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TETRAPLEURA TETRAPTERA (PREKESE) AND SPICES (GINGER AND TURKEY BERRY) TO MANUFACTURE PREKESE MIXED SPICE DRINK

MAHAMA MERI

(190000301)

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APRIL, 2021

DECLARATION

STUDENT'S DECLARATION

I, MAHAMA MERI, 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……..……

SUPERVISOR'S DECLARATION

I hereby declare that the preparation and presentation of this work was supervised in accordance with the guidelines and supervision of this dissertation as laid down by the University of Education, Winneba.

SUPERVISOR'S NAME: DR. GILBERT OWIAH SAMPSON

SIGNATURE……

DATE……..……..……

DEDICATION

I dedicate this work to the almighty God for keeping me through this course with his protection ,guidance, and Support.

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May the Most High God be glorified for how far he has brought me. He has been so grateful throughout my life time and I will forever appreciate and acknowledge his presence in my life.

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ABSTRACT

This research was conducted to assess the possibility of using prekese, ginger and turkey berry to produce prekese mix spiced drink. Nutritional studies have shown that *Prekese* extract has some useful therapeutic action easing hypertension, and Asthma. To this effect, the aim of the study was to use *Tetrapleura tetraptera* (Prekese) and spices (ginger and turkey berry) to manufacture prekese mixed spice drink to prevent post-harvest losses of prekese and spices (ginger and turkey berry) in Ghana. Four different products were thus prepared, labeled, The mean values of the samples P01 = Control (100% Prekese drink), P02 = (prekese and ginger), P03 = (prekese and turkey berry) P04 = (prekese, ginger and turkey berry). Prepared products were then examined for their proximate composition with the standard AACC, 2000. Sensory evaluation analysis was also conducted under the 'hedonic scale' measure of 1-7 score points. Data was analyzed win an Excel database spread sheet at $P < 0.05$ level of probability. Proximate composition analysis showed no significant difference between the means of the constituent nutrients measured. However, the proportionate increased percentage crude fat, crude fibre and protein; 4.29%$\pm$2.45, 2.47$\pm$0.28 and 7.49$\pm$2.94 respectively, showed the potential effect of ginger and turkey berries in the production of prekese mix spice drink. Percentage carbohydrate decreased with increasing proportion of ginger and turkey berry, recording 37.56$\pm$5.81 for sample P04. The sensory analysis also showed no significant difference at $P < 0.05$ between the means and according to the hedonic scale evaluation, P02, P03 and P04 composite drink compared to P01, the 100% prekese drink were "moderately liked" and "like very much" that is, between 5.3 to 6.6 by the fifteen semi-trained panelist. The Ministry of Health should create public awareness regarding the health benefits of consuming *prekese, ginger and turkey berry* to enhance public awareness and consumption.

CHAPTER ONE

INTRODUCTION

1.1 Background to the study

Tetrapleura tetraptera (family Fabaceae) is a deciduous tree native to tropical Africa where it is distributed from Mauritania to Tanzania (Katende et al. 2015; Blay 2017). The tree grows up to 25m high, with a diameter at breast height (DBH) of 1.5 –3.0 m. Although its preferred habitats are savannah woodlands, dry forests and riverine forests, it is most common in dense rainforests and preserved forest patches around villages.

The species is commonly known as "Prekese" in Ghana, "Aidan" in Nigeria and "Kikangabalimu" in Uganda. The meaning of these local names reflects the knowledge and use of the species by local communities in each country. For instance, the word "Prekese" in Twi dialect in Ghana means "soup perfume"; "Aidan" in Yoruba dialect in Nigeria means "cast no spell"; and "Kikangabalimu" in Rwamba dialect in Uganda means "it scares ghosts". In agreement with its local names, T. tetraptera is reported to have various medicinal and nutritional properties (Adesina et al. 2016).

The species medicinal attributes are due to presence of bio-active compounds (alkaloids, flavonoids, saponins, tannins, phenols and glycosides) which are essential for health (Okwu 2013). For instance, *T. tetraptera* fruit is reported to have anti-arthritis, anti-inflammatory and anti-diabetic properties (Ojewole and Adewunmi 2004). Aladesanmi (2007) and Soladoye et al. (2014) also indicated its use in managing schistosomiasis, a chronic parasitic disease caused by blood flukes (trematode worms).

The nutritional attributes of *T. tetraptera* are due to essential food micronutrients, including iron and zinc found in the dry fruit (Akin-Idowu et al. 2011; Uyoh et al. 2013). The species is found throughout the high forest zone, in riverine forest, in the southern

savannah wood land and in the forest outliers in the African plains and are native to Benin, Burkina Faso, Cambodia, Chad, Cote d'Ivoire, Gambia, Ghana, Guinea, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, Togo and Uganda. (Gyamfi et al. 2016).

The dry fruit has a characteristic aroma which makes it a popular seasoning spice in Ghana, Southern and Eastern Nigeria (Essien *et al*., 2014; Adesina*, 20*12; Okwu, 2011). The fruit shell, fruit pulp and seed contain varying amounts of nutrients such as protein, lipids and minerals which are comparable to and some are even higher than popular spices and ginger (Essien *et al*., 2014). It is also a source of minerals e.g. calcium, phosphorus, potassium, zinc and iron. The plant has many traditional uses, mainly in the management of convulsion, leprosy, inflammation and rheumatic pains, schistosomiasis, asthma and hypertension (Ojewole & Adesina, 2012).

The fruit shell, fruit pulp and seed contained varying amounts of nutrients such as protein, lipids and minerals which are comparable and some are even higher than popular spices and ginger (Essien *et al*., 2014). Okwu (2013) reported that the proximate composition of *T. tetraptera* as follows: crude protein (7.44% - 17.50%), crude lipid (4.98% - 20.36%), crude fibre (17% - 20.24%), carbohydrate (43.18% - 49.06%) and food energy (234.18% - 42,379.48 gl Cal). The species is also a source of minerals e.g. calcium, phosphorus, potassium, zinc and iron. In Ghana, it is used as a source of vitamins in diets (Okwu, 2013).

Ginger, (*Zingiber offificinale* Roscoe, Zingiberaceae) is one of the most important cash crop and principal spice of India and abroad (Bartley and Jacobs, 2010). Ginger is believed to be native of South East Asia and originated in Indo-China region where it has been used in food and medicines for over 5000 years (Purseglove *et al.* 2011). In India, it

is grown in an area of 1,32,000 hectares with a production of 6,55,000 thousand million tonnes (Anonymous, 2014b). Ginger is widely used around the world in food as a spice both in fresh and dried form which adds flavour to the meal, creating a fresh, spicy pungent taste (Jayashree *et al.* 2012).

Ginger is widely used around the world in food as a spice both in fresh and dried form which adds flavour to the meal by creating spicy pungent taste (Jayashree *et al*. 2012). Ginger is used extensively in food, beverage and confectionary industries in products such as marmalade, pickles, chutney, ginger wine, liquors and other bakery products (Wang *et al*. 2011). The chemical components of the ginger rhizome vary considerably, depending on the location of cultivation and postharvest treatments (Ali *et al*. 2008).

Ginger contains polyphenol compounds such as gingerol and its derivatives (Chen *et al*. 2016 and Rahaman *et al*. 2013) such as zingiberone, bisabolene, camphene, geranial, linalool, borneol and oleoresin (combination of volatile oils and resin) that accounts for its characteristic aroma and therapeutic properties. Dry ginger contains essential oil 1-3 per cent, oleoresin 5-10 per cent, starch 50-55 per cent and moisture 7-12 per cent with small quantities of protein, fibre, fats and ash (Aruoma *et al*. 2017). Ginger is found effective for treatment of poor digestion, heartburn, vomiting and nausea, prevents motion sickness, migraine headaches without side effects and also stimulate the appetite (Platel and Srinivasan, 2000; Mustafa and Srivastava, 2010).

Turkey berry is one vegetable that grows in the wild in Ghana and has been used in food preparation over the centuries. Traditionally, it is added to palm fruits to make soup. Although it has taken a while for its true nutritional and medicinal values to be recognized in Ghana (Asiedu-Darko, 2010), it has in recent times been vigorously sought after for its medicinal properties (Asiedu-Darko, 2010). Compared to other regions like

Thailand, India, and South America, where it has been consumed for medicinal purposes for so long (Agrawal, Bajpei, Patil & Bavaskar, 2010) there are hardly any documented recipes that use the Turkey berry in Ghana.

The sale of Turkey berry in Ghana has moved from selling on tables in the market to being packaged in polythene bags and sold not just in the market but in stores and shopping malls. Packaging the berry and making them more attractive and acceptable to the average Ghanaian consumer may help increase its consumption.

Asiedu-Addo (2014), reports that Turkey berry is believed to boost blood levels and is often used in preventing and treating anaemia. The rise in the consumption of the berry has also been attributed to the fact that doctors, midwives and traditional healers often recommend it for patients who are anaemic to help improve blood haemoglobin levels and general immune function. However, there is no documented scientific evidence in the Ghanaian literature that Turkey berry (*Solanum torvum sw.*) improves haemoglobin levels in the blood.

Arthan, Kittakoop, Esen & Svasti (2009), reported a moderate α-glucosidase inhibitory action of the berry, making it a possible anti-diabetic agent. They further explained that the turkey berry decrease postprandial hyperglycemia where glucose absorption is reduced by preventing carbohydrate hydrolysis through reduction of α-amylase and α-glucosidase in the digestive organs. This study therefore would use Tetrapleura Tetraptera (Prekese) and spices (ginger and turkey berry) to manufacture prekese mixed spice drink to prevent post-harvest losses of prekese and spices (ginger and turkey berry) in Ghana.

1.2 Statement of problem

Prekese has many potential uses for instance it is a potential source of raw material for the growing pole industry of Ghana, which is currently based on teak. Farmers are critical of negative environmental impact of teak therefore it is a suitable indigenous substitute which is agro-forestry and environmentally friendly (Adewunmi, 2008).

Nutritional study has shown that *Prekese* extract has some useful therapeutic action easing hypertension, and Asthma. Active constituents include Scopletin which appears to have a relaxing action on smooth muscle, helping to ease constriction in the Bronchioles of the lung, and on constricted blood vessels (Adewunmi, 2008).

Fresh ginger are perishable in nature and are spoiled due to improper handling, growth of spoilage microorganisms, susceptibility to rhizome rot, wilting and sprouting, action of naturally occurring enzyme, chemical reactions and structural changes during storage (Baranowski, 1985). Processing ginger into dried product is an important method of reducing perishability and also to increase storage stability (Pezzutti *et al*. 2017).

In years past, many ignored it as it grew wildly in their backyards. Some children even humiliated the berry and used them as “bullets” on broomstick guns. Neighbours who used them for food picked them from the backyards of friends. But in recent times, many have grown to love the berry. Those who love to use it would rather have its medicinal benefits and a little bit of bitter-sweet taste on their tongues for a short while. Others just love the bitterness it leaves in the mouth; bitter is better, they say. Yet others are irritated by the many seeds in the berry.

Whether it is a myth or not, coupled with the rising cost of medications in developing countries where majority of individuals still rely on traditional medicines, it is necessary to investigate the potential of using Turkey berry for the said medicinal purposes. This

study therefore would use Tetrapleura Tetraptera (Prekese) and spices (ginger and turkey berry) to manufacture prekese mixed spice drink to prevent post-harvest losses of prekese and spices (ginger and turkey berry) in Ghana.

1.3 Purpose of the study

The aim of the study is to use Tetrapleura Tetraptera (Prekese) and spices (ginger and turkey berry) to manufacture prekese mixed spice drink to prevent post-harvest losses of prekese and spices (ginger and turkey berry) in Ghana.

1.4 Specific Objectives of the study

However, the specific objectives will include:

1. To assess consumer preferences of prekese mixed spice wine.
2. To evaluate the variations in the ratios of prekese extract to ginger juice on the physiochemical qualities of the prekese mixed spice wine.
3. To evaluate the variations in the ratios of prekese extract to turkey berry juice on sensory acceptability of the wine.

1.5 Research Questions

1. What are the consumer preferences of prekese mixed spice wine?
2. What are the variations in the ratios of prekese extract to ginger juice on the physiochemical qualities of the prekese mixed spice wine?
3. What are the variations in the ratios of prekese extract to turkey berry juice on sensory acceptability of the wine?

1.6 Significance of the Study

Using Prekese, ginger and turkey berry for the production of prekese mixed wine will create employment, generate income for farmers and address the post-harvest losses associated with the local spices on the local market in Ghana. The findings of this study will inform decisions with regards to the preservation and storage of Tetrapleura Tetraptera (Prekese), ginger and turkey berry.

1.7 Scope of the Study

The study will be the production of wine from Tetrapleura Tetraptera (Prekese), ginger and turkey berry. Physicochemical properties, sensory properties and overall acceptability of the wine produced will also be determined.

1.8 Organisation of the Study

The organization of the study involves five main chapters. This outline how and what the researcher hopes to do in the study. The study consists of; Chapter one will present the background of the study, statement of the problem, purpose of the study, objectives of the study, research questions, significance of the study, scope of the study and organization of the study. Chapter two will be the literature review. In this section of the research literature materials of other authors are discussed and reviewed. This includes articles, newsletters, magazines, textbooks, reports etc.

Chapter three will discuss the research methodology adopted for the study and relevant justifications. It will outline the methodologies for carrying out the secondary and primary data collections and how results will be analyzed. The methodology will include the Introduction, Research Design, Population of the study, Sampling Techniques and Sample size, Data collection approach (Primary and Secondary data), Research

instrument (Questionnaires/interview) and Administration of the Research instrument. Chapter four will present the analysis of data, interpretation and discussion of the results of the sensory evaluation report. Chapter five is the final chapter of the study, it will focus on the summary of findings, conclusions and recommendation.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

2.1 Ecology of *Tetrapleura tetrapetra (Prekese)*

In West Africa, the plant *Tetrapleura tetraptera* (locally known as *Prekese*) is popular among the Akans of Ghana for its use as a spice, as some dietary supplement rich in vitamins and a medicine for many ailments. Traditionally, the fruits, leaves, bark and roots are perceived to have important medicinal properties (Thomas *et al*., 2011). Research has demonstrated how careful planting of *Tetrapleura tetraptera* in areas of high Billharzia transmission can reduce the rates of infection, offering countries with limited resource a more environmentally and financially friendly way of protecting their populations from this dreaded disease.

Prekese is a deciduous tree that sheds its leaves annually and grows approximately 20 to 25 meters in height. It is distinguished by round smallish crown that tends to flatten when old. Younger trees of *Tetrapleura tetraptera* have slender bole however, the older ones have low and sharp buttresses. The grey-brownish bark has a very smooth texture while the leaves are glabrous and hairy in appearance. It bears up to 5-10 pairs of pinnae that measure approximately 5 to 10 cm long with 6 to 12 leaves on both sides of the pinna stalk. The top of the tree can be marginally notched sometimes while the base is basically hairless with slender stems (Abii, and Amarachi, 2007). *Tetrapleura tetraptera* bears flowers that are sort of cream and pink in colour but they tend to change to orange colour on maturity. The flowers are located in the upper leaf axils and are always in pairs with short stamens and slender stalks. The aridan fruit hangs on stout stalks at the edges of the branches and they are characteristically brownish in colour.

The fruit (pod) measures about 15 to 25 cm long and is distinguished by its 4 longitudinal ridges that are slightly curved. Two of the ridges are woody while the other two contains soft, aromatic and oily pulp. The pod contains tiny, hard seeds that measure approximately 8 mm long. The fruit is distinguished by its fleshy pulp when fresh but this fleshy pulp tends to be very strong when dried. The inner part of the aridan fruit is characterised by tiny black-brownish seeds (Aderibigbe, Iwalewa, Adesina and Agboola, 2010). *Tetrapleura tetrapetra* has two varieties, namely *Tetrapleura thoningii* and *Adenonthera tetraptera*, both of which belong to the Genera *Tetrapleura* and of the family *Minosaceae*.

The plant is a perennial tree, about 30 m high and found in the lowland forest of tropical Africa particularly in the West Central and East Africa. The fruit consists of a fleshy pulp with some small brownish black seeds. The fruits are green when tender but dark, reddish brown when fully ripe. The fruit has four longitudinal wing-like fleshy ridges of about 10 cm broad with two of the ridges hard and woody while the remaining two are soft and fluffy. The fruits have fragrance, pungent aromatic odour. It is a single-stemmed, robust, perennial tree of about 30m. It has a grey/brown, smooth/rough bark with branches.

The flower is yellow/pink and racemes white. The fruit has dark brown, four winged pods (12–25cm x 3.5–6.5cm). It is generally found in the lowland forest of tropical Africa. The fruit consists of a fleshy pulp with small, brownish-black seeds. The fruit possesses a fragrant, characteristically pungent aromatic odour, which acts as an insect repellent and a spice in foods (Aladesanmi, 2007). The dry fruit has a characteristic aroma which makes it a popular seasoning spice in Southern and Eastern Nigeria (Essien *et al*., 2014). The fruit shell, fruit pulp and seed contain varying amounts of nutrients

such as protein, lipids and minerals which are comparable to and some are even higher than popular spices and ginger (Essien *et al*., 2014).

It is also a source of minerals e.g. calcium, phosphorus, potassium, zinc and iron. The plant has many traditional uses, mainly in the management of convulsion, leprosy, inflammation and rheumatic pains, schistosomiasis, asthma and hypertension (Ojewole and Adesina, 2012). The ethanol extract and saponins from the bark of the stem exerts an inhibitory effect on luteinizing hormone released by pituitary cells, suggesting its use as contraceptive agent (El-Izzi *et al*., 2010). It is used extensively in soups for nursing mothers to prevent post-partum contractions (Nwawu and Akali, 2016) and gastro-intestinal disorders especially stomach ulceration (Noamesi *et al*., 2012).

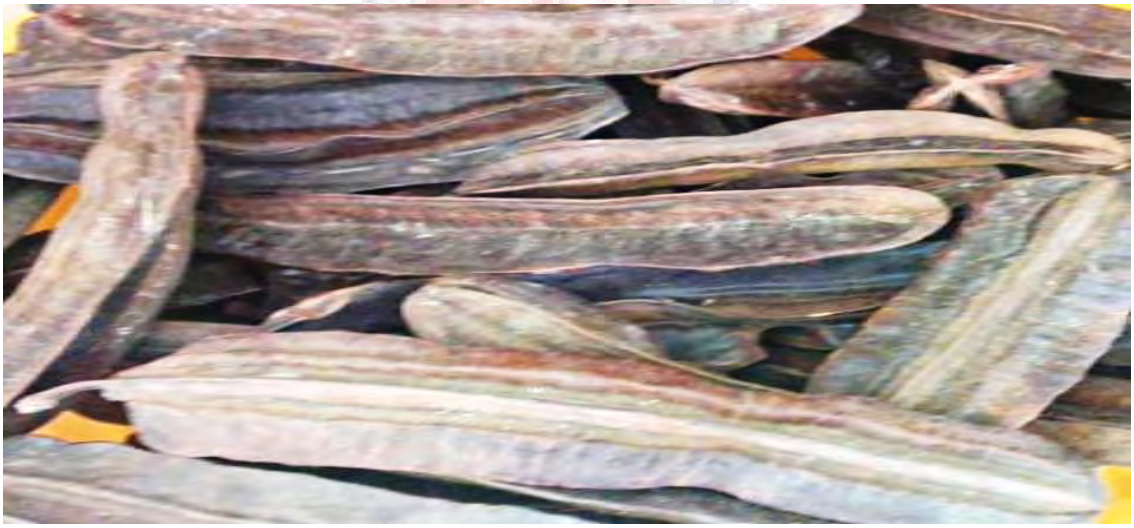

Plate 1: Prekese pods

Prekese is highly sought after due to its high medicinal and aromatic values and as such it is used for several purposes ranging from culinary, healing, therapeutic to cosmetology. Researchers also reveal that this plant has anti-inflammatory, hypotensive, neuromuscular, cardiovascular, anti-ulcerative, molluscicidal and anti-microbial properties (Aderibigbe, *et al,* 2010).

2.2 Nutrientional composition of *Tetrapleura tetrapetra*

The shells, pulps and seeds of both fresh and dry fruits of *Tetrapleura tetrapetra* have varying amounts of protein, lipids and minerals, all of which are comparable and in some cases even higher than those of popular spices such as red pepper, onion, curry and ginger (Essien *et al.*, 2014). Crude protein is very low in the fleshy mesocarp (2.12 %) and seed (0.51%) but is not at all in the woody mesocarp (Essien *et al*., 2014). Both fresh fruits and seeds are rich in potassium, iron, magnesium and phosphorus but low in sodium.

The fruits have less than 5 mg / 100 g of zinc and nickel. Sucrose and fructose occur in traces in both the fruits and seeds. The dried fruits have 7.44 % to 17.50 % crude protein, 17.0 % to 20.24 % crude fibre, 4.98 to 20.36 % lipid, 43.18 % to 49.06 % carbohydrate and 234.42 g / cal to 379.48 g / cal food energy (Okwu, 2013). The fruit oil is a good drying oil with a few unsaturated bonds. The seeds have the amino acids L-r- methylene glutamic acid and L-r- ethyldiene glutamic acid (Gmelin and Olesen, 2007). The fruit contains cinnamon and caffeine acids (Adesina *et al 20*10). The fruit also contains the essential oils saponosides triterpenes, - aessculetin, caumarins, tannins, steroids and triterpene glycosides.

Also present in the fruit are the phytochemicals, oxalates (8.14 to 16 Mg / 100 g), tannins (16.5 to 35.7 mg / 100 g) and hydrocyanic acid (hydrogen cyanide) (98 to 100 mg/100 g), saponins, alkaloids, steroids and flavonoids.

2.3 Medicinal uses of *Tetrapleura tetrapetra*

The fruits are used locally in Ghana and Nigeria for food flavouring, in soap and pomade preparations. The fruit is premixed with soap base made from palm kernel oil or shear butter to improve the foaming properties of the soap (Adebayo *et al*., 2000).

Convalescents bathe with the infusion of the fruit for healing. The bark, root and fruit of the plant are used in the management of convulsion, leprosy, inflammation and rheumatic pains (Dalziel, 2008; Adesina *et al*., 2010). Infusion of the whole fruit is taken as a recuperative tonic (Ojewole and Adesina, 2013).

Saponin extracted from the fruits has been proven to be a potent hypotensive and nonsposmolytic agent in traditional infusion (Obidoa and Obasi, 2011). In Eastern Nigeria, the fruits are used to prepare pepper soups for mothers after labour to prevent postpartum contraction (Nwawu and Akah, 2016), and also for normal cooking for its flavouring and cleansing effects. Extracts of the fruits exhibit anti-ulcer activity, confirming its use in ethnomedical medicine to treat ulceration in gastro-intestinal disorder (Noamesi *et al*., 2012). The fruit shell, fruit pulp and seed contained varying amounts of nutrients such as protein, lipids and minerals which are comparable and some are even higher than popular spices and ginger (Essien *et al*., 2014).

Okwu (2013) reported that the proximate composition of *T. tetraptera* as follows: crude protein (7.44% - 17.50%), crude lipid (4.98% - 20.36%), crude fibre (17% - 20.24%), carbohydrate (43.18% - 49.06%) and food energy (234.18% - 42,379.48 gl Cal). The species is also a source of minerals e.g. calcium, phosphorus, potassium, zinc and iron. In Ghana, it is used as a source of vitamins in diets (Okwu, 2013). According to Abii and Amarachi (2007), it was observed that the dry fruit of *tetrapleura tetraptera* contains 9% ash, 4% oil and 3% moisture. The plant has many traditional uses, mainly in the management of convulsion, leprosy, inflammation and rheumatic pains, schistosomiasis, asthma and hypertension (Ojewole and Adesina, 2013).

The ethanol extract and saponins from the bark of the stem exerts an inhibitory effect on luteinizing hormone released by pituitary cells, suggesting its use as contraceptive agent (El-Izzi *et al*., 2010). It is used extensively in soups for nursing mothers to prevent post-partum contractions (Nwawu and Akali, 2016) and gastro-intestinal disorders especially stomach ulceration (Noamesi *et al*., 2012). Phytochemical screening revealed the presence of tannins phenolic compounds, saponins, alkaloids, steroids and flavoniods which are assuumed to be responsible for its varied biological and pharmacological properties (Okwu, 2013). *T. tetraptera* is common on the fringe of the West African rainforest belt.

Trees are widespread in the forests of tropical Africa, especially secondary forest. The species is found throughout the high forest zone, in the southern savannah-woodland and in the forest outliers of the African plains (Orwa *et al.,* 2009). The tree is deciduous, losing its leaves in December. Flowering begins towards the end of February and ends in early April. The indehiscent pods mature and ripen from September to December. When the pods fall, their scent attracts rodents, which probably disperse the seeds (Orwa *et al*., 2009).

2.4 Nutrition Facts of *Prekese (Tetrapleura tetraptera)*

Prekese is highly valuable because it contains a high amount of essential phytochemicals and nutrients that are vital for the healthy functioning of the body. It is an excellent source of potassium, iron, calcium, zinc, flavonoids, phosphorous, tannins, alkaloids, saponins, steroids and phenolic compounds. It also contains 234.42 to 379.48g/cal of food energy, 7.44% to 17.50% of crude protein and 4.98% - 20.36% of crude lipid (Aderibigbe, *et al,* 2010).

2.4.1 How to Use Prekese

Prekese pods can be crushed, ground, grated or broken into tiny pieces before adding to food or using for medicinal purposes. Alternatively, the pod can be broken into two or added whole to food during preparation but in this case, remember to scoop it out from the food before serving. It is important to add this spice a lot more earlier in the food while cooking so that it can infuse properly for more flavourful and aromatic smell. For herbal medicines, the stem, bark, root, leaves and pods of prekese can be infused, boiled, soaked, squeezed, extracted, crushed or transformed into concoctions.

2.5 The health benefits of consuming tetrapleura tetraptera in the Ghanaian community.

Prekese or Tetrapleura tetraplera is a native of west tropical Africa and belongs to the pea family. The fruits of the plant have a pungent aromatic odor due to which it also possesses insect repellent properties. It is primarily used as spices. It is used as medicinal plant primarily in Ghana and Nigeria and other African countries. Some of the top diseases for which it is used medicinally are inflammation, convulsions, skin ailments like leprosy, and rheumatoid pains. *Prekese* is also called as Uyayak, Edeminang, Osakirisa, Osho, Dawo, Ojewole, and Adewunmi. *Prekese* is a rich source of antioxidants and has a high concentration of vitamins, minerals, and phytochemicals. It also does have anti-inflammatory properties. Its leaves bark and above all fruits contain medicinal properties (Abii, and Amarachi, 2007). Over the past years, plants have become an indispensable source of food and medicine.

To a larger extent, most people depend greatly on medicinal plants as an important source of remedy and treatment for most casual and life-threatening diseases. As a result, there is a growing demand all over the world for these medicinal plants. Aside from

tackling diseases, people are resorting more to these medicinal plants as a means of reducing the use of chemical (orthodox) medicines that could potentially be detrimental to human health. Interestingly, most of these plants are used in our everyday cooking as herbs, spices, seasonings and preservatives.

But the truth is that we often consume most of these essential medicinal plants in the form of spices without even acknowledging what our bodies gain from them (Abii, and Amarachi, 2007). Furthermore, the use of these medicinal plants as food, preservatives, spices and as instrument for preventing and tackling the development of microorganisms in human bodies has become an area of extensive studies. One of such valuable medicinal plants is *Prekese*.

2.6 Benefits of *Tetrapleura Tetraptera (Prekese)*

2.6.1 Contraceptive Properties

Saponin and ethanol extract from the stem and bark of this plant has an inhibitory effect on luteinizing hormone released by the pituitary gland. This suggests why this plant equally serves as a contraceptive (Adetunji & Aladesanmi, 2016).

2.6.2 **Management of convulsion**

In folk medicine, both the stem, leaves and fruit of the prekese are used for producing herbal concoction for managing convulsion. Studies reveal that the aqueous extract of this plant exhibits anticonvulsant activities and this confirms it's inhibitory effects on the central nervous system. In traditional medicine, herbal mixture out of ingredients including stem, fruit, and leaves has a positive effect on treating convulsions.

As per a study done at University of KwaZulu-Natal it was found that aqueous extract of the fruit contains anticonvulsant properties. It is also helpful for epilepsy patients in management and control of the condition. The fruit extract has the ability to slow down the nervous system (Adetunji & Aladesanmi, 2016).

2.6.3 Management of Leprosy

Studies reveal that *prekese* can be used for treating leprosy, which is an infectious disease that affects mainly the skin, nerves and the mucous membranes thereby causing blemishes and lumps on the skin. Severe cases of leprosy can lead to deformities and mutilation (Akah and Nwabie, 2013).

2.6.4 **Anti-inflammatory Properties**

The extract of this plant is known for its anti-inflammatory properties and this suggests its inhibitory impacts against certain human pathogens. As a result, it can be used for reducing inflammation of the body, arthritic pains and rheumatoid pains (Akah and Nwabie, 2013).

2.6.5 Antimicrobial

Due to the antibacterial and antimicrobial property of the *prekese*, the fruit extract is used in making of soap. The soap does not only have medicinal benefits for skin but it also improves the hardness and the foaming (Bella *et al.,* 2013).

2.6.6 Culinary Purposes

Dried taub fruit is known for its distinguished aromatic and flavorful fragrance and as such used as a spice for flavouring assorted dishes such as meat pepper soup, palm kernel soup (banga soup or ofe akwu), nsala (white soup), fish pepper soup etc. To use

this spice, you can either crush it before adding to food or break into smaller portions before adding in the food while cooking (Bella *et al.,* 2013).

2.6.7 Supports the Cardiovascular System

Prekese supports the cardiovascular system due to its constituents of essential phytochemical and as such can be used for preventing and treating heart diseases (Bella *et al.,* 2013).

2.6.8 **Molluscicidal Properties**

Studies reveal that the aqueous extracts from the stalk, leaves, stem, bark and roots of the *prekese* plant contain molluscicidal properties. This suggests why this plant acts as a pesticide for fighting against molluscs and pests. *Prekese* is normally used in gardening, planting and agriculture for offering protections and control against gastropod pests especially snails and slugs that feed on/damage crops and other valuable plants in the farmland (Effiong *et al,* 2014).

2.6.9 Dermatological Care

The fruit can be dried and blended into powdered form for producing dermatological products such as soap. The great attention drawn towards the use of this plant for manufacturing soap is due to its high antimicrobial and antibacterial properties. It is worthy to note that the aridan plant helps to promote soap foaming as well as its hardness. To make soap with prekese, the dried powdered herbs can be combined with shea butter, palm kernel oil or any other bases of choice. Soaps produced with these three key ingredients have superior qualities unlike those with individual base (Effiong et al, 2014).

2.6.10 Treatment of Hypertension

In folk medicine, the stem and bark extracts of taub (Tetrapleura tetraptera) can be used for preventing and treating hypertension. Researchers agree that Tetrapleura tetraptera is effective for preventing high blood pressure and for improving the oxidative position in salt model of hypertension patients (Effiong et al, 2014).

2.6.11 **Treatment of Diabetes**

The stem and bark extracts of *Tetrapleura tetraptera* (Taub) can be used for preparing herbal medicines for treating diabetes (Effiong *et al,* 2014).

2.6.12 **Supports the Immune System**

Being an excellent source of key vitamins such as potassium, iron, calcium, magnesium and zinc, aridan helps to strengthen our immune system. Iron helps to regenerate lost blood, zinc offers protection against viruses especially those that can cause respiratory tract infections while calcium and potassium helps to manage, prevent and control bones and muscles disorders (Effiong *et al,* 2014).

2.6.13 Post-partum Care

Prekese pod is traditionally used for preparing special soups for newborn mothers immediately they put to bed in other to avoid post-partum contraction. Although *prekese* can be used alone for this sort of postnatal soup preparation however, it can be used together with piper guineese, gongronema latifolium and scotch bonnet pepper for superior action. Using this spice for post-partum care is attributed to its high constituents of calcium, iron and potassium, which are very important for new mothers. Furthermore, it helps to restore and replenish lost blood for new mothers and promotes lactation.

Prekese pod is used as an additive in the soup which is served to postpartum mother to avoid contraction. The pods are rich in potassium, iron, and calcium which are the three most important ingredients required for postpartum woman. The soup also helps in the production of milk in new mothers and helps to restore the lost blood (Ekwenye, *et al,* 2010).

2.6.14 Wound Healing Properties

Wet fruit extract of the dry *prekese* has very good wound healing properties. Traditionally the aqueous extract from the fruit is used for healing which is proved scientifically too. However, the low concentration (200mg/ml) of the extract proved to be more efficient than when high concentration (2000mg/ml) extract was taken. The study was done at the University of Uyo. To have best effects always use the fruit extract in low concentration for healing wounds. *Prekese* pods contain essential chemical compounds such as flavonoids, triterpenoid glycoside (aridanin) and phenols, which have been reported effective for healing wounds (Ekwenye, *et al,* 2010).

2.6.15 Anti-oxidizing Properties

Prekese is an excellent source of antioxidants such as polyphenols, alkaloids, tannins and flavonoids. Antioxidants help to protect our body from oxidative damage by scavenging for free radicals thereby preventing peroxidation. It is important to note that free radicals and reactive oxygen species formed during oxidation process contribute immensely to diseases such as cardiovascular diseases, cancer, diabetes as well as ageing. Prekese fruit has a remarkable chemodiversity due to its constituents of polyphenols. It also has a strong radical reducing and scavenging abilities (Ekwenye, *et al,* 2010).

2.6.16 Treatment of Asthma

Traditionally, this plant can be used for treating asthma.

2.6.17 Treatment of Schistosomiasis

Studies reveal that *prekese* can be used for treating schistosomiasis. This is an infection that is also known as snail fever or bilharziasis caused by parasitic flukes of the genus Schistosoma. This infection occurs mainly in the tropical regions and eastern Asia and is mostly transmitted to humans through snails or fecal-contaminated fresh water. Common symptoms of schistosomiasis include anemia, pain, fever and breakdown of the infected organs (Ekwenye, *et al,* 2010).

2.6.18 Treatment of Gastrointestinal Disorders

The fruit can be used for treating gastrointestinal disorders such as stomach pain, diarrhea, vomiting etc due to its constituents of phytochemicals.

2.6.19 Antibacterial Ability

Researchers reveal that water extracts and alcoholic mixture of the *Prekese* fruit can inhibit the growth of Staphylococcus aureus. The presence of glycosides and tannins in ethanolic and water extracts of *Prekese* have been proven effective for inhibiting the growth of bacteria (Ekwenye, *et al,* 2010).

2.6.20 Analgesic Properties

In the same study mentioned above, it was also found that *Prekese* contains strong analgesic properties. Due to this, the extract is often used to manage arthritic pain. It reduces inflammation in arthritis and rheumatism patients (Ekwenye, *et al,* 2010).

2.6.21 Fever & Enema

A person who is recovering from a medical condition is often asked to bathe with water soaked with whole fruit. This also gives fast relief from feverish conditions. Similar infusion also helps people suffering from constipation, enema, and emetic (Ekwenye, *et al,* 2010).

2.6.22 Flavonoids & Phenolic Acids

Prekese is rich in flavonoids which possess antioxidant and anti-inflammatory benefits. These properties of the fruit help in the prevention of heart diseases. Phenolics extract of the fruit was found to be beneficial in prevention and control of hyperuricaemia. This is attributed to its phenolic acids and flavonoids content (Ekwenye, *et al,* 2010).

2.6.23 Diabetes

As per a study done on rats, it was found that *Tetrapleura tetraptera* or Uyayak is very beneficial in controlling type 2 diabetes mellitus. It was also found that *prekese* fruit extract was beneficial in lowering blood glucose levels in both fasting and non-fasting conditions.

2.6.24 Mosquito Repellant

The fruit has a strong smell due to which it is often used as the mosquito repellant and is effective too. This property is attributed to the presence of essential oils in it.

2.6.25 Gastrointestinal Disorders

Its uses in gastrointestinal-related ailments could be attributed to the presence of phytochemicals. The fruit extract is often used traditionally in curing problems like

diarrhea, vomiting or stomach pain. *Prekese* is often called as wonder fruit due to its immense medicinal properties and effective health benefits in curing lot of diseases (Ekwenye, *et al,* 2010).

2.7 The sensory characteristics of tetrapleura tetraptera in Ghanaian dishes.

Boateng, Dari, Adzitey, & Teye, (2015) carried out their research to determine the effect of "prekese" *(Tetrapleura Tetraptera)* seed powder on the sensory characteristics and nutritional qualities of pork sausage. A total of 4kg of minced pork was used. The pork was divided into four equal parts (1kg per treatment). Each treatment contain the following: (T1) control (without PSP), (T2) with 3g of PSP, (T3) with 4g of PSP and (T4) with 5g of PSP. The sausages were stuffed into casing and vacuum sealed in transparent polythene bags and refrigerated at 2^{o}C for laboratory and sensory analysis. The sensory analysis was conducted to determine the effect of 'prekese' seed powder on the sensory characteristics of the product. Crude fat, crude protein, moisture content and pH were determined to find out the effect of the seed powder on the nutritional qualities of the products.

The results showed that, the inclusion of up to 5g of PSP has no significant effects on taste, colour, *prekese* flavour, aroma and overall-liking. There were no significant differences ($P > 0.05$) in the crude fat of the products but there were significant differences ($P < 0.05$) in terms of moisture, crude protein and pH. Crude protein of T1, T3 and T4 were significantly higher ($P < 0.05$) than T2. The moisture content of T2 product was the highest followed by T4, T1 and T3. pH of the products T1, T2 and T3 were significantly higher ($P < 0.05$) than T4 (Boateng, *et al,* 2015)

2.8 The shelf-life of food spiced with *T. tetraptera* pod extract on the local and international market

According to Achi, (2016), the biological active components from pods of *Tetraptera tetrapleura* Taub were analysed by phytochemical methods and spectral analyses. The main components were tannins and glycosides. Antibacterial activity, determined with the impregnated paper disc methods, was observed against four typed bacterial strains, *Staphylococcus aureus* ATTCC 12600, *Bacillus subtilis* (ATCC6051), *Pseudomonas aeruginosa*, (ATCC10145) and *Escherichia coli* (ATCC11775). The activity was particularly high against *Staph aureus*, *P. aeruginosa* and *E. coli*, which are common foodborne bacteria. Minimum inhibitory concentrations of the extract were determined to be 250 g mL^{-1} against *E. coli*, *Staph aureus* and *P. aeruginosa* or 500 g mL^{-1} against *B. subtilis*.

The addition of 4% (v/v) of the extract to culture broth reduced the viable counts of the test organisms from 2 to 6 log factors after incubation at 37 ^{O}C for 24 h. In general, a lower activity was observed in the presence of *B. subtilis*. With the increase of concentration, the antibacterial activity of the extracts also increased. These results suggest the potential use of the above extract for reducing the number or preventing the growth of pathogens in food systems and therefore, increasing the shelf life of the food spiced with *Prekese*. Spices and herbs have been reported to be potent sources of natural antioxidants. Spices are known to impact flavour and improve overall organoleptic quality of foods.

The use of naturally occurring materials like spices as preservatives has been proved to be a promising alternative to the use of chemicals. The effects of Aframomum danielli and Zingiber officinale crude extract on the storability of fried bean cake snacks were investigated. Proximate and sensory analyses of the snack were also assessed. The fried

bean cakes were spiced with 0.2, 0.4, 0.6, 0.8 and 1% of both spices, the untreated sample was also prepared making a total of 11 samples. Proximate analyses revealed that moisture ranged from 0.85-1.05%, protein 80.00-78.70%, fat 2.09-1.08%, ash 1.50-1.30%, fibre 2.00-1.80%, carbohydrate 10.25-12.75% and dry matter 3.52-2.30%.

Sensory evaluation shows that there was no significant difference ($p<0.5$) among the treated and untreated samples in terms of all the sensory attributes evaluated. Storage stability test also indicated the preservative effects of the incorporated extracts on spoilage microorganisms at ambient temperature when compared to the control sample. There was, with respect to concentration of extract added, little significant difference in preservative effect between samples preserved with alligator pepper and ginger extracts.

Conclusively, the fried bean cake snacks treated with 0.2% and 0.4% of both spices were more acceptable generally and stable than the ones treated with 0.6 and 0.8% of both spices. The fried bean cake snacks treated with 1% of both spices were unacceptable in terms of all the sensory attributes evaluated. It has long been recognized that some plant materials exhibit antimicrobial properties. The use of these plant materials as preservatives and as means of preventing microorganism development in foods has become the subject of extensive studies (Gould, 2006). In particular, the inhibitory effects of extracts of many kinds of herbs and spices against food borne spoilage bacteria and pathogens have been reported. Among these are cassia, clove, garlic, sage, oregano, pimento, thyme and allspice (Shelef, 2013; Zaika and Kissinger, 2011).

Currently, there is growing demand worldwide of consumers for minimizing chemical preservation that can be detrimental to human health (Cho *et al*., 2015; Smid and Gorris, 2009). Consequently, spices, herbs and naturally occurring phenolics from various plants sources are being studied in detail in response to consumer requirements for fresher and more natural additive-free products (Nychas, 2015; Tassou *et al*., 2007).

Tetrapleura tetraptera Taub, family Mimosaceae, locally known as *oshosho* in South eastern Nigeria has widely varied applications in Nigerian folk medicine. The pods notably have an appealing culiniary use. Apparently, they are used to prepare soups for mothers from the first day of delivery to relieve post parturition contraction and as a lactation aid (Enwere, 1998). The antimicrobial activity of this plant has been exploited in the formulation of the dried powdered fruits of the plant. Thus dried powdered herbs have been formulated into soap bases using palm kernel oil (Adebayo *et al*., 2010). At the same time most of the folkloric claims agree in the traditional use of the fruit for management of convulsion, leprosy, inflammation and rheumatoid pains (Dalziel, 2008).

The molluscicidal activity of the extracts from the leaf, leaf stalk, stem-bark, root-bark have been exploited for long, but studies on the antibacterial effects of the essential oil from its fruits are scarce. Given the limited research information in this area the purpose of this study was to examine the antibacterial effects of the essential oil of the pods of *T. tetraptera* extracted using different solvents, to identify the chemical components of the extract and to determine at which concentration they were bacteriostatic and bactericidal to some food borne pathogenic bacteria. Such studies are essential if the full potential of *T. tetraptera* as a pharmacologic preparation in increasing the shelf-life of foods is to be exploited.

2.9 Ginger

Ginger, botanically known as *Zingiber officinale* Roscoe, belongs to the Zingiberaceae family, which encompasses 47 genera and 1400 species, including turmeric (*Curcuma longa*) and cardamom (two main genera, *Elettaria* and *Amomum*.) The genus, *Zingiber,* contains 150 species; however, the only species extensively used for flavoring is *Z. officinale* (Ravindran and Nirmal Babu, 2015). It is grown from April to December at an optimal elevation between 300 and 900m (Pruthy, 2013); requiring a warm, humid climate while preferring light shade (Jayachandran *et al., 20*11).

2.9.1 Traditional Uses of Ginger and Its Uses Today

2.9.2 As a Spice and Flavorant

Ginger is an ingredient found in the world's cuisine. Legend has it that the first gingerbread was made by a baker on the Isle of Rhodes near Greece around 2400 B.C. In the 1500's, gingerbread was known to be Queen Elizabeth I's favorite treat (Farrell, 2015) and during the Middle Ages, tavern keepers would keep a constant supply of ground ginger powder so customers could sprinkle it on their beer (Rosengarten, 2009). Today it is used in several products including Indian masala mixes, pumpkin pie spice, ginger ale, etc. Ginger based products are less popular in the Western world as compared to Australia, Thailand, Japan and China; the Buderim Company in Queensland, Australia, for example, produces more than 100 gingerbased products (Ravindran and Nirmal Babu, 2015).

2.9.3 For Medicinal Purposes

Ginger has been used for medicinal purposes long before its understanding. Traditionally ginger is used in both fresh and dried forms in Chinese, Indian, Indonesian and Japanese medicines for the treatment of: arthritis, rheumatism, sprains, muscular aches, asthma, sore throats, motion sickness, indigestion, nausea, vomiting, diarrhea, constipation, hypertension, dementia, etc. (Cho *et al.,* 2011; Badreldin *et al.,* 2008; Pharmacopoeia of the People's Republic of China, 2010). In ancient India, ginger was primarily used as a medicine rather than as a flavorant and was referred to as the *mahaoushadha* (the great medicine) and *vishwabheshaja* (the universal cure) (Ravindran and Nirmal Babu, 2015).

Ayurveda is a traditional approach to medicine that is native to India; ginger has been widely used in Ayurvedic medicine to treat a variety of gastrointestinal ailments. Modern homeopathic uses of ginger are quite similar and are popularly used for the treatment of indigestion, nausea due to motion sickness, pregnancy and for patients undergoing chemotherapy.

2.10 The Chemical Components of Ginger

Steam distillation and supercritical carbon dioxide (CO2) extraction yield an essential oil containing volatile components, whereas, solvent extraction yields oleoresins containing non-volatiles and tastants (Ravindran and Nirmal Babu, 2015). The first chemical study of ginger (Cochin) was done by J.O. Thresh in 1879 (Yearbook of Pharmacy, 1879, 1881 and 1882).

Some of the main volatiles identified by Connell in 1970 are "the sesquiterpene hydrocarbons: (-)- -zingiberene, (+)-ar-curcumene, -bisabolene, - sesquiphellandrene, farnesene, -selinene, -elemene and -zingiberene. Other monoterpene hydrocarbons identified are: -pinene, -pinene, myrcene, - phellandrene, limonene, *para*-cymene,

cumene, and oxygenated compounds: 1,8- cineole, d-borneol, linalool, neral, geranial, bornyl acetate; aliphatic aldehydes: nonanal, decanal; ketones: methylheptenone; alcohols: 2-heptanol, 2-nonanol; esters of acetic and caprylic acid and chavicol" (Connell, 2010).

The non-volatiles known to be responsible for the pungency of ginger are the gingerols and shogaols. [6]-gingerol was first identified by Lapworth in 1917; in 1969, Connell and Sutherland established the *S*-configuration for the hydroxyl group. Gingerols undergo dehydration readily due to the thermally labile betahydroxy-keto group, thereby forming the corresponding shogaols.

The production of *n*-hexanal after alkaline hydrolysis of gingerol afforded the name [6]-gingerol while the name shogaol, was derived from the Japanese word for ginger, "shoga". Gingerols and shogaols are not only responsible for the pungency of the ginger oleoresin but have been proven to be responsible for its antioxidant capability as well (Kikuzaki and Nakatani, 2013).

2.11 The Use of Ginger as an Antioxidant

2.11.1 Health Related Active Compounds

Antioxidants are present in nutraceuticals which refers to foods that have inherent health benefits greater than their dietary need and are consumed to help treat or prevent specific diseases. Nutraceuticals are typically plants, fruits, vegetables, roots and seeds because they internally produce their own antioxidants to combat oxidative stress offering a source of natural antioxidants. Carotenoids, flavonoids, cinnamic acids, benzoic acids, folic acid, ascorbic acid, tocopherols, tocotrienols are some of the natural antioxidants produced by the before mentioned botanicals for their own oxidative protection (Ghasemzadeh *et al.,* 2010).

Oxidative damage in living tissue results in an inflammatory response which can also lead to the increased risk of chronic diseases such as cancer, coronary atherosclerosis and other age-related, degenerative diseases (Stoilova *et al.,* 2007; Astley, 2013). Dietary antioxidants found in nutraceuticals help to eliminate or prevent the accumulation of the damaging oxidative products within the botanical and have proven to be useful for human health as well.

Gingerols and shogaols are the most well-known and studied antioxidants in ginger and have shown to have several pharmacological effects including the inhibition of prostaglandin biosynthesis, anti-hepatotoxicity, cardiotonic and antiplatelet (Cho *et al.,* 2011).

2.11.2 The Use of Ginger as an Antioxidant in Food

An ethanolic ginger extract made from ground ginger rhizomes was mixed with raw, ground pork meat (0.5% w/w) with which, patties were formed. The patties were roasted and kept frozen at 4°C for 21 days before the fat was extracted. Compared to the patties without ginger extract, those with, had lower evidence of triacylglycerol hydrolysis, hydroperoxide formation and overall, lower peroxide values (Takacsova *et al.,* 2010).

Another application involving the antioxidant effect of ginger powder has been achieved in cookie dough. Both ginger and cumin powder were tested for their antioxidant ability in scavenging DPPH using the methanolic extracts of the finely ground cookies containing one to five percent powder based on 100g of flour. The results showed a linear increase in the antioxidant activity with the increased percentage of both powders, and ginger, having a greater scavenging effect than cumin (Abdel-Samie *et al*., 2010). The linear increase in efficiency is also congruent with the study of ginger extract in

sunflower oil and the thermal stability and antioxidant strength after heat treatment of the ginger extract (Salariya and Habib, 2013).

Similarly, to the auto-oxidation of lipids in biological membranes, oxidation degradation can also occur in food. Fat oxidation, for example, leads to an occurrence of several chain reactions forming double bonds, alcohols, aldehydes and ketones which generate off-flavors and the reduce the nutritional value (Stoilova *et al*., 2007).

For decades, food technologists and flavorists around the world have used antioxidants to retard or inhibit the spoilage and rancidity of foods caused by oxidation reactions. The most common synthetic antioxidants used in the food and flavor industry are butylated hydroxytoluene (BHT) and butylated hydroxyanisole (BHA). However, as the trend amongst food consumers and suppliers to avoid synthetic additives continues to increase, so does the importance of conducting research that identifies, understands and utilizes antioxidants of natural origin.

The efficiency of ginger extracts, and that of gingerols and shogaols, has been compared to the synthetic antioxidants, BHT and BHA, and select natural antioxidants, namely, -tocopherol and ascorbic acid, which will be discussed in the literature review section of this composition.

2.12 Turkey Berry (Solanum Torvum)

The *Solanum torvum* (Solanaceae) plant, a common plant is geographically traced from Florida through southern Alabama and West Indies thus Mexico through Central and South America through Brazil. The plant is also found in numerous tropical nations in Africa (Little et al., 2014). It is additionally found in a few sections of Asia.

With just a modest number in the calm zones, there are around 2000 types of *Solanum* on the planet that are for the most part appropriated in the tropical and sub-tropical regions (Jennifer et al., 2007). It is a little Solanaceous bush appropriated generally in Pakistan, India, Malaya, China, Philippines, and tropical America (Nasir, 2015) and has around 21 species and one assortment in this sort is utilized for home grown drug (Hu et al., 2009).

Pharmacological investigations show that the stem and foundation of S. *torvum* have hostile to tumor, against viral, hostile to bacterial, mitigating, and other restoratively crucial impacts. Among the major chemical components of *S. torvum* are steroids, steroid saponins, steroid alkaloids, and phenols. In Ghana, the *solanum torvum* is acquired from various forest zones especially in the Ashanti, Brong-Ahafo, and certain parts of central region and also in the backyards of most homes. *Solanum torvum* was widely naturalized in the hotter beach front areas in north and east of Australia (Batianoff and Butler, 2012). It was perhaps at the same time naturalized in the beach front areas northern New South Wales and in Tropical Africa, Asia and southeastern America (Cowie and Kerrigan, 2007).

2.12.1 The S*olanum Torvum P*lant

Solanum torvum grows as a short (about 2-4 m tall), erect shrub with lots of branches and into large thorny impermeable undergrowth (Mohan and Bhandare 2012). The fruits of *Solanum torvum* are groups of little green berries (around 1 cm in breadth) that end up noticeably yellow when completely developed. The fruits come in various levels of thin skins, rounded in shape with darker seeds (Little *et al*., 2014; Howard 2009; Liogier 2015). *Solanum torvum* grows every year in height around 0.75-1.5m. The plant may be killed by within two years by bushes at which stage pruning wouldn't even help it survive (IPIF, 2007).

According to (Little *et al*, 2014), the *solanum torvum* plant is usually 2 or 3m in height and 2cm in basal diameter, but may reach 5m in height and 8cm in basal diameter. The shrub usually has a single stem at ground level, but it may branch on the lower stem. The stem bark is gray and nearly smooth with raised lenticels. The inner bark has a green layer over an Ivory color while the roots are white. According to Tu Forest and Kim Starr, Starr Environmental, turkey berry is a broadleaved, evergreen shrub that can grow to about 16 ft. (4.9 m) in height. The stems are armed with stout, straight, or lightly curved prickles (Van Brakel, 2008).

According to the USDA (2007), the more youthful stems are green or purplish in shading and now and then meagerly canvassed in thistles of about 3-7mm. More established stems end up plainly darker or greenish-dark colored and in the long run lose their covering of hairs. The similarly huge, on the other hand orchestrated leaves are usually borne on stalks of 1 - 5 cm long and the leaves are extensively egg-molded in layout (i.e. applaud) or practically adjusted fit as a fiddle with whole to shallowly-lobed edges. In any case, the leaves of more youthful plants might be all the more profoundly lobed (i.e. pinnatisect).

Whenever exhibited, the tips leaf and flaps might be pointed or adjusted and that of grown-up plants don't have any prickles. The seedlings and youthful plants may have some little prickles on their upper surfaces. More so the surface and whitish undersides, are shrouded in star-molded hairs. Likewise the little, white blossoms happen in huge, spread groups. Plants bloom ceaselessly in the wake of achieving a stature of 3.3 to 4.9 ft. (1 to 1.5 m).

The flowers of the plant sprout in bunches on a single stalk of about 2-17mm long holding about 15-100 flowers on a single stalk with about five white petals (9-12 mm long), combined at the base with green sepals of about 2.5-6 mm. As indicated by Bostock and Holland (2007), the plant is viewed as ecological weed in Queensland, and lately recorded as a need ecological weed in no less than one Natural Resource Management locale.

2.12.2 Varieties

There are other species which belong to the genus Solanum, and they are, *Solanum ficifolium*, *Solanum ferrugineumgiant*, *Solanum chrysotrichum, Solanum lycocarpum, Solanum grandiflorum, Solanum bahamense* of Carl Linnaeus (as var. *persicifolium*) *Solanum chrysotrichum* of von Schlechtendal (as var. *pleiotomum*) *Solanum ferrugineum* (as var. *ferrugineum*, var. *hartwegianum*) *Solanum lanceolatum* of Cavanilles (as var. *schiedeanum*) *Solanum macaonense* (as var. *lasiostylum*), *Solanum rudepannum* (as var. *fructipendulum*, var. *ochraceo-ferrugineum*), *Solanum scuticum* (as ssp./var. *brasiliense*, var. *daturifolium*, var. *genuinum*) (Langeland and Burks, 2008).

2.13 Medicinal and Nutritional benefits of Turkey berry

In Ghana and many other countries, the fruits and leaves are used for food and many traditional medical practices respectively (Adjanohoun *et al.*, 2016). *Solanum torvum* are utilized as a part of conventional drug as tonic and haemopoietic operators and for the treatment of torments. Generally, in the North-West Province of Cameroon, the juice of natural product is utilized for the treatment of jigger wounds, abscesses, skin contaminations, for example, ringworm and competitor's foot in man and dermatophilosis in creatures (Siemonsma and Piluek, 2014). Research shows that the

natural products contain phytoconstituents, for example, steroid glycosides and saponins, settled oil; vitamin B gathering; vitamin C; press salts: saponins and steroidal alkaloids.

In Ghana, a few sections of the plant have been utilized either as a haemostatic after labor or as a wellspring of saponin for the hemi union of cortisone and sex hormones or for exacerbating tranquilizers, diuretics or stomach related tonics. Its organic products are utilized as a part of the treatment of weakness, wounds, snakebites, inciting lactation, and as hors d'oeuvres though the leaves are utilized as a part of the treatment of stomach torment, whitlow, colds and whooping hack.

It has pain relieving and calming (Ndebia *et al*., 2007), antimicrobial (Ajaiyeoba, 2009; Chah *et al*., 2010), antiviral (Arthan *et al*., 2012), antiulcer (Nguelefack *et al*., 2008a), immuno-secretory (Israf *et al*., 2014), anti-oxidant (Sivapriya and Srinivas, 2007), cardiovascular and anti-platelet aggregation properties. *S. torvum* contains a number of pharmacologically active chemicals like isoflavonoid sulfate and steroidal glycosides (Yahara *et al*., 2016; Arthan *et al*., 2012). For a long time, diverse ethnic gatherings have utilized the dried stem and foundation of this plant for treatment of different illnesses. Its Chinese therapeutic name is Jinniukou. As indicated by Chah *et al*. (2010), the methanol concentrate of S. *torvum* natural product exhibited intriguing development restraining action against microscopic organisms generally connected with pyogenic contaminations. The watched exercises may offer a help for a portion of the employments of the organic product squeeze in ethnomedicine.

Diabetes mellitus is a standout amongst the most genuine unending infections around the world. It is caused by ceaseless hyperglycemia and creates alongside increments in stoutness and maturing in the general populace. (Lord *et al*., 2008). One of the therapeutic methods to decreasing postprandial hyperglycemia is to retard the absorption

of glucose by the inhibition of carbohydrate hydrolyzing enzymes -amylase and glucosidase in the digestive organs. The fruit of *Solanum torvum* is an inhibitor of sucrose and maltase. Screening experiments for rat intestinal glucosidase (sucrose and maltase) inhibitors in 325 plants cultivated in Japan's southern island, Tanegashima, marked reserve against both sucrose and maltase in the extract of the fruit of *Solanum torvum*.

Yahara *et al*. (2016) indicates that *solanum torvum* fruits are moderate inhibitors against glucosidase which provides a prospect for anti-diabetics. In any case, S. torvum displayed some level of cell reinforcement action and DNA repair ability on oxidative DNA harm caused by free radicals (Abas *et al*., 2016). In a distributed novel, protein was disconnected from the water concentrate of S. *torvum* seed and that ended up being successful cell reinforcement, even at low measurement, when contrasted with prestigious standard manufactured cancer prevention agents (Sivapriya and Srinivas, 2007). Be that as it may, fluid concentrate of S. *torvum* uncovers intense calming and pain relieving properties (Ndebia *et al*., 2007). In Ghana, the leaves are utilized to treat frosty; the natural products are utilized to upgrade the hemoglobin in pregnant ladies, lactating moms and people experiencing sickliness.

2.14 Nutritional Composition of S*olanum Torvum*

Solanum torvum is composed of the following vital minerals and nutrients which are very supportive in curing and averting diseases. Vitamin A, Iron (24.5 mg), Calcium (0.28 mg), Fat (1.7 mg), Fiber (56.9 mg). According to Akoto *et al.* (2015), the fruits of *Solanum torvum* possess very high moisture content (86.230%), carbohydrates 7.033%, proteins 2.322%, fats 0.278%, ash 0.143% and crude fiber 3.993%. They also did an analysis for essential metal contents and had following outcomes; iron 76.869mg/kg,

manganese 19.466 mg/kg, calcium 221.583 mg/kg, copper 2.642mg/kg and zinc 21.460mg/kg. In the determination of the vitamins, it contains 0.078mg/100g and 2.686 mg/100g for vitamins A and C respectively.

There was similar study conducted in India where proximate composition analysis revealed a lower moisture percentage (80.5 %) but much higher ash content (12.3 %). Iron, copper and manganese were found to be below 0.5 µg/mL (which is equivalent to mg/kg or ppm). Calcium was the most predominant mineral as well in that study (Bhagyashree *et al*., 2012).

Prior to the recent sale of packaged Turkey berry in stores and malls, Ghanaians consumed turkey berry as a vegetable for its nutritional properties and not necessarily for its medicinal properties as is being promoted now. Turkey berry is an ancient herb used in many Ayurvedic treatments. It has sedative, diuretic and digestive properties, stimulating regular bowel movement and killing harmful bacteria in the stomach and intestines. Turkey berry is also used worldwide to treat various ailments like piles, asthma, chest phlegm, tuberculosis and severe cough. Cook et al. (2007), reports that

asthmatic children in Britain who consumed vegetables and fruits more than once a day had better lung function. The higher intake of vegetables and fruits seemed to increase the ventilation function of the lungs. A powder made out of dried heated Turkey berry mixed with little oil is used in treating people who cough or habour excessive mucus in their respiratory track (Royal Horticultural Society, 2011).

Asiedu-Addo (2014) reports the use of turkey berry in soups, sauces and stews by Ghanaian consumers. This report also highlights the use of Turkey berry in healing night blindness when roasted and mixed with food grains such as millets. Kannan et al. (2012) reports of antibacterial properties of the berry and its potential to remove bacterial

infestations in the intestine, and take care of regular bowel movement. The green fresh fruits are edible and used by Ghanaian women in preparing palm nut soup and "kontomire" stew (Royal Horticultural Society, 2011). Similar uses of the berry have been reported in other West African countries such as Ivory Coast where the fruits are also incorporated into soups and sauces (Gautier-Béuin, 2011).

In parts of Asia, specifically India, the berry is consumed either raw or cooked. It is usually soaked in curd, dried and fried to make sundaikkai vattral which is known to improve digestion. Vegetables do impart their own characteristic flavour, colour, and texture to diets and undergo changes during storage and cooking.

2.15 Chemical Constituents of Turkey Berry

Phytochemical screening of methanolic extract of sun dried Turkey berry (Turkey berry) tested positive for alkaloids, flavonoids, saponins, tannins, glycosides, fixed oil, vitamin B group, vitamin C and iron salts (George, Patrick & Terrick, 2011). They further report a number of chemical constituents like neochlorogenin 6-O-β-D-quinovo pyranoside, neochlorogenin 6-O-β-D-xylopyranosyl-(1→3)-β-D quinovopyranoside, neochlorogenin 6-O-α-L-rhamnopyranosyl-(1→3)-β-Dquinovopyranoside,sola-genin6-O-βDquinovopyranoside,solagenin6-O-α-Lrhamnopyranosyl-(1→3)-β-Dquinovopyranoside, isoque-rcetin, rutin, kaempferol and quercetin.Other studies report that the flavonoid content of Turkey berry is mainly responsible for its antioxidant, antihypertensive, metabolic correction and nephro protective activities**.**

2.16 The Percent Daily Value (%DV) of Nutrients

There are two sets of reference values for reporting nutrients in nutrition labeling: 1) Daily Reference Values (DRVs) and 2) Reference Daily Intakes (RDIs). These values assist consumers in interpreting information about the amount of a nutrient that is present

in a food and in comparing nutritional values of food products. The daily values for the required nutrients are shown in Table 1 below. DRVs are established for adults and children four or more years of age, as are RDIs, with the exception of protein.

DRVs are provided for total fat, saturated fat, cholesterol, total carbohydrate, dietary fibre, sodium, potassium, and protein. RDIs are provided for vitamins and minerals and for protein for children less than four years of age and for pregnant and lactating women. In order to limit consumer confusion, however, the label includes a single term (i.e., Daily Value (DV)), to designate both the DRVs and RDIs. The Food and Drug Administration, USA, has not set a Daily Value for trans-fat, and health experts recommend/ avoiding trans-fat to lower the risk of cardiovascular disease. Similarly, there is no established DV for sugar because there is no recommended amount of sugar for a healthy population.

Table 2.1: The Daily Values of Nutrients

Food Component	**DV**
Total Fat	65 (g)
Saturated Fat	20 g
Cholesterol	300 (mg)
Sodium	2,400 mg
Potassium	3,500 mg
Total Carbohydrate	300 g
Dietary Fiber	25 g
Protein	50 g
Calcium	1,000 mg
Iron	18 mg
Iodine	150 µg
Magnesium	400 mg
Zinc	15 mg
Copper	2 mg
Manganese	2 mg

Source: USA FDA (2013)

The Percent Daily Value (% DV) of foods is a guide to the nutrients in one serving of food. It is calculated by dividing the amount of the nutrient contained in the serving size of a food product by its Daily Value and then multiplying that number by 100. For example, if a food product has 3 mg of iron and the Daily Value for iron is 18 mg, the % DV for iron would be 16%, that is, (3 mg ÷ 18 mg) × 100 = 16% DV. Likewise, if a food contains 15% of calcium, it means that one serving provides 15 percent of the calcium needed each day.

The Percent Daily Values are based on a 2,000-calorie diet for healthy adults. The % DV shows the specific amount of nutrient a food contains (whether a little or a lot). For example, it helps in determining whether a food is high or low in specific nutrients: If a food has 5% or less of a nutrient, it is considered to be low in that nutrient. If it has 20% or more, it is considered to be high in that nutrient.

The % DV is not meant to track total nutrient intake for the day. This is because some of the foods eaten (like vegetables, fruit, and fresh meat) do not have a Nutrition Facts table. To get the most benefit from Percent Daily Values, one has to use it to choose foods that are higher in the nutrients that must be consumed more, that is vitamins, minerals and fiber and to limit foods high in fat, cholesterol and sodium (Zeratsky, 2013). It is also used to compare two different food products to make healthier food choices.

The % DV column on the Nutrition Facts table does not add up to 100%. Each nutrient in the Nutrition Facts table has its own Daily Value. The Daily Values for nutrients are based on the highest recommended intakes. They apply to most people ages 2 and over, but do not include extra nutrient needs for women who are pregnant or breastfeeding.

CHAPTER THREE

MATERIAL AND METHODS

3.1 Raw Material

The material used, experimental details and techniques employed in the investigation are furnished in this chapter. Food grade chemicals and reagents for chemical analysis were obtained from the Department of Food Science and Technology, KNUST.

Raw material such as *Tetrapleura tetraptera* (Prekese) and spices (fresh tender ginger rhizome ginger and turkey berry) used for conducting study were procured from local market and brought to the Department of Food Science and Technology, KNUST. Different ingredients like sugar, salt, black salt, thyme seed, mint etc. were also procured from the local market.

3.2 Standardization of *"Prekese"* and ginger peeling methods

In order to standardize the most suitable, quick and efficient method of peeling, different peeling methods like conventional hand peeling, gunny bag peeling, lye peeling, abrasive peeling and mechanical peeling (mechanical peeler cum polisher were evaluated on the basis of time (minute), recovery (%), peel content (%) and ease of handling of rhizomes. Following techniques were used for optimization of peeling methods:

3.2.1 Conventional Hand peeling:

This method consists of manual peeling of pre-soaked (25 minutes) individual "Prekese" and ginger pieces by using knives (Shahid and Hussain, 2012 and Singh *et al*. 2008)

3.2.2 Gunny bag peeling:

For gunny bag peeling the pre-soaked *"Prekese"* and ginger pieces (25 minutes) were placed in gunny bags and peeling was done by rubbing and scrapping the prekese and

ginger rhizomes in between layers of gunny bags. After peeling the ginger rhizome pieces were washed thoroughly under tap water.

3.2.3 Abrasive peeling:

The abrasive peeler consists of an upright cylinder provided at the bottom with a rapidly revolving disc, which in addition to its rotator or motion undergoes an adulatory movement. In abrasive peeling the prekese and ginger is fed into abrasive peeler, the disc made of carborundum crystals revolves, water is sprayed onto peeler thus washing away the grated peelings and facilitating the peeling process (Cruess, 2018).

3.2.4 Mechanical peeling:

The mechanical peeler is a rolled drum whose inner surface is made of carborundum where the rough surface and rolling of drum facilitate complete peeling. Further there is a water supply provided to the drum. The drum inside contains a pipe with holes through which the water is sprinkled all over inside to remove the peel and wash the prekese and rhizomes simultaneously.

3.2.5 Lye peeling

In this method pre-soaked ginger was immersed in 2 per cent NaOH solution for 2 hours followed by manual removal of peel under constant flow of tap water (Joshi *et al*. 2011). The method with maximum recovery and minimum peel content in a minimum time period was standardized as the best ginger peeling method.

3.3 Standardization of the process for the preparation of Prekese and ginger appetizing flakes

The fresh Prekese and rhizomes were peeled by the standardized peeling method (Expt. 3.2.1) and sliced into suitable size (3-4× 0.4×0.4 cm3) with the help of stainless steel knife for effective blending.

Sugar concentrations = 3 (100% dry sugar, 70% and 50%)

Duration of dip = 3 (3, 4 and 5 hours)

3.4 Blending of Prekese, Ginger and turkey berry into appetizing mixture:

The best treatment combination from the previous experiment was blended into the appetizing mixture. The appetizing mixture was prepared by mixing of prekese, ginger, and turkey berry in a suitable concentration standardized in the preliminary experiments. The composition of appetizing mixture used was:

Prekese mixture - 15g

Ginger - 10g

Turkey berry - 10g

Mint powder - 10g

Sugar - 5g

3.5 Research design

Complete randomized design (CRD) was used in this study and the principal factor was formulation type. The effect of different formulations on proximate composition, mineral contents, Vitamin A and C, zinc and iron extractability, in vivo protein digestibility and viscosity of the prekese mixed spice samples were assessed and compared. The mathematical expression is shown in Equation 1.

$y_{ij} = \mu_i + \tau_i + \varepsilon_{ij}$.....(i)

i=1, 2,..., t, j=1,2,.....(ii)

Where μ is the overall mean, τi is the ith treatment effect and ε_{ij} is the random effect due to jth replication receiving ith treatment.

3.6 Chemical analyses

3.6.1 Determination of Protein

Protein was determined by Kjeldahl method using standard AOAC Method (2000). About 2g of drink samples were taken in digestion flask then 10-15 ml of concentrated H2SO4 and 8g of digestion mixture i.e. K2SO4: CuSO4 (8:1) was added. The flask was swirled in order to mix the contents thoroughly then placed on the heater for about 2 hours to start digestion till the mixture became (blue green color). The digest was cooled and transferred to 100 ml volumetric flask and volume made up to mark by the addition of distilled water. 10 ml of the digest was introduced in the distillation tube then 10 ml of 0.5 N NaOH was gradually added.

Distillation was continuing for at least 10 minutes and NH3 produced was collected as NH4 OH in a conical flask containing 20 ml of 4% boric acid solution with few drops of modified methyl red indicator. During distillation yellowish color appeared due to NH4 OH. The distillate was then titrated against standard 0.1 N HCL solutions till the pink color appeared.

The percentage of protein was calculated using the following formula

%Protein = 6.25* %N(*Correction factor)……..eqn i

%N = (SB) * 0.014*D $^{100/\text{weight}}$ of the sample…….....eqn. ii

Where. S is Sample titration reading, B is blank titration reading, N is =normality of HCL, D is=dilution of sample after digestion, V=Volume taken for distillation and 0.014=Mill equivalent weight of Nitrogen.

3.6.2 Determination of Fat

Fat determination was carried out according to AOAC (1999) method 945.87 Soxhlet ether extraction using the Soxhlet extractor. During the process the Soxhlet extractor was fitted up with 150ml of Petroleum spirit (40 – 60oC). Then a 5g of a sample potion was accurately weighed into an extraction thimble that previously dried in an oven. The thimble was then pluged lightly with cotton wool and placed in the extractor.

The condenser of the Soxhlet extractor was replaced with the heating mantle while making sure that the joints are tight. The source of heat was then adjusted such that the solvent boiled gently and be able to siphon over for about three hours. Then the condenser was detached and the thimble removed. In addition to that the round bottomed flask containing the solvent and the extracted fat was detached. Solvent and fat are separated by using the rotary vacuum or water bath (Wagtech, Laborota 4001, Uk) in a fume hood, the flask was placed in the oven at 100oC and dried to constant weight. The flask was then cooled in the desiccator and weighed after cooling. Then the extracted fat was determined using the formula;

Percentage fat (%Fat) = *(weight of cup +weight of empty cup/sample weight x 100*

Where: EE =*Ether extract / fat content.*

3.6.3 Determination of Crude fiber

Crude fibre was determined according to AOAC (1990) Method No. 14:020 through hot digestion with acid and alkali solutions. A bottle with reagents (sulphuric acid) was

placed on a hot plate and heated to a temperature of 95 to 100oC. The samples were loaded on the weighed crucibles, locked in position with a handle and placed in front of the radiator in the hot extraction unit while ensuring the safety latch engaged. Then the reflectors were placed in front of the crucibles and valves turned off. The cold water tape for the reflux system was opened and the main button pressed to start the extractor. Hot extraction was then carried out by pouring reagents into the columns from the top using a funnel to the mark (100mls/150mls/200mls).

The heater was switched on and then three drops of anti-foaming agent (n-octanol) were added in each column. The boiling speed was moderated by using the heater control. While extraction going on distilled water and sodium hydroxide solution were heated in beaker and bottle respectively. By the end of extraction, the heater was turned off, the water suction pump was started and the valves pressed to vacuum position. The sample containing crucibles were then washed three times with hot water using special water sprayer followed by drying them. The operation was then repeated from step one for the second extraction with sodium hydroxide solution. The crucibles were then released from the extractor using a safety hook.

Using crucible holder, the crucibles were transferred to the cold extraction unit. Then the crucibles washed three times with acetone contained in the wash bottle. Crucibles contained samples were dried in an oven at 100oC and then taken to the desiccators. After cooling the crucible in the desiccators, crucibles and sample were reweighed and final weights recorded. The percentage fibre content on both dry and wet basis was then calculated following the formula;

$$\text{Crude fibre (on wet basis)} = \frac{\textit{weight of crucible and dryresidue - weight of crucible and Ash}}{\textit{Sample weight}} \times 100$$

Crude fibre (on dry basis) = % fibreonwet basis/ % Drymatter *x 100*

3.6.4 Dry Matter and moisture content determination

Moisture content was determined according to Tomohiro (1990), whereby 5g of drink samples were taken and placed on a dry Petri dish of known weight and weighed. Thereafter, the sample on the petri dish was taken to the oven preset at 110oC for drying for about 5 hours. The sample was then cooled in the desiccator and weighed again. After every four hours of oven drying, the sample was taken out of oven, cooled in the desiccators and weighed. The process repeated till a constant weight was attained. Percentage moisture content was then calculated using the following formula.

$$\% MC = \frac{(Dish + sample\ before\ drying) - (dish + sample\ after\ drying)}{(Dish + sample\ before\ drying) - Empty\ dish} x\ 100$$

3.6.5 Determination of total carbohydrates content

The carbohydrate content was determined by difference on dry weight basis.The total percentages of the fat, crude protein, ash, dietary fibre were deducted from 100%, the remainder accounts for carbohydrate content.

On dry weight basis

% Carbohydrate (CHO)= 1*00% - (% Fat + Ash + dietary Fibre + Crude Protein)*

3.7 Vitamins determination

3.7.1 Vitamin C (Ascorbic acid) determination

A weight of 2g of the drink was measured using weighing scale; 10ml of 10% Trichloroacetic acid (TCA) solution was added. The mixture was shaken for few minutes and left to extract the contents, the extracted solution was then diluted to 50ml with excess 10% TCA solution and filtered using No. 1 Whatman filter papers. 10ml of the filtrate was taken into 250ml conical flask and titrated with standard solution of 2,6-Dichlorophenolindophenol, Sodium salt until faint pink colour obtained which persist

for10 seconds. (Tomohiro, 1990). The Vitamin C content was then calculated using the formula below:

$$\text{Vitamin C content in mg/100g of the sample} = \frac{(A - B) * C * V * 100}{D * S}$$

Where, A is volume in ml of the Indophenols solution used for sample, B is volume in ml of the indophenols solution used for blank, C is mass in mg of ascorbic acid equivalent to 1.0ml indophenols solution, S is mass of sample in (g) taken for analysis and V = total volume of extract in milliliters

3.7.2 Beta carotene determination

Beta carotene determination was done according to Delia and Mieko (2004) whereby 0.2- 0.3g of a flour and 5g of drink samples were measured and homogenized 4 times using 50mls proportions of cold acetone before extracted. The extract was transferred into the separating funnel contained petroleum ether (40-60oC Bp), followed by a thorough washing with about 300mls of distilled water until the extracts were acetone free. During the washing process, the distilled water was put along the walls of the glass separating funnel to avoid formation of emulations (water stones) in the carotenoid extracts.

The washed samples were then passed through anhydrous sodium sulphate to make it free from any trace of water. The dried carotene extracts were then collected into a clean and dry volumetric flask. Beta carotene stock standard solution with the concentration of 100µg/ml was prepared. This stock solution diluted serially to obtain 0, 0.25, 0.5, 1.0, 2.0, 4.0, 6.0, 8.0, 10.0 and 12.0 µg/ml concentrations. The extract and diluted standards was then read under UV-Visible Spectrophotometer Wagtech, CECIL 2021 at 450nm to obtain its optical density (OD) which was able to estimate the Beta carotenes in the

sample. Linear regression equation obtained from the standard plot and the beta carotene content of the unknowns calculated as described by (Rasaki *et al*., 2009).

3.7.3 Determination of mineral content

The analysis of minerals was done according to the AOAC (1999) procedures by the use of UNICAM, 919 Atomic Absorption Spectrophotometer (AAS). Samples were dried and then ashed at 450 0C under a gradual increase of 500 C temperature per hour.

3.7.4 Iron and zinc solubility

Iron and zinc solubility were determined using a method by Duhan *et al*. (2002). The minerals in the samples (1.0 g) were extracted with 10 ml of 0.03 N HCl by shaking at 37 °C for 3 h. The mixture was filtered with Whatman # 42 filter paper and was oven dried at 100 °C and wet acid digested. The amounts of the HCl-extractable zinc and iron in the digested samples were determined following procedures for mineral determination.

Mineral extractability % = *Mineral extractaqble in 0.03N Hcl/Total mineral x 100.*

3.7.5 Nutrient density determination

Prekese mixed spice drink samples were prepared at different ratio (200g, 250g, 300g, 350g and 400g) in 1500ml hot water. The viscosities of these drink were measured using HAAKE viscometer 2 plus version 1.5. Flour rates of the drink were determined to know which the flour rate could give the drink with acceptable viscosity (2500-3000Cp) (Thaoge *et al.,* 2003). After obtaining the flour rate with acceptable viscosity, the energy, protein, iron, zinc and vitamin A densities of all drink samples were calculated based on the flour rate obtained. The nutrient densities of the drink samples were calculated using the formulae;

Nutrient density (100ml) = *Flour rate/100ml x Nutrient /100g*

3.7.6 In *vitro* protein digestibility

In *vitro* protein digestibility was determined according to the method explained by Tilley and Brit (1961). About 5g g of drink samples were dried and digested anaerobically with rumen microorganism at 38oC for 48hr. The samples were dried in the oven for 6 hours at 1000C and grounded to pass 0.8mm sieve. The buffer solution was made up according to the formula for synthetic saliva of Dougall (1948) adding the CaCl2 last the solution is thoroughly saturated with CO2 at 380C until it became clear. The samples were put in the test tubes, mixed with rumen liquor and buffer solution, stirred and gassed with carbon dioxide.

The tubes were incubated at 38oC in the dark for 48 hours, being shaken 3 to 4 times a day by hand. The tubes were centrifuged immediately for 15mins, and then the supernatant was discarded. After discarding the supernatant, 50 ml of freshly-made pepsin solution was added to the residues. The tubes were then incubated at 38oC for 48hours with occasional shaking. After incubation, supernatants were discarded and insoluble residue was washed with water. The tubes with residues were dried at 1000C so as to get the dry weight of the samples. Digestibility is weight of digestible material in 100g of herbage dry matter. After all these procedures the in vitro dry matter digestibility (%) was calculated by formula below;

$$IVDMD=\frac{100*(\text{Sample dry matter}) - (\text{residual dry matter-residue . Incubated reagent blank})}{\text{Sample dry matter}}$$

3.8 Statistical data analysis

The data were analysed by using R statistical package (R Development Core Team, Version 3.0.0, Vienna, Austria) for one-way analysis of variances to determine the significant differences between the factor means at ($p<0.05$). Means were separated by Turkey's Honest Significant Difference at $p < 0.05$. Results were presented in tabular form as mean ±SD.

CHAPTER FOUR

RESULTS AND DISCUSSION

This chapter presents the results and discussions of the findings per the study. The results and discussions cover the following main areas:

(a) Proximate analysis

(b) Sensory evaluation analysis

4.1 Proximate analysis

Mean values of the four *prekese* mixed spice samples

The mean values of the samples PRODUCT 01 = Control (100% Prekese drink), PRODUCT 02 = (prekese and ginger), PRODUCT 03 = (prekese and turkey berry) PRODUCT 04 = (prekese, ginger and turkey berry) were recorded and analysed below.

Proximate analysis was employed to determine the physiochemical constituents of the various product samples that were prepared. The 'Weende System of Analysis' was adopted, being the most widely used method for determining the composition of feedstuffs. The system partitions feedstuff into 6 fractions: water, ash, protein, ether extract (crude fat), crude fibre and nitrogen-free extract (carbohydrates). Table 4.1 shows results of the proximate composition of the mean values of the four prekese mixed spice drink samples.

Table 4.1: Percentage mean values of the proximate composition of the four prekese mixed spice samples formulations developed.

Product	Moisture (%)	Ash (%)	Crude fat (%)	Crude fibre (%)	Protein (%)	Carbohydrate (NFE) %
P 01	8.89±0.62	7.62±0.53	4.29%±2.45	2.47±0.28	7.49±2.94	24.93±5.81
P 02	8.75±0.62	7.19±0.53	8.32±2.45	3.83±0.28	8.72±2.94	31.46±5.81
P 03	8.87±0.62	6.72±0.42	9.78±2.45	26.61±0.28	8.64±2.94	35.67±5.81
P 04	9.63±0.62	8.54±0.42	16.57±2.45	42.12±0.28	9.82±2.94	37.56±5.81
CV%	7.68	89.66	12.87	24.12	29.47	13.13
LSD	1.35	1.10	2.45	0.69	7.35	14.51

Samples: PRODUCT 01 = Control (100% Prekese drink), PRODUCT 02 = (prekese and ginger), PRODUCT 03 = (prekese and turkey berry) PRODUCT 04 = (prekese, ginger and turkey berry).

4.2 Proximate Composition of Product 04, Product 03, Product 02 and Product 01.

4.2.1 Moisture content:

Moisture content determination is an integral part of the proximate composition analysis of food. Product 04, and product 03 recorded had a relatively higher moisture (8.89%) content compared to the Product 02 and product 01 (9.72%), however ANOVA revealed no significant difference (P>0.05). Moisture content suggests the water activity of the food and is used as a measure of stability and susceptibility to microbial contamination (Edak, 2017).

4.2.2 Ash

Ash refers to the inorganic residue remaining after either ignition or complete oxidation of organic matter in a foodstuff (Nielsen, 2010). It represents the total mineral content in foods. The ash content is a measure/ reflection of mineral contents present in the food material. The study results revealed that the total ash contents of product 04, product 03, and product 02 and product 01 ranged from 7.62 % to 8.57% with product 04 and product 03 recording the highest whiles product 02, and product 01 recorded the lowest. The mean of ash content in this result agrees with the findings of Adetuya (2009) (7.19 – 9.63 g/100 g). The ash content recorded in the current study was relatively lower than what was recorded by Gemede et al (2015) and this can be attributed to the differences in climatic conditions, genetic compositions among the spices used in the various research.

4.2.3 Crude fat:

The levels of crude fat varied from 16.57% to 4.29% for the product 04 and product 03 and product 02 and product 01, respectively. In these finding, the crude fat content of the product 04 and product 03 was higher than the value reported by Emmanuel (0.18 g/100 g) whereas lower than the value reported by Adetuyi (2009) (9.22 to 10.57 g/100 g).

4.2.4 Crude fibre:

Dietary fibre reduces the risk of colon cancer, reduces blood cholesterol levels and to a large extent aids in digestion. The crude fiber content varied significantly ($p<0.05$) from 26.61% to 42.12% for product 04, product 03 and product 02 and product 01 respectively. The mean crude fibre recorded for both product 04, product 03 and product 02 and product 01 are comparable to work done by Gemede et al (2015). Interest in fibre evaluation has increased due to the recent information on the potential role of dietary

fibre in human nutrition. Evidences from epidemiological studies suggest that high fibre consumption may contribute to a reduction in the incidence of certain diseases like diabetes, coronary heart disease, colon cancer, high blood pressure, obesity and various digestive disorders.

Dietary fibre is known to alter the coronary environment in such a way as to protect against colorectal diseases. It provides protection by increasing faecal bulk, which dilutes the increased colonic bile that occurs with high fat diet. When found in excess, it may bind some essential trace elements leading to deficiency of some minerals such as iron and zinc.

4.2.5 Protein

This proportionate addition effect was also observed for protein as shown in Table 4.1. That is, protein contents of the Product 04, and product 03 recorded had a relatively higher (9.82%) content compared to the Product 02 and product 01 (7.49%), however ANOVA revealed no significant difference ($P>0.05$). The increase in the protein content agrees with the report of other workers (Olaoye *et al*., 2006) and indicates that generally the addition of turkey berry and ginger to prekese drink increases the nutritional content of the drink.

4.2.6 Total carbohydrate

The carbohydrate content of the samples varied from 24.93 % to 37.56% in the product 04, and product 03, and product 02 and product 01 respectively. The carbohydrate content recorded in the current study were lower than what was reported by Gemede et al (2015). This could be attributed to the high nitrogen content of the spices used. The use of naturally occurring materials like spices as preservatives has been proved to be a

promising alternative to the use of chemicals. The effects of Aframomum danielli and Zingiber officinale crude extract on the storability of fried bean cake snacks were investigated. Proximate and sensory analyses of the snack were also assessed. The fried bean cakes were spiced with 0.2, 0.4, 0.6, 0.8 and 1% of both spices, the untreated sample was also prepared making a total of 11 samples. Proximate analyses revealed that moisture ranged from 0.85-1.05%, protein 80.00-78.70%, fat 2.09-1.08%, ash 1.50-1.30%, fibre 2.00-1.80%, carbohydrate 10.25-12.75% and dry matter 3.52-2.30%.

4.3 Sensory evaluation analysis of composite rock cakes

Sensory evaluation is a scientific discipline used to evoke measure, analyze, and interpret those responses to products that are perceived by the senses of sight, smell, touch, taste, and hearing (Stone and Sidel 1993). It was done to determine the degree of liking of the products according to the five senses as stated above. Table 4.2 displays the average score of the sensory evaluation as administered by the Hedonic Rating Scale (1-7) under the following food characteristics; colour, taste, after taste, hardness and overall acceptance.

Table 4.2: Average score of sensory evaluation of formulations

Product	Food characteristics					
	Appearance	Aroma	Taste	Texture	After taste	Overall acceptance
PRODUCT 01	6.4±0.27	6.2±0.41	5.4±0.37	6.1±0.23	5.5±0.13	7.4±0.45
PRODUCT 02	6.5±0.27	6.3±0.41	5.6±0.37	6.3±0.23	5.9±0.13	7.5±0.45
PRODUCT 03	6.6±0.27	6.4±0.41	5.7±0.37	6.4±0.23	6.4±0.13	7.6±0.45
PRODUCT 04	6.8±0.27	6.5±0.41	5.9±0.37	6.5±0.23	6.6±0.13	7.8±0.45
CV%	5.67	8.23	7.45	4.42	3.37	6.89
LSD	0.76	1.03	0.95	0.54	0.44	1.89

Samples: PRODUCT 01 = Control (100% Prekese drink), PRODUCT 02 = (prekese and ginger), PRODUCT 03 = (prekese and turkey berry) PRODUCT 04 = (prekese, ginger and turkey berry).

4.3.1 Appearance/Colour

Appearance or colour is a sensory attribute that consumers explore in purchasing new products due to its aesthetic appeal. Generally, it refers to the appearance of the product. Table 4.3 presents the statistical description of the colour of the composite rock cakes.

Table 4.3 Descriptive statistics of colour of composite *prekese* drink

	Formulation			
Statistics	P01	P02	P03	P04
Mean	5.93	5.98	6.03	6.06
StdDev	±0.27	±0.27	±0.27	±0.27
CV%	5.58	5.58	5.58	5.58

Samples: PRODUCT 01 = Control (100% Prekese drink), PRODUCT 02 = (prekese and ginger), PRODUCT 03 = (prekese and turkey berry) PRODUCT 04 = (prekese, ginger and turkey berry).

According to the hedonic scale, the respective mean values showed that the entire four different samples were liked very much. The sample which recorded the highest mean appearance was sample product 04 (6.06), product 03 (6.03) was the second highest with product 02 (5.92) having the minimum mean appearance comparing the appearance of the samples, there was no significant difference between them with a p-value of 0.87.

4.3.2 Aroma

The sample which recorded the highest mean aroma was PRODUCT 02 (6.43), PRODUCT 04 (6.26) was the second highest with PRODUCT 03 (5.66) having the minimum mean aroma. Comparing the aroma of the samples, there was no significant difference between them with a p-value of 0.22.

Table 4.3 Descriptive statistics of aroma of prekese mixed spice samples

	Formulation			
Statistics	PO1	PO2	P03	PO4
Mean	5.54	6.43	5.66	6.26
StdDev	±0.29	±0.29	±0.29	±0.29
CV%	5.58	5.58	5.58	5.58

Samples: PRODUCT 01 = Control (100% Prekese drink), PRODUCT 02 = (prekese and ginger), PRODUCT 03 = (prekese and turkey berry) PRODUCT 04 = (prekese, ginger and turkey berry).

4.3.3 Taste

Taste refers to sensation perceived by the tongue which includes sweet, salty, sourness and bitterness (Potter and Hotchkiss, 1996). The sample which recorded the highest mean taste was PRODUCT 04 (6.57), PRODUCT 03 (6.43) was the second highest with PRODUCT 02 (5.76) having the minimum mean aroma. Comparing the aroma of the samples, there was no significant difference between PRODUCT 04, PRODUCT 03 and PRODUCT 02 with a p-value of 0.98 and 0.22 respectively. However, there was a significant difference between the mean taste of product 02 and product 01 with a p-value of 0.01 which is less than the α-value of 0.05.

Also the was no significant difference between the taste of Product 03 and Product 04 with a p-value of 0.38, but there was a significant difference between the taste of sample Product 02 and Product 02 with a p-value of 0.04. This implies that, the taste of all four sample were generally satisfactory. The low standard deviation (±0.41) value which implies close distribution of the mean values of the samples to the hedonic scale values

of "like very much" and "like moderately" further emphasizes on the general satisfactory assertion by the respondents.

Table 4.4 Descriptive statistics of taste of prekese mixed spice samples

	Formulation			
Statistics	P01	P02	P03	P04
Mean	5.54	5.76	6.43	6.57
StdDev	±0.41	±0.41	±0.41	±0.41
CV%	8.23	8.23	8.23	8.23

Samples: PRODUCT 01 = Control (100% Prekese drink), PRODUCT 02 = (prekese and ginger), PRODUCT 03 = (prekese and turkey berry) PRODUCT 04 = (prekese, ginger and turkey berry).

4.3.4 After taste

After taste refers to the comments or remarks made by the panelists after tasting the products. From the Table 4.5, all samples were not significantly different (at $P < 0.05$) from each other, implying that, the sample which recorded the highest mean after taste was Product 04 (6.32), Product 03 (6.23) was the second highest with product 02 (6.12) having the minimum mean after taste. Comparing the after taste of the samples, there was no significant difference between them with a p-value of 0.44. From the hedonic scale, sample P03 and P04 were liked very much while P02 and P01 were moderately liked.

Table 4.5 Descriptive statistics of after taste of prekese mixed spice samples

	Formulation			
Statistics	P01	P02	P03	P04
Mean	5.97	6.12	6.23	6.32
StdDev	±0.37	±0.37	±0.37	±0.37
CV%	7.45	7.45	7.45	7.45

Samples: PRODUCT 01 = Control (100% Prekese drink), PRODUCT 02 = (prekese and ginger), PRODUCT 03 = (prekese and turkey berry) PRODUCT 04 = (prekese, ginger and turkey berry).

4.3.5 Texture

The sample which recorded the highest mean texture was Product 04 (6.19), product 03 (5.95) was the second highest with Product 02 (5.83) having the minimum mean texture. Comparing the texture of the samples, there was no significant difference between them with a p-value of 0.73.

Table 4.6 Descriptive statistics of texture of prekese mixed spice samples

	Formulation			
Statistics	P01	P02	P03	P04
Mean	5.63	5.83	5.95	6.19
StdDev	±0.20	±0.23	±0.23	±0.23
CV%	4.42	4.42	4.42	4.42

Samples: PRODUCT 01 = Control (100% Prekese drink), PRODUCT 02 = (prekese and ginger), PRODUCT 03 = (prekese and turkey berry) PRODUCT 04 = (prekese, ginger and turkey berry).

4.3.6 Overall acceptance

Consumers choose foods based on the quality which is the degree of excellence and include taste, appearance and nutritional content which have significance and make for acceptance (Potter and Hotchkiss, 1996). With reference to the hedonic scale values, the means of overall acceptance of the prekese drink showed that samples P03 and P04 were liked very much while P01 and P02 moderately liked. The overall acceptability was calculated using the mean of the appearance, aroma, taste, texture and after taste. This was done in order to get the actual mean overall acceptability since some of the participants score of overall acceptability was not in accordance with the score they chose for the individual parameters of taste, color and texture. The sample with the highest acceptability was Product 04 (6.76), followed by Product 03 (6.58), with Product 02 recording the least acceptability (5.98).

However, under One-way analysis of variance (ANOVA) statistical model at P <0.05 level of probability as showed no significant difference between all the samples, P03 to P04. This implies that, the panelists have generally approved the drink produced from the blends of the prekese, turkey berry and ginger as compared to the traditional, the 100% prekese drink.

Table 4.7 Descriptive statistics of overall acceptance of prekese mixed spice samples

	Formulation			
Statistics	P01	P02	P03	P04
Mean	5.32	5.98	6.58	6.76
StdDev	±0.13	±0.13	±0.13	±0.13
CV%	3.37	3.37	3.37	3.37

Samples: PRODUCT 01 = Control (100% Prekese drink), PRODUCT 02 = (prekese and ginger), PRODUCT 03 = (prekese and turkey berry) PRODUCT 04 = (prekese, ginger and turkey berry).

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.0 Introduction

This chapter contains the summary of findings, conclusion, recommendations and suggestions for further research.

5.1 Conclusion

The sample which recorded the highest mean appearance was sample product 04 (6.06), product 03 (6.03) was the second highest with product 02 (5.92) having the minimum mean appearance comparing the appearance of the samples with a p-value of 0.87.

The sample which recorded the highest mean aroma was PRODUCT 02 (6.43), PRODUCT 04 (6.26) was the second highest with PRODUCT 03 (5.66) having the minimum mean aroma. Comparing the aroma of the samples, there was no significant difference between them with a p-value of 0.22.

The sample which recorded the highest mean taste was PRODUCT 04 (6.57), PRODUCT 03 (6.43) was the second highest with PRODUCT 02 (5.76) having the minimum mean aroma. Comparing the aroma of the samples, there was no significant difference between PRODUCT 04, PRODUCT 03 and PRODUCT 02 with a p-value of 0.98 and 0.22 respectively. However, there was a significant difference between the mean taste of product 02 and product 01 with a p-value of 0.01 which is less than the α-value of 0.05. Also the was no significant difference between the taste of Product 03 and Product 04 with a p-value of 0.38, but there was a significant difference between the taste of sample Product 02 and Product 02 with a p-value of 0.04.

The sample which recorded the highest mean texture was Product 04 (6.19), product 03 (5.95) was the second highest with Product 02 (5.83) having the minimum mean texture. Comparing the texture of the samples, there was no significant difference between them with a p-value of 0.73.

The sample which recorded the highest mean after taste was Product 04 (6.32), Product 03 (6.23) was the second highest with product 02 (6.12) having the minimum mean after taste. Comparing the after taste of the samples, there was no significant difference between them with a p-value of 0.44. The sample with the highest acceptability was Product 04 (6.76), followed by Product 03 (6.58), with Product 02 recording the least acceptability (5.98).

5.2 Recommendation

Based on the conclusion of the study, the following recommendations were made:

1. The Ministry of Health should create public awareness regarding the health benefits of consuming *prekese, ginger and turkey berry* to enhance public awareness and consumption.
2. The Government of Ghana should invest in medical and laboratory research to unravel the numerous hidden advantages of consuming *prekese, ginger and turkey berry*.

5.3 Suggestions for Further Research

Based on the limitations of the study, the researcher suggested that further studies should also be done to establish the effect of *T. tetraptera* on the nutritional quality of fresh foods in the international market.

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APPENDIX

SCORE SHEET FOR SENSORY EVALUATION DATA

AKENTEN APPIAH-MINKA UNIVERSITY OF SKILLS TRAINING AND ENTREPRENEURIAL DEVELOPMENT

Sample: PREKESE MIXED SPICE (Prekese drink, prekese and ginger, prekese and turkey berry, and prekese, ginger and turkey berry)

Name: ……. Sex: …….

Yon have been provided with PRODUCT 01 = Control (100% Prekese drink) PRODUCT 02 = (prekese and ginger) PRODUCT 03 = (prekese and turkey berry) PRODUCT 04 = (prekese, ginger and turkey berry) and you are expected to make a fair assessment based on a seven point hedonic scale. That is;

7 = like extremely

6 = like very much

5 = like moderately

4 = neither like nor dislike

3 = dislike moderately

2 = dislike very much

1 = dislike extremely

The assessment are to be done base on the following food characteristics; Colour, Flavour, Taste, Texture, Sourness and overall acceptance as shown below.

Sample	Colour	Flavour	Taste	Texture	Sourness	Overall acceptance
Product 01	……..	……	…….	……..	……	……
Product 02	……...	……	……	……..	……...	……...
Product 03	……	……	……	……..	……	……
Product 04	……	……	……	……..	……	……

PRODUCT 01 = Control (100% Prekese drink) PRODUCT 02 = (prekese and ginger) PRODUCT 03 = (prekese and turkey berry), PRODUCT 04 = (prekese, ginger and turkey berry);

Any other comments:

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……..……

……..…

Thanks very much for your co-operation.