitorius*, *Solanum macrocarpon* and *Amaranthus cruentus* in Ghana. *International Journal of Biochemistry and Molecular Biology*, **14**(2), 17–24. Retrieved from <https://e-century.us/files/ijbmb/14/2/ijbmb0149285.pdf>
- Owoeye, Y. T. (2020). Proximate and mineral composition of *Corchorus olitorius* in response to fertilizer types. *Research Journal of Agriculture and Forestry Sciences*, **9**(3), 1–4. Retrieved from https://www.isca.me/AGRI_FORESTRY/Archive/v9/i3/1.ISCA-RJAFS-2020-026.pdf
- Usman, Y. B. (2021). Historical perspectives of the Sokoto Caliphate and its contemporary relevance. *Journal of African History and Culture*, **13**(1), 12–21.