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Effect of blanching and drying on micronutrients and anti-nutritional factors in false sesame and common bean leaves

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EFFECT OF BLANCHING AND DRYING ON MICRONUTRIENTS AND ANTI-NUTRITIONAL FACTORS IN FALSE SESAME AND COMMON BEAN LEAVES

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A Dissertation Submitted in Partial Fulfilment of the Requirements for the Degree of Master's in Life Sciences of the Nelson Mandela African Institution of Science and Technology

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ABSTRACT

The effects of blanching and drying on micro-nutrients: β-Carotene, Vitamin C, Folic acid, Iron (Fe), Zinc (Zn), Phosphorus (P) and anti-nutrients: Tannins and Oxalates composition of False Sesame Leaves (FSL) and Common Bean Leaves (CBL) were investigated. Vegetables consumption and preservation technologies used were assessed using questionnaire. Micronutrients content: β-Carotene, Vitamin C, and folic acid were analyzed using HPLC method while Fe, Zn were determined using Atomic Absorption Spectrophotometer (AAS) and Phosphorus was determined using UV-VIS Spectrophotometer. The oxalate and tannin were determined by titration and Folin Ciocalteu method. Several vegetables consumed were identified, FSL (16.9%) (Bahi) and CBL (21%) (Mbeya rural) were one of those. In vegetable processing, boiling (76.9%) and sun drying (15%) were reported in Bahi and Mbeya Rural Districts, respectively. Sun drying was the commonly used method in both Districts. Folic acid and β- Carotene were below detection limits in both vegetables. The vitamin C content in fresh FSL and CBL was 16.28 and 5.48 mg/ 100g, respectively, yet the content was significantly reduced ($p<0.05$) by blanching and sun drying. False sesame leaves contained P (700 mg/kg), Fe (115.75 ± 2.23 mg/kg) and Zn (14.13 mg/kg) whereas in CBL P was 600 mg/kg Fe (652.76 mg/kg) and Zn (41.04 ± 0.28 mg/kg). Levels of P, Fe and Zn were significantly ($p<0.05$) increased by sun drying. Tannin and oxalate content in blanched and sun dried leaves were lower than in fresh leaves. Sun drying of FSL and CBL while covering after blanching further reduced tannins and oxalates, thus it is recommended as an effective method in anti-nutrients elimination.

DECLARATION

I, Agness Kandonga, declare to the Senate that this thesis is my own original work. It is being submitted for the Master's degree in Life Sciences, Nelson Mandela African Institution of Science and Technology. It has not been submitted for any degree or examination at any other University.

Signature …….. Date: ……

Agness Kandonga

The above declaration is confirmed by:

Signature …….. Date: ……...

Dr. Athanasia O. Matemu (Supervisor 1)

Signature …….. Date: ……..

Dr. Edna E. Makule (Supervisor 2)

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CERTIFICATION

The undersigned certify that they have read and hereby recommend for acceptance by the Nelson Mandela African Institution of Science and Technology (NM-AIST) a dissertation entitled “Effect of blanching and drying on micronutrients and anti-nutritional factors in False sesame and Common bean leaves”, in fulfillment of the requirements for the degree of Master’s in Life Sciences of the Nelson Mandela African Institution of Science and Technology.

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Dr. Edna E. Makule

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DEDICATION

I dedicate this dissertation to my family; my father Charles Kandonga, my mother Rose Kandonga and my siblings Frank, Joseph, Elisha and Heavenlight. Thank you for having trust in me, I will always cherish your presence in my life.

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LIST OF ABREVIATIONS

AAS	Atomic Absorption Spectrometry
AOAC	Association of Official Analytical Chemists
ATONU	Agriculture To Nutrition
Ca	Calcium
CBL	Common Bean Leaves
Fe	Iron
FSL	False Sesame Leaves
HPLC	High Pressure Liquid Chromatography
ICP-MS	Inductively Coupled Plasma Mass Spectrophotometer
K	Potassium
Mg	Magnesium
MS	Mass Spectrometry
N	Sodium
P	Phosphorus
POD	Peroxidase
SPSS	Statistical Package for Social Sciences
UNICEF	United Nations Children's Fund
Zn	Zinc

CHAPTER ONE

INTRODUCTION

1.1 Background Information

False sesame (*Ceratotheca sesamoides* Endl.) leaves (FSL) and Common bean (*Phaseolus vulgaris* L.) leaves (CBL) make an imperative part of the diet of people in Central and Southern zone of Tanzanian. These vegetables are famous due to their indignity and availability in these respective areas. False sesame and CBL contain vitamins and minerals (Barros and Prudencio, 2016; Fasakin, 2004), that enrich the human body including protection against diseases, such as anemia, scurvy, night blindness and others. Prior to consumption, FSL and CBL are subjected to a number of processing techniques, such as blanching and drying for preservation purposes. Blanching process is important since it helps in inactivation of enzymes, which may cause changes in flavour, texture and colour of the vegetables during storage as well as reducing anti-nutritional factors (Egbuonu and Nzewi, 2016; Mosha *et al*., 1995; Xiao *et al*., 2017). Drying as one of preservation techniques increases the shelf life of vegetables by creating unfavourable condition for microbial growth (Kiharaso *et al*., 2017). Notwithstanding the mentioned benefits, processing methods may positively or negatively influence nutrients content of vegetables. In Miglio *et al*. (2008), slightly increase of carotenoids (14%) with boiling treatment has reported while drying resulted in micronutrients loss (Yakubu *et al*., 2012). Its loss is associated with the sensitivity to heat, light, oxygen, pH of the solvent and/or combinations of all these (Lee and Kader, 2000). In addition to that, FSL and CBL seem to contain anti-nutritional factors such as tannin and oxalate that may affect the bio-availability of the nutrients.

Despite the fact that, these vegetables are locally available and may contribute in combating micronutrients deficiencies, Fe and vitamin A deficiency are still prevailing in Bahi and Mbeya rural Districts (URT-MoHCDGEC, 2015). In addition, evaluation of micronutrient and anti-nutritional content of the vegetables in the districts have not yet been documented. Moreover, the effects of the processing methods on the chemical compositions of CBL and FSL at household level have not been investigated and documented. Therefore, the study was carried out to evaluate the effect of processing methods on vitamin A, B_9, C, Fe, Zn and P, tannin and oxalate in FSL and CBL.

1.2 Problem Statement and Justification

Tanzania is amongst the developing countries with large population reported to suffer from micronutrient deficiencies mainly vitamin A, zinc and iron. According to URT-MoHCDGEC (2015), overall 58% of children (6-59 months), 45% of women of reproductive age (15 - 49) are anaemic. From the UNICEF conceptual framework of malnutrition point of view, micronutrient deficiency is caused by many factors one of them being house hold food insecurity. The common assumption that increasing agriculture and food production will automatically lead to improvements in nutrition is not valid. Contrary to this, 55% of children aged 6 to 59 months were reported to be anaemic in Mbeya region 2015 (URT-MoHCDGEC, 2015) despite Mbeya being a leading producer of food crops including vegetables in Tanzania. In the other hand 48% of children aged 6 to 59 months were reported to be anaemic in Dodoma region (URT-MoHCDGEC, 2015). Various factors may be linked with micronutrients deficiencies in the vegetables. The common ones are associated with home based processing methods used, nature of the soil where vegetables are grown also presence of anti-nutritional factors. Therefore, efficient and effective home based vegetable processing methods need to be identified in order to ensure maximum nutrients retention in processed food.

1.3 Objectives

1.3.1 Main Objective

The main objective of this research study was to assess the effect of blanching and drying on the micronutrients and anti-nutritional factors in FSL and CBL found in Bahi (Dodoma) and Mbeya rural (Mbeya), Tanzania.

1.3.2 Specific Objectives

(i) To study the local practices on the vegetable use, processing and preservation in Bahi and Mbeya rural Districts.

(ii) To assess the nutritional and anti-nutritional contents of FSL and CBL in Mbeya rural and Bahi Districts

(iii) To evaluate the effect of blanching and drying on micro nutrients and anti-nutrients content of FSL and CBL.

1.4 Research Questions

(i) What are the local practices on the use, processing and preservation of leafy vegetables?

(ii) What are micronutrients and anti-nutritional content in raw FSL and CBL?

(iii) How does blanching and drying affect the composition of FSL and CBL?

1.5 Significance of the Study

The study will provide vital information on the nutrient and anti-nutrients composition of FSL and CBL which are limited. This will increase awareness and encourage the consumption and utilization of these low-priced sources of not well-known food items seasonally; hence help to improve food security. The study will also assist in establishing the superlative processing methods with higher nutrient retention for FSL and CBL. Finally, this study will generate information that can be useful for program planners/policy makers working on nutrition intervention measures in Tanzania as to which part to focus on; food production, processing or both.

CHAPTER TWO

LITERATURE REVIEW

2.1 Vegetable Samples Descriptions

2.1.1 *Ceratotheca sesamoides* Endl.

(i) Plant

False sesame (*Ceratotheca sesamoides* Endl.) (Fig. 1) is an annual herbaceous plant belonging to the family Pedaliaceae (Fasakin, 2004). The plant predominantly exists in Africa, Indo Malayan region and tropical Australia (Fasakin, 2004). It has sixteen (16) genera and sixty (60) species. False sesame is the tropical annual plant growing up to 1.2 meters tall, sometimes with a woody rootstock (Fasakin, 2004). Growth can be upright, but the stems are normally horizontal with each plant producing 10 or more stems scrambling along the ground (Fasakin, 2004). A popular vegetable in many parts of Africa including the central zones of Tanzania, where the plant is often harvested from the wild for local use of its edible seeds and leaves as well as its medicinal virtues (Fasakin, 2004). Leaves and fruits are also eaten whole or in parts either raw or cooked. Sesames family were reported to be a good source of protein, oil, vitamins and minerals (Fasakin, 2004).

Figure 1: False sesame plant A and flowers B (Own Data, 2018).

(ii) Utilization of *Ceratotheca sesamoides* Endl. leaves

False sesame leaves are widely spread in Africa, some are planted while others grow by themselves in the forest (Fasakin, 2004). False Sesame Leaves are a famous indigenous vegetable in Dodoma, Central Tanzania consumed as a leafy vegetable. According to Denton

and Schippers (2004) leaves and flowers of false sesame are consumed as a vegetable. They are good source of protein, fat, carbohydrate and minerals such as Ca, P and Fe. Not only that, the seeds are also rich in vitamin B group such as, riboflavin, thiamin and niacin (Stadlmayr *et al*., 2012). The oil extracted from the seeds is similar in composition to sesame oil. It contains phenyl propanoid lignan sesamin, which showed cytotoxic (including anti-tumor) Antihypertensive, anti-inflammatory, insecticidal activities and antioxidant (Denton *et al*., 2004). Leaves are steeped in water and the slimy liquid dropped into the eyes to treat conjunctivitis. Also, macerated leaves eases delivery in both humans and animals (Denton *et al*., 2004). Moreover, false sesame has been reported to have aphrodisiac, effects against jaundice, snakebites and skin illnesses (Bedigian, 2003). Paradoxically, in spite of all the benefits provided by this plant, no study has been done to assess their quality and the effect of processing methods on their chemical composition in Tanzania. An effort is obligatory to determine the chemical composition, quality and benefits of using these plants and to stimulate interest in their utilization beyond the traditional localities as they are effective supplements to the starchy staple foods which are usually consumed while mimicking the effect of processing methods used.

2.1.2 *Phaseolus vulgaris* L.

(i) Plant

The Common bean (*Phaseolus vulgaris* L.) (Fig. 2) is a major grain legume consumed worldwide for its edible seeds and pods. It is a highly polymorphic warm-season, herbaceous annual (Peter *et al*., 2013). Bean Leaves can be a source of proteins, vitamins (thiamine, riboflavin, niacin, vitamin B_6 and folic acid), dietary fiber (14 - 19%) (particularly soluble fiber), minerals (Ca, Fe, Cu, Zn, P, K and Mg) and unsaturated fatty acids (Barros and Prudencio, 2016). Also, they are associated with protection against cardiovascular diseases, diabetes, obesity, colon cancer and other degenerative diseases (Barros and Prudencio, 2016). Information on how beans leaves are processed prior to consumption are limited, locally most of people boil them for quite sometimes and discard the boiling water due to its bitterness. As a method of preserving it, they dry them under direct sunlight or blanch them for some time, dry and store them in buckets.

Figure 2: Common bean plants (*Phaseolus vulgaris*) (Own Data, 2018).

(ii) Utilization of *Phaseolus vulgaris* leaves

Common bean plant is well known for several benefits apart from it being the most consumed legume as the main protein of poor community. Common beans are rich in vitamins such as B group though is small amount, minerals such as calcium, potassium, iron and fibres (Barros and Prudencio, 2016). Beans are said to be used as anti-acne, bladder, burns, cardiac, carminative, depurative, diabetes, diarrhea, diuretic, tenesmus, dysentery, eczema, emollient, hiccups, itch, kidney, sciatica, rheumatism , and dropsy, diabetes and obesity problems (Estelle *et al*., 2018; Zainish *et al*., 2016). Only few communities such as of the Southern Highland of Tanzania consume CBL as an indigenous vegetable due to limited knowledge present concerning its nutrition and anti-nutritional factors; also toxic compounds that may affect their health. Common bean leaves are highly known and consumed by a large number of people as a vegetable.

2.2 Nutritional Composition of FSL and CBL

According to Fakasan (2004) on the study of proximate composition of bungu (*Ceratotheca sesamoides* Endl.) in leaves and seeds, the presence of minerals such as calcium, phosphorus and potassium was reported. Apart from that, FSL contain a number of vitamins. It has been documented that, raw FSL contain vitamins, such as niacin, riboflavin, folate and vitamin C. However, it is in minimal amount (Stadlmayr *et al*., 2012). Similar study conducted by Makinde and Akinoso (2013) on the nutrient composition and effect of processing treatments on anti-nutritional factors of Nigerian sesame (*Sesamum indicum* Linn) cultivars, which is in

the same family with False sesame, revealed the presence of fibres, and minerals, such as calcium, potassium and phosphorus. On other hand, bean leaves have been reported as a good source of vitamins, such as vitamin A, but also minerals such as, Fe and Zn (Emmanuel, 2014).

2.3 Effects of Processing on Individual Nutrients of Public Health Concern

Micronutrients deficiency such of iron, vitamin A, Zinc and folic acid are of public health concern since they affect population at large. These nutrients (including P) are required by our bodies in small amounts but their deficiency has significant consequences for our wellbeing, growth and development.

2.3.1 β-carotene

Beta-carotene *(a form of v*itamin A) is essential in maintaining healthy eyesight and immune system functions. Beta-carotene deficiencies lead to increased risk of blindness and death from infections such as measles and diarrhea to children (Bhan *et al*., 2001; Nkafamiya *et al*., 2010). Carotenoids are highly sensitive to light but also cooking processes such as steaming and frying. According to Miglio *et al*. (2008) boiling, steaming and frying, methods had a small but significant effect on total carotenoids. It showed that boiling had a slight increase of the initial concentration of carotenoids specifically lutein while 34 and 43% of carotene initial concentration was lost during steaming and frying, respectively.

2.3.2 Folic Acid (Vitamin B_9)

Folic acid is water soluble vitamin essential for the earliest stage growth and development of the brain, spinal cord, and skull. Folic acid deficiency resulting to serious birth defects termed as Neural Tube Defects (NTDs). Additionally, the vitamin is associated with protection against degenerative diseases such as cardiovascular diseases and certain cancers (Choi and Mason, 2000). As other water soluble vitamins, it can dissolve certainly into the water, but also degraded with thermal processing treatments. As reported by McKillop *et al*. (2002), folic is described to be sensitive to heat and oxidation, and abrupt loss after different treatments such as blanching or heating of vegetables or model solutions containing it.

2.3.3 Vitamin C

Vitamin C is a water soluble vitamin required for healthy skin, bones and muscles. Vitamin C plays a vital function in manufacturing collagens, the connective tissue that holds bones

together, also activation of enzymes (Nkafamiya *et al.*, 2010; Singh and Harshal, 2016). Additionally, it has antioxidant functions thus provides protections against cancers (Singh and Harshal, 2016). Vitamin C deficiency may result in scurvy (bleeding gums). Vitamin C is among most sensitive nutrients affected by heat, but also leaches out when it comes into contact with water. A study conducted by Singh and Harshal (2016) on the effects of cooking on content of Vitamin C in green leafy vegetables reported that Vitamin C is highly sensitive to oxidation and leaching into water during cooking. The nutrient begins to degrade immediately after harvest and degrades steadily during storage and other processes hence it is used in estimating overall nutrients retention in food. The loss of vitamin C in green leafy vegetables is due to the processing method employed in its preparation. The losses observed were high especially when the vegetables were subjected to boiling and microwave heating as compared to blanching. Loss as a result of boiling, microwave heating and blanching can be justified since vitamin C is water soluble and heat labile.

2.3.4 Iron, Zinc and Phosphorus

Minerals are vital for our bodies' growth and metabolism. They cannot be synthesized in our bodies, hence are required to be supplied by food and water consumed (Sharif, 2011). They are required in small amounts, yet their deficiency result to noteworthy effects. Iron deficiency in women and children lead to the development of anaemia while zinc deficiency results in impaired gastrointestinal and immune functions (Hemmige *et al*., 2017; Sharif, 2011). Phosphorus is essential for health bones and teeth, formation of cell structure. Additional to that, as a component of DNA and RNA, phosphorus is involved in the storage and transmission of genetic material; it triggers enzymes, hormones and cell-signaling molecules through phosphorylation (Hemmige *et al*., 2017; Sharif, 2011). Some of processing methods may affect minerals composition with exception to thermal processes (Musa and Ogbadoyi, 2014). According to Ilelaboye *et al*. (2013) Fe as well as other minerals decrease significantly during processing methods such as blanching. The concentration of all the mineral elements analyzed was reduced significantly with blanching treatments (Ilelaboye *et al*., 2013). This loss of nutrients is due to leaching of mineral into blanching water. These findings were in agreement with Mepba (2016) who also observed significant (p<0.05) reductions in K, Na, Ca, P, Fe, content of blanched and cooked tender and matured cassava leaves.

2.4 Anti-nutritional Factors

Anti-nutritional factors are secondary plant metabolites synthesized by plants as a part of defense against herbivorous, insects and pathogens attack or as a means to survive in adverse growing conditions (Bora, 2014). Anti-nutritional factors take account of saponins, tannins, flavonoids, alkaloids, trypsin (protease) inhibitors, oxalates, phytates, haemagluttinins (lectins), cyanogenic glycosides, cardiac glycosides, coumarins and gossypol (Kiranmayi, 2014). Anti-nutritional factors can be categorized into different groups according to their impact; (a) Factors that affect protein digestibility and utilization such as protease inhibitors, tannins, saponins and lectins; (b) factors that affect mineral utilization such as phytates, gossypol pigments, oxalates and glucosinolates; (c) factors that stimulate the immune system and may cause a damaging hypersensitivity reaction, such as antigenic proteins; (d) factors with a negative effect on the digestion of carbohydrates, such as amylase inhibitors, phenolic compound and flatulence (e) factors; miscellaneous substances, such as mycotoxins, mimosine, cyanogens, nitrates, alkaloids, photosensitizing agents, phyto-oestogens and sponins.

Information on anti-nutritional composition of tannin and oxalate are limited. However, different scholars reported the presence of anti-nutritional factors in leafy vegetables. The study done by Essack *et al*. (2017) and Ilelaboye *et al*. (2013), reported anti-nutritional factors such as tannins, phytic acid, alkaloids, oxalic acid, and cyanogenic glycoside in thirteen varieties of vegetables including; *Amaranthus dubius, Amaranthus hybridus, Asystasia gangetica, Bidens pilosa, Ceratotheca triloba, Chenopodium album, Emex australis, Galinsoga parviflora, Guilleminea densa, Momordica balsamina, Oxygonum sinuatum, Physalis viscosa and Solanum nigrum.*

2.4.1 Effects of Various Processing Methods on Anti-nutritional Factors

It has been reported that, different processing methods have significant effects in reducing anti-nutritional factors contained in leafy vegetables. Study by Musa and Ogbadoyi (2012) reported the significant reduction of cyanide, nitrate and oxalate with cooking treatment. Similar to the study by Ilelaboye *et al*. (2013), which reported also the reduction in phytate, oxalate, saponin, tannin and cyanide contents of the vegetables, respectively due to cooking methods (cooking without blanching and cooking after blanching).

2.5 Effects of Processing Methods

2.5.1 Blanching

Blanching is the brief boiling or steaming of whole foods like fruits and vegetables to inactivate the enzymes that would otherwise cause unwanted changes to the food during preservation and storage. These changes include loss of colour, flavour, texture and nutrient density. Vegetables are supposed to be blanched before freezing or drying them. While blanching dramatically reduces the rate of nutrient loss from food storage and preservation, it may cause some nutrient loss, particularly a reduction in water soluble nutrients (Xiao *et al*., 2017). A study conducted on blanching of foods and its effects reported decrease in the nutritional value of foods (Odedeji *et al*., 2014). Nutrients leach out from the product sample especially during water blanching, and also vitamins are degraded by heat. Vitamin C (ascorbic acid) is by far the most commonly assayed nutrient in blanching probably because of its high solubility and heat susceptibility making it a conservative indicator of nutrient retention.

2.5.2 Drying

Drying involves reducing or removing of moisture content in such a way that, the product is converted to a new form (Hawlader *et al*., 2006). Drying vegetables can be done for several reasons; mainly, shelf life extension whereas it creates environment which does not support microbial growth, hence it ensures food security, bulk reduction which eases packaging, reduce transportation cost and storage, also increasing varieties (product formulations) (James *et al*., 2018; Jayaraman and Gupta, 2007; Kiharason *et al*., 2017). There are different methods in which drying can be achieved. Such methods include; open sun, oven, microwave, vacuum, steam and dryers such as solar, spouted bed, fluidized bed, infrared, convective, desiccant and others (Chua and Chou, 2003; Kiharason *et al*., 2017; Panyawong and Devahastin, 2007; Sobowale *et al*., 2010). Drying processes do not affect only the quantity of the dried product, but also its quality (physical and chemical). A study by Tsado *et al*. (2015) on the effect of different processing methods on nutrition composition of bitter leaf showed that, sun drying had significant effect on reducing vitamin C (Eggermont, 2006). Similarly, a study by Ekpa *et al*. (2016) argued that despite drying being the cheapest and frequently used method for increasing vegetable shelf life, it is reported to cause detrimental loss of nutrients such as vitamin C and other bioactive compounds. Controlled drying methods such as oven, and dryers showed reduced effects on nutrients reduction (Chua and

Chou, 2003; Kiharason *et al*., 2017), however the cost is still unbearable, hence open sun drying remained an option for the local communities as reported by Ekpa *et al*. (2016).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Materials

The chemicals, reagents and list of equipment used in this study were as shown in Table 1 and 2.

Table 1: Chemicals and reagents

S/N	Name of chemical/Reagent	Manufacturers
1	Folin and Ciocalteu's Phenol reagent (2N)	Loba Chemie Pvt. Ltd. Mumbai,India
2	H_2O_2	Fishers Scientific UK Limited. Leicestershire, UK
3	n- hexane	RFCL limited. Okhla, India
4	Beta carotene standard	(Sigma-Aldrich, USA)
5	Methanol	RFCL limited. Okhla India
6	Acetonitrile	Loba Chemie Pvt. Ltd. Mumbai, India
7	Distilled water	Arusha TECH, Tanzania
8	Dithiothreitol (DDT)	Sigma-Aldrich, USA
9	Vitamin C standard	Sigma-Aldrich, USA
10	Monopotassium phosphate (KH_2PO_4)	SMiTH chemicals, India
11	Phosphoric acid (H_3PO_4)	Loba Chemie Pvt. Ltd. Mumbai, India
12	Phosphate buffer	Fishers Scientific UK Limited. Leicestershire, UK
13	2-mercaptoethanol	Sigma-Aldrich, USA
14	Folic acid standard (Sigma-Aldrich)	Sigma-Aldrich, USA
15	NaOH	Loba Chemie Pvt. Ltd. Mumbai,India
16	Nitric acid (HNO_3)	Loba Chemie Pvt. Ltd. Mumbai,India
17	Hydrochloric acid (HCl)	Loba Chemie Pvt. Ltd. Mumbai,India
18	Sulphuric acid (H_2SO_4)	Loba Chemie Pvt. Ltd. Mumbai,India
19	Acetone	Loba Chemie Pvt. Ltd. Mumbai,India
20	Potassium permanganate (KMn_4).	SMiTH chemicals, India
21	Gallic Acid	Loba Chemie Pvt. Ltd. Mumbai,India
22	Polyvinyl-polypirrolidone (PVPP).	MERCK, SA
23	HPLC water	Finer Limited. Gujarat, India.

Table 2: List of Equipment

S/N	Name of Equipment/ Instrument	Manufacturers
1	pH meter	Orion star A214, Indonesia
2	Orbital incubator (S1600C)	Bibby Scientific Limited, UK
3	Water bath (WBH-200)	MRC Laboratory equipment, Germany
4	Whatman filter paper no 1	Fisher Scientific, UK
5	Magnetic stirrer (SB 161-3)	Bibby Scientific Limited, UK
6	Analytical HPLC machine (Shimadzu LC 10 AVP)	Shimadzu Corporation, Japan
7	Centrifuge (0008-128-10)	Hettich, Germany
8	0.45 µm membrane	Fisher Scientific, UK
9	Analytical weighing balance (PA214)	OHAUS, China
10	Muffle furnace (Cole Parmer Box Furnace-CBFL516C)	Cole-Parmer, U State
11	BIOMATE 6 uv-vis Thermo scientific (UNICO spectrophotometer 2800)	UNICO, USA
12	AAS (UNICAM 919)	TECMEC Limited
13	TopMix FB15024	Fisher Scientific, UK

3.2 Description of the Study Area

This study was carried out in Mbeya rural and Bahi Districts in Mbeya and Dodoma regions, respectively. Two wards in each district (one village from each ward) were purposively selected based on the involvement in Agriculture to Nutrition Project whereas the farmers had been provided with agriculture and nutrition knowledge. The selected villages were: Utengule Usongwe ward; Mbalizi and Nsalala ward; Nsalala village (Mbeya rural District); Bahi ward; Bahi sokoni village and Zanka ward; Mayamaya village (Bahi District) (Fig. 3). Mbeya region is located in the Southern Highlands (latitude 8°54′ S, longitude: 33°27′ E, altitude 1697 m with an average temperature of 20.1 °C and average annual rainfall 1023 mm). Dodoma region is located in the Central zone of Tanzania (latitude 6°10'S, longitude 35°45'E and altitude 1120 m with an average temperature of 22.6 °C and the average annual rainfall of 564 mm in a year). Dodoma is semiarid region hence it mostly experiences drought condition (Ephrahim and Bwagalilo, 2014), food crops including vegetables are grown seasonal and typically likely to be stored for dry season use. Dodoma is experiencing micronutrients deficiency problems with 48% of children aged 6-59 months reported to be anemic (URT-MoHCDGEC, 2015).

3.3 Information on the Local Practices of the Vegetables

Information on vegetable consumption and preservation technologies used by locals were collected using structured questionnaire in the selected villages of Mbeya and Bahi Districts. A total of 74 (Bahi District) and 69 (Mbeya District) informants identified as Agriculture to Nutrition Project (funded by Bill and Melinda Gates Foundation) beneficiaries responded to the questions.

3.4 Vegetable Samples Collection

False Sesame leaves were collected in Bahi District, Dodoma in April, 2018 (Fig. 1). Common Bean Leaves were collected in Mbeya Rural District, Mbeya region in June, 2018 (Fig. 2). To preserve its freshness, the vegetables were kept in zip bags (unzipped) and stored in cooling box with indirect contact with ice cubes and immediately transported to the laboratory for further analysis. Vegetable samples were identified and authenticated by botanist at the Tropical Pesticides Research Institute (TPRI) Arusha, Tanzania under identification voucher "ACK 01 for False Sesame and ACK 02 for Common Bean", respectively. The vegetables were selected based on its indignity in its locality area (Bahi and Mbeya rural).

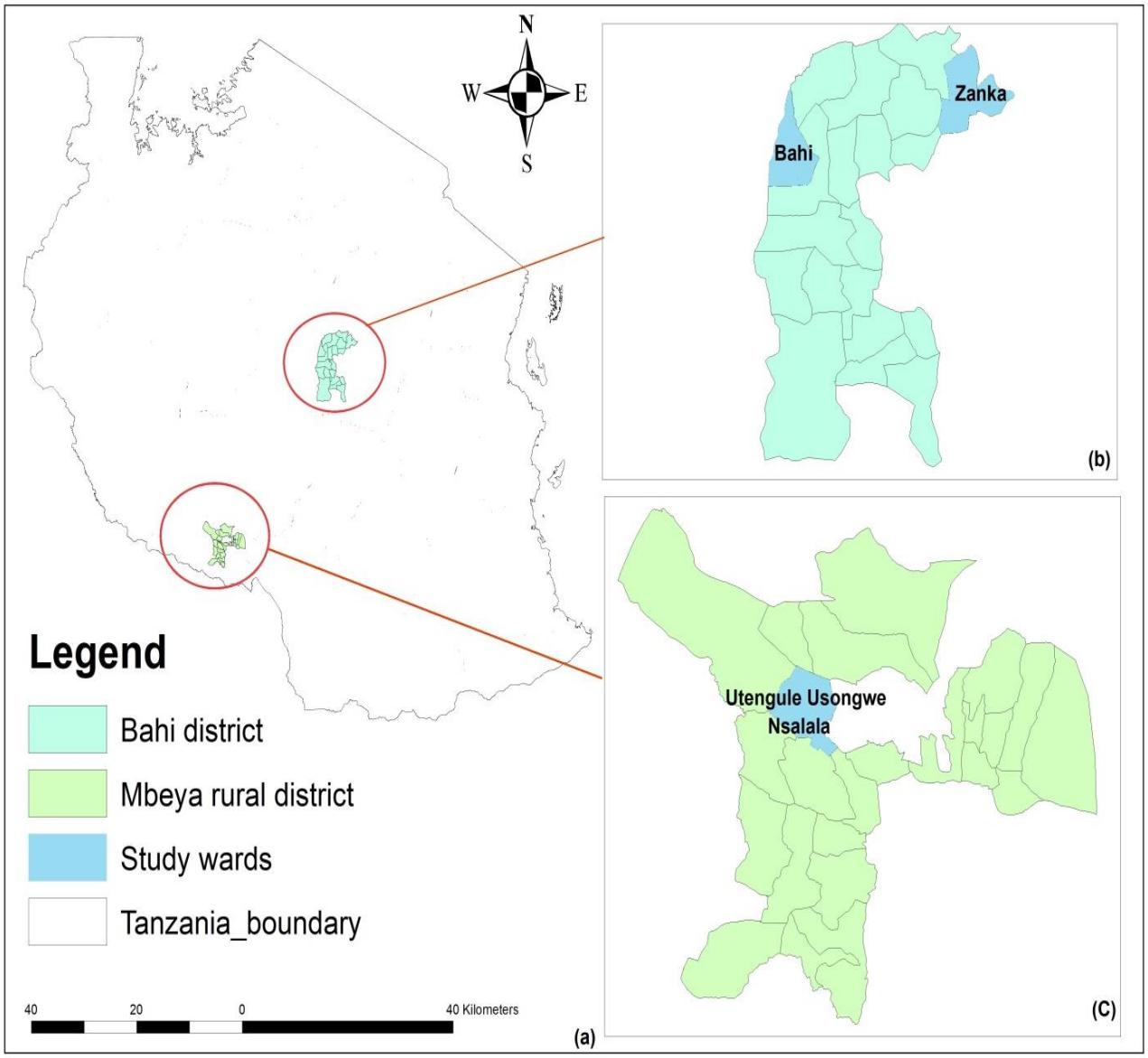


Figure 3: Map Showing Study Area. A: Tanzania map B: Bahi district C: Mbeya Rural District

3.5 Vegetable Sample Preparation

Collected vegetable samples were stored at 4°C for one day before blanching treatments. False sesame leaves (Fig. 4) were separated from stalks and flowers. False sesame leaves were not washed to avoid it getting slippery due to its nature. Common bean leaves (Fig. 5) were separated from stalks; discoloured leaves were removed and washed with deionized water. Clean cloth was used to remove excess water. Common bean leaves were cut approximately half a centimeter using sharp knife and the remaining vegetable left whole. A portion of CBL, 510 g each was placed in a water bath (WBH-200, Germany) and blanched at 70°C for 3 and 5 minutes separately. A portion of CBL, 10 g was removed for

micronutrients and anti-nutritional factors analyses while the remaining portion was subjected to drying experiments. Likewise, a portion of whole FSL (510 g) in a zip bag was immersed into (WBH-200, Germany) and blanched at 70°C for 3 and 5 minutes separately (Tsado *et al.*, 2015). Thereafter, 10 g of FSL were separated for analysis as blanched samples and remained portion for drying purposes. Vegetables were subjected to sun drying (Fig. 6); covered with white or black cloth and uncovered at an average temperature of 33.9°C for 3 days, respectively until the weight of the sample remained constant. Fresh whole (un-blanched) vegetables were used as control.

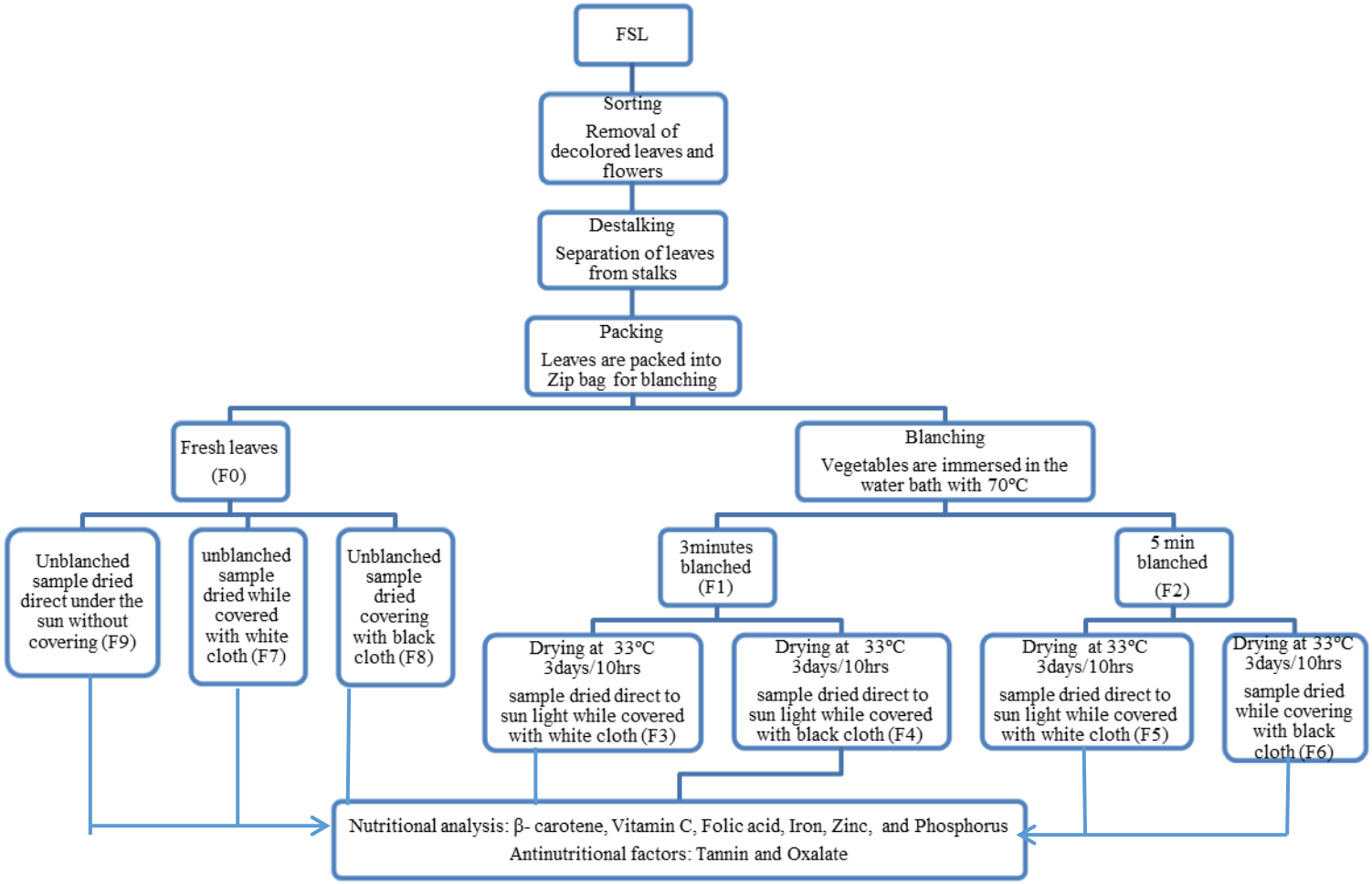


Figure 4: False sesame leaves preparation, processing and analysis layout

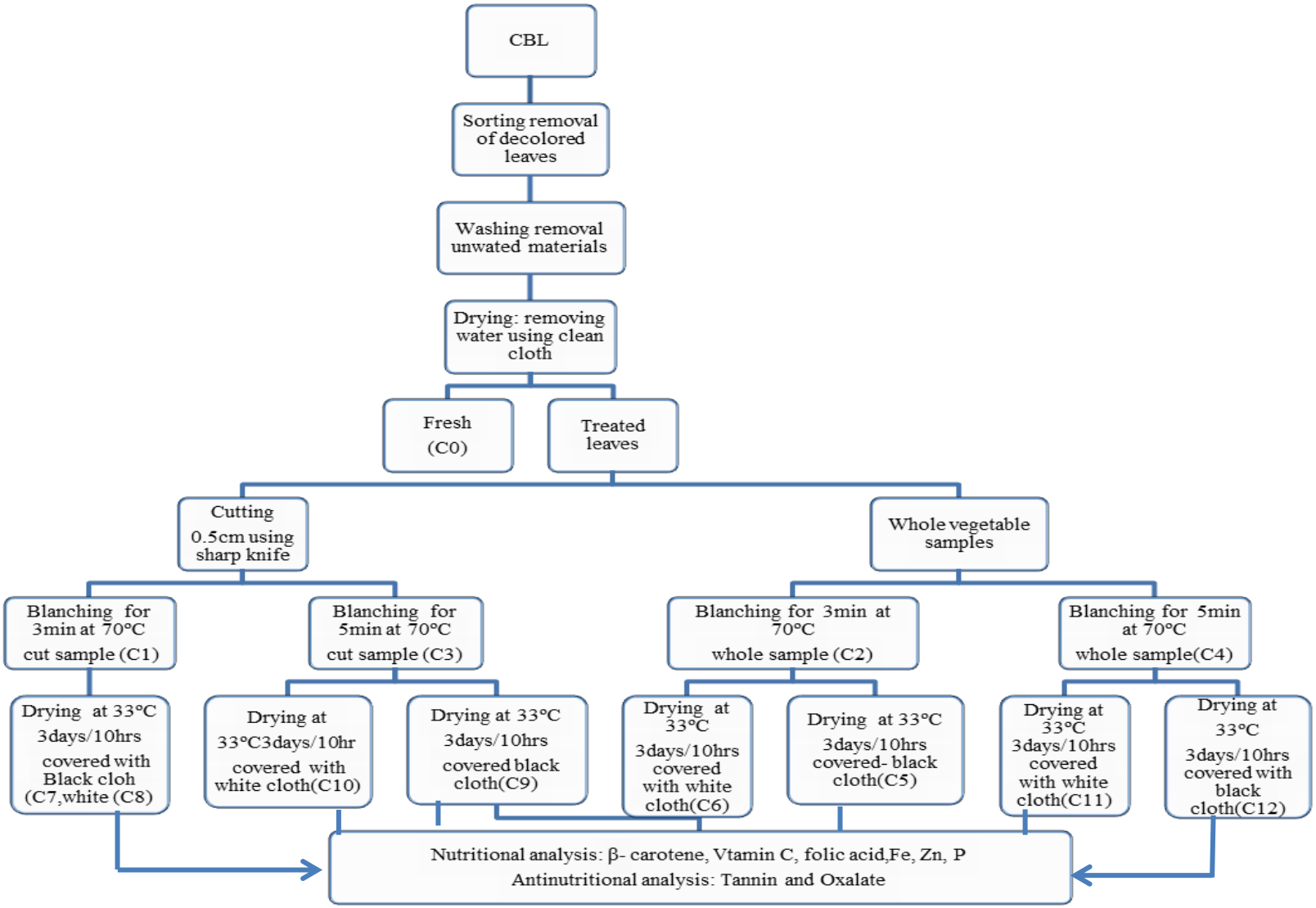


Figure 5: Common bean leaves preparation, processing and analysis layout

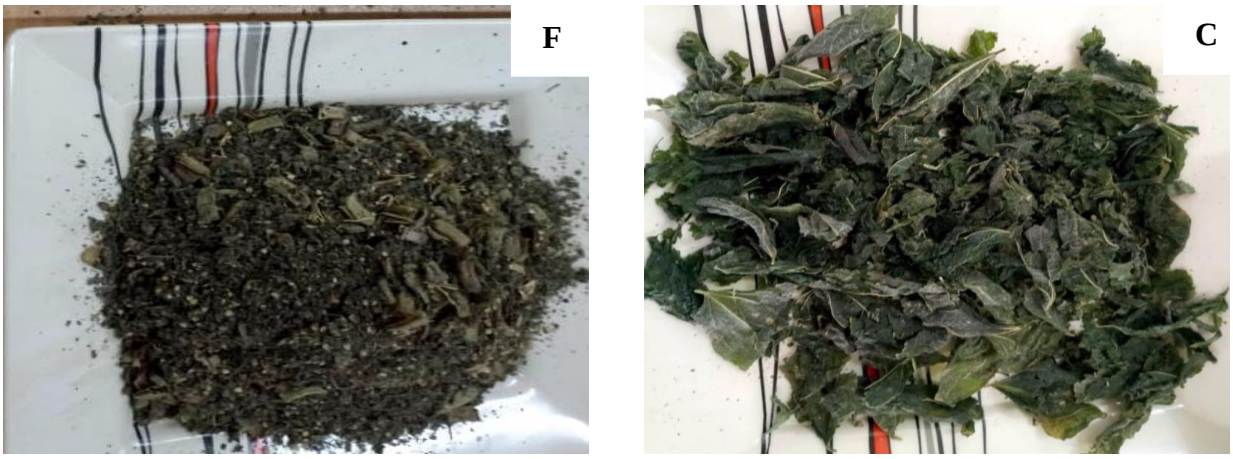


Figure 6: Dried FSL (F) and CBL (C) (Own Data, 2018).

3.6 Enzymatic Activity Test

Peroxidase enzyme activity test was done as described by Hui *et al*. (2006). A 0.5 mL sample of 3.0% H_2O_2 (30% hydrogen peroxide required 3%; to make 5 mL, 0.5mL of hydrogen peroxide was dissolved in 4.5 mL of distilled water) was added on the surface of the vegetables. Pinkish colour development was an indication of the presence of peroxide and perfusion of bubbles signified presence of oxidase enzymes.

3.7 Nutritional Analysis

3.7.1 Determination of Carotenoids Content

Carotenoids content of the CBL and FSL was determined using a method previously described by Pakistan *et al*. (2007). Two grams of the grinded CBL and FSL samples were mixed with 50 mL of n-hexane (RFCL limited A-3, India) in the falcon tubes (Merck, South Africa) and shaken in the orbital incubator (Orbital S1600C, UK) for 15 min. Mixtures were filtered using Whatman filter paper no. 1 (Fisher Scientific, UK) to obtain a supernatant, which was then evaporated using water bath (WBH-200, Germany) at 50°C for 48 h. The remained solid particles were re-dissolved in an aliquot of n-hexane for HPLC determination.

(i) Beta carotene standard preparation

Beta carotene standard (Sigma-Aldrich, Germany) was freshly prepared from standard stock solution (100 ppm) by mixing 10 mg of β-carotene standard in 100 mL n-hexane. In preparation for a standard curve, several dilutions were prepared; 80 ppm, 60 ppm, 40 ppm and 20 ppm.

(ii) Beta carotene determination by HPLC

An aliquot (10 µL) CBL, FSL and standard were set for automatic injection and into analytical HPLC (Shimadzu LC 10 AVP, Japan) coupled with C_{18} reversed phase particle size 5 µm, diameter 4.6 mm, length 250 mm (Shimadzu, Japan). Detection wavelength was 470 nm, with isocratic elution at a flow rate of 0.5 mL/min, peak responses were observed at 9.1 min. HPLC mobile phase was prepared by mixing methanol with acetonitrile (8:2 v/v).

3.7.2 Vitamin C Determination

Vitamin C content was determined by using procedures discussed by Woollard *et al*. (2014). Five grams of vegetable sample was extracted using 30 mL of distilled water and centrifuged for 30 minutes at rpm 3500 (Hettich centrifuge 0008-128-10, Germany). After centrifugation, supernatant was filtered using Whatman filter paper no. 1. One milligram of Dithiothreitol (DDT) was added in each 1 mL of filtrate; the mixture was shaken then filtrated through 0.45 µm membranes (Fisher Scientific, UK).

(i) Vitamin C standard preparation

Ascorbic acid standard (Sigma-Aldrich, Germany) was prepared from stock solution made by dissolving 5 mg of ascorbic acid in 100 mL of distilled water. Working solutions with different concentration were prepared; 50 ppm, 40 ppm 30 ppm and 10 ppm, then 10 mg of dithiothreitol was added to each standard and solutions were shaken.

(ii) Samples preparation for HPLC analysis

Samples and standards were prepared for HPLC injection by mixing with the mobile phase followed with an addition of 1 g dithiothreitol (Sigma-Aldrich, USA), mixture was stirred until dissolved, and then pH adjustment to 2.5 with concentrated Phosphoric acid. Solution was diluted to 1 L with distilled water, and filtered through 0.45 µm membrane. Then it was inserted in HPLC machine (Shimadzu LC 10 AVP) coupled with C_{18} reversed phase particle size 5 µm, diameter 4.6 mm, length 250 mm for determination step. High Performance

Liquid Chromatography mobile phase was prepared by mixing (KH_2PO_4) (SMiTH chemicals, India) (0.5%, w/v), pH 2.5, with Dithiothreitol (0.1%, w/v; prepared by adding 5 g of KH_2PO_4 in 1 L volumetric flask with 950 mL water. High Performance Liquid Chromatography detector was fixed at 254 nm with flow rate of 0.5 mL/min for 30 min, followed by mobile phase for 1 h to equilibrate column. Peak responses were measured at 4 min; Plotting against concentration was done electronically. The concentration of vitamin C (mg/100 g) was interpolated directly from the calibration regression using LC solution software, from automated constructed calibration curve and the actual concentration of vitamin C in the sample was calculated using the formula below;

Formula 1: Calculation of vitamin C concentration

$$Vitamin\ C\ concentration = \frac{Concentration \times Dilution\ factor}{Weight\ of\ the\ sample \times 10}$$

3.7.3 Determination of Folic Acid

Folic acid analysis was done according to the method of Rahimi and Goodarzi (2011) with some modifications. Three grams of vegetables samples were extracted with 50 mL of 0.1 mol/L Phosphate buffer (pH 7.0) and 2-mercaptoethanol 0.1% (v/v). The mixture was shaken for 30 min in orbital incubator (S1600C, UK), and centrifuged (Hettich centrifuge 008-128-10, Germany) at 3500 rpm for 15 min. The supernatant was filtered through a 0.45 µm membrane before chromatography analysis.

(i) Folic acid standard preparation

Folic acid standard (Sigma-Aldrich, Germany) was prepared by using standard stock solution of (100 ppm) which was prepared by mixing10 mg of folic acid powder in 100 mL of distilled water. Working solutions were prepared; 80 ppm, 60 ppm, 40 ppm and 20 ppm.

(ii) Samples preparation for HPLC analysis

Samples and standards were prepared for HPLC injection by mixing with the mobile phase, thereafter inserted into analytical HPLC machine (Shimadzu LC 10 AVP, Japan) coupled with C_{18} reversed phase particle size 5 µm, diameter 4.6 mm, length 250 mm. Samples were eluted with 5 mL NaOH (0.005 mol/L) pH 10. Folic acid was detected at the wavelength of detector at 254 nm; sample injection was 10 µL with the flow rate of 0.5 mL/min. The

stationary phase was flushed with 5 mL methanol and 5 mL de-ionized water to activate the stationary phase. Peak responses were observed at 14 min. Monopotassium sulphate (KH_2PO_4) with pH of 3.6 (adjusted by phosphoric acid (H_3PO_4) (Loba Chemie Pvt. Ltd, India) was used as a mobile phase.

3.7.4 Mineral Analysis

Minerals (Fe, Zn and P) were determined by the method described by Ifeoma (2014). Two grams of sample were weighed and ashed in a muffle furnace (Cole Parmer Box Furnace-CBFL516C, United State) overnight at a temperature of 500°C. Samples were cooled and 5 mL 1N HNO_3 (Loba Chemie Pvt. Ltd, India) solution were added. Sample was evaporated to dryness and returned to the furnace and heated at 400°C for 15 min until a perfectly greyish white color was observed. Ashes were cooled and 40 mL of 1N HCl (Loba Chemie Pvt. Ltd, India) solution was added then filtered into a 50 mL volumetric flask. The crucible and filter paper was washed with additional 10 mL portion of 0.1N HCl solution. Iron and zinc, were determined using AAS UNICAM 919 (Hitachi High-Technologies Corporation, Japan,) at wavelength of 248.3 nm for iron and 213.9 nm for Zn and P was determined using BIOMATE 6 UV-VIS Thermo scientific (UNICO spectrophotometer 2800, USA) at wavelength of 885 nm and concentration were obtained.

3.8 Anti-nutritional Factors

3.8.1 Oxalate Determination

Oxalate determination was done using titration method as described by Agbaire (2012). Sample was extracted using 75 mL of 3M H_2SO_4 (Making 500 mL; Dissolve 79.95 mL of H_2SO_4 in 420.05 mL of distilled H_2O). Mixture was shaken for 15 min in the orbital incubator (S1600C, UK). To obtain a supernatant, mixture was filtered using Whatman filter paper no. 1 then it was titrated against 0.05M KMn_4 (SMiTH chemicals, India) (making 1000 mL; Dissolve 7.9015 g in 1000 mL of distilled water) solution until faint pink colour which persisted for 30 seconds was observed. Oxalate content was calculated by taking 1 mL of 0.05 M $KMnO_4$ as equivalent to 2.2 mg of oxalate (Jonathan and Funmilola, 2014).

3.8.2 Tannins Content

Tannin content was estimated as the difference between total phenolic and non-tannin phenolic content in vegetable sample. Total phenolic content in FSL and CBL were determined in terms of gallic acid equivalents (GAE) using Folin Ciocalteu method

(Singleton *et al*., 1998) with slight modification. Samples were extracted using 10 mL of 70% aqueous acetone. Absorbance of samples was measured at 750 nm using ultraviolet visible spectrophotometer (UV-Vis) (UNICO Spectrophotometer 2800 UV/VIS, USA). Total phenolic content was then calculated based on the standard curve of gallic acid (Loba Chemie Pvt. Ltd, India) and expressed as mg/g of Gallic Acid Equivalent (GAE). To determine non-tannin phenolic content, 2 mL of the diluted juice sample was mixed with 2 mL of distilled water and 200 mg polyvinyl-polypirrolidone (PVPP) (Merck, SA). The mixture was vortexed using vortex (Top Mix FB15024 Fisher Scientific, UK), left for 15 min at 4°C and then centrifuged for 10 min at 3000 rpm. Non-tannin phenolic content in the supernatant was determined in the way similar to the total phenolic content.

3.9 Statistical Analysis

Statistical Package for the Social Sciences (SPSS) version 20 was used to analyze the results obtained from the survey data. All the analyses on chemical compositions were carried out in duplicate and expressed as mean concentration using Analysis of Variance (ANOVA), Means were compared by Duncan's Multiple Range Test (DMRT), and separated by Least Significant Difference (LSD) test using GenStat software 15^{th} edition and the significance was accepted at $p<0.05$ (Ndawula *et al.*, 2004).

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Local Practices on the Use, Processing and Preservation of Green Leafy Vegetables

Results on the vegetable availability, consumption, accessibility and preservation are shown in Table 3 and 4. Results showed that, vegetables such as CBL (21%), amaranth (19.4%), cowpeas (16%), pumpkin leaves (15.4%), spinach (11.1%), cabbage (4.3%), night shade (3.1%), cassava leaves (1.5%) and sweet potato leaves (0.9%), were grown and consumed in Mbeya rural districts. Most access of green leafy vegetable was through purchase (50.8%) but also growing which accounted for 49.2%. About 23.2% of Mbeya rural communities preserved vegetable for dry season use (Table 3 and 4).

Table 3: Vegetable consumption and accessibility in Mbeya Rural District

Attribute	**Consumption**		**Growing**	
Vegetable type	**Frequency**	**(%)**	**Frequency**	**(%)**
Amaranth	63	19.4	60	49.2
Beans leaves	69	21.3	60	49.2
Spinach	36	11.1	60	49.2
Pumpkin leaves	50	15.4	60	49.2
Potato leaves	3	0.9	60	49.2
Cabbage	14	4.3	60	49.2
Night shade	10	3.1	60	49.2
Cowpea leaves	52	16	60	49.2
Okra leaves	22	6.8	60	49.2
Cassava leaves	5	1.5	60	49.2

Respondent vegetables consumption preferences and how they access vegetables

Table 4: Vegetable accessibility and preservation in Mbeya Rural District

Attribute	Buying		Preservation for dry season use	
Vegetable type	**Frequency**	**(%)**	**Frequency**	**(%)**
Amaranth	62	50.8	0	0
Beans leaves	62	50.8	16	23.2
Spinach	62	50.8	0	0
Pumpkin leaves	62	50.8	0	0
Potato leaves	62	50.8	0	0
Cabbage	62	50.8	0	0
Night shade	62	50.8	0	0
Cowpea leaves	62	50.8	0	0
Okra leaves	62	50.8	0	0
Cassava leaves	62	50.8	0	0

This was due to the climatic conditions that favour vegetable availability throughout the year at affordable prices. Therefore, most individuals did not see the necessity to preserve vegetables, instead they prepared for consumption fresh form.

In Bahi District, mostly consumed vegetables were in the order of FSL >amaranth > cowpeas leaves> pumpkin leaves > potato leaves > okra leaves > spinach > night shade > spider plant > cabbage> CBL > cassava leaves (Table 5 and 6). However, the most consumed were FSL, amaranth, cowpea leaves and pumpkin leaves, respectively~~,~~ Vegetable consumption was highly affected by accessibility of the vegetable itself (Table 5 and 6).

Table 5: Vegetable consumption and accessibility in Bahi District

Attribute	Consumption		Growing		Buying	
Vegetable type	**Frequency**	**(%)**	**Frequency**	**(%)**	**Frequency**	**(%)**
Amaranth	69	16.5	22	17.7	33	26.6
False sesame	71	16.9	0	0	33	26.6
Cowpea leaves	64	15.3	22	17.7	33	26.6
Potato leaves	48	11.5	22	17.7	33	26.6
Pumpkin leaves	56	13.4	22	17.7	33	26.6
Okra leaves	33	7.9	22	17.7	33	26.6
Night shade	16	3.8	22	17.7	33	26.6
Beans leaves	1	0.2	22	17.7	33	26.6
Spinach	30	7.2	22	17.7	33	26.6
Cabbage	14	3.3	22	17.7	33	26.6
Spider plant	16	3.8	22	17.7	33	26.6
Cassava leaves	1	0.2	22	17.7	33	26.6

Table 6: Vegetable availability, consumption, accessibility and preservation in Bahi District

Attribute	Wild growing		Preservation for dry season use	
Vegetable type	**Frequency**	**(%)**	**Frequency**	**(%)**
Amaranth	0	0	16	21.6
FSL	69	55.6	73	98.6
Cowpea leaves	0	0	73	98.6
Potato leaves	0	0	40	56.1
Pumpkin leaves	0	0	43	58.1
Okra leaves	0	0	2	2.7
Night shade	0	0	0	0
CBL	0	0	1	1.4
Spinach	0	0	0	0
Cabbage	0	0	0	0
Spider plant	0	0	10	13.5
Cassava leaves	0	0	0	0

For instance FSL were highly consumed (16.9%), whereas it was the only vegetable obtained in the wild, hence it was priceless but also indigenous to Dodoma local societies. However, due to the climatic conditions of the place, preserving vegetables was inevitable (Ephrahim and Bwagalilo, 2014). About 98.6% of Bahi communities preserved vegetables for dry season use. Among vegetables preserved included; FSL (98.6%), cowpeas leaves (98.6%), pumpkin leaves (58.1%), potato leaves (56.1%) amaranth (21.6), spider plant (13.5%), okra leaves (2.7%) and CBL (1.4%).

The need for dying is well justified by a number of scholars (Ifeoma, 2014; Kiharason *et al*., 2017; Sobowale *et al*., 2010). In their descriptions, vegetables are highly perishable and seasonal in such a way that, they are abundant during wet seasons and scarce during dry season. Therefore, vegetable preservation becomes of importance. In addition to that, sun drying has been reported by Mepba *et al*. (2016) the most common and cheap method used in drying of edible leafy vegetables.

4.1.1 Local Vegetable Processing Technologies Used for Shelf Life Extension Purpose

Results on the local vegetable processing technologies (Fig. 7) used for shelf life extension purpose are presented in Table 7. Results unveil that, 23.2% of respondent boiled vegetables in water for about 5 min to 1 h in Mbeya. Likewise, 87.8% of respondents in Bahi also boiled before sun drying. In this study, it was found that boiling vegetables (5 min to 1 h) before sun drying (except for FSL) was the most common and preferable practice used in both Bahi and Mbeya rural districts (87 and 23.2%, respectively).

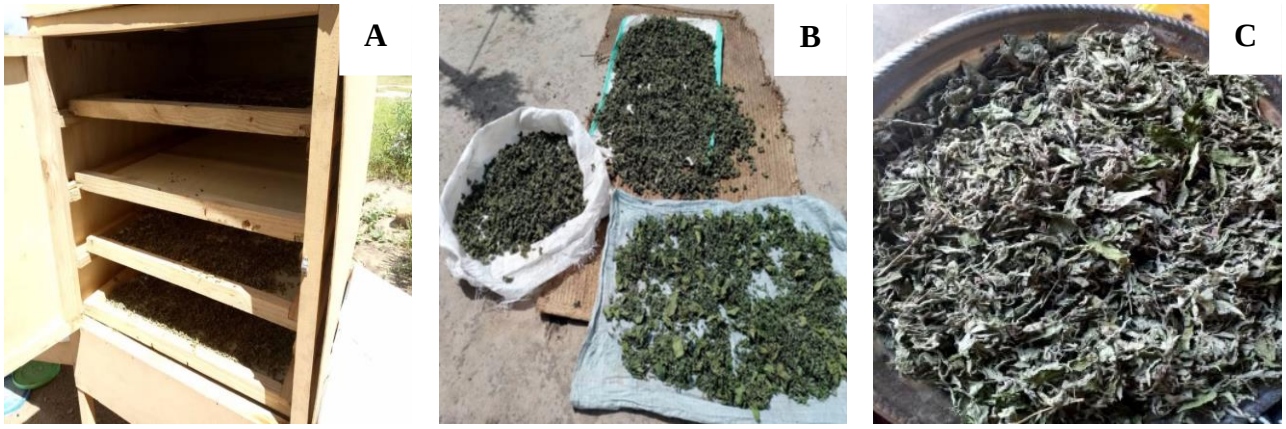


Figure 7: Drying methods used in Mbeya rural and Bahi district, A: using solar dryers (locally made), B: Drying direct to the sun and C: Drying inside the house

Table 7: Local vegetable processing technologies used for shelf life extension purpose

		Bahi District		Mbeya Rural	
Pretreatment before drying	**Drying method**	**Frequency**	**(%)**	**Frequency**	**(%)**
No treatment (Fresh vegetables)	Drying direct under the sun	5	6.8	0	0
	Drying using solar dryer	0	0	1	1.4
	Covered with cloth during drying	0	0	53	76.8
	Drying inside the house	1	1.4	53	76.8
	Drying under shade	0	0	53	76.8
Boiling vegetables in water for 5min - 1hr	Drying direct under the sun	50	87.7	15	23.2
	Drying using solar dryer	9	12.2	0	23.2
	Covered with cloth during drying	5	6.8	0	0
	Drying inside the house	0	1.4	0	0
	Drying under shade	1	1.4	0	0

Moreover, other practices such as drying using solar dryers (locally made) (12.2%), covering with a cloth (6.8%), inside houses (1.4%) and drying under shade (1.4%) were observed in Bahi district. In Mbeya, use of solar dryers (23.2%) was also reported. Most of people boiled vegetables for such a long period of time and then drying which may devastate the nutrients composition of vegetables especially for those nutrients which were heat sensitive like vitamin C (Ilelaboye *et al*., 2013; Wang *et al*., 1997). Also, cooking for long time has a negative effect on the sensory qualities (Hamouz and Driskell, 2006; Miglio *et al*., 2008; Ogliano and Ellegrini, 2008).

4.1.2 Leafy Vegetables Cooking Recipes in Bahi and Mbeya Rural

Bahi and Mbeya Rural communities used different ingredients in cooking leafy vegetables. This was as observed in Table 8. Majority of respondents used oil, onions and salt (97.7%); oil, tomato and salt (92.6%); oil, onions, tomato, carrot and belly pepper (81.3%); oil, onions, tomatoes, salt and garlic (94.1%) and the lowest value was 44.3% where individuals used oil, tomatoes, salt and groundnuts in Bahi. On the other hand, Mbeya Rural District used ingredients such as oil, onions, salt (100%); oil, tomato, salt, (96.7%); oil, onions, tomato, carrot and belly pepper (81.7%); oil, onion, tomato, salt and garlic (76.5%); oil, onion, salt and groundnut (82.9%); oil, onion, salt and groundnuts (83.7%); oil, onions, salt and milk

Table 8: Leafy vegetables cooking recipes in Bahi and Mbeya Rural District

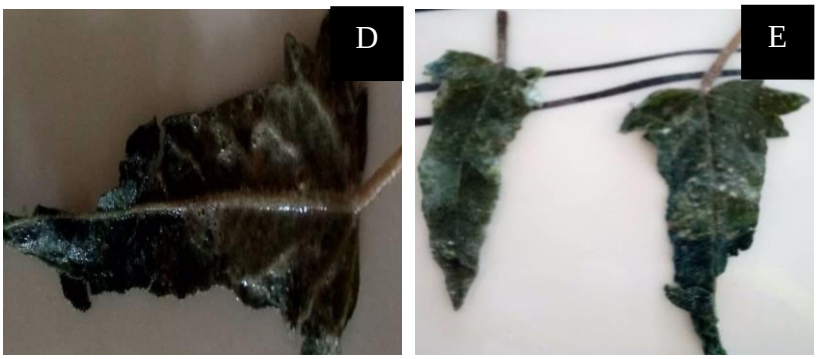
		Bahi District		Mbeya Rural	
Vegetables	**Recipe**	**Frequency**	**(%)**	**Frequency**	**(%)**
Fresh Vegetables	Oil, onions, salt and vegetables	72	97.7	69	100
	Oil, onions, tomatoes, salt and vegetables	69	92.6	66.7	96.7
	Oil, onions, tomatoes, carrots, salt and vegetables	60	81.3	56.4	81.7
	Oil, onions, tomatoes, carrots, belly peppers, salt and vegetables	51	69	51.6	74.8
	Oil, onions, tomatoes, salt, garlic and vegetables	70	94.1	52.8	76.5
	Oil, onions, tomatoes, carrots, belly peppers, garlic, salt and vegetables	54	73.6	45.1	65.4
	Oil, onions, salt, groundnuts and vegetables	72.3	97.7	57.2	82.9
	Oil onions, tomatoes, salt, ground nuts and vegetables	44.2	59.7	57.8	83.7
	Oil, onions, tomatoes, carrots, salt, groundnuts and vegetables	51.3	69.3	50.6	73.4
	Oil, onions, tomatoes, carrots, belly peppers, groundnuts salt and vegetables	44.7	60.4	47.4	68.6
	Oil, onions, tomatoes, salt, garlic, groundnuts and vegetables	59.1	79.9	49.1	71.2
	Oil, onions, tomatoes, carrots, belly peppers, garlic, salt, groundnuts and vegetables	48.3	65.3	42.2	61.2
	Oil, onions, salt, milk and vegetables	55.7	75.3	51.7	75
	Oil onions, tomatoes, salt, milk and vegetables	56	75.6	53.4	77.3
	Oil, onions, tomatoes, carrots, salt, milk and vegetables	51.6	69.1	47	68.1
	Oil, onions, tomatoes, carrots, belly peppers, milk, salt and vegetables	44.5	60.2	44.2	64.1
	Oil, onions, tomatoes, salt, garlic, milk and vegetables	59	79.7	45.5	65.9
	Oil, onions, tomatoes, carrots, belly peppers, garlic, salt, milk and vegetables	48.2	65.2	39.5	57.2
	Oil, onions, tomatoes, salt and vegetables	69	92.6	66.7	96.7
	Oil, onions, tomatoes, carrots, salt and vegetables	60	81.3	56.4	81.7
Processed	Oil, onion, salt and vegetables	72	97.7	69	100
	Oil, onions, tomatoes, carrots, belly peppers, salt and vegetables	51	69	51.6	74.8
	Oil, onions, tomatoes, carrots, belly peppers, garlic, salt and vegetables	54	73.6	45.1	65.4
	Oil, onions, salt, groundnuts and vegetables	72.3	97.7	57.2	82.9
	Oil onions, tomatoes, salt, ground nuts and vegetables	44.2	59.7	57.8	83.7
	Oil, onions, tomatoes, carrots, salt, groundnuts and vegetables	51.3	69.3	50.6	73.4
	Oil, onions, tomatoes, carrots, belly peppers, groundnuts salt and vegetables	44.7	60.4	47.4	68.6
	Oil, onions, tomatoes, salt, garlic, groundnuts and vegetables	59.1	79.9	49.1	71.2
	Oil, onions, tomatoes, carrots, belly peppers, garlic, salt, groundnuts and vegetables	48.3	65.3	42.2	61.2
	Oil, onions, salt, milk and vegetables	55.7	75.3	51.7	75
	Oil onions, tomatoes, salt, milk and vegetables	56	75.6	53.4	77.3
	Oil, onions, tomatoes, carrots, salt, milk and vegetables	51.6	69.1	47	68.1
	Oil, onions, tomatoes, carrots, belly peppers, milk, salt and vegetables	44.5	60.2	44.2	64.1
	Oil, onions, tomatoes, salt, garlic, milk and vegetables	59	79.7	45.5	65.9
	Oil, onions, tomatoes, carrots, belly peppers, garlic, salt, milk and vegetables	48.2	65.2	39.5	57.2

(75%) and oil, onions, tomato, salt, carrot, belly pepper, garlic and milk, which was the lowest value. This study substantiates that Bahi and Mbeya rural communities improve nutritional value of the foods they consume through supplementation with vegetables they consume. This helps to compliment the nutrients loss during processing, since added ingredients contain various nutrients such as protein, vitamins; A, B, C, minerals like calcium and iron (Mourad and Bettache, 2014; Pareek *et al*., 2017).

4.2 Enzymatic Activity Test

Peroxidase enzyme activity test results showed that enzymes activities in blanched sample (C4) were inactivated completely after 5 min (Fig. 9 (c)) compared to 3 min blanching (C2) and un-blanched leafy vegetables (C0) (Fig. 9 (b) and (a)) in CBL. Similar to FSL, 3 min blanching (F1) showed insignificant difference in enzymes inactivation compared to 5 min blanching (F2) (Fig. 9 (e); left) compared to fresh leaves (F0) (Fig. 9 (d)) whereas perfusion bubbles were observed. This study is in agreement with the study by Xiao *et al.* (2017), which reported the effective inactivation of enzymes in Paprika pods that were blanched for 80, 90 and 100ºC, while samples blanched for less time (1 min) at the sample temperature did not show effect.

(a-c)



(d-e)

Figure 8: Enzyme activity test in (a) C0 (b) C2, (c) C4 (d) F0 (e) F1right and F2 left

4.3 Nutritional Content of Vegetable Samples

4.3.1 β –Carotene Content of FSL and CBL

Obtained results showed that β–carotene in both FSL and CBL were below detection limit in fresh leaves (Fig. 9). Similarly, Stadlmayr *et al*. (2012) reported, no β- carotene observed in FSL. Presence of other nutrients but not β-carotene of Bungu (*Ceratotheca sesamoides* Endl.) leaves and seeds has been reported Fasakin (2015). Besides, β–carotene content in CBL contradict the values reported by Emmanuel (2014).

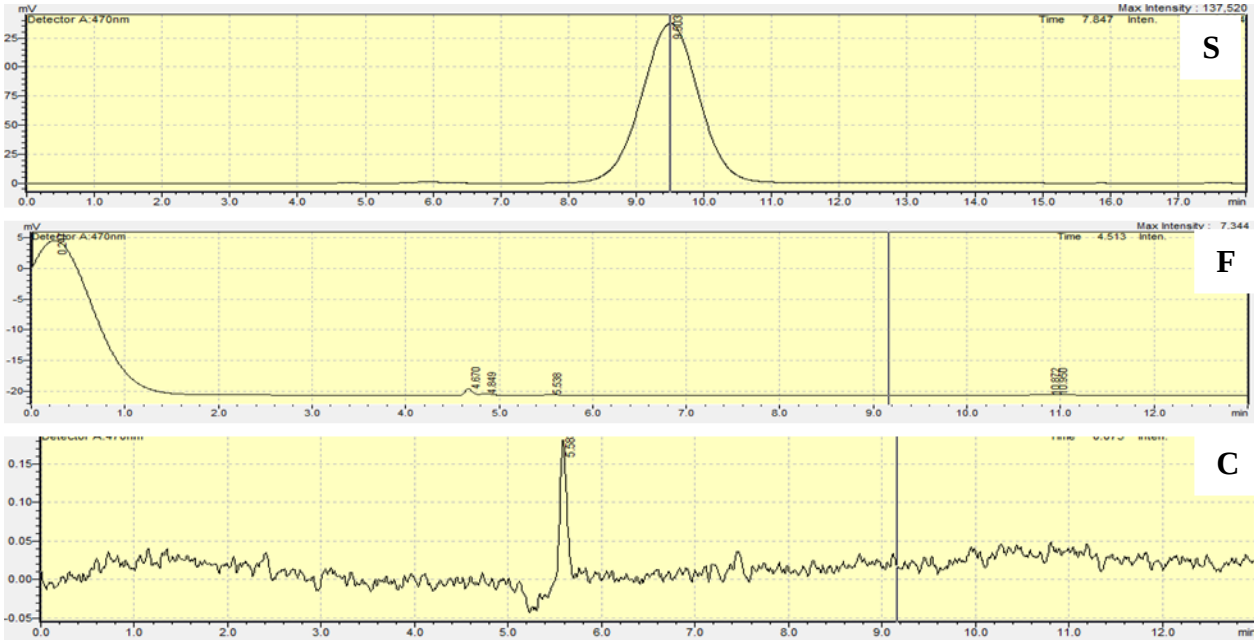


Figure 9: HPLC chromatograms of Beta carotene in S- standard, F-FSL and C- CBL, UV 470 nm

4.3.2 Vitamin C Content of FSL and CBL

Vitamin C content of FSL and CBL are indicated in Table 9. Vitamin C content in all treated FSL was significantly reduced as compared to fresh FSL (Fig. 10, 11, 12, 13 and 14). A reduction in vitamin C content was observed in blanched FSL (F1 and F2) as compared to fresh (F0). However, there was no significant difference ($p>0.05$) between the two treatments. The mean vitamin C content in all treated FSL ranged from 12.13 mg/100 g for F1 to 0.08 mg/100 g for F9, respectively (Table 9). Blanching and sun drying while covering with white (F3 and F5) and black (F4 and F6) clothes showed 4.63 – 50.60 and 6.13 – 25.25 folds protective effect to vitamin C content compared to fresh leaves. The results have shown that blanching (3 min) and sun-drying while covering with a white cloth (F3) retained a significant amount of vitamin C compared with black cloth (F4) or drying without covering (F9). For this case, covering vegetables with white and black colour (F4-F8) showed no

significant variation ($p>0.05$) in the vitamin C content. On the other hand, comparing with fresh FSL (F0), F3 and F4 had 0.02 – 0.25 folds retention of vitamin C. Furthermore, substantial loss in this vitamin (99.51%) was observed in un-blanched, uncovered sun dried FSL (F9) in comparison with fresh FSL (F0) Table 9 Similar findings by Ndawula *et al*. (2004) reported 84.54% loss of vitamin C in fruits and cowpea leaves under open sun drying. Ndawula *et al*. (2004) reported alterations in vegetable vitamin C content caused by open-sun drying, vis queen-covered and polyethylene-covered solar-dryers. These observations are in agreement with those reported by Babalola *et al*. (2010) that showed significant ($p<0.05$) reduction of the vitamin in blanched and dried samples, whereas sun drying had the most effect compared to other treatments. Maximum losses of vitamin C by direct sun-drying may be attributed to the direct ultra-violet rays of the sun, which induce ascorbic acid degradation (Tikekar *et al*., 2011; Tsado *et al*., 2015). Additionally, vitamin C loss is supported by the fact that vitamin C is water soluble which is labile and unstable to heat thereby increasing time for the contact with water causes more leaching out of vitamin C (Saranya *et al*., 2017). From this study, blanching (3 min) was the most effective method in retaining vitamin C (74.5%) in FSL followed with blanching (5 min) (64.93%), respectively.

Loss of vitamin C from CBL for both blanching and sun drying treatments was also observed (Table 9). Complete loss of vitamin C was observed in sun dried CBL; C7, and C8−C15, both with 0% retention as compared to fresh leaves (C0). Vitamin C loss in cut and blanched (C1 and C3) was 70.62−91.24% respectively. In other hand, whole, blanched CBL (C2 and C4) losses of vitamin C was between 71−73%. Additionally, no significant difference ($p>0.05$) observed in vitamin C losses were observed in blanched (3 min) sundried leaves covered with different colored cloths C5 and C6). Thus colour of the cloth had no protecting effect on vitamin C since it is sensitive to heat and light (Lee and Kader, 2000). For CBL, neither single nor combined processing methods proved to be effective in vitamin C retention. However, to avoid further losses, blanching (3 min) can be considered as a least the favorable practice to retain vitamin C.

Table 9: Effect of blanching and drying on Vitamin C composition of FSL and CBL

Vegetable	Sample treatments	Vitamin C (mg/100g)
False sesame leaves	F0 (0 min)	16.28 ± 3.156^{d}
	F1 (3 min)	12.13 ± 3.08^{c}
	F2 (5 min)	10.57 ± 0.7^{c}
	F3 (3 min, covered with WC)	4.05 ± 1.40^{b}
	F4 (3 min, covered with BC)	2.02 ± 0.71^{ab}
	F5 (5 min, covered with WC)	0.37 ± 0.52^{ab}
	F6 (5 min, covered with BC)	0.49 ± 0.39^{ab}
	F7 (0 min, covered with BC)	1.42 ± 0.97^{ab}
	F8 (0 min, covered with WC)	1.69 ± 0.25^{ab}
	F9 (0 min, uncovered)	0.08 ± 0.08^{a}
Common bean leaves	C0 (0 min)	5.48 ± 0.15^{e}
	C1 (3 min, cut)	0.48 ± 0.02^{b}
	C2 (3 min, whole)	1.61 ± 0.12^{d}
	C3 (5 min, cut)	0.43 ± 0.04^{b}
	C4 (5 min, whole)	1.48 ± 0.04^{c}
	C5 (3 min, whole, covered BC)	0.06 ± 0.08^{a}
	C6 (3 min, whole, covered WC)	0.13 ± 0.13^{a}
	C7 (3 min, cut, covered BC)	0.0^{a}
	C8 (3 min, cut, covered WC)	0.05 ± 0.06^{a}
	C9 (5 min, cut, covered BC)	0.0^{a}
	C10 (5 min, cut, covered WC)	0.0^{a}
	C11 (5 min, whole, covered BC)	0.0^{a}
	C12 (5 min, whole, covered WC)	0.0^{a}
	C13 (0 min, covered with WC)	0.0^{a}
	C14 (0 min, covered with BC)	0.0^{a}
	C15 (0 min, uncovered)	0.0^{a}

Note: WC: White Cloth; BC: Black Cloth. Means with the same letters in a column not significantly different ($p > 0.05$) in Duncan's Multiple Range Tests. Values are represented in Mean ± SD, (n=2).

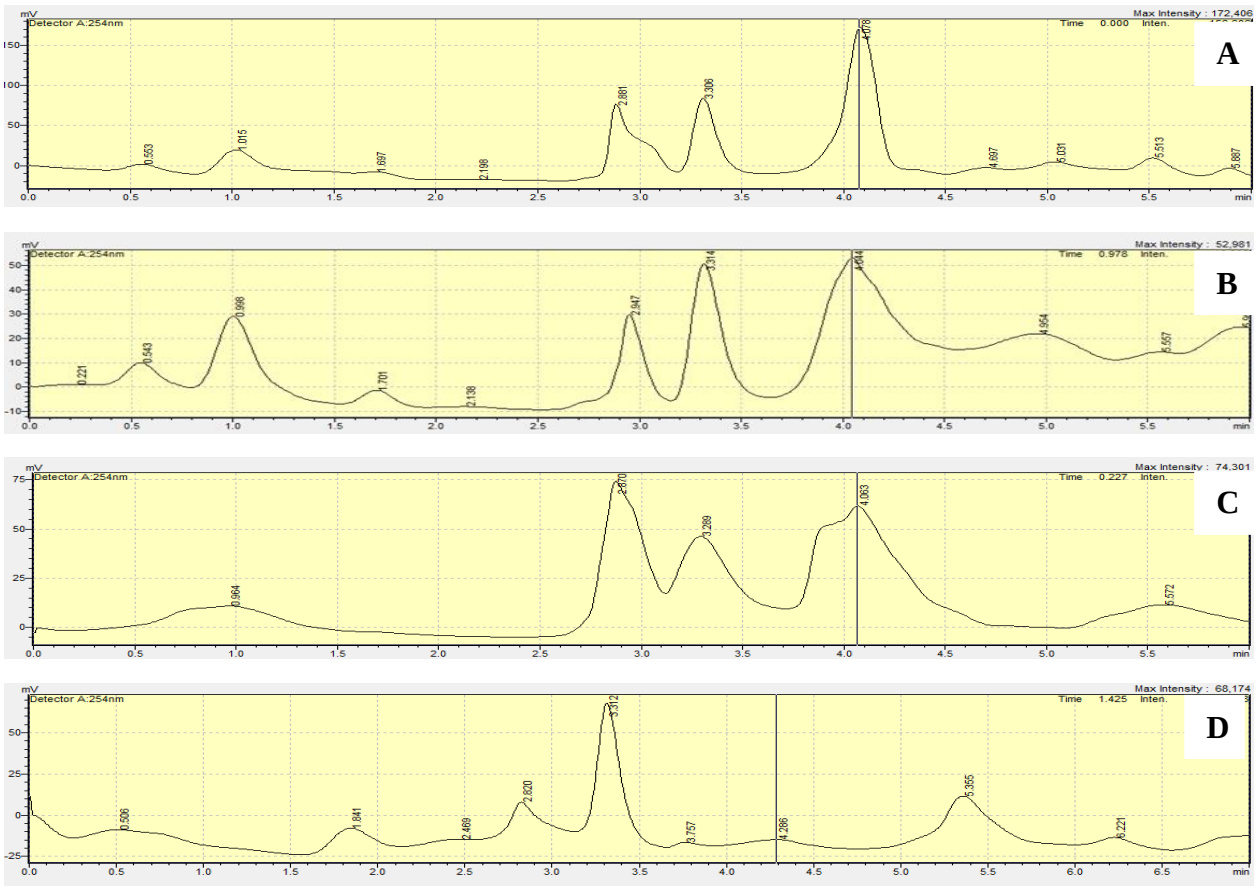


Figure 10: HPLC chromatograms of vitamin C in FSL, A-D (F0-F3), UV 254 nm, t_R =4.01to 4.07 min.

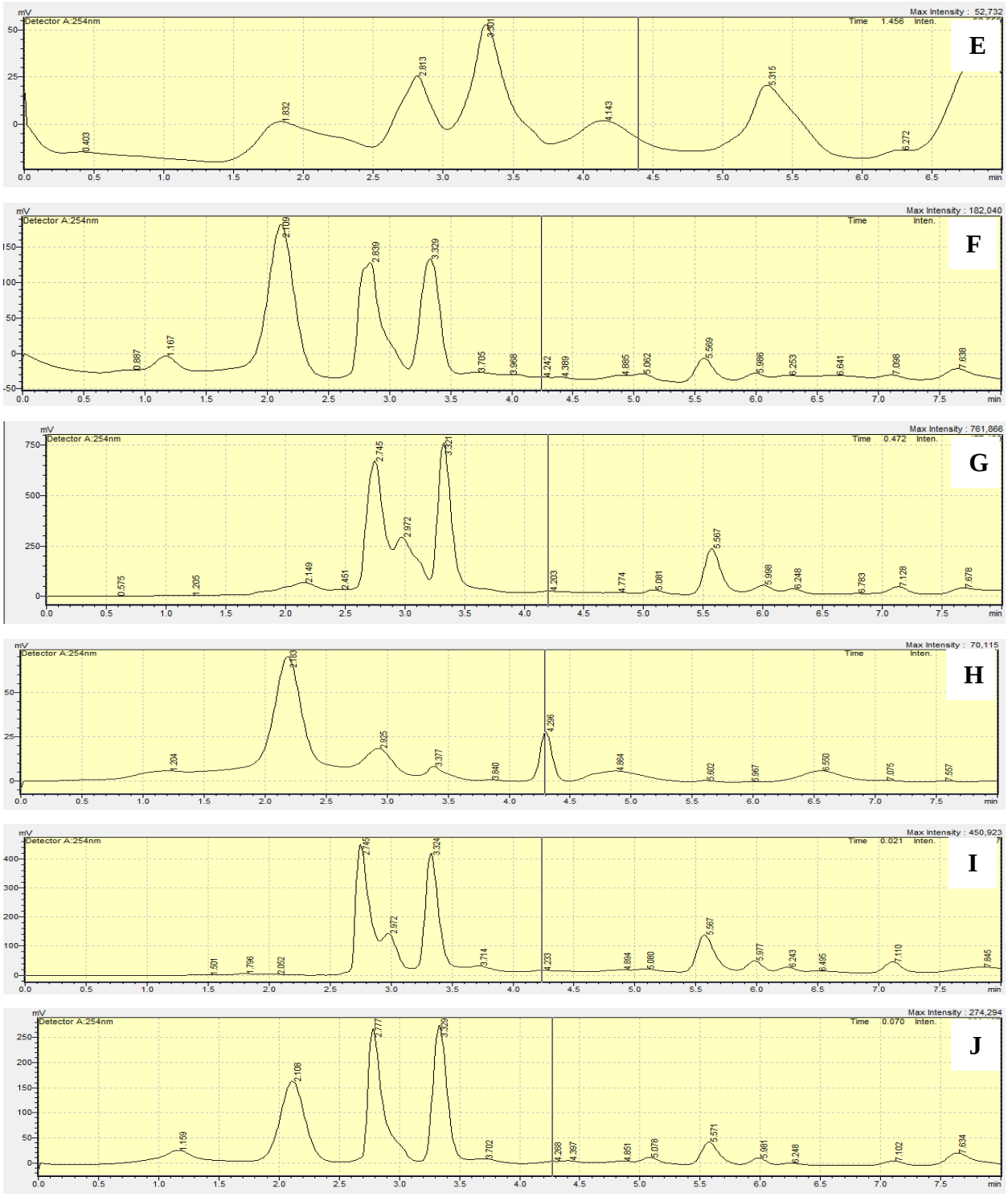


Figure 11: HPLC chromatograms of vit. C in FSL, E-J (F4-F9), UV 254nm, t_R =4.1 to 4.2 min

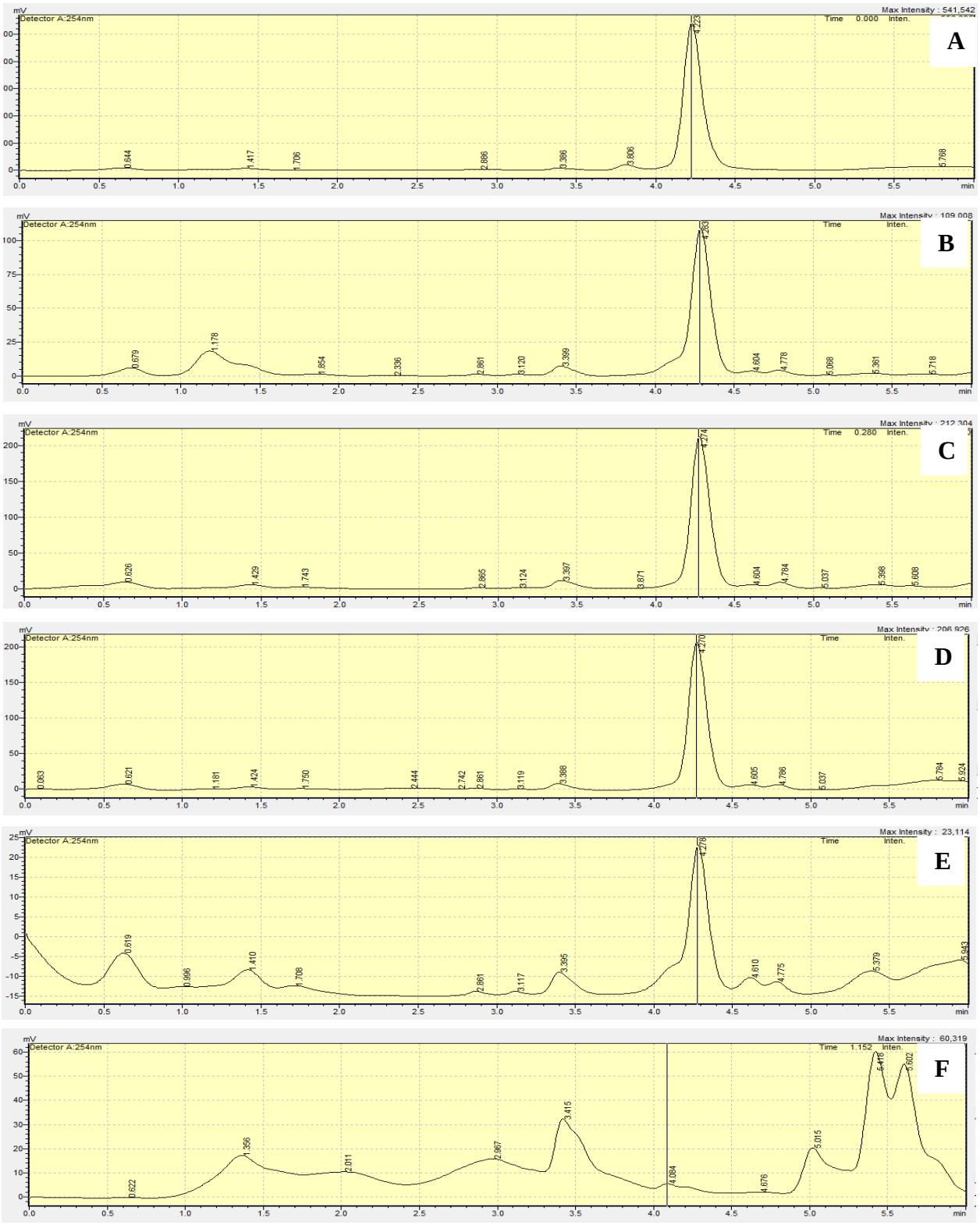


Figure 12: HPLC chromatograms of vit. C in CBL, A-F (C0-C6) UV 254nm, t_R = 4.08 to 4.2

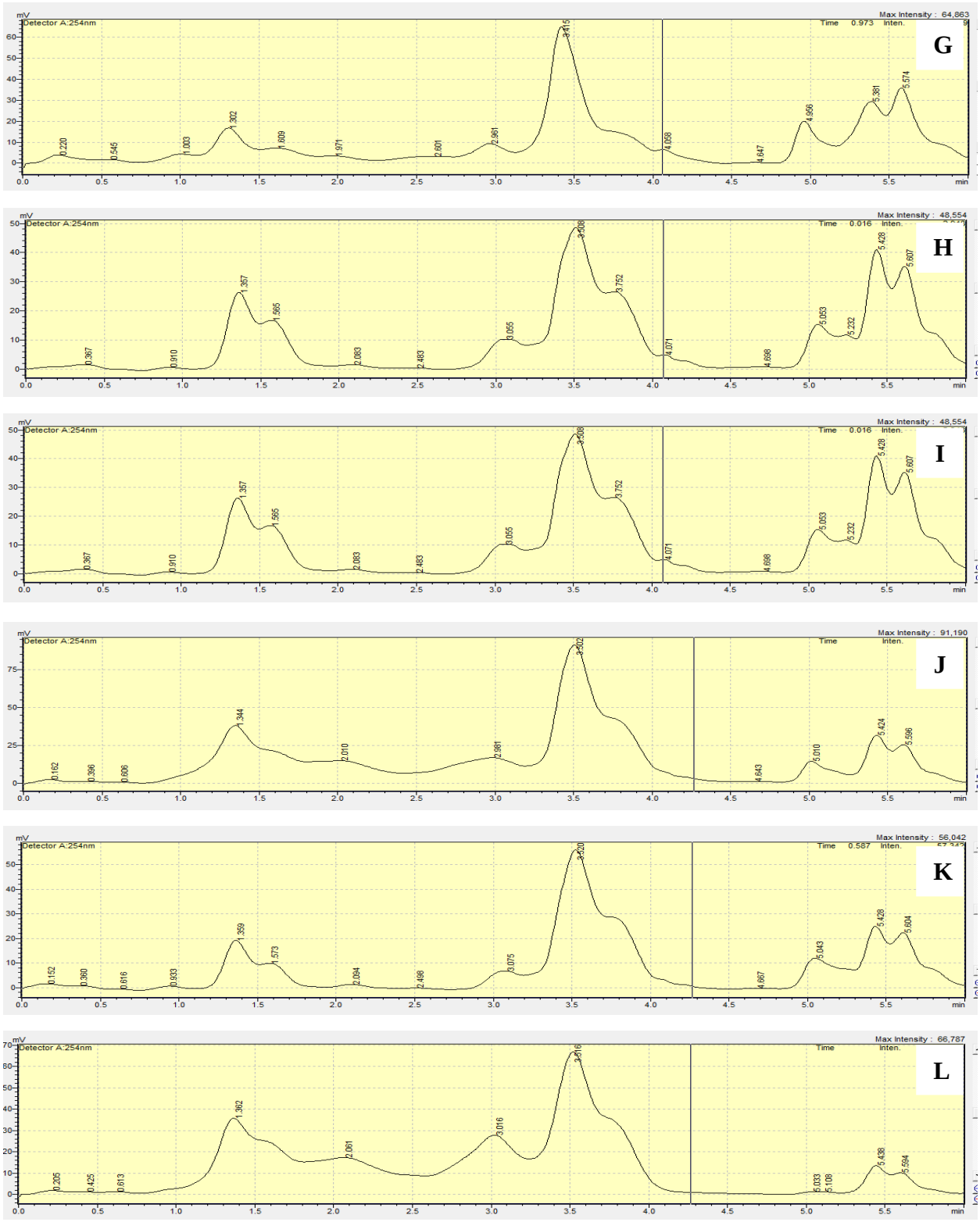


Figure 13: HPLC chromatograms of vit. C in CBL, G-L (C7-C12) UV 254nm, t_R = 4.05 to 4.07 min

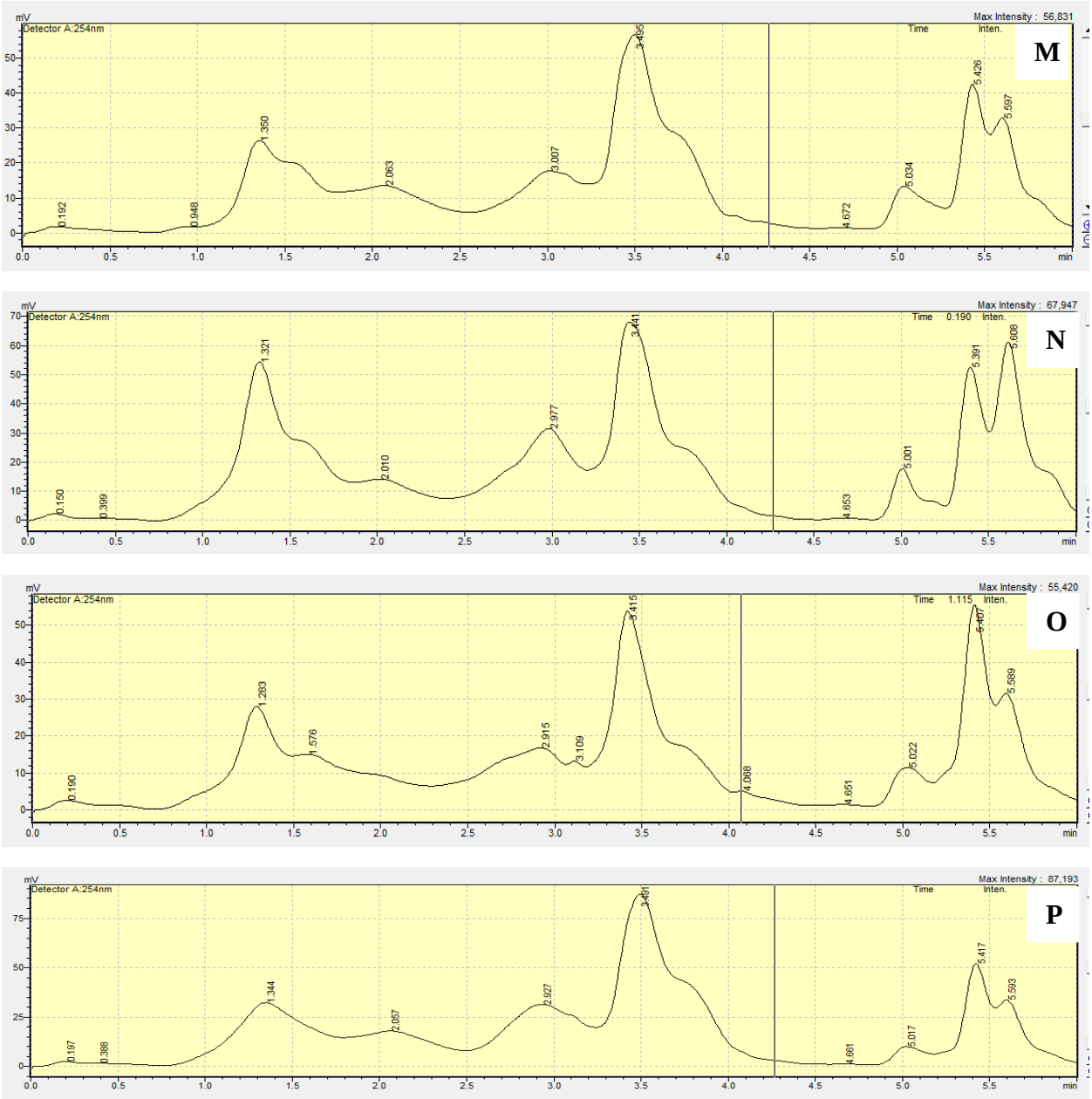


Figure 14: HPLC chromatograms of vitamin C in CBL, M-P (C8-C15) UV 254nm, t_R = 4.06 min

4.3.3 Folic Acid Content of FSL and CBL

Obtained results showed that folic acid in both FSL and CBL were below detection limit (Fig. 15, 16 and 17). The study is contrary with findings by Stadlmayr *et al*. (2012) in West Africa, where the presence of folic acid in FSL is reported. Likewise, other studies on green leafy vegetables as a natural source of reported presence of folic acid (Hemmige and Abbey, 2017; Tonea and Giuchici, 2010; Tsado *et al*., 2015).

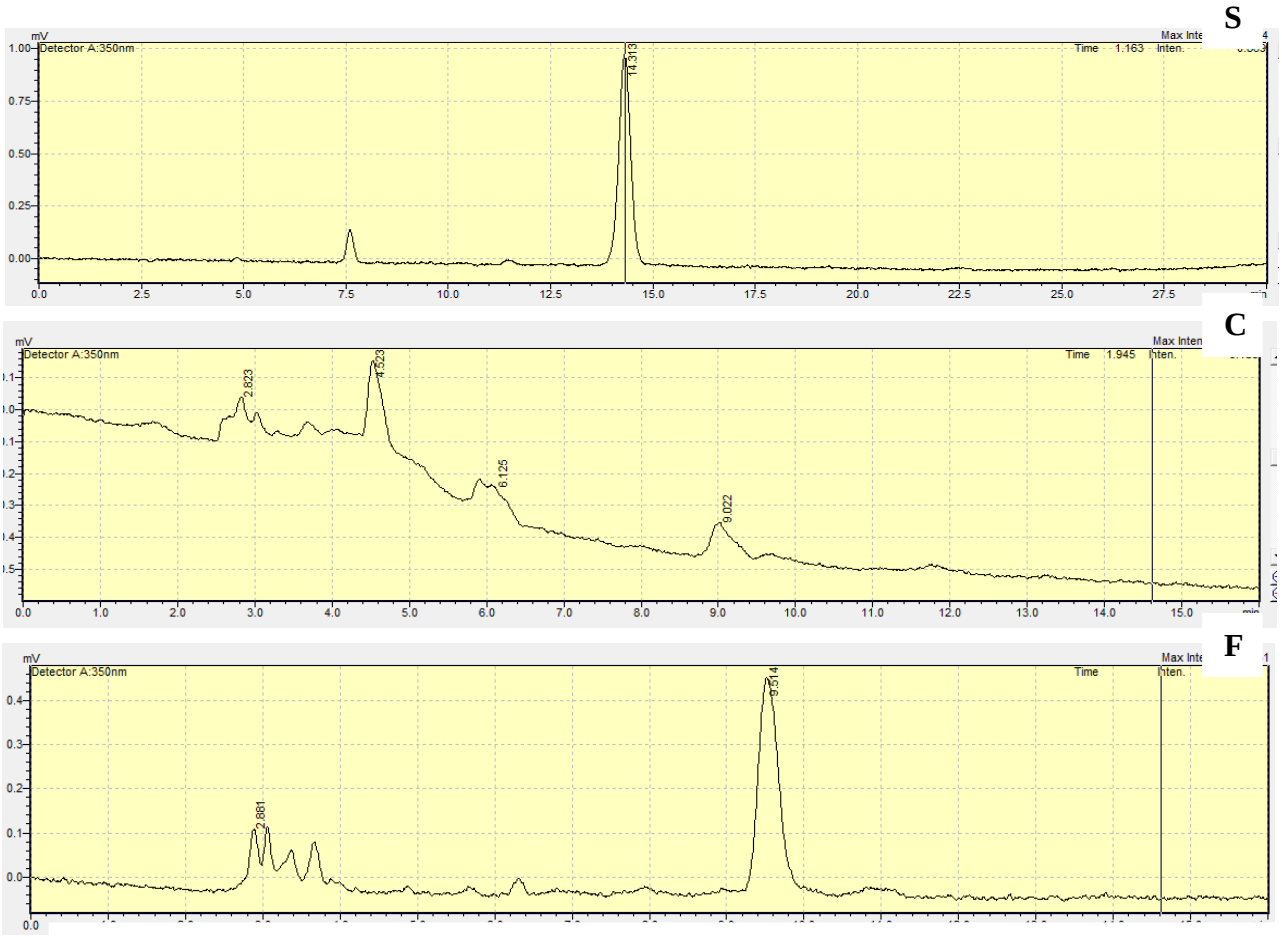


Figure 15: HPLC chromatograms of Folic acid in S-standard, C-CBL and F- FCL

4.3.4 Minerals composition of FSL and CBL

Phosphorus, Fe and Zn were analyzed as three important mineral elements in FSL and CBL (Table 10).

Table 10: Effects processing methods on minerals containing in FSL and CBL

Vegetable	Sample treatments	Phosphorus (mg/kg)	Iron (mg/kg)	Zinc (mg/kg)
False sesame leaves (FSL)	F0 (0 min,)	700.00 ± 0.00^{c}	115.75 ± 2.23^{c}	14.13 ± 0.00^{c}
	F1 (3 min)	610.50 ± 0.71^{b}	74.81 ± 2.23^{b}	8.40 ± 0.00^{a}
	F2 (5 min)	500.00 ± 0.00^{a}	63.78 ± 0.00^{a}	8.20 ± 0.28^{a}
	F3 (3 min, covered with WC)	1594.50 ± 7.78^{e}	225.00 ± 0.00^{e}	21.93 ± 0.18^{d}
	F4 (3 min, covered with BC)	1600.00 ± 0.00^{e}	224.96 ± 0.00^{e}	21.93 ± 0.57^{d}
	F5 (5 min, covered with WC)	800.00 ± 0.00^{d}	128.35 ± 2.23^{d}	10.91 ± 0.41^{b}
	F6 (5 min, covered with BC)	800.30 ± 0.42^{d}	126.87 ±1.41^{d}	11.09 ± 0.12^{b}
	F7 (0 min, covered with BC)	3608.50 ± 0.71^{f}	663.91 ± 0.30^{f}	482.00 ±1.12^{e}
	F8 (0 min, covered with WC)	3600.00 ± 0.00^{f}	663.91 ± 0.28^{f}	483.00 ± 0.00^{e}
	F9 (0 min, uncovered)	3610.00 ± 14.14^{f}	664.30 ± 0.00^{f}	482.51 ± 0.71^{e}
Common bean leaves (CBL)	C0 (0min)	600.00 ± 0.00^{c}	652.76 ± 0.00^{i}	41.04 ± 0.28^{f}
	C1 (3 min, cut)	250.00 ± 70.71^{b}	295.30 ± 295.3^{d}	24.33 ± 0.417^{c}
	C2 (3 min, whole)	300.00 ± 0.00^{b}	315.80 ± 0.00^{e}	29.86 ± 0.141^{d}
	C3 (5 min, cut)	165.00 ± 4.24^{a}	57.50 ± 0.00^{a}	6.42 ± 0.00^{a}
	C4 (5 min, whole)	262.00 ± 1.41^{b}	104.72 ± 0.00^{b}	15.91 ± 0.00^{b}
	C5 (3 min, whole, covered BC)	3500.05 ± 0.07^{g}	630.00 ± 0.00^{h}	312.44 ± 0.01^{i}
	C6 (3 min, whole, covered WC)	3500.30 ± 0.42^{g}	626.90 ± 9.30^{h}	311.47 ± 0.00^{i}
	C7 (3 min, cut, covered BC)	2805.00 ± 7.07^{f}	564.00 ± 0.00^{g}	225.42 ± 1.40^{h}
	C8 (3 min, cut, covered WC)	2800.00 ± 0.00^{f}	564.80 ± 2.06^{g}	225.02 ± 0.00^{h}
	C9 (5 min, cut, covered BC)	1696.85 ± 4.46^{e}	381.20 ± 0.00^{f}	79.02 ± 0.00^{g}
	C10 (5 min, cut, covered WC)	1700.15 ± 0.21^{e}	382.10 ± 0.00^{f}	81.62 ± 2.11^{g}
	C11 (5 min, whole, covered BC)	1300.00 ± 0.00^{d}	271.70 ± 0.00^{c}	37.70 ± 0.28^{e}
	C12 (5 min, whole, covered WC)	1304.00 ± 5.66^{d}	269.60 ± 0.00^{c}	38.00 ± 0.00^{e}
	C13 (0 min, covered with WC)	4550.00 ± 70.71^{h}	763.00 ± 0.00^{j}	336.37 ± 4.28^{j}
	C14 (0 min, covered with BC)	4570.00 ± 42.43^{h}	760.40 ± 0.00^{j}	338.18 ± 1.40^{j}
	C15 (0min, uncovered)	4510.00 ± 0.00^{h}	759.70 ± 0.00^{j}	338.14 ± 0.01^{j}

Note: WC: White Cloth; BC: Black Cloth. Means with the same letters in a column not significantly different ($p > 0.05$) in Duncan's Multiple Range Tests. Values are represented in Mean ± SD, (n=2).

Phosphorus, Fe and Zn are of the public health concern as they are required in very small amounts but they are very vital for development, disease prevention and wellbeing. Their absence may result in severe consequences.

From the results, sun drying treatment revealed no significant effect in reducing P content of FSL and CBL. Moreover, lowest P content was observed in fresh FSL (F0) and CBL (C0) as compared to dried ones. Similarly, blanched FSL had 0.02− 0.28 folds (2.78− 28.57%) significant reduction in P content. Similar trend of results was observed in CBL with 0.5– 0.72 folds (50−72.5%) significant reduction in P content in blanched (C1 – C4). Sun drying of blanched FSL covered or uncovered with white or black cloth (F3 – F9) showed 1.14 – 5.16 folds (114.28 - 515.71%) increase in P content (Table 10). A substantial increase in P

content was observed in un-blanched covered F7 – F9, respectively. Likewise, a substantial 2.17 – 7.61 folds (216.66% −761.66%) increase of P content was observed in blanched sundried covered or uncovered with white or black cloth (C5 – C15) (Table 10). Furthermore, lowest P content was observed in CBL cut and blanched for 5 min (C3). No significant difference ($p>0.05$) in P content for sun dried while covering with black and white, thus color had no effect in P retention. Besides, differences were subject to variation in blanching time.

The results of Fe content of FSL and CBL are summarized in Table 10. Blanching of both FSL and CBL for 3 and 5 min resulted in 0.44−0.35 folds (44.89−35.36%) reduction in Fe content. A reduction in Fe content in CBL was observed in cut, blanched (0.91−0.54 folds (54.76−91.1%), and whole, blanched (0.51−0.83 folds (51.62−83.95%). Sun drying had no significant effect ($p>0.05$) in reducing Fe content of FSL and CBL as compared to blanching. However, dried samples showed significant increase in Fe (1.10−5.74 folds (109.6−573.9%) for FSL and (0.41 – 1.16 folds (41.62−116.88%) for CBL compared to fresh leaves. Since Fe content were not affected by sun drying treatment, colour of cloths didn't show significant difference in Fe retention, rather the differences were subject to variation in blanching time (Table 10).

Zinc content of FSL and CBL are as indicated in Table 10. Blanching for different time significantly reduced the amount of Zn; moreover the effect of blanching time was insignificant. Fresh leaves had significant low Zn content compared to dried samples of both and CBL. Zinc content was significantly reduced ($p<0.05$) in CBL cut, blanched (0.40 – 0.84 folds (40.71−84.35%), and whole, blanched (0.27 – 0.61 folds (99.27−61.84%) regardless of blanching time. For FSL 0.40 – 0.41 folds (40.55−41.96%) decrease in Zn was observed. Mean Zn content of unblanched covered or uncovered (F9 and C13 – C15) was 34.18 and 8.23 folds (3418.25 and 823.58%) higher for FSL and CBL compared to fresh leaves. Also, it was the highest among other treatments (Table 10). No significant difference ($p>0.05$) in Zn content was observed in all dried vegetables covered with cloth of different colours. Additionally, sun drying had no effects on Zn content of both samples.

Similar findings were reported by Adepoju *et al*. (2015) regarding minerals; Fe, Zn, Ca, K, P and other minerals in dry Okro (*Abelmoschus esculentus*) compared to the fresh ones. Generally, it was observed that fresh leaves had small content of minerals compared to dried samples. This is simply because fresh leaves had high amount of water whereas same weight was taken in dry samples for analysis. More than 50% of initial weight was lost during sun

drying, thus fresh leaves weighed less compared to dried samples. Reduction in mineral content could be due to leaching out of minerals during blanching in hot water. This is in agreement with findings by Ilelaboye *et al*. (2013). Likewise, Hefnawy (2011) and Wang *et al*. (1997) reported significant reduction in mineral content of leafy vegetable in response to blanching due to leaching caused by blanching water. Drying treatment shows positive effect in retaining mineral content of both vegetables hence standstill as the best practice to maximize the mineral content of consumed vegetables compared when taken fresh.

4.4 Anti-nutritional Factors of Vegetable Samples

4.4.1 Tannin Content

Results on tannin content of FSL and CBL are as presented in Table 11. Tannin content of CBL was reduced significantly with blanching whereas in FSL increasing blanching time to 5 min was more effective in reducing the tannins.

Nevertheless, combined treatments (blanching and drying) while covered showed effect on eliminating tannins in both FSL by 12.16 to 25.29% (F3 – F6) and CBL by 78.25 to 88.02% (C5 – C12), respectively. Besides, a further reduction up to 25.29% was observed with extended blanching time (5 min), sundried covered with back (F5) and white (F6) cloth.

Table 11: Effect of different processing methods on anti-nutritional factors

Vegetable	Treatment	Tannins (mg/g)	Oxalate (mg/100 g)
False Sesame Leaves (FSL)	F0 (0 min)	95.45 ± 3.17^{g}	32.62 ± 5.21^{c}
	F1 (3 min)	95.45 ± 3.17^{g}	14.77 ± 0.58^{a}
	F2 (5 min)	90.79 ± 1.95^{f}	10.70 ± 0.14^{a}
	F3 (3 min, covered with WC)	82.86 ± 0.49^{e}	11.33 ± 0.60^{a}
	F4 (3 min, covered with BC)	83.72 ± 1.71^{e}	11.05 ± 0.21^{a}
	F5 (5 min, covered with WC)	72.69 ± 0.73^{ab}	9.55 ± 0.21^{a}
	F6 (5 min, covered with BC)	71.31 ± 0.73^{a}	10.20 ± 0.14^{a}
	F7 (0 min, covered with BC)	77.69 ± 2.44^{cd}	30.79 ± 2.22^{bc}
	F8 (0 min, covered with WC)	77.17 ± 1.22^{bcd}	30.47 ± 0.29^{bc}
	F9 (0 min, uncovered)	73.90 ± 2.44^{ab}	26.24 ± 3.81^{b}
Common Bean Leaves (CBL)	C0 (0min)	519.10 ± 2.93^{h}	56.32 ± 2.49^{q}
	C1 (3min, cut)	179.80 ± 0.98^{g}	29.19 ± 2.89^{cd}
	C2 (3 min, whole)	165.30 ± 0.98^{f}	26.11 ± 0.96^{c}
	C3 (5 min, cut)	136.70 ± 1.46^{e}	17.62 ± 4.70^{b}
	C4 (5 min, whole)	95.30 ± 0.49^{c}	16.72 ± 0.23^{b}
	C5 (3 min, whole, covered BC)	112.90 ± 1.95^{d}	5.53 ± 0.26^{a}
	C6 (3 min, whole, covered WC)	112.30 ± 5.61^{d}	6.32 ± 0.23^{a}
	C7 (3 min, cut, covered BC)	68.60 ± 2.68^{a}	4.31 ± 0.68^{a}
	C8 (3 min, cut, covered WC)	77.90 ± 2.19^{b}	3.45 ± 0.00^{a}
	C9 (5 min, cut, covered BC)	64.20 ± 0.49^{a}	2.77 ± 0.53^{a}
	C10 (5 min, cut, covered WC)	63.70 ± 0.73^{a}	3.19 ± 0.16^{a}
	C11(5 min, whole, covered BC)	62.20 ± 0.49^{a}	2.70 ± 0.14^{a}
	C12 (5 min, whole, covered WC)	64.40 ± 2.19^{a}	2.40 ± 0.28^{a}
	C13 (0 min, covered with WC)	135.80 ± 12.92^{e}	37.38 ± 0.28^{e}
	C14 (0 min, covered with BC)	135.60 ± 12.92^{e}	41.01 ± 1.68^{f}
	C15 (0 min, uncovered)	80.10 ± 0.00^{b}	31.90 ± 1.56^{d}

Note: WC: White Cloth; BC: Black Cloth. Means with the same letters in a column not significantly different ($p > 0.05$) in Duncan's Multiple Range Tests. Values are represented in Mean ± SD, (n=2)

This further suggests that sun drying has a positive effect in removal of tannins if combined with blanching for 5 min. In addition, sun drying of unblanched and covered (F7 and F8) and uncovered (F9) had significantly reduced tannin content. In comparison, F5 and F9 exhibited similar effect in elimination of tannins in FSL. On the other hand, blanching for 5 min and sun drying while covered was the most effective methods with up to 88.02% reduction in tannins in CBL (C9 - C12), moreover cutting, whole, colour of the cover (white and black) and blanching time showed no effect (Table 11). Various studies have also reported on the effect of blanching treatment in reducing tannin content of green leafy vegetables (Egbuonu and Nzewi, 2016; Mosha *et al*., 1995; Ogbadoyi, 2012). Also, a study by Dahiya and Dhawan (2004) reported a significant effect on reducing tannin content of vegetables and fruits.

4.4.2 Oxalate Content

Table 11 summarizes the results oxalate contents in raw and processed FSL and CBL. Significant reduction in oxalate content was observed in blanched FSL (54.72 − 67.20%) to; cut blanched CBL (48.17% − 68.71%) and whole blanched CBL (53.64 − 70.31%),

respectively. A further reduction in oxalate by 65.27 −70.72% and 66.12 − 68.73% folds was achieved when blanched leaves were sun dried while covering with white (F3 and F5) and black cloth (F4 and F6). In CBL, sun drying of blanched leaves while covered or uncovered with white or black cloth (C5 – C12) further reduced oxalate content in the range 88.79− 95.74%, compared to fresh leaves. However, no significant difference was observed between treatments (Table 11). Besides, sun-drying of unblanched FSL covered with black (F7) or white (F8) cloth and significantly reduced oxalate content with no variation between, as opposed to unblanched, uncovered (F9). On the other hand, sun drying of unblanched CBL covered with white (C13) or black (C14) cloth and uncovered (C15) showed 27.18 −43.36% reduction in oxalate, which is the least effect as compared to other treatments. Likewise, 31.26 − 49.24% reduction in the oxalate in blanched green leafy vegetables has been reported (Ilelaboye *et al*., 2013).

A decrease in total oxalate after boiling but also, insignificant differences in oxalate content of sun dried vegetables have been reported (Ogbadoyi, 2012). The effect of cooking methods (blanching) on mineral and anti-nutrient composition of some green leafy vegetables has been reported by Ilelaboye *et al*. (2013) with 76.7 −87.88% reduction of oxalate. Similarly, this study reported 27.18− 95.74% and 5.61− 70.72% reduction of oxalate in CBL and FSL, respectively. Sun drying while covering after blanching showed maximum effect in reducing oxalate in both FSL and CBL. On the contrary, Mosha *et al*. (1995) recommended blanching as an effective method for reducing the heat sensitive anti-nutritional factors in green vegetables.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The study to assessed local practices on the use, processing and preservation of leafy vegetables found in Bahi and Mbeya Rural District. Different vegetable varieties consumed in Bahi and Mbeya Rural District communities were identified. Wild weed FSL and CBL were among the most preferable and used vegetables in the areas. This study has revealed that there are various processes undertaken before vegetable are consumed, including preservation processes. It was found that, most of Bahi people preserved vegetables for dry season use due to vegetable scarcity during this season. Various methods were used for drying vegetables. Reported methods included; drying under shade, drying inside the house, drying using solar dryer, drying while covering with cloth and also drying directly under the sun. Direct sun drying was the most common method used in Bahi District. Both methods were found to be effective in drying vegetables, though they seem to contribute to the nutrients losses, hence contribute to nutrients deficiencies. Mbeya rural communities were not drying vegetables for dry season use, except for very few respondents who were doing it for flavor. Hence, drying for food security was not the reason. On the use of false sesame seeds and flowers, results ratify that, most of the Bahi communities do not regard false sesame seeds and flowers as edible. Meanwhile, other studies revealed the nutrients composition of false sesame seeds including; fatty acids, protein, iron, zinc calcium and others, which are so beneficial to our wellbeing.

Results on vitamins content of both vegetable samples revealed that β-carotene and folic acid were below detection limit. Vitamin C was observed in both samples. However, it was mostly affected by processing techniques used before consumption. The study revealed the presence of minerals such as Fe, Zn and P in both samples. Fresh leaves had significant low minerals content compared to dried leaves. Mineral content of both vegetables were mostly affected by blanching since minerals leach into blanching water. This was observed utmost in cut samples of CBL whereby the leaves matrices were more exposed. From this study, it was observed that, combined treatments, blanching and drying had significant effect in reducing anti-nutritional factors contained in both FSL and CBL. However, blanching was d most effective in reducing anti-nutritional factors in the leaves.

5.2 Recommendations

From the study, several vegetables were identified and reported to be preferred by Bahi communities but practically only two vegetables were mostly dried for future use as food. Food diversification including vegetables should be encouraged so that nutrients that are not contained in one vegetable could be supplemented with those from the other vegetable. Also, the use of drying methods which minimize the effect of sun light should be encouraged. Such methods include drying while covering with the cloth of any colour, use of solar dryer and other methods. Vegetable drying in Mbeya Rural District should be given less emphasis since fresh leafy vegetables are highly available and can be easily accessed all over the year. To add nutritional value of FSL, flowers and seeds should be incorporated in the diet since they provide our body with vital nutrients.

Vitamin C is among most sensitive nutrients, hence to ensure its availability processing methods that will favour its availability, i.e., minimize its losses must be ensured. Such methods include; the use of minimum time during blanching or cooking since vitamin C is water soluble vitamin. For the sake of mineral requirements, the use of dried vegetables should be encouraged compared to fresh leaves. Based on these research findings, blanching should be encouraged as an option for reducing anti-nutritional factors, and nutrient retention if carefully done. However, for mineral retention sun drying is the best method. Nevertheless, more studies need to be done in this cheap source of nutrients to make full exploitation of these vegetables to improve our health.

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APPENDIX

Questionnaire on the processing, use, storage and preservation of local vegetable consumed in Mbeya rural and Bahi District

Questionnaire no.……

1. PART A: GENERAL INFORMATION

1. Name ……
2. Age …….
3. Sex: 1. Male [ ] Female [ ]
4. District ……
Ward……
5. Village …….……

SEASON: Wet/Dry

SECTION B: Information on vegetables and its use.

6. Which time of the year do you consume a lot of vegetables? why?
……
……

7. Which type of edible vegetables grown locally in your area? Can you mention them?
……
……
……

8. Method of cultivation: how do you grow these vegetables?
1. Cultivating [ ]
2. Self-growing (wild vegetables) [ ]
3. Others [ ].
Specify……...

9. Which type of vegetable do you consume?
……
……
10. How often do you consume them? weekly basis? Monthly basis?
……
……

11. Which Season of the year do you have plenty of vegetables?
1. Rain/wet season [ ]
2. Dry season [ ] 3. Always [ ]
Which vegetables are these?
……
……

SECTION C: Vegetable processing and preservation.

12. How do you prepare and cook green leafy vegetables?
……..……
……

……
13. Which ingredients do you use when cooking green leafy vegetables?
……
……
14. Which type of vegetables do you store and use it in dry season?
……
……

15. Is there any reason for storing these vegetable for summer use?
……..
……..
16. Is there any difference between dried and fresh vegetables?
……
……

17. Which processing methods do you use/ how do you prepare these vegetables before preservation? (Probe until you get a good answer)
……
……
……
……
18. Do you boil vegetables prior to drying?
1. Yes [ ]
2. No [ ]

19. If the answer above is Yes, for how long?
1. 3minutes [ ]
2. 5 minutes [ ]
3. 30 minutes [ ]
4. 1hour and above [ ]

20. Which types of vegetables do you boil before drying? …….....
……
……
21. Why?
.....……..**.....**
……

22. How do you boil them?
……
……
23. Is there any different between the boiled vegetable prior to drying and the one which is dried without boiling? Mention (Probe)
……
……
24. How do you store dried vegetables prior to consumption in summer time?
……
……

25. Do you know False sesame seeds? YES/NO (If the answer is YES, go to the following Question)
26. Are they edible? YES/NO (If the answer is YES, go to the following Question)

27. Do you eat them? YES/NO

28. Mention other uses of the False sesame seeds?.....
.....

Eat vegetables, strengthen your health status.