PROXIMATE ANALYSIS AND TOTAL LYCOPENE LEVELS OF THREE CULTIVARS OF TOMATOES OBTAINED FROM KANO STATE, NIGERIA

BY

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A DISSERTATION SUBMITTED TO THE DEPARTMENT OF PURE AND INDUSTRIAL CHEMISTRY, FACULTY OF SCIENCE, BAYERO UNIVERSITY, KANO IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF SCIENCE (M.Sc) IN ANALYTICAL CHEMISTRY

NOVEMBER, 2016.

DECLARATION

I Mohammed Attahiru hereby declare that this work is a product of my own research efforts; undertaken under the supervision of Prof. A. A. Audu and has not been presented and will not be presented elsewhere for the award of a degree or certificate. All sources have been duly acknowledged.

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CERTIFICATION

This is to certify that the research work for this dissertation and subsequent preparation of this dissertation by Mohammed Attahiru with registration number (SPS/12/MCH/00002) were carried out under my supervision.

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APPROVAL

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ACKNOWLEDGEMENTS

I give my endless thanks to Allah (S.W.T) for blessing me with the opportunity to carry out this study to enrich my knowledge and capacity. May His endless blessing be upon His beloved messenger Prophet Muhammad, his progeny and his guided companions, also those who follow them in the right direction till the last day. Many thanks to my supervisor Prof. A. A. Audu for all the time spent with me in the laboratory, patience, and advice. The uncommon encouragement you gave me saw through difficult times.

I am grateful to my lecturers of Department Pure and Industrial Chemistry, Bayero University, Kano for the knowledge they impacted in me and other lecturers of the department who I was not opportune to be mentored by them; I thank you all. Also, I thank all my friends and extended families who gave contributions into my life directly or indirectly. I finally would like to thank my parents and siblings who always stood by me, who shared not only the pleasing but also the difficult moments. Daily mentioning of my M.Sc research in all your prayers was a source of inspiration. Thank you very much and may Allah bless you all. Above all, I am grateful to Allah (the Almighty), for his love, guide and protection over me, and for making this thesis a reality and a success. Alhamdulillah.

DEDICATION

This project is dedicated to Allah Almighty with praise, my parents and siblings with affection.

ABSTRACT

The study was conducted to determine the proximate composition of three cultivars of tomatoes and their lycopene levels as obtained from six local government areas of Kano State. Standard analytical methods were used in the analyses and the mean results were, lycopene 6.88, 6.88, 7.83 mg/100g, titratable acidity 0.15, 0.16, 0.15%, total soluble solids 8.36, 8.14, 8.25%, crude fiber 1.19, 1.23, 0.99%, vitamin C 3.73, 4.59, 4.34 mg/100g, crude protein 2.26, 2.23, 2.60%, ash content 0.18, 0.14, 0.14%, and moisture 90.75, 88.43, 84.14% for Roma VF, Ronita and UTC respectively. The proximate compositions were quite similar to values reported for most other cultivars. The mean lycopene values for Roma VF, Ronita and UTC in relation to ketchup were 61.87, 61.87, 70.41%; 17.70, 17.70, 20.14% for tomato paste and 97.59, 97.59, 111.06% for tomato juices respectively. The results have shown that these cultivars exhibit good potential for use industrially in the paste production as indicated by their high total soluble solids contents.

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CHAPTER ONE

1.0 Introduction

Vegetables are the major source of vitamins, crude fiber, protein, antioxidant and minerals though the protein content is usually poor. Vitamins, lycopene and minerals are the main regulator in metabolism in human (Robinson and Decker-Walker, 1997). Some of the vegetables are used in raw form as salad, stew and soup but most of them require cooking for the improvement of digestibility and palatability. Vegetable production has been adopted as a strategy for improving livelihood and alleviating the malnutrition by regularly eating fruit and green leafy vegetables (South pacific Foods, 1995).

Tomato (lycopersicon esculentum Mill.) is one of the most important edible and nutritious vegetable crops. It belongs to the family Solanaceae, and cultivated in almost all home gardens and also in the field for its adaptability to wide range of soils. It is widely cultivated in tropical, sub-tropical and temperate climates, and ranks third in terms of world vegetable production. Tomato being a climatic and perishable vegetable, has a very short shelf life, usually 2-3 weeks (ANON, 2002). Nutritionally, tomato is one of very important of vegetables that cannot be neglected in daily meals. Tomato is a source of vitamins A and C and contains lycopene, a powerful antioxidant which removes free radicals that interfere with normal cell growth and activity. Antioxidants help prevent diseases in plants, animals and humans. Lycopene is responsible for the characteristic deep red color of ripe tomatoes (Rodriguez-Amaya and Kimura, 2004; Collins *et al*., 2006). Physicochemical properties of tomato are among the important determinants of its consumer acceptability. Tomato contains a large quantity of water, calcium, and niacin all of which are of great importance in the metabolic activities of man. Cropping of

tomatoes during the wet and dry seasons contributes immensely to the national requirement but the bulk of production is from the dry season particularly in Northern States (South Pacific Foods, 1995). Poor tomato yield was attributed to non-development of flowers into fruits and found that only 50% of the flowers produced developed into fruits. Thus sink size was a limiting factor to fruit production in tomato. Tomato is currently a popular fruit vegetable in Nigeria, however, its production in Nigeria is low compared to those of the temperate zones due to differences in crop environmental conditions, lack of high yielding varieties and cultural practices applied to the crop on the field. Tomato is regarded as the most vital vegetable after onions and pepper. In ascertaining the quality of tomatoes, assessments of the levels of moisture, titratable acid, crude fiber, protein, ash, vitamin C, total soluble solid, and lycopene are usually needed (Adelana, 1975).

High fiber foods requires more chewing and may take longer to eat, thus potentially limiting the total energy intake. These qualities are believed to be involved in the control of energy balance and body weight. However, the strongest evidence to support fiber's role in weight management comes from studies that found an association between a fiber-rich diet and lower body mass index (BMI). Although evidence suggest that increased fiber intake results in increased satiety and decreased hunger (Howarth *et al.,* 2001). A decrease in effective activity Insulin-like growth factor-1(IGF-1) can be expected to retard cancer development and in some instances to slow cancer growth. The higher intakes of arginine and Pyrivugenic amino acids in vegetarians provides the protective effects of plant proteins against cardiovascular diseases and cancer (McCarty, 1997). High protein intakes have been implicated in chronic diseases such as obesity, cancer, coronary heart disease, renal stone and renal insufficiency (IOM, 2002). Most research studies examining the link between fiber and cancer have focused on colorectal cancer with

fewer studies on breast cancer. The relationship of fiber intake to colon cancer has been the subject of many investigations (Bingham *et al.,* 2003). The evidence for fiber's role in reducing risk of coronary heart disease (CHD) is strong enough that the recommended for fiber is based on the intake level observed to protect against CHD (IOM, 2002). The American Heart Association's 2006 Diet and Lifestyle Recommendations emphasized high-fiber foods, especially whole grain products, legumes, fruits and vegetables, as part of an overall dietary pattern to reduce the risk of heart disease in the general population and also prevent the rise in blood levels of triglycerides, a consequence often associated with low fat, high carbohydrate diet (Lichtenstein *et al.,* 2006; Obarzanek *et al.,* 2001). Dietary fiber is thought to play an important role in reducing the risk of diabetes and nutritionally managing the diseases by helping to normalize the glucose response and decrease insulin concentration and requirements. Higher intakes between 13-16 grams per day or greater of dietary fiber, especially cereal fiber has been associated with lower risk of type 2 diabetes and insulin sensitivity (Schulze *et al.,* 2004; Weickert *et al.,* 2006). The recommended level of dietary fiber is 14 g/100Kcal and one-half of grain intakes as whole grains are consistent with fiber and whole grain intakes goals set for the general population. Meals rich in fiber are processed more slowly by the body, provide more volume compared to lower fiber meals, and tend to produce a feeling of fullness with fewer calories (American Diabetes Association, 2006).

Severe deficiency of vitamin C causes scurvy. Symptoms appear when the serum level falls below 0.2 mg/dl. A total pool of less than 300 mg is associated with symptoms of scurvy while maximum body pools are limited to about 2 g. Several ascorbic acid deficiency symptoms including swollen and inflamed gums, loosening of teeth, dryness of mouth and eyes, loss of hair, and dry itching skin. These symptoms reflected the role of ascorbic acid in the maintenance

of collagen and blood vessel integrity. Scurvy is an acute or chronic disease characterized by hemorrhagic manifestations and abnormal osteoid and dentin formation. The psychological manifestations of scurvy include depression and hysteria. This potentially fatal condition can be prevented with as little as 10 mg ascorbic acid per day, an amount easily obtained through consumption of fresh fruits and vegetables (IOM, 2002).

Lycopene is an unsaturated acyclic carotenoid with eleven linear conjugated and two non-conjugated double bonds. The red color of certain fruits and vegetables such as tomato, red grapes, watermelon and red guava is due to the presence of lycopene (Stah and Sies, 1996).It occurs naturally in the *trans*- form and can be isomerized to mono-cis or poly-cis due to the exposure to high temperatures, light, oxygen, acids, catalyst and metal ions. Its chain structure with an extensive conjugated polyene system is important for its biological properties such as susceptibility to oxidative degradation (Shi *et al.*, 2002). It is a lipophilic compound with hydrophobic characteristics due to its acyclic structure and it is soluble in organic solvents such as chloroform, hexane, benzene, methylenechloride, acetone and petroleum ether (Stah and Sies, 1996).

1.1 Moisture Content

Moisture content of food is of great importance to every food processor as a number of biochemical reactions and physiological changes in food depend very much on the moisture content. To its even greater significance, is the effect of moisture on the stability and quality of foods. Therefore, moisture determination is one of the vital components of food evaluated in the laboratories. Water occurs in foods in at least three forms. A certain amount may be present as free water in the inter-regular spaces and within the pores of the material. Such water retains its

usual physical properties to serve as a dispersing agent for colloidal substances and as a solvent for crystalline compounds. Some part of the water is absorbed on the surface of macromolecular colloids (starches, pectins, cellulose and proteins). The water is closely associated with the absorbing macromolecules by forces of absorption, which are attributed to Van der waal forces or to hydrogen bond formation. Finally, some of the water is in bond form in combination with various substances, such as water of hydration. Several methods are available for the determination of moisture in foods and these include indirect distillation (drying), direct distillation, electrical moisture meters and chemical (Lees, 1971).

1.2 Titratable Acidity

Organic acids can dictate the dominant micro flora in foods. Many pathogenic and food spoilage microorganisms are unable to grow in high acids foods. The ratio of sugar, fructose and sucrose to acids gives an accurate prediction of tasteness for many high-acid foods. The Brix/acids ratio is usually a better predictor of flavor quality than Brix or acid alone. Acids tend to decrease with the maturity of vegetables and fruits, while sugar, sucrose and fructose content increases. Therefore, the Brix/acid ratio is often used as an index of fruit maturity. The ratio is often used as an index of fruit maturity. The ratio can also be affected by climate, variety and horticultural practices. The citric, lactic, tartaric and malic acids are the common acids in fruits and vegetables. Food acids are typically quantified by titration with a standard base. This process provides total acidity, commonly referred to as titratable acidity. Titratable acidity is such a determining factor in food quality and is one of the most frequently run analytical tests in the food industry. Although tests for many food components have changed along with advances in analytical technology, procedures for titratable acidity have not changed substantially in over 100 years. This attests to the simplicity and time-honored importance of the procedures.

These acids may act as nutrients, flavor components, flavor enhancers, gelling agents and chelate for certain destabilizing ions, suppressors of enzymatic browning, and reducing entities (Nielsen, 2002).

1.3 Crude Fiber

Dietary fiber is defined as lignin and plant polysaccharides that cannot be digested by enzymes. The major components of dietary fiber are cellulose, pectins, hemicelluloses, hydrocolloids, and lignin. The liberal ingestion of dietary fiber from variety of foods help prevent colon cancer, heart disease and it also assist to normalize blood lipids and thereby reduce cardiovascular disease. The introduction of fiber rich foods, including whole grains breads, cereals as well as fruits and vegetables, early in a child's life have been shown to promote acceptance and continued consumption of these foods later in life. Researches have shown that healthful foods may need to be introduced up to eight or ten times before the food are accepted ((Nielsen, 2002). The development of new fiber ingredients and improvements in food formulations have and will continue to improve the taste of fiber containing processed foods (Nielsen, 2002).

1.4 Crude Protein

Protein is the major component of body tissues and is an essential nutrient for growth. The body is in a dynamic state with protein and other nitrogenous compounds being degraded and re-synthesized continuously. More protein is turned over daily in the body than is ordinarily consumed in the diet. Proteins are large molecules made up of amino acids bonded together by peptide linkages. They provide the essential amino acids, which are the initial materials for tissue synthesis and consistent of tissue protein. Thus, it was often referred to as the "Currency" of protein nutrition and metabolism. Proteins are important for the formation of regulatory

compound, some hormones and all enzymes. Proteins defend the body against diseases and have unique conformations that could only be altered by denaturants such as heat, acid, alkali, 8M urea, 6M guanidine-HCl, organic solvent and detergents. The solubility as well as functionality of proteins could also be altered by naturants (Nielsen, 2002). The nature of proteins in tomatoes are two globulins, designated as α and β. The α-globulin being low in amino acid, while it is unusually high in the β-compound. It is of interest to note that these globulins are high in both argine and lysine. The β-globulin contains also an unusually large amount of histidine, but in the α-globulin the histidine content is low. Tomatoes have significantly higher levels of arginine and pyruvigenic amino acids glycine, alanine and serine (Krajcovicova-Kudlackova *et al.*, 2005).

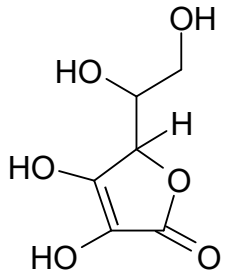
1.5 Ash Content

Ash refers to the inorganic residue remaining after either ignition or the complete oxidation of organic matter in a substance. Three major types of ashing are followed, dry ashing for the majority of samples, wet ashing (oxidation) for samples with high fat content such as meat and meat products, and low temperature plasma dry ashing for sample with volatile elemental contents. Most dry samples i.e vegetables, whole grain and cereals need no preparation while fresh vegetables need to be dried prior to ashing. Ash content may be of important factors for nutritional evaluation because certain foods are high in particular minerals which are indicated by high ash content. Usually a constant elemental content is observed for the ash of animal products, but that plant sources are variable (Nielsen, 2002).

1.6 Vitamin C

Vitamin C, with the chemical formula $C_6H_8O_6$ and a molecular weight of 176.12 g/mol is a very important constituent of tomatoes. This water soluble vitamin is important in forming collagen, a

protein that gives structure to bones, cartilage, muscle, and blood vessels. It also helps to maintain capillaries, teeth, and aids in the absorption of iron. Ascorbic acid, as a reducing agent maintains the enzyme, prolylhydroxylate, in an active form, by keeping the iron atom in a reduced state. The natural form of the vitamin C is the L- isomer. Vitamin C has demonstrated antiviral and antibacterial effects in vitro and plays a role in microsomal hydroxylation reactions that catalyse cholesterol catabolism and detoxification of xenobiotic chemicals and in the metabolism of neutransmitters (Ginter, 1982; Sies and Stahl, 1995; Levine *et al*., 1995). Ascorbic acid is widely distributed in nature, mostly rich in fresh fruits and leafy vegetables such as guava, mango, papaya, tomatoes, spinach e.t.c (Tee *et al.,* 1997). Daily recommended intakes of ascorbic acid are 210 to 280 mg, depending on food content factor. Ascorbic acid is the least stable of all vitamins and is easily destroyed during processing and storage. Exposure to oxygen, prolonged heating in the presence of oxygen, contact with mineral (iron and copper) and exposure to light are destructive to the ascorbic acid content of foods (Levine *et al.,* 1999). A fresh ripe tomato fruit weighing 100 g contains about 10.4-44.6 mg ascorbic acid. Vitamin C content of tomatoes differs with cultural practices, cultivars and postharvest handling practices (Nielsen, 2002).

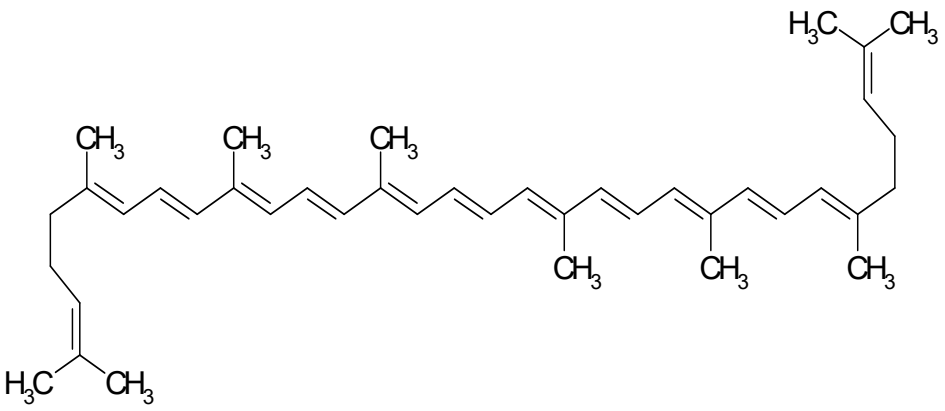


$C_6H_8O_6$

Structure of Vitamin C (Ascorbic acid)

1.7 Lycopene

Lycopene as the red colored pigment is abundantly found in red colored fruits and vegetables such as tomato, papaya, pink grapefruit, pink guava and watermelon. It is a hydrocarbon with extended conjugated double bond system which is an important feature in the carotenoids responsible for their attractive colors and thus forms the light absorbing chromophore. The existence of visible color in these compounds is due to the presence of at least seven conjugated double bonds. The greater the number of conjugated double bonds, the longer the wavelength value for maximum absorption (Rodriguez-Amaya and Kimura, 2004). This natural colored pigment from plants have drawn great attention worldwide. These pigments display various colors and are made up of different phytochemicals commonly found in food such as orange (β-carotene), yellowish-green (lutein), green (chlorophyll), and blue-purple (anthocyanin) (Mortensen, 2006). Lycopene is one of the popular pigments highly accepted by food industry as a food additive and also for its health benefits. As a red colorant and antioxidant agent, the demand for lycopene is still increasing. Accordingly, the total world consumption of lycopene was tripled to 15,000 tons in 2004 compared to 5000 tons in 1995 (Mortensen, 2006). This has made it necessary for alternative sources for the production of natural lycopene. Previously, *in vitro* and *in vivo* studies exhibited that lycopene has a beneficial role in chronic diseases such as cardiovascular, atherosclerosis, cancer and neurodegenerative disorders. The importance of natural food additives is given more attention due to an extensive use of the natural ingredients rather than synthetic compounds in food, cosmetics and pharmaceuticals. Meanwhile, the prices of raw materials are increasing and their availability is decreasing (Mortensen, 2006).



$C_{40}H_{56}$

Structure of Lycopene

1.7.1 Lycopene Absorption

As a fat soluble compound, lycopene has a similar absorption as dietary fat. In the stomach and duodenum, lycopene will separate from the food matrix and subsequently dissolve in the lipid phase (Krinsky and Johnson, 2005). Prior to absorption, the lipid phase will form droplets, resulting from the reaction with bile salts and pancreatic lipases. Then, it enters the duodenum and appears as the multi-lamellar lipid vesicles (Clinton, 1998). Finally, the lipid vesicles will absorb it into the small intestine by passive or diffusion process (Krinsky and Johnson, 2005). The absorption of lycopene was reported to be lower compared to other carotenoids base on an *in vitro* study using the Caco-2 cell line (During and Harrison, 2004). However, there are many factors that might affect the absorption of lycopene. The degree of lycopene release from the food matrix into the digestive tract was lowered when the indigestible fraction increases (Goni et al., 2006). High fibers diets will reduce the uptake of lycopene and decrease lycopene adsorption whereby lycopene supplemented together with different dietary fibers has resulted in the reduction of plasma lycopene for more than 40% (Riedl *et al.,* 1999). The bio-accessibility of lycopene in the intestine was higher in the large intestine (57%) than the small intestine (40%),

but the potential for lycopene absorption in the large intestine is negligible (Goñi *et al.,* 2006). Furthermore, an *in vitro* study using Caco-2 cells showed that the uptake of *cis*-lycopene was significantly greater than the trans- isomer (Failla *et al.*, 2008). Thus, cis-isomers have higher bioavailability than *trans*-isomers. The nature of the human body is believed to cause the isomerization of lycopene along the digestive tract as 60% of cis-lycopene isomers occurred in human plasma, even though the only consumption of the lycopene rich food consisted of all *trans* lycopene (>90%). An *in vivo* study also explained that the acidic condition in gastric medium will enhance isomerization of the all *trans*-lycopene to cis-isomers (Richelle *et al.,* 2002). Food processing is one of the factors which can affect the bioavailability of lycopene, and thus increase absorption. The distribution of lycopene in human organs and plasma has been reported by Erdman (2005), where higher concentrations of lycopene are found in the liver, adrenal and reproductive tissues than in other tissues. A review by Mortensen, (2006) noted about the same level of lycopene concentrations in human tissues but was not detectable in brainstem tissue.

1.7.2 Interaction of Lycopene with Other Antioxidants

The combinations of lycopene and other antioxidants such as vitamin C, vitamin E and β-carotene has exhibited higher scavenging activity on 2,2-diphenyl-1-picrylhydrazyl(DPPH) radical than their individual antioxidant activity (Cantrell *et al*., 2003). Besides, lycopene combined with other antioxidants also gave a better inhibiting effect towards dienehydroperoxides produced from linoleic methyl ester with 2,2'-azobis(2,4-dimethylvaleronitrile) (AMVN) induced oxidation (Liu *et al*., 2007). Lycopene was also reported to help in repairing the vitamin E radical.

Previously, lycopene was reported to react effectively with vitamin E radical in the lipophilic compartment (Truscott, 1996). Inversely, their reaction with the hydrophilic vitamin C was expected to be less effective. Yeum *et al.*, (2004) had suggested a model for the synergistic interactions among the antioxidants located in the hydrophilic and lipophilic compartments of plasma. Besides, there might be lycopene-carotenoid interaction in biological system. Lycopene is the strongest reducing agent and able to reduce the radical cations of lutein and zeaxanthin, but not β-carotene (Liu *et al*., 2007). Lycopene in combination with other antioxidants such as vitamins E and C, polyphenols and other carotenoids have wide potential for human health (Shixian *et al*., 2005). A recent formulation of antioxidant mixtures in the development of nutritional products has been in favors for their health benefits (Castro *et al*., 2005).

1.7.3 Other Health Benefits and Safety Aspect

Lycopene have health benefit effects as in the improvement of other disease conditions. Treatment of lycopene (1, 2 and 4 mg/kg) in streptozotocin-induced diabetic rats has significantly attenuated cognitive deficit, increased acetyl cholinesterase activity, oxidative-nitrosative stress and inflammation (Kuhad *et al*., 2008). Akbaraly *et al.,* (2007) also suggested that low plasma lycopene levels could contribute to cognitive impairment. Dietary supplementation or adequate intake of lycopene and vitamin A rich foods may therefore be beneficial in asthmatic and rheumatoid arthritis, the safety aspect of bioactive compounds in products has been received much attention from food scientists to avoid any side effects. Either synthetic lycopene or from natural sources have been reported to be safe (Generally Recognized as Safe, GRAS) when used in as food additive (Thrumbo, 2005).

Toxicity studies have demonstrated that usage of synthetic lycopene in rats and rabbits will cause a direct maternal or developmental toxicity at high dosages 2 or 3 g/kg/day. Hence, the safest

observed level for lycopene intake is up to 75 mg/day (Christian *et al*., 2003). Thrumbo, 2005 reviewed no adverse effects were found from animal consumption of dietary or formulated lycopene up to 3 g/kg per day. However, only 7–10% of lycopene will be absorbed and 50% of it will be excreted through the faeces and urine while the rest remains in the body.

1.7.4 Thermal Effect on Lycopene Content

Thermal processing is used in the food industry to preserve food products and maintain the nutritional quality. Traditionally, sun drying is the easiest and cheapest technique, and it is commonly used in poor countries or small and medium industries for food preservation. However the disadvantages are food processing enhances lycopene destruction and increases the process duration (Rodriguez-Amaya and Kimura, 2004). The alternative method is oven drying of the food materials. However, lycopene is a heat sensitive compound and degraded when exposed to heat. The temperature is an important factor for thermal processing in order to remove the moisture with minimum destruction of lycopene and other nutrients. Besides, heating of lycopene in oil bath at different times had been shown to enhance the degradation of lycopene when increased in temperature from 50 to 150°C (Lee and Chen, 2002). Chang *et al.,* (2006) reported that thermal processing enhanced lycopene isomerization and increased lycopene extracting ability by breaking down the cell walls and weakening the interaction between lycopene and the tissue matrix of samples. Hot air drying at 80°C for the first 2 hr plus shifting the drying temperature to 60°C for another 6 hr were reported to yield higher lycopene content as compared to fresh and freeze dried sample. Besides, treatment of tomatoes with forced air drying at 42°C for 48 hr has shown a significant increase in lycopene contents (Kerkhofs *et al*., 2005). In contrast, semi-drying method for drying of tomatoes using a forced air drying at 42°C for 8 hr showed a significant decrease in lycopene content (Toor and Savage, 2006).

Lycopene stability is always considered by researchers to ensure that lycopene is able to be preserved until utilization. A study done by Shi *et al.,*(1999) showed that higher levels of lycopene *cis*-isomers, lower total lycopene and *trans* isomers were obtained from tomato using air drying method at 95°C for 6–10 hr as compared to the vacuum drying and osmotic treatment methods. However, lycopene and other lipophilic antioxidant compounds in tomato pulps have high stability after air drying (Giovanelli *et al.*, 2002). In air drying processing, total lycopene was affected by isomerization and oxidation, while there was a significant increase in cis-isomers and decreased in *trans*-isomers when the temperature and processing time increased (Shi *et al.,* 1999). Thus, the duration of thermal process also play an important role in lycopene accessibility analysis. Besides, Hsu (2008) revealed that hot-break processing (92°C for 2 min) and cold-break processing (60°C for 2 min) did not enhance the lycopene extractability and degradation. It was probably due to insufficient temperature and time.

Moisture content is closely related to lycopene degradation. When moisture is retained, the water soluble compounds will act as catalyst during lycopene degradation. Goula *et al.,* (2006) reported that degradation of lycopene in tomato pulp was reduced when the moisture content decreased from 95% to 55%, with a minimum degradation rate in between 50 to 55% of moisture content. Thus, the catalytic effect of lycopene degradation will be eliminated when the moisture is removed.

1.8 Aim

The aim of the study is to undertake a comparative analysis of the proximate and lycopene contents of three varieties of tomatoes commonly produced in Kano.

1.8.1 Objectives

a. To undertake the proximate analysis of the three varieties of tomatoes.

b. To determine the lycopene and vitamin C contents of the three varieties.

c. To compare the results with international standards.

1.8.2 Scope of the Research

The study will cover sampling of tomatoes varieties from Yan kaba and Janguza markets, Kano State Nigeria. The samples were Roma VF, Ronita and UTC which was identified in Botany in Biology Department and Agronomy Department in Faculty of Agriculture. Analysis will be carried out to ascertain the proximate levels of some key factors as well as the lycopene levels of the three varieties.

1.8.3 Justification of the Study

It is on record that a lot of research has been done on proximate analysis and total lycopene levels of different varieties of tomatoes in Nigeria and other part of the world. Adebooye *et al.*, (2006) conducted a research to determine how tomato quality were affected by phosphorus (P) nutrition of the three varieties (Ibadan local, Roma VF, and NHLe158-13) in Ibadan Oyo State. Adubofuor *et al.,* (2010) conducted a research on comparative study related to the physicochemical properties and sensory qualities of tomato juice and cocktail juice produced from oranges, tomatoes and carrots in Ghana. Adebooye and Oloyede, (2005) conducted research on the effects of season on growth, fruit yield and nutrient profile of two landraces of trichosanthes cucumerina L. Malami and Mohammed, (2013) conducted research on the effect of heat treatment on the lycopene content of tomato puree in Kano State Nigeria.

Generally, few cases were reported on such analyses from the North-Western part of Nigeria especially Kano state. The present research is therefore conducted to evaluate the proximate parameters and lycopene content of three varieties of tomatoes (Roma VF, Ronita and UTC) produced in the area for comparison with established standards.

CHAPTER TWO

2.0 Literature Review

2.1 Proximate Analysis

Adebooye *et al.*, (2006) reported on the quality of three varieties of tomato (Lycopersicon esculentum (L.) Mill) as affected by Phosphorus Rates. The studies were conducted to determine how tomato quality were affected by phosphorus (P) nutrition of the three varieties Ibadan local, Roma VF, and NHLe158-13. The phosphorus level had significant effect on pH, total soluble solids (TSS), Lycopene, ascorbic acid, crude fiber and crude protein content of tomato fruits with optimum values recorded. The pH, moisture content and lycopene contents were significantly higher during the early season than late season while TSS, ascorbic acid, crude fiber and crude protein content were significantly higher in late season than early season. The season had no effect significant effect on ether extract content. Suleiman *et al*., (2011) reported suitability of some tomato (lycopersicon esculentum Mill.) genotypes so as to evaluate the quality of some newly breed Sudanese tomato genotypes at the National Institute for Promotion of Horticultural Exports- Gezira University. The proximate chemical analysis revealed that moisture content of the different fresh tomato samples ranged between 92% and 94%, also notable differences were observed in protein, and ash contents.

Adubofuor *et al.,* (2010) carried out a comparative study related to the physicochemical properties and sensory qualities of tomato juice and cocktail juice produced from oranges, tomatoes and carrots. Two varieties of tomatoes, known as the Bolga and Ashanti varieties were processed into juice using the gravity method. Analysis such as total soluble solids, titratable acidity, lycopene, vitamins A and C were carried out. Sensory analysis on both juices indicated

that the Bolga variety was significantly preferred. Gharezi *et al.,* (2012) reported the effect of postharvest treatment on stored cherry tomatoes and observed physicochemical changes recorded in relation to days of storage. Significant differences were observed among the chemical parameters due to various postharvest treatments and storage condition. Adebooye and Oloyede, (2005) reported effects of season on growth, fruit yield and nutrient profile of two landraces of trichosanthes cucumerina L. The studies were conducted in the early and late seasons to determine the effects of season on growth, fruit yield and nutrient profile of two landraces (variant I & II) of snake tomatoes. The early season crop had significantly higher ascorbic acid composition (25.2 mg/100g) than the late season (18.0 mg\100g) while late season crop had significantly higher ether extract, crude fiber, and total sugar compared to the early season crop. The anti-nutritional oxalate and crude protein compositions were neither affected by variant nor season nor their interaction.

Owusu *et al.,* (2012) reported the effect of drying methods on physicochemical properties of pretreated tomato (Lycopersicon esculentum mill.) slices. The effects of drying methods on physicochemical properties using white vinegar and sodium chloride/white vinegar mixture, pretreated tomato slices were studied at the drying temperatures of 45^{o}C and 55^{o}C. Significantly, higher moisture was removed in the treated samples than the control one. The dried tomato slices had higher titratable acidity but lower total soluble solids compared to the fresh sample. Kolawole *et al.,* (2010) reported the drying effect of varying light frequencies on the proximate and microbial composition of tomato. Tomato samples we dried at different frequencies of light using clothes of different colors with wooden drying fabrication. The proximate composition and microbial count of the tomato fruits were determined. Results showed that temperature and relative humidity of the environment affected the rate of drying tomato as well as the growth of

spoilage organisms in the fruits. Tomato dried with light green color frequency had the highest amount of protein and carbohydrate (13.78% and 51.37%, respectively), dark blue color had the highest amount of fat (0.97%), and light blue color had the highest fibre (25.30%), while the highest percentage of ash content was observed in black color (54.30%). All data from the color frequencies were significantly different (higher or lower) from the control at ($p<0.05$). Ajayi and Oderinde, (2013) reported effects of different home storage conditions and preservation on some chemical constituents of tomato (lycopersicon esculentum). The experiment involved three postharvest treatments comprising of fruits without preservative used as the control, fruits preserved with groundnut oil and fruit preserved with salt. The tomato samples were evaluated for changes in total soluble solids, pH, sugar, and Salt content, ascorbic acid, and ash contents. Results obtained indicated that total soluble solid, pH, sugar, salt, ascorbic acid and ash contents of fresh and dehydrated sample decreased with different storage conditions while their acidity showed an increase. Powdered tomato samples were found to withstand long term storage and their chemical constituents showed minimal change over the period of the study. The results revealed that preservation by powdering technique proved to be a better technique and worthy of further industrial investigation.

Teka, (2013) reported analysis of the effect of maturity stage on the post-harvest biochemical quality characteristics of tomato (lycopersicon esculentum MILL.). Results indicated that maturity stage at harvest significantly ($p<0.05$) affected quality attributes of tomato fruit. The highest value of pH (4.63) and TA (3.98%) was recorded in full ripe and mature green stage respectively. The increase in pH was paralleled by a decrease in titratable acidity. The highest value of total sugar (6.40%), reducing sugar (9.00%) and TSS (6.57Brix) were shown by full ripe tomatoes. As tomatoes mature, there is generally an increase in sugar content and decrease in

acidity. The pH, percentage of total sugar, reducing sugar, TSS was found to increase with advances of maturity stages at harvest. Alvi *et al.,* (2003) reported effect of peeling and cooking on nutrients in vegetables. The four vegetables (brinjal, bitter gourd, colocasia and tomato) were subjected for total protein, crude fiber, ash content and ascorbic acids in raw peeled, raw cooked and peeled cooked. Four minerals reduced significantly in both peeling and cooking especially in peeled cooking. Vitamins losses were highly significant in both peeling and cooking. Ndigwe *et al.,* (2012) reported the variations in physicochemical and sensory qualities of canned unpeeled halved tomatoes as influenced by cultivar, soak treatment and brine composition of two commonly consumed tomato cultivars (Ibadan-local and Roma VF) and their physicochemical and sensory qualities after thermal processing under various conditions were evaluated. Fresh Ibadan-local had higher titratable acidity (0.66%) while Roma VF had higher ascorbic acid (23.22 mg/100g), however total soluble solids, pH, total solids and lycopene were not significantly different ($p<0.05$). The dried weight and pH of canned Roma VF halves were 91.71% and 4.82 respectively, while corresponding halves for canned Ibadan-local were 79.25% and 4.94. The tomato halves canned in 0.1% NaCl brine had lower dried weight (77.67%), total solids (4.94%), titratable acidity (0.26%) and ascorbic acid values (91.8%, 5.25%, 0.31% and 8.93 mg/100g respectively) obtained from tomato halves processed in combined brine solution 0.1% $CaCl_2$.

Onifade *et al.,* (2013) reported some physical properties and thin layer drying characteristics of local varieties of tomatoes (lycopersicon lycopersicum). The quality of oven and sun dried products were analysed for nutritional contents (protein, crude fiber, ascorbic acid and carotene) and antioxidant (lycopene). The nutritional values of oven dried products such as protein (1.51%), ascorbic acid (17.06 mg/100g), crude fiber (2.25%), carotene (0.46 mg/100), phenol

(14.18 mg/100g) and lycopene 12.95 mg/100) while the values of sun dried products were 0.52%, 11.75 mg/100, 0.93%, 0.14 mg/100, 6.91 mg/100 and 5.91 mg/100 respectively. The statistical analysis shows that the result were statistically significant ($p<0.05$). Quartey *et al.,* (2012) reported the induced mutations for improved lycopene, total anti-oxidant properties and other quality factors in wild tomato (Solanum pimpinellifolium L). Five gamma radiation induced variant line of wild tomato, selected in the M_3 generation following mutagenic treatment of seeds using three doses (150, 300, & 450 GY, respectively) of gamma radiation from a Co-60 gamma source, were analysed for lycopene, total antioxidant properties, total soluble solids and pH. Fruits of variant line recorded high lycopene, total antioxidant, total soluble solids and lowest pH values. The study indicated that wild tomato has immense nutritional properties which can be further improved through mutation breeding. Bicanic *et al.,* (2013) reported rapid, accurate, and direct determination of total lycopene content in tomato paste. The analysis of lycopene in tomato paste can be carried out using HPLC and Spectrophotometry, or by evaluating the color. The concentration of lycopene in tomato paste ranged between 25-150 mg/100g product. Nunoo *et al.,* (2014) reported characterization of some physicochemical properties of F5 breeding lines of tomatoes. The work was done to evaluate the physicochemical properties of selected lines. The Vitamin C content was observed to be high in wosowoso (78.86 mg/100g) and least being T_{14} (20.83 mg/100g) and among the various lines, the highest total titratable acidity was recorded in Roma, T_{11} (1.18%) while lowest (0.55%). Most of the generation lines performed better than their parents and thus can be selected for further breeding work.

Znidarcic *et al.,* (2010) reported on the influence of post-harvest temperatures on physicochemical quality of tomatoes (Lycopersicon esculentum Mill.). There were slight

changes in soluble solids and titratable acids content during storage period. Although soluble solids increased slightly over storage period. The titratable acidity, tended to be lower at 5ºC with significant difference observed only on day 14 of storage. The results showed that lower temperature does not significantly reduce vitamin C content in comparison with higher temperature, with the exception on day 7 of storage. Salunkhe *et al.*, (1974) reported that total soluble solids content increases with fruit maturity through biosynthesis process or degradation of polysaccharides. Olakojo and Adetula, (2014) reported the comparison of qualitative and quantitative traits of some advanced breeding lines of tomato (Lycopersicon esculentum L). Significant differences exist in properties such as percentage titratable acid, organic acids, sugars and dry matter contents. Titratable acid is highly and positively correlated with dry matter content, citric acid and malic acid, while malic acid among others was negatively and significantly correlated with fructose, glucose and pH.

2.2 Analysis of Lycopene

Ordonez-Santos and Ledezma-Realpe, (2013) reported lycopene concentration and physicochemical properties of tropical fruits. The study was to evaluate the lycopene concentration and physico-chemical properties of ripe tropical fruits for immediate consumption. Chonto tomatoes had greater lycopene contents than Milano or Long Life Milano tomatoes, 107 as against 89, 58 µg/g fresh weight respectively ($p<0.001$). Milano tomato presented the best physicochemical properties than other fruits. Wawrzyniak *et al.,* (2005) reported lycopene content of selected foods available on the Polish market and estimated its intakes. The lycopene content of fresh tomatoes ranged from 1.21 to 6.43 mg/100g, the average content of tomato paste was 38.88 mg/100g, of ketchups (11.12 mg/100g), and of tomato juices (7.05 mg/100g).

Lycopene intake was estimated at 1-93 mg/person/day. The main sources of lycopene were fresh tomatoes which contributed 52.2% of the total amount of this carotenoid in the diet.

Malami and Mohammed, (2013) reported effect of heat treatment on the lycopene content of tomato puree. The results showed that lycopene was relatively stable during thermal treatment and however, the result suggested that thermal processes might break down cell walls and enhance the release of lycopene from the tomato matrix. Adedeji and Ajayi, (2012) reported improvement of lycopene extraction with polygalacturonase and cellulose from tomato fruit (lycopersicon esculentum Mill.) deteriorated by Aspergillus Niger. Freshly ripe tomato fruits of the Roma VF and Ibadan local varieties were allowed to deteriorate after infection with a 96 hr old culture of Aspergillus Niger. The yield of lycopene was 45.25 mg/kg and 45.86 mg/kg for enzymes extracted from the Roma VF and Ibadan local varieties of tomato respectively. Barrette and Garcia, (2006) reported assessing lycopene content in California processing tomatoes. Growing interest in the potential health protective role of lycopene is bringing attention to the content of lycopene in tomatoes (55-181 mg/kg) was observed in juice prepared from selected cultivars of tomatoes grown in nine California countries. An evaluation of nine processing tomato cultivars harvested in one season on four separate dates indicated that lycopene concentration of tomatoes decreases with maturation on the plant. Lycopene concentration of tomatoes is dependent on the growing season, location, cultivar and maturity. Unlu *et al.*, 2007 reported that the heating of tomato sauce purposely to induce isomerization of all trans-lycopene to cis-isomers caused increased bioavailability of lycopene.

Furthermore, *in vitro* study showed sun dried tomatoes gave the highest bioavailabiliy of lycopene as compared to fresh and canned tomatoes (Karakaya and Yilmaz, 2007). Ahuja *et al*., 2006 reported that ingestion of lycopene together with oil would also help in increasing its

bioavailability. Fielding *et al.,* (2005) reported that tomatoes cooked with olive oil greatly increase the lycopene level in human plasma as compared to the tomatoes cooked without olive oil.

CHAPTER THREE

3.0 Materials and Methods

3.1 Reagents

All reagents used were of analytical grade without further purification. These include acetone, n-hexane, and ethanol obtained from Sigma Aldrich (Maldrid, Spain).

3.2 Apparatus

All the glassware used in this work were washed thoroughly with warm detergent solutions, rinsed with distilled water and oven dried at 100^{o}C. All the weighings were done using electric weighing balance AB54 model. The lycopene was determined using JENWAY (6405) UV-visible spectrophotometer. Protein content was determined using Micro-kjeldahl and steam distillation. Crude fiber was determined using muffle furnance. Vitamin C was determined using titration method.

3.3 Methodology

3.3.1 Sample Collection and Pretreatment

Three varieties of tomatoes used for the study were randomly purchased from Yankaba and Janguza vegetable markets, Kano metropolis and was transported to the Chemistry laboratory in black plastic bags. The samples were rinsed with tap water then by distilled water and stored in black polythene bags separately in 2L plastic bucket with identification.

3.3.2 Determination of Moisture Content

Ten grams (10 g) of each cultivar was weighed into petri-dish and dried in an oven at 105°C until the weight of the petri-dish with its content remained constant. The content was then cooled in the desiccator (Gharezi *et al*., 2012).

$$\text{moisture content (\%)} = \frac{\text{initial weight } (w_i) - \text{final weight } (w_f)}{\text{weight of sample } (w_s)} \times 100$$

3.3.3 Determination of Total Soluble Solids

Ten grams (10 g) of homogenized tomato sample were weighed into 50 cm^3 of centrifuge vials and span at 300 rpm for 10 min inside tube. Two centimeter cubic (2 cm^3) of the supernatant was measured into pre-weighed glass Petri-dishes and the weight taken before drying in an oven at a temperature of 60°C for 17 hour. Samples were weighed after oven drying and the results expressed in percentages. All measurements were done in triplicate (Quartey *et al*., 2012).

$$\text{TSS } \left(\frac{mg}{cm^3}\right) = \frac{WR \times 100}{Vs}$$

Where WR is differences in the weight (mg)

Vs is volume of sample filtered used (cm^3)

3.3.4 Crude Fiber Determination

One hundred grams (100 g) of sample was weighed into a beaker and 50 cm^3 of H_2SO_4 (1.25%) was added. The mixture was then boiled for 1 hr, filtered and the residue was then boiled with amount of the water to remove the excess acid. Hot 50 cm^3 of NaOH (1.25%) was added and the mixture was boiled for 1 hr. It was then filtered, washed with amount of the water until is free

from alkali. The residue was then rinsed with acetone and dried in oven at 110ºC for 2 hr and the weight was then recorded. The dried residue was ashed in muffle furnace at 600ºC for 3 hr, cooled in a desiccator and weighed. The crude fiber content was calculated by difference (AOAC, 2005).

$$\text{crudefiber (\%)} = \frac{W_2 - W_3}{W_1} \times 100$$

Where W_2 – weight of crucible with residue

W_3- weight of crucible with Ash content

W_1- weight of crucible with fresh sample

3.3.4.1 Preparation of 1.25% H_2SO_4

1.25 cm^3 of H_2SO_4 was dissolved in 98.75 cm^3 of water.

3.3.4.2 Preparation of 1.25% NaOH

1.25 g of NaOH was dissolved in 98.75 $cm^3$of water.

3.3.5 Crude Protein Determination

The 0.2 g of sample was weighed into the digestion tube. 0.8 g of catalyst mixture was added (0.7 g sodium sulphate, 0.06 g copper sulphate, and 0.04 g mercury (II) oxide red). Fifteen centimeter cubic (15 cm^3) of Conc. Sulphuric acid was then added and the tube swirled gently until the mixture was thoroughly mixed. The mixture was heated cautiously for 2 hr until the solution became clear and 15 cm^3 of 40% NaOH was then added. The mixture was allowed to cool and then transferred into 100 cm^3 volumetric flasks and diluted to mark with distilled water. Ten centimeter cubic (10 cm^3) of 2% boric acid was measured into 100 cm^3 Erlenmeyer flask

and 1-2 drop of Methyl red indicator was added to 10 cm^3 of digested aliquot was then transferred into distillation apparatus and it was then distilled into the boric/indicator for 15 min. The distillate was then titrated with 0.025M HCl to a pink end point and the burette reading was taken (titre value), (AOAC, 1990).

$$\%N = (0.014(\frac{MeN}{100}\ g) \times \text{titre value} \times \text{volume of digest } (100\ cm^3) \times \text{molarity ofacid } (0.025M)/(\text{weight of sample}(0.2\ g) \times \text{volume ofaliquot used}(10\ cm^3) \times 100$$

3.3.5.1 Preparation of 2% Boric Acid

2 cm^3 of Boric acid was dissolved 98 cm^3 of water and was shaken to have a homogeneous solution.

3.3.5.2 Preparation of 40% NaOH

Forty gram (40 g) of NaOH was dissolved in 60 cm^3 of water and then made up to mark.

3.3.6 Determination of Titratable Acidity

Ten centimeter cubic (10 cm^3) of filtered juice was diluted with 50 cm^3 of water. Ten centimeter cubic (10 cm^3) aliquot was taken from this sample and titrated with 0.1M NaOH using phenolphthalein indicator (2-3 drops). The appearance of light pink color was marked as the end point and acidity value was computed (Gharezi *et al.*, 2012).

$$\%\ \text{acid} = \frac{\text{titre value } \times \text{ molarity} \times M_{eq.}\text{wt of acid}}{\text{volume of sample}} \times 100$$

Where M_{eq} is milli equivalent

3.3.6.1 Preparation of 500 cm^3 of 0.1M $NaOH_{(aq)}$ Solution

$$g = \frac{0.1M \times MM_{NaOH} \times 500cm^3}{1000}$$

MM_{NaOHaq} = 40 g/mol

$$= \frac{0.1 \times 40 \times 500}{1000}$$

$$= 2\ g$$

2 g of NaOH is needed to prepare 500 cm^3 of 0.1M.

3.3.7 Determination of Ash Content

Two gram (2 g) of the dried tomato sample was placed in a porcelain crucible and ashed in a muffle furnace at 600ºC for three hours (Owusu *et al.,* 2012).

$$\%\ ash = \frac{\text{weight of crucible after ash } (W_3) - \text{weight of empty crucible } (W_1)}{\text{weight of sample } (W_2)} \times 100$$

3.3.8 Determination of Vitamin C

Five centimeter cubic (5 cm^3) of sample plus 1 cm^3 of acetic acid was titrated with the indophenols dye solution until a faint pink color persisted for at least 15 sec. Five centimeter cubic (5 cm^3) of standard ascorbic acid was titrated with the indophenols' (dye solution) until a faint pink color persisted as in the above. These were carried out in triplicate and the volumes of indophenols used were used to calculate the vitamin C levels in the standard and as well as the samples (AOAC, 1994).

$$\text{VitaminC}\ (\frac{\text{mg}}{100\text{g}}) = \frac{\text{T} \times \text{concentration of standard}\ (\frac{2\text{mg}}{\text{dl}})}{\text{S (titre value)}}$$

Where T is titre value for the sample, S = standard titre value.

3.3.9 Extraction of Lycopene

One hundred grams (100 g) sample was ground to a homogeneous puree using an electric tissue blender and was transferred into 250 cm^3 beaker. Fifty centimeter cubic (50 cm^3) hexane-acetone-ethanol solution (2:1:1 v/v/v) was added into the beaker. It was shaken for 15 min on a electric shaker. Thereafter, 3 cm^3 of distilled water was added and the sample was shaken for another 5 min. The solution was transferred into 250 cm^3separatory funnel and allowed to stand for 5 min to enable phase separation. The upper layer (hexane) was then collected into an amber screw (amber bottle) vials and used for the Spectrophotometric analysis**.** An aliquot of the hexane extract was then transferred into a 1 cm^3 quartz cuvette and the absorbance taken at 503 nm against the solvent-blank using JENWAY (6405) UV-Visible spectrophotometer. The lycopene content of each sample was then estimated by a relation (Fish *et al.,* 2002).

$$\text{Lycopene (mg/ Kg tissue)} = \frac{A_{503nm}}{17.2\times10^4\backslash M\backslash cm} \times \frac{536.6g}{\text{Mole}} \times \frac{1L}{10^3 cm^3} \times \frac{10^3 mg}{1g} \times \frac{10 cm^3}{\text{Kg tissue}}$$

$$= \frac{A_{503nm}\ \text{x}\ 0.0312}{\text{Kg tissue}}$$

$$\text{Lycopene (mg/g tissue)} = \frac{A_{503nm} \times 31.2}{\text{g tissue}}$$

Where 17.2×10^4 is the molecular extinction coefficient of lycopene at 503 nm (Fish *et al*., 2002).

CHAPTER FOUR

4.0 Results and Discussion

4.1 Moisture Content

Fig. 4.1 shows the levels of moisture content in the three cultivars with the average levels for Roma VF, Ronita, and UTC as 90.75, 88.43, and 84.15% respectively. The results have shown that the moisture content is dependent on the cultivar. Roma VF from Gwale has the highest value followed by Ronita from Gwale. Ronita and Roma VF from Gwarzo and Karaye have close values of moisture content while UTC from Gwarzo has the least of all the cultivars. Apart from Dawakin Tofa where UTC showed higher moisture content, there is a continuous trend in the moisture distribution in the cultivars in relation to the location of cultivation. Various values have been previously reported for tomatoes, the moisture contents of Roma VF and UTC of this study were close to those of Oko-ibom and Asiegbu, (2007) 88.19%, and Adubofuor *et al.,*(2010) 90.67%, but higher than those of Adebooye *et al.,* (2006) 78.56% which might be due to environmental factor and variety. Since foods with low moisture content have longer shelf life compared to the one with high moisture contents, thus UTC have relatively longer shelf-life compared with Roma VF and Ronita.

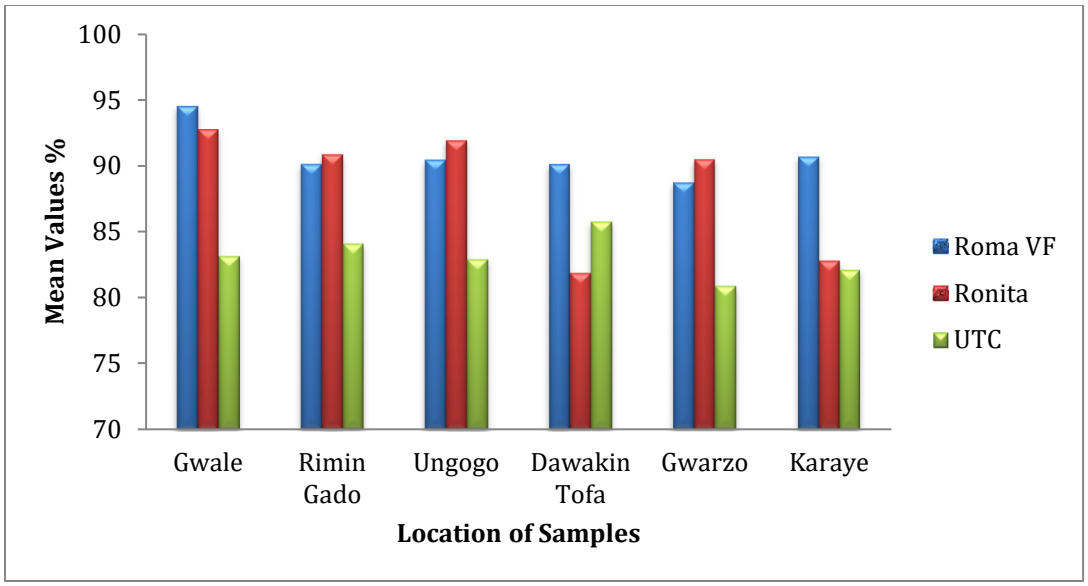


Figure 4.1: Levels of moisture content in the three cultivars.

4.2 Ash Content

The average ash content of Roma VF, Ronita, and UTC was 0.18, 0.14, and 0.14% respectively. The highest levels of ash content were observed in the Roma VF obtained from all the local governments while the ash content of UTC was least among all the local government except in Dawakin Tofa where Ronita had the least ash content as shown in Fig. 4.2. On the nutritional evaluation of these cultivars the Roma VF has more minerals than those of Ronita and UTC (Nielsen, 2002). The values obtained for the three cultivars were observed to be low when compared with published results of Adubofuor et al., (2010) 0.22%, Kolawole *et al.,* (2010) 54.30%, Ojiako and Igwe (2008) 0.27% and Alvi *et al.,* (2003) 0.40% which could be due to ability of the cultivars to take essential metal from the soil.

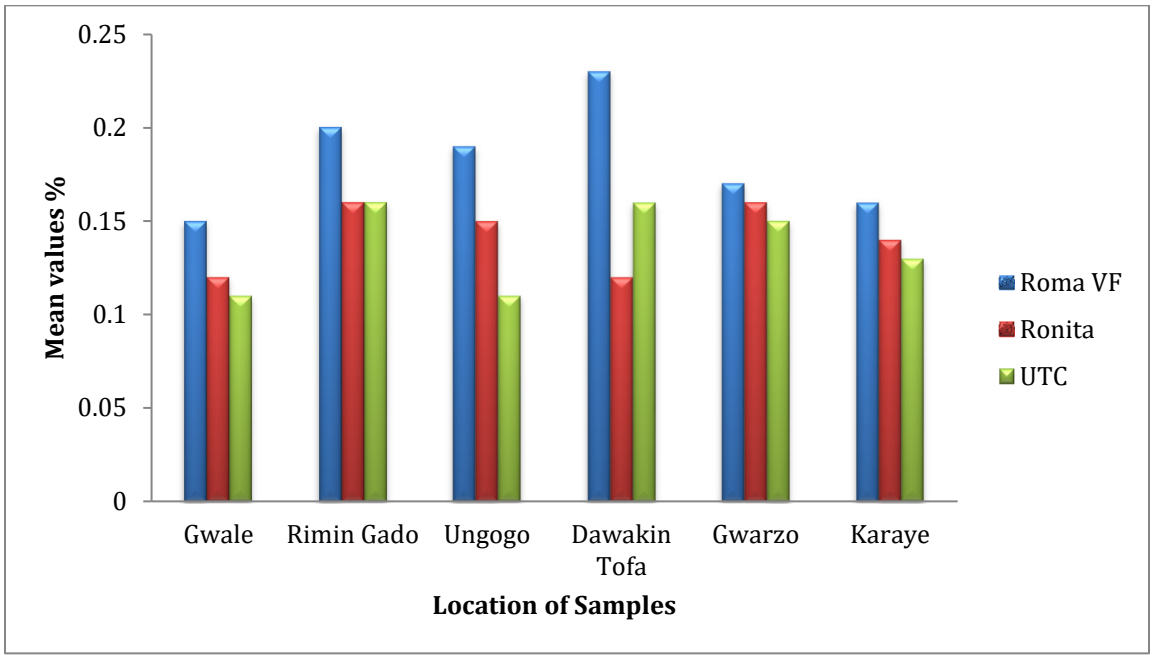


Figure 4.2: Levels of ash content in the three cultivars.

4.3 Total Soluble Solids

The average total soluble solids content (TSS) of Roma VF, Ronita, and UTC were 8.36, 8.14, and 8.25% respectively. The Roma VF from Dawakin Tofa has the highest TSS value of all the three cultivars followed by UTC from Ungogo. The three cultivars from Gwale and Karaye have the same TSS while Ronita from Gwarzo has the least TSS value of all the three cultivars as shown in Fig. 4.3. These results were in agreement with Oko-Ibom and Asiegbu, (2007) 8-8.40% but higher than Teka, (2013) 6.75%, Adebooye *et al.,* (2006) 3.25%, Nunoo *et al.,* (2014) 6.48%, and Adubofuor *et al.,* (2010) 4.22%. This could be attributed to increase total soluble solids during ripening due to degradation of polysaccharides to simple sugars. Campos *et al.,* (2006) have also reported value of TSS of around 4.5% which was considered low for industrial grade tomatoes. According to Cemeroglu *et al.,* (2003) as TSS in industrial tomatoes increases, the tomato paste efficiency also increases and thus recommended the value to be between 5 and 6.5% as needed for industrial grade tomatoes. These three cultivars would be good in paste production industrially because of the high TSS value which is higher than recommended values.

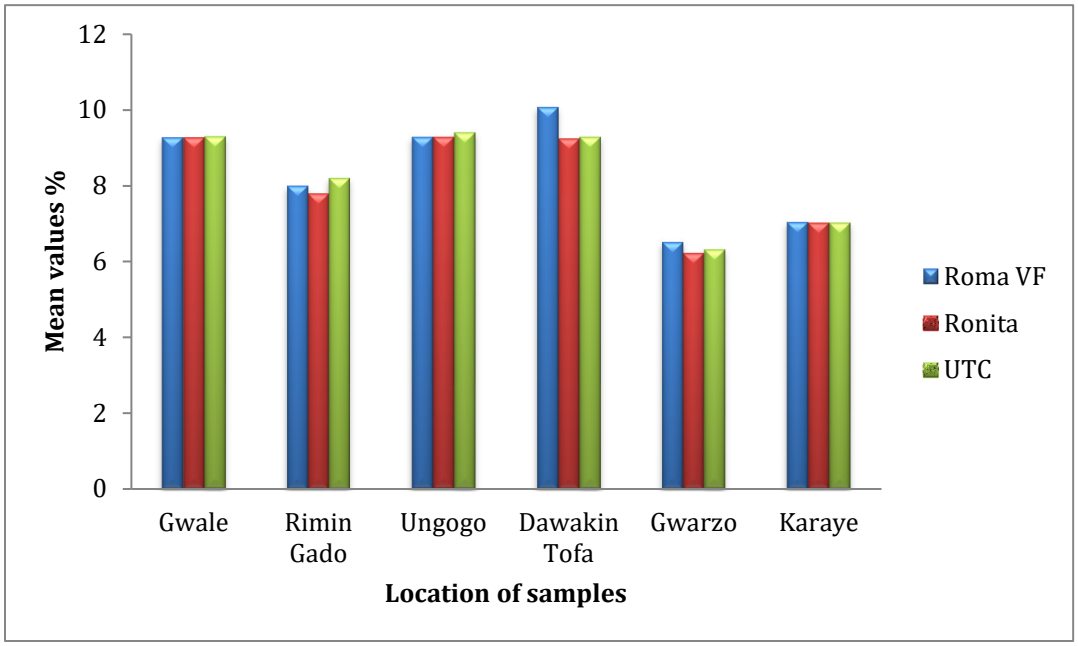


Figure 4.3: Levels of total soluble solids content in the three cultivars.

4.4 Crude Fiber

Fig. 4.4 showed the levels of crude fiber content in the three cultivars with average levels of Roma VF, Ronita, and UTC being 1.19, 1.23, and 0.99% respectively. The highest values were observed in Roma VF from Dawakin Tofa and Gwale while Roma VF and Ronita from Gwarzo have the same crude fiber. Roma VF from Rimin Gado has the least crude fiber of the three cultivars. These results were observed low when compared with the values Onifade *et al.,* (2013) 2.25%, Adebooye and Oloyede, (2005) 1.60, and Olaniyi *et al.,* (2013) 6.48% but higher than Adebooye *et al.,* (2006) 0.70% from some other cultivars which might be due to the level of moisture content and variety. Consumption of Ronita cultivar might help in curing diabetes and coronary heart diseases because of its high crude fiber (IOM, 2002).

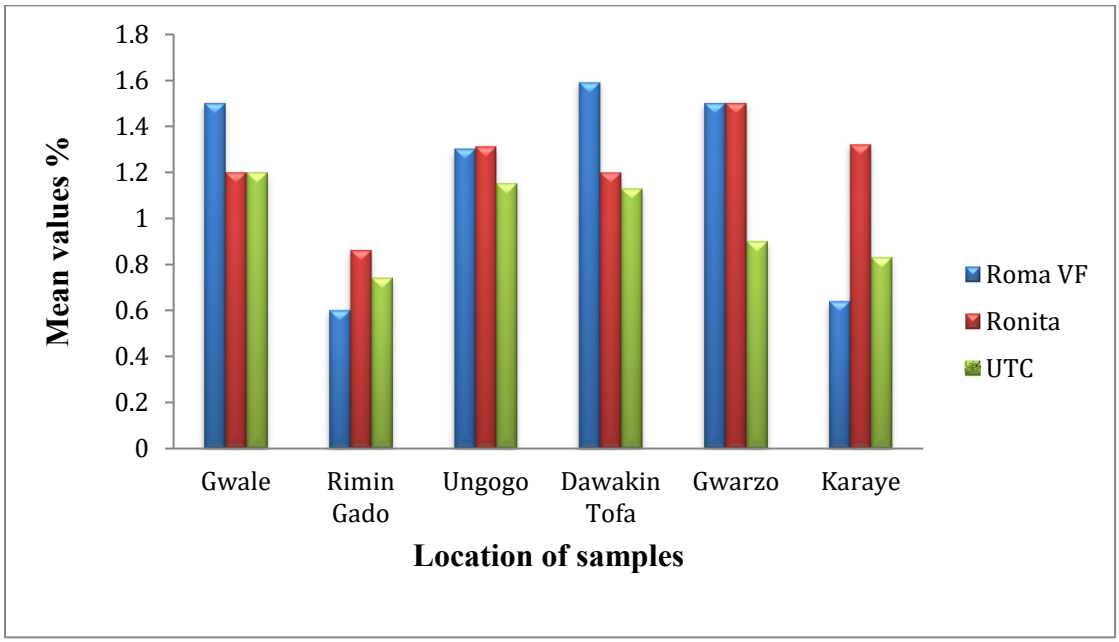


Figure 4.4: Levels of crude fiber content in the three cultivars.

4.5 Titratable Acidity

The average titratable acidity content of Roma VF, Ronita, and UTC was 0.15, 0.16, and 0.15% respectively. The highest value was observed in Ronita from Dawakin Tofa followed by the three cultivars from Rimin Gado while Ronita from Ungogo has the least titratable acidity as shown in Fig. 4.5. Various values have been previously reported for tomatoes cultivars, while the results in the study were observed low when compared with those of Adubofuor et al., (2010) 3.53-4.32%, Ndigwe *et al.,* (2012) 0.66% and Gharezi *et al.,* (2012) 1.70%. It was reported that higher fruit acidity is an advantage, as it causes a lower incidence for fungal infection (Nielsen, 2002). Thus these cultivars are susceptible to spoilage because of their lower percent acidity level. These three cultivars need a preservative to preserve it from spoilage.

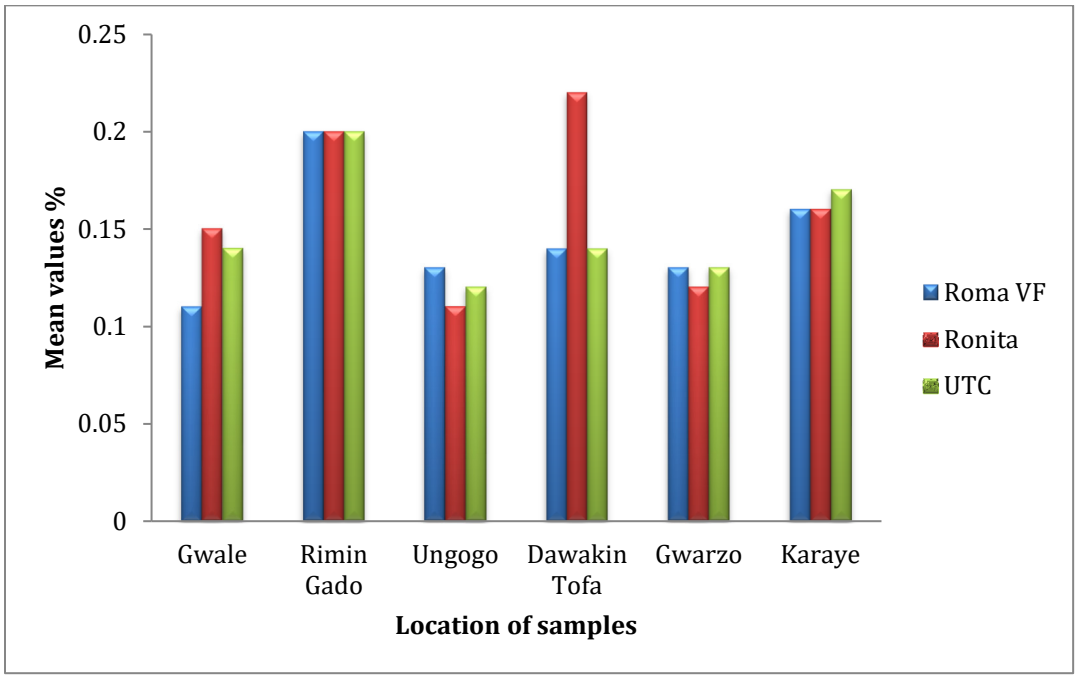


Figure 4.5: Levels of titratable acidity content in the three cultivars.

4.6 Crude Protein

The average crude protein content of Roma VF, Ronita, and UTC was 2.26, 2.23, and 2.60% respectively. The highest protein level was observed in UTC from Gwarzo, Rimin Gadoand Karaye as shown in Fig. 4.6. Various values have been previously reported for other tomatoes cultivars but result of Ronita in this study was very close to that of Hossain *et al.,* (2010) 2.22% but lower than those from Roma VF and UTC. The three cultivars were lower than that of Olaniyi *et al.,* (2010) 26.10% but higher than those from Adebooye and Oloyede, (2005) 2.10-2.14%, Adebooye *et al.,* (2006) 0.44% and Onifade *et al*., (2013) 1.51%. The above results can be related to the fact that when moisture is high, the cell plasma is diluted; protein forming enzymes are retarded thus reducing protein synthesis (Konova and Rainova, 1981). The variations in the results of Fig. 4. 6 might be due to geographical factors.

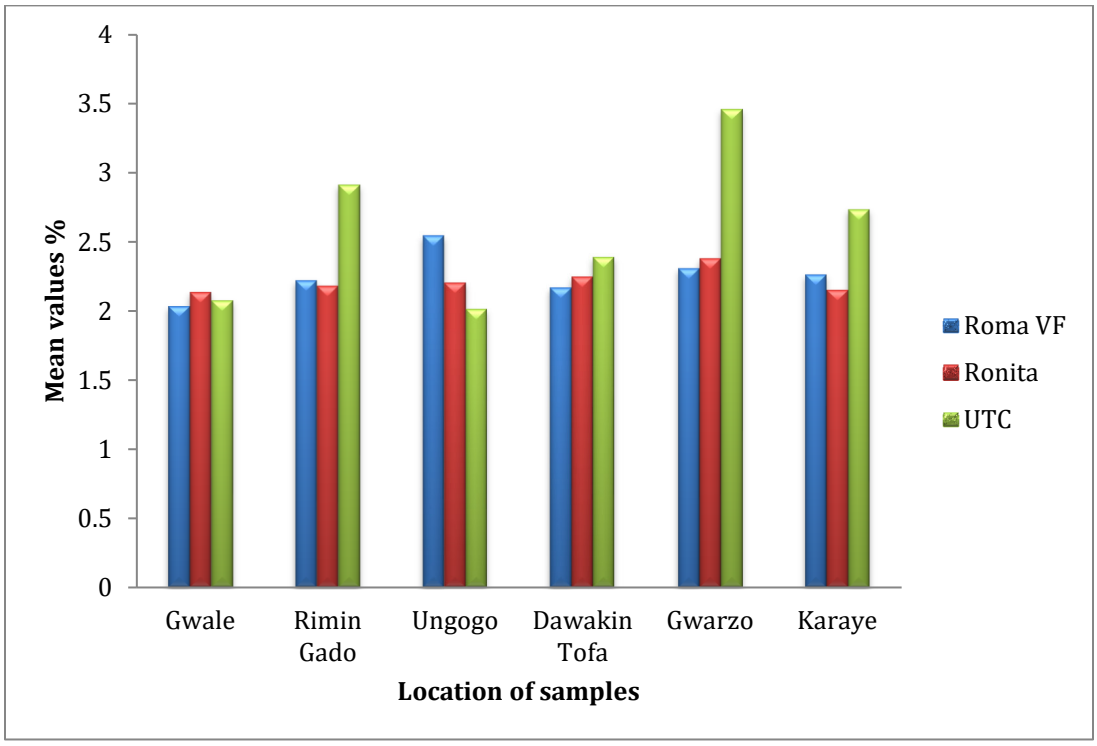


Figure 4.6: Levels of crude protein content in the three cultivars.

4.7 Vitamin C

The average vitamin C content of Roma VF, Ronita, and UTC was 3.73, 4.59, and 4.34 mg/100g respectively. The vitamin C was observed to be highest in Ronita from Gwarzo, followed by UTC from Ungogo and then Ronita from Gwarzo while the UTC from Dawakin Tofa has the least vitamin C content of all the three cultivars as shown in Fig. 4.7. The vitamin C content for the three was found to be low which might be due to environmental factors as vitamin C is known to vary with respect to weather as observed with level in tomato fruits (Fatunla and Ogunsua, 1972). Various values have been previously reported for tomatoes, the results of this study were higher than those from Olaniyi *et al.*, (2010) 0.22 mg/100g and Znidarcic *et al.,* (2010) 2.50-3.50 mg/100g but lower than Ndigwe *et al.,* (2012), 23.22 mg/100g and Nunoo et al., (2014), 78.86 mg/100g. The values obtained for vitamin C in this study presented negative trend with total soluble solids. This is similar to the observation of Silva and Scott, (1973) which showed that increasing the total soluble solids resulted in decreased concentration of vitamin C.

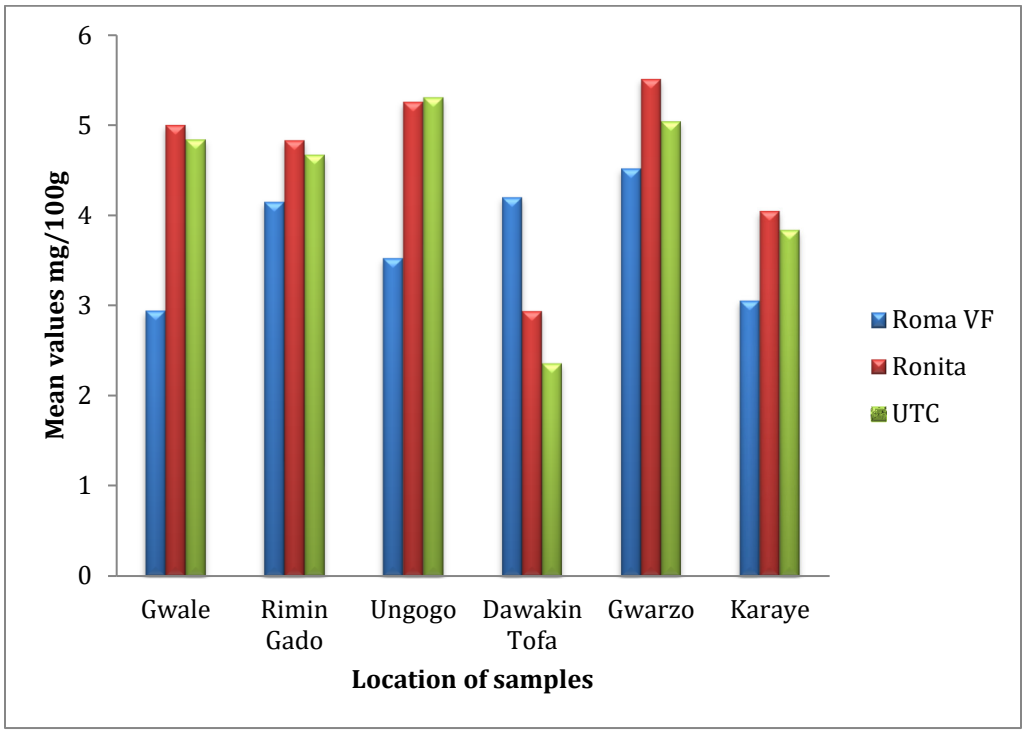


Figure 4.7: Levels of Vitamin C Content in the three cultivars.

4.8 Lycopene

The average lycopene levels as shown in Fig. 4.8 have content of Roma VF, Ronita, and UTC as 6.88, 6.88, and 7.83 mg/100g respectively. The lycopene were observed to be highest in Dawakin Tofa followed by Gwale. It was observed that Roma VF and Ronita from both Ungogo and Rimin Gado have nearly the same lycopene levels. The UTC cultivar physically has a deeper red color compared with the other two varieties. Various values have been previously reported for lycopene levels in tomatoes, the values obtained in this study were in agreement with Malami and Mohammed, (2013) 5.5-20.23 mg/100g. Higher than Adedeji and Ajayi, (2012) 45.25 mg/kg and 45.86 mg/kg, Wawrzyniak *et al.,* (2005) 6.43 mg/100g, Barrette and Garcia, (2006) 55-181 mg/Kg but lower than Bicanic *et al.,* (2013) 25-150 mg/100g and Onifade *et al*., (2013) 12.95 mg/100g. The observed variations in levels which might be due to changes in environmental factors such as light, oxygen, temperature e.t.c. Regular consumption of these three cultivars can be recommended for the overall health of the consumer because of their high lycopene levels. These values are about three times the values reported by Wawrzyniak *et al*., (2005), with its daily uptake of 1.93 mg/person/day.

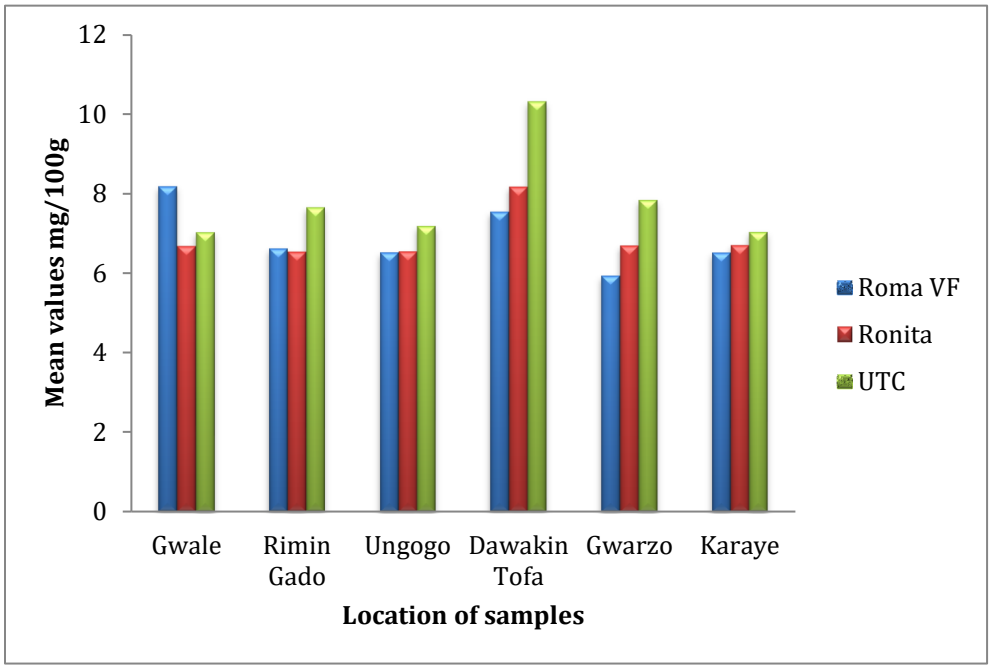


Figure 4.8: Levels of lycopene content in the three cultivars.

CHAPTER FIVE

5.0 Conclusion

These three cultivars of tomato studied have no much difference on their physicochemical quality parameters such as titratable acidity, total soluble solids, ash content, crude fiber, crude protein, moisture content, vitamin C and lycopene. All the three cultivars have high lycopene content which can meet the daily uptake of lycopene by man according to Wawrzyniak *et al.,*(2005) who reported its daily uptake as 1.93 mg/person/day and they are all good industrial tomatoes because of high total soluble solids.

5.1 Recommendation

The proximate analysis of the tomatoes tissues are affected by several ecological factors as such future studies should be carried out to determine levels of total sugar, ether extract, vitamin A, and essential metals in these cultivars. Medicinal benefit apart from its nutrition values should be propagated as results have shown that these three tomato cultivars can be good industrial raw materials that should be cultivated in large quantities. Preservation method should also be developed to enhance their usage.

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APPENDIX

The proximate analysis and its lycopene determination results of tomatoes cultivars (Roma VF, Ronita, and UTC) were presented in Tables 4.1, 4.2, and 4.3. Their mean and standard deviations were used to assess their levels.

Table 4.1: Mean values for proximate analysis and its lycopene content for Roma VF.

Location of samples	Moisture content (%)	Ash content (%)	Total soluble solids (%)	Crude fiber (%)	Titratable acidity (%)	Crude protein (%)	Vitamin C mg/100g	Lycopene mg/100g
Gwale	94.48 ±0.09	0.15 ±0.01	9.27 ±0.02	1.50 ±0.01	0.11 ±0.08	2.03 ±0.10	2.94 ±0.18	8.17 ±0.08
Rimin Gado	90.13 ±0.05	0.20 ±0.01	8.00 ±0.01	0.60 ±0.01	0.20 ±0.01	2.22 ±0.05	4.15 ±0.09	6.61 ±0.03
Ungogo	90.41 ±0.06	0.19 ±0.01	9.28 ±0.01	1.30 ±0.00	0.13 ±0.01	2.54 ±0.06	3.52 ±0.09	6.50 ±0.02
Dawakin Tofa	90.10 ±0.07	0.23 ±0.01	10.08 ±0.02	1.59 ±0.02	0.14 ±0.01	2.17 ±0.03	4.20 ±0.20	7.54 ±0.09
Gwarzo	88.72 ±0.03	0.17 ±0.01	6.50 ±0.01	1.50 ±0.01	0.13 ±0.01	2.31 ±0.06	4.52 ±0.18	5.94 ±0.02
Karaye	90.65 ±0.03	0.16 ±0.01	7.02 ±0.08	0.64 ±0.01	0.16 ±0.01	2.26 ±0.03	3.05 ±0.09	6.50 ±0.01

Table 4.2: Mean values for proximate analysis and its lycopene content for Ronita.

Location of sample	Moisture content (%)	Ash content (%)	Total soluble solids (%)	Crude fiber (%)	Titratable acidity (%)	Crude protein (%)	Vitamin C mg/100g	Lycopene mg/100g
Gwale	92.74 ±0.04	0.12 ±0.01	9.27 ±0.01	1.20 ±0.02	0.15 ±0.01	2.13 ±0.02	4.99 ±0.24	6.67 ±0.11
Rimin Gado	90.87 ±0.04	0.16 ±0.00	7.80 ±0.10	0.86 ±0.00	0.20 ±0.01	2.18 ±0.01	4.83 ±0.09	6.53 ±0.02
Ungogo	91.89 ±0.03	0.15 ±0.01	9.28 ±0.00	1.31 ±0.02	0.11 ±0.01	2.20 ±0.02	5.25 ±0.09	6.53 ±0.02
Dawakin Tofa	81.85 ±0.03	0.12 ±0.02	9.25 ±0.04	1.20 ±0.05	0.22 ±0.03	2.25 ±0.03	2.94 ±0.30	8.17 ±0.04
Gwarzo	90.47 ±0.05	0.16 ±0.01	6.21 ±0.02	1.50 ±0.00	0.12 ±0.01	2.38 ±0.30	5.51 ±0.16	6.70 ±0.01
Karaye	82.78 ±0.02	0.14 ±0.01	7.00 ±0.03	1.23 ±0.02	0.16 ±0.01	2.15 ±0.02	4.04 ±0.18	6.69 ±0.02

Table 4.3: Mean values for proximate analysis and its lycopene content for UTC.

Location of sample	Moisture content (%)	Ash content (%)	Total soluble solids (%)	Crude fiber (%)	Titratable acidity (%)	Crude protein (%)	Vitamin C mg/100g	Lycopene mg/100g
Gwale	83.12 ±0.01	0.11 ±0.01	9.29 ±0.04	1.20 ±0.01	0.14 ±0.00	2.07 ±0.00	4.83 ±0.24	7.02 ±0.02
Rimin Gado	84.09 ±0.04	0.16 ±0.01	8.20 ±0.10	0.74 ±0.00	0.20 ±0.01	2.91 ±0.30	4.67 ±0.18	7.64 ±0.02
Ungogo	82.89 ±0.00	0.11 ±0.01	9.39 ±0.01	1.15 ±0.00	0.12 ±0.00	2.01 ±0.30	5.30 ±0.18	7.16 ±0.03
Dawakin Tofa	85.74 ±0.01	0.16 ±0.02	9.29 ±0.03	1.13 ±0.02	0.14 ±0.00	2.39 ±0.02	2.36 ±0.16	10.31 ±0.70
Gwarzo	80.88 ±0.04	0.15 ±0.01	6.30 ±0.02	0.902 ±0.00	0.13 ±0.00	3.46 ±0.30	5.04 ±0.27	7.84 ±0.04
Karaye	82.09 ±0.02	0.13 ±0.01	7.00 ±0.02	0.83 ±0.99	0.17 ±0.00	2.73 ±0.00	3.83 ±0.18	7.02 ±0.03