University of Education, Winneba http://ir.uew.edu.gh

UNIVERSITY OF EDUCATION, WINNEBA

COLLEGE OF TECHNOLOGY EDUCATION, KUMASI

NUTRITIONAL COMPOSITION OF WATERMELON SEEDS

ERNESTINE AKOSUA AMEGADZIE

(190014258)

A dissertation in the Department of Hospitality and Tourism Education, Faculty of Vocational Education, submitted to the School of Graduate Studies, in partial fulfilment of the requirements for the award of the Master of Technology (Catering and Hospitality) in the University of Education, Winneba

APRIL, 2021

University of Education, Winneba http://ir.uew.edu.gh

DECLARATION

Student's Declaration

I, ERNESTINE AKOSUA AMEGADZIE, declare that this Dissertation, with the exception of quotations and references contained in published works, which have all been identified and duly acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole, for another degree elsewhere.

.

SIGNATURE: …………………………..… DATE: ………………………………...

ERNESTINE AKOSUA AMEGADZIE

Supervisor's Declaration

I hereby declare that the programme and supervision of this work was supervised in accordance with guideline with supervision of dissertation as laid by the University of Education, Winneba, and Kumasi Campus.

SIGNATURE: …………………………….……… DATE: ……………….………………

DR. GILBERT OWIAH SAMPSON

University of Education, Winneba http://ir.uew.edu.gh

ACKNOWLEDGEMENT

First and foremost, praises and thanks to the God, the Almighty, for His showers of blessings throughout my research work to complete the research successfully.

I would like to express my deep and sincere gratitude to my research supervisor, Dr. Gilbert Owiah Sampson for giving me the opportunity to do the research and providing invaluable guidance throughout this research. His dynamism, vision, sincerity and motivation have deeply inspired me. He has taught me the methodology to carry out the research and to present the research works as clearly as possible. It was a great privilege and honor to work and study under his guidance. I am extremely grateful for what he has offered me. I would also like to thank him for empathy and great sense of humor. I express my gratitude to the University of Education, Winneba – Kumasi Campus for granting me the opportunity to undertake this master's degree course in its catering and hospitality department and providing me with a serene environment and facilities to complete this research project. Special thanks to all my lecturers who imparted to me the knowledge and shared their truthful and illuminating views on a number of current issues on catering and hospitality, and other related subjects. Their input proved to be very helpful in writing this research project.

I am extremely grateful to my parents for their love, prayers, caring and sacrifices for educating and preparing me for my future. Also, I express my thanks to my uncle, brother for their support and valuable prayer.

University of Education, Winneba http://ir.uew.edu.gh

DEDICATION

I dedicate my dissertation work to myself (Ernestine Akosua Amegadzie), my sweet mother (Beatrice Awo Kemeh), my Brother (Gordon Kwame Acheapong) and my friend (Philip Kudjo Aduna) for their assistance, financial and moral support to all individuals who contributed towards my studies. God bless you all and restore whatever you have lost.

University of Education, Winneba http://ir.uew.edu.gh

ABSTRACT

Watermelon (*Citrullus lanatus*) a fruit crop, is herbaceous creeping plant belonging to the family Cucurbitaceous. It is mainly propagated by seeds and thrives best in warm areas. It can be grown along the coastal areas of Ghana, the forest zone and especially along riverbeds in the Northern Savannah areas. Watermelon is a highly purchased fruit because of its highly nutritious nature, and it thirst quenching ability. Watermelon is purchased on the daily by consumers, the seeds of these watermelon is just thrown away and tossed in the trash can leading to high wastage of these seeds in the country. The objectives of this study is to determine the proximate composition of watermelon seeds and to determine some selected mineral composition of watermelon seeds. Two varieties of the watermelon seed were used; Sweet Baby and Karoka varieties. For the proximate analysis, the moisture content, protein, fat, carbohydrate, crude ash and fibre were determined. The minerals determined were Phosphorus, Potassium, Sodium and Calcium. From the experimental results, it is possible to state that these seeds which were analyzed contained significant quantities of the various nutrients being analyzed. It was observed that for all the parameters measured, there was a statistical difference between the proximate and mineral composition for the two seed varieties except the Fat content which there was no statistical difference between the two varieties. Potassium was also found to be the highest mineral in the minerals investigated in this experiment with Potassium contents 33500.2±0.10 and 38100.6±0.10 for Sweet Baby and Karoka varieties respectively. The findings from this study showed that the watermelon seed varieties; Sweet baby and Karoka were good sources of various nutrients. These nutrients were present in high quantities.

University of Education, Winneba http://ir.uew.edu.gh

TABLE OF CONTENT

University of Education, Winneba http://ir.uew.edu.gh

LIST OF TABLES

University of Education, Winneba http://ir.uew.edu.gh

LIST OF FIGURES

University of Education, Winneba http://ir.uew.edu.gh

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Watermelon (*Citrullus lanatus*) a fruit crop, is herbaceous creeping plant belonging to the family Cucurbitaceous. It is mainly propagated by seeds and thrives best in warm areas. It is a tropical plant and requires a lot of sunshine and high temperature of over 25°C for optimum growth (Gwana *et al*., 2014). Watermelon thrives best in a drained fertile soil of acidic nature. It can be grown along the coastal areas of Ghana, the forest zone and especially along riverbeds in the Northern Savannah areas (MOA 2011). According to Tabiri *et al.* (2016), Watermelons originated in tropical Africa, and Sanskrit and early Egyptian records indicate that they have been cultivated for more than 4000 years. Melons belong to the family *Cucurbitaceae.* Watermelons grow on the vine classified as *Citrullus lanatus*. Watermelon grows as a trailing vine (Gwana *et al*., 2014).

Most watermelon varieties are determined based on their sugar content and the sweetness of the fruit as stated in Tak & Jain (2016). Watermelon is low in calories, but it is known to be highly nutritious and quench thirst. Watermelon is mostly used for fresh salad, dessert, snack, and for decorations. The juice of the watermelon fruit can also be used in the making of various drinks. In Namibia, the juice is fermented into a refreshing, lightly alcoholic drink (Tabiri *et al.,* 2016). In some parts of Africa, the rind is sliced, dried, cooked and eaten. Pickled watermelon rind is widely eaten in some parts of USA. The fruit is known to be a good source of lycopene and carotenoid. It also serves as a scavenger for free radicals that contribute to various health conditions such as asthma, atherosclerosis, diabetes, colon cancer and arthritis. Tak&Jain (2016) mentions that watermelon seed is high in fiber and citrulline; an amino acid the body uses to make arginine.

Watermelon seeds are a part of the watermelon fruit that is underutilized. It is mostly thrown away after taken out of the watermelon in Ghana and other parts of the world. Mostly the watermelon seed is just kept for replanting by farmers limiting its use in Ghana as well as other parts of the world. Watermelon's Seeds, the dried seeds (dark flat) of the fruit are used as snacks when salted and roasted in China, Israel, etc. In Africa, some research have showed that the seeds are made into coarse flour or oil may be extracted from them and use for domestic consumption, and the juice can be extracted from watermelon to produced wine (Gwana *et al*., 2014). Watermelon seeds are known to be highly nutritional; they are rich sources of protein, vitamins B, and minerals (such as magnesium, potassium, phosphorous, sodium, iron, zinc, manganese and copper) and fat among others as well as phytochemicals (Tak &Jain, 2016). The seeds of watermelons are known to have economic benefits especially in countries where cultivation is on the increase.

There is dearth of information on the nutritional quality watermelon seeds in Ghana. This gives the watermelon seed limited usage because not much is known about the watermelon seed and hence not much can be utilized with the seed. This study is aimed at analyzing the proximate composition of the watermelon seed as well as the mineral content of the watermelon seed. This will help explore the usage of the watermelon seed for health benefits, food benefits etc. This study will also help serve as a steppingstone for further future research on watermelon seeds.

1.2 Statement of the problem

Watermelon is a highly purchased fruit because of its highly nutritious nature, and it thirst quenching ability. It also has various usage across the food chain hence, it is highly patronized by most individuals. Therefore, every watermelon purchased on the daily by consumers, the seeds of these watermelon is just thrown away and tossed in the trash can leading to high

University of Education, Winneba http://ir.uew.edu.gh

wastage of these seeds in the country. This is also as a result of limited usage of the watermelon seed.

Also due to watermelon seeds being underutilized it is usually regarded as having low value. Low value in terms of limited usage and this is as a result of little research done on the watermelon seed and hence not much is known about the seed and therefore cannot be used for various things. Watermelon is usually sold in Ghana at cheap prices and hence famers don't make so much money from watermelon. Watermelon is very underutilized and is mostly used for fruit salad and fresh drinks but not much exploited making watermelon farmers mostly poor.

Lastly, during the peak seasons of watermelon, it goes waste because so many people do not purchase watermelon. This is as a result of watermelon being in abundance and since it has limited use so many goes waste during this season.

1.3 Main Objective

To determine the nutritional composition of Watermelon seeds.

1.3.1 Specific Objectives

a) To determine the proximate composition of watermelon seeds

b) To determine some selected mineral composition of watermelon seeds.

1.4 Significance of the study

Since watermelon seeds are highly underutilized in the Ghanaian markets and just thrown away, this study will provide more insight on the nutritional composition of the seed and will show it benefits in several fields and hence seeds will not just be thrown away but can be used by various individuals in various fields.

The findings from this study will help understand the value of the watermelon seed. Knowing the nutritional composition of the watermelon seed will help add value to the watermelon seed hence can be used in the health field to help eradicate diseases or in the food industry where it can be used for various purposes depending on the dominant nutrients in the seed.

Knowing the nutritional composition of the watermelon seed can help increase the revenue on watermelon because the value has been increased and when it is known that the seed can be used for several purposes farmers can capitalized to make money from the selling of the watermelon and even the seed separately to help liberate them from their poverty.

Lastly, this study will be a stepping stone for other research into the study of watermelon seeds and also provide so many uses of the watermelon seed and hence watermelon will not go waste during the peak season because watermelon seed will have various uses based on the nutritional composition.

University of Education, Winneba http://ir.uew.edu.gh

CHAPTER TWO

LITERATURE REVIEW

2.1 History and Biological Classification of Watermelon

Watermelon (*Citrullus lanatus*) a fruit crop, is a herbaceous creeping plant belonging to the family *cucurbitaceae*. According to Munisse et al., (2011), Watermelon is an important horticultural crop, mostly known for its sweet and juicy fruit, grown in warm climates all over the world. It is mainly propagated by seeds and thrives best in warm areas. Watermelon is mostly cultivated as an under sown intercrop together with cereals or root crops (Ramazan et al., 2012). It is a tropical plant and requires a lot of sunshine and high temperature of over 25°C for optimum growth. Watermelon thrives best in a drained fertile soil of fairly acidic nature. It can be grown along the coastal areas of Ghana, the forest zone and especially along river beds in the Northern Savannah areas (Tabiri et al., 2016).

Watermelons originated in tropical Africa, and Sanskrit and early Egyptian records indicate that they have been cultivated for more than 4000 years. Melons belong to the family Cucurbitaceae. Muskmelons, winter melons, and European cantaloupes grow on the vine classified as *Cucumis melo.* Muskmelons are derived from *Cucumis melo* variety *reticulatus.* Winter melons are derived from *Cucumis melo* variety *inodorus.* The true cantaloupe is classified as *Cucumis melo* variety *cantalupensis.* Watermelons grow on the vine classified as *Citrullus lanatus*. Watermelon (*Citrullus lanatus*) is a type of melon, member of the gourd family, cultivated extensively for its pleasant-tasting fruit, is one of the most economically important fruit in the Cucurbitaceae family (Gwana et al., 2014).

Watermelon grows as a trailing vine. Its original habitat was tropical Africa, particularly the region of the Kalahari Desert, but its popularity became widespread early in history, and today it is cultivated throughout the world. Watermelon is also grown and became popular in the northern part of Nigeria, especially in the central and north – eastern Nigeria. There are more than 1200 varieties of watermelon ranges in size, shape and colour of the flesh, shipping ability of rind and sweetness of the flesh. The name Watermelon is generally acceptable, but, the name of different varieties may be given due to the colour, shape, level of sweetness or location or place of the first cultivation of the variety. Hence, the name given to a variety may not be acceptable in another place.

Watermelon's Seeds, the dried seeds (dark flat) of the fruit are used as snacks when salted and roasted in China, Israel, etc. In Africa, the seeds are made into coarse flour or oil may be extracted from them and use for domestic consumption, and the juice can be extracted from watermelon to produced wine.

2.2 Varieties of Watermelon

Watermelon has been found to have more than 100 varieties which range in weight from less than 1.4kg to more about 32kg (Anikwe et al., 2016). The shape of watermelon is round or oblong. It has a smooth skin and may have varying colors ranging from light green to a darker green. Some few watermelon varieties have been found to have stripes on them as mentioned in Pardo et al., (1997). The flesh watermelon may have colors of red, orange, yellow or white. Flesh watermelon are very juicy and crunchy. They have black seeds and they are found inside the fruit.

Watermelon has several varieties and these varieties are linked to exterior and interior characteristics of the watermelon. The exterior characteristics are defined by the shape, size, rotting, exterior humidity, defects etc. while the interior characteristics are defined by other parameters such as color, aroma, flavor, ripeness, texture (Pardo et al., 1997).

University of Education, Winneba http://ir.uew.edu.gh

Table 2. 1: Mean Values Of The Physical-Chemical And Sensorial Parameters Of Some Watermelon Varieties Tested

Varieties	Flavor	Texture	Visual Color	Firmness
Crimson Sweet	0.6	1.4	1.0	101.9
Florida Giant	0.6	0.9	-0.4	133.3
Isola	0.4	-0.4	-0.1	88.2
Klondike	0.8	1.3	0.0	107.8
Panonia	-0.6	0.4	1.5	156.8
Sugar Baby	0.3	0.8	-0.8	98.0
Sugar bell	0.9	1.4	0.8	117.6
Sweet Marvel	0.8	0.4	1.4	107.8
Apirena	1.3	2.1	1.9	137.2
AR-3404	1.8	2.4	2.4	117.6
AR-3406	1.0	1.8	2.4	127.4
Antigua	1.1	1.1	0.6	166.6
Recueja	0.7	0.5	-0.9	78.4

Source: Pardo et al., 1997

2.3 Production and Economic importance of Watermelon in World

Huh et al. (2008) mentioned that Watermelon (*Citrullus lanatus*) is a highly cultivated crop and also the highly consumed fruit in the world. In addition, the trading and consumption of the crop is vital to livelihood and entrenchment of food security in some parts of South Africa (Dovie et al., 2003). Goreta et al. (2005) asserted about 6.8% of the total area in the world devoted to vegetable production is dedicated to watermelon. Although it is an indigenous African crop, Africa hardly registers its presence in global production; with countries like China, Turkey, Iran and Mexico dominating in world production (Varmudy, 2012). In spite of

University of Education, Winneba http://ir.uew.edu.gh

its importance globally, watermelon have its peculiarities and challenges in its marketing in different parts of the world. In Kentucky, USA, fresh watermelons are marketed at farms and road side auctions, retail and wholesale markets (University of Kentucky, 2010). In Oklahoma, the marketing of water melon involves shipping of the fruits to other states, sale at farms and roadside stance and the use of brokers (Robert et al., 1996). In Indian, the marketing of water melon is confronted with issues like problem of transportation, the use of numerous agents and mobile traders and lack of an organized marketing system among others (Varmudy, 2012).

2.4 Production and Economic importance of Watermelon in Ghana

In Ghana, Trevor (2008) noted that it is a crop which serves as an important source of revenue to farmers especially in times of unfavorable weather conditions since it is able to withstand harsh weather conditions as compared to other crops.

The mean marketing margins for the major players from the deconstructed marketing margins analysis were as follows; GH¢1738.80 for farmers, GH¢156,360.00 for wholesalers and GH¢5,664.10 for retailers. On the subject of marketing cost, farmers, wholesalers and retailers on the average incurred GH¢949.00, GH¢31,388.00 and GH¢576.00 respectively. Also, farmers on the average obtained a profit margin of Gh¢789.84, representing 45.42% of marketing margin per annum, wholesalers recorded an average profit margin of GH¢124980.00 representing 79.93% of the marketing margin per annum while retailers obtained an average profit margin of GH¢5088.10 per annum representing 89.83% of the marketing margin as shown in Table 3. The result of the study on the profit and marketing margin several that profit margins were high among the chain drivers (retailers and wholesalers). This is partly explained by the relatively higher marketing cost used by farmers with less than proportionate returns with low marketing cost.

2.5 Nutritional composition of some Watermelon and seed varieties

Citrullus lanatus contains about 6% sugar and 92% water by weight. As with many other fruits, it is a source of vitamin C. The composition of dried egusi seed without shell per 100 g include: water 5.1 g, energy 2340 kJ (557 kcal), protein 28.3 g, fat 47.4 g, carbohydrate 15.3 g, Calcium 54 mg, Phosphorous 755 mg, iron 7.3 mg, thiamin 0.19 mg, riboflavin 0.15 mg, niacin 3.55 mg and folate 58 µg. The seed being an excellent source of energy and contains no hydrocyanic acid, making it suitable as livestock feed. The seed oil contains glycosides of linoleic, oleic, palmitic and stearic acids. The fruit flesh contains bitter cucurbitacins (Schippers, 2002). The composition of watermelon per 100 g edible portion (50–70% of the mature fruit) include: water 91.5 g, energy 134 kJ (32 kcal), protein 0.6 g, fat 0.4 g, carbohydrate 7.2 g, Calcium 8 mg, Phosphorous 9 mg, iron 0.17 mg, thiamine 0.08 mg, riboflavin 0.02 mg, niacin 0.2 mg, folate 2 mg and ascorbic acid 9.6 mg (USDA, 2002). `

Table 2. 2: Proximate composition of seeds of three watermelon varieties.

Watermelon variety %	Moisture %	Protein %	Fat %	Ash %	Fibre %	Carbohydrate	Energy (kcal/100g)
Charleston gray	7.87±0.12[b]	17.75±0.97[a]	26.83±4.24[a]	3.00±1.00[a]	40.75±6.12[a]	11.67±6.62[a]	359.15±34.19[a]
Crimson Sweet	7.40±0.00[c]	17.09±0.92[a]	26.50±4.27[a]	2.00±1.00[a]	39.09±0.50[a]	15.32±4.51[a]	368.11±19.91[a]
Black diamond	8.00±0.00[a]	16.33±0.97[a]	27.83±2.63[a]	3.00±0.00[a]	43.28±3.44[a]	9.56±4.65[a]	354.05±10.14[a]

Source: Tabiri et al., (2016)

Table 2. 3: Mineral Composition of seeds of three watermelon varieties

Watermelon variety	%P	%Ca	%Mn	%K	%Na	%Mg	Fe (mg/100g)	Cu (mg/100g)	Zn (mg/100g)
Charleston gray	0.17±0.00[a]	0.16±0.02[a]	0.02±0.00[b]	3.57±0.14[b]	0.07±0.01[a]	0.15±0.01[a]	3.71±0.06[c]	0.38±0.06[b]	3.71±0.06[b]
Crimson Sweet	0.22±0.03[a]	0.11±0.01[a]	0.04±0.00[c]	3.40±0.07[b]	0.08±0.00[a]	0.14±0.02[a]	2.72±0.11[b]	0.45±0.24[b]	0.81±0.02[b]
Black diamond	0.18±0.02[a]	0.14±0.03[a]	0.09±0.01[a]	3.85±0.11[a]	0.17±0.02[a]	0.17±0.02[a]	4.60±0.07[a]	0.58±0.03[a]	0.66±0.03[c]

Source: Tabiri et al., (2016).

2.6 Utilization of Watermelon

Recently more attention has been focused on the utilization of food-processing byproducts and wastes, as well as underutilized agricultural products (Hanan and Abdelrahman, 2020). Obviously, such utilization would contribute to maximizing the available resources and result in the production of various new products for food. At the same time, a major contribution to avoiding waste disposal problems could be made.

Bakery products are widely consumed and are becoming a major component of the international food market. Cake is one of the most common bakery products consumed by people in the world. Nowadays, cake manufacturers face a major problem of lipid oxidation which limits the shelf life of their products (Lean and Mohamed, 1999). Bakery products such as cakes particularly those with high lipid content tend to become rancid after prolonged storage owing to the oxidation of polyunsaturated fatty acids (Hanan and Abdelrahman, 2020). Special attention has given to the use of natural antioxidant because of the worldwide trend to avoid or minimize synthetic food additives. And since Watermelons have been found to be high in antioxidants they are added to help prevent oxidation of the lipids in these baked products.

Watermelon is mostly used for fresh salad, dessert, snack, and for decorations. The juice of the watermelon fruit can also be used in the making of various drinks. In Namibia, the juice is fermented into a refreshing, lightly alcoholic drink (Tabiri et al., 2016). In some parts of Africa, the rind is sliced, dried, cooked and eaten. Pickled watermelon rind is widely eaten in some parts of USA. The fruit is known to be a good source of lycopene and carotenoid. It also serves as a scavenger for free radicals that contribute to various health conditions such as asthma, atherosclerosis, diabetes, colon cancer and arthritis. Tak&Jain (2016) mentions that watermelon seed is high in fibre and citrulline; an amino acid the body uses to make arginine.

University of Education, Winneba http://ir.uew.edu.gh

2.7 Occurrence of phytochemicals (antinutrients) in Watermelon Seed

Phytochemicals are a group of naturally occurring bioactive compounds that are produced by plants as secondary metabolites (Molyneux et al, 2007). When fruits contain relatively higher levels of antinutrients, it reduces the nutritive value of the nutritional profile of the cashews (Sharma et al., 2011). Examples of antinutrients in foods include phytates, oxalates, phenolic compounds, Lathyrogens, glucosinolates, flavonoids eg. Tannins. Antinutrients, also known as phytonutrients, reduce the maximum utilization of major food nutrients such as proteins, carbohydrates and vitamins. It has therefore been established that the consumption of watermelon seeds which has proteins and carbohydrate does not guarantee their efficient absorption into the bloodstream due to the inhibitory action from these phytonutrients (Ugwu and Oranye, 2006).

Antinutrients which are present in foods are somewhat poisonous to humans and animals depending on the quantities that are ingested (Hendek and Bektas, 2018). Antinutritional factors occur in plants at varying amounts and also at different part of plants making them very toxic when parts with the highest concentrations are consumed. Generally, antinutrients are categorized into two major groups. These are the heat stable group of antinutrients including phytic acid, tannins, alkaloids, saponins etc and the heat labile phytonutrients which comprises lectins, cyanogenic glycosides, protease inhibitors etc (Soetan and Oyewole, 2009).

The mineral and protein contribution of watermelon seed to a person's nutritional requirement is thus limited, owing to the numerous existing antinutrients that occurs in the seeds rendering them unavailable for humans. Watermelon therefore have low protein digestibility (Kumar et al., 2006).

For this reason, many processes are being investigated to drastically minimise antinutrients in foods. Processes such as autoclaving, soaking, boiling, roasting are being used to minimise the occurrence of antinutrients in cashew nut. These methods are being optimized to ensure that the major food nutrients are minimally affected by some of these methods (Jain et al 2018).

2.8 Properties and general characteristics of antinutrients

Antinutrients, refers to a class of compounds natural or artificial that interferes with the absorption of nutrients. Although all these antinutrients commonly inhibits the abosorption of nutrient, they each have different chemical properties (Apenten, 2001).

Some antinutrients are water-insoluble whilst others are water soluble. Other antinutrients may even be more resistant to heat treatments and so therefore understanding these properties about antinutrient gives a great insight into the methods that must be employed to reduce their prevalence in foods.

2.8.1 Alkaloids

Alkaloids are a group of compounds derived from plants as secondary metabolites. They are highly diverse natural compounds that contain at least one nitrogen atom and a heterocyclic ring. Most toxic alkaloids have been known to contain high number of nitrogen and a complex aromaticity (Da Silva et al., 2007). There are about 200,000 subclasses of alkaloids and they are produced specific to each plant although different plants may produce similar classes of alkaloids. Alkaloids have so many applications in the pharmaceutical industry; in the production of semi-synthetic psychoactive drugs (Kittakoop et al., 2014). Alkaloids usually have neutral to acidic properties and almost all alkaloids evoke bitterness.

University of Education, Winneba http://ir.uew.edu.gh

Figure 2. 1: Structure of some alkaloids.

2.8.2 Tannins

Tannins (commonly referred to as tannic acid) are generally characterised as water-soluble, astringent complex phenolic substances derived from plants (Swanson, 2004). Tannins as phytochemicals have been known to characteristically bind to proteins and other metallic ions, (Okuda and Ito, 2011). Foods high in tannins are classified as being of low nutritional value because its hinders the digestibility of proteins and the absorption amino acids in the body.

FAO (1992) indicated that tannin binds strongly to protein and also interferes with digestion by inhibiting enzymes involved in digestion whilst rendering iron and vitamin B12 unavailable. It is therefore necessary to remove or reduce the amount of tannins in locally processed seeds to ensure the full absorption of nutrients into the body system upon consumption.

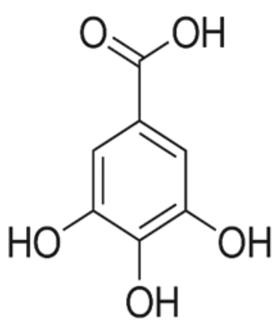

Figure 2. 2:. Primary structure of hydrolysable tannin.

2.8.3 Oxalates

Oxalates(ethanedioate) are dianionic molecules with the formula C2O42- which are usually salts of oxalic acid and other mineral compounds. Oxalates usually form coordination with other divalent cations such as Ca2+, Na+, Mg2+ etc.

Oxalic acids in themselves are soluble compounds but their complexation with minerals renders them insoluble precipitates which has been a leading cause of nephrolithiasis (kidney stones) arising from the complexation of oxalates and calcium ions (Han et al, 2015). Of all the types of kidney stones that are present, calcium oxalates accounts for about 79% of nephrolithiasis in humans (Spivacow et al., 2016).

2.8.4 Lectins

Lectins are carbohydrate binding protein antinutrients that occurs in several nuts and seeds. Foods such as grains, legumes, nuts, seeds and vegetables usually contain high levels of lectins

They exhibit a high level of specificity for binding to carbohydrates and other sugar moieties. Lectins have many biochemical importance with regards to the identification of blood groups, antigen types etc. However, nutritionally, since they bind to carbohydrates and sugar moieties, they render them unavailable for absorption (Viswambari et al., 2010). Lectins are toxic phytonutrients (antinutrients) which can only be inactivated by proper processing and preparation of the raw food product. High levels of lectins may lead to adverse effects such as nutritional deficiencies and immune (allergic) reactions.

2.8.5 Phytates

Phytates, a phosphate ester of inositol (myo-inositol hexakisphoSphate) being a salt of phytic acid is widely distributed antinutrient in plant seeds and nuts (Gupta, 2015). Due to the molecular structure of phytates, they have a stronger affinity for divalent cations such as Zn2+, Mn2+, Ca2+, Cu2+ etc, thereby interfering in intestinal mineral absorption. The relationship between proteins and phytates are pH dependent; at low pH, phytates bind to proteins to form insoluble complexes which makes them unavailable for absorption (Nissar et al, 2017). Many treatments given to seeds and nuts such as soaking, fermenting, and roasting are able to drastically reduce the amounts of phytates in foods (Nissar et al., 2017).

2.9 Benefits of phytochemicals(antinutrients) to human nutrition

Anti-nutrients are primarily responsible for many detrimental effects relating to the absorption of macronutrients and micronutrients, however, at low concentrations, some antinutrients have been found to exert beneficial health effects (Fekadu, 2014).

Phytates, tannins, lectins etc have also been shown to reduce plasma cholesterol and triglycerides, blood glucose and insulin response to foods high in starch (Habtamu and Ratta, 2014). All these can be achieved when aantinutrients are found in smaller quantities in foods. Moreover, these antinutrients/phytochemicals have been shown to reduce many of forms cancers. This implies that antinutrients are not characteristically harmful although they lack significant nutritive value (Habtamu and Ratta, 2014).

Alkaloids for instance are involved in the recognition of gene coding compatibility of specific genotypes. They are thus involved in the endogenous regulation mechanism by either stimulating, inhibiting or terminating growth of cells and tissues in the body (Shen et. al, 2017).

2.10 Toxicity of phytochemicals(antinutrients) to humans

Traditionally, antinutrients are known to be toxic to humans and so as much as possible, many processing methods are employed to minimise their levels in foods (Soetan and Oyewole, 2009). Many antinutrients are thus classified as phytotoxins due to their health compromising effects when consumed in unregulated amounts. For example, aristolochic acid poses carcinogenic threat even at low doses to the human nutrition (Heinrich et al., 2009). Others such as polyphenols and flavonoids may sometimes act as pro-oxidants which deleteriously inhibit the antioxiding mechanism of antioxidants in foods.

2.11 Bioactivities of Watermelon

2.11.1 Anti-Inflammatory Activity

In-vivo and in-vitro anti-inflammatory activity of Citrullus lanatus seed oil (CLSO) in carrageenan induced paw edema in rat model and In-vitro anti-inflammatory activity was carried out. The potency of the oil compared with standard diclofenac (10 mg/kg) showed significant reduction of edema in carrageenan induced rat paw edema model maximum at 3hr (percentage reduction in paw volume 44.44%, 55.56% and 63.11% for CLSO (50 mg/kg), CLSO(100mg/kg) and Diclofenac (10mg/kg) respectably and CLSO at concentration of 100, 250 and 500 mcg/ml showed

42.35%, 68.48% and 78.50% protection of HRBC in hypotonic solution respectably. All the results

were compared with standard diclofenac at 50, 100 and 200 mcg/ml which showed 43.74%, 63.93% and 86.73% protection of HRBC in hypotonic solution respectably (Madhavi, et al., 2012).

2.11.2 Antimicrobial activities

The antimicrobial activities of crude chloroform, hexane and ethanol leaves, stem, fruits and seeds extracts from Citrullus lanatus var. citroides (CL) was carried out against bacteria (Escherichia coli, Staphylococcus aureus, Pseudomonas aeruginosa, Bacillus subtilis and Proteus vulgaris) and fungi (Aspergillus nigar and Candida albican). Cup-plate diffusion and disc diffusion method were used. Analysis of the data revealed that, the chloroform extract of the fruit exhibited the maximum antibacterial activity. It showed antibacterial activity against S. aureus: 36 mm, B. subtilis; 38 mm, E. coli; 37 mm, P. valgaris; 23 mm and P. aerguinosa; 19 mm. Results were compared concurrently to standard drugs; clotrimazole and gentamicin (Erhirhie and Ekene, 2013). Based on the current findings, it was concluded that Citrullus lanatus var. citroides (CL) has antimicrobial activity, which is as potent as standard antimicrobial drugs against the selected microorganisms (Loiy, et al., 2011).

UNIVERSITY OF EDUCATION, WINNEBA

CHAPTER THREE

MATERIALS AND METHODS

3.1 Materials and equipment

Plastic tray, bucket, bowl, cutting knife, plastic spatula, clean white cotton cloth, sterile absorbable cotton wool, plastic sieve, crucible dish, reagent bottles (various types), measuring cylinder, flasks, large mouth, brown, sample bottles, Whatman filter paper (No.1), hand gloves, hot air oven, muffle furnace, Vanier caliper, measuring tape, weighing balance, analytical balance and atomic absorption spectrophotometer (AAS).

3.2 Source of Sample

Samples of two (2) varieties of Watermelon's (*C. lanatus*) fruits will be randomly selected and collected in various forms and shapes directly from the farm where they had been cultivated. The samples will then be transported to the Laboratory, Department of Nutrition and Food Science, University of Ghana where they will be kept in a cool, dry area until ready for processing and analysis of the fruit's Seeds.

3.3 Sample Preparation

The Laboratory bench will be washed, cleaned and disinfected with hydrogen hypochlorite (bleach) solution soaked with cotton wool. The Watermelon's fruits will be washed in tap water, rinse in distilled water, and lastly in deionised water and were allowed to drained respectively. The weight and the length of the watermelon's fruits will be taken by using measuring tape and weighing balance. The watermelon's fruits will then be cut into two (2) at the Centre and the diameter will be read and taken. It will then be cut again radially into long slices and the seeds will be removed from the sliced fruit by using plastic Spatula and transferred into plastic bucket containing tap water. It will be washed thoroughly with tap water

University of Education, Winneba http://ir.uew.edu.gh

and sieved through a plastic Sieve. It will then be rinsed with distilled water and lastly with deionized water and drained respectively.

3.4 Methods

3.4.1 Proximate analysis of Watermelon seed

3.4.1.1 Determination of Moisture Content

The moisture content of the samples will be determined using the air oven method of AOAC (2010). Two grams (2g) of each sample will be put into a washed and dried moisture dish and placed in the oven at a temperature of 105˚C for 5 hours. The samples will be cooled in a desiccator and weighed. The weight loss will be obtained as the moisture content and is calculated as:

$$\% \text{ Moisture content} = (W2-W3)/(W2-W1)\times 100$$

Where; W1 = initial weight of empty moisture cans; W2 = weight of moisture cans + sample before drying; W3 = final weight of moisture cans + sample after drying

3.4.1.2. Determination of Crude Protein Content

The crude protein of the samples will be determined by the semi-micro Kjeldahl technique described by AOAC (2010). 1 gram (1.0g) of the sample will be put into a Kjeldahl flask. Three grams (3g) anhydrous sodium sulphate and one (1g) of hydrated copper sulphate (catalyst) will be added into the flask. Then, 20 ml of concentrated tetraoxosulphate (IV) acid (H2SO4) is added to digest the sample. The digestion will continue until a solution is observed. The clear solution will be cooled and be made up to 100 ml with distilled water and a digest of about 5 ml will be collected for distillation. Then, 5 ml of 60% sodium hydroxide (NaOH) will be put into the distillation flask and distillation will be allowed to take place for some minutes. The ammonia distilled off is absorbed by boric acid indicator and is titrated with 0.01M hydrochloric acid (HCl). The titre value of the end point at which the colour changed from green to pink were taken. The crude protein is calculated as:

% Crude protein = (0.0001401×6.25)/ (W×5) ×100

Where; T= titre value; W= weight of sample dried

3.4.1.3. Determination of Crude Fat Content

The solvent extraction method as described by AOAC (2010) will be used. The extraction flasks are to be washed with petroleum ether, dried and cooled and weigl oil in the extraction flask will then be dried in the oven, cooled and finally weighed. The fat content is expressed as a percentage of raw materials. The difference in weight of empty flasks and the flask with oil content which will be calculated as:

% Fat content = (C-B)/A×100

Where; A = Weight of sample; B = Weight of empty flask; C = Weight of flask + Oil.

3.4.1.4. Determination of Ash

The ash content of the sample will be determined by the method stated in AOAC (2010). A silica dish is heated to about 60˚C, cooled in a desiccator and weighed. Five milligrams (5 mg) of the sample is put into the silica dish and transferred to the furnace. The temperature of the furnace is then allowed to reach about 600˚C after placing the dish in it. The temperature is maintained until whitish-grey colour is obtained indicating that all the organic matter content of the sample has been destroyed. The dish is then brought out from the furnace and cooled in the desiccator and re-weighed. The percentage ash content will be calculated as:

Percentage ash content = (C-A)/ (B-A)×100

Where: A = weight of empty dish; B = weight of empty dish + sample before ashing; C = weight dish + ash

3.4.1.5 Crude Fibre Determination

A defatted sample of about 2.0g will be transferred into a 750ml Erlenmeyer flask containing 200 ml of boiling 1.25% H_2SO_4 and refluxed for about 45 minutes with add anti-foaming agent. Digestion flask will be connected immediately with condenser and heated. At the end of 30 minutes, flask was removed, filtered immediately through linen and wash with boiling water until are no longer acid.

NaOH solution will be heated to boiling point and kept at this temperature under reflux condenser until used. Residue is washed back into the flask into 200 ml of the boiling NaOH solution and flask connected with reflux condenser and boiled for exactly 30 minutes.

After 30 minutes, flask will be removed and immediately filtered through a Gooch Crucible. Thorough washing was done with boiling H_2O, and again with about 15ml of 95% ethanol. Crucible and contents will be dried at 110^0C to constant weight, cooled in the desiccator and weighed. Contents of crucible will then be incinerated in muffle furnace at 550^0C for 30 minutes until the carbonaceous matter is consumed. Cooled in a desiccator and weighed. Loss in the weight is then recorded as crude fibre (AACC, 2000)

<u>Calculation</u>

% crude fibre= $\frac{A-B}{C}$ x 100 where A= wt. of dry crucible and sample

B= wt. of incinerated crucible and ash, C= sample weight

3.4.1.6 Determination of Total Carbohydrate

Carbohydrate was determined as the nitrogen free extraction calculated by difference as described by AOAC (2010). The formula below will be used:

% Carbohydrate = 100 %-%(protein+fat+fibre+ash+moisture)

3.4.2 Mineral Analysis of Watermelon Seeds

Minerals of each sample of the dried and ashed watermelon's seeds will be determined by digesting the ash with 3M Hydrochloric acid (Tabiri *et al.*, 2016). The cations (Ca, Mg, K, Na, Zn, Cu, Mn and Fe) will be determined using flame atomic absorption spectrophotometer (model VGP 210, Buck Scientific, USA).

3.5 Statistical Analysis

Statistical significance tests were performed using SPSS (v.20, IBM SPSS Statistics, US) at $p < 0.05$ by means of one-way analysis of variance (ANOVA) followed by LSD post hoc multiple comparisons.

University of Education, Winneba http://ir.uew.edu.gh

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Proximate Composition of Watermelon Seed Samples

The results in table 4.1 shows analysis of the proximate composition of watermelon seed samples from two varieties which include; Sweet baby and Karoka varieties. The proximate components analyzed were; Moisture Content, Carbohydrate, Protein, Fats, Ash, Fibre.

Table 4. 1: Proximate composition of sweet baby and karoka varieties of watermelon seeds

Proximate composition	Varieties	
	Sweet Baby	**Karoka**
Moisture	11.642 ± 0.002^{a}	9.584 ± 0.015^{b}
Carbohydrate	12.792 ± 0.455^{b}	17.211 ± 0.319^{a}
Proteins	16.575 ± 0.010^{a}	15.690 ± 0.010^{b}
Fats	26.542 ± 0.471^{a}	25.876 ± 0.018^{a}
Ash	2.444 ± 0.004^{a}	2.261 ± 0.018^{b}
Fibre	30.004 ± 0.016^{a}	29.377 ± 0.338^{b}

Data are presented as Mean ± S.D. Means within a column with different superscripts are statistically significantly different at $p \leq 0.05$.

4.1.1 Moisture Content of Watermelon Seed Samples

The two different watermelon seed varieties were Sweet Baby and Karoka recorded moisture contents 11.642±0.002 and 9.584±0.015 respectively. A p-value of 0.000 was obtained from the statistical analysis of the mean moisture content values of the two different watermelon seed varieties signifying that there was a statistically significant difference between the watermelon seed varieties.

Rekha & Rose (2016) stated that moisture content of watermelon seed is 6.4 but the analysis done on the Sweet Baby and Karoka variety indicates a higher value which could be as result of several factors. The most striking factor for this is the varieties of the seeds analyzed. The variety of seeds can play an important role in the difference in vales. Another reason for the difference in the values reported by Rekha and Rose could be as a result of the storage period before the analysis. It could lead to the absorption of more moisture (Tibiri et al., 2016).

4.1.2 Carbohydrate Content of Watermelon Seed Varieties

The two watermelon seed varieties which were Sweet Baby and Karoka had values 12.792±0.45 and 17.211±0.319, respectively. A p-value of 0.000 was obtained from the statistical analysis of the means that the Carbohydrate values of the two different watermelon seed varieties signify that there was a statistically significant different between the watermelon seed varieties.

Tibiri et al., (2016) reported values of Carbohydrates for three different varieties to be around the values gotten in this study. All the values gotten from the study done by Tibiri et al., (2016) for Carbohydrate were all different just like the varieties of Sweet Baby and Karoka which indicates that variety is a unique variable that can lead to difference in the Carbohydrate content.

4.1.3 Protein Content of Watermelon Seed Varieties

The two watermelon seed varieties which were Sweet Baby and Karoka had values 16.575±0.010 and 15.690±0.010 respectively. A p-value of 0.000 was obtained from the statistical analysis of the means that the Protein values of the two different watermelon seed varieties signify that there was a statistically significant different between the watermelon seed varieties.

A study done by Rekha and Rose (2016) showed that watermelon seed had a protein content of 68.4 and another study done by (Gwana et al., 2014) also showed that Protein content for Sassako Variety had a protein content of 6.1±0.06. This is an indication that varieties have their own conditions for growth which can influence the nutrient contents.

4.1.4 Fat Content of Watermelon Seed Varieties

The two watermelon seed varieties which were Sweet Baby and Karoka had values 26.542±0.471 and 25.876±0.018 respectively. A p-value of 0.071 was obtained from the statistical analysis of the means that the Fat content values of the two different watermelon seed varieties signify that there was a no statistically significant different between the watermelon seed varieties.

According to Gwana et al., the fat content of other varieties is found to be equal. This study also makes similar observations indicating that the fat content of the various varieties is equal. That is, there is no significant difference between the Sweet Baby and Karoka variety for fat content.

4.1.5 Ash Content of Watermelon Seed Varieties

The two watermelon seed varieties which were Sweet Baby and Karoka had values 2.444±0.004 and 2.261±0.018 respectively. A p-value of 0.000 was obtained from the statistical analysis of the means that the Ash content values of the two different watermelon seed varieties signify that there was a statistically significant different between the watermelon seed varieties.

Rekha and Rose (2016) also states that varietal changes in the composition of watermelon can be as a result of several factors that affect the watermelon. Some of these factors include; temperature, relative humility, Climatic conditions for growth etc. This study also makes similar observations indicating that there is a difference between the ash content of the various varieties.

4.1.6 Fibre Content of Watermelon Seed Varieties

The Fibre content of the two different watermelon seed varieties were represented on a graph below in Figure 4.6. The two watermelon seed varieties which were Sweet Baby and Karoka had values 30.004±0.016 and 29.377±0.338 respectively. A p-value of 0.000 was obtained from the statistical analysis of the means that the Fibre content values of the two different watermelon seed varieties signify that there was a statistically significant different between the watermelon seed varieties.

4.2 Mineral Composition of Watermelon Seed Samples

The table 4.2 shows the mineral composition of the two watermelon seed varieties that were analyzed. The two watermelon seed varieties analyzed were the Sweet Baby and Karoka varieties.

The mineral components analyzed include; Phosphorus, Potassium, Calcium, Sodium.

Table 4. 2: MINERAL COMPOSITION OF SWEET BABY AND KAROKA

Mineral composition	Varieties (mg)		P-value
	Sweet Baby	Karoka	
Phosphorus	2200.37±0.12[a]	1900.17±0.12[b]	0.000
Potassium	33500.2±0.10[b]	38100.6±0.1[a]	0.000
Calcium	1100.53±0.06[b]	1200.27±0.06[a]	0.000
Sodium	900.23±0.40[a]	700.63±0.29[b]	0.000

Varieties

Data are presented as Mean ± S.D. Means within a column with different superscripts are statistically significantly different at $p \leq 0.05$.

For all the various mineral components that were analyzed, it was observed that the p-values for all of them were below significance of 0.05 which was an indication that there was a statistical difference between the mineral components for both varieties.

4.2.1 Phosphorus Content of Watermelon Seed Varieties

The two different watermelon seed varieties were Sweet Baby and Karoka which had Phosphorus contents 2200.37±0.12 and 1900.17±0.12, respectively. A p-value of 0.000 was obtained from the statistical analysis of the mean Phosphorus content values of the two different watermelon seed varieties signifying that there was a statistically significant difference between the watermelon seed varieties. Phosphorus is a mineral that the body uses to build bones and teeth and to make proteins that grow and repair cells and tissues. According to Tabiri et. al. (2016), Some of the benefits of phosphorus include: keeping the bones and teeth strong, helping the muscles contract, aiding muscle recovery after exercise, filtering and removing waste from the kidneys, promoting healthy nerve conduction throughout the body, making DNA and RNA and managing the body's energy usage and storage.

4.2.2 Potassium Content of Watermelon Seed Varieties

The two different watermelon seed varieties were Sweet Baby and Karoka which had Potassium contents 33500.2±0.10 and 38100.6±0.10 respectively. A p-value of 0.000 was obtained from the statistical analysis of the mean Potassium content values of the two different watermelon seed varieties signifying that there was a statistically significant difference between the watermelon seed varieties.

According to Gwana et al., (2014), the potassium content for Sassako variety seed was reported to be 3187.00±0.02 which is less than the Sweet baby and the Karoka variety investigated in this test. The difference in the potassium contains in the different varieties could be largely as a result of varietal change in the different seeds. Potassium was also found to be the highest mineral in the minerals investigated in this test. Tibiri et al., (2016) also reported potassium being one of the highest mineral present when investigated. Insufficient potassium intakes can increase blood pressure, kidney stone risk, bone turnover, urinary calcium excretion, and salt sensitivity (meaning that changes in sodium intakes affect blood pressure to a greater than normal extent) hence the need to take up potassium in our diet (Tibiri et al., 2016)

4.2.3 Calcium Content of Watermelon Seed Varieties

The two different watermelon seed varieties were Sweet Baby and Karoka which had Calcium contents 1100.53±0.06 and 1200.27±0.06 respectively. A p-value of 0.000 was obtained from the statistical analysis of the mean Calcium content values of the two different watermelon seed varieties signifying that there was a statistically significant difference between the watermelon seed varieties.

It was reported in Gwana et al., (2014) that the Calcium content of the Sassako variety seed was 2076.07±0.056 which was higher that the Sweet baby and the Karoka varieties investigated. This could be largely as a result of Climatic conditions for growth of the varieties. Tibiri et al., (2016) mentioned that climatic conditions necessary for growth of the varieties could be a reason for the vast difference in the Calcium contents of the Sweet baby and Karoka against the Sassako variety. Calcium is the most plentiful mineral found in the human body. Calcium helps your body with: building strong bones and teeth, clotting blood, sending and receiving nerve signals, squeezing and relaxing muscles, releasing hormones and other chemicals as well as keeping a normal heartbeat. Hence having low calcium in your body may lead to Hypocalcemia, also known as calcium deficiency disease, occurs when the blood has low levels of calcium. A long-term calcium deficiency can lead to dental changes, cataracts, alterations in the brain, and osteoporosis, which causes the bones to become brittle (Apenten, 2001).

4.2.4 Sodium Content of Watermelon Seed Varieties

The two different watermelon seed varieties were Sweet Baby and Karoka which had Sodium contents 900.23±0.40 and 700.63±0.29, respectively. A p-value of 0.000 was obtained from the statistical analysis of the mean Sodium content values of the two different watermelon seed varieties signifying that there was a statistically significant difference between the watermelon seed varieties.

Tibiri et al., (2016) reported that Charleston gray and Crimson sweet had Sodium content of 700.00±0.01 and 800.00±0.00 respectively. It was observed that the Karoka variety analyzed in this study had similar Sodium content as the Crimson sweet variety. It was also observed that the sodium content of the varieties reported by (Tibiri et al., 2016) and the Sweet baby and Karoka varieties analyzed in this test were similar.

University of Education, Winneba http://ir.uew.edu.gh

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The determinations and evaluation of proximate composition and mineral from the two varieties of the Water melons (*C. lanatus*) seeds; the *Sweet Baby* and *Karoka* varieties which were cultivated in Ghana was conducted. The findings from this study showed that the watermelon seed varieties; Sweet baby and Karoka were good sources of various nutrients. These nutrients were present in high quantities. Also, it was observed that the seed from the two varieties were high in potassium and could be a good source of potassium.

5.2 Recommendation

When these plant varieties fruits (*C. Lanatus*) were been cultivated in large scale farming (Horticultural farming), a lots of products would be obtained from the foods and oil mill industries that processing them and a lot of income would be generated which will increase the Gross Domestic Products and Income at large. The Government and Private sectors are urged to encourage the large scale farmers to participate in the cultivation of watermelon of the varieties of *Sweet Baby* and *Karoka*, this is because of its economic values which would increase the Gross.

REFERENCES

AOAC (2010). Official methods of Analysis of Association of Official Analytical Chemists 18th ed., Published by AOAC International, Gaithersburg, Maryland, USA

Apenten, R. K. O. (2001.). Antinutritional Factors in Food Legume and effects of processing. The role of food, agriculture, forestry and fisheries in human nutrition, 4, 82-116.

FAO (1992). Cashew nut processing and utilization in Sub-Saharan African FAO Committee Gabriele P., Natasha I., Mariapaola C. *et al*,.(2017) “Oxidative Stress: Harms and Benefits for Human Health,” Oxidative Medicine and Cellular Longevity, vol. 1, Article ID 8416763, . https://doi.org/10.1155/2017/8416763.

Fekadu, G. H. (2014). Antinutritional Factors in Plant Foods: Potential Health Benefits and Adverse Effects. International Journal of Nutrition and Food Sciences, 3(4), 284. https://doi.org/10.11648/j.ijnfs.20140304.18

Gupta, R. K., Gangoliya, S. S., and Singh, N. K. (2015). Reduction of phytic acid and enhancement of bioavailable micronutrients in food grains. *Journal of food science and technology*, *52*(2), 676–684. doi:10.1007/s13197-013-0978-y

Gwana, A. M., Bako, M. M., Bagudu, B. Y., Sadiq, A. B., Abdullahi, M. M. (2014). Determinations of phytochemical, vitamin, mineral and proximate compositions of varieties of watermelon seeds cultivated in Borno State, North – Eastern Nigeria. International Journal of Nutrition and Food Sciences; 3(4): 238-245

Habtamu, F. G. and Ratta N. (2014). Antinutritional Factors in Plant Foods: Potential Health Benefits and Adverse Effects, *International Journal of Nutrition and Food Sciences*. **Vol. 3**, No. 4, pp. 284-289. doi: 10.11648/j.ijnfs.20140304.18.

Hanan, M.A. A, and Abdelrahman R. A. (2013). Utilization of watermelon rinds and sharlyn melon peels as a natural source of dietary fiber and antioxidants in cake. Annals of Agricultural Science (2013) 58(1), 83–95.

Han, H., Segal, A. M., Seifter, J. L., & Dwyer, J. T. (2015). Nutritional Management of Kidney Stones (Nephrolithiasis), 137–152.

Heinrich M, Chan J, Wanke S., Neinhuis C, Simmonds M.S. (2009). "Local uses of Aristolochia species and content of nephrotoxic aristolochic acid 1 and 2--a global assessment based on bibliographic sources". *Journal of Ethnopharmacology*. **125** (1): 108–44. doi:10.1016/j.jep.2009.05.028.

Hendek, E. M. and Bektas M. (2018). Enhancement of Bioavailable Micronutrients and Reduction of Antinutrients in Foods with some Processes

Kittakoop, P., Mahidol C, & Ruchirawat S (2014). "Alkaloids as important scaffolds in therapeutic drugs for the treatments of cancer, tuberculosis, and smoking cessation". *Current Top MedicinalChem*istry **14** (2):239252. doi:10.2174/1568026613666131216105049. PMID 24359196.

Kumar, R. S., Brannigan, J. A., Prabhune, A. A., Pundle, A. V, & Dodson, G. G. (2006). 1 (18), 1–26. https://doi.org/10.1074/jbc.M604172200

Lean, L.P., Mohamed, S., (1999). Antioxidative and antimycotic effects of turmeric, lemon-grass, betel leaves, clove, black pepper leaves and Garcinia atriviridis on butter cakes. Journal of the Science of Food and Agriculture 79, 1817–1822.

Loiy, E. A. H., Hasnah M. S., Sakina M. Ahemd Y., Waleed S. N Koko, & Siddig I. A. (2011). In vitro Antimicrobial activities of chloroformic, hexane and ethanolic extracts of

Citrullus lanatus var. citroides (Wild melon). Journal of Medicinal Plants Research. 5(8), pp. 1338-1344.

Madhavi, P., Maruthi R., Kamala V., Habibur R., M. & Chinna E. (2012). Evaluation of Anti-Inflammatory Activity of Citrullus lanatus Seed Oil by In-vivo and In-vitro Models. Int. Res J Pharm. App Sci., 2(4): 104-10.

Ministry of Agriculture (2011). Facts sheet of watermelon production in Ghana.

Molyneux R. J., Lee S. T., Gardner D. R., Panter K. E. & James L. F. (2007). "Phytochemicals: the good, the bad and the ugly?". Phytochemistry. 68 (22–24): 2973–85. doi:10.1016/j.phytochem.2007.09.004.

Nissar, J., Ahad, T., Naik, H. R., & Hussain, S. Z. (2017). A review phytic acid : As antinutrient or nutraceutical, 6(6), 1554–1560.

Okuda, T., & Ito, H. (2011). Tannins of constant structure in medicinal and food plants-hydrolyzable tannins and polyphenols related to tannins. Molecules, 16(3), 2191–2217. https://doi.org/10.3390/molecules16032191

Schippers, R. R., (2002). African indigenous vegetables, an overview of the cultivated species. Revised edition on CDROM. National Resources International Limited, Aylesford, United Kingdom.

Sharma, S., Kaur M, Goyal R, & Gill B. S. (2011). Physical characteristics and nutritional composition of some new soybean (Glycine max (L.) Merrill) genotypes, *Journal of Food Science and Technology*. DOI:10.1007/s13197-011-0517- 7.

Shen, C., Guo, H., Chen, H., Shi, Y., Meng, Y., Lu, J., and Wang, H. (2017). Identification and analysis of genes associated with the synthesis of bioactive constituents in

Dendrobium officinale using RNA-Seq, *Scientific reports*, ***7***(1), 187. doi:10.1038/s41598-017-00292-8.

Soetan, K.O. & Oyewole, O.E. (2009) The Need for Adequate Processing to Reduce the Antinutritional Factors in Plants Used as Human Foods and Animal Feeds: A Review. *African Journal of Food Science,* **3,** 223-232.

Spivacow, F. R., Valle, E. E. D. E. L., Lores, E., Rey, P. G., Metabólicas, I. D. I., Salvador, U., & Aires, B. (2016). Original Article Kidney Stones : Composition , Frequency And Relation To Metabolic Diagnosis Results, 343–348.C

Swanson, B. G. (2004). Tannins and Polyphenols. Encyclopedia of Food Sciences and Nutrition, 5729–5733. https://doi.org/10.1016/b0-12-227055-x/01178-0

Tabiri, B., Agbenorhevi, J. K., Wireko-Manu, F. D., & Ompouma, E. I. (2016). Watermelon Seeds

as Food: Nutrient Composition, Phytochemicals and Antioxidant Activity. International Journal of Nutrition and Food Sciences; 5(2): 139-144.

Tak, J. & Jain, S. (2016). Nutrient potential of watermelon (Citrullus lanatus) seeds and its

incorporation in product preparation. Food Science Research Journal; Volume 7 : Issue 2 : October 2016; 202-206

Ugwu, F. M, & Oranye N. A. (2006). Effects of some processing methods on the toxic components of African bread fruit (*Treculia africana*), *Africa Journal of Biotechnology*. **5** (22): 2329.

University of Education, Winneba http://ir.uew.edu.gh

USDA, (2002). USDA nutrient database for standard reference, release 15. [Internet] U.S. Department of Agriculture, Beltsville Human Nutrition Research Center, Beltsville Md, United States. http://www.nal.usda.gov/fnic/foodco mp. Accessed June 2003.2333**.**

Viswambari, D, R.; Basilrose, M. R. & Mercy, P. D. (2010). "Prospect for lectins in arthropods",*ItalianJournal of Zoology*. **77** (3):Pp.254260. doi:10.1080/11250003.2010492794.