ADDIS ABABA UNIVERSITY
COLLEGE OF NATURAL AND COMPUTATIONAL SCIENCES
CENTER FOR FOOD SCIENCE AND NUTRITION

NUTRITIONAL COMPOSITIONS AND ANTIOXIDATIVE CAPACITY OF RED AND YELLOW COLOR OF IMMATURE AND MATURED CORN SILKS AND SENSORY ACCEPTABILITY OF ITS TEA GROWN IN ETHIOPIA

BY

MERSHA W/GEBRAIL

ADVISOR

Dr. ASHAGRIE ZEWDU

A Thesis Submitted To Collage of Natural and Computational Sciences of Addis Ababa University in Partial Fulfillment of the Requirements for the Degree of Master in Food Science and Nutrition

ADDIS ABABA, ETHIOPIA

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DECLARATION

I the under designed, declare that this thesis is original work and has never been presented in any other universities as well as research centers and all source of materials used for this thesis has been fully acknowledged.

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3. ___________________________	____________________

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ACRONYMS

CGMP……………………..	Cyclic Guanosine Monophosphate
CS………………………	Corn Silk
CSE………………………..	Corn Silk Ear
CSP………………………...	Corn Silk Powder
DPPH………………………	Diphenyl Picryl Hydrazyl
FAOSTAT...………………	Food and Agriculture Organization Corporate Statistical Database
NAD(P)H………………..	Nicotinamide Adenine Dinucleotide Phosphate, Hydrogen
RIM--------------------------	Red Immature
RM---------------------------	Red Mature
ROS …………………….	Reactive Oxygen Species
SD…………………………	Standard Deviation
SOD ………………………	Superoxide Dismutase
TDF………………………..	Total Dietary Fiber
TLC………………………..	Tine layer chromatography
WHO……………………..	World Health Organization
YCE………………………	Young Corn Ear
YIM--------------------------	Yellow Immature
YM---------------------------	Yellow Mature

ABSTRACT

Corn silks are the female inflorescences of maize which arise from the fusion of two carpels that surrounds a single ovule. After a successful fertilization, this ovule becomes a kernel in the maize cob. During pollination, the tassel release amounts of pollen that are captured by the silks. This study was discussing on nutritional, antioxidant and antinutritional capacity of matured and immature silks of red and yellow color of the white corn and its tea that was collected from Merti agro industry zone

Both immature and mature red and yellow corn silks were good source of nutritional compositions. Immature red and yellow silks contained significantly higher lipid (1.75% &1.5%) and protein (16.55% &14.87%). The mature red and yellow silk were, higher in composition of ash (8%), and total dietary fiber (40.22% & 36.61 %.)

In mineral determination, immature red silk was rich source of Ca(22.07mg/100gm), K (3235.45mg/100gm), Na(16.01mg/100gm) Cu(7.5mg/100gm) and Mn(15.78mg/100gm) but Mg(20.43mg/100gm), Fe(14.01mg/100gm) and Zn(6.5mg/100gm) was higher in immature yellow silk. Ca(34.62mg/100gm), Mg(20.89mg/100gm), K(3196.7mg/100gm), Na(19.99mg/100gm), Mn(13.83mg/100gm) and Zn (7.1mg/100gm) were higher in mature red silk than yellow silk but Fe(14.63mg/100gm) was higher in matured yellow silk.

DPPH antioxidant analysis methods polyphenol, flavonoid and free radical scavenging activities were computed, so the content of total polyphenol (1.98mgGAE/100gm & 2.1mgGAE/100gm) and flavonoid (3.96mgCE/100gm & 3.25mgCE/100gm) were higher in immature red and yellow silks respectively than mature red and yellow silks. Both matured and immature red (3.79 & 3.96mgCE/100gm) silks have higher flavonoid contents than yellow immature and matured (2.93& 3.25mgCE/100gm) silk. The free radical scavenging capacities EC50 were higher in immature red and yellow (3.84 & 3.79) silks than matured red and yellow (5.48 &6.57) silks respectively. Tannins were higher in immature red and yellow (9.63mg/100gm & 6.05mg/100gm) silks than matured red and yellow (3.43mg/100gm &1.71mg/100gm) silks respectively. Because of their antioxidant effects and the presence of higher amount of K in the corn silk it has health benefits, its tea from each type of corn silk were sensory acceptable by the panelists.

Key word: - *corn silk, antioxidant, nutritional composition, health benefit*

1 . INTRODUCTION

1.1 Background

In the Western world, the term maize is used interchangeably with corn. The reason for this is that all grains were called corn under early British and American trade and the name was retained for maize because it was the most common grain in commerce (Rahman,*et al*., 2014).

Corn (Zeamays) is the only important cereal indigenous to the Western Hemisphere. The oldest corn of record was dependent upon man for its survival. Following discovery, corn moved quickly to Europe, Africa and Asia. From Spain, it spread northward to the short-growing-season areas of France, Germany, Austria and Eastern Europe, where selection for early maturity has produced some of the earliest commercial varieties of corn now available. Corn is grown from sea-level to altitudes of more than 12,000 feet and from the equator to about 50°north and south latitudes. Corn variation may be artificially defined according to kernel type as follows: dent, flint, flour, sweet, pop and pod corn. Except for pod corn, these divisions are based on the quality, quantity and pattern of endosperm composition in the kernel and are not indicative of natural relationships (Pruitt, 2016).

Corn and its other plant parts are used in various food, agricultural and health applications. Corn cereal is being a significant staple food for some countries. It contains nutritious components essential for health. Its pericarp contains high crude fiber (about 87%) which constituted with 67% hemi cellulose, 23% cellulose and 0.1% of lignin. Its endosperm is rich in starch (87.6%) and protein (8%). The germ however is characterized by high composition of crude fat (33%), protein (18.4%) and minerals. The immature corn (baby corn) contains high protein (25.58%) and dietary fiber (30.4%) content and lower content of crude lipid (3.67%) and 3.74% of ash and appreciable total sugar content (10.07 g/100 g) (Rahman,.*et al.*,2014).

On the other nutrient, immature corn contained 5.43 mg/100 g of ascorbic acid amino acid (0.05 g/g methionine, 2.85 g/g isoleucine and 0.6756 g/g leucine). In addition, some minerals such as Ca, Mg and P were presented at 95,345 and 898.62 mg/100 g, respectively (Wan Rosli,.*et al., 2011)*

Corn silks are the female inflorescences of maize which arise from the fusion of two carpals that surrounds a single ovule. After a successful fertilization, this ovule becomes a kernel in the maize cob. During pollination, the tassel release amounts of pollen that are captured by the silks. Then, a tube grows from a pollen grain captured by a hair silk. This pollen tube penetrates into the hair silk delivering two sperm cells for a double fertilization. Maize silks are attributed to the presence of polysaccharides or polyphenols. Forinstance, the reduction of cholesterol and fat deposition has been linked to the content of antioxidant flavonoids in the silks (Mendoza-López,*et al*..,2017).

Antioxidant can inhibit or delay oxidation process although at lower concentration than the biomolecule it is protecting. Utilization of synthetic antioxidants as food preservatives has raised consumers' consciousness toward health due to some adverse effects. For instance, an excessive use of butylatedhydroxyanisole (BHA) and butylatedhydroxytoluene (BHT) is harmful and accompanied with side effects thus restricted their uses (Rosli and Anis,2012).

The uses of natural antioxidant are varied. Tocopherols have strong capacity to inhibit lipid oxidation and are used in foods while gallic acid derived from Peltiphyllumpeltatum has shown nephro protective effect. Plants are rich sources of polyphenols and can act as antioxidant. In addition, the harmful effects of free radicals which are known to be associated with several diseases such as cardiovascular disease, diabetes mellitus, cancer, arthrosclerosis, neurodegenerative disease and ageing can be prevented with sufficient intake of polyphenols in the diet (Alam, 2011).

These secondary plant metabolites are not only widely distributed in fruits, vegetables, cereals, Leaves and roots but the underutilized plant sources like seeds, peels and bran have been reported to exhibit strong antioxidative effects(Ranum,*et al*...,2014).

However, the information in Ethiopia regarding the nutritional composition such as proximate and mineral composition and antioxidant capacity of the silks from immature and mature corn are still lacking. Therefore, the objectives of this study is to determine the proximate of silks obtained from these two types of silks, to determine the antioxidant capacity of metanolic extracts of these silks and develop tea from corn silk powder.

1.2 Statement of the Problem

A study was done previously on the nutritional compositions and antioxidative capacity of the silk obtained from immature and mature corn in the Kota Bharu district, Kelantan state of Peninsular Malaysia which is found in a tropical climate, with temperatures from 21 to 32 °C and intermittent rain throughout the year. The wet season is the east-coast monsoon season from November to January. Both immature and mature silks were good source of nutritional compositions. Immature silks contained significantly higher moisture (89.31%) (fresh basis), lipid (1.27%) and protein (12.96%) content than the mature silk. Mature silks contained higher composition of ash (5.51%), carbohydrate (29.74%) and total dietary fiber (51.25 g/100 g), than the immature silk. In the mineral determination, immature silk was rich source of Ca (1087.08µg/g), Mg (1219.17µg/g), Cu (5.60µg/g) and Zn (46.37µg/g) than the mature silks. In contrast, other minerals such as K (35671.67µg/g), Na(266.67µg/g), Fe (4.5µ0g/g) and Mn (35.57µg/g) were found higher in the mature silk (Rahman,*et al..,2014*).

In contrast to this study other study said the content of polysaccharides and polyphenols in the corn silks differed significantly among the maize landraces tested. Some silks accumulated large amounts of polysaccharides like those obtained from the landrace Cristalino, which resembles those hybrid varieties of yellow sweet maize. Whereas, silks from the landrace Cónico had the highest antioxidant capacity and polyphenol content. The presence of the flavonoid maysin was confirmed by tine layer chromatography (TLC) in silks of the landrace Cónico but not in silks from the landraces Gordo and Cristalino. The beneficial effects of maize silks are attributed to either their polyphenol or polysaccharide content (Mendoza-López, *et al*,..2017).

According to the literatures corn silk have nutritional and antioxidant value, but when we come to our country Ethiopia it is not considered as a food. Even though the climate condition which the corn grown and the type of corn silk that the corn gives do have different in their nutritional and antioxidant contents, so we have to conduct an extensive research considering nutritional and antioxidant levels of corn silk under a desired sample amount and develop tea from it.

1.3 Significance of the Study

This study focuses on determining the nutritional and antioxidant composition of corn silk in their maturity and color type and development tea from it, and then identify which corn silks contain lower or higher level of nutritional and antioxidant effect on the basis of color and maturity level.

The study is initiated to assess the practices of our farmers and the consumers of corn toward corn silk. Because of its antioxidative characteristics, it is important to determine the value of corn silk in human health by producing tea product.

This study gives us a clear view on the contents of corn silk in their nutrition perspective as well as the antioxidative properties, if it is detected. This help us to use the corn silks for healthcare applications and its remarkable bioactivities as antioxidant, hyperglycemia reduction antidepressant, anti-fatigue and effective diuretic agent.

1.4 Objectives

1.4.1. General Objective

To evaluate the nutritional, antioxidant capacity of matured and immature corn silk and develop tea product from it.

1.4.2 Specific Objective

- To determine the nutritional value(protein, lipids, carbohydrate, and fibers)of red and yellowcolor of matured and immature corn silk.
- To determine the mineral composition (Ca, Mg, K, Na, Cu, Fe, Mn and Zn) red and yellowcolor of matured and immature corn silk.
- To determine the antioxidative capacity of (Total PhenolContents and Total flavonoid content) and antioxidant properties (free radical scavenging)red and yellow color of matured and immature corn silk.
- Determine the antinutritional factor of tannin from matured and immature red and yellow color of corn silk
- To develop tea from matured and immature red and yellow color of corn silk and determine its sensory acceptability

2 . LITERATURE REVIEW

2.1. Corn/ Maize

The center of origin of maize is the Mesoamerican region, probably in the Mexican highlands, from where it spread rapidly. Archaeological records and phylogenetic analysis suggest that domestication began at least 6,000 years ago. Maize spread around the world after European discovery of the Americas in the 15^{th}C, in temperate zones. Maize is only known as a cultivated crop and its exact genealogy remains uncertain. Zeamays Parviglumisishypo the sized to be the progenitor of cultivated maize (Luo& Wang, 2012).

Maize can be grown in a number of environments from 58° North (Eg, Canada and the Russian Federation) to 40° South (eg Chile). Generally, tropical maize is grown between 30°North and 30° South, subtropical maize between 30 and 34° both North or South, and temperate maize beyond 34° latitudes. It can be grown in a range of altitudes from sea level up to 3,800 meters and with growing seasons between 42 and 400 days. This ability to grow in a wide range of environments is reflected in the high diversity of morphological and physiological traits (Gene Technology Regulator, 2008).

Maize (Zeamays) is the most important grain crop in South Africa and is produced throughout the country under diverse environments. Successful maize production depends on the correct application of production inputs that will sustain the environment as well as agricultural production. In developed countries, maize is consumed mainly as second-cycle produce, in the form of meat, eggs and dairy products. In developing countries, maize is consumed directly and serves as staple diet for some 200 million people (Du Plessis, *2003*).

Different types of maize are grown throughout the world, with one important difference being color. Maize kernels can be different colors ranging from white to yellow to red to black. Most of the maize grown in the United States is yellow, whereas people in Africa, Central America, and the southern United States prefer white maize. Yellow maize is not popular in Africa for reasons associated with the perception of social status: apparently it is associated with food-aid programs and is perceived as being consumed only by poor people. Also, the feed industry consumes mostly yellow maize in the manufacture of animal feed.

But the main reason for the preference for white maize is simply one of tradition people are used to eating a white product in these countries, usually the whiter the better. This preference means a lower consumption of carotene and cryptoxanthin, vitamin A precursors, present in higher concentrations in yellow and orange maize. This also shows up in the preference for meal and flour made with higher extraction rates, which are whiter than the whole-grain products, but also with lower contents of fiber, vitamins, and minerals (Ranum,*et al*...,2014).

The quality of white maize is important since it affects the milling performance, grading, and yield of high-quality products. There is a classification of maize on the basis of the size and composition of the endosperm, resulting in an artificial definition by kernel type as follows:- dent, flint, waxy, flour, sweet, pop, Indian, and pod corn. Another difference or classification criterion is the sweetness or amount of sugar. The amount of residual sugar depends on the variety of maize and when it is harvested from the field. Sweet maize stores poorly and must be eaten fresh, canned, or frozen before the kernels age, becoming small, tough, and starchy. Sweet varieties cannot be fortified (Ranum,.*et al,2014*).

Estimated maize consumption in grams per person per day in countries where maize is considered an important food source (i.e., above 50 g/person/day)were corrected for an average 80% extraction rate, using the Food and Agriculture Organization Corporate Statistical Database (FAOSTAT) food balance sheets (Elmadfa& Meyer, 2010).

The morphology, of corn are Root system, Leaves, Stem and Maize ear: The maize ear (the female inflorescence) terminates one or more lateral branches, usually half way up the stem. Bracts enclose the ear. The silk of the flowers at the bottom appear first and there after those on the upper part of the ear. It remains receptive to pollen for approximately three weeks but after the tenth day, receptivity decreases (Du Plessis, *2003*).

2.2. Corn Silk

Corn silks are a bundle of silky, long and yellowish strands which could be seen on top of both baby corn and corn fruit. The immature part of a corn plant called baby corn is an unfertilized female flower which is usually harvested after 60 days of planting. Conversely, a corn fruit is developed from a fertilized female flower that is later grown into a corn fruit after 4 months of planting. Corns have been used extensively as foods, feeds and are processed to produce oil, starch and ethanol (Rosli and Anis, 2012).

Figure 1: Matured and Immature corn silk

Matured corn silk

Immature corn silk

Corn silk is predominantly discarded together with other parts of the plant due to lack of effective utilization. The silks function as a stigma of a female flower and as the fruit develops, the silk elongates beyond the cob covering the edible plant part. Traditionally, the hairs are used as a diuretic agent to ease the passing of stones or gravel in kidneys and urinary bladder (Maksimovic and Kovacevic, 2003).

2.3. Nutritional Compositions ofCorn Silk

Good nutrition can help prevent disease and promote health. There are six categories of nutrients that the body needs to acquire from food: protein, carbohydrates, fat, fibers, vitamins and minerals, and water. Information about food composition is necessary for the assessment of diet quality and the development and application of food-based dietary guidelines, providing a useful tool for the field of public health nutrition (Elmadfa & Meyer. 2010).

Nutritional composition of Pollens and seeds are the nutritious and edible parts of maize. Seeds are consumed in raw and cooked form that serves as good source of carbohydrates. Corn contain vitamin B-complex such as B1 (thiamine), B2(niacin), B3(riboflavin), B5 (pantothenic acid) and B6 that makes it commendable for hair, skin, digestion, heart and brain. It contains vitamin C, A and K together with large amount of beta-carotene and fair amount of selenium that helps to improve thyroid gland and play important role in proper functioning of immune system. It has higher content of protein and fat as compared to other cereals (Kumar, *et al*.., 2013).

The protein content of immature and mature silks may be influenced by the functions and biosynthesis of amino acids taking place during developmental processes of pollinated and unpollinated silk tissue. It has been reported that amino acids were actively metabolized in immature cob at early stage of silk emergence in order to regulate the seed growth (Rahman and WanRosli 2014 and Seebauer,.*et al*.,2004).

Corn silk contains maizeric acid, fixed oils, resin, sugar, mucilage, salt and fibers essential for our diet. Phytochemical secondary metabolites such as saponin, allantoin, sterol, stigmasterol, alkaloids, hordenine and polyphenols are found in leaves, seeds and corn silk (Kumar,*et al*.., 2013).

Both immature and mature silks could be considered as good source of nutritional compositions. AS shown in Table 1the immature silks contained significantly higher content of moisture ($P< 0.05$) than the mature silks. Lipid and protein content decreased nearly 50% and 31%, respectively in mature silks compared to those in immature silks. The composition of ash, carbohydrate and total dietary fiber of both silks was not significantly different ($P> 0.05$) (Nurhanan,.*et al*..,2013).

Table 1: Nutritional compositions (%, dry basis) of immature and mature corn silk

Nutritional compound	Corn silk	
	Immature silks	Mature silks
Moisture (fresh)	89.31 ± 0.74[a]	84.42 ± 0.65[b]
Moisture (oven-dried)	4.15 ± 0.21[b]	3.90 ± 0.22[b]
Crude lipid	1.27 ± 0.16[a]	0.66 ± 0.17[b]
Crude protein	12.96 ± 0.38[a]	8.95 ± 0.21[b]
Ash (%)	5.28 ± 0.13[a]	5.51 ± 0.24[a]
Carbohydrate	27.80 ± 2.25[a]	29.74 ± 1.26[a]
Total dietary fiber (g/100 g)	48.50 ± 2.88[a]	51.24 ± 1.50[a]

[(a,b)]Mean values with different letters in the same row are significantly different ($P<0.05$).

Corn silk is effective either fresh or dried. Laboratory analysis reveals high amounts of silicon, potassium, calcium, magnesium, iron and phosphorus. It is also an excellent source of B vitamins and PABA. Along with chlorophyll, resin and a fixed oil, maizenic acid is the active principle in corn silk. Vitamin K is used by the body's mechanism that controls bleeding. Corn silk has been used as diuretic, antilithiasic, uricosuric, and antiseptic. It is used for the treatment of edema as well as for cystitis, gout, kidney stones, nephritis, and prostatitis this is because of the antioxidative effects or scavenging capacity of free radicals (Thoudam,.*et al.*.,2011).

2.4. Mineral Compositions of Corn Silk

Plants, like all other living things, need food for their growth and development. Plants require 16 essential elements. Carbon, hydrogen, and oxygen are derived from the atmosphere, soil and water. The remaining 13 essential elements (nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, zinc, manganese, copper, boron, molybdenum, and chlorine) are supplied either from soil minerals and soil organic matter or by organic or inorganic fertilizers (Uchida,R, 2000 and Maathuis,2009).

The highest mineral contents presented in fresh and oven dried corn silk were Ca, K, Mg, Mn and Zn. The aqueous extracts of Zeamays ear contained important diabetic-friendly sugar (fructose and sucrose) constituents while it aqueous extract residues consisted essential dietary fiber compounds. Thus, Zeamays ear extracts and its residues contained important nutritional elements and could potentially be an alternative source of dietary and sugar components in processed food products. (Wan Rosli,.,*et al..2010*).

As shown in Table 2Immature silks contained significantly higher level of Ca,Mg, Cu and Zn while other minerals such as K, Na and Fe were significantly higher in the mature silks ($P< 0.05$) (Nurhanan,*et al*..,2013).

Table 2: Mineral contents of immature and mature corn silk

Minerals	**Minerals level in(µg/g)**	
Macro elements	Immature silks	Mature silks
Calcium (Ca)	1087.08 ± 105.51^{a}	707.04 ± 94.41^{b}
Magnesium (Mg)	1219.17 ± 143.07^{a}	361.50 ± 20.53^{b}
Potassium (K)	26281.67 ± 1379.7^{a}	35671.67 ± 2466^{b}
sodium (Na)	190.67 ± 22.61^{a}	266.67 ± 15.65^{b}
Micro elements	Immature silks	Mature silks
Copper(Cu)	5.60 ± 0.4^{a}	4.12 ± 0.38^{b}
Iron (Fe)	2.17 ± 0.15^{a}	4.50 ± 0.49^{b}
Manganese(Mn)	32.17 ± 3.14^{a}	35.57 ± 2.26^{a}
Zinc(Zn)	46.37 ± 4.21^{a}	$35.92\ 4.24^{b}$

$^{(a,b)}$Mean values with different letters in the same row are significantly different ($P<0.05$).

2.5. Health Effect of Corn Silk

In the ancient time, corn has been used to pacify kapha, pitta, anorexia, general debilities, emaciation and haemorrhoids. It is a potent antioxidant that guards body from harming by free radicals responsible for cellular damage and/or cancer. It has the potential to alleviate pain and possess analgesic activity as well. Helping production of sex related hormones assemble it good for sexual health especially for men with erectile dysfunctions. It is believed to improve symptoms of rheumatism as B-complex is able to improve joint motility. Major nutrient of corn silk is potassium that is powerful diuretic (Kumar,.*et al*.., 2013).

According to results of Velazquezd, *et al*. (2005) the diuretic effect of corn silk was attributed to its high K content. In addition to this effect, which was accompanied by increased excretion of

Na and K from the body, K has been reported to attenuate vascular contractions and to reduce the elevated blood pressure. Humans require large amounts of K, Mg and Ca in their diet, and K is generally consumed in adequate amounts. Given the Mg and Ca deficiencies are common in many developed and developing countries, the results indicate that matured silks stage are much more suitable for use as a source of these micro- and macro minerals than silks at silking stage.

Major nutrient of corn silk is potassium that is powerful diuretic. In Europe and some other countries such as French, Spain, Greece including India; corn silk is used to conquer urinary tract infections and kidney stones. While in China it has been widely taken in case of fluid retention and jaundice. Corn silk improves blood pressure and support liver functioning as well as producing bile. Roots, leaves and corn silk as decoction are used for bladder while the decoction of cob as tea is used for stomach complaints. It acts as a good emollient for ulcer, wound and swelling. In some places decoction of corn silk and parched corn is extremely useful in nausea and vomiting (Kumar,.*et al..,* 2013).

Corn silk refers to the stigmas of Zea mays L. (Gramineae) from the female flowers of maize. Based on its flavonoid contents, it is medicinally used in the treatment of a number of diseases. Screening of plants against pathogenic bacteria is an important step to validate its medicinal properties (Nessa,..*et al,* 2012).

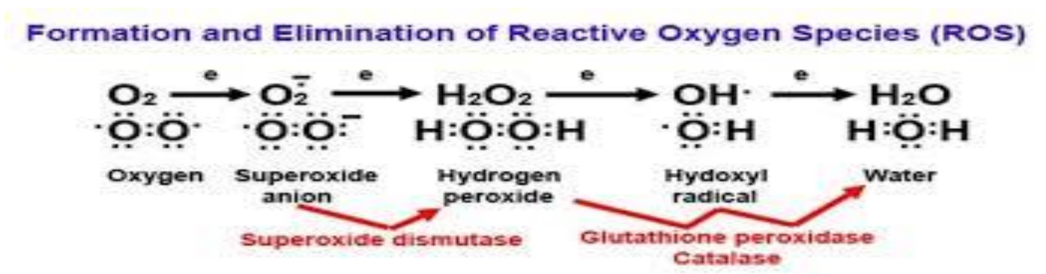
According to Guo,(2009) Corn silk ear treatment reduced hyperglycemia in alloxan -induced diabetic mices. The action of CSE on glyicemic metabolism is not via increasing glycogen and inhibiting gluconeogenesis but through increasing insulin level as well as recovering the injured β-cells.

2.6. Free Radicals and Antioxidants

2.6.1. Free Radicals

Free radicals can be defined as molecules or molecular fragments containing one or more unpaired electrons in atomic or molecular orbital. This unpaired electron(s) usually gives a considerable degree of reactivity to the free radical. Radicals derived from oxygen represent the most important class of radical species generated in living systems (Valko,.*et al*…,2007).

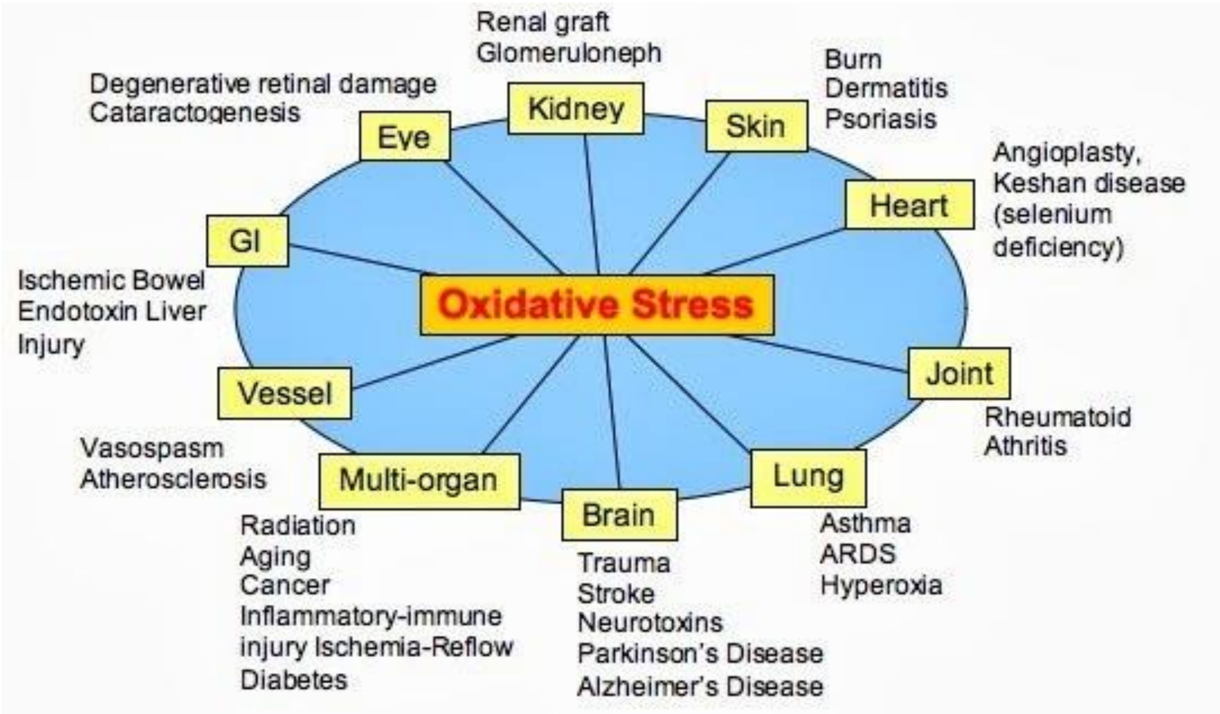
Figure 2: Formation of free radicals



The causes of the poisonous properties of free radicals were obscure prior to the publication of Gershman's free radical theory of oxygen toxicity in 1954, which states that the toxicity of oxygen is due to partially reduced forms of oxygen. Second epoch of the research of free radicals in biological systems was explored in 1969 when McCord and Fridovich discovered the enzyme superoxide dismutase (SOD) and thus provided convincing evidence about the importance of free radicals. A third era of free radicals in biological systems dates from 1977 when Mittal and Murad provided evidence that the hydroxyl radical,•OH, stimulates activation of guanylatecyclase and formation of the "second messenger" cyclic guanosine monophosphate (cGMP) (Valko,.*et al*…,2007).

According to Valko,.*et al*,..2007) Overproduction of ROS, most frequently either by excessive stimulation of NAD (P)H by cytokines, or by the mitochondrial electron transport chain and xanthineoxidase result in oxidative stress. Oxidative stress is a deleterious process that can be an important mediator of damage to cell structures and consequently various disease states and ageing.

Figure 3: Effect of oxidative stress



2.6.2. Phytonutrientsand Antioxidant

A number of other dietary antioxidant substances exist beyond the traditional vitamins. Many plant-derived substances, collectively termed "phytonutrients," or "phytochemicals," are becoming increasingly known for their antioxidant activity. Phenolic compounds such as flavonoids are ubiquitous within the plant kingdom: approximately 3,000 flavonoid substances have been described. In plants, flavonoids serve as protectors against a wide variety of environmental stresses while, in humans flavonoids appear to function as "biological response modifiers" Flavonoids have been demonstrated to have anti-inflammatory, anti-allergenic, anti-viral, anti-aging, and anti-carcinogenic activity. The broad therapeutic effects of flavonoids can be largely attributed to their antioxidant properties. In addition to an antioxidant effect, flavonoid compounds may exert protection against heart disease through the inhibition of cyclooxygenase and lipoxygenase activities in platelets and macrophages (*Mark,1998).*

The choice of varying solvent polarities had influence on the extractability of bioactive compounds. The nature of solvent may explain on its capacity to recover as many antioxidants as possible and solvent having higher polarity exerted higher percentage of recovery (Nurhanan, *et al*., 2013).

According to Karuppuchamy&Selvakumar, (2011) Phytochemical constituents, free radical scavenging activity and total antioxidant activity of various extracts of corn silk were carried out in different studies. Phytochemicals were extracted from corn silk using various solvents such as benzene, chloroform, ethanol, ethyl acetate, methanol and petroleum ether. Screening of phytochemicals showed positive results for the presence of flavonoids, alkaloids, phenols, steroids, glycosides, carbohydrates, terpenoids and tannins. Phytochemicals were extracted best in methanol. Free radical scavenging activity was determined using DPPH assay as DPPH is a stable antioxidant. Methanolic extract was found to have maximum DPPH scavenging activity (95.5%) and lowest chloroform (44.2%) and total antioxidant activity of methanol 82.5mg/ml and the lowest 45.5mg/ml ethyl acetate. These activities may be due to the presence of flavonoids, alkaloids, phenols, steroids, glycosides and tannins in corn silk.

Antioxidants are capable of stabilizing or deactivating, free radicals before they attack cells. Antioxidants are absolutely critical for maintaining optimal cellular and systemic health and well-being. To protect the cells and organ systems of the body against reactive oxygen species, humans have evolved a highly sophisticated and complex antioxidant protection system. It involves a variety of components, both endogenous and exogenous in origin, that function interactively and synergistically to neutralize free radicals. These components include (*Mark, 1998)*:

- Nutrient-derived antioxidants like ascorbic acid (vitamin C), tocopherols and tocotrienols (vitamin E), carotenoids, and other low molecular weight compounds such as glutathione and lipoic acid.
- Antioxidant enzymes, e.g., superoxide dismutase, glutathione peroxidase, and glutathione reductase, which catalyze free radical quenching reactions.
- Metal binding proteins, such as ferritin, lactoferrin, albumin, and ceruloplasmin that sequester free iron and copper ions that are capable of catalyzing oxidative reactions.
- Numerous other antioxidant phytonutrients present in a wide variety of plant foods.

2.7. Antioxidant Capacity and Property of Corn Silk

Using plants as a good source of antioxidants have been examined by many researchers. CS extract bears comparable antioxidant activity to the standard compounds. Its constituents scavenge free radicals, chelate the catalytic metal ions, and may exert a protective effect against oxidative damage induced to cellular macromolecules. The preliminary chemical examination of alcoholic-water extract has shown the presence of phenols and flavonoids, which may be responsible of the antioxidant and lipidperoxidation inhibitory activities. The high scavenging property of CS may be due to hydroxyl groups existing in the phenolic compounds (Ebrahimzadeh,.*et al.., 2008).*

A study conducted in Thailand reported that silks from purple maize had twice polyphenol content than those from yellow maize and five times more than silks from white maize similarly red and pink silks from hybrid maize cultivated in Serbia had more polyphenols and flavonoids than green and yellow silks. According to other authors, the silks accumulate more polyphenols than other parts of the corn plant like the husks, rachis or even the grains of the maize cob (Mendoza-López, *et al.., 2017).*

According to Zilic, (2016), Corn silks at the silking stage are much more suitable for use as a source of phenolic compounds than silks at the R4 dough stage, as well as Menthapiperita and Ginkgo biloba. Following of green tea and Melissa officinalis, pinky silkof ZP 341 hybrid had the highest content of total phenolic compounds. According to zilic finding there were no significant differences between corn silks at the silking stage and medicinal herbs for average antioxidant activity. Due to their high antioxidant activity, the research indicates a possibility to apply corn silks extract or tea in the therapy of diseases caused by oxidative stress. In addition to tea, corn silk could be novel and a potent source of natural antioxidants used as dietary supplements, as well as ingredients for functional foods.

The amount of antioxidative effects of corn silk is different in the type of land they grown according to Mendoza-López, (2017) the content of polysaccharides and polyphenols in the maize silks differed significantly among the maize landraces tested. Some silks accumulated large amounts of polysaccharides like those obtained from the landrace Cristalino which resembles those hybrid varieties of yellow sweet maize. Whereas silks from the landrace

Cónicohad the highest antioxidant capacity and polyphenol content. The presence of the flavonoid maysin was confirmed by TLC in silks of the landrace Cónico but not in silks from the landraces Gordo and Cristalino. The beneficial effects of maize silks are attributed to either their polyphenol or polysaccharide content.

Flavonoids play a variety of biological activities in plants, animals, and bacteria. In plants, flavonoids have long been known to be synthesized in particular sites and are responsible for color, aroma of flowers, fruit to attract pollinators consequently fruit dispersion; help in seed, spore germination, growth and development of seedling. Flavonoids protect plants from different biotic and abiotic stresses and act as unique UV-filter, function as signal molecules, allelopathic compounds, phytoalexins, detoxifying agents, antimicrobial defensive compounds (Samanta& das, 2011).

According to WanRosli (2014) both immature and mature silks could be considered as good source of nutritional compositions and antioxidant capacity. The immature silks contained significantly higher content of moisture ($P < 0.05$) than the mature silks. Immature silks had significantly higher content of polyphenol and flavonoid content ($P < 0.05$) than the mature silk which was shown by the ethanol and water extract, respectively. Both ethanol extracts of immature and mature silks possessed strong free radical scavenging capacity compared to the water and ethyl acetate extract. The ethanol extract of immature silk however had the highest antioxidant capacity compared to same extracts of mature silks.

2.8. Antinutritional Factor Tannins in Corn Silk

According to Emire,.*et al*,..,(2013) Food poisoning arising from plant secondary metabolites, otherwise known as anti-nutritional factors, other than cyanogenic glycosides, has not been properly addressed in Nigeria, and indeed in most parts of the developing world/countries, that depend/feed mostly on vegetable-based diets. People have therefore died out of ignorance, poverty and inadequate nutrition education, especially within the African societies. The anti-nutritional factors may be defined as those substances generated in natural food stuffs by the normal metabolism of species and by different mechanisms (e.g. inactivation of some nutrients, diminution of the digestive process, or metabolic utilization of feed) which exert effects contrary to optimum nutrition.

Tannins are defined as water-soluble polymeric phenolics that precipitate proteins. The profiles and quantities of polyphenols and tannins in foods are affected by processing due to their highly reactive nature, which may affect their anti-oxidant activity and the nutritional value of foods (Khandelwal,.,*et al*..,2010).

Therefore, foods rich in tannins are considered to be of low nutritional value. However, recent findings indicate that the major effect of tannins was not due to their inhibition on food consumption or digestion but rather the decreased efficiency in converting the absorbed nutrients to new body substances. Interestingly, many reports indicated negative association between tea consumption and incidences of cancers. Tea polyphenols and many tannin components were suggested to be anticarcinogenic. Many tannin molecules have also been shown to reduce the mutagenic activity of a number of mutagens. The anticarcinogenic and antimutagenic potentials of tannins may be related to their antioxidative property, which is important in protecting cellular oxidative damage, including lipid peroxidaton. The generation of superoxide radicals was reported to be inhibited by tannins and related compounds (Ozcan,..*et al*,..2014).

Teas with high levels of tannins have a bitter taste accompanied by strong astringency, seen especially in green and black tea. The tannins found in tea are thearubigins, most prominently theaflavins. When the anti-oxidizing agents such as catechin in the tea become oxidized, theaflavins are produced. Tannins in tea are responsible for the antioxidant activities of black and other dark teas. The health benefits of tannin come from its anti- carcinogenic and anti-mutagenic properties, mostly due to its anti-oxidizing nature (Chen, 2009).

Total condensed tannin in corn silk, rosemary and senna tea was less than 1mg CE/g but green tea was more than 9mg CE/g (kilic,..*et a*l,..,2017).

In other study fully developed matured silks of fifteen maize hybrids were tested and the result of tannins ranging from 746.3mg/100gm to 2497.5mg/100g (Maksimović,..*et al*,..,2005)

2.9. Tea

All teas start with plucking fresh leaves. The young leaves of the tea bush are hand-plucked to select only the finest quality leaf-grade teas. With a few exceptions all Peet's teas are "fine-plucked". Fine plucking is the practice of taking only the top two leaves and a bud from each shoot. The finest potential flavors and aromas are concentrated in this youngest growth; making fine-plucking, one of the first steps in selecting the best quality teas for Peet's. Coarse plucking uses the coarser more mature leaves lower down on the shoot, which cannot deliver as fine or complex a quality due to their having more cellulose and woody structure and therefore less of the components that develop aroma and flavor during processing. Since all tea comes from the same plant (Camellia sinensis), it's the different processing that results in a wide range of flavors in the cup and provides us with the five categories of tea: white, green, oolong, black and pu-erh. Not all teas go through same steps. Black Tea Processing Steps:-Picking, Withering, Rolling, Oxidation, Drying and Grading. Green Tea Processing Steps:- Picking, De-enzyming, Rolling, Drying and Grading (Narotzki,.*et al*,.,2012).

There are two main forms of tea, the fermented and the non-fermented forms. Black tea belongs to the fermented form of tea. The main group of chemical substances present in the flush is polyphenols which undergo oxidative changes during the stage of fermentation in the manufacture of black tea. The oxidized polyphenols form colored substances referred to as theaflavins and thearubigins which are mainly responsible for the color and character of black tea liquor. On the other hand green tea is a non-fermented form of tea. The method of processing is basically different from that of black tea' as green tea is not subjected to fermentation which stage is totally eliminated by a process called de-enzyming or inactivation of the enzyme polyphenol oxidase. The processed green tea retains the green color and the chemical composition of the green leaf without major changes (Samarasingham, 1990).

2.10. Corn Silk Tea

In herbal medicine, the part of the corn that is used is the long stigmas, called silks, which grow from the top end of the corn's 'ear'. This plant is known to most as a valuable food source, the silken tassels of the Corn are the most popular form of medicine for the herbalist. Fresh green corn silk is collected from the cob and dried for tea or processed into tincture. This medicine keeps the entire urinary tract clean; offering relief to chronic suffers of bladder infections (Whelan. 2011).

Figure 4: Corn Silk Tea

The concentration of potassium in corn silk makes it a wonderful supplement for a variety of kidney problems. Potassium is a key mineral in healing the kidneys. Corn silk offers more per gram than bananas. Human bodies are designed to eat mostly plants which are high in potassium and low in sodium. The modern diet is woefully lacking in raw fruits and vegetables. Corn silk offers the stabilizing action of a diuretic with elevated levels of potassium to keep both blood pressure and excess weight down (Corn silk tea, a beloved drink. 2015,Jan 26).

Corn silk tea is traditionally served to children to help prevent bed wetting, also known as enuresis. Elderly patients with enuresis benefit from this delicately flavored tea as well (Whelan. 2011).

According to Kilic,..*et al*,..(2017) antioxidant activities of *Camellia sinensis* (green tea), Zea*mays* (corn silk), *Cassia* sp. (senna) and *Rosmarinusofficinalis* (rosemary) herbal teas brewed at different water temperatures (60°C, 80°C and 100°C). The highest values were found in brewed at 100 °C temperatures in among all herbal teas. Consequently, it can be stated that plant species, solvent types, boiling temperatures can affect the total phenolic content, total flavonoid content and condensed tannin content so the total phenol contents of corn silks were higher than rosemary tea but lower than senna and green tea, total flavonoid content of corn silk tea is less than rosemary, green tea and senna tea in the case of total condensed tannin corn silk, rosemary and senna tea was less than 1mg CE/g but green tea was more than 9mg CE/g.

2.11. Sensory Acceptability

The discipline of hedonic response flourished swiftly in 20th century along with the growth of food processing industries. It encompasses a set of techniques required for the precise measurements of human reactions to foodstuff ultimately persuading the consumer perceptions. Sensory evaluation is a scientific method used to evoke, measure, analysis and interpret those responses to products as perceived through the senses of sight, hearing, touch, smell and taste (Stone and Sidel 1993).

Sensory testing can help to pinpoint the imperative sensory characteristics driving acceptability. It can be useful to ascertain target consumers, product competitors and assess the new ideas. Now a days, chemical and physical properties of the product driving sensory attributes are ascertained by combining data obtained from sensory and instrumental testing. Sensory evaluation can determine the impact of scaling up pilot samples to large-scale manufacture (Sharif,.*et al*,..2017).

There is no one instrument that can replicate or replace the human response, making the sensory evaluation component of any food study essential. Sensory analysis is applicable to a variety of areas such as product development, product improvement, quality control, storage studies and process development (Watts,.*et al*,..1989)

There are many types of sensory analysis methods the most popular being difference tests, descriptive analysis and consumer acceptance testing and each testing method has different goal (Vaclavik and Christen, 2008).

Differences or discrimination test are one of sensory testing method which are designed to determine whether there is a difference between products. Descriptive sensory analysis is defined as a sensory testing method by which the attributes of a food or a product are identified and quantified, using human subjects who have been specifically trained for this purpose. The primary aim of all descriptive techniques is to generate quantitative data which describes the similarities and differences among a set of product (Stone and Sidel, 1993: and Vaclavik and Christen, 2008). Acceptance or preference tests are used to determine whether a specific consumer group like or prefers a particular product .this is necessary for the development and marketing of new products (Vaclavik and Christen, 2008).

3 . MATERIALS AND METHODS

3.1. Location of the Study and Sampling

The study was conducted in Merti agro industry zone, located at 8ˈ23ˈ to 8ˈ45ˈ N and 39ˈ33ˈto 39ˈ50ˈ E, 174Km from Addis Ababa, lies in the Oromia regional state of Ethiopia. The samples were collected randomly from white corn and collect the red and yellow color of silk samples from the matured after 30 days of the silk emerged and immature after 3 days of the silk emerged.

Figure 5: *Merti* agro industry zone corn farm

Figure 6: Red and yellow color of silk samples

3.2. Corn silk Samples Collected

Adequate amount of samples were collected from red and yellow color of matured and immature corn silks. Samples were collected randomly according to its maturity level and color type to analyze each parameters and production of tea.

Figure 7: Corn silk samples

3.3. Sample Preparation for Analysis

Cut the upper parts of mature and immature corn silks with scissors from its husk. Fresh corn silks were chopped and dried in an oven at 50ºC for 2 days. Dried corn silks are kept in a sealed plastic bag at 4ºC. Prior to analysis, the corn silk was ground into powder form. Silk samples were extracted with methanol for further analysis (Nurhanan, *et al*., 2013).

Figure 8: Dried and chopped corn silk sample

3.4. Nutritional Composition Analysis

Nutritional composition (moisture, protein, lipid and ash) were determined according to (AOAC, 2000).

3.4.1 Moisture Analysis

Moisture content of fresh and oven dried silks were determined using an oven-dry technique and expressed as fresh and dry basis, respectively crucibles were dried in a drying oven at 105^0c for 1 hour. After an hour cooled in a desiccators for 30 minutes then measure the weighed of crucibles (W1). 5 gm from each corn silk sample was measured and put in crucible and measure the weighed (W2) then the crucible containing the sample was dried in oven drier at 50^0c for 2 days. After two days cooled the hot crucibles in the desiccators then measure the dried sample and crucible (W3). The moisture content of corn silks were calculated by:-

$$\textbf{Moisture \%} = \quad \boldsymbol{W2 - W3/W2 - W1 \times 100}$$

3.4.2 Crud Protein Analysis

Protein content was determined by using the Kjeldahl method. 0.5 gm of samples was taken from each corn silk samples and put in flasks then 6ml of concentrated sulphuric acid was added for digested. Little by little drop 3.5 ml of hydrogen peroxide was added and 3gm catalytic mixture of potassium sulphate and copper sulphate was added and react for 15 minutes. Then the mixture was digested in digestion stove at 370^0c for 4 hours until a clear digest was obtained, then cooled in the hood on the track. Then after 25ml of distilled water was added to prevent precipitation of sulphate. 25ml of 35%NAOH was added to neutralize sulphuric acid and thus, insure complete release of ammonia. 250ml Erlenmeyer flask containing 25ml of four %H_3BO_3, 25ml of dilute water and 3 drops of methyl red indicator was placed as receiver on the distillation unit. Finally the distillate was titrated with standardize 0.1 N HCL until the appearance of the first pink color at that end point measure the amount of HCL consumed. Blank was run to subtract reagent nitrogen from the samples nitrogen. The amount of protein was calculated by using: -

$$\textbf{Crud protein \%} = (V2-V1) \times N \times 14 \times 6.25 / 10 \times W$$

V1= volume (ml) of hydrochloric acid solution required for the blank test

V2= volume (ml) of hydrochloric acid solution consumed by the samples

N= Normality of hydrochloric acid

W= weight of the sample

10=factor relating mg/g 14= equivalent weight of nitrogen 6.25= conversion factor for food.

3.4.3 Crud Fat Analysis

Crud fat was extracted using Soxhlet apparatus. 2gm of dried samples from each corn silk was weighed and put in thimble containing fat free cotton (W1). The extract cylinder was washed with distilled water and detergent and then dried and weighed (W2).Then add 50ml of diethyl ether with boiling point 34.6^0c was added in to the cylinder and the thimble was immersed in to the cylinder containing diethyl ether for 2 hours. Fat extraction was done for extra 2 hours, while the temperature was set at 55^0c, after this the cylinder containing the extracted fat was dried in oven drier for 30 minutes at 70^0c, at the end the cylinder containing the extract was cooled in a desiccators for 20 minutes and weighed (W3). Then the amount of fat extract was calculated by using:-

$$\textbf{Crud fat \%} = W3-W2/W1$$

W= weight of samples, W2= weight of cylinder, W3= weight of cylinder +fat, W3-W2= weight of fat

3.4.4 Total Dietary Fiber Analysis

Total dietary fiber analysis composition of corn silks was determined according to the methods of AOAC (2000). The analysis was involving digestion, filtration, washing, drying and combustion.

3.5. Mineral Analysis

Using acid digestion procedure (Wet Ashing Method) the dried selected corn silk samples of air dried in the laboratory were removed and mixed uniformly by coning, pulverized and quartering. The samples were sieved through a 2 mm sieve to remove coarse particles. 1g of sieved of the corn silk samples were weighed out into 100ml conical flask. The samples were digested by the addition of 20ml of aquaregia (mixture of HCl and HNO3, ratio 3:1) and 10ml of 30% H_2O_2. The H_2O_2 was added in small portions to avoid any possible over flow leading to loss of material from the conical flask. The analyt was digesting for 2hr in 100ml conical flask covered with a watch glass, and reflex over a hot plate at 90°C for 2 hours. The conical flask wall and watch glass was washed with distilled water and the sample was filtered out to separate the insoluble solid from the supernatant liquid. The volume was adjusted to 100ml with distilled water. Blank solution was handled as detailed for the samples.

$$\text{Mg/100g} = \frac{\text{(Mineral conc. found in mg/L)*(volume of volumetric flask in L) *100 g * DF}}{\text{Sample weight in g}} \quad (1)$$

3.6. Antioxidant Capacity and Property of Corn Silk

3.6.1. Extraction for Antioxidant Analysis

5 gm sample was taken from each corn silk and mix with 50ml methanol and shake by shaker for 24 hrs. Then filter the supernatant with filter paper. The methanol in the supernatant mixture was evaporated by rotary evaporator, then measure the yield of each samples and calculate with the proportion by 50mg/ml (50mg =1ml) and made a stock solution (Barros, Baptista, & Ferreira 2007).

3.6.1.1. Determination of Total Polyphenol Content of Corn Silks

The total phenolic content (TPC) was determined by spectrophotometry, using gallic acid as a standard, using the Folin–Ciocalteau method (Kaur et al., 2008). Briefly, 0.1 mL of the diluted sample extract was transferred in tubes containing 1.0 mL of a 1/10 dilution of Folin-Ciocalteu's reagent in distilled water. After waiting for 10minutes, 0.8 mL of a sodium carbonate solution (7.5% w/v) was added to the sample. The tubes were then allowed to stand at room temperature for 30 min before absorbance at 765 nm was measured. The TPC was expressed as gallicacid equivalents (GAE) in mg/100 mL of corn silk. The concentration of polyphenols in samples was derived from a standard curve of gallic acid ranging from 0.02 to 0.14 mg/L.

3.6.1.2. Determination of Total Flavonoid Content of Corn Silks

Total flavonoid content was determined by a colorimetric assay described by Ozsoy,*et al*. (2008). An aliquot of 0.25 ml of the extract (1000 µg/ml) will be added with 75 µl of $NaNO_2$ (5% w/v) and the mixture is left to stand at room temperature for 6 min. Thereafter, 150 µl of $AlCl_3$ (10% w/v) is added and allowed to react for another 5 min before adding 500 µl of NaOH (1 M). The volume is then adjusted to2.5 ml with distilled water and mixed thoroughly. The absorbance is measured at 510 nm against blank which contained the same mixture without sample. Total flavonoid content were expressed as mg CAE/g extract, through the (+)-catechin calibration curve.

3.6.2. Free Radical Scavenging of Corn Silks

The effect of methanolic extracts on the DPPH radical was estimated according to Kirby and Schmidt (1997). A 0.004% solution of DPPH radical solution in methanol was prepared and then 4 ml of this solution was mixed with 1 ml of various concentrations (1–8mg/ml) of the extracts in methanol. Finally, the samples were incubated for 30 min in the dark at room temperature. Scavenging capacity was read spectrophotometrically (Perkin Elmer Lamda 950 UV/Vis/NIR) by monitoring the decrease in absorbance at 517 nm. Ascorbic acid was used as a standard and mixture without extract was used as the control. Inhibition of free radical DPPH in percent (I%) is then calculated:

$$\text{Radical Scavenging Activity} = \frac{A0-A1}{A0} \times 100\%$$

Where A0 is the absorbance of the control andA1 is the absorbance of the sample. The extract concentration providing 50% of radicals scavenging activity (EC50) was calculated (Woldegiorgis.,*et al*,..,2014).

3.7. Analysis of Tannins

Tannin content of corn silk samples was determined using the method of Burnes (1971) as cited in Adane, *et al* (2013). About 1 g of powdered corn silk was weighted in a screw capped test tube and 10mL of 1% HCl in methanol was added to each test tube containing the samples, next the test tube shaked for 24 hours at room temperature using mechanical shaker. After 24 hour of shaking, the tubes were centrifuged at 1000xg for 5 minutes. One mL of the clear supernatant was taken and mixed with 5mL of vanillin-HCl reagent in another test tube. Then, the mixture was allowed to stand for 20 minutes in order to complete the reaction. After 20 minutes the absorbance was read at 500nm using UV-VIS spectrophotometer. Finally, the concentration of tannins was calculated using D-catechin standard curve (0, 0.2, 0.4, 0.6, 0.8 and 1ml) or (0, 12, 24, 36, 48, and 60mg/100g) and the results were expressed as catechin equivalent of tannins in milligram per 100g dry weight. The following formula was used to calculate the tannin content of the samples.

$$\text{Tannins (mg/100g)} = \frac{[(\text{absorbance of sample} - \text{Absorbance of blank}) - \text{Intercept}]}{\text{Slope x density x weight of sample}}$$

3.8. Development of Tea from Corn Silks and Sensory Acceptability

3.8.1 Development of Tea and Its Preparation

There were control sample and experimental samples. The control samples were processed black and green tea whereas the experimental samples were the mature and immature red and yellow corn silk. Then compare the taste, color, flavor and aroma of the corn silk in respect of control with some amount of sugar.

We had taken 2gm dried samples from each sample as of the control standard green and black teas and add to 250ml (amount of one cup). Then add some amount of sugar to mask the bitterness of the taste and wait for 3 minutes to get the desired color.

3.8.2 Sensory Acceptability Evaluation

Sensory evaluations were carried out by 15 untrained consumers consisting of Food science and nutrition and staff of the School of natural and computational Sciences, 4 kilo Campus students. They evaluated by contrasting samples for color, taste, flavor and aroma with the control, corn silk tea flavor, color, aroma and taste overall acceptance on a 9 point hedonic scale (0 = dislike extremely and 9 = like extremely). During the evaluation session, each panelist was provided the samples and the control tea with coded cup and the sensory evaluation questionnaires that they wrote their evaluation result. Significance was established at $P \leq 0.05$ (Wan Rosli, 2011).

By using over all acceptance test result of tea we perceived difference between control and samples and among samples. It helps to determine the difference or similarities between existing treatments and the nature and intensity of difference.

3.9. Experimental Design and Statistical Analysis

The experimental design was completely randomization technique. All results were presented as mean (±SD) values of three replicates. Analysis of variance (ANOVA) was performed using SPSS V. 20 (SPSS Inc., Chicago, IL, USA) and mean values were statistically different at $P \leq 0.05$. The significantly different results were further separated using the Duncan multiple range test (SPSS Inc., Chicago, IL, USA).

4 . RESULTS

4.1 Nutritional Compositions of Corn Silks

Nutritional compositions of immature (red and yellow) and mature (red and yellow) corn silk are shown in Table 3. Overall, the moisture content of immature red and yellow silks consecutively (88.16% and 86.85%) were significantly higher than mature red and yellow silks (83.83% and 84.56%) (P value <0.05). However, the moisture content after oven drying was the immature red and yellow corn silk (3.5% and 4.1%) consecutively and the matured red and yellow were (5.9% and 6.6%).

The protein content of red and yellow matured silk was (14.3% and 13.3%) and immature red and yellow silks (16.55% and 14.87%) respectively. The red matured and immature silk was higher protein content than yellow matured and immature. The protein composition of immature red and yellow silks were significantly higher than those of matured red and yellow silks (P value <0.05).

Lipid content of immature red and yellow silks was (1.75% and 1.5%) and the lipid content of matured red and yellow (1.3% and 1.37%) respectively. The lipid composition of immature red and yellow silks was significantly higher than those of matured red and yellow silks (P value <0.05).

There was a significant difference between the ash content of immature red and yellow silks (6.2% and 6.8%) and there was no different between the ash content of red and yellow matured silk (both were 8%) (P >0.05).

The carbohydrate content of immature red and yellow silks were (49.98% and 53.03%) and the matured silks of red and yellow were (36.24% and 40.7%) respectively there were more than a 10% difference between immature corn silk and matured with the same silk color this shows the immature silk had higher carbohydrate content than matured corn silk.

The total dietary fibers of immature red and yellow corn silk respectively (25.5% and 23.79%) and matured red and yellow corn silks were (40.22% and 36.61%). The result shows there is no a significant difference in fiber content of immature red and yellow corn silk but there was a significant difference between the matured red and yellow color of corn silk (P >0.05). Generally the matured corn silk had much amount of fiber than the immature corn silk.

Table 3: Nutritional composition of corn silk

Nutritional composition	**Nutritional composition in %**			
	Immature silks		Mature silks	
	Red	Yellow	Red	Yellow
Moisture (fresh)	88.16^{b}±0.76	86.85^{b}±1.25	83.83^{a}±0.25	84.56^{a}±0.65
Moisture (oven dry)	3.5^{a}±0.3	4.1^{b}±0.057	5.9^{c}±0.1	6.6^{d}±0.2
Crud lipid	1.75^{b}±0.25	1.5^{b}	1.3^{a}±0.18	1.37^{a}±0.125
Crud protein	16.55^{d}±0.25	14.87^{c}±0.15	14.3^{b}±0.1	13.3^{a}±0.2
Ash	6.2^{a}±0.1	6.8^{b}±0.3	8^{c}±0.4	8^{c}±0.1
Carbohydrate	49.98^{c}±1.32	53.03^{d}±1.51	36.24^{a}±1.33	40.7^{b}±0.95
Total dietary fiber(g/100g)	25.51^{a}±1.25	23.79^{a}±1.73	40.22^{c}±0.85	36.61^{b}±1.25

$^{(a,b,c\&d)}$ Mean values with different letters in the immature and matured row are significantly different (P<0.05).

4.2 Mineral Composition of Corn Silks

Mineral contents (Ca, Mg, K, Na, Cu, Fe, Mn and Zn) of the silks from immature and mature red and yellow corns were shown in Table 4. In general, the content of macro elements such as Ca, Mg, K and Na in immature silks was statistically different from the mature silk. Ca,Na and Mg content were higher in matured corn silk than immature, but K content was much higher in immature red and yellow silks (3235.45±0.63 and 3075.97±0.89 mg/100g) and (3196.7±1.96 and 2917.28±1.93 mg/100g)respectively and there is a significant difference in its color type and maturity level of silk. But the immature mineral content potassium was much higher than other minerals.

However the amount of sodium in immature red and yellow corn silk (16.01±0.04 and 8 ±0.03 mg/100g) was lower compared to matured red and yellow corn silk (19.99±0.025 and 11.99±0.015mg/100g) respectively. Both immature and mature silks contained appreciable amounts of trace elements (Table 4). The content of Cu, Fe, Mn and Zn varied according to the color and maturity of silk. The amount of Cu and Mn in red immature silk (7.5±0.1and 15.78±0.06 mg/100g) respectively were higher than the yellow immature silk (7.29±0.115 and

8.23±0.065 mg/100g), but Fe and Zn were higher in immature yellow corn silk (14.01± 0.168 and 6.5± 0.25 mg/100g) than red immature silk (10.38±0.36 and 4.35± mg/100g) the contents were statistically different (P> 0.05).

Table 4: Mineral composition of corn silk

Minerals	**Minerals level in(mg/100g)**			
Macro elements	Immature silks		Mature silks	
	Red	Yellow	Red	Yellow
Calcium (Ca)	$22.067^{b}\pm0.0153$	$18.63^{a}\pm0.205$	$34.623^{d}\pm0.252$	$28.776^{c}\pm0.025$
Magnesium (Mg)	$16.04^{a}\pm0.138$	$20.43^{c}\pm0.35$	$20.89^{c}\pm0.42$	$18.48^{b}\pm0.358$
Potassium (K)	$3235.45^{d}\pm0.63$	$3075.97^{b}\pm0.89$	$3196.7^{c}\pm1.96$	$2917.28^{a}\pm1.93$
sodium (Na)	$16.01^{c}\pm0.04$	$8^{a}\pm0.02$	$19.99^{d}\pm0.025$	$11.99^{b}\pm0.015$
Micro elements				
Copper(Cu)	$7.5^{a}\pm0.1$	$7.29^{a}\pm0.115$	$9.5^{b}\pm0.257$	$9.45^{b}\pm0.11$
Iron (Fe)	$10.38^{a}\pm0.36$	$14.01^{c}\pm0.168$	$10.77^{b}\pm0.33$	$14.63^{d}\pm0.153$
Manganese(Mn)	$15.78^{d}\pm0.06$	$8.23^{b}\pm0.065$	$13.83^{c}\pm0.075$	$6.3^{a}\pm0.075$
Zinc(Zn)	$4.35^{a}\pm0.13$	$6.5^{c}\pm0.25$	$7.1^{d}\pm0.35$	$5.12^{b}\pm0.159$

(a,b,c&d) Mean values with different letters in the immature and matured row are significantly different (P<0.05).

4.3 Total Polyphenol and Flavonoid Content of Corn Silks

The total phenolic and flavonoid contents of immature and mature silks using methanol solvent extract are shown in Table 5.The immature corn silks exhibited significantly higher antioxidant effect than the mature corn silk (P < 0.05).

Total polyphenol content of crude extracts of immature (yellow and red) and mature (yellow and red) silks varied from 2.1 to 1.98 mg GAE/100g extract and 1.34 to 1.36 mg GAE/g extract, respectively. Among the immature corn silk the yellow immature corn silk had higher polyphenol (2.1mg GAE/100g) than the red immature silk which had (1.98 mg GAE/100g), but there was no a significant difference between red and yellow matured corn silk.

In the case of immature and mature red and yellow silks the flavonoid content was higher in red immature corn silks than the rest silks. The immature and matured yellow and red corn silks range between 3.25 to 3.98 mg CAE/100g, and 2.93 to 3.79 mg CAE/100g respectively, between the verities in the immature corn silk, red immature corn silk had higher flavonoid content (3.98 mg CAE/100g). There was no a significant difference between red mature and immature corn silks. But when we compare among their maturity level red immature and matured were higher than yellow matured and immature silks.

Table 5: Total Phenol, Flavonoid, DPPH and Tannin contents of corn silk

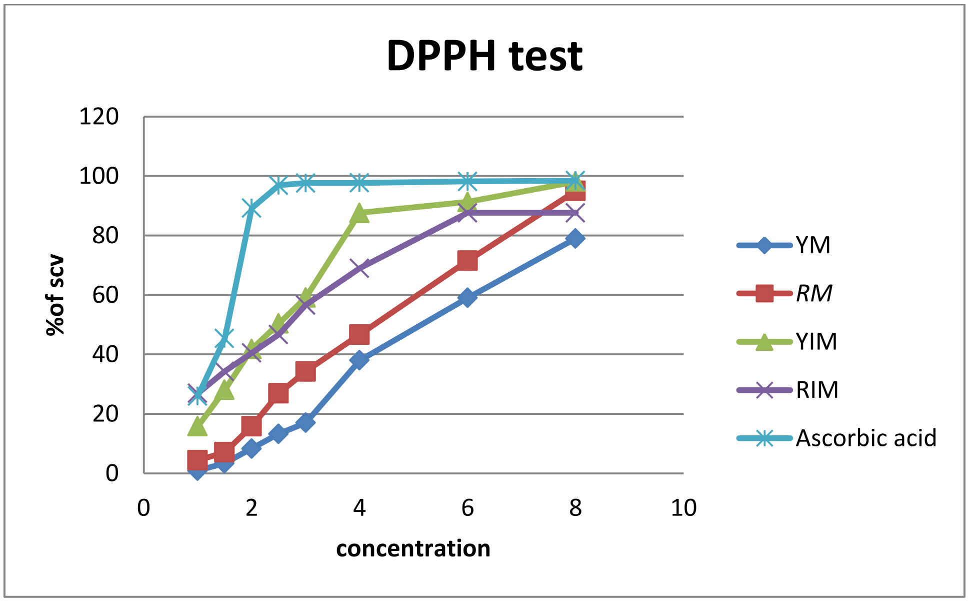
Corn silks	Total phenol(mg GAE/100g)	Total flavonoids (mgCE/100g)	DPPH scavenging (EC50) mg/ml	Tannins mg/100gm
Red mature	$1.36^{a}\pm0.075$	$3.79^{c}\pm0.092$	5.48	$3.43^{b}\pm0.125$
Red immature	$1.98^{b}\pm0.15$	$3.96^{c}\pm0.022$	3.84	$9.63^{d}\pm0.53$
Yellow matured	$1.34^{a}\pm0.016$	$2.93^{a}\pm0.22$	6.57	$1.71^{a}\pm0.13$
Yellow immature	$2.1^{b}\pm0.37$	$3.25^{b}\pm0.065$	3.79	$6.05^{c}\pm0.31$

$^{(a,b,c\&d)}$ Mean values with different letters in the immature and matured column are significantly different (P<0.05).

4.4 DPPH Free Radical Scavenging Capacity of Corn Silks

The antioxidant capacity of immature and mature silk methanol extracts as measured by using the DPPH free radical scavenging method. All extracts had showed a dose-dependent response when exposed to different concentration of extracts (1–8 mg/ml). Higher percentage of inhibition was observed at higher concentration. The percentage of inhibition of immature and matured red and yellow corn silk extracts were ranged from (EC50 3.84mg/ml to 3.79 mg/ml) and (EC50 6.57 mg/ml to 5.48 mg/ml) respectively (Table 5). Extract of immature silk demonstrated a higher percentage of inhibition compared to the mature silk (Fig. 9). These results indicated that antioxidant compounds present in immature silk extracts are prone to donate hydrogen atom to DPPH free radical giving rise to its scavenging capacity. A lower scavenging capacity was observed in mature silks. The percentage of inhibition among immature silk yellow silk was slightly higher than red silk. In the case of mature silk red silk was significantly higher than yellow silk.

Figure 9: Graph of DPPH scavenging capacity of the corn silk sample and standard



4.5 Tannins Content of Corn Silks

As shown in Table 3 the tannin contents of corn silk was varied in its color and maturation. In this study the amount of tannin in immature red and yellow corn silk was (9.63±0.53 and 6.05±0.31) respectively and in the case of matured red and yellow corn silk the amount of tannin was three fold lower than the immature corn silk which was (3.43±0.125 and 1.71±0.13). This shows that the amount of tannin was higher in immature corn silk than matured corn silk.

4.6 Sensory Acceptability of Developed Corn Silks Tea

It is understandable that the sensory properties of a food product are important determinants of its acceptability and preference among consumers. In this study there were 15 panelists tasted the control (green and black tea) and the sample matured and immature red and yellow corn silk. They tested the taste, color, flavor, aroma and overall acceptability of the prepared tea. The results showed significant differences ($p<0.05$) in the consumer preference for most of the attributes of corn silk and control tea (Table 6). According to the panelist result we compare the samples with the control; all of the samples were better acceptability in their taste, color, flavor, and aroma of green tea but less acceptability than black tea in their taste, color, flavor, and aroma.

As we compare over all acceptability among the samples YIM (yellow immature) and YM (yellow matured) had better acceptability than RIM (red immature) and RM (red matured). Except this among all samples there were no significant differences in their taste, color, flavor, aroma and over all acceptability according to the judgers taste result.

Table 6: Sensory acceptability evaluation of corn silk tea

Sample and control	Taste	Color	Flavor	Aroma	Over all acceptability
Black tea	7.13[a]	7.66[a]	7.4[a]	7.46[a]	7.2[a]
Green tea	3.6[a]	7[d]	4.33[b]	5.4[c]	4.66[b]
YIM	6[a]	6.6[a]	6.13[a]	6.2[a]	6.26[a]
RIM	6.26[a]	6.53[a]	5.86[a]	6.2[a]	6.13[a]
YM	6.26[a]	6.8[a]	6.13[a]	6.06[a]	6.26[a]
RM	6.06[a]	6.2[a]	6[a]	6.2[a]	6.13[a]

[(a,b,c&d)] Mean values with different letters in the immature and matured row are significantly different (P<0.05).

Figure 10 Color of corn silk tea and its control

5 . DISCUSSION

In this study the moisture content of oven-dried silks which were dried at 50°C for two days; the recorded moisture of immature and matured red silks were 3.5% and5.9% and the yellow immature and matured silks were 4.1% and 6.6%. Among the immature and matured corn silks the red immature and matured had low moisture contents than yellow immature and matured silks. According to Nurhanan,*et al* (2013) dried samples with 55 °C for 48 h recorded the moisture content of 3.90%.–4.15%. The moisture content of dried matured silk from white kernel dried sample f 24 for h at 45°C was 6.2% (Mendoza-López,..*et al*..,2018). Due to the differences in temperature, duration of drying and the maturity levels of silks were made variation of moisture contents among different literatures. There for the maturity level, temperature and duration of time affects the moisture contents of silks.

In this study the protein content of both immature and mature corn red silks were 16.55% and 14.3% respectively and immature and mature yellow silks were 14.87 and 13.3%. Among the maturity level of silks and its color immature red and yellow color of silks has higher amounts of protein than matured red and yellow color of silks. However the matured dried and fresh corn silk from different farming area was collected and the white kernel silk protein contents was 16.7% (Mendoza-López,..*et al*..,2018). According to Nurhanan,*et al* (2013) the immature sweet corn silk and fully ripped corn silk were analyzed and the result of protein contents were 12.96 and 8.95% respectively. Our study were slightly higher than Nurhanan,*et al*..(2013) this is may be because of the duration or time of silk collected; that means immature silk was collected three days after emerging of silk and the matured silk were collected at 30 days after emerging of silk and also it may be the time when metabolization of amino acids took place to develop corn seed.

The protein content of immature and mature silks may be influenced by the functions and biosynthesis of amino acids taking place during developmental processes of pollinated and unpollinated silk tissue. Amino acids were actively metabolized in immature cob at early stage of silk emergence in order to regulate the seed growth (Rahman and WanRosli 2014 and Seebauer,.*et al*.,2004).

The crud lipid content of both immature and mature corn red silks in our study was 1.75% and 1.3% respectively, and immature and mature corn yellow silks respectively was 1.5 and 1.37% on the basis of its maturity level immature and matured red silks has higher lipids content than immature and matured yellow color silks. However the matured dried and fresh corn silk from different farming area was collected and the white kernel silk fat contents were 0.9% (Mendoza-López,..*et al*..,2018). According to Nurhanan,*et al* (2013) the immature sweet corn silk and fully ripped corn silk were analyzed and the result of crud lipids contents were 1.27 and 0.66% respectively. Our study was slightly higher than both studies this was may be because of time of maturity level of samples during collection may affect the amount of lipids in silks.

The TDF content of red matured and immature corn silks were 40.22 and 25.51 % respectively, and yellow matured and immature corn silk content of TDF were respectively 36.61 and 23.79%. Matured red and yellow corn silks were higher TDF than immature red and yellow silks. According to Mendoza-López,..*et al*.., (2018). The content of TDF of white kernel silk was 53.3%. On other study the result of immature and matured corn silk content of TDF were 48.5 and 51.24% Nurhanan,.*et al* (2013). These results were higher than amount of matured silks of our study. Even though there was a variation of TDF among studies there may be some difference during sample collection that means the difference of maturity levels of samples; it affects the amount of fiber in the corn silk. Whatever the case corn silks could be considered as a rich source of dietary fiber thus may confer good health benefits.

Mineral composition of the silks of immature and mature parts was varied. The variations could be attributable to the difference cultivar, plant nutrition, climate and soil conditions (Hamurcu,.*et al*., 2010). The distribution of mineral composition is related to certain functions of the plant part during development. Ca is one of essential mineral which is required for structuring of cell wall and membranes, indirectly assists in improving crop yields by reducing soil acidity when soils are limed (Uchida, R. 2000). K ion is very important in biophysical and biochemical functions as it is highly mobile in plants (Szczerba, *et al*., 2009). In stigma, K ion involves in regulation growth of a pollen tube (Holdaway-Clarke and Hepler, 2003; Zienkiewicz, *et al*., 2011). Zn is required in protein synthesis, genetic entities stability and metabolism of carbohydrate and lipid. Mn plays the role as enzymes activator in tricarboxylic acid cycle photosynthetic function photosynthesis, fatty acid and carotenoid synthesis (Uchida,. 2000). Mg is abundant in plant tissue and is associated with a wide range of cellular functions including photosynthesis, protein synthesis which involves in ribosomal structures and functions (Maathuis, 2009). Fe is essential in the heme-enzyme system in plant metabolism (photosynthesis and respiration). The enzymes involved include catalase, peroxidase, cytochromeoxidase, and other cytochromes and has been strongly associated with protein metabolism (Uchida, 2000). Both lime and nickel applications influenced plant growth, reducing plant development with increased nickel application without liming. It was also observed that both lime and nickel applications altered micronutrient levels in the maize plants, independent of which part of the plant was evaluated. Nickel played an antagonistic role with manganese and zinc and a synergistic role with copper and iron (Torres, *et al*,..2016).

In this study the amount of Ca, Mg and Na were higher in matured (30 days) corn silk, but K was higher in immature (3 days) silk. Cu and Zn were higher in matured corn silk and Mn was higher in immature corn silk in comparison there is no significant difference in iron content between immature and mature corn silk. Generally in this study K had the highest amount of mineral in both silks.

According to Rahman and WanRosli (2014), immature silk was a richer source of Ca, Mg, Cu and Zn than mature silk, while other minerals such as K, Na, Fe and Mn were found to be in a higher amount in mature silk. Generally, silk is a very rich source of K. The minerals contents of 5 days after emergence and 25 days after emergence purple, green, pinky, and yellow color corn silk were collected and computed the finding shows highest amount of K were found in 5 days after emergence corn silk than 25 days corn silk but Na, Ca and Mg were higher in 25 day emergence silk (Žilić, *et al..,* 2016). It can be observed that the mineral content depends on silk maturity stage, if it was collected from fully matured corn silk or after development of seed the important elements due to formation of seed become decreased.

According to results of Velazquezd,.*et al*. (2005) and *Kuma*r,*et al.., (2013)* the diuretic effect of corn silk was attributed to its high K content. In addition to this effect, which was accompanied by increased excretion of Na and K from the body, K has been reported to attenuate vascular contractions and to reduce the elevated blood pressure. Humans require large amounts of K, Mg and Ca in their diet, and K is generally consumed in adequate amounts. Given the Mg and Ca deficiencies are common in many developed and developing countries, our results indicate that matured silks stage are much more suitable for use as a source of these micro- and macro minerals than silks at silking stage.

According to Karuppuchamy & Selvakumar,(2011), phytochemical constituents, free radical scavenging activity and total antioxidant activity of various extracts of corn silk were carried out in different studies. Phytochemicals were extracted from corn silk using various solvents such as benzene, chloroform, ethanol, ethyl acetate, methanol and petroleum ether. Screening of phytochemicals showed positive results for the presence of flavonoids, alkaloids, phenols, steroids, glycosides, carbohydrates, terpenoids and tannins. Phytochemicals were extracted best in methanol.

Free radical scavenging activity was determined using DPPH assay as DPPH is a stable antioxidant. Methanolic extract was found to have maximum DPPH scavenging activity 95.5% and lowest chloroform 44.2% and total antioxidant activity of methanol 82.5mg/ml and the lowest 45.5mg/ml ethyl acetate. These activities may be due to the presence of flavonoids, alkaloids, phenols, steroids, glycosides and tannins in corn silk. There are primary factors influencing the variability of phytochemicals in plants comprising genotype, size and maturity, soil conditions, fertilization, irrigation, pesticide utilization, disease and pests, location and climate, and season (Solihah, 2012).

In this study we also used methanol to extract total phenolics, and total flavonoids content; as shown in Tab.3 the total phenolic contents in red matured and immature were 1.36 and 1.98mgGAE/100gm and the total flavonoid contents were 3.79 and 3.96mgCE/100g respectively. Similarly the yellow matured and immature corn silk contents of total phenol were 1.34 and 2.1mgGAE/100gm and flavonoid content were 2.93 and 3.25mgCE/100g respectively. Among the samples we found that better amount of total polyphenol and total flavonoid in immature yellow and red silks than matured yellow and red silks.

According to Alam,. (2011) Upper parts of Egyptian corn silk (dark brown parts, exposed to the air) and lower parts (light yellow parts, not exposed to the air) were used then, the upper parts corn silk contain more amounts of these phytochemicals 180 μg GAEs/g and 119.47 μg/g respectively than lower parts of corn silk 151.33 μg GAEs/g and 101.66 μg/g respectively.

According to Mendoza-López,,*et al*,.,(2018). Silks from all the variants of the landrace Cónicokernel of (red, dark red and white brown dent) had about 10-fold more phenolic compounds than silks from white dented or yellow-dented maize, the amount of phenolic and flavonoid contents of silks from white dent was 2.4 GAE and 0.493QE respectively. A study conducted in Thailand reported that silks from purple maize had twice polyphenol content than those from yellow maize and five times more than silks from white maize (Sarepoua, *et al*., 2015). A study conducted in Belgrade, Serbia reported that total flavonoid contents of 5 days after emergence and 25 days after emergence purple, green, pinky, and yellow color corn silk were collected and computed, the finding shows highest amount of total polyphenol, total flavonoid and chlorophyll were found in 5 days after emergence corn silk than 25 days corn silk (Žilić.,*et al*..,2016).

Even though flavonoids play a significant role in various stages of plant growth and their existence in the environmental stresses, like scavenging reactive oxygen species and fight continuously against polluted atmosphere and responsible for unique colors of flowers and fruit which are necessary for pollination and subsequently fruit dispersion in different places and thus help in reproduction (Samanta, & Das, 2011).

Flavonoids were active against eleven bacteria out of twelve bacteria but were not sensitive against Escherichia coli and Candid albicans. When compared with gentamycin, which was active against all the bacteria tested. Flavonoids showed significantly ($p<0.05$) higher sensitivity against a number of bacteria than gentamycin (Nessa, &Mohamed, 2012).

Maturity stage may influence accumulation of bioactive compounds. In such case, older plant having lower extract recovery than the immature ones had has also been observed in tea leaves extracts (Farhoosh, *et al*., 2007 and Rahman and WanRosli, 2014). So it is better to take the corn silks at immature stage than matured.

Antioxidant extract acts as hydrogen donors to DPPH free radical thus inhibits oxidation process. Polyphenols include many classes of compounds (phenolic acids, flavanols, xanthones, kaempferol etc.) and act as free radical scavengers. Flavonoid which is the major class of polyphenols exhibits strong antioxidant capacities (Fraga and Oteiza, 2011).

In the present work as shown in table-3 the immature corn silk had higher polyphenol and flavonoid content than the matured corn silk, and the cumulative effect indicates the immature silk had higher content of DPPH than that of the matured corn silks. These showed the highest free radical scavenging activities were observed in immature corn silk.

Antioxidant activity of ethanolic extract of both upper parts of corn silk (dark brown parts, exposed to the air) and lower parts (light yellow parts, not exposed to the air) was determined spectrophotometrically using total antioxidant activity and DPPH scavenging activity methods. Regarding DPPH scavenging activity, it was found that upper parts were found to have the highest DPPH scavenging activity IC50 = 0.704 mg/ml were as the lower parts IC50 = 1.001mg/ml (Alam, 2011). These results match morphological differences "in color" between upper darker parts and lower lighter parts of corn silk, (Stapleton and Walbot, 2009)

According to Mendoza-López,..*et al*,.,(2018).The antioxidant activity of maize-silks extracts is primarily attributed to the presence of phenolic compounds such as flavonoids and tannins. Whereas, the concentration of anthocyanins contributes to the antioxidant activity of maize-silks extracts but not significantly (Sarepoua, *et al*,., 2013).

The red maize silks which had the highest polyphenol, flavonoid and anthocyanin content did not exhibit the highest antioxidant activity (EC50 = 216 μg mL−1). Furthermore, the brown silks from white maize had a higher antioxidant activity than silks from red maize, even with a concentration of polyphenols 10-fold lower (Mendoza-López, *et al*,.,2018). Macromolecules such as polysaccharides strongly interact with phenolic compounds, binding non-covalently with the hydroxyl groups attached to the ring structure of phenolics, which are mainly responsible for the antioxidant efficiency of flavonoids (Landete, 2012).

Flavonoids and other phenolics can protect maize DNA from the induction of ultraviolet radiation damage, since upper parts of corn silk were exposed to sun more than lower parts, so accumulation of phenolics, and flavonoids in upper parts of corn silk more than their corresponding in lower parts can be considered as a defensive mechanism in the plant (Alam, 2011).

The antioxidant capacity has decreased during maturity stage and this may be associated with apparent decrease in the total polyhenols and flavonoid contents as compared to the immature part. As the plant grew older, new biosynthesis of polyphenols may interrupt or end thus decrease the content of polyphenols. The reduction of polyphenol content has also been attributed by oxidation of polyphenols during the maturity stage (Shwartz,.*et al*., 2009). Due to different reasons the antioxidant effects of corn silks were higher during the immature level so better to take before the corn silks were matured.

Plants generally contain anti- nutrients acquired from fertilizer and pesticides and several naturally occurring chemicals. Some of these chemicals are known as ‘‘secondary metabolites’’ and they have been shown to be highly biologically active. They include saponins, tannins, flavonoids, alkaloids, trypsin (protease) inhibitors, oxalates, phytates, haemagluttinins (lectins), cyanogenic glycosides, cardiac glycosides, coumarins and gossypol. The list is inexhaustible. Some of these plant chemicals have been shown to be deleterious to health or evidently advantageous to human and animal health if consumed in appropriate amounts after adequate processing (Emire..,*et al*.., 2013).

Tannins, commonly referred as tannic acid, have been reported to be responsible for decreases in feed intake, growth rate, feed efficiency, net metabolizable energy, and protein digestibility in experimental animals. However, many researches indicated that the major effect of tannins was not due to their inhibition on food consumption or digestion but rather the decreased efficiency in converting the absorbed nutrients to new body substances. The anticarcinogenic and antimutagenic potentials of tannins may be related to their antioxidative property, which is important in protecting cellular oxidative damage, including lipid peroxidation (Ozcan,.,*et al*., (2014).

As shown in Tab 3 the tannin contents of immature red and yellow corn silks had 9.63 and 6.05mg/100gm respectively which were significantly higher than matured red and yellow corn silk, 3.43 and 1.71mg/100gm respectively. It shows when the silks going to be matured the tannin contents would be decreased.

When we compare with a study was conducted by taking Corn from Pasar Siti Khadijah in Kota Bharu. The variety used was vegetable corn. It was harvested during aged 45-50 days. The hair generally emerged 5-7 days before harvested. The result of methanolic extract was amounted 4.03mg/100gm of TAE (Solihah,..*et al*,.,2012). Our study result was higher than this study.

According to Khandelwal,..*et al*..,(2010). Soaking, germination and pressure-cooking proved to be effective household strategies to reduce the levels of polyphenols and tannins in pulse-based foods, thereby enhancing the bioavailability of pulse protein. There is a need to determine the extent to which the remaining polyphenols and tannins are rendered unavailable by these processing techniques.

For medicinal purpose CS is harvested just before pollination occurs and can be used in fresh or dried form (Hasanudin,.*et al*,2012). So the immature samples that we harvested before pollination was more important than matured samples. As shown in Tab 6 there were no a significant difference in the overall acceptability of the immature and matured corn silk tea samples; this was may be because of the maturation level of corn silks and other external factors affect nutritional and antioxidant activities and its property .

6 . CONCLUSION

In conclusion, both immature and mature red and yellow silks could be considered as good source of nutritional and antioxidant properties. The immature red and yellow silks contained significantly higher content of moisture ($P < 0.05$) than the mature red and yellow silks. Lipid and protein content was not significantly different between matured and immature red and yellow silks. The composition of ash and total dietary fiber were higher in matured red and yellow than immature red and yellow, but carbohydrate were higher in immature red and yellow than matured red and yellow silks.

Immature red and yellow silks contained significantly higher level of K and Mn than matured red and yellow silks while other minerals such as Ca, Na, Cu, Fe and Zn were significantly higher in the mature red and yellow silks than immature silks ($P < 0.05$).

High amount of flavonoid and phenolic compounds were in immature red and yellow corn silks than matured red and yellow silks these were leading to an antioxidant activity in the extract. Immature corn silk has shown good antioxidant activities with the methanolic extract showing excellent antioxidant properties in all free radical scavenging. Therefore, immature corn silk could be considered as a potential source of antioxidant to benefit the food and health industries than matured silk.

In DPPH scavenging properties of EC50 immature red and yellow corn silks were higher than matured red and yellow corn silks.

Amount of tannins were higher in immature red and yellow corn silks than matured red and yellow corn silks.

Due to their high antioxidant activity of corn silks, our research indicates a possibility to produce corn silks extract tea in comparison to a standard black and green tea. The sensory analysis result indicated that all corn silk extract tea were acceptable by the panelists comparing with the control. Therefore using this tea may be helpful for therapy of diseases caused by oxidative stress. High level of potassium in immature corn silk associated with diuretic effect.

7 . RECOMMENDATION

- Ethiopians farmer do not have knowledge about the nutritional and antioxidant values of corn silk so they discard the silk out of the husks and put in garbage. This study focused on the white corn silks it contained high amount of nutritional value and antioxidant properties. According to Mendoza-López,..*et al*,.,(2018) the white corn silk has less in antioxidant effect than red, dark red, brown and yellow color corn silks. Our farmer can't plant the different color of kernel because of these we loss important nutrients and antioxidant effects from silks of the corn. So it is better to plant different color types of corn in order to improve our heath by using these silks of the corn.
- According to the panelist sensory acceptability of corn silk tea was better than green tea so drinking immature and matured corn silk tea to alleviate some stress causing diseases.
- Recommend the tea processing industries to use corn silk as one ingredient or type to produce tea for their consumers.
- Further studies should be conducted on the isolation of chemical structure that can provide the necessary component as a radical scavenger and a potent source of natural antioxidants used as dietary supplements, as well as ingredients for functional foods.

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APPENDICES

Appendix 1

INFORMED CONSENT FORM FOR SENSORY EVALUATION PANELISTS TO PARTICIPATE IN:

Descriptive Analysis for corn silk tea product Study

Dear panelist, you are invited to participate in a study involving corn silk tea evaluation. The overall objective of this study is to develop a descriptive list of terms for the tea to be tested. This product will be evaluated using a sensory evaluation method known as descriptive analysis. You will be oriented to identify, name and classify a range of **color**, **taste, flavor** and **aroma** characteristics of these samples. You will be asked to taste and expectorate the samples, and to rate the samples for intensity of each characteristic. If you have prior experience of any allergic reactions to tea product, you should not participate in this study. If you experience allergic reactions any time during the study, you should discontinue the study. There is no direct benefit to you for participating in this study. You are free to withdraw from the study at any time and for any reason. We also reserve the rights to terminate your participation of the study at any time and for any reason.

Your performance and data in this research is confidential. Responses are coded to be confidential and any publications or presentation of the results of the research will only include information about group performance.

You are encouraged to ask any questions that you might have about this study whether before, during, or after your participation. Questions can be addressed to Mr. Mersha W/gebrail (+251921018095, mershawg@gmail.com).

I understand the above information and voluntarily consent to participate in the study described above. I have been given a copy of this consent form.

____

Signature   Date

Appendix 2

Hedonic test

Dear panelist, you are invited to participate in a study involving corn silk tea evaluation. Please taste the samples in the order presented, moving from top to bottom and rank them in level of score given in the table. (Put '**X**' sign on the Box) code____________

501

Hedonic Scale rating	**Color**	**Taste**	**Aroma**	**Flavor**	**Over all acceptability**
Like extremely					
Like very much					
Like moderately					
Like slightly					
Neither like nor dislike					
Dislike slightly					
Dislike moderately					
Dislike very much					
Dislike extremely					

786

Hedonic Scale rating	**Color**	**Taste**	**Aroma**	**Flavor**	**Over all acceptability**
Like extremely					
Like very much					
Like moderately					
Like slightly					
Neither like nor dislike					
Dislike slightly					
Dislike moderately					
Dislike very much					
Dislike extremely					

742

Hedonic Scale rating	**Color**	**Taste**	**Aroma**	**Flavor**	**Over all acceptability**
Like extremely					
Like very much					
Like moderately					
Like slightly					
Neither like nor dislike					
Dislike slightly					
Dislike moderately					
Dislike very much					
Dislike extremely					

503

Hedonic Scale rating	**Color**	**Taste**	**Aroma**	**Flavor**	**Over all acceptability**
Like extremely					
Like very much					
Like moderately					
Like slightly					
Neither like nor dislike					
Dislike slightly					
Dislike moderately					
Dislike very much					
Dislike extremely					

775

Hedonic Scale rating	Color	Taste	Aroma	Flavor	Over all acceptability
Like extremely					
Like very much					
Like moderately					
Like slightly					
Neither like nor dislike					
Dislike slightly					
Dislike moderately					
Dislike very much					
Dislike extremely					

797

Hedonic Scale rating	Color	Taste	Aroma	Flavor	Over all acceptability
Like extremely					
Like very much					
Like moderately					
Like slightly					
Neither like nor dislike					
Dislike slightly					
Dislike moderately					
Dislike very much					
Dislike extremely					

Appendix 3

Hedonic rating scale

Tea characteristics: aroma, taste, color and flavor

Score value assigned

Like extremely = 9 Like very much= 8 Like moderately=7 Like slightly=6Neither like nor dislike=5 Dislike slightly = 4 Dislike moderately= 3Dislike very much =2 Dislike extremely = 1

Tester

Characteristics	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total score	Average score
Aroma																	
Taste																	
Color																	
Flavor																	
Total																	

<u>Code of tea</u>

Black tea --------- 501

Green tea ------- 503

YIM----------------742

YM-----------------775

RIM----------------776

RM-----------------797

Appendix 4

Sensory evaluation of corn silk tea

Corn silk tea color in comparison with the control

Panelist in the hall