UNIVERSITY OF CAPE COAST

DEVELOPMENT OF HERB TEA FROM *HIBISCUS SABDRIFFA*, GINGER AND DANDELION

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BY

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DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of our own original research and no part of it has been presented for another degree in this University or elsewhere.

Candidate's Signature: …….. Date: …….....

Name: Celestina Donkor

Supervisor's Declaration:

I hereby declare that the preparation and presentation of this thesis was supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

Supervisor's Signature:…… Date:……

Name: Prof. Mrs. Sarah Darkwah

ABSTRACT

The drinking of tea started hundreds of years prior explicitly in China, and has over the course of the years become an indivisible piece of most societies around the world. This study, hence, determined to develop a tea from *hibiscus sabdriffa*, ginger, and dandelion to help improve the nutritional and health status of workers and give alternative use of these plants to people and families. Experimental research design was used for the study. Eighty sedentary workers were purposively sampled, to evaluate 6 herb tea samples code named CHT, DHT, LHT, LDHT, CCT and LCT and a control Lipton. A questionnaire was used to collect quantitative data from the research participants. The samples were formulated from hibiscus, ginger and dandelion. The nutrients and sensory appeal of the herb tea were nutrient dense with high protein content ranging from 15.49 in CCT to 0 .86 the least in the control. Although the control had the least in protein content, it turned out to have 10.42 as the highest in moisture content. CHT, DHT, LHT, LDHT, CCT and LCT ranges from 62.29, 62.14,55.49,55.40 ,54.49,52.57 respectively in carbohydrates and fibre but lower in fats. The dry matter content was higher in infusion with magnesium recording very insignificant in the infusion. All the formulations recorded high mineral contents in the composite tea. LCT was the most accepted, followed by CCT, LDHT, LHT, LIPTON, DHT and CHT in that other. Comments received from the evaluation by panellists showed that the appealing colour and the aroma of LCT made panellist prefer it most to the other formulations and the control. Using hibiscus flavoured brand of lipton as control will be well acceptable to the other formulations.

KEY WORDS

- Hibiscus sabdriffa
- Ginger
- Dandelion

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DEDICATION

To my husband, my parents, siblings, friends and the staff of Atonsu Junior High School 'B', Kumasi.

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CHAPTER ONE

INTRODUCTION

Background to the Study

The drinking of tea started hundreds of years prior explicitly in China, and has over the course of the years become an indivisible piece of most societies around the world. As indicated by Damayanti *et al.* (2008), tea is a sort of refreshment taken generally close to water among most societies. Its overall ubiquity is because of its exceptional smell and trademark flavour. Tea is at present the most generally burned-through drink on the planet according to Schmidt *et al*. (2005) and along these lines positions as a significant world food item for greater part of individuals.

According to McKay and Blumberg, (2002), tea drinking is popular for its appealing fragrance and taste just as the extraordinary spot it holds in the way of life of numerous social orders. As of late, there is reestablished interest in tea due to the development of customer familiarity with medical advantages got from its utilization. It hence has a place with a quickly growing business sector of "health drinks" (Byun & Han, 2004). It gives a few bioactive mixtures, is significantly wholesome, has remedial properties and other potential medical advantages (Chaturvedula & Prakash, 2011; Sharangi, 2009).

Customarily, tea has been arranged into green (non - aged), oolong (semi-matured) and dark teas (completely aged) as per the handling condition utilized during assembling (Kirk & Sawyer, 1991). Currently, a fourth classification called herb or spice tea is acquiring expanding notoriety among

shoppers. In contrast to customary teas, herb/spice teas are made from parts of plants either than Camellia (Bender, 2006).

Many investigations have led to the wellbeing significance of tea against malignant growth, cardiovascular sicknesses. A review directed by the Chinses Longitudinal Healthy Longevity Survey (CLHLS), somewhere between 2005 and 2014, found a virtual all-inclusive connection between tea drinking and lower report of misery among the older explicitly herbs tea. Tea utilization declines the danger of dementia. (Shen *et al*.,2019).

Much more plant parts (herbs) are being utilized for some restorative reason and other wellbeing related capacities for instance herbs used in the readiness of refreshments are still vigorously under exploited aside their immense wellbeing possibilities (Abbey & Timpo, 1999). In this research, I was intrested to investigate the possibility of creating tea from three herbaceous plants for the development of composite tea and also investigate its wholesomeness. This is planned to decrease post reap loses, lessen irregularity and control different wellbeing challenges. Three ingredeints of herbs for the development of a composite tea are *Hibiscus sabdariffa* (Roselle), Ginger *(Zingiber Officinale)* and Dandelion *(Taraxacum*).

Hibiscus sabdriffa (Roselle) is a fragrant, astringent spice utilized in numerous foods because of its many advantages including the readiness of refreshments. The primary fixing in a Roselle drink is the Roselle Calyx filled generally in tropical and sub-tropical areas. *Hibiscus sabdriffa* likewise contains nutrients and minerals including aluminum, manganese, magnesium and potassium. It is utilized as medicine, normal colorant and fixing in utilitarian refreshments (Langner *et al.*, 1998). It contains sodium, calcium,

phosphorus and iron (Jolad *et al.*, 2004). Research has shown that the every day utilization of tea from roselle altogether brought down systolic strain and diastolic pulse in grown-ups with moderate fundamental hypertension and type 2 diabetes (Hopkins *et al*., 2013b).

Ginger is the normal name for *Zingiber officinale* which was initially cultivated in China and presently similarly spread all through the entire world. It is a monocot plant broadly utilized as spice and medication (Abbey & Timpo, 1999). Gengerol is the vital bioactive compound found in ginger. It has an impact on the health of people, because it possesses amazing antioxidant and anti-inflamatory properties. Ginger confers flavor and sharpness to food and drinks (Bakhru, 1992). It contains high amount of nutrients like magnesium and other different vital minerals that assist in helping the immune system in battling other viral infections.

Dandelion is botanically known as *Taraxacum*. It is an enormous variety of blooming plants belonging to the family of *Asteraceae*. Albeit a great many people consider dandelion a troublesome weed, the plant has for some time been utilized in homes, grown for medication and tea concoctions to help with food digestion and a plethora of medical issues for the most part tied with aging and the growth such as hypertension, diabetes, cardiovascular breakdown, liver illnesses among others (Davaatseren *et al*., 2013).

Individuals' mindfulness in the utilization of tea and its medical advantages is continuously expanding. This realization gave the light to the need to foster a tea utilizing hibiscus, ginger and dandelion as composite mix and survey its nutritional value, its worthiness and utilization.

Statement of the Problem

Tea drinking dates back centuries ago and it is believed to have originated from China. (Schmidt *et al*.,2005). Most teas are made from camellia plant and other plants are gradually been used for same purpose. Teas available on the market are sometimes expensive and not mostly a blend of herbs that would supply nutrients and minerals. Ghanaians in the metropolitan area are drinking a lot of teas which are not nutritious, therefore a blended tea from local herbs and less costly available to supply significant amounts of nutrients would be one way to solve existing micronutrient defieciency among people.

In addition, *Hibiscus sabdriffa* has also gained recognition in Ghana and served and sold on the market as soft drink. It is made with added spices and people go in for it for its sensory qualities and health benefits. (Langner *et al.*,1998). Dandelion and ginger also contain anti-inflammatory and antioxidants properties, which are also used as medication and in the preparation of beverages like tea (Bakhru, 1992; Yarnell & Abascal, 2009). Aside the numerous uses of dandelion and ginger in the preparation of food, they contain many nutritional and health benefits d other appeals such as its soothing nature. (Damayanti *et a*l., 2008).

A combination of roselle, ginger and dandelion as a tea will be great start of a day and bring out variety in the production of beverages and bring to light the health potentials and nutritional benefits of these herbs to consumers. This will help reduce health and nutritional related problems among individuals and families, avoid post-harvest loss, malnutrition, and increase the demand and competitive market access for roselle, ginger, and dandelion.

It also has the tendency to be cash growing produce, generative substantive revenue for growers and creating a whole industry for producers and consumers (Hudec *et al*., 2007).

Purpose of the Study

The main purpose of the study is to develop an acceptable herb tea from *Hibiscus sabdriffa*, Ginger and Dandelion.

Objectives

The study's objectives are to:

1. Develop herb tea with six different proportional preparations of hibiscus, ginger and dandelion.
2. Analyse the nutritional composition of hibiscus, ginger and dandelion using its dried forms
3. Analyse the nutritional constituents of the six formulated tea preparations.
4. Compare the mineral compositions in formulated composite tea and infusion herb tea.
5. Sensorily evaluate the acceptability of the six developed products

Research Hypothesis

1. H_{01}: There is no statistically significant differences in the level of nutrients in dried herbs (hibiscus, ginger and dandelion).

2. H_{02}: There is no statistically significant differences in the level of nutrients in the composite (developed) teas (CHT, DHT, LHT, LDHT, CCT & LCT)

Significance of the Study

The findings of this study will provide consumers with another alternative to herbal teas, thereby adding varieties to the already known teas. It will bring light to the potentials and nutritional benefits of these plants (hibiscus, ginger and Dandelion) for food development product which will help reduce health and nutritional problems of individuals as well as families.

Also, post-harvest processing will increase demand for hibiscus *sabdriffa* (Roselle), ginger *(Zingiber officinale),* dandelion (*Taraxacum*) and consequently stimulate increased production in the areas where it is grown and possibly introduce in the areas where there is potential. More production of these plants will create jobs increase family's income. The sensory features and inclinations of herb teas in general will be better understood. It will help to promote herb tea product development studies.

Delimitations

The study focused on the selected herb plants (hibiscus, ginger and dandelion) for the development of tea, its nutritional value and sensory evaluation of composite blend tea from hibiscus, ginger and dandelion. Proximate analysis will be carried out on fat, protein, carbohydrates, minerals, ash, fibre and moisture content of the developed product.

Panelists for sensory evaluation were selected sedentary workers in Asokwa Municipality in the Ashanti Region.

Presentation of Work

This thesis is organized in five chapters. Chapter one covers the background of the study, problem statement, objectives and scope of the study. Chapter two looks at the review of related relevant literature on Tea, Hibiscus

and Dandelion. Chapter three gives a description of the methods, materials, tools, procedures used in gathering information and analyzing the data. Chapter four focused on presentation of results in the form of tables, charts and the discussion of results/findings. Chapter five focused on conclusions and recommendations of the study.

CHAPTER TWO

LITERATURE REVIEW

Herb tea, also known as herbal tea, have gained significant popularity in recent years due to their potential health benefits and unique flavors. Among the various herb tea blends available, a combination of Hibiscus sabdariffa (commonly known as hibiscus), Ginger, and Dandelion has garnered attention for its rich taste and reputed health-promoting properties. This chapter delves into the preparation of tea, origin of hibiscus tea, origin of ginger, origin of dandelion and further look into their uses and explores its potential health benefits.

Preparation of Tea

Tea is a sweet-smelling refreshment or fluid item regularly ready by pouring hot water or bubbling water over restored or new leaves of the *Camellia sinensis* (Tao *et al*., 2008). It can likewise be ready by implantation of dried pieces of plants (spice tea). Spice teas are for the most part ready as natural combination produced using leaves, seeds, roots and rhizomes of different plants (Ravikumar, 2014).

Types of Tea

There are three fundamental types of tea: green tea, oolong tea and dark tea as indicated by how it is being handled during assembling (Kirk & Sawyer, 1991). Handling of green tea includes next to zero aging and the tea leaf regularly remains sensibly green. Oolong tea goes through incomplete aging while dark tea goes through complete maturation (Rinzler, 2000). In Asia, green tea is very popular. Dark tea is exceptionally well known in Africa, Europe and USA. A fourth class or kind of tea which is presently

acquiring fame among its consumers and is known as spice tea or home-grown tea.

According to Owusu and Odamtten, (1999), the nonexclusive label "tea" has been given to a mixture of dry plant pieces of different higher plant tastes. Reports in India demonstrates elective wellsprings of tea from leaves of fine mangrove species. A more appropriate term for mixtures of different pieces of plants rather than camellia is 'spice tea'. It is a spice tea that is characterized as an imbuement of leaves, organic products, stem, roots and so on, produced using plants parts other than camellia sp. Different names of spice tea are 'natural tea' or 'tisane'. Spice tea is utilized for its insect fiery and enemies of microscopic organisms' properties; which as a rule helps individuals living with HIV (Ravikumar, 2014). Cinnamon (*Cinamomu Zeylanicum Blume*) leaves, Citronella (*Cymbopogon nardus*) leaves, Ginger (*Zingiber Officinale*) and Roselle leaves (*Hibiscus sabdriffa*) are all used in Ghana with other native spices in making refreshments and other spice tea has turned into a typical practice (Owusu and Odamtten, 1999).

Moreover, a few ads teas might contain extra spices from different plants materials; bits of organic products, blossoms, and so forth; planned to confer flavor tone or taste to the tea. Models incorporate "Baron Dark Tea"; dark with bergamot and jasmine tea added; "lipton Tea" dark added with berry hisbiscus; dark tea added with jasmine blossoms (Davaatseren *et al.*, 2013).

Sensory attributes of tea

Lee and Chambers, (2007) posits that green tea, in particular, has been focused on utilising both substance and practical tactics. Kumazawa and Masuda, (2002), claims that unpredictable components of different teas carry

about fifty fragrant dynamic mixes, together with some that can produce nutty, popcorn-like, metallic, floral, minty, and fruity flavours. Age and the degree of maturation importantly affect unstable character compounds. Flavor changes when tea is ready with various water temperatures and preparing times particularly green tea. *Epigallocatechin gallate* and *epigallocatechin* assume key part in the progressions of tactile characteristics of a handled green tea drink (Wang *et al.*, 2016). Mixing of spice and fixings like leaves, grains can influence the kind of tea (Kim *et al.*, 2013). Newly blended watery arrangements acquired from dried leaves of *Camellia sinensis* contain a combination of around 300 mixtures which are liable for the trademark properties and taste of tea (Qiang *et al*., 2009).

. There is a wide regular assortment of plant materials with unmistakable tactile characteristics and possibilities elements of spice tea. Mixing of three unique spices (hibiscus, ginger and dandelion) will inspire particular properties which might be more attractive than individual spice.

Production of tea in the world

Tea is produced in somewhere near 30 countries. In the past twenty years the most significance change in tea creation has been the improvement of tea bequests in Africa and South America (Basu Majumder *et al.*, 2010) .

Tea delivering nations can be promoted partitioned into two sorts dependent on speculation conventional makers of tea, restless to ensure their pieces of the pie, who put especially in the recovery of exchange regions, Kenya, Malawi, Tanzania, and Uganda; and somewhat new makers in the expansionary stage who put resources into request to have a bigger piece of the overall industry model (Kirk & Sawyer 1997).

The world tea creation saw an expansion of 6000 to 5.07 million tons in 2013. Growth on the planet yield was because of significant expansions in the tea delivering nations. China stayed the biggest tea creating country with production of 1.9 million tons, representing in excess of 38% of the world aggregate, while creation in India, the biggest second maker, additionally expanded in 2013. Other major delivering African nations of tea expanded in 2013 including Kenya, one of the biggest trading nations of tea with 436 300 tons followed by, Uganda 58300 tons, Malawi 46500 tons, Tanzania 32 400 tons and Rwanda 25 200 tons,

Additionally, Burundi, Zimbabwe, South Africa and other African nations likewise expanded marginally in the creation and the utilization of tea in the year 2013 (McGuire, 2015). The creation and drinking of tea are continuously expanding maximally on the planet of Africa. In Ghana the utilization of spices for the creation of refreshments just as tea is turning into a typical practice (Owusu & Odamtten, 1999).

Health benefits of consuming tea

Tea leaves had first been consumed for their flavour and scent. However, consumers' interest in tea has grown as a result of a greater awareness of its health benefits (Byun & Han, 2004). Explicit wellbeing claims in different nations remember advancement of respiratory wellbeing and decrease for cholesterol and pulse (MINTEL., 2005). Consequently, teas are viewed as utilitarian food varieties alongside refreshments, for example, sports beverages, products of the soil juices (Byun & Han 2004). Tea is a rich in phenolic which demonstrated many medical advantages(Marongiu *et al*., 2004). Larsen and Larsen (2006) gave an account of a few organic exercises

of polyphenols in tea including antibacterial, insect cancer-causing, calming, hostile to viral, against unfavorably susceptible, estrogenic and safe – invigorating impacts. They're also noted for producing a strong liquid solvency (Wang *et al*., 2016).

Worldwide, tea is second inline after water because of its amazing taste and exceptional advantages towards wellbeing (Mozaffari-Khosravi et al., 2009). Utilization of tea, especially green tea, has been related with low occurrence of persistent pathologies in which oxidative pressure has been accounted for to be involved, like malignant growth (Krüger *et al.*, 2009) and cardiovascular illnesses (Cvd's). Utilization of tea is progressively being demonstrated to be related with improved cardiovascular and metabolic wellbeing. Spice tea and green tea explicitly caused an expansion in movement of proteins ensnared in cell assurance against receptive oxygen species. This activity is joined with direct activity on oxygen species by de delivery in the nitric oxide plasma focus (Negishi *et al.*, 2004). Its admission builds the ingestion of fatty substances and cholesterol and these discoveries are as per the way that it expands discharge of fat in the body (Raederstorff *et al*., 2003).

Different examinations have exhibited the connection between tea utilization and therapy of cellular breakdown in the lungs. Tea drinking was related with diminished danger of cellular breakdown in the lungs in male cigarette smokers for a situation control study in Uruguay (Mendilaharsu, Stefani, Deneo-Pellegrini, Carzogio & Ronco, 1998). Once more, with the issue of disease, epidemiological examinations have shown aftereffects of the connection between green tea admission and hazard of bosom malignant

growth. Stages I and II bosom malignant growth patients showed a lower repeat rate and a more extended sickness - free period while devouring in excess of 5 cups of green tea each a day contrasted with those burning-through under 4cups each a day (Nguyen *et al.*, 2012).

The utilization of tea might influence glucose digestion and insulin flagging, causing interest in the wellbeing impact of diabetes. In a huge associate of U.S. moderately aged and more established ladies from the Ladies' Wellbeing Study, ladies who devoured more than or 4 cups each a day of tea had a 30% lower hazard of creating type 2 diabetes than the people who didn't burn-through tea (Colle *et al.*, 2012).

The Public authority of Netherlands, in their public dietary rules, suggested individuals drink three cups of green or dark tea each day on an assortment of proof connecting tea utilization to the diminished danger of stroke and hypertension (Kromhout *et al.*, 2016). Close by ever-famous assortments of green and dark tea, spice teas additionally have uncountable medical advantages. Home grown tea has since a long time ago been utilized as helpful vehicle in Chinese, Indian and other native clinical frameworks (Negishi *et al.*, 2004). Chamomile and peppermint are the premise of probably the most well-known natural teas, with the mitigating hostile to mutagenic reactions to chamomile, and unwinding impacts on the gastrointestinal lot being described by the utilization of peppermint (McKay & Blumberg, 2002).

Scarcely any investigations have announced the advantageous impacts of tea against ligament illness in people. In a review in England, it was observed that the individuals who drank tea had more prominent bone mineral thickness than the people who didn't drink tea (Hegarty *et al.*, 2000).

The term' tea' is utilized to depict dark, green, red or white tea but at the same time is utilized concerning natural imbuements acquired from plants other than camellia. Teas likewise mean combinations of dried natural product, spices, flavors, and different increases (Samolińska *et al.,* 2017). As often as possible, the formula of such combinations might contain tea leaves by any means. Contingent upon the structure, they are utilized, among different applications, in natural medication or in weight reduction medicines (Samolińska *et al*., 2017).

Taking into account this, it is valued that tea contains numerous wellbeing parts and advantages that assistance to lessen the danger of creating ongoing illnesses like malignant growth, cardiovascular infections, joint pain, diabetes and other genuine medical conditions. Subsequently, mixing three distinct spices (hibiscus, ginger and dandelion) in forming composite tea that will be advantageous to customers in term of wellbeing shrewd and different advantages

Nutritional composition of tea

Teas contain tannin substances, flavonols, proteins and amino acids, smell delivering unstable substances, catalysts, nutrients, mineral components just as alkaloids (Colle *et al.,* 2012). Tea contains minerals and minor components, for example, K, Mn, Cr, Ni and Zn which are fundamental for human teeth (Alam *et al.,* 2020). The significance of tea drinks in every day diet is for the most part associated with their important supplements and mineral components. The constant utilization of dark and green tea got from the plant Camellia sinensis goes back a few thousand years, and health advantages of primary polyphenolics catehins and flavonoids compound.

(Khan & Mukhtar, 2013; Suzuki *et al.*, 2012). Spice teas contain an abundance of mixtures and could assume a critical part in conveying supplements and synthetic substances to make up for inferior quality eating regimen. Natural tea as respect o macronutrients is said to contain undeniable level or measure of calcium and magnesium a transcendent microelement (Samolińska *et al.*, 2017).

The handling of tea decides the substance of bioactive fixings; consequently, it ought not out of the ordinary that every assortment of tea, green, dark, red and spice tea will address an alternate bundle of mixtures of physiological significance (Marongiu *et al.*, 2004). Spies' teas contain tannin substances, proteins and amino acids, fragrance delivering unpredictable substances, chemicals, nutrients, mineral mixtures just as alkaloids. The significance of tea refreshments in day-by-day diet is principally associated with their important mineral components like Na, K, Mn, Mg (Corp & Pendry, 2013). Moreover, full scale and microelements in tea plants can aggregate aluminum, whose substance might arrive at the degree of 1g/1kg in dried leaves (Fung *et al.*, 2003).

Hibiscus Sabdriffa (Roselle)

Origin of Hibiscus sabdariffa

There is a significant dispute about the start of Roselle among different analysts. (Mozaffari-Khosravi *et al.*, 2009) proposed Roselle is a neighborhood plant of West Africa whilst according to Appel (2003), *Hibiscus sabdriffa* (Roselle) was begun from Malaysia and it grew basically in tropical and subtropical spaces of the world.

Description of hibiscus sabdriffa (Roselle)

Hibiscus Sabdriffa (Roselle) is an erect yearly spice having a place with the family Malvaceae. Hibiscus has multiple hundred species disseminated all throughout the planet and are utilized as elaborate plants (Singh *et al.,* 2017). A portion of the types of hibiscuses have specific wellbeing or restorative properties of which *hibiscus sabdriffa* is one (Qi *et al.,* 2005). It is normally named "red tawny" or "roselle". *Hibiscus sabdriffa* is presently a local in West Africa and its developed all through the jungles (Ramadan *et al.,* 2011). In the United States, it is known as Florida Roselle, Florida, Smash Berry, and Indian Roselle; in Malaysia, it is known as 'asam kumberg,' in the Caribbean as'sorrel,' in Sudan as 'karkade,' and in some West African countries like Ghana as 'bisap.' (Fung *et al.,* 2003).

Roselle is predominantly developed to be burned-through, other hibiscus assortments are planted for their filaments. Among different groupings of hibiscus, Hibiscus altissima and Hibiscus sabdriffa are the commonest.

The developing time of hibiscus sabdriffa goes from 4 to a half year. It can either be engendered from cutting or by direct cultivating which is awesome (Ramadan *et al.,* 2011) despite the fact that penetrable soil is awesome for developing *hibiscus sabdriffa,* it can adjust to assortment of soil in a hotter muggier environment (Robert, 2005).

Tabel 1: Names of roselle in different regions of the world

Country/ Region	Vernacular name	Source
Caribbean	Sorrel	Halimatul *et al.*, 2007
Latin America	Jamaica	
Florida	Cranberry	
Asia	Mesta, Meshta	
Sudan and Middle East	Karkade	Abu-Tarboush *et al.*,1997
Southern Africa	Omutete	Omemu *et al*., 2006.
West Africa	Bissap	
Ghana	Riaripari (Guan), Siiro Sobolo or Rarna in (Hausa (Dagbani) Sakpa (Ga), Evema (Ewe) Bito (Moshii),	

Source (Mehdi *et al* 2020)

Uses and domestic application of h*ibiscus sabdriffa* (Roselle)

Despite the fact that, the employments of various pieces of roselle, including seeds, leaves, and stems, are numerous they can be used for medicine and food. *Hibiscus sabdriffa* is a multi-use plant and conceivable incorporation of its calyx in the creation of juices, wine, gelatin, pudding, cake, frozen yogurt and enhancing (Adeoye *et al*., n.d.).

Roselle calyces are used to manufacture energising beverages, tea, syrups, puddings, sauces, fillings, and aroma throughout tropical Africa, the West Indies, the Philippines, and Indonesia (D'Heureux-Calix & Badrie, 2004). The unrefined substance of soda and restorative spice arrangements are made using roselle isolates (Jolad *et al*., 2004). Roselle is an important fibre crop as well as a lush vegetable.

Oil is one of the reasons Chad is developing its yield. Roselle oil is primarily used in cooking, but it can also be used as a component in the creation of paintings. The plant's decorative value continues to pique people's interest. It's being promoted as a cut bloom by Israeli ranchers. (Jolad *et al*., 2004).

Figure 1: Hibiscus Sabdriffa (Roselle Plant with Red Calyx)

Nutritional composition of hibiscus (Roselle)

Roselle is high in vitamin C, calcium, niacin, riboflavin, and flavonoids, among other nutrients and minerals. Roselle calyx had 1.4109 mgg of ascorbic corrosive, according to (Fung *et al*., 2003)

Ascorbic acid corrosive assumes a critical wholesome part in food varieties. It is fundamental supplement for human; a lack causes Scurvy and an element in helping the invulnerable framework. It is a powerful cancer prevention agent, shielding the body from oxidative pressure. Critical amounts of ascorbic corrosive (vitamin C) are also known to be present in the calyces. (Wong *et al.*, 2002).

According to Wong *et al.* (2002), the ascorbic corrosive content of roselle calyx was 1.4109 mg/g. Acids by and large assume a huge part in affecting the flavor of both regular and handled food items by bestowing a

harsh or sharp taste to food. Roselle contains minerals including sodium, calcium, manganese, phosphorus, potassium and iron (Janick & Paul, 2008; Shivali & Kamboj, 2009). The seeds from hibiscus contained considerable amounts of protein, carb, fat and phosphorus.

Roselle calyces have anthocyanins, which are brilliantly crimson, water-soluble flavonoids. According to (Khafaga & Koch 1980), the anthocyanin concentration of calyx varies between 1.7 and 2.75 percent per dry load. Roselle anthocyanins may apply an impact on buyer insight because of its radiant red tone. This is on the grounds that appearance of food, especially shading, can have a radiant impact on flavor of food agreeableness (Nazlin *et al.,* 1999). Shading is regularly taken as a record of acceptability and dietary. It is likewise wealthy in natural corrosive carotene and absolute sugar contingent upon the geological region (Cisse *et al*., 2009)

Health benefits of roselle (*hibiscus sabdriffa*)

Wang *et al.*, (2016) proposed that day by day utilization of hibiscus anthocyanin may be compelling in bringing down oxidative harm. Mazza (2000) indicated contains anthocyanins which serve as antibacterial, antiviral, antiallergic, antithrombotic and cancer prevention agent. Anthocyanims have been related with their cell reinforcement appropriately in the job of decrease of coronary heart sicknesses and malignant growth and to improve the body's resistant framework (Nazlin *et al.,* 1999).

Every day utilization of tea from Roselle fundamentally brought down systolic circulatory strain and diastolic pulse in grown-ups with moderate fundamental hypertension and type 2 diabetes (Hopkins *et al.,* 2013). Pulse

bringing down impact: The adequacy of a fluid concentrate of Roselle on gentle to direct hypertension was examined in many explores.

Hypo-lipidemic impacts: As indicated by a review directed among hyper-cholesterolemic patients, two containers of Roselle separate (1g), given three times each day (for an aggregate of 3g/day), essentially brought down serum cholesterol (Lin *et al.,* 2007). Another logical concentrate additionally affirmed that ethanolic extricate from the leaves of Roselle fundamentally display hypo-lipidemic impact (Marongiu *et al.*, 2004). Roselle was examined among subjects, some with and some without metabolic condition. Subjects with metabolic disorder getting ethanolic concentrate of Roselle altogether decreased glucose, complete cholesterol and low-thickness lipoprotein while expanding high thickness lipoprotein (Gurrola-Díaz *et al*., 2010).

Hostile to helmentic and against microbial impacts; Roselle is known for its antibacterial, antifungal and hostile to parasitic activities. Oil separated from seeds of Roselle has been displayed to have an in vitro inhibitory impact on *Bacillus anthracis and Staphylococcus albus* (Naturland, 2004). Fluid and ethanol were likewise observed to be viable against *Schistosoma mansoni* and different microorganisms (Hatil & Moneer, 2006). (Afolabi *et al.*, 2008) showed the antibacterial impact of hibiscus extricate on *Streptococcus mutans*, a bacterium from oral cavity.

In a comparative study, hibiscus was found to have antibacterial properties against Campylobacter species (Qiang *et al.,* 2009). Ethanol concentrations of Roselle dry leaves reduce aflatoxin production and have an inhibitory effect against some parasites in vitro (Guerin & Reveillere, 1984 ;Singh *et al*.,2017).

Against oxidant impact: Antioxidative movement is a defensive ability of a substance that suppresses oxidative systems by rummaging receptive oxygen and free radicals. It shields lining organelles from untimely cell harm and diminishes maturing. Countless *invitro* and in *vivo* studies have shown that Roselle calyxes contain powerful cancer prevention agent.

Against diabetic action: Extricated polyphenolic parts of Roselle and their impact in a kind II diabetic rodent model (high fat eating routine model) concentrates on uncovered enemy of insulin obstruction properties of concentrate at a portion level of 200mg/kg, and decrease in hyper glycaemia and hyper insulinemia (Peng *et al*., 2011).

Fluid concentrates of roselle calyces have been shown to have solid cancer prevention agent impacts (Hirunpanich *et al.*, 2006).

It was additionally detailed that Roselle is considered as a potential enemy of heftiness specialist (Dafallah & Al-Mustafa, 1996). Separates from Roselle are likewise known to have impact on incendiary sickness. (Dafallah & Al-Mustafa 1996).

Home grown medication applications; Roselle is utilized in numerous people meds. It is esteemed for its gentle purgative impact, capacity to build pee, alleviation during blistering climate and treatment of breaks in the feet, bilious, bruises and wounds (Yadong *et al.*, 2005).

Ginger (*Zingiber Officinale)*

Origin of ginger

Ginger with the logical name (*Zingiber Officinale* Rosc) was begun in the Indo – Malayan district, but presently broadly conveyed across the jungles of Asia, Africa, America and Australia and numerous nations as a zest and

therapeutic plant. (Purseglove *et al.*, 1981). The Middle Easterners acquainted ginger with East Africa in the thirteenth century CE and the Portugese spread it to West Africa and the Pacific islands for business development (Ravindran *et al.*, 2016).

It is likewise realized that ginger was brought to Mexico by the Spaniards and later acquainted with Jamaica, the latter at present being one of the world's chief makers of this species (Bordia *et al.*, 1997). As of late, ginger has been brought into different tropical nations where various chemotypes have been created. (Ravindran *et al.*, 2016).

Description and chemical composition of ginger

Ginger (*Zingiber officinale* Rosc) is an individual from the Zingiberaceae group of plants. The English expression 'ginger' started from Sanskrit word 'Sringavera' which means horn-like. The underground stem (rhizome) is utilized for planning of ginger. This rhizome can be handled into a powder, syrup, unstable oil, and oleoresin.

Jolad *et al* (2004) revealed that they have distinguished 51 mixtures on naturally developed new ginger, 31 mixtures were recently announced as constituents of ginger and extra 20 are yet to be portrayed. North of 50 parts is supposed to be found in ginger oil. (Ali *et al.*, 2008).

General uses and domestic application of ginger

Ginger confers flavor and sharpness to food and drinks (Pruthy, 1993; Bakhru, 1999). Ginger a vital part of curry powder, sauces, ginger bread and ginger seasoned carbonated beverages. (Bakhru, 1999).

Figure 2: Pictorial representation of ginger

Nutritional components of ginger

The majority of the food parts including full scale and miniature supplements assume significant part as a nutraceutical and gives potential medical advantages. (Bernal *et al.*, 2010). Dietary fiber, polyunsaturated unsaturated fats (PUFA), proteins, amino acids, minerals, nutrients and other bioactive mixtures are considered as valuable supplement parts (Andlauer & Fürst, 2002).

Ginger is utilized as primary flavoring material in the eating routine. It assumes huge part as taste enhancer since it contains fundamental oils. Ginger contains nutrients such as B-carotene, vitamin C and minerals. (Sangwan *et al.*, 2014).

In the new ginger rhizome, the gingerols were recognized as the significant dynamic parts and gingerol [5-hydroxy-1-(4-hydroxy-3-methoxy phenyl) decan-3-one of the most constituent in the gingerol. The powdered rhizome according to Singh *et al.*, (2017) contains 3-6% greasy oil, 9% protein, 60-70% sugars, 3-8% unrefined fiber, around 8% debris, 9-12% water

and 2-3% unpredictable oil. The unstable oil comprises of principally mono and sesquiterpenes, camphene, beta-phellandrene, curcumene, cineole, geranyl acetic acid derivation, terphineol, terpenes, borneol, geraniol, limonene, linalool, alpha-zingiberene (30-70%), beta-sesquiphellandrene (15-20%), beta bisabolene (10-15%) and alpha-farmesene. In dried ginger powder, shogaol represents the main bioactive agent of gingerol is an overwhelming impactful constituent. Oleoresin, which is segregated by (CH3)2CO and ethanol extraction, contains 4-7.5% of dried powder, impactful substances to be specific gingerol, shogaol, zingerone and paradol. (Asnani & Verma, 2007).

Health benefits of ginger

Pharmacological effects of ginger

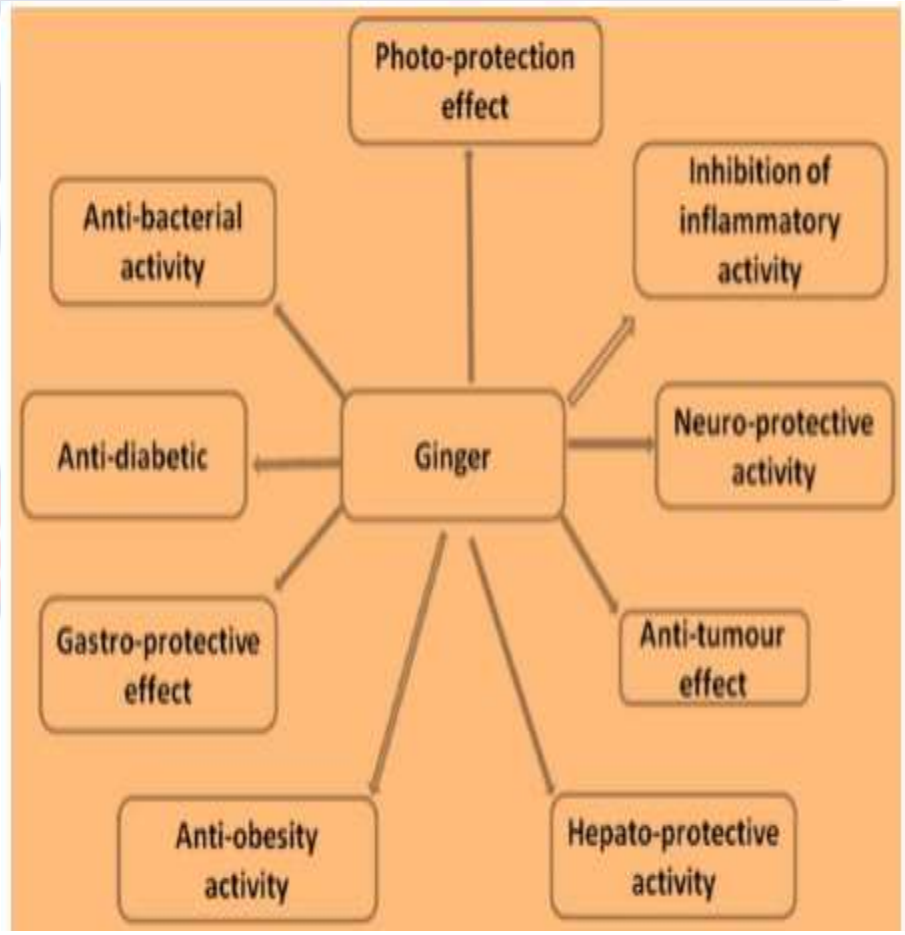


Figure 3: Pharmacological effects of ginger

Source: (Singh *et al*., 2015).

Since old occasions, in different populaces around the world, incendiary issues and other illnesses like arthritic situations have been managed with ginger. In vitro studies and a few creature preliminaries give proof that ginger has the ability to improve manifestations of aggravation related conditions like joint pain (Singletary, 2010). Ginger concentrate additionally represses reaction of proteins (Grzanna *et al*., 2005).

CH3)2CO concentrate of ginger applied a portion subordinate effective calming movement in mice regardless of the gingerol focus in the concentrate (Minghetti *et al*., 2007).

Against oxidant activity; Ginger and some particular constituents have shown cancer prevention agent impacts in a few cell culture frameworks. (Singh et al., 2015). Besides, there are creature concentrates on showing that ginger concentrates and individual ginger constituents, for example, gingerol can ensure a few tissues and organs against harm because of an assortment of moxidation-inciting stressors like bright B (UVB) and COX-2 expression a promising remedial specialist against UVB initiated skin problems (Zedah & Kor, 2014). El-Abhar *et al*. (2008) exhibited that ginger concentrate additionally enhanced acidic corrosive actuated ulcerative colitis, logical because of its cell reinforcement and calming activities.

Cholesterol-bringing down properties: In an investigation of trial rodents, a low portion of ginger (50 mg/kg/d) showed no impact on decrease in the cholesterol levels but caused critical changes in high dosages of ginger (500 mg/kg/d) lower cholesterol levels (Thomson *et al.*, 2002).

Ginger has been accounted for to have chemo preventive movement in colon disease (Akhani *et al*., 2004). Gingerol likewise hinders the

development of human colorectal malignant growth cells (Bode & Dong, 2011), and initiates apoptosis and autophagocytosis in ovarian disease cells (Rhode *et al.,* 2007). Ginger and its constituents are likewise viable against pancreatic malignant growth. Park *et al.,* (2006) expressed that 6-gingerol restrains the development of pancreatic disease. It likewise manages tight intersection related proteins and smothers attack and metastatis of pancreatic cells. Alongside the *vitro* studies, creature studies showed that shogaols in ginger smothered development of pancreatic disease and potentiated the impacts of gemcitabine in concealment of cancer development (Zhou *et al.,* 2014).

Ginger is prescribed to expecting ladies as an antenatal medication just as to mitigate the 'morning disorder's during pregnancy (Ozgoli, Goli & Moattar, 2009; Broussard *et al*., 2010) and movement ailment. Chinese medication has also been intimately used ginger since the fourth century. The Chinese direct ginger for a wide assortment of clinical issues like stomachache, migraine, looseness of the bowels, sickness, cholera, asthma, heart conditions, respiratory problems, toothache and rheumatic grievances (Award & Lutz, 2000).

Impact on Osteoarthritis, an exceptionally sanitized and normalized ginger concentrate had a genuinely critical impact on lessening indications of Osteoarthritis of the knee. This impact was moderate. There was a decent security profile, with generally gentle GI antagonistic occasions in the ginger concentrate bunch (Altman & Marcussen, 2001).

Impact on headache, 500-600mg of ginger powder organization at the beginning of headache for 3-4 days at timespan hours, answered to give help from headache assault (Mustafa & Srivastava, 1999).

Neuro defensive action, the neuroprotective impact is somewhat inferable from an adversarial activity of ginger root extractson monosodium glutamate impact, so the monoamines content was expanded. From these outcomes, we can say that the ginger concentrate plays a neuroprotective part against monosodium glutamate poisonousness impact (Waggas, 2009).

Ginger as against diabetic: a few animal studies demonstrate that ginger might be useful in bringing down risky blood glucose and lipid focuses. Explicit concentrates of ginger brought down blood glucose, cholesterol, and fatty substance levels and expanded high-thickness lipoprotein cholesterol fixations.

Antimicrobial impacts, ginger has solid antibacterial and some antifungal properties. These microbes age undigested starches causing tooting. This can be neutralized with ginger. It represses the development of *Escherichia coli, Proteus sp, Staphylococci, Streptococci and Salmonella* (Singh, 2015).

Dandelion *(Taraxacum Officinale)*

Origin of dandelion

The normal dandelion [*Taraxacum officinale* (Weber) ex Wigg.] is from the Asteraceae family. Its name gets from French: 'gouge de-lion', which means in a real sense 'lion's tooth', motivated by the state of its leaves (Schütz, Csrle and Schieber, 2006). The English name is dandelion, the Latin name Taraxacum is supposed to begin from Greek signifying 'infection cure' (Yarne

and Absacal, 2009). Taraxacum officinale, ordinarily called Dandelion, is herbaceous enduring having a place with family Asteraceae (Compositae) It's said that the dandelion's clinical history comes to past set up accounts (Yarnell & Abascal, 2009). What is recorded, comes from everywhere the world, in light of the fact that the dandelion's capacity to get by in an assortment of environments. Early records come from Asia, Europe and North America hence it's hard to decide its local climate. In the tenth and eleventh century, Middle Easterner doctors applied the dandelion for inward treatment (Schutz *et al*., 2006). The Native Individuals of North America; Iroquois, Ojibwae, and Rappahannock, likewise utilized the dandelion in their customary medication rehearses. Dandelion is delivered for therapeutic purposes and food, either developed from wild sources or developed. It is dominatingly developed and delivered in Bulgaria, Romania, Hungary, and Poland (Brock, 2004). Dandelion happens in the jungles, in cool good countries (1,200-1,500 m of elevation) and in warm sub-mild and calm zones around the northern side of the equator. It can endure dry spell and ice (Mingarro, Square, Galan, Vincente, Martinez & Acero, 2015). *Taraxacum* is systematically intricate. In any case, because of a record dated 659 Promotion in Asia conceivably reporting Taraxacum mongolicum, people trust that it's of Asian beginning. (Yarnell & Abascal, 2009).

The dandelion has gotten fascinating names since the beginning including "pee in the bed", "pig nose", and "witches' milk" in addition to some more (Sweeney, Vora, Ulbricht &Basch, 2005). The English name itself as far as we might be concerned, "dandelion" comes from "imprint de-lion" from the French portraying its yellow fluorets. The Latin name Taraxacum is said to

start from the Greek signifying "sickness cure" (Yarnell & Abascal, 2009). All the more explicitly, it's a blend of "taraxis" alluding to aggravation, and "akeomai" which means fix (Schutz *et al*., 2006).

Nature and characteristics of dandelion (*Taraxacum*)

Dandelion which is deductively known as Taraxacum class is an individual from the Asteraceae and clan of lactuceae Dandelion is profoundly entwined inside society's development. Taraxacum has gotten fascinating names since the beginning remembering 'pee for the bed',' pig nose 'and 'witches' milk' in addition to some more (Sueeney *et al*., 2005).

Both the names and records of the dandelion are evidential of its capacity to live around the world. In 1987, a concentrate by Hegi reports that there are 36 to 57 unique types of Taraxacums.

In any case, this doesn't indicate microspecies. College of Maryland reports that there is north of 100 species. Accordingly, the dandelion can acquire an enormous reach in size of development. The taproot can be 15 centimeters however is known in certain species to grow up to 1 meter (Schutz *et al*., 2006). They pass on range from 5 to 40 centimeters in length, as does the tail. The blossoms just develop somewhere in the range of 7 and 15 millimeters in width however concentrates on report that dandelion can accomplish 170 seeds a head, adding to in excess of 2000 seeds for each plant. One thick space of dandelions can create up to 240,000,000 seeds for every section of land for one year (Doll & Trower, 2002).

The dandelion can likewise create seeds without fertilization. One more benefit for the *Taraxacum* sort is various strategies for hereditary duplication, including diploid, triploid, and tetraploid. It's concentrated on that

Taraxacum can keep up with various hereditary variety relying upon its territorial climate to make due (Menken, Smith & Nook Nijis, 1995). With a compelling method for dispersal, and enormous hereditary variety, it appears to be conceivable that the dandelion could get by in various districts all throughout the planet

Uses and domestic application of dandelion

According to a Kansas State University Agriculture Experiment, dandelion is utilised as an infusion (tea), infused oil, and therapeutic food. It is used in the preparation of foods like as salads. Dandelion is a popular food with a long history of human consumption, and as such, it poses low danger of injury.

Figure 4: A pictorial representative of dandelion leaves

Nutritional composition of dandelion

Dandelion is a rich source of vitamins and minerals, especially vitamin A and C, as well as iron and calcium, carrying more iron and calcium than spinach (Ghaly & Akoik, 2010 a). A study published in the American Journal of Biochemistry and Biotechnology in 2012 found that the protein content of

dandelion leaves was 4.70 percent. In comparison to vegetables and fruits, the results showed that dandelion leaves are a decent source of supplemental protein.

Dandelion has a higher protein content than other leaves and vegetables such as cabbage, tomato, cucumber, and tobacco, with percentages of 4.47 percent, 0.91 percent, 0.65 percent, tobacco 4.35 percent, and 4.70 percent for dandelion (Ghaly & Alkoik,2010 a). Compared to sea buckthorn leaves, dandelion leaves have more than three times the potassium and two times the calcium. Potassium and calcium levels in dandelion leaves were 6.51 and 0.67 g 100 g1 DM, respectively. (Ghaly & Alkoik,2010 a).

Dandelion leaves contain an average of 3.43 g potassium and 0.96 g calcium per 100 g1 DM, according to published research (Harrington *et al*. 2006). Gallaher *et al*. (2006) found that 3.5 cups of dandelion infusion delivered a significant amount of potassium (10 percent daily value). Vitamins (A, C, D, E, and B), inositol, lecithin, and minerals (iron, magnesium, salt, calcium, silica, copper, phosphorus, zinc, and manganese) are also abundant in dandelion (Ata, Farooq & Javed, 2011). Dandelion is one of the highest producers of beta-carotene (11,000 g/100 g leaves, the same as carrots), the precursor to vitamin A. (Mir, Sawhney & Jassal, 2015).

Carbohydrates (e.g., inulin), carotenoids (e.g., lutein), fatty acids (e.g., myristic acid), minerals, sugars (e.g., glucose, fructose, and sucrose), choline vitamins, mucilage, and pectin are all found in the roots of dandelion. Inulin, a complex carbohydrate (fructo-oligosaccharides) found in up to 45 percent of the roots, has a number of health benefits, including the clearance of

pathogens in the gastrointestinal tract and the prevention of obesity, cancer, and osteoporosis (Roberfroid, 1999).

Health benefits of dandelion (*Taraxacum officinale*)

Dandelion flowers have been found to be an effective antioxidant, implying that they could be used in chemotherapy or pharmaceutical manufacture (Hudec, Buedova, Kobida, Komora, Macho, Kojan & Chlebo, 2007). Because of its anti-inflammatory characteristics, dandelion is a popular herbal treatment for gout (Corp & Pendry, 2013). It functions as a cleaning agent; (Corp & Pendry, 2013). the roots of dandelion have the highest concentration of nutrients for treating liver and spleen infections Taraxacum officinale is also being studied for its potential as a diabetes treatment (Davaatseren *et al*., 2013; Swantson –Flatt, Day, Flatt, Gould & Bailey, 1989).

Dandelion and its constituents have anti-diabetic properties: The pharmacological activity of components such as sesquiterpene lactones, triterpenes/phytosterols (taraxasterol), phenols, flavonoids, and phenolic acids in dandelion have showed a range of anti-diabetic benefits (Schützet *et al*., 2006). The main cause of Type 2 Diabetes (T2D) is insulin secretion and sensitivity dysregulation, which results in high blood sugar levels (hyperglycemia) and Type 2 Diabetes, which comprises fructooligo saccharides, is found in the root of the dandelion (FOS). FOS is a complex carbohydrate that helps bifidobacteria in the gastrointestinal tract destroy infections. FOS boosts the immune system and so prevents aberrant cell proliferation as a result of mineral intake. This complex carbohydrate can aid with blood sugar regulation.

When combined with a high concentration of water extract, plant extracts lower hyperglycemia. Chlorogenic acid (CGA) has been suggested as a possible anti-obesity and anti-inflammatory agent. It also has an effect on insulin secretion and sensitivity, making it a promising future treatment option.

Taraxacum officinale is being studied for its potential as a diabetes treatment (Davaatseren *et al*., 2013; Swanston-Flatt *et al*., 1989). Davaatseren et al (2013), on the other hand, found that rats with lower insulin resistance, a trait often associated with type 2 diabetes, were healthier. Studies also suggest that the dandelion is still advised for anti-diabetic purposes in various countries, including Turkey, Bonsia, Herzegovina, and Mexico (Wright, 'Van-Buren, Kroner, & Koning, 2007). This is encouraging in terms of finding prospective aids for the enormous number of people who have been diagnosed with diabetes.

The earliest reference of the dandelion being used medicinally dates back to 659 AD in Traditional Chinese medicine for diuresis (Yarnell & Abasacal, 2009). The word "piss in bed" was not chosen at random; it is derived from the French term "pissenlit," which means "dandelion." The digestive stimulant characteristics of the dandelion plant's bitter components; leaves and bloom the bitter taste is caused by sesquiterpene lactones, however it is these chemicals that aid digestion. The dandelion has long been utilised as a diuretic supplement throughout history, including in Traditional Chinese medicine, Mexican herbal medicine, and North American traditional medicine. (Sweeney *et al*., 2005; Schutz *et al*., 2006). Dandelion has not been well studied using modern scientific methodologies for most clinical applications.

The leaf is traditionally thought to be a useful bitter and fairly powerful diuretic. Dandelion is approved as a diuretic by the German Commission E, as well as for use in anorexia, dyspepsia, and biliary irregularities (Ali, 1989; Ali *et al*., 2019).

The leaf and root of *Taraxacum officinale* were traditionally employed in herbal medicine as a diuretic and laxative, according to a Canadian monograph (Biel *et al*.,2017). More research is needed, but Taraxacum officinale shows promise as a diuretic aid, according to the researchers. Dandelion roots are also strong in inulin, which may help the broiler chicken sector because chickens lack an enzyme for digestion, sesquiterpene lactones also have a cholagogic action (Yarnell & Abasacal, 2009). The increase of bile from wildlife, according to German author Faber, is evidence of this. When the gall bladder contracts, internal chemicals are propelled into the small intestine (Schutz *et al*., 2006). According to a 2007 study by Wright et al, dandelion ingestion can affect urine volume, but some species have a greater impact than others. Although it has a long history in traditional medicine, the dandelion has shown to have diuretic and digestive qualities.

Effect of Antioxidants Oxidative stress is seen in a variety of chronic liver illnesses, including viral hepatitis, alcoholic steatohepatitis, and nonalcoholic steatohepatitis. Oxidative stress causes harmful processes in the liver, resulting in liver disease. In order to preserve homeostasis, antioxidants must be restored. Consuming natural substances with antioxidant potential is one technique of replenishing antioxidants (Casas-Grajales & Muriel, 2015).

Hepatic fibrosis is a common complication of chronic liver injury, and reversing fibrosis before it progresses to the cirrhotic stage would be an

obvious treatment strategy (Lee, Wallace & Friedman, 2015). In experimental animals, Taraxacum officinale extract was tested against drug and chemical-induced hepatic fibrosis and showed promising outcomes. According to the findings, *Taraxacum officinale* administration promotes the total regression of fibrosis and the stimulation of hepatic regeneration powers.

Anticancer Properties, Hepatocellular carcinoma (HCC) is the most frequent type of liver cancer, accounting for 90 percent of all cases. Due to the high rates of tumour recurrence and widespread metastasis, HCC usually has a poor prognosis (Mao & Wang, 2015). According to recent findings, natural compounds, particularly those found in Taraxacum root extract, have a lot of potential as non-toxic and effective alternatives to the current chemotherapies.

HIV-1 replication and reverse transcriptase activity are both inhibited. Acute immunodeficiency syndrome is caused by the human immunodeficiency virus type 1 (HIV-1) (AIDS). This disease is a major public health concern around the world. There is currently no viable HIV-1 vaccine available (Cohen *et al*., 2007). As a result, the only way to reduce morbidity and mortality in HIV-1 infected people is to use prophylaxis and antiviral medications. Antiretroviral medicines targeting viral proteins at different stages of the HIV-1 life cycle or host factors have been produced. The virus cell-based fluorescence assay with pseudo type particles is an efficient and cost-effective screening technology that has been used to screen new HIV-19 agents. (Lindsten, Uhikora, Konvalinka Masucci, & Dantuma, 2001). Without producing replication-competent viruses, pseudotyped viruses created in this system may imitate most steps of the HIV-1 life cycle, including viral protein creation, assembly, release, maturation, entrance, integration, and replication.

This method could lead to the discovery of inhibitors for a variety of viral and cellular processes that are required for HIV replication (Kremb, Helter, Heller, Hoffmann, Wolff & Kleinschmidt, 2010). The expression of reporter genes, as reflected by the percentage of GFP-positive cells, was used to determine the degree of HIV-1 replication. The inhibitory effect of dandelion on RT enzyme activity was determined using a reverse transcriptase test kit. These findings demonstrate that dandelion extract has a substantial inhibitory effect on HIV-1 replication and reverse transcriptase function.

The effect of dandelion as a liver tonic has been acknowledged in Chinese, Indian, and Russian folk medicine. Dandelion and other herbs are used in traditional Chinese medicine to cure hepatitis (Modaresi *et al*., 2012). The root and herb of *Taraxacum officinale* (TO) have traditionally been used to cure a variety of diseases, including liver and gallbladder problems. It's used to boost the immune system's response to upper respiratory infections including bronchitis and pneumonia, as well as to treat mastitis, anaemia, and inflammation with a topical compress (Blumental, Cladbery &Brinkman, 2000).

Dandelion is also used in Chinese traditional medicine to treat jaundice and kidney illness (Lindsten *et al*.,2001). Dandelion was also used to cure the liver and spleen, as well as gout, according to a German physician in 1543. Water extracts from the root of *Taraxacum officinale* have been found to reduce copper and zinc hepatic levels in mice with inebriated livers (Domitrovic, Jakovac, Romic, Rahelic, Tadic, 2010). It also has potential restorative properties for hepatic diseases. *Taraxacum officinale* is beneficial in relieving toxicity by boosting antioxidant components, according to a

similar study in vivo and in vitro using alcohol-induced mice (You *et al*., 2010). As a result, the dandelion may contain strong detoxifying chemicals that can help with liver treatment.

Dandelion root preparations are still recommended by naturopaths for liver detoxification (*Sweeney et al*., 2005). Taraxacum, as an antioxidant, aids in the treatment and detoxification of the liver. With the rise in popularity of cleansing diets, the dandelion could become a natural ally in maintaining good health.

Given the importance of *hibiscus sabdriffa*, ginger, and dandelion in terms of nutritional and health benefits, combining these three herbs for the development of tea will be extremely beneficial to consumers and users.

Food product development

The process of creating new food items or improving on current ones is known as food product development. In the food sector, it is regarded as a necessary and vital procedure (Earle, & Anderson, 2001). Food product development cannot be ignored if the food sector is to survive in today's competitive market. Every food sector relies on it as a foundation and a critical aspect. Stewart-Knox & Mitchell (Stewart-Knox & Mitchell, 2003). The absence of product development in the food business could result in the industry's demise. Food industries that do not have a plan for food product development or process often compete solely on price, favouring only those with the lowest cost inputs or manufacturing expenses.

The process of food product development, according to Rudder, Ainsworth, and Holgate (2001), consists of numerous stages, including idea and concept generation, screening, research, development, sensory evaluation

and product testing, and market launch activities. As a result, a product can be nutritious, healthful, convenient, and safe to consume, but if it does not appeal to consumers' sensory qualities, it will fail. Sensory evaluation is also used to choose the most favoured product from among the several formulations made to match the sensory attributes of the consumer.

sensory evaluation

Sensory assessment is a scientific approach for measuring, analysing, and interpreting data derived from the properties of foods and materials as perceived by consumers' senses of sight, smell, taste, touch, and hearing (Stone & Sidel, 2004). Taste, hearing, touch, sight, and smell are the five senses that experience the properties of food. Sensory evaluation is important in the food industry, and it can help with product development, product upgrading, quality control, storage stability, product grading, process modification, cost reduction, rating, consumer acceptance and/or opinions, panellist selection, consumer preference, and training (Singh-Ackbarali & Maharaj, 2014).

There are many different types of sensory evaluation procedures, but the difference tests, descriptive analysis, and consumer acceptance test are the most popular (Yang & Lee, 2019). The number of sensory differences between samples is estimated using difference tests. To determine the level of customer approval for a product, consumer preference, acceptance, and hedonic (degree of liking) tests are performed. The category scales, paired-comparison test, and ranking tests can all be used to measure product acceptance.

Food acceptability is heavily influenced by sensory characteristics such as texture, colour, aroma, and flavour. Because they have an impact on consumers' appetite and preferences, appearance and colour have become essential criteria in the food sector in terms of how they are presented.

Food colour is thought to play an important role in influencing customer like and acceptance of a wide range of food products. (2015, Spence) However, according to Singh-Ackbatali and Maharaj (2014), appearance and colour can awaken or inhibit consumer desire and preference, and so are indications of the intrinsic good quality of meals related with acceptability.

CHAPTER THREE

RESEARCH METHODS

The study's materials and methods are presented in this chapter. The research design, study area, research instruments, data collection strategy, how data obtained will be evaluated and interpreted, and ethical considerations are all be captured and elaboratively explored in this chapter.

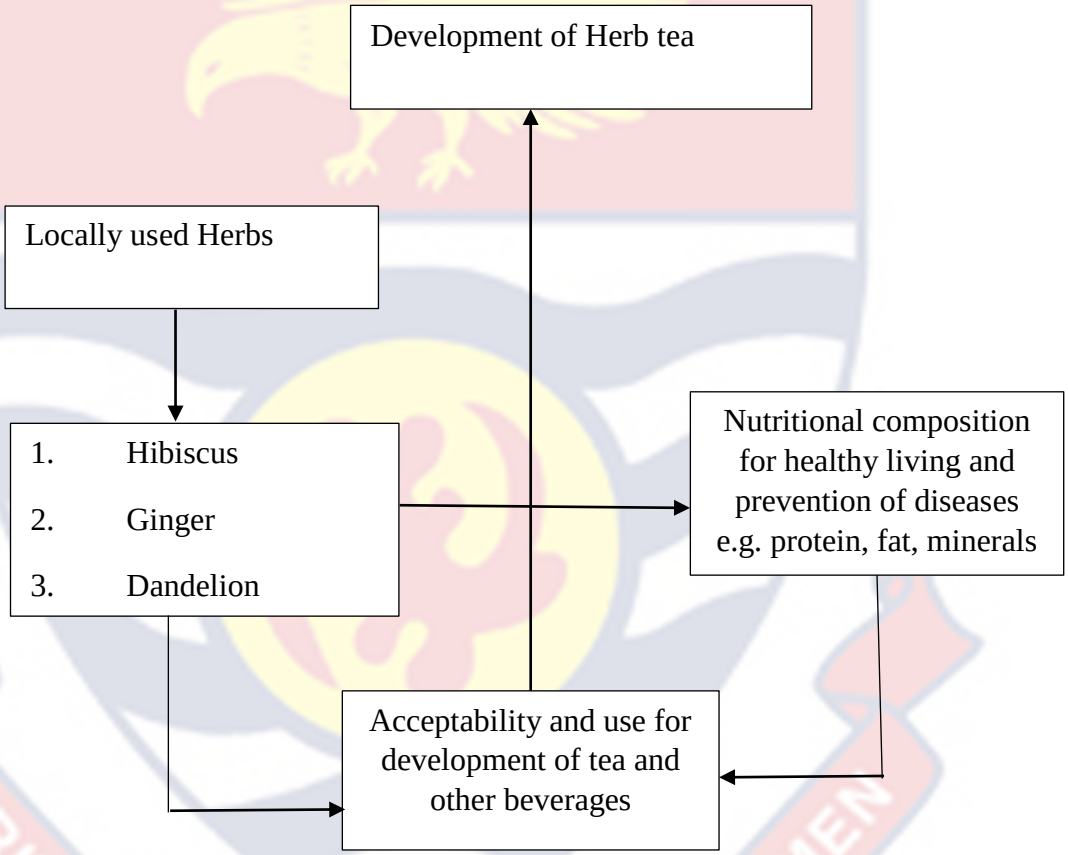


Figure 5: Development of herb teas

Research Design

The study was conducted using the experimental research design. Experimental research involves intentionally manipulating variables as determined by the researcher as she finds important to the study, to see the direct cause and effect. The treatment or manipulation of the variables causes

change or otherwise in the independent variable (Flannelly *et al.*, 2014).in the study to determine the influence of the hibiscus, ginger and dandelion at varying quantities in terms of their nutritional value and sensory properties (taste, colour, aroma and flavour), the formulation was manipulated to determine their effects. The formulations that were manipulated were the CHT, CCT, DHT, LHT LCT, and LDHT formulations. The design was deemed appropriate for the study because inherently, it enables the researcher to identify the nutritional constituents of the composite tea and determine the functional characteristics and evaluate sensorily acceptability of the tea.

Study Area

The research was conducted in the Asokwa Municipality in Ghana's Ashanti Region in West Africa. The Kumasi Metropolitan Assembly (KMA) was carved out of the Asokwa Municipal Assembly (AskMA) by a Legislative Instrument (L.I) 2294,2018, which was passed by Parliament on the 21st of December, 2017, under section 3 of the Local Governance Act,2016 (Act 936). The municipality is in three zones (Asokwa, Ahinsan and Atonsu). Asokwa Municipality is situated in the heart of the region, between 6.35 degrees North and 6.40 degrees South, and 1.30 degrees West and 1.35 degrees East, and approximately 250 to 300 metres above sea level. In terms of population, Asokwa Municipal has a population of 140,161 people according to the 2010 Census, and it is expected to grow by 2.7 percent to 182,950 people between 2017 and 2020 (Asokwa Municipal Assembly, 2020).

Population

The target population, according to Amedahe (2000), is the demographic that the researcher would like to generalise. Adane (2013) also claims that the target population relates to the empirical units employed in the investigation, such as people, things, and occurrences. The study's target group includes all sedentary workers (teachers, office workers, and drivers) in the Asokwa Municipal in the Ashanti area between the ages of 18 and 45.

Sample and Sampling Procedure.

Recruitment of participant

Sampling was done within Asokwa Municipality where a total of 120 sedentary workers were purposively selected from teachers, office workers, drivers and dress markers respectively between the ages of 18 and 45 years based on their familiarity and frequent usage with the herbs and also their willingness to participate in the study.

80 sedentary workers were randomly selected from the 120 where Twenty-five (25) teachers were selected 30 office workers, 15 drivers and 10 dress markers respectively as illustrated on table 2.

Table 2- Sample Size of Sedentary Workers in Asokwa Municipal

Gender	Teachers	Office workers	Drivers	Dress markers	Total
Male	15	17	12	5	49
Female	10	13	3	5	31
Total	25	30	15	10	80

Source: Field data, Donkor (2021)

Data Collection Instruments

The data collection instrument (questionnaire) was self-developed and reviewed by a sensory evaluation specialist to test its efficacy in drawing relevant information about the acceptability of the six formulations (CHT, CCT, DHT, LHT LCT, LDHT). A nine-point Hedonic scale was used to help measure the sensory characteristics of the Herb tea

Other instruments for collecting data and for the preparation of samples and proximate analysis included: weighing scale model: LA214, oven UNE 700, spectro photometer model; 4001/4, desiccator, furnace model; AAF 11/3, soxhle, kjedahl apparatus model; Kjeltec 2100, crucible, fibretec 2010, zip lock bag plastic

Ethical consideration

Every researcher is bound by ethical considerations, but especially in social research, the commitment is deepened because one has to deal with people and their personal data (Punch, 2008). In social research, moral considerations and respect for participants are critical. As a result, various ethical problems were considered in this study, including permission, anonymity, and confidentiality of the responders.

Concent forms were attached to each Evaluation Form (Questionnaire) for each panellist to sign after reading carefully the purpose of the study. Also, the University of Cape Coast Graduate School department in charge of ethical issues (Institutional Review Board) perused my methodology and deemed it appropriate for my research and its objectives. The Graduate school of the University Cape Coast consequently consented to the continuance of this study.

On the subject of confidentiality, every attempt was taken to keep participant responses private. The research participants were instructed to keep their responses hidden from other participants as well as from the researcher The responses were kept private, and the information provided was not be shared with participants they knew. On the Evaluation form, names were not permitted, and no space was supplied on the form to support this.

Two highly trained assistants helped with the data collection. The role of the assitants were to guide respondents on how to respond to the questionnaires in relation to the tasting of the herb tea. The sensory evaluation took place at the Asokwa Municipal Conference Hall.

Data Collection Procedure

Materials and methods

Three plants materials namely: dried Roselle (*Hibiscus sabdariffa*) was procured from the Abura market in Cape Coast, Ghana, fresh Ginger (*Zingiber officinale*) and fresh dandelion (*Taraxacum*) were harvested from University of Cape Coast Farms. Lipton (control) was purchased at Cape Coast, Abura market. The samples were later transported to the Technology Village Laboratory of the School of Agriculture, University of Cape Coast, Ghana. The materials were sorted and damaged ones were discarded. The samples were then processed at the University of Cape Coast Chemical laboratory for its sensory properties per the set objectives for the study.

Sample Preparation for Proximate Analysis

Dried roselle (*Hibiscus sabdriffa*)

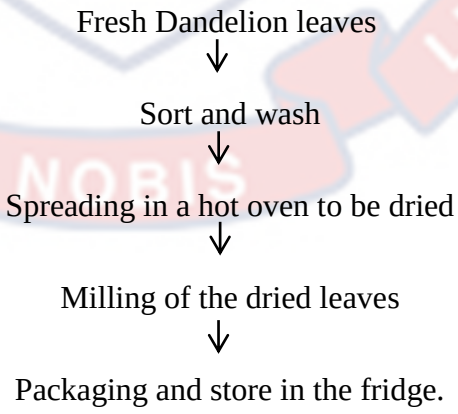
The dried Roselle calyx was sort to remove stones and foreign materials, weigh and then milled for 15 seconds using an electric mill

(Panasonic mixer grinder, MX-AC 2015). It was then packed into zip lock bags and stored in the refrigerator. The packed milled roselle was than stored in a freezer for further analysis.

A flow chart showing the processing of Hibiscus for Composite tea. Adapted from Adeleke & Odedeji (2010).

Fresh dandelion

The fresh dandelion leaves were cleaned under running distilled water to remove all dirt and other extraneous materials. The cleaned fresh dandelion was dried in oven (Gallenkamp Sanyo/Weiss England) at 60 oC for 18 hours. Later on, the dried samples were milled for 15 seconds using an electric mill (Panasonic mixer grinder, MX-AC 2015). The milled sample was then kept in an air-tight container (zip bag) and stored in a freezer until further analysis.



A flow chart showing the processing of Dandelion for Composite tea. Adapted from Adeleke & Odedeji (2010)

Fresh ginger

The fresh ginger roots were thoroughly cleaned under running distilled water and subsequently diced into reasonable pieces appropriate for the drying process. The samples were then dried in an oven (Gallenkamp Sanyo/Weiss England) at 60 oC for 18 hours. The dried samples were later crushed in an electric mill (Panasonic mixer grinder, MX-AC 2015). The milled sample was then kept in an air-tight container (zip bag) and stored in a freezer until further analysis.

Fresh ginger root
↓
Clean and wash
↓
Cut into smaller sizes
↓
Dried in an oven
↓
Milling the dried ginger
↓
Packaging and store in the fridge.

A flow chart showing the processing of Ginger for composite tea. Adapted from Adeleke & Odedeji (2010)

Composite tea formulations

The three ingredients were mixed into composite teas in six (6) different varying proportions of percentage ratios as shown in Table 3 below. The percentages were obtained using Design Expert (2007). After the generation of the formulations, 2g of the composite tea samples were put into a tea bag (in triplicate) and Lipton weighing 2g was used as a control.

Table 3: Percentage (%) formulation of composite tea (herb tea)

Samples	Roselle (%)	Ginger (%)	Dandelion (%)	Total%)
CHT	50.0	25.0	25.0	100
DHT	25.0	25.0	50.0	100
LHT	25.0	50.0	25.0	100
LDHT	30.0	35.0	35.0	100
CCT	20.0	20.0	60.0	100
LCT	40.0	40.0	20.0	100
Lipton	-	-	-	100

Lipton as control

Source: Field data Donkor (2021).

Moisture content determination

Porclain crucibles were washed, dried and weighed. About 10-12g of the fresh samples were weighed into clean oven dried crucibles. Filled crucibles were spread over the base of a thermostatically controlled oven at 105 ºC for 48 hours. This ensured equal distribution of heat to the samples. After 48 hours, the heated samples were removed from the oven and quickly transferred into a desiccator. This prevented any moisture from entering the sample. Samples were then removed and quickly weighed three times or in triplicates. The moisture content in the samples were calculated using the formula below.

$$\% \text{ moisture} = \frac{W2 - W3}{W2 - W1} \times 100$$

Where: W1 = Weight of crucible

W2 = Weight of crucible + fresh grated sample

W3 = Weight of crucible + Dry samples

Ash determination

Ash content of material represent inorganic residue left behind after burning of organic matter or the mineral content present in the sample. Ten grams (10 g) of sample was weighed and transferred into a weighed crucible and placed in a carbolite furnace (model AAF1100) at 105 ºC for about an hour and then transferred to furnace at a temperature of 550 ºC overnight, the heating continued until all the carbon particles were burn away. The ash in the crucible was removed from the furnace and placed in a dessicator, allowed to cool, after which was weighed. The ash was then calculated using the formula below.

$$\% \text{ Ash} = \frac{W3 - W1}{W2 - W1} \times 100$$

Where:

W1 = Weight of crucible,

W2 = Weight of crucible + fresh grated sample,

W3 = Weight of crucible + Ash

Oil/ Fat Determination

Reagents

1: Petroleum Spirit

About 10g of the milled samples were weighed into a 50 × 10mm soxhlet extraction thimble. This was transferred to a 50 ml capacity soxhlet extractor. A clean dry 250 ml round bottom flask was weighed. About 150 ml Petroleum spirit was added and connected to the soxhlet extractor and extraction was done for 4 hours using a heating mantle as a source of heating. After the 4 hours the flask was removed and placed in an oven at 60℃ for 2

hours. The round bottom flask was removed, cooled in a desiccator and weighed. The percentage fat/oil was calculated as followed.

Calculation

Crude Fat (%) = $\frac{W\,2 - W1 \times 100}{W3}$,

Where:

W1 = Weight of empty flask

W2 = Weight of flask + fat

W3 = Weight of samples taken

Carbohydrate determination

Reagent

1: Glucose Solution

Stock solution: (1ml is equivalent to 0.25mg glucose), 0.250g D-glucose (dried in a vacuum oven at 70°C oven P_2O_5) was dissolved in water and diluted to 1 liter. Working standards: a range of 0 – 20 ml stock solution was pipette into 50ml flasks such that 2ml of each standard gives a range from 0- 0.20mg glucose and diluted to volume.

2: Anthrone Reagent

Add carefully 760 ml conc H_2SO_4 was carefully added to 330ml of water in a boiling flask and kept cool while mixing. A 1g of anthrone was added followed by 1g of thiourea and dissolve using a magnetic stirrer. Transfer to a dark bottle and leave for 2hours before use. Store at + 1°C.

Extraction procedure

Fifty milligrams (50 mg) of the milled sample was weighed into a 50ml conical flask, 30ml of distilled water was added and a glass bubble placed in neck to simmer gently on a hot plate for 2 hours. It was topped up to

30ml periodically and let to set and cool slightly, and then filtered through a No.44 Whatman paper into a 50ml volumetric flask and dilute to volume when cool. The extract was prepared shortly before color development. A blank was prepared by taking it through same procedure.

Colour development

Two mililitres (2 ml) of each standard was pipetted into a set of boiling tubes and 2ml of the extract and water blank was also pipetted into a boiling tube. Standards and samples were treated the same way. Ten (10 ml) of anthrone solution was added rapidly to mix and the tubes immersed in running tap water or ice bath. The tubes were placed in a beaker of boiling water in a dark fume cupboard and boil for 10minutes.

The tubes were then placed in cold water and allowed to cool, preferably in the dark. The optical density was measured at 625nm or with a red filter using water as a reference. A calibration graph was prepared from the standards and used to obtain mg glucose in the sample aliquot. The blank determination was treated same way and subtraction done where necessary.

$$\text{Soluble carbohydrates (\%)} = \frac{C\ (\text{mg}) \times \text{extract volume (ml)}}{10 \times \text{aliquot (ml)} \times \text{sample wt (g)}}$$

Where C = carbohydrate concentration from the calibration graph

Protein determination

Protein present in food is calculated from nitrogen concentration of the food. The kjeldahl was used in the determination of protein. The method can be divided into three steps: digestion, neutralization or distillation and titration.

Digestion

About 0.2g of the sample was weighed into a 100 ml Kjeldahl flask. 4.4mL of the digestion reagent was added and the samples digested at 360 ºC for two hours. A blank was prepared of the digestion mixture without sample) were carried out in the same way. After the digestion, the digests were transferred quantitatively into 50ml volumetric flasks and made up to the volume.

Distillation

A steam distillation apparatus was set up. The distillation apparatus was flushed with distilled water for about twenty (20) minutes. After flushing out the apparatus, five (5) millilitres of boric acid indicator solution were poured into a 100 ml conical flask was placed under the condenser of the distillation apparatus with the tip of the condenser completely immersed in the boric acid solution. An aliquot of the sample digest was transferred to the reaction chamber through the trap funnel. Alkali mixture of 10 ml was added to commence distillation immediately and about 50mL of the distillate was collected.

Titration

The distillate was titrated with 0.1N HCl solution until the solution changed from green to the initial colour of the indicator (wine red). Digestion blanks were treated the same way and subtracted from the sample titre value. The titre values obtained were used to calculate the nitrogen and hence the protein content. The conversion factor used was 6.25.

$$\%\text{Total Nitrogen (\%N)} = \frac{(\text{Sample titre value} - \text{Blank titre value}) \text{ X } 0.1 \text{ x} 0.01401 \text{ x } 100}{\textit{sample weig ht X } 10}$$

% Protein = %N x 6.25

Crude fibre determination

Reagents

Sodium hydroxide, 1.25 %

Dissolve 12.5 g NaoH in 700 ml distilled water in a 1000 ml volumetric flask and dilute to volume.

Sulphuric Acid, 1.25 %

Add 12.5 g conc. Sulphuric acid to a volumetric flask containing 400ml distilled water and dilute to volume.

About 1g of the sample was weighed and placed in a boiling flask, 100ml of the 1.25% sulphuric acid solution was added and boiled for 30mins.After the boiling, filtration was done in a numbered sintered glass crucible. The residue was transferred back into the boiling flask and 100 ml of the 1.25% NaOH solution was added and boiled for 30mins. Filtration continued after the boiling and the residue washed with boiling water and methanol. The crucible was dried in an oven at 105 degrees celcius overnight and weighed. The crucible was placed in a furnace at 500 degrees celcius for about 4 hours. The crucible was slowly cooled to room temp in a desiccator and weighed.

Calculation

$$\%\text{ Crude fibre} = \frac{\text{weight loss thro ashing}}{\text{Sample weight}} \times 100$$

AOAC (2008)

Preparation of sample solution for the determination of N, K, Na, Ca, Mg, P, Zn, Cu & Fe

The preparation of sample solutions suitable for elemental analysis involves an oxidation process which is necessary for the destruction of the organic matter, through acid oxidation before a complete elemental analysis can be carried out.

Sulphuric acid-hydrogen peroxide digestion

The digestion mixture comprises 350mL of hydrogen peroxide, 0.42g of selenium powder, 14g Lithium Sulphate and 420mL Sulphuric acid. The digestion procedure as outlined in *Stewarte et al.*, 1974 states that between 0.1000g to 0.2000g of the oven-dried ground sample was weighed into a 100 mL Kjeldahl flask and 4.4 mL of the mixed digestion reagent was added and the samples digested at 360 ^{o}C for two hours. Blank digestions (digestion of the digestion mixture without sample) were carried out in the same way. After the digestion, the digests were transferred quantitatively into 100mL volumetric flasks and made up to volume.

Colorimetric determination of phosphorus (P) using the ascorbic acid method

The procedure requires the preparation of colour forming reagent and P standard solutions. The colour forming reagent is made up of reagents A and B. Reagent A is made up of 12 g ammonium molybdate in 20ml distilled water 0.2908g of potassium antimony tartarate in 100 ml distilled water and 1L of 2.5M H_2SO_4. The three solutions were mixed together in a 2L volumetric flask and made up to volume with distilled water.

Reagent B was prepared by dissolving 1.56 g of ascorbic acid to every 200 mL of reagent A. A stock solution of 100μgP/mL solution was prepared from which 5μgP/mL solution a set of working standards of P with concentrations 0, 0.1, 0.2, 0.4, 0.6, 0.8 and 1.0μgP/mL in 25 mL volumetric flasks. 2 mL aliquot of the digested samples were pipette into 25 mL volumetric flasks. Two millilitre aliquot of the blank digest were pipette into each of the working standards to give the samples and the standards the same background solution.

Ten militre (10ml) of distilled water was added to the standards as well as the samples after which 4 mL of reagent B was added and their volumes made up to 25 mL with distilled water and mixed thoroughly. The flasks were allowed to stand for 15minutes for colour development after which the absorbances of the standards and samples were determined using a spectrophotometer at a wavelength of 882nm. A calibration curve was plotted using their concentrations and absorbances. The concentrations of the sample solutions were extrapolated from the standard curve.

Calculation

If C = μgP/mL obtained from the graph,

then μgP/g (sample) = $\frac{\text{C x Dilution Factor}}{\text{weight of sample}}$

(IITA, 1985)

Determination of potassium and sodium

Potassium and sodium in the digested samples were determined using a flame photometer. In the determination the following working standards of both K and Na were prepared: 0,2,4,6,8 and 10 μg/mL. The working standards as well as the sample solutions were aspirated individually into the flame

photometer and their emissions (readings) recorded. A calibration curve was plotted using the concentrations and emissions of the working standards. The concentrations of the sample solutions were extrapolated from the standard curve using their emissions.

Calculation

$$\mu gK/g = \frac{C \times \text{solution volume}}{\text{Sample weight}}$$

Stewarte et al (1974)

Determination of calcium and magnesium by EDTA titration

The method involves chelation of the cations with ethylene diaminetetra-acetic acid (EDTA). The procedure involved the determination of calcium and magnesium together and the determination calcium alone and magnesium found by difference.

Calcium and magnesium together were determined by placing an aliquot of 10mL of the sample solution in a 250mL conical flask and the solution was diluted to 150mL with distilled water 15mL of buffer solution and 1mL each of potassium cynacide, hydroxylamine hydrochloride, potassium ferro-cyanide and triethanolamine (TEA). Five drops of erichrome Black T (EBT) were added and the solution was titrated against 0.005M EDTA. Calcium was determined by pipetting 10mL of the sample solution into 250conical flask and diluted to 150mL with distilled water. 1mL each of potassium cyanide, hydroxyl-amine-hydrocloride potassium ferro-cyanide and TEA five drops of calcon indicator were added and the solution was titrated with 0.005M EDTA.

Calculations

$$\% \text{ Ca} = \frac{0.005 \text{ x } 40.08 \text{ x T}}{\text{Sample wt}}$$

$$\% \text{ Mg} = \frac{0.005 \text{ x } 24.31 \text{ x T}}{\text{Sample wt}}$$

Where T = titre value

Determination of iron, copper and zinc using atomic absorption spectrophotometer

Standard solutions of 1, 2 and 5μg/mL solutions of Fe, Cu and Zn were prepared. The standard solutions were aspirated into the atomic absorption spectrophotometer (AAs) and the respective calibration curves were plotted on the AAS. As the sample solutions were aspirated, their respective concentrations were provided.

Calculations

$$\text{Fe } (\mu\text{g/g}) = \frac{\text{C x solution volume}}{\text{Sample weight}}$$

$$\text{Cu } (\mu\text{g/g}) = \frac{\text{C x solution volume}}{\text{Sample weight}}$$

$$\text{Zn } (\mu\text{g/g}) = \frac{\text{C x solution volume}}{\text{Sample weight}}$$

FAO (2008).

Data Collection

Sensory evaluation

Sensory evaluation of the composite teas or herb tea was conducted using Lipton tea brand as control (Dzah, 2015) to determine preference rating of the samples for aroma, flavour, colour, taste, and overall acceptability using 80 untrained member panelist (45 males and 35 females). The selection of sensory panelist was based on those: familiar with tea, herbs being used, quality parameters, in good health and willing to participate in the exercise;

which included teachers, office workers, drivers and dress markers in the Asokwa Municipality.

The selected panellist had no previous knowledge of the sample composition to be tested in order to avoid any form of bias. Two grams (2 g) of the composite sample was infused with 100 ml distilled boiled water for 10 min and the panelist were asked to examine the tea samples at room temperature using a 9-point hedonic scale. Where: 9 = like extremely and 1 = dislike extremely (Lawless & Heymann, 2010). Two grams (2 g) of tea in 100 ml water was selected based on British Standard 6008: ISO 3101 (BSI, 1980).

Data processing Analysis

Statistical analysis

The sensory evaluation of the herb tea was done by Panellists. The responses from the Panellists were used to complete the questionnaire for further analysis. The research data collected in respect to the questionnaires were screened to eliminate questionnaires that were not fully completed.

In analyzing the objectives, statistical software called Statistical Package for Social Scientist software for windows vision 18 was used. Descriptive mean and standard deviation were used to analyse objectives one to three. The data for objective two was further presented with a bar chart to give the pictorial view of the data. One-way ANOVA was used from the predictive analytical software for windows was to analyse hypothesis one and two. To evaluate the sensory properties of the teas, Analysis of variance (ANOVA) was used to determine the significant difference between the control and develop teas. Significance was accepted with multiple comparion through Post Hoc testing with Tukey Test.

CHAPTER FOUR

RESULTS AND DISCUSSION

This chapter presents the results and discussion of the findings from the field. The study was to develop tea from *Hibiscus sabdriffa*, ginger and dandelion for human consumption. The presentation of the results covered the demographic information of panellists, the formulations that were developed from ginger, dandelion and hibiscus, proximate analysis and the sensory evaluation of the formulations.

Demographic Data of Panellists

The biographical information on the panellists for the sensory evaluation of the herbal tea formulations are presented in Table 4. The biographical information in Table 3 consists of gender and age of the panellists.

Table 4: Demographic Information of Panellists

Characteristics	Frequency	Percentage
Gender		
Male	45	56.25
Female	35	43.75
Age (years) range		
15-20	8	10.00
21-25	28	35.00
26-30	15	18.75
31-35	13	16.25
36-40	9	11.25
41-45	7	8.75

Source: Field data, Donkor (2021)

The Result in Table 4 shows that 80 panellists took part in the sensory evaluation of the control and formulated herbal teas. Majority of the panellists were males forming about 56% (45) with the remaining panellists being

females and forming 35, (44%). About 8.75% of the Panellist fell within the ages of 41-45, with regards to those in the age range of 21-23 years 28 representing 35%. In the case of the ages of the participants, panellists having their ages ranged from 41 – 45 were few 7 (8.75%) while those having their ages from 21-23 years were more 28 (35%). Table 4 shows that (51) of the total participants (panellists) were in their early 30s. Those above their early 30's was 29 in number.

Objective One: Develop Herb Tea with Six Different Proportional Preparations of Hibiscus, Ginger and Dandelion.

Herb teas have been successfully formulated from the combinations of different proportions of hibiscus, ginger and dandelion plants. The conceptualized flow diagram as presented in Chapter Three of this thesis was followed through in developing the herbal teas. The formulated herbal teas are presented in Figure 6. The formulated herb teas came in different tastes, flavours, colour and acceptability. The formulated herb tea formulations were six and were coded 'LCT' (Lesta Composite Tea) 'CCT' (Cele Composite Tea), 'LDHT' (Leata Donkor Herb Tea), 'LHT (Lesta Herb Tea)', 'DHT (Donkor Herb Tea)' and 'CHT (Cele Herb Tea)'. The coding of the formulations was done to disguise the exact names of the formulations from the panellists. This was to prevent the panellists from having any clue prior to the sensory evaluation for their acceptability.

Figure 6: Formulated herb teas

***Source: Field* data Donkor (2021).**

Objective Two: Analyse the Nutritional Composition of Hibiscus, Ginger and Dandelion Using its Dried Forms.

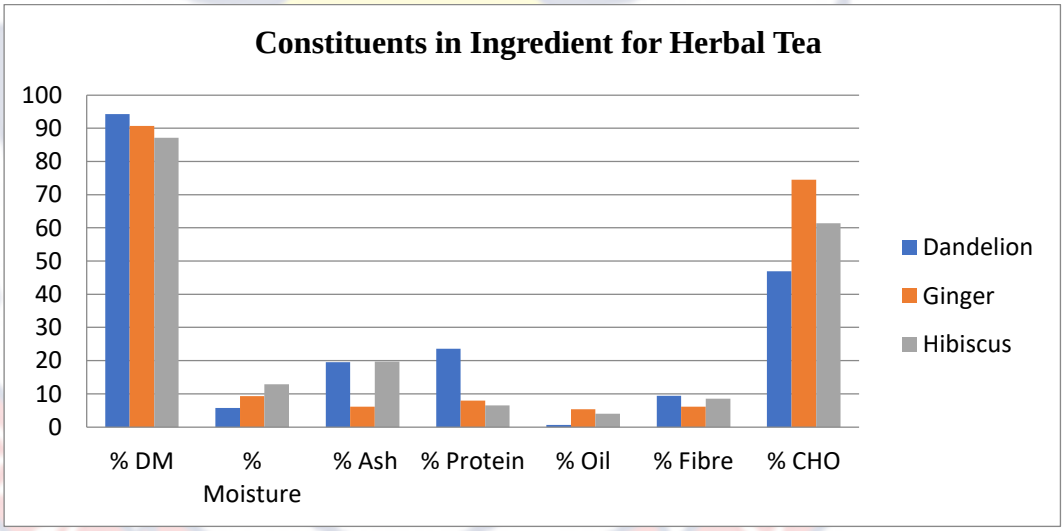


Figure 7: Proximate analysis of three herbs

***Source:* Field Data Donkor (2021).**

The chemical constituents of the herbs used to formulate the teas, has been presented in Figure 7. The result as in Figure 7 shows Dry matter (DM), moisture content, ash content, protein, oil, fibre and carbohydrate (CHO) analysed on a bar chart. The total dry matter (DM) of dandelion had the

highest dry matter representing 94 % followed by ginger 90 % and the least was hibiscus representing 87 %. The next highest nutrient constituent was CHO and interestingly, the dandelion had the least amount of 1.5%. Ginger on the other hand had the second highest of 74 %.

For moisture content, the highest value was 12.3 % for hibiscus, followed by ginger 10 % and dandelion, which was 6 %. The ash percentage was found to be 20% for dandelion and hibiscus, ginger, (7%) was found to be least. Protein in dandelion was 24.5 %, this in accordance with Ghaly *et al* (2012) who reported earlier dandelion is rich in protein with 20% as compared to other leaves and vegetables like cucumber, cabbage and tomatoes. and the other two herbs ginger and hibiscus were below 10 %.

Amount of lipids in the different herbs were small with ginger having the highest 5.6%. Hibiscus had negligible lipid content and was below 1%. The fibre constituent for dandelion was 10 % and the least 7 % for ginger.

Objective Three: Analyse the Nutritional Constituent of the Six Formulated Tea Preparations and the Lipton (Control).

Findings of objective three is presented in Table 5. The results have been presented using mean and standard deviation**.**

Table 5: Nutritional Composition of Composite Tea Formulations and Lipton (Control) Nutritional Constituents of Formulations

Sample	%DM	%Moisture	%Ash	%Protein	% Oil	%Fibre	%CHO
CHT	90.00±0.28	9.99±0.28	19.26±0.41	9.67±0.27	3.23±0.12	12.33±0.22	55.49±0.78
DHT	90.78±0.16	9.22±0.16	16.63±0.14	13.58±0.39	4.75±0.85	10.65±0.34	54.38±0.32
LHT	90.49±0.17	9.51±0.17	13.44±0.33	10.59±0.8	4.28±0.09	9.55±0.09	62.14±0.29
LDHT	90.41±0.17	9.59±0.17	15.44±0.02	12.13±0.15	4.36±0.20	12.65±0.15	55.40±0.32
CCT	92.01±0.07	7.99±0.07	15.66±0.26	15.49±0.38	5.13±0.13	11.12±0.11	52.57±0.58
LCT	90.64±0.09	9.36±0.9	13.29±0.20	9.40±0.14	4.17±0.14	10.84±0.24	62.29±0.54
LIPTON (Control)	89.58±0.27	10.42±0.7	4.35±0.27	0.86±0.12	0.00±0.00	12.19±0.24	0.00±0.00

Source: Field data, Donkor (2021) *Values are averages of triplicate Determinations-Data is represented as mean ± standard deviation

The yellow label brand of Lipton was used as control to sensorily analyse the acceptability and nutritional composition of the developed herb teas. It is the commonest tea known and consumed most in Ghana both workers and students. Lipton is not consumed for medical and health purposes only but it's also consumed as refreshing beverage with the addition of a sweetner and milk unlike other type of tea brands in Ghana.

Lipton as control to herb tea was used to identify the relationship between herb tea and tea produce from tea plant (Camelia) interms of sensory qualities and nutritional constituents. Aronically Lipton tea could be categorized under herb or herbal tea .it is originally manufactured from plant. According to Wioletta *et al.,* (2016), currently tea is not used to describe only black, green, red or white but it is used to reference any infusion obtained from plants or parts of plants. Lipton and herbal teas are described as teas being manufactured from parts of plants. According to Bender (2006) any infusion prepared from parts of plant or camellia (tea plant) is called tea. Therefore, Lipton was use as a control for the six developed teas to analyse the acceptability of the developed herb teas accurately and easily.

The nutritional compositions of the formulated teas and control (Lipton) were seven. These included dry matter (DM), moisture, ash, protein, oil, fibre and carbohydrate. The dry matter (DM) for the formulations ranged from 89.31 to 92.08. The DM for the seven teas indicated that CCT had the highest mean value of 92.08 while the least mean value of 89.85 was for Lipton (control)

Percentage moisture level in the formulations ranged from 7.92 to 11.12. For CCT and Lipton respectively. The difference between the highest mean value and the lowest mean value was 3.2 which is about three times the values of all the moisture determined in the formulations. The control tea (Lipton) had the highest percentage moisture. However, the percentage moisture formulated teas were lower than Lipton (control). CCT was found to contain the lowest percentage of moisture. The next higher presence of moisture followed by DHT with a mean difference of 1.32. Comparing the mean values of the moisture content to %DM quantities in the formulations, the moisture content happened to be lower than the %DM.

The dry matter (DM) being the highest constituents in the ingredients used for the herbal tea preparation was very good. Dry matter in general do help food not to be susceptible fungi and moulds at a faster rate (Richardson *et al*., 2002) and its high quantity found in the ingredients used for the tea formulation therefore makes it to be kept for a longer period on the shelf.

Ash content for the formulations ranged from 4.08 to 19.62. This falls within the range of other commercial tea samples which are above ten (10) (Adnan *et al*., 2013). The highest mean value of ash was recorded for CHT while the least was for Lipton; the next higher mean value was for LCT. The ash content of samples refers to the total mineral composition in the sample. The high content of ash suggests that the samples are good sources of minerals (Mohammed & Suleiman, 2009).

The protein content in the formulations ranges from 0.74 to 15.87. The other mean values for the formulated teas were high with 9.26 for LCT and higher as 15.87 for CCT. The mean values for protein are comparably a little

lower than that of the ash quantities that were found in the same formulated samples. Protein is one of the essential nutrients needed in the body for building as well as growth. The highest recording of protein in the formulations is as results of dandelion since dandelion is said to be a good source of protein as compare to other plants according to Ghaly *et al*. (2012). However, the percentage of protein in the various formulations is higher as determined in other tea. (Adnan *et al*., 2013).

The lipid content in the formulations including the control were all less than six (6) and their mean values ranges from 0.00 to 5.26. It can be noted that the control product did not have oil presence in Lipton. Oil or Fat is needed in the body for energy, the high amount of oil in the formulation is because of the ginger, ginger is known as a source of fats and oil. (Andlauer & Fürst, 2002). However, the oil content in the other formulations starts from 4.03 and increased to 5.26. The difference between the mean values for each formulation apart from the control is $\pm$ 1.

Abeshu *et al.* (2016) reported that increasing the intake of dietary fibre generally increases stool bulk which causes flatulence and decreases appetite. The mean value of fibre content in the formulations ranged from 9.46 to 12.80. LHT recorded the least mean value while LDHT recorded the highest.

The percentage of fibre content in the various samples or formulations ranges from 9.55% to 12.65% which LDHT recording the highest fibre and LHT recording the least amount of fibre. Lipton as the control recorded the third highest with 12.19%.CHT also recorded the second highest with 12.33%. The presence of ginger help in the significance content and percentage of fibre as indicated that ginger is good source of fibre. (Singh, 2015).

In the case of carbohydrate content, it was found that Lipton (control) recorded nothing (zero) and LCT recorded the highest mean value with a percentage of 62.29. Aside the insignificant content of carbohydrate in the control (Lipton), all other values in formulations range from 50 to 60.

In Table 5, it was observed that all the nutritional constituents that have been found in the formulations varied in quantity. In comparing and contrasting the percentage mean values, the control (Lipton) had less quantity for all the nutrients presents except for moisture and fibre. It was revealed that in general, the quantity for dry matter was high while the moisture levels were low. In the case of ash content, the quantity appreciates up a little and decline for protein. The mean value for oil content also declined abit. The fibre content also increased substantially as compared to the lipid content. The carbohydrate content was also very high for all the formulation except for Lipton (Control).

It can therefore, be concluded that all the six developed formulations have seven nutritional constituents. The dry matter content for CHT was low while the highest was found in CCT formulation. With respect to moisture content, CCT formulation had the lowest quantity while CHT have the highest quantity aside the control (Lipton). The ash content was less in LCT aside the Control (Lipton) with the highest being CHT formulation. LCT recorded the least protein content, aside the Control and CCT being the highest protein content among the six formulations. The oil content in LCT was less with the Control (Lipton) recording zero. The highest quantity of oil content was found in CCT formulation. LHT recorded the least in terms fibre and the highest content of fibre was recorded for CHT formulation. In the case of

carbohydrate content, the least quantity found was in CCT aside the Control tea and the highest value was for LCT.

Objective Four: Compare the Mineral Compositions in Formulated Composite Tea and Infusion Herb Tea.

The minerals that were found in the composite tea and the infused tea to make the analysis handy and comprehensive have been presented in Table 6.

Table 6: Minerals Present in Formulated Composite Tea and Infusion Herbal Tea

Sample		P ug/g (Mean / Std. Dev.)	K ug/g (Mean / Std. Dev.)	Na ug/g (Mean / Std. Dev.)	Fe ug/g (Mean / Std. Dev.)	Cu ug/g (Mean / Std. Dev.)	Zn ug/g (Mean / Std. Dev.)	%Ca (Mean / Std. Dev.)	%Mg (Mean / Std. Dev.)
CHT	Composite	1580.56 ±9.29	222.32 ±192.17	1156.11 ±24.10	749.58 ±17.79	406.02 ±13.97	41.29 ±6.75	2.05 ±0.04	0.37 ±0.02
	Infusion	29.15 ±0.34	519.03 ±4.25	17.36 ±0.58	12.23 ±0.15	4.23 ±0.02	2.72 ±0.01	362.72 ±2.00	-
DHT	Composite	1873.88 ±53.32	10231.56 ±147.03	1465.49 ±27.54	681.59 ±32.13	415.66 ±17.82	98.89 ±3.11	1.73 ±0.18	0.29 ±0.01
	Infusion	52.45 ±0.37	792.01 ±1.61	34.07 ±0.16	19.63 ±0.15	4.42 ±0.01	5.52 ±0.15	360.72 ±2.00	-
LHT	Composite	1740.58 ±13.38	8593.14 ±331.95	975.05 ±29.24	509.33 ±36.44	391.05 ±14.08	77.57 ±8.60	1.44 ±0.05	0.41 ±0.01
	Infusion	42.59 ±0.85	621 ±2.78	20.61 ±0.28	12.94 ±0.14	3.23 ±0.02	6.42 ±0.01	300.60 ±2.00	-
LDHT	Composite	1767.63 ±22.21	9442.10 ±48.72	1242.94 ±26.05	541.51 ±9.59	347.86 ±4.98	53.63 ±8.76	1.39 ±0.05	0.20 ±0.00
	Infusion	48.70 ±0.52	774.37 ±2.78	36.86 ±0.43	15.200 ±0.10	2.87 ±0.15	5.86 ±0.01	325.31 ±3.06	-
CCT	Composite	2669.71 ±33.32	10784.28 ±169.84	2076.56 ±64.09	662.59 ±30.92	550.08 ±13.92	66.62 ±2.44	2.34 ±0.02	0.37 ±0.01

Table 6 continued		P ug/g	K ug/g	Na ug/g	Fe ug/g	Cu ug/g	Zn ug/g	Ca	Mg
LCT	Infusion	51.86 ±0.34	830.08 ±2.79	39.55 ±0.28	14.26 ±0.15	2.32 ±0.02	6.02 ±0.01	364.72 ±2.00	-
	Composite	2210.29 ±59.03	7811.62 ±231.66	980.08 ±11.59	486.28 ±8.38	573.32 ±5.52	66.03 ±1.06	1.29 ±0.03	0.21 ±0.00
LIPTON (YELLOW LABEL)	Infusion	35.02 ±0.52	610.03 ±2.78	18.94 ±0.28	13.93 ±0.02	2.13 ±0.01	4.96 ±0.01	326.65 ±2.01	-
	Composite	949.07 ±16.39	3456.24 ±246.46	170.34 ±6.23	38.09 ±1.37	135.76 ±3.37	36.62 ±1.33	0.46 ±0.02	0.06 ±0.00
	Infusion	30.97 ±0.19	537.60 ±2.78	3.06 ±0.28	11.82 ±0.02	1.92 ±0.02	3.22 ±0.15	223.11 ±3.06	-

Source: Field data, Donkor (2021)

The mineral elements found in the composite teas in the present study have confirmed the study conducted by Rocz *et al*. (2017) on tea composition. In a similar study by Alam *et al.* (2020) they found some mineral elements in the composition of the herbal tea. The minerals found were K, Mn, Cr, Ni and Zn while in the current study, P, K, Na, Fe, Cu, Zn, Ca and Mg were found. This clearly suggested that much more mineral elements have been detected in the current formulations (CHT, DHT, LHT, LDHT, CCT and LCT) than what was found in earlier studies.

In Table 6, the formulations were analyzed for both macro and micro elements or minerals in composite tea and compared with nutrients (minerals) in the tea infusion.

In the case of Phosphorus presence in the formulations, the mean value measured in ug/g shown that the composite and the infusion teas have significant values. The Phosphorus contents for the various formulations were very high for all the composite tea as compared to that of the infusion tea. For the composite tea, the least mean value was 965.45 for the control (Lipton) and the highest mean of 2,669.71 ug/g for CCT. (20% Roselle + 20% ginger + 60% dandelion).

The mean for CHT (50% Roselle + 25% ginger +25% dandelion) with respect to Potassium was less for the composite tea as compared to the infusion tea. The mean difference between their quantities was 108.79. DHT which is made up of (25% Roselle +25% ginger +50% dandelion), the mean difference between the composite and the infusion tea quantities for Potassium was 9,584.97 while LHT (25% Roselle + 50% ginger +25% dandelion) mean difference between the composite and infusion tea was 8,301.31. The mean

difference between the composite and infusion tea for LDHT was found to be 8,713.58. CCT had a mean difference of 10,121.25 in respect to the composite and infusion tea. Meanwhile, LCT (40% roselle + 40% ginger + 20% dandelion) had mean difference of 612.81 for the composite and infusion tea. The control tea (Lipton) had its mean difference for the composite and the infusion tea to be 3,162.32.

Sodium as one of the essential minerals found in the composite and infused herbal tea had varied mean values. CHT sample, the mean difference between the composite and infusion tea was 162.27. With respect to DHT, the mean difference for composite and infusion was found to be 1458.80. Meanwhile, the difference in the mean value for LHT concerning the composite tea and infusion was 983.40. Mean difference of 1,231.7 existed between the composite and the infusion tea for LDHT. The mean differences for CCT and LCT in terms of the composite and infusion tea were 2100.82 and 972.45 respectively. The Control tea (Lipton) had mean difference of 173.23 between composite and infusion tea.

The iron presence in the composite and the infusion tea has a mean difference of 754.99 for CHT while DHT was 693.94. The mean difference found for LHT was 532.69 having compared the composite and infusion tea. Therefore, LDHT, CCT, LCT and Lipton, their mean differences for the composite and infusion tea were 535.80, 679.10, 480.71 and 24.88 respectively.

From Table 6 that the mean for copper content in the formulations were generally less in quantity as compared to the crude iron. Copper as one of the minerals found in the formulations with respect to the composite tea and

infusion had mean difference of 415.74 for CHT while DHT, was 429.05. LHT had mean difference between the composite and infusion tea to be 401.88 meanwhile, 349.82 was also recorded for LDHT between the composite and the infused tea. The mean difference for CCT was 561.66 with respect to the composite and infused tea. Moreover, for LCT, the mean difference for the composite and infusion tea was 576.70 with the control (Lipton tea) recorded 137.19.

The Zinc presence in the composite and the infusion tea did vary as it was in the previous minerals that have been found. The variations in the mean for CHT, DHT, LHT and LDHT in terms of the composite and infusion tea were 45.31, 96.33, 79.74 and 56.52 respectively. In the case of the remaining samples; CCT, LCT and the control (Lipton) had mean differences in the composite and the infusion to be 63.03, 62.12 and 34.58 respectively.

Calcium as one of the minerals found, 362.63, 360.81, 301.11, 326.93 and 364.36 were the mean differences present in CHT, DHT, LHT, LDHT and CCT respectively. The rest of the mean difference found for LCT and Lipton the control was 363.34 and 225.69 respectively. The result as presented in Table 5 had indicated that magnesium was not present in the infusion tea but however, it was present in the composite tea in a marginal quantity. The range of the value of magnesium presence in the composite tea was 0.06 and 0.42 with respect to Lipton and LHT teas.

In view of the analysis done, the emerged trend was that magnesium was also not found in the teas when infusion was done for the same products/samples. The phosphorus content found for the composite teas were so high however, its in presence in the infused tea were marginal. Again, for

the potassium content in the composite tea, the mean values were equally higher than that of infusion tea except CHT. Also, in the case of sodium, the mean values were equally higher than the infused teas for all the samples. The same trend of higher mean values for all the composite teas recorded for iron, copper, zinc and calcium in the formulated teas and the Control tea (Lipton).

The formulations contain the necessary minerals with their significant percentages except magnesium that recorded low numbers in both composite tea and infusion. Minerals are needed for various functions in the body for example calcium plays vital role in teeth formation, bones strengthening, muscle formation system and better functioning of the heart. (Obiajunwa *et al*., 2002). The three ingredients for the formulations (Roselle, hibiscus and ginger) are good sources of minerals (Nuturland, 2004; Bernal *et al*., 2010; Ata et al., 2011).

From the Table 6 it can be reported that mineral content in composite tea differ in the infusion. The percentages of the various minerals in the composite rise higher than that of infusion. This is in accordance with Dambiec *et al*. (2013) with the view that high amount of minerals presents in tea leaves and made teas but these elements are not transferred in high amounts to humans through infusion. This difference in composite tea and infusion is sometimes as a result of the origin of the herbs and where it was grown. (McKenzie *et al*., 2010).

Objective Five: Sensorily Evaluate Acceptability of the Six Developed Products.

In answering the research question five, the result from the Panellists in evaluating the sensory has been presented in Table 6. To analyze the

acceptability of the six developed teas and the control (Lipton), three sensory attributes were put into consideration. The attributes were colour, taste and aroma/Flavour. The post hoc test was use to analyze the overall acceptability of the formulations. This has been presented in Table 7. The comments on the formulated teas have also been presented qualitatively with respect to each sample to support the analysis.

Table 7: Acceptability of Herbal tea and the Control (Lipton)

Attribute	Sample	N	Mean	Std. Dev.	Std. Error
	CHT	80	1.53	0.7	.075
	DHT	80	1.83	1.4	.152
	LHT	80	3.08	0.9	.099
Colour	LDHT	80	3.48	1.3	.141
	CCT	80	3.45	1.0	.117
	LCT	80	3.91	1.6	.177
	Control	80	2.28	0.8	.087
	CHT	80	1.80	0.6	.065
	DHT	80	2.18	1.6	.181
	LHT	80	2.91	1.9	.132
Taste	LDHT	80	3.60	1.2	.130
	CCT	80	3.65	1.3	.150
	LCT	80	4.30	1.6	.177
	Control	80	2.44	1.1	.119
	CHT	80	1.83	0.8	.090
	DHT	80	2.24	1.4	.153
	LHT	80	2.83	1.4	.158
Aroma/Flavour	LDHT	80	3.23	1.4	.158
	CCT	80	3.59	0.9	.100
	LCT	80	3.83	1.3	.148
	Control	80	2.39	0.9	.095

Source: Field data, Donkor (2021) *Control (Lipton)

In Table 7, the mean result for colour attributes had indicated that LCT and LDHT were the most accepted samples with 3.91 and 3.48 means and standard deviations of 1.56 and 1.26 respectively. Spence (2015) asserted that the initial qualities that attract people towards food choices were colour and appearance. Colour and appearance are inherent characteristics for quality of

food and is tied closely to its acceptability Singh- (Ackbarali & Maharaj 2014).

In terms of the taste attribute, the mean values indicated that LCT had been the most accepted formulation and this was followed by CCT in that order. According to Bazaz, Baba and Masoodi. (2016), they have reported that taste is an important attribute in sensory evaluation of food. However, even though a food product may command an appeal in its high aesthetic quality and high energy density, its taste and smell may not add to the appeal of the consumer and may be consequently be rejected.

In terms of flavour or aroma LCT was much accepted followed by CCT.It had 40% of ginger and 40% of hibiscus which brought out its pungency because of the ginger. According to Bazaz et al (2016), the smell or aroma of a food is quintessential to its taste and contributes immensely to its acceptance and ingestion. It is an important consideration when analysing the acceptability of food samples. The last but not the least, was LCT. It obtained the highest mean scores in terms of acceptability and a standard deviation score of 1.32.

Table 8 represent the overall sensory acceptability of the formulations.

Table 8: Post Hoc Test (Tukey B[a]) on Overall Acceptability

		Subset for alpha = 0.05				
Formulations	**N**	**1**	**2**	**3**	**4**	**5**
CHT	80	1.59				
DHT	80		2.18			
Control	80		2.40			
LHT	80			3.08		
LDHT	80			3.49	3.49	
CCT	80				3.75	3.75
LCT	80					4.05

Source: Field data, Donkor (2021) *Control (Lipton) yellow label

The Turkey B Post Hoc had indicated that sample CHT was least accepted formulation and this was followed by DHT, Lipton, LHT, LDHT, CCT and LCT.

General Comments by Panellist on Formulated Herbal Teas

The desired formulations received several taste, colour and flavour comments from the participants. The samples represented a plethora of choices that consumers could choose from. This approach was in line with the earlier formulation that had been done by Choi *et al*. (2009) which comprised of factors like tea-water, ratio-length of infusion etc. It was obvious that creating wrong ratios of the tea had the the potential of ruining desired outcomes. The composite teas were good for the eye to see and even the infused teas were difficult to be differentiated from the control tea (Lipton)

From the questionnaire given to panellists, they commented on the samples that were to be evaluated which formed the basis of the acceptability

of the herb tea. In the views of eighty panellists, the taste of the developed herb teas had almost similar taste except Lipton. The taste according to the panellists, were good and nice. LHT, one of the developed herb teas, was chasracterised as spicy by some panellists as part of their review. This, I attribute to the high level of ginger in that sample. It contained 50% ginger, 25% hibiscus and 25% dandelion.

In terms of colour, taste and aroma, 12 of the panellists were of the view that Lipton was better than all of the developed herb tea. Also, one panellist had noted that the aroma for LHT was good. One person also said 'LHT tasted hot'. Ten of the panellists were of the view that the developed herb teas had a good taste but could not get used to the after feel in the mouth. CCT was as if they had tasted medicine this was on account of the high percentage level of dandelion than the other herbs; dandelion in nature has a bitter-sour taste. Meanwhile, seven other panellists said 'CHT tasted like 'sobolo' drink'.

Eleven (11) other panellists indicated that CHT was good. They preferred CHT to the others because they took a liking to its colour and taste. Meanwhile, one of the panellists recommended that CHT could be sold in the market since it tasted good and it would be acceptable in the open market. Three other panellists suggested all the developed teas could be placed on sale since they were good and tasted well. On the contrary, one of the panellists indicated that Lipton without sugar was a bit difficult to drink as compared to CHT.

Two panellists indicated that Lipton had a better aroma than the other samples except CHT and LCT which they reported possessed an attractive

colour. LHT had good aroma but however, had a pungent smell in the opinion of one of the panellists. In a similar manner, one other panellist noted that CHT and LCT had a similar taste. CCT sample was reported by 11 panellists to possess a mild bitter taste.

The sensory evaluation on the six formulations revealed that the most accepted formulation was LCT. The contributing factors that caused the panellists to choose LCT as their most favourite formulation was the colour, taste and flavour/aroma. The sight of human helps in selecting things that is catching and pleasing to the eyes. The colours of the new formulations were all attractive to the eyes but that of LCT, according to the results, was obviously the product with the most appeal.

In general, based on the analysis of the quantitative and qualitative results, it was therefore concluded that LCT was the most accepted formulation and this was followed by CCT, LDHT, LHT, Lipton, DHT and CHT (LCT>CCT > LDHT > LHT > Lipton > DHT > CHT).

Research Hypothesis One

H_{01}: There is no statistically significance difference in the level of nutrients in dried herbs (hibiscus, ginger and dandelion) used for the formulation.

In testing research hypothesis one, the descriptive and ANOVA tables have been presented to help in the analysis of the result and its subsequent discussion.

Table 9: Descriptive result of available Nutrients in the herb used

		N	Mean	Std. Deviation	Std. Error
%DM	Dandelion	3	87.17	0.4	.20
	Ginger	3	94.33	0.2	.14
	Hibiscus	3	90.67	0.3	.18
%Moisture	Dandelion	3	12.83	0.4	.20
	Ginger	3	5.67	0.2	.14
	Hibiscus	3	9.33	0.3	.18
%Ash	Dandelion	3	19.69	0.3	.15
	Ginger	3	19.59	0.1	.06
	Hibiscus	3	6.11	0.3	.16
%Protein	Dandelion	3	6.47	0.2	.12
	Ginger	3	23.38	0.2	.10
	Hibiscus	3	7.94	0.1	.04
%Oil	Dandelion	3	3.97	0.03	.01
	Ginger	3	.58	0.01	.01
	Hibiscus	3	5.37	0.2	.12
%Fibre	Dandelion	3	8.49	0.1	.04
	Ginger	3	9.34	0.03	.01
	Hibiscus	3	6.09	0.03	.02
%CHO	Dandelion	3	61.36	0.4	.24
	Ginger	3	47.08	0.3	.15
	Hibiscus	3	74.45	0.5	.28

Source: Field data, Donkor (2021)

The result in Table 9 shows seven nutrients that were found in the herbs used for the herb tea formulations. The dandelion had the least mean value and the highest mean value was ginger with respect to the content of dry matter present. The percentage of moisture content in ginger had the least mean value while dandelion had the highest mean value. The percentage ash content in hibiscus was low and dandelion recorded the highest value. Protein content in dandelion was low and that of ginger was very high. The oil content

in ginger was very low while in hibiscus, the quantity was high. With respect to the fibre content, hibiscus had the lowest content and ginger had the highest content. The last but not the least nutrient found was carbohydrate and its content was low in ginger and high in hibiscus.

Table 10 presents the result on the One-way ANOVA of the nutrients in the herbs for the tea formulations.

Table 10: ANOVA Result on Available Nutrients in the Herbs

		Sum of Squares	Df	Mean Square	F	Sig.
%DM	Between Groups	77.01	2	38.50	415.76	.00
	Within Groups	.56	6	.09		
%Moisture	Between Groups	77.01	2	38.50	415.75	.00
	Within Groups	.56	6	.09		
%Ash	Between Groups	366.49	2	183.24	3461.71	.00
	Within Groups	.32	6	.05		
%Protein	Between Groups	526.48	2	263.24	9622.18	.00
	Within Groups	.16	6	.03		
	Total	526.64	8			
%Oil	Between Groups	36.32	2	18.16	1162.26	.00
	Within Groups	.094	6	.016		
%Fibre	Between Groups	17.05	2	8.53	3656.19	.00
	Within Groups	.014	6	.00		
%CHO	Between Groups	1126.49	2	563.25	3643.76	.00
	Within Groups	.93	6	.16		

Source: Field data, Donkor (2021)

In Table 9, all the nutrients found through analysing dry matter, moisture, ash, protein, oil, fibre and carbohydrate were significant ($p<0.05$). At the level of significance, $\alpha = 0.05$; Sig. (2-tailed) = .00 and p = .00; the level of nutrients (dry matter, moisture, ash, protein, oil, fibre and carbohydrate) in the dried herbs used for the formulations were significant. The study therefore failed to accept the null hypothesis. It is therefore concluded that there is a statistically significant difference in the level of nutrients in dried herbs used for the formulation (hibiscus, ginger and dandelion).

Research Hypothesis Two

H_{02}: There is no statistically significance difference in the level of nutrients (minerals) in composite tea (CHT, DHT, LHT, LDHT, CCT & LCT).

The result to help in testing the hypothesis has been presented in Tables 10 and 11 respectively.

Table 11: Descriptive Result of Nutrients available in the Composite Tea

Nutrients (Minerals)	Tea	N	Mean	Std. Deviation	Std. Error
	CHT	3	1580.56	9.3	5.37
	DHT	3	1873.88	53.3	30.78
	LHT	3	1740.58	13.4	7.73
P ug/g	LDHT	3	1767.63	22.2	12.82
	CCT	3	2669.71	33.3	19.24
	LCT	3	2210.29	59.0	34.08
	CHT	3	8222.32	192.1	110.95
	DHT	3	10231.56	147.0	84.89
	LHT	3	8593.14	331.95	191.66
K ug/g	LDHT	3	9442.10	48.7	28.13
	CCT	3	10784.28	169.8	98.06
	LCT	3	7811.62	231.7	133.75
	CHT	3	1156.11	24.1	13.91
	DHT	3	1465.49	27.5	15.90
	LHT	3	975.05	29.3	16.89
Na ug/g	LDHT	3	1242.94	26.1	15.04
	CCT	3	2076.56	64.1	37.01
	LCT	3	980.08	11.6	6.689510
	CHT	3	749.58	17.8	10.27
Fe ug/g	DHT	3	681.59	32.1	18.55
	LHT	3	509.33	36.4	21.04
	LDHT	3	541.51	9.6	5.54
	CCT	3	662.59	30.9	17.85
	LCT	3	486.28	8.4	4.84
	CHT	3	406.02	13.97	8.07
	DHT	3	415.66	17.8	10.29
Cu ug/g	LHT	3	391.05	14.1	8.13
	LDHT	3	347.86	4.98	2.88
	CCT	3	550.08	13.9	8.04
	LCT	3	573.32	5.5	3.190024
	CHT	3	41.29	6.8	3.89
	DHT	3	98.89	3.1	1.79
	LHT	3	77.57	8.6	4.96
Zn ug/g	LDHT	3	53.63	8.8	5.06
	CCT	3	66.62	2.5	1.41
	LCT	3	66.03	1.1	.61
	CHT	3	2.05	0.04	.02
	DHT	3	1.73	0.02	.01
	LHT	3	1.44	0.1	.03
%Ca	LDHT	3	1.39	0.1	.03
	CCT	3	2.34	.02	.01
	LCT	3	1.29	.03	.01
	CHT	3	.37	.02	.01
	DHT	3	.29	.01	.00
	LHT	3	.41	.01	.01
	LDHT	3	.20	.00	.00
%Mg	CCT	3	.37	.01	.01
	LCT	3	.20	.00	.00

Source: Field data, Donkor (2021)

The results in Table 11 indicate the nutrients (minerals) available in the composite tea. The results shown that CHT had the least mean value and the highest mean value was CCT with respect to phosphorus content. In the case of the potassium (K), the mean values in the composite teas ranged from 7811.62 to 10,784.28. The least and the maximum mean values as indicated in Table 11 with respect to the potassium content in the composite tea was for LCT and CCT respectively. The sodium presence that was found for the composite teas have the least mean to be 975.05 for LHT and the highest of 2076.56 was also recorded for CCT.

The iron content in the composite teas had the least mean value for LCT and the highest value for CCT. LDHT recorded the lowest content for copper and LCT recording the highest. It can be gleaned that Zinc content in the composite tea was low for CHT and high in CCT sample. The calcium content found in LDHT was relatively low as compared to the content found in CCT sample. LDHT had less mean value as compared to LHT in terms of the Magnesium content in the composite teas.

It can be concluded that there were eight different nutrients (minerals) that were found in the composite teas (P, K, Na, Fe, Cu, Zn, Ca and Mg). It can further be added that the presence of magnesium and calcium in the composites were less with respect to the other nutrients (mineral) that were found in the formulations. Some of the nutrients (minerals) recorded very high mean figures while others had very low figures.

Table 12: ANOVA result of Nutrients (Minerals) Available in Composite Tea

		Sum of Squares	df	Mean Square	F	Sig.
P ug/g	Between Groups	2405208.17	5	481041.634	352.15	.00
	Within Groups	16392.24	12	1366.020		
K ug/g	Between Groups	20646583.62	5	4129316.724	97.68	.00
	Within Groups	507269.89	12	42272.491		
Na ug/g	Between Groups	2582334.78	5	516466.956	435.44	.00
	Within Groups	14232.90	12	1186.075		
Fe ug/g	Between Groups	172092.67	5	34418.533	54.41	.00
	Within Groups	7590.37	12	632.531		
Cu ug/g	Between Groups	126602.69	5	25320.537	158.17	.00
	Within Groups	1921.00	12	160.083		
Zn ug/g	Between Groups	5906.19	5	1181.239	33.23	.00
	Within Groups	426.52	12	35.544		
%Ca	Between Groups	2.59	5	.517	342.96	.00
	Within Groups	.02	12	.002		
%Mg	Between Groups	.11	5	.023	205.63	.00
	Within Groups	.00	12	.000		

Source: Field data, Donkor (2021)

Table 12 presents the ANOVA results of nutrients (minerals) available in the composite teas. The results for the presence of phosphorus in the composite had its p-value less than 0.05. The nutrients (minerals) that were present (K, Na, Fe, Cu, Zn, Ca and Mg) in the composite teas were also less

than 0.05 between the groups. It can therefore be concluded based on the significant values in Table 12 there is a significant statistical difference in the level of nutrients (minerals) content in the composite teas (CHT, DHT, LHT, LDHT, CCT & LCT).

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

The chapter presents the summary, conclusion and recommendations of this current study. The study looked at the development of herb tea from hibiscus *sabdriffa*, ginger and dandelion.

Summary of the Study

The consumption of tea dates centuries ago and it is as relevant to its consumers now as it was then. The development of tea from herbal sources is of much significance since it comes with little or no side effects. The side effects that might be associated with the drinking of the herbal tea was envisaged to be minimal or none at all since artificial additives were eliminated completely in the formulations. The consumers of herb tea are usually under the assumption that they obtain an unadulterated nutrient supply from the herbs involved in their teas.

The study was guided by four research objectives and two hypotheses to find answers to the problem statement which was the core of the study. The relevant theoretical and empirical literatures were reviewed to give a better understanding to the study. The literature covered the nutritional composition of tea, the origin of herbs for the formulation and the documented health benefits of dandelion, ginger and hibiscus.

The research design adopted for the study was the experimental design which made it possible to manipulate the various ingredients that were used to formulate the herbal tea. The various formulations (LCT', 'CCT', 'LDHT',

'LHT', 'DHT' and 'CHT') were analysed to determine the composition of the formulated herbal teas. The sensory evaluation for the acceptability of the six herbal formulations was guided by the use of sensory properties (taste, appearance or colour and aroma). The study was conducted in Asokwa Municipality of Kumasi. The data for the study were in two parts. The first part was set to determine the chemical and nutritional composition of ginger, dandelion and hibiscus which were analysed in the chemical laboratory. The chemical analysis of the formulations followed the agreed procedure of AOAC (2008) for each nutrient (protein, potassium, sodium, iron, copper, zinc) in the herbal tea.

Second part of the study set out to sensorily evaluate the acceptability of the formulated herbal teas. Eighty (80) panellists took part in the sensory analysis. The participants were purposively drawn from the Asokwa Municipality. The sensory evaluation of the formulated herbal tea was to assess their acceptability. Descriptive statistics was used to analyse the five research objectives and the inferential statistics was used to analyse the research hypotheses.

Key Findings

The study revealed that it was possible to formulate different flavours of herbal tea from ginger, dandelion and hibiscus. The formulations that were arrived at were six. The formulations were coded as 'LCT', 'CCT', 'LDHT', 'LHT', 'DHT' and 'CHT'. The formulations had different tastes, colours and flavours.

The ingredients used for the herbal tea formulations contained chemical constituents of dry matter, moisture, ash, protein, oil, fibre and carbohydrate at varied quantities in the dried herb. The dry matter had the highest quantity found in the formulation ranging from 92.01 % to 89.58 % followed by the carbohydrate also ranging from 62.29 % to 52.57 5. The oil quantity found was very negligible in terms of the other chemical constituents that were found. Nutritional compositions of the herbs used in formulating the teas and the control tea (Lipton) were concluded to all have the same nutrients. However, in the control tea, the carbohydrate quantity was zero while the developed/formulated teas had substantial quantities of carbohydrates. In the control tea (Lipton), protein recorded the least amount of 0.86 % as compare to the other formulations arranging from 15 % to 9.40%, magnesium which was present in the composite tea was not detected in the infusion tea. The phosphorus quantity found in the composite tea was high relative to the quantity found in the infusion tea. The study further found that potassium was present in the composite tea and their mean values were equally higher than that of infusion tea except CHT. Also, in the case of sodium, the mean values were equally higher than the infused teas for all the samples. The same trend of higher mean values for the composite teas cut across in the case of iron, Copper, Zinc and Calcium and the Control tea (Lipton). Comparing the infusion herb teas with their composite tea in terms of minerals, it was found that there is significance difference in the minerals found in herb teas and their

infusion. Minerals in infusion herb teas decrease as minerals in composite herb teas increase.

The acceptability of the formulated herbal tea and the control (Lipton) showed that LCT was the most accepted formulation and this was followed by CCT, LDHT, LHT, Lipton, DHT and CHT (LCT>CCT>LDHT>LHT>Lipton>DHT>CHT). The formulation that received the most acceptability was LCT which contained 2 grams of tea bag, formulated by 0.8g of hibiscus, 0.8g of ginger and 0.4g of dandelion.

The first research hypothesis revealed that there was a statistically significant difference in the level of nutrients in dried herbs used for the formulation. The study further found in the second hypothesis that there was a statistically significant difference in the nutrient levels of the formulated teas (CHT, DHT, LHT, LDHT, CCT & LCT).

Conclusions

The study supports data that stipulate that herbal tea could be formulated from local herbs such as ginger, hibiscus and dandelion for human consumption which are less expensive. The nutrients in the formulations are revealed high quantity of protein, carbohydrates, fats, minerals dry matter and moisture content after the proximate analysis.CCT formulation with (60% dandelion + 20 % ginger + 20 % hibiscus) recorded high quantity of protein recording 15. 49 % as compared to the control (Lipton) recorded 0.89 % which below 1%. Eventhough sample CCT revealed high percentage of protein, dry matter and fat but it was not the most acceptable formulation.

The most acceptable formulation after sensory evaluation was LCT (40 % hibiscus + 30 % ginger + 30% dandelion). LCT had 91 % dry matter, 9 % moisture content ,13 % ash content ,9 % protein content ,4 % fat, 11 % fibre and 62 % carbohydrate. LCT as the best among the samples; as the most panellist preferred it interms of colour, flavour, taste and overall acceptability. This has reported that acceptabity of a product is not based on the nutrient content only but its sensory qualities count most. (Singh-Ackbatali & Maharaj 2014).

The presence of different nutrients (minerals) in the infusion herb tea decreases in quantity as minerals in composite herb tea increases in quantiy. This is in accordance with Dambiec *et al* (2013) which states that nutrients in infusion and composite teas sometimes differ in terms of quantity. Consuming any of the formulations could be helpful provide some macro micronutrients needed by the human body. The human body needs different kinds of nutrients for varied function. The presence of more than two nutrients in the any of the formulations is a good note which serve as a supplementary nutrient missing in most of diets in Ghana. The study has therefore revealed what was not known earlier on the nutrients in the herbal tea. This knowledge has therefore bridged the missing link of how useful ginger, dandelion and hibiscus flower are in herbal tea preparation. The level of nutrients especially at varied grams when well formulated is very good for its acceptability for consumption.

Recommendations

The study establishes the fact that local consumable plants such as ginger, dandelion and hibiscus could be combined in a given proportion for herbal tea. This therefore makes it necessary for investigation as its local production and low cost of production makes it a viable industry to explore. Agric-extension officers could therefore take advantage of this to organize local farmers to encourage the production and growing of these plants (ginger, hibiscus, dandelion) at the areas where its grown in large quantities. The production of these herb could boost the income level for farmers since the ingredients are found locally. This could help to curtail rural-urban migration where the youth leave their rural areas to the big cities searching for non-existent job opportunities. The earnings of the people in the rural areas would improve upon the living conditions of the people.

Knowing the relevance of the nutrients in the herbal tea could encourage homes and families to use these herbs in other food preparation and consume the infusion from the ginger, dandelion and hibiscus to bring variety in their intake of beverages,

It could be recommended to the hospitality institutions; business men and women to produce tea from these plants to be served to customers since it contains high level of nutrients which could help reduce health related problems among people

The significant nature of the three ingredients used for the herbal tea formulation makes it clear how relevant all herbs and shrubs are to human

health and development. The forestry commission should therefore encourage the general public not to destroy the local vegetation but rather plant ginger, dandelion and hibiscus in their backyards. Aside using the ingredients for herbal tea preparation, it could be used for other recipes which are already known.

Suggestions for Further Studies

The current study looked at how ginger, dandelion and hibiscus flower could be used to formulate herbal tea. The panellists were from one municipality, Asokwa in the Kumasi Metropolis which represents a minor group in comparison to the size and coverage and impact of this research. It is therefore recommended that the same study be carried out in other municipalities in Ghana to compare the findings and especially the acceptability of the formulations.

It is further suggested that ginger, pepper corn and dandelion is studied to see their viability in formulating tea or drink. Also, the shelf-life of the formulated tea should be calculated. This could add another value to the new formulation and thereby boost the confidence of the potential consumers.

There is the need to conduct studies on microbial count for the most preferred formulated herb tea. It is also recommended to conduct a study on combining fruits and herbs (dandelion and hibiscus) to further research in herb formulations and add variety and increase choice preference for consumers.

A cost evaluation for the accepted herb tea product should be conducted in comparison to the Lipton (control) yellow label. This will enable buyers to make informed financial choices about the tea to consume.

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APPENDICES

APPENDIX A

SENSORY EVALUATION QUESTIONNAIRE

The purpose of this evaluation is to collect data on herb tea formulated from hibiscus sabdriffa (roselle), ginger and dandelion to ascertain its sensory qualities and preferences. The study is for academic purpose therefore your candid response would be of great help to the study. Any information given would be for the said purpose and be assured that your identity would not be revealed under any circumstance.

Date:…… Panellist ID:……..

Biographical Information of Respondents

Please tick [√] your age range.

Age (years): 15-20 [ ] 21-25 [ ] 26 -30 [ ] 31 -35 [ ] 41- 45 [ ]

Please tick [√] your gender

Gender: male [ ] female [ ]

Like extremely =1, like very much =2, like moderately = 3, like slightly =4, neither like nor dislike = 5, dislike slightly = 6, dislike moderately =7, dislike very mush = 8, dislike extremely = 9.

Sample	Colour	Taste	Aroma/flavor	Overall acceptability
CHT				
DHT				
LHT				
LDHT				

CCT

LCT

LIPTON

Comments: ……

……

……

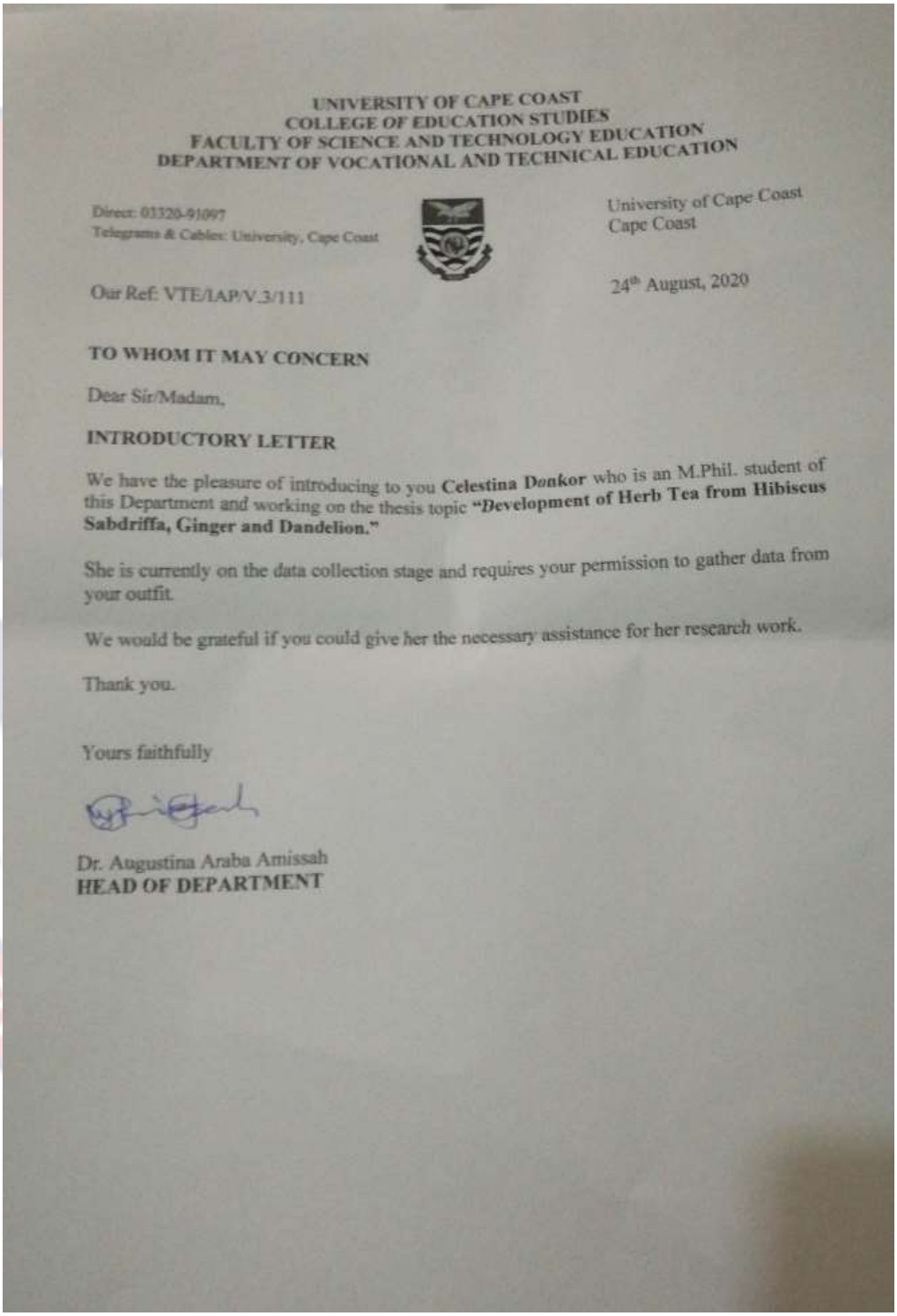
……

……

Thank you for your participation

Appendix B

Introductory Letter



UNIVERSITY OF CAPE COAST
COLLEGE OF EDUCATION STUDIES
FACULTY OF SCIENCE AND TECHNOLOGY EDUCATION
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University of Cape Coast
Cape Coast

Our Ref: VTE/IAP/V.3/111

24th August, 2020

TO WHOM IT MAY CONCERN

Dear Sir/Madam,

INTRODUCTORY LETTER

We have the pleasure of introducing to you **Celestina Donkor** who is an M.Phil. student of this Department and working on the thesis topic **"Development of Herb Tea from Hibiscus Sabdriffa, Ginger and Dandelion."**

She is currently on the data collection stage and requires your permission to gather data from your outfit.

We would be grateful if you could give her the necessary assistance for her research work.

Thank you.

Yours faithfully

Dr. Augustina Araba Amissah
HEAD OF DEPARTMENT

Appendix C

ETHICAL CLEARANCE

UNIVERSITY OF CAPE COAST
INSTITUTIONAL REVIEW BOARD SECRETARIAT
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OMB NO: 0990-0279
IORG #: IORG0009096

9TH APRIL, 2021

Ms. Celestina Donkor
Department of Vocational and Technical Education
University of Cape Coast

Dear Ms. Donkor,

ETHICAL CLEARANCE – ID (UCCIRB/CES/2021/20)

The University of Cape Coast Institutional Review Board (UCCIRB) has granted **Provisional Approval** for the implementation of your research titled **Development of herb Tea from Hibiscus Sabdriffa, Ginger and Dandelion.** This approval is valid from 9TH April, 2021 to 8TH April, 2022. You may apply for a renewal subject to submission of all the required documents that will be prescribed by the UCCIRB.

Please note that any modification to the project must be submitted to the UCCIRB for review and approval before its implementation. You are required to submit periodic review of the protocol to the Board and a final full review to the UCCIRB on completion of the research. The UCCIRB may observe or cause to be observed procedures and records of the research during and after implementation.

You are also required to report all serious adverse events related to this study to the UCCIRB within seven days verbally and fourteen days in writing.

Always quote the protocol identification number in all future correspondence with us in relation to this protocol.

Yours faithfully,

Samuel Asiedu Owusu, PhD
UCCIRB Administrator

ADMINISTRATOR
INSTITUTIONAL REVIEW BOARD
UNIVERSITY OF CAPE COAST