

**EFFECTS OF GROWING CONDITIONS ON QUALITY OF DOMESTICATED  
WILD VEGETABLES: A CASE OF WILD VEGETABLES GROWN AROUND  
BALANGAI FOREST RESERVE, LUSHOTO DISTRICT**

**BY**

**MARTHA WILLIAM KIMAMBO**

**A THESIS SUBMITTED IN FULFILMENT OF REQUIREMENT FOR THE  
DEGREE OF MSc. IN MANAGEMENT OF NATURAL RESOURCES AND  
SUSTAINABLE AGRICULTURE OF SOKOINE UNIVERSITY OF  
AGRICULTURE, MOROGORO, TANZANIA.**

**2009**

## ABSTRACT

This study aimed at determining the quality of wild vegetables under different growing conditions. Data was collected using a self-administered questionnaire and single time collected samples from planted wild vegetables were laboratory tested to determine nutrient values. SAS statistical tool was used to analyse the data. Vitamin C content was found to be highest in *Solanum scabrum* ( $3.40 \pm 0.1\text{mg}/100\text{gm}$ ) under forest conditions, followed by *Launaea cornuta* ( $3.1 \pm 0.1\text{mg}/100\text{gm}$ ) under tree growing conditions; vitamin A content was highest in *Launaea cornuta* ( $480.6 \pm 10.1\mu\text{g}/\text{g}$ ) under tree growing conditions and second highest ( $467.6 \pm 10.1\mu\text{g}/\text{g}$ ) under banana shade growing conditions. Zinc content was highest in *Bidens pilosa* ( $9.70 \pm 0.1\text{mg}/100\text{gm}$ ) under open space growing conditions, followed by *Basella alba* and *Solanum Scabrum* ( $9.10 \pm 0.1\text{mg}/100\text{gm}$ ) under open space and banana shade growing conditions respectively. Iron content was highest in *Bidens pilosa* ( $52.4 \pm 0.4\text{mg}/100\text{g}$ ) under banana shade growing conditions and second highest ( $32.7 \pm 0.4\text{mg}/100\text{g}$ ) under forest growing conditions, followed by *Launaea cornuta* ( $13.5 \pm 0.4\text{mg}/100\text{g}$ ) under banana shade growing conditions; calcium content was highest in *Bidens pilosa* ( $575.7 \pm 2.7\text{mg}/100\text{g}$ ) under banana shade growing conditions, followed by *Solanum Scabrum* and *Basella alba* ( $448.2 \pm 2.7\text{mg}/100\text{g}$ ) under the same forest growing conditions; crude protein content was highest in *Solanum scabrum* ( $6.4 \pm 0.04\text{mg}/100\text{g}$ ) under forest growing conditions, followed by *Bidens pilosa* ( $6.3 \pm 0.04\text{mg}/100\text{g}$ ) under banana shade growing conditions; crude fibre content, which was highest in *Basella alba* ( $1.8 \pm 0.03\text{mg}/100\text{g}$ ) under open space growing conditions, was followed by *Solanum scabrum* ( $1.7 \pm 0.04\text{mg}/100\text{g}$ ) under banana shade growing conditions. These findings show that domestication of wild vegetables is possible and can equally provide quality nutrients for human consumption. Domestication will safeguard wild vegetables from the current practise of deforestation by

excessive harvesting direct from natural forests. Research on seed production from wild vegetables and distribution for domestication is recommended.

**DECLARATION**

I, MARTHA W. KIMAMBO, do hereby declare to the SENATE of Sokoine of Agriculture (SUA) that the work I presented here is the result of my original work, and that it has never been submitted for a higher degree award in any other University.

---

Martha W. Kimambo  
(MSc. Candidate)

---

Date

The above declaration is confirmed

---

Prof. K. F. S. Hamza  
(Supervisor)

---

Date

---

Dr. Reuben Mwamakimbullah  
(Supervisor)

---

Date

**COPYRIGHT**

No part of this dissertation may be duplicated, stored in any retrieval system or transmitted in any form or by any means without prior written permission of the author or Sokoine University of Agriculture on the behalf.

## **ACKNOWLEDGEMENTS**

I wish to express my sincere gratitude to my supervisors, Prof K. F. S. Hamza and Dr Reuben Mwamakimbullah of Department of Wood Utilization, for their directive and valuable constructive guidance, suggestions, corrections and encouragements during the whole period of the study. I also wish to express my appreciation to my loving husband, Mnuka Florentine, Dr Yongollo M.G.S .and my mother Violeth Kimambo, my sisters Janerose, Mary, Josephine, Edith, my brothers and our children Amadeus, Frank, Anneth and Violeth for their encouragement tolerance and for their painstaking endurance during long session of my absence from home. The help I got from the Head of Department of Agriculture and Livestock of Moshi Municipal Council, Dr. A. E. Tarimo and fellow staff members for their assistance during my field study is also acknowledged.

I acknowledge the farmers from Kweminyasa and Mahange villages for their good participation during my field Study. My heart-felt thanks go to my friends and all colleagues who in one way or another supported and contributed to this study. Lastly, but not least, I give thanks to the Almighty God for His mercy and guidance to me throughout my studies.

## **DEDICATION**

This piece of work is dedicated to my parents, the Late William Kimambo and my mother Violeth Kimambo, Mr Florentine Mnuka, Dr Yongollo M.G.S., my sisters, my brothers and my children Amadeus, Frank, Anneth, and Violeth.

## TABLE OF CONTENTS

<b>ABSTRACT.....</b>	<b>ii</b>
<b>DECLARATION.....</b>	<b>iv</b>
<b>COPYRIGHT.....</b>	<b>v</b>
<b>ACKNOWLEDGEMENTS.....</b>	<b>vi</b>
<b>DEDICATION.....</b>	<b>vii</b>
<b>TABLE OF CONTENTS.....</b>	<b>viii</b>
<b>LIST OF TABLES.....</b>	<b>xiii</b>
<b>LIST OF PLATES.....</b>	<b>xv</b>
<b>LIST OF APPENDICES.....</b>	<b>xvi</b>
<b>LIST OF ABBREVIATIONS AND SYMBOLS.....</b>	<b>xvii</b>
<b>CHAPTER ONE.....</b>	<b>1</b>
<b>1.0 INTRODUCTION.....</b>	<b>1</b>
1.1 BACKGROUND INFORMATION.....	1
1.2 PROBLEM STATEMENT AND JUSTIFICATION.....	2
1.3 OBJECTIVE.....	4
1.3.1 <i>Specific objectives</i> .....	4
<b>CHAPTER TWO.....</b>	<b>5</b>
<b>2.0 LITERATURE REVIEW.....</b>	<b>5</b>
2.1 OVERVIEW.....	5
2.2 AVAILABILITY, NUTRITIONAL AND MEDICINAL VALUE OF WILD VEGETABLES.....	6
2.2.1 <i>Availability</i> .....	6
2.2.2 <i>Nutritional value</i> .....	7
2.2.3 <i>Medicinal value</i> .....	8
2.2.4 <i>Vegetables and their vernacular names</i> .....	8

2.2.5 Processing for preservation.....	9
2.3 EFFECT OF LEVEL OF EDUCATION ON USE OF WILD VEGETABLES:.....	9
2.4 GROWING SITES AND ENVIRONMENTAL VARIABILITY.....	10
2.5 QUALITY PARAMETERS OF NATURAL AND CULTIVATED WILD VEGETABLES.....	10
<b>CHAPTER THREE.....</b>	<b>12</b>
<b>3.0 MATERIALS AND METHODS.....</b>	<b>12</b>
3.1 STUDY AREA DESCRIPTION.....	12
3.2 FIELDWORK PROCEDURES.....	14
3.3 DETERMINATION OF MOST PREFERRED SPECIES AND INDIGENOUS KNOWLEDGE ON WILD VEGETABLES.....	14
3.3.1 Household sample size.....	14
3.3.2 Interviews and questionnaires:.....	16
3.3.3 Wild vegetable identification and sample collection for laboratory analysis...16	
3.4 DOMESTICATION OF WILD VEGETABLES.....	17
3.4.1 Seeds and vine collection, handling for sowing, planting and growing.....17	
3.4.2 Experimental design.....	17
3.4.3 Harvesting of samples for laboratory analysis.....	18
3.5 LABORATORY ANALYSIS OF HARVESTED SAMPLES OF WILD VEGETABLES.....	18
3.5.1 Moisture content determination of different wild vegetables.....	18
3.5.2 Determination of Protein content.....	18
3.5.3 Determination of crude fibre.....	19
3.5.4 Determination of minerals (iron and zinc and calcium).....	19
3.5.5 Determination of $\beta$ -carotene (vitamin A).....	19
3.5.6 Determination of vitamin C.....	20
3.6 DATA ANALYSIS.....	20

<b>CHAPTER FOUR.....</b>	<b>22</b>
<b>4.0 RESULTS AND DISCUSSION.....</b>	<b>22</b>
4.1 AGE AND SEX COMPOSITION OF THE RESPONDENTS.....	22
<b>4.2 INDIGENOUS KNOWLEDGE ON WILD VEGETABLES.....</b>	<b>22</b>
4.3.1 <i>Types of wild vegetables observed in the study area.....</i>	<i>22</i>
4.3.2 <i>Methods of post harvest preservation of wild vegetable.....</i>	<i>25</i>
4.3.3 <i>Facilities used for storage of wild vegetables.....</i>	<i>26</i>
4.3.4 <i>Techniques employed to prepare wild vegetables for food.....</i>	<i>27</i>
4.3.5 <i>Wild vegetable cultivation practices in Balangai area.....</i>	<i>28</i>
4.3.6 <i>Other uses of wild vegetables.....</i>	<i>31</i>
4.3.7 <i>Pests and diseases.....</i>	<i>31</i>
4.4 NUTRITIVE VALUES OF WILD VEGETABLES IN DIFFERENT GROWING CONDITIONS..	32
4.4.1 <i>Effect of growing conditions (shade) on moisture content (mg/100g) for</i> <i>four species of wild vegetables.....</i>	<i>32</i>
4.4.1.1 Differences in moisture content between species and within the growing conditions.....	32
4.4.1.2 Differences in moisture content within species and between the growing conditions.....	34
4.4.2 <i>Effect of growing conditions (shade) on vitamin C content (mg/100g) for</i> <i>four species of wild vegetables.....</i>	<i>35</i>
4.4.2.1 Differences in vitamin C content between species and within the growing conditions.....	35
4.4.2.2 Differences in vitamin C content within species and between the growing conditions.....	37
4.4.3 <i>Effect of growing conditions (shade) on vitamin A content (mg/100g)</i> <i>for four species of wild vegetables.....</i>	<i>38</i>

4.4.3.1 Differences in vitamin A content between species and within the growing conditions.....	38
4.4.3.2 Differences in vitamin A content within species and between the growing conditions.....	39
4.4.4 <i>Effect of growing conditions (shade) on calcium content (mg/100g) for four species of wild vegetables.....</i>	41
4.4.4.1 Differences in calcium content between species and within the growing conditions.....	41
4.4.4.2 Differences in calcium content within species and between the growing conditions.....	42
4.4.5 <i>Effect of growing conditions (shade) on zinc content (mg/100g) for four species of wild vegetables.....</i>	43
4.4.5.1 Differences in zinc content between species and within the growing conditions.....	43
4.4.5.2 Differences in zinc content within species and between the growing conditions.....	45
4.4.6 <i>Effect of growing conditions (shade) on vitamin A content (mg/100g) for four species of wild vegetables.....</i>	46
4.4.6.1 Differences in iron content between species and within the growing conditions.....	46
4.4.6.2 Differences in iron content within species and between the growing conditions.....	48
4.4.7 <i>Effect of growing conditions (shade) on vitamin A content (mg/100g) for four species of wild vegetables.....</i>	50
4.4.7.1 Differences in protein content between species and within the growing conditions.....	50

4.4.7.2 Differences in protein content within species and between the growing conditions.....	51
4.4.8 <i>Effect of growing conditions (shade) on crude fibre content (mg/100g) for four species of wild vegetable.....</i>	53
4.4.8.1 Differences in crude fibre content between species and within the growing conditions.....	53
4.4.8.2 Differences in Crude fibre content within species and between the growing conditions.....	54
<b>CHAPTER FIVE.....</b>	<b>57</b>
<b>5.0 CONCLUSION AND RECOMMENDATIONS.....</b>	<b>57</b>
5.1 CONCLUSION.....	57
5.2 RECOMMENDATIONS.....	58
<b>REFERENCES.....</b>	<b>60</b>
<b>APPENDICES.....</b>	<b>68</b>

## LIST OF TABLES

Table 1: Sex and age composition of respondents in Balangai community.....	22
Table 2: Some of the wild vegetables found in Balangai Forest and their availability calendar.....	24
Table 3: Methods commonly used in processing wild vegetables for Preservation in Kweminyasa and Mahange villages Lushoto Districts.....	25
Table 4: Storage facilities used for Preservation of wild vegetables in Kweminyasa and Mahange villages in Lushoto District.....	27
Table 5: Methods commonly used in preparation of wild vegetables for table in Balangai area in Lushoto District.....	27
Table 6: Conditions under which wild vegetables were obtained in Kweminyasa and Mahange villages in Lushoto District.....	29
Table 7: Effect of growing conditions (shade) on moisture content (mg/100g) for four species of wild vegetables.....	33
Table 8: Effect of growing conditions on vitamin C content (mg/100g) for four species of wild vegetables.....	36
Table 9: Effect of growing conditions on vitamin A $\mu\text{g/g}$ content for four species of wild vegetables.....	39
Table 10: Effect of growing conditions on calcium content (mg/100g) for four species of wild vegetables.....	42
Table 11: Effect of growing conditions on zinc content (mg/100g) for four species of wild vegetables.....	45
Table 12: Effect of growing conditions on iron content (mg/100g) for four species of wild vegetables.....	48

Table 13: Effect of growing conditions on crude protein content (mg/100g) for four species of wild vegetables.....	51
Table 14: Effect of growing conditions on crude fibre content (mg/100g) for four species of wild vegetables.....	54
Table 15: Nutritional values of domesticated wild vegetables and a growing condition in which each performed best.....	59

## LIST OF PLATES

Plate 1: Map – Tanzania map with Lushoto.....	13
Plate 2: (a)-(e); Investigation of wild and domesticated vegetables in a market in Balangai area of Lushoto District (a) Wild <i>Amaranthus</i> spp (Bwache); (b) <i>Cleome gynandra</i> (Mgagani); (c) <i>Ipomoea batata</i> ; (Talata) (d) <i>Solanum</i> spp; (Mnavu bwache) (e) <i>Launaea cornuta</i> (Mshunga).....	23
Plate 3: (a)–(d) Growing conditions under which wild vegetables were cultivated in Kweminyasa and Mahenge villages of Lushoto District: : (a) Wild vegetable species grown under tree shade; (b) Wild vegetable species grown in open space; (c): Wild vegetable species grown under banana shade; (d): Wild vegetable species grown under improvised shade.....	30

**LIST OF APPENDICES**

Appendix 1: Structured questionnaire:.....	68
Appendix 2: Proximate composition analysis.....	71

**LIST OF ABBREVIATIONS AND SYMBOLS**

AOAC	Association of Official Analytical Chemistry
cm	centimetre
FAO	Food and Agriculture Organization of the United Nations
g	gram(s)
GLM	General Linear Model
min	minute(s)
ml	millilitre(s)
PDIFF	Probability of Finding Difference
SAS	Statistical Analysis System
SECAP	Soil Erosion and Agroforestry Project
UNESCO	United Nations Education, Science and Culture Organization
URT	The United Republic of Tanzania
µg	microgram(s) = $10^{-6}$ gram

## CHAPTER ONE

### 1.0 INTRODUCTION

#### 1.1 Background Information

Micronutrient deficiency is a universal problem, which presently affects over two billion people worldwide, resulting in poor health, low worker productivity, and high rates of mortality and morbidity (Flyman and Afolayan, 2006). Deficiency in micronutrients has led to increased rates of chronic diseases and permanent impairment of cognitive abilities in infants born to micronutrient deficient mothers. Wild vegetables have been the mainstay of human diets for centuries, providing millions of consumers with important micronutrients, such as vitamins and minerals needed to maintain health and promote immunity against infections. According to Humphry *et al.* (1993), several studies show that many species of wild green vegetables are rich sources of nutrients. Hence, they could make an important contribution to combating micronutrient malnutrition as well as providing food security.

Unfortunately, wild vegetables are currently underutilized, and have been neglected by researchers and policy makers. Their promotion and integration into human diets could assist in their protracted use and consequent conservation. However, the chemical, nutritional and toxicological properties of especially local wild vegetables, the bioavailability of micronutrients present in them, and their modification by various processing techniques still need to be properly established and documented before their use as an alternative dietary source can be advocated (Flyman and Afolayan, 2006). Such information would be of fundamental importance in addressing dietary deficiencies in impoverished African rural communities. African wild vegetables have several values and properties that make them useful plants to the community. These vegetables have been

documented to have a high nutritive value with regard to micro-nutrients and in certain cases; their content supersedes that of the exotic ones. Wild vegetables have medicinal properties and can treat ailments that pertain to stomach problems especially the bitter types; they grow very fast and produce a lot of seed within a short period. Most of them can withstand nutritional stress and drought. They have mechanisms within them that enable them to withstand stress (Abukutsa-Onyango *et al* 2005). Despite the enumerated value, these vegetables have been neglected by stakeholders in terms of research, extension, education and utilization

Research on the important role of wild vegetables in Tanzania's health sector, diets and as an income source has not so far addressed the maintenance or enhancement of quality of cultivated wild vegetables by simulating their natural growing conditions.

This study is part of an ongoing research work titled "Empowering of local communities with skills of sustainable wild vegetables and fruits utilization for poverty alleviation and biodiversity conservation in East and West Usambara and Udzungwa mountain blocks"; some of the information has already been gathered for some plants.

## **1.2 Problem Statement and Justification**

It has been noted that wild vegetables have continued to be consumed as a part of the diet of communities around forest resources. Further, some studies show that these wild vegetables have most often been accessed by women who have been collecting them from nearby forests as a nutritious food source on trial basis, before finally being adopted as home garden vegetables. Furthermore, there is very limited documentation about how this transition from dependence on forests to dependence on fields for wild food plants occurs.

Moreover, it has been observed that as communities continue to gather wild vegetables from these forest resources, eventually, as the resources continue to diminish, time will come when most of the species will disappear as biodiversity continues to be compromised.

Utilization without cultivation could lead to depletion of the wild vegetables from their natural habitat. To sustain them they need to be preserved and exploited in a planned manner. This can be achieved if they are cultivated, so that their performance is studied and managed just like other crops. The UN Food and Agriculture Organization (FAO,1988) emphasized the need to preserve new plant resources to broaden the biological diversity base in human nutrition; recently there has been increased interest in wild species because of their possible medicinal value in diets (Michele *et al.* 2008). Naturally domesticated wild vegetables are subjected to different environmental conditions. Nevertheless, they grow well and are adapted to natural conditions and resistant to diseases. Mere harvesting from natural forest does not change constitution of the plants, whereas cultivation means growing in a different unnatural environment, in terms of soil type and composition, humidity and other factors which might change the plant physiology (Edmonds and James, 1997). This change could affect its nutritive value (Michele *et al.*, 2008). Therefore, this study targets to evaluate the effect of different growing conditions on cultivated wild vegetables with a view to improve/maintain their quality. Quality in this aspect means nutritive value, which includes vitamins A and C and minerals, calcium, zinc and iron. The study results will enhance domestication management of wild vegetables. The results of this study are expected to be used in providing insight into the possibility of cultivation of wild vegetables instead of harvesting directly from the natural forest and hence maintain biodiversity of the forests. Also the results will increase the awareness of their nutritive value and minimize the cost of

vegetable substitutes, which would otherwise be incurred in purchasing. Besides, the study will contribute towards reduction of travel time by gatherers to the forests to collect the wild vegetables for food.

### **1.3 Objective**

To determine the quality of domesticated wild vegetables by simulating their natural growing conditions.

#### **1.3.1 Specific objectives**

The specific objectives were as follow

1. To evaluate the indigenous knowledge on domestication of wild vegetables.
2. To determine most preferred types of wild vegetables used within the community
3. To determine the contents of vitamins and minerals of domesticated wild vegetables under different growing conditions.
4. To determine contents of vitamins and minerals of wild vegetables obtained from natural growing conditions i.e. forest.
5. To compare quality parameters of wild and cultivated wild vegetables.

### **Hypothesis**

***H<sub>0</sub>***: Growing conditions have no effect on quality of cultivated wild vegetables

***H<sub>i</sub>***: Growing conditions have effect on quality of cultivated wild vegetables

## CHAPTER TWO

### 2.0 LITERATURE REVIEW

#### 2.1 Overview

Micronutrient deficiency is a universal problem, which presently affects over two billion people worldwide, resulting in poor health, low worker productivity, high rates of mortality and morbidity (Flyman and Afolayan, 2006). Deficiency in micronutrients has led to increased rates of chronic diseases and permanent impairment of cognitive abilities in infants born to micronutrient deficient mothers. Wild vegetables have been the mainstay of human diets for centuries, providing millions of consumers with important micronutrients, such as vitamins and minerals needed to maintain health and promote immunity against infections (Flyman and Afolayan, 2006). In comparison with cultivated plants wild vegetables are non timber forest products (NTFP) whose leaves or aerial parts have been integrated in a community's culture for use as food over a large span of time. They may be sourced from the wild (in nature) or may be domesticated in house gardens and farm lands (Ogoye-Ndegwa and Aagaard-Hansen, 2003; Midmore *et al.*, 1991). Consumption of vegetables from the wild or from home gardens is important for nutrition of rural as well as urban populations (FAO, 1988).

Wild vegetable species are important for local nutrition for many reasons. First, they make up a large percentage of food intakes even if other food constituents are available. Vainio-Matilla (2000), in her dietary study in the Usambara Mountains of Tanzania, showed that wild vegetables accounted for over 80% of all leafy vegetables consumed. Indeed, wild vegetables were the major ingredient in side dishes or condiments to staple foods in 25–43% of the meals recorded in different villages (Weinberger and Msuya, 2004). Second, they give diversity, and add flavour and taste to daily food intake( Shackleton *et al.*,

(1998); Asfaw, (1997). Third, almost all of these wild vegetables are good sources of micronutrients including iron and calcium as well as vitamins A, B complex, C and E. One example is amaranth which contains more of these nutrients compared to a typical exotic leafy vegetable, white cabbage (Weinberger and Msuya, 2004 Ezekwe *et al.*, 1999; Mathenge, 1997; Nordeide *et al.*, 1996; Humphry *et al.*, 1993). Fourth, most of the wild vegetables may be preserved by drying during the rainy season; hence important for food security during times of drought and poor harvests. Wild vegetables are regarded as easily obtainable, and palatable. Some of the recorded species are not indigenous but naturalized. Most of the recorded species are ruderal, growing by the road sides and as weeds of arable land (Vainio Matilla, 2000). Wild vegetables are also important in their ecological value, agronomic value, cultural value and creation of employment (Abbiw 1997; Okafor, 1997). Ecologically, wild vegetables have a unique advantage within the local farming systems in that they thrive during the hot and wet seasons and many of them are environment friendly hence require no pesticides and fertilizers in their management (Chweya and Eyzaguirre, 1999; UNESCO, 1999). Forest plays a direct and indirect role in food production and food security. Non wood forest products such as wild vegetables may be collected for direct consumption or be sold to generate funds to supplement household budget.

## **2.2 Availability, Nutritional and Medicinal Value of Wild Vegetables**

### **2.2.1 Availability**

Differences in climate, soil and vegetation are reflected in differences in the availability and use of edible plants. Some wild foods are commonly eaten, whilst other types of gathering characterized a particular biome of certain area or indigenous tradition of a certain ethnic group. The extent of the use of wild green leafy vegetables varies in different lifestyles across Africa: a greater diversity of species is used in agricultural and agro-paastoral communities than among hunter-gatherers (Vainio-Matilla, 2000). Modi *et*

*al.*, (2006) reported that, availability of wild vegetables (plant numbers and yield) at Ezigeni location in Umbumbulu, South Africa increased from August to October, but there was a significant difference between species. However, leafy vegetable availability seems to decline earlier (May) than that of food crops, and the former become scarce by midwinter (June, July) until spring (August), when their growth resumes. Keding *et al* (2007) reported that lower ratios in Arumeru and Singida vis-à-vis wild traditional vegetables' lower popularity, importance and availability can be attributed to the grade of urbanization and population density, which spare less uncultivated areas as a habitat for wild vegetables. In all districts studied, only few vegetables are both cultivated and collected from the wild. One example is amaranth as there are different amaranth cultivars or landraces and wild forms available in Tanzania.

### **2.2.2 Nutritional value**

Wild vegetables are an important source of carbohydrates, proteins, fibre, vitamins (such as vitamins A and C), and minerals (such as zinc, iron, calcium) and iodine (Ohiokpehai, 2003). Proteins are emphasized in diets of young children as their deficiency may cause kwashiorkor, which is very common in weaned children. The deficiency of both carbohydrates and protein causes underweight in children, which could affect the growth of children causing brain under development. Active forms of vitamin A participate in 3 essential functions, namely, visual perception, cellular differentiation and immune response. Vitamin C in human nutrition plays the role of a biological reducing agent and may be linked to its prevention of degenerative diseases, such as cataracts, certain cancers and cardiovascular diseases (Bowman and Russel, 2001). Iron is essential for the formation of protein in red blood cells (haemoglobin) that carries oxygen from the lungs to all cells of the body (Ohiokpehai, 2003). Zinc is an essential element in human nutrition, and its importance to human health has received much recent attention. Zinc plays an

important role in the proper functioning of the immune system, cell division, cell growth, and wound healing. It is also involved in the senses of taste and smell, as well as in the metabolism of carbohydrates (Bowman and Russel, 2001). Calcium is an important component of a healthy diet and a mineral necessary for life. Long-term calcium deficiency can lead to rickets and poor blood clotting and in case of a menopausal woman, it can lead to osteoporosis, in which the bone deteriorates and there is an increased risk of fractures.

### **2.2.3 Medicinal value**

Besides being used as food, some of the vegetables are known to be of medicinal value (Olsen and Nielsen, 1999; UNESCO, 1997). They are used to treat different kinds of ailments, ranging from simple wounds affecting various parts of the body, to treating the more complex ailments such as spirit possession, and the evil eye. They can also be used for love potions and as protective charms (Ogoye-Ndegwa and Aagaard-Hansen, 2003; Geissler *et al.* 2002). Wild vegetables are also important in their ecological value, agronomic value, cultural value and creation of employment (Abbiw 1997; Okafor, 1997). Michele *et al.* (2008) reported that plant species that grow in the wild also provide secondary metabolites such as phenolic acid compounds and flavonoids, which occur widely in the plant kingdom. It has been proven that, if these metabolites are consumed in significant volumes, they have a protective effect on human health.

### **2.2.4 Vegetables and their vernacular names**

A study done by Vainio-Matilla (2000) in Usambara reported the following vegetables in both vernacular and botanical names: Bwache (*Ammaranthus spinosus*), mbwembwe (*Bidens pilosa*), ngereza (*Galinsoga paviflora*), mshunga (*Laucea cornuta*), ndelema (*Basella alba*), linjangombe (*Emillia coccinea*), mshunga kwake (*Sonchus oleraseus* L),

nkhongo (*Commelina benghalensis*), yugwa (*xanthosoma sagittifolia*), and maeze/eze/gimbi (*Colocasia esculenta*). In addition, the communities have developed skills to incorporate into home gardens and sell part of the wild vegetables under the vernacular names at the local market for use as part of their meals. However, there is limited documented literature on these wild vegetables.

### **2.2.5 Processing for preservation**

According to Bujulu and Matee (2005) they showed that most of wild vegetables can be dried and stored for future use, but this practice greatly reduces the crop's nutritional value. Processing for future storage is common in Tanzania but done in different ways. Wild vegetables can be dried uncooked. Tender leaves are picked and a bit crashed by hand or cut into small pieces by knife and sun dried. Processing for preservation for a long period involves steam boiling by wrapping in a clean white material and immersed in salted boiling water for about 5 minutes. After boiling the vegetables are sieved, opening the material and sun dried on a clean flat container for about two (2) days. The wild vegetables are sun dried because if left indoors; they rot easily. The dried wild vegetables are usually stored in sacks or jute bags. Storage is usually in well ventilated place with little possibility for insect attack. Some of the produce can be stored for over one year.

### **2.3 Effect of Level of Education on Use of Wild Vegetables:**

Ethnic origin was found to greatly influence consumption of wild vegetables. However, Kimiywe, *et al.* (2007), found that there was no significant relationship between household income and education level and choice or use of wild vegetables. Other factors influencing the choice and consumption of indigenous vegetable included: occupation, sex, income and education levels. Some of the reasons for not consuming the vegetables included prohibitive costs and not knowing how to cook them especially those from other tribes.

## 2.4 Growing Sites and Environmental Variability

Wild vegetables were reportedly grown at different sites. The sites include near homestead, fertile portions of the cropland, abandoned homesteads and cattle enclosure, near riverbanks and cropland (Chweya and Eyzaguirre, 1999). Some vegetable species are habitat specific (Maundu *et al.* 1999).

Moreover, the leaves harvested from the shade-grown plants were more palatable, being less bitter' than those harvested from plants grown in full sun. Examples of commonly used but bitter species are *Launaea cornuta* (mshunga) and *Cleome gynandra* (Mgagani) (Vainio-Matilla, 2000). Fawusi *et-al.* (1983) later found that plants of *Solanum scabrum* would tolerate up to 60% shading, but that full sun was beneficial to growth. Earlier shade experiments by Singh (1971), however, demonstrated that full sun was necessary for floral initiation, but that partial shade resulted in a better growth performance in Indian plants con specific with *Solanum scabrum* and *Solanum villosum*. Moreover, the Author obtained significantly higher growth and biomass values when these plants were grown in open conditions during the Indian winter and in shade during the summer. Such observations were undoubtedly associated with accompanying temperature and soil moisture values, but were considered to explain the restriction of these plants to shady moist localities during summer months, and their occurrence in more open habitats during the winter in India.

## 2.5 Quality Parameters of Natural and Cultivated Wild Vegetables

Wild vegetables contain relatively high amounts of beta-carotene, the precursor of vitamin A and vitamin C (Chweya, 1994). They also contain modest levels of minerals, such as iron and calcium. On the other hand, they generally contain low levels of the macro-nutrients: proteins and lipids. One reason for this is their high content of water; (80-90%) Chweya, 1994) reported that a protein level ranging from 0.8 to 5.5 g/100 g fresh leaves of

nine species of traditional leafy vegetables commonly eaten in Kenya. Crude fibre may be defined as the remnants of the edible parts of plants or analogous carbohydrates that are resistant to digestion and absorption in the human small intestine with complete or partial fermentation in the large intestine. Crude fibre has physiological importance such as lowering plasma cholesterol levels, modifying the glycaemic response, improving larger bowel function, and lowering nutrient availability occur both in isolated fibre fractions and in fibre rich foods. Rumm, *et al* (1997). During plant growth in the wild vegetables there was a general increase in crude fibre over time depending on the physiological stage of the plant (Pisarikova *et al.*, 2007).

## **CHAPTER THREE**

### **3.0 MATERIALS AND METHODS**

#### **3.1 Study Area Description**

Lushoto district is located in the Northern Eastern part of Tanzania. The district covers a total area of about 4,500 squares kilometers. It lies between longitude 38°10' and 38° 36' East of Greenwich and latitude 4°24' and 5° 15' South of the Equator, at an altitude between 800 to 2300m above sea level (Kerkhof, 1990). Annual temperature varies with altitude, where at 500 meters above sea level, temperature ranges from 25 °C to 27 °C while between altitude 1500 to 1800 above sea level, temperatures range from 16 °C to 18 °C. The period between June to early September is the coldest season of the year with temperatures ranging from 15 to 20 °C and sometimes drop to 3 °C (SECAP, 1996) as cited by Boniface., 2004). This district receives bimodal rainfall pattern which ranges between 600 to 1200mm (Msangi 1990 cited by Shemdoo 2003). The dominating soil type is latosols, however in the lower wetter areas soils are humic ferralic whereas in the drier area soils are humic ferrisol, (URT 2002 cited by Shemdoo, (2004).

A total population of 491,970 people from 80,263 households was recorded by URT (2002) cited by Shemdoo (2004) and that of the villages of Kweminyasa and Mahange is 3243 and 1840 respectively (Kipingu, personal communication, 2008). The district, as well as the two villages, is dominated by the Sambaa ethnic group, composing 80% of the total population of the district.



Source: [www.geocities.com](http://www.geocities.com)

**Plate 1: Map – Tanzania map with Lushoto**

These are followed by Pare, Mbugu and other minority tribes, who compose 14%, 5% and 1% respectively of the whole population (Johansson, 2001). The major economic activity in Lushoto district is agriculture including horticulture. Horticulture produce is sold in the local market or transported to large towns like Tanga and Dar es Salaam. The main economic activities in the named villages include growing of cash crops, such as tea and coffee and food crops that includes vegetables and root crops. The choice of the study area, which is Balangai Forest Reserve and two of its five surrounding villages, on the availability of wide diversity of wild vegetables. Consequently, Lushoto district was

purposeful by virtue of Balangai Forest Reserve and the two villages of Kweminyasa and Mahange lying within the District. The two villages, Kweminyasa and Mahange, cover an area of 1958 and 976 hectares respectively (Kipingu, personal communication, 2008).

### **3.2 Fieldwork Procedures**

This research involved field work in two villages namely; Kweminyasa and Mahange of Lushoto district, it covered the period from 25 September 2008 to 30 January 2009. First, agriculture village extension staffs from the two villages were contacted to get first hand information and assist in identification of study villages and collaborating farmers. Then, the two study villages were picked from the six villages surrounding Balangai forest. This was followed by interviews. Thirdly, types of wild vegetables which are preferred and commonly consumed by people in the study community were listed (See Table 2). Basing on data gathered wild vegetables were identified, seeds harvested and grown in homesteads different environments. Lastly samples for laboratory were collected and analyzed.

### **3.3 Determination of Most Preferred Species and Indigenous Knowledge on Wild Vegetables**

#### **3.3.1 Household sample size**

The sample was determined using the following expression (Kothari, 2004):

$$n = \frac{z^2 pq}{e^2}$$

Where  $n$  = desired sample size;

$z$  = the value of the standard variate at 95 per cent confidence level

$p$  = sample proportion of the target population (users of wild vegetables),  $q = 1 - p$ .

$e$  = the acceptable error.

- $p$  was determined through a pilot survey and
- $e$  was determined iteratively on site.
- Reasonable sample size i.e. minimum sample size is 30 households

***Calculation for estimating sample size***

Given that

$$n = \frac{z^2 * pq}{e^2}$$

Where  $z = 95\%$  confidence level = 1.96

$P = 1 - q = 0.981$  and  $q = 0.019$

$e = \pm 5\% = 0.05$

Therefore, substituting,

We have: 
$$n = \frac{1.96^2 * 0.998 * 0.02}{0.05^2}$$

$$= \frac{3.8416 * 0.01996}{0.0025}$$

$$= \frac{0.07667}{0.0025}$$

$$= 30.6 \text{ or approx. } \mathbf{30}.$$

### **3.3.2 Interviews and questionnaires:**

A self administered questionnaire (Appendix 1) was used to capture information about preferred wild vegetables by households. Preference was assessed by respondents giving scores to each of the listed wild vegetables. The most preferred wild vegetables scored 4, followed by 3, 2, 1 and 0. In that order, the least preferred scored 1 and those not preferred at all scored 0. Wild vegetables sold were noted according to the local names given by market vendors. Questionnaire among the villagers were conducted in Swahili. Thirty respondents i.e. 15 from each village were randomly selected from a list of 100 households in the two villages that practice use of wild vegetables.

### **3.3.3 Wild vegetable identification and sample collection for laboratory analysis**

Wild vegetables were searched in the forest surrounded by five villages. Two villages were selected from identified areas where farmers usually harvest wild vegetables. Given that the two selected and non selected villages utilized the same forest as a source of wild vegetables, a total of five sites were identified for sampling of forest wild vegetables. It was therefore assumed that these wild vegetables sampled could represent all of the vegetables in the forest. The distance from one site was half kilometre to two kilometers within the forest.

In the forest four species of wild vegetables were selected for collection of samples for laboratory analysis and planting or sowing in the house hold plots under different environmental conditions. The selection of the four species was based on results from the market and questionnaire study. The most commonly sold and preferred wild vegetables were: *Solanum Scabrum*, *Bidens pilosa*, *Launaea cornuta* and *Basella alba*. Seeds of *Solanum scabrum*, *Bidens pilosa* and *Launaea cornuta*. These vegetables

were taken from forest for sowing in different conditions around the households. Whereas, vines as planting material were taken from *Basella alba*.

### **3.4 Domestication of Wild Vegetables**

#### **3.4.1 Seeds and vine collection, handling for sowing, planting and growing**

Seeds of *Solanum scabrum*, *Bidens pilosa* and *Launaea cornuta* were selected for planting. Only dry seeds were harvested, pooled and stored in a paper bag. No further treatment was applied to the seeds. Thus, they were planted directly after one week storage at room temperature in a dry room. Before sowing, seed beds were prepared by simple ploughing, just as it is done by farmers in the area. No fertilizer was added. Whereas, vines of *Basella alba* with length of about 15 to 20 cms were cut and planted directly without storage. These were planted within the habitats of communities at Kweminyasa and Mahange villages under four different growing conditions, namely: tree shade, banana plantations, improvised shade and open spaces. The Plants were provided with supplementary irrigation using watering cans, which is a common practice in the area. Encroaching plants such as weeds were hand-picked to remain with clear stands of intended plants in each respective plot.

#### **3.4.2 Experimental design**

The effect of growing conditions was captured through Randomized Complete Block Design, i.e. plots under different growing conditions (tree shade, banana plantations, improvised shade and open spaces ) were selected and seeds of wild vegetables from Balangai forest were planted to four treatments of most preferred plant species ( *Solanum Scabrum*, *Basella alba*, *Bidens pilosa* and *Launaea cornuta*). The forest growing condition was taken as control.

### **3.4.3 Harvesting of samples for laboratory analysis**

Samples for laboratory analysis were harvested when plants were of one and half months of age. This was at the point of 60% flowering of plant population. The edible portion, which included leaves and young petioles were cut as practiced by the Balangai communities when they harvest wild vegetables. Care was taken to only pick plant parts and not any material that would affect laboratory results e.g. insects, twigs and other plant materials. The picked parts were briefly air swilled (shaken) to remove dust and soil particles. After harvest they were packed in air tight bags. Care was taken not to further expose the samples to sunlight after harvesting by undertaking these last steps in the shade. Samples from each of the studied condition were pooled as one sample. These were immediately stored in a cool box with ice packs to maintain a temperature of + 4 to 8°C. The ice packs were replenished with fresh ice every 12 hours, when transporting to Sokoine University of Agriculture laboratories.

## **3.5 Laboratory Analysis of Harvested Samples of Wild Vegetables**

### **3.5.1 Moisture content determination of different wild vegetables**

Moisture content was determined by drying a known sample weight in an oven at 110°C for 24 hours until constant weight was obtained. The difference in weight after drying is termed as moisture content of the sample.

### **3.5.2 Determination of Protein content**

Protein content was determined by using Macro-Kjeldahl method, sulphuric acid used for digesting the food product, distilling and titrating using methyl red and bromocresol green indicators. The amount of solvent used reflects nitrogen content of the sample which is then converted into protein by multiplying with the set factor depending on the sample.

### **3.5.3 Determination of crude fibre**

Crude protein was determined by using a Hennenberg-Stohmann method whereby the sample was sequentially hot-digested with sulphuric acid and sodium hydroxide solutions, after it has been cold extracted with defeating solvents. The residues are termed as crude fibre.

### **3.5.4 Determination of minerals (iron and zinc and calcium)**

The Atomic Absorption Spectrophotometer (AAS) method was applied to determine iron and zinc content (AOAC, 2000). A total of 0.5 g of sample was weighed into a digestion tube. Then 5 ml of 68% nitric acid was added and left overnight. The digestion tube was placed in the digestion block and temperature set at 1250°C and digested for one hour. It was then removed and the tube cooled. A total of 5 ml of 30% hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>) was added and heated to about 700°C. After cooling, 5 ml of 30% H<sub>2</sub>O<sub>2</sub> was again added and heated once more to 700°C. The treatment was repeated until the digest was colourless. Temperature was increased to 1800°C and continued digesting to almost dryness, and was let to cool. A total of 10 ml of 10% nitric acid was added and the dissolved digest transferred quantitatively to a 50 ml volumetric flask. The flask was filled to mark with distilled water and mixed. The solution was then used to determine iron and zinc and calcium contents by the AAS.

### **3.5.5 Determination of $\beta$ -carotene (vitamin A)**

The  $\beta$ -carotene content was determined by using the high-performance liquid chromatography (HPLC) method. (Kimura and Rodriguez-Amaya, 2003). One gram of vacuum-dried vegetable was mixed thoroughly with 100 ml of 6 hexane: 4 acetone (v/v) solution, and 0.1 g MgCO<sub>3</sub> in a homogenizer. Acetone was then washed out five times with salt-saturated water. The hexane extract was filtered with a 0.45- $\mu$ mol filter. Analyses

were performed using HPLC (HPLC; Waters, Milford, Mass.) equipped with a 717 plus autosampler, 600 controller, 996 photodiode array detector with a 125 × 4-mm LiChrospher 100 RP-18e column, 5 µm (Merck, Darmstadt, Germany) under isocratic conditions at ambient temperatures. The mobile phase was 75 acetonitrile: 25 methanols (v/v) at a flow rate of 1.5 mL/min. β-carotene quantification were carried out at a single wavelength of 436 nm. Concentration of the TLC purified β-carotenoid standard (Sigma Chemical Co., St Louis, MO) was calculated by absorption coefficient A1% 1 cm in ethanol prior to HPLC analysis for calibration.

### 3.5.6 Determination of vitamin C

Vitamin C was extracted using Trichloroacetic acid solution. The extracts were titrated using 2, 6-Dichlorophenol indophenol (DCPIP). The vitamin C content of the sample is then calculated using the following equation:

$$\text{Vitamin C content in mg/100g} = \frac{(A-B) * C * K * 100}{S * M}$$

Where; A = Sample titration value

B = Blank titration value

C = DCPIP factor (0.01086)

K = Sample dilution volume

M = Sample volume used for analysis

S = Sample weight

### 3.6 Data Analysis

Data were analysed using GLM procedures of SAS (2001) with growing conditions (forest, improvised shade, trees, banana shade and open space) and species (*Launaea*

*cornuta*, *Bidens pilosa*, *Basella alba* and *Solanum Scabrum* as independent variables against nutrient concentration (vitamins, minerals, proteins, fibre and water). Residues were considered as random effects and that means were separated by the Least Squares Means separation test using the PDIFF option when the respective F-test was significant ( $P < 0.005$ ).

## CHAPTER FOUR

### 4.0 RESULTS AND DISCUSSION

#### 4.1 Age and Sex Composition of the Respondents

A total of 30 households' representatives participated in this study, through a questionnaire interview, of which 15 were from Kweminyasa village and 15 from Mahange village. Out of 30 villagers interviewed 11 were males and 19 were females. Their ages ranged from 21 to 62 years, whereby only 5 were below 30 years. None of them migrated recently to this area. This meant that information gathered from the respondents was based on life experience in the area and therefore reliable (Table 1).

**Table 1: Sex and age composition of respondents in Balangai community**

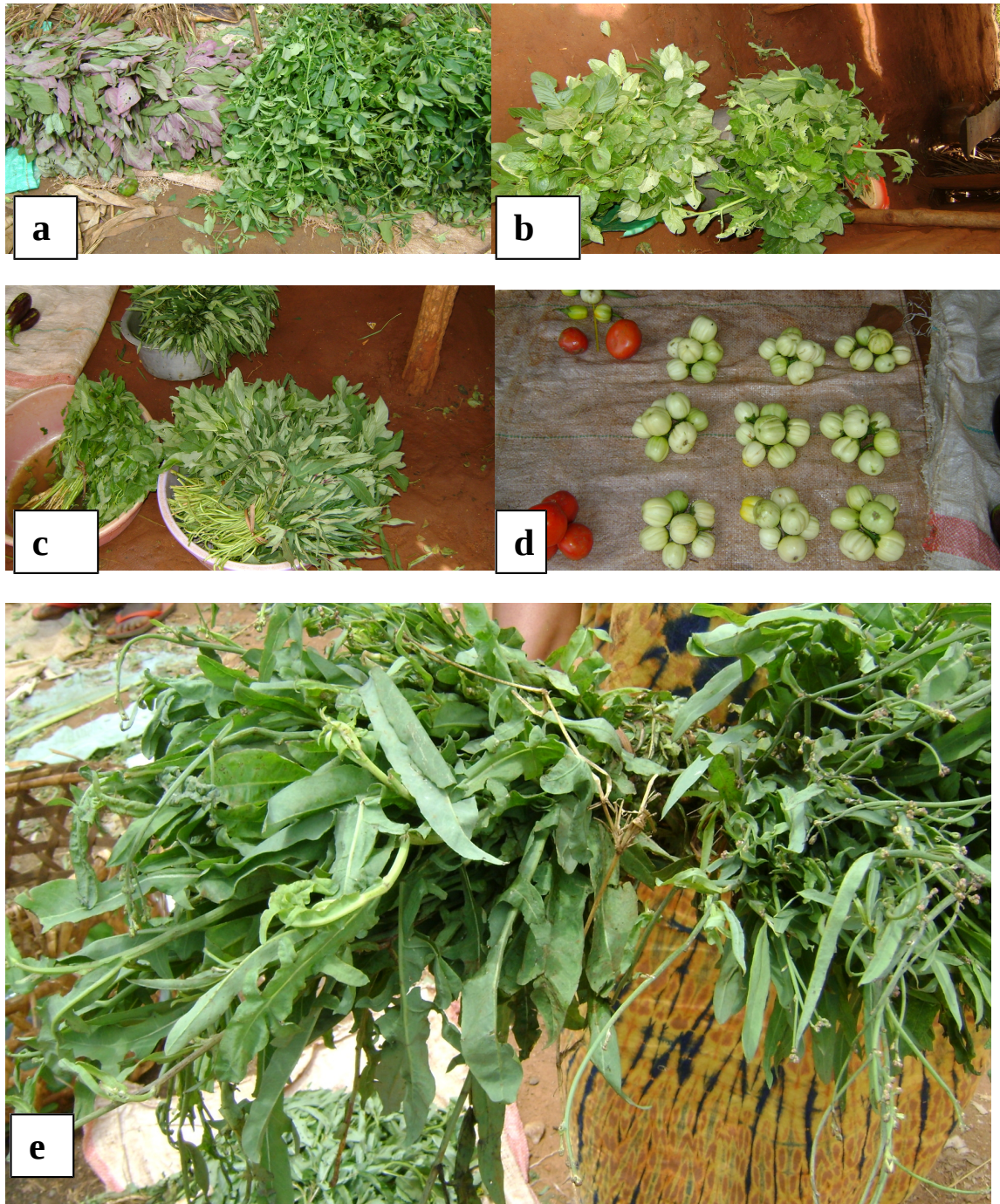
Sex	Age group in years					Total
	<30	30≤40	40≤50	50≤60	>60	
Male	2(6.7)	4(13.3)	2(6.7)	3(10)	0(0)	11 (36.7)
Female	3(10)	10(33.4)	2(6.6)	3(10)	1(3.3)	19 (63.3)
<b>Total</b>	<b>5 (16.7)</b>	<b>14 (46.7)</b>	<b>4 (13.3)</b>	<b>6 (20)</b>	<b>1(3.3)</b>	<b>30 (100)</b>

Key to table 1: Numbers in parentheses are percentages

#### 4.2 Indigenous Knowledge on Wild Vegetables

##### 4.3.1 Types of wild vegetables observed in the study area

In this study, interviews and observations in the homesteads and at markets revealed that a total of fifteen wild plant species were being utilized as vegetables by the Balangai forest community (Plates 2 a-e). These were either harvested from the forest surrounding the study villages and some were already being domesticated (Table 2).



**Plate 2: (a)-(e); Investigation of wild and domesticated vegetables in a market in Balangai area of Lushoto District (a) Wild *Amaranthus* spp (Bwache); (b) *Cleome gynandra* (Mgagani); (c) *Ipomoea batata*; (Talata) (d) *Solanum* spp; (Mnavu bwache) (e) *Launaea cornuta* (Mshunga)**

**Table 2: Some of the wild vegetables found in Balangai Forest and their availability calendar**

S/ N	Local Name	Scientific Name	Ranking	Availability during the year											
				J	F	M	A	M	J	J	A	S	O	N	D
1	Mnavu bwache	<i>Solanum Scabrum</i>	1				a	a	a	a	a				
2	Mbwembwe	<i>Bidens pilosa</i>	2		a	a	a	a	a						
3	Ndelema	<i>Basella alba</i>	3		a	a	a	a	a						
4	Mshunga	<i>Launaea cornuta</i>	4		a	a	a	a	a						
5	Mnavu zinge	<i>Nicandra physalodes</i>	5		a	a	a	a	a	a					
6	Bwache	<i>Amaranthus spp</i>	6				a	a	a	a					
7	Ngereza	<i>Galinsoga paviflora</i>	7				a	a	a	a					
8	Mlenda	<i>Ceratotheca specie</i>	8				a	a	a	a	a	a			
9	Mgagani	<i>Cleome gynandra</i>	9		a	a	a	a	a	a	a	a			
10	Talata	<i>Ipomoea scrabra</i>	10		a	a	a	a	a						
11	Utambangowe	<i>Itewittia subulobata</i>	11		a	a	a	a	a						
12	Tufia	<i>Urtica mastis</i>	12				a	a	a	a	a				
13	Kapugutilo	<i>Chenopodium spp</i>	13			a	a	a	a	a	a	a	a		
14	Kidelete	<i>Aerva kanata</i>	14				a	a	a	a	a				
15	Pupu	<i>Larptea ovalifolia</i>	15			a	a	a	a	a	a				

Note: a - availability of wild vegetables in a year

#### 4.3.2 Methods of post harvest preservation of wild vegetable

In this study, five methods for preservation of wild vegetables were observed as shown in Table 3. These are (i) sun drying which was observed in 43.3% of the 30 households, followed by (ii) not processing at all (33.4%), i.e. they mainly use them immediately after harvesting, whereas (iii) boiling and then drying, and (iv) blanching and then drying are each practiced by 10%, the least (v) smoking is practiced by 3.3% of respondents. These results show that in totality 66.6% of the respondents practice some sort of wild vegetable preservation.

**Table 3: Methods commonly used in processing wild vegetables for Preservation in Kweminyasa and Mahange villages Lushoto Districts**

	Number of Respondents (%)	Methods of processing used for preservation of wild vegetables				
		Drying (%)	Boiling/ drying (%)	Blanchi ng/dryi ng (%)	Smokin g (%)	No processing (%)
<b>Village</b>						
<b>Kweminyasa</b>	50%	23.3%	6.7%	0%	3.3%	16.7%
<b>Mahange</b>	50%	20%	3.3 %	10%	0%	16.7%
<b>Total</b>	<b>100%</b>	<b>43.3%</b>	<b>10. %</b>	<b>10%</b>	<b>3.3%</b>	<b>33.4%</b>

The above results show that the majority of the people either preserve the vegetables or use them fresh. Given that vegetables are prone to perishing, preservation guarantees the use of vegetables for a long period even when the season for planting and growing ends.

Chweya and Eyzaguirre, (1999), showed that most of wild vegetables can be dried and stored for future use, but this practice greatly reduces the crop's nutritional value. Processing for future storage is common in Tanzania but done in different ways. Wild vegetables can be dried uncooked. Tender leaves are picked and lightly crushed by hand or

cut into small pieces by knife and sun dried. Processing for preservation for a long period involves steam boiling by wrapping in a clean white material and immersed in salted boiling water for about 5 minutes. After boiling the vegetables are drained and sun dried on a clean flat container for about two days. Further, Chweya and Eyzaguirre (1999) pointed out that wild vegetable are usually stored in containers in a well ventilated place. Such produce can be stored for over a year.

#### **4.3.3 Facilities used for storage of wild vegetables**

As shown in Table 4 the majority of wild vegetables in Balangai community are stored for future use, where 25 (83.3%) out of 30 respondents store wild vegetables in different utensils. Of the 25, who store their vegetables 7 (28%) store them in tins. This is 23.3% of the total number of respondents. Others use guards to store vegetables. Use of guards is practiced by 33.4% of the total number of respondents. They also use plastic bags to store wild vegetables, and of the total respondents only 5 (16.7%) used plastic bags. Guards are the commonly used utensils for storage. 16.7% reported using guards, opposed to 10% and 6.6% at Kweminyasa. At Mahange the use of tins, guards and plastic bags was 13.3%, 10% and 10% respectively.

**Table 4: Storage facilities used for Preservation of wild vegetables in Kweminyasa and Mahange villages in Lushoto District**

Village	Number of Respondents (%)	Storage utensil			
		Tins (%)	Guards (%)	Plastic bags (%)	No storage (%)
<b>Kweminyasa</b>	50	10	16.7	6.6	16.7
<b>Mahange</b>	50	13.3	10	10	16.7
<b>Total</b>	100	23.3	26.7	16.7	33.4

#### 4.3.4 Techniques employed to prepare wild vegetables for food

Methods commonly used in preparation of wild vegetables for food in Balangai area are presented in Table 5. There are five ways which are practiced to prepare wild vegetables before they are used as stew that constitute part of the food they eat. These were namely; (i) only suspending in water and boiling, (ii) frying in different types of commercially available cooking oils, (iii) suspending in water mixed with butter of either coconut or ground nut and boiled, (iv) boiled mixed in water and meat, and lastly, (v) sun dried and the cooked.

**Table 5: Methods commonly used in preparation of wild vegetables for table in Balangai area in Lushoto District**

Village	Number of Respondents (%)	Methods of Preparation				
		Boiling (%)	Frying (%)	Mixed with coconut/ground nut butter (%)	Mixed with meat (%)	Sun dried then cooked (%)
<b>Kweminyasa</b>	50	10		16.7	0	3.3
<b>Mahange</b>	50	6.7	23.3	13.3	3.3	3.4
<b>Total</b>	<b>100</b>	<b>16.7</b>	<b>43.3</b>	<b>30</b>	<b>3.3</b>	<b>6.7</b>

Of the five techniques frying and mixing with coconut and groundnut butters were the most commonly used techniques with percentages ranking highest at 43.3% and 30% respectively. These were followed by boiling alone (16.7%) and the lowest was mixing

with meat (3.3%). Preparation of vegetables together with other food ingredients shows the role of wild vegetables in addition of value and taste to other food components that compose stew. However, on the other side dependence in frying and using butter of coconut or groundnut clearly indicate the need for high fat level in the meal with little topping up of protein. In addition, frying subjects vegetables to high temperature that could confound their nutritive value.

As presented by Mutotsi, *et al.* (2005), the rationale behind the cooking of African vegetables is to improve the bioavailability of nutrients and destroy aflatoxins, which may cause poisoning. The main methods of cooking African vegetables involve boiling in unspecified amounts of water, or some form of wet heating. This may contribute to nutrient loss. Most of the micronutrients, especially vitamins, are heat-sensitive and/or can be oxidized easily. Their levels, therefore, become reduced in preparation.

#### **4.3.5 Wild vegetable cultivation practices in Balangai area**

The sources of wild vegetables were observed to be from different locations. They were either cultivated or just picked from the forest as wild. Results in Table 6 reveal that although these vegetables are termed as wild vegetables, domestication has started. Where 50% of the respondents cultivate them on open space gardens, 20% in shade and 13.3% intercropped with other agricultural crops. Only 16.7% harvest them as purely wild growing plants.

**Table 6: Conditions under which wild vegetables were obtained in Kweminyasa and Mahange villages in Lushoto District**

<b>Village</b>	<b>Number of Respondents</b>	<b>Environment condition under which vegetables are grown</b>
----------------	------------------------------	---

	(%)	Open space	Shade	Intercropping	Not
		(%)	(%)	(%)	cultivated (%)
<b>Kweminyasa</b>	50	26.7	13.3	0	10
<b>Mahange</b>	50	23.3	6.7	13.3	6.7
<b>Total</b>	<b>100</b>	<b>50</b>	<b>20.</b>	<b>13.3</b>	<b>16.7</b>

Some vegetable species are habitat specific (Maundu *et al.* 1999). Moreover, the leaves harvested from the shade-grown plants were more palatable, being less bitter' than those harvested from plants grown in full sun. Fawusi *et-al.* (1983) later found that plants of *Solanum scabrum* would tolerate up to 60% shading, but that full sun was beneficial to growth. Earlier shade experiments by Singh (1971), however, demonstrated that full sun was necessary for floral initiation, but that partial shade resulted in a better growth performance in Indian plants conspecific with *Solanum scabrum* and *Solanum villosum*. The Author obtained significantly higher growth and biomass values when these plants were grown in open conditions during the Indian winter and in shade during the summer. Such observations were undoubtedly associated with accompanying temperature and soil moisture values, but were considered to explain the restriction of these plants to shady moist localities during summer months, and their occurrence in more open habitats during the winter in India.



**Plate 3: (a)–(d) Growing conditions under which wild vegetables were cultivated in Kweminyasa and Mahenge villages of Lushoto District: : (a) Wild vegetable species grown under tree shade; (b) Wild vegetable species grown in open space; (c): Wild vegetable species grown under banana shade; (d): Wild vegetable species grown under improvised shade**

#### 4.3.6 Other uses of wild vegetables

The study shows that besides the use of wild vegetables as food source among members of the community, all 30 household representatives interviewed identified income generation as the other importance use, and seven pointed out medicinal use as well. Normally, household food consumption requirements are given priority and selling is for excess produce. This is usually done by women to earn some cash for minor home requirements such as school-related expenses for children and domestic requirements, e.g. buying salt, cooking oil and kerosene.

The respondents revealed that wild vegetables have medicinal properties especially the bitter types such as *Launaea cornuta* (Mshunga) that have been known to heal stomach related ailments and prevention and cure of malaria whereas *Basella alba* is said to cure skin diseases and to increase blood.

#### 4.3.7 Pests and diseases

Further, it was found out that most villagers were aware of the kinds of diseases and insect pests that attacked wild vegetables and what kind of remedy to use for a specific problem. The damage by insect pests has often been mentioned as one of the constraints to the production of indigenous vegetables. Sucking pests – such as Aphids, mites, thrips, bugs, and hoppers are common insect pests. The seeds and leaves of neem (*Azadirachta indica*) and are known to have pest control properties.

#### **4.4 Nutritive Values of Wild Vegetables in Different Growing Conditions**

The effects of growing conditions on nutrient concentration for *Launaea cornuta*, *Bidens pilosa*, *Basella alba* and *Solanum scabrum* are presented in Tables 7 to 14.

Determination of nutrient levels of crude fibre, calcium, zinc, beta-carotene, proteins, iron, ascorbic acid and moisture content of leaves of wild vegetable samples was done before onset of fruiting to determine their levels at this developmental stage. There was a difference in nutrient levels between the species and across the different growing conditions. Nutrient contents with respect to crude fibre, calcium and zinc increased significantly ( $P < 0.001$ ) while ascorbic acid, iron and beta-carotene decreased significantly with changes in developmental stages of the plants. Also with regard to moisture content there was a significance difference within the species and in different environmental conditions.

##### **4.4.1 Effect of growing conditions (shade) on moisture content (mg/100g) for four species of wild vegetables**

###### **4.4.1.1 Differences in moisture content between species and within the growing conditions**

Difference in moisture content between species and within the growing conditions is presented in Table 7. It can be observed in that *Basella alba* had the highest moisture content (90.5 mg/100g) under forest growing conditions, followed by *Launaea cornuta* (87.2 mg/100g); *Solanum Scabrum* had the lowest (81.7 mg/100g). Also, *Basella alba* had the highest moisture content (89.4 mg/100g) under improvised conditions, followed by *Solanum Scabrum* (88.0 mg/100g); *Bidens pilosa* had the lowest (84.6 mg/100g).

Further, *Basella alba* had the highest moisture content (91.2 mg/100g) under Tree shade growing conditions followed by *Solanum scabrum* (89.6 mg/100g), while *Bidens pilosa* had the lowest (85.6 mg/100g).

Under Banana shade *Solanum scabrum* had the highest moisture content (89.9 mg/100g), followed by *Launaea cornuta* (86.9 mg/100 g); *Basella alba* had the lowest (81.6 mg/100g).

Under the Open space, *Basella alba* had the highest moisture content (89.4 mg/100g), followed by *Launaea cornuta* (87.2 mg/100g), while *Bidens pilosa* had the lowest (82.6 mg/100g).

**Table 7: Effect of growing conditions (shade) on moisture content (mg/100g) for four species of wild vegetables**

Vegetable species	Treatments					SE	Significance
	Forest	Improvised	Tree	Banana	Open Space		
<i>Launaea cornuta</i>	87.2	85.2	86.0	86.9	87.2	10.2	NS
<i>Bidens pilosa</i>	84.3	84.6	85.6	85.2	82.6	10.2	NS
<i>Basella alba</i>	90.5	89.4	91.2	81.6	89.4	10.2	NS
<i>Solanum scabrum</i>	81.7	88.0	89.6	89.9	82.8	10.2	NS
<b>Significance</b>	NS	NS	NS	NS	NS		

Within rows, least squares means with common superscript are not significantly different ( $P > 0.05$ ).

Significance: NS, not significant; \*,  $P < 0.05$ ; \*\*,  $P < 0.01$ ; \*\*\*,  $P < 0.001$  and SE, standard error of mean

#### 4.4.1.2 Differences in moisture content within species and between the growing conditions

Also, it can be observed in Table 7 that *Launaea cornuta* had the highest moisture content (87.2 mg/100g) under both the forest and open space growing conditions, compared to its moisture content under the rest of the growing conditions, while the least moisture content (85.2 mg/100g) was obtained under improvised shade growing conditions.

Similarly, it can be observed that *Bidens pilosa* had the highest moisture content (85.6 mg/100g), under tree growing conditions and the second highest moisture content (85.2 mg/100g) under banana growing conditions. The lowest (82.6 mg/100g) was obtained under open space growing conditions.

Furthermore, *Basella alba*, had the highest moisture content (91.2 mg/100g) under tree shade growing conditions, while the second highest moisture content (90.5 mg/100g) was under forest growing conditions. The lowest (81.6 mg/100g) was obtained under banana shade growing conditions. *Solanum scabrum* had the highest moisture content (89.9 mg/100g), under banana shade growing conditions and the second highest moisture content (86.6 mg/100g) was obtained under tree shade growing conditions.

Statistically, all these moisture levels did not show significant difference between species as well as within differing growing conditions. The highest moisture content for *Basella alba* observed in the study is expected since the species is succulent. The lowest moisture content under banana might be caused by moisture competitions by crops near the crops. Unfortunately, in the literature there is no comparable information on moisture content in wild vegetables grown under the five growing conditions. The higher amount of moisture content in *Basella alba* (91.2 mg/100g) would tend to make the vegetable more

susceptible to deterioration compared to the rest due to higher water activity, which favours growth of spoilage micro-organisms. Hence, preservation techniques will need to employ more energy to drive off undesirable moisture to required levels.

Therefore, from the study outcomes the information obtained may be used to compile an inventory that will be used in future to characterize the conducive growing conditions, which will produce quality wild vegetables with enhanced nutrient values, especially those matching or even surpassing the forest growing conditions in order to ensure sustainability and conservation of biodiversity of the forests.

#### **4.4.2 Effect of growing conditions (shade) on vitamin C content (mg/100g) for four species of wild vegetables**

##### **4.4.2.1 Differences in vitamin C content between species and within the growing conditions**

Difference in vitamin C content between species and within the growing conditions is presented in table 8. It can be observed in that *Solanum Scabrum* had the highest vitamin C content (3.4 mg/100g) under forest growing conditions followed by *Bidens pilosa* (1.7mg/100g), while *Launaea cornuta* had the lowest vitamin C content (0.7mg/100g). Therefore, there is significant difference between species; since the vegetables differ genetically the variations should be expected.

As shown in Table 8, *Launaea cornuta* had the highest vitamin C content (2.3 mg/100g) under improvised shade growing conditions, followed by *Solanum Scabrum* (1.7 mg/100g); *Bidens pilosa* had the lowest (1.1mg/100g). Therefore, there is significant difference between species; since the vegetables differ genetically the variations should be expected.

*Launaea cornuta* had the highest vitamin C content (3.1mg/100g) under tree shade growing conditions, followed by *Bidens pilosa* (2.4 mg/100g); *Basella alba* had the lowest (1.3mg/100g). Therefore, there is significant difference between species; since the vegetables differ genetically the variations should be expected.

Further, as it can be observed in Table 8, *Bidens pilosa* had the highest vitamin C content (1.8mg/100g) banana shade growing conditions, followed by *Basella alba* (1.5 mg/100g); *Launaea cornuta* had the lowest (1.2 mg/100g).

From Table 8, it can also be observed that *Bidens pilosa* had the highest vitamin C content (2.8mg/100g) under open space growing conditions, followed by *Solanum scabrum* (2.5mg/100g). *Launaea cornuta* had the lowest (1.2mg/100g). Therefore, there is significant difference between species; since the vegetables differ genetically the variations should be expected.

**Table 8: Effect of growing conditions on vitamin C content (mg/100g) for four species of wild vegetables**

Vegetable species	Treatments					SE	Significance
	Forest	Improvised	Tree	Open			
				Banana	Space		
<i>Launaea cornuta</i>	0.7 <sup>d</sup>	2.3 <sup>b</sup>	3.1 <sup>a</sup>	1.2 <sup>c</sup>	1.2 <sup>c</sup>	0.1	***
<i>Bidens pilosa</i>	1.7 <sup>c</sup>	1.1 <sup>d</sup>	2.4 <sup>b</sup>	1.8 <sup>c</sup>	2.8 <sup>a</sup>	0.1	***
<i>Basella alba</i>	0.8 <sup>c</sup>	1.2 <sup>b</sup>	1.3 <sup>b</sup>	1.5 <sup>b</sup>	1.6 <sup>a</sup>	0.1	***
<i>Solanum scabrum</i>	3.4 <sup>a</sup>	1.7 <sup>c</sup>	1.6 <sup>c</sup>	1.3 <sup>c</sup>	2.5 <sup>b</sup>	0.1	***
Significance	***	***	***	NS	***		

Within rows, least squares means with common superscript are not significantly different ( $P > 0.05$ ).

Significance: NS, not significant; \*,  $P < 0.05$ ; \*\*,  $P < 0.01$ ; \*\*\*,  $P < 0.001$  and SE, standard error of mean

#### 4.4.2.2 Differences in vitamin C content within species and between the growing conditions

The results in Table 8 also show that *Launaea cornuta* had the highest vitamin C content (3.1mg/100g) under tree shade, while the second highest was (2.3mg/100g) under improvised shade; the least vitamin C content (0.7mg/100g) was obtained under forest growing conditions. These findings differ from those reported by Lyimo *et al.*, (2003) in a study carried out in Morogoro, Tanzania, in which *Launaea cornuta* had higher vitamin C content (15.9mg/100g). The difference in amount of vitamin C could be attributed to the differences in soil fertility and localities from which the wild vegetables were obtained.

Also, the results in Table 8 show that *Bidens pilosa* had the highest vitamin C content (2.8mg/100g) under open space growing conditions, and the second highest (2.4mg/100g) under tree shade. The least (1.1mg/100g) was under improvised shade. These findings differ from those reported by Lyimo *et al.*, (2003) (58.2mg/100g). The difference might have been caused by the different growing conditions.

Further, the results show that *Basella alba* had the highest vitamin C content (1.6mg/100g) under open space growing conditions, and second highest (1.5mg/100g) under banana shade. The third (1.3mg/100g) was under tree shade. The least (0.8mg/100g) was under forest. These findings differ sharply from those reported by Lyimo *et al.*, (98.7mg/100g), possibly due to different localities and soil types.

The results also show that *Solanum scabrum* had the highest vitamin C content (3.4mg/100g) under forest growing conditions and the second highest (2.5mg/100g) under open space. The third (1.6mg/100g) was under tree shade, while the lowest (1.3mg/100g)

was under banana shade. These findings also differ highly from those reported by Lyimo *et al.*, (234.5g/100g), probably due to the different localities and growing conditions.

Therefore, from the study outcomes the information obtained may be used to compile an inventory that will be used in future to characterize the conducive growing conditions, which will produce quality wild vegetables with enhanced nutrient values, especially those matching or even surpassing the forest growing conditions in order to ensure sustainability and conservation of biodiversity of the forests

#### **4.4.3 Effect of growing conditions (shade) on vitamin A content (mg/100g) for four species of wild vegetables**

##### **4.4.3.1 Differences in vitamin A content between species and within the growing conditions**

Difference in vitamin A content between species and within the growing conditions is presented in Table 9. It can be observed from that *Solanum scabrum* had the highest vitamin A content (445.7 µg/g), under forest growing conditions, followed by *Bidens pilosa* (236.4 µg/g) and *Basella alba* (250.5µg/g). The least was *Launaea cornuta* (225.1 µg/g).

It can also be observed from Table 9 that *Bidens pilosa* had the highest vitamin A content (349.1 µg/g) under improvised shade, followed by *Launaea cornuta* (326.0 µg/g) and *Basella alba* (297.3 µg/g). The lowest was *Solanum scabrum* (226.3 µg/g).

Also, it can observed from the table that *Launaea cornuta* had the highest vitamin A content (480.6 µg/g), under tree shade, followed by *Bidens pilosa* (392.0 µg/g) and *Basella alba* (339.3 µg/g). The lowest was *Solanum Scabrum* (234.9 µg/g).

Further, it can be observed that *Launaea cornuta* had the highest vitamin A content (467.7 µg/g) under banana shade, followed by *Bidens pilosa* (397.0 µg/g) and *Basella alba* (279.6 µg/g). The lowest was *Solanum scabrum* (218.8 µg/g).

Furthermore, *Bidens pilosa* had the highest vitamin A content (337.5 µg/g) under open space growing conditions, followed by *Solanum Scabrum* (291.2 µg/g) and *Launaea cornuta* (287.4 µg/g). The lowest was *Basella alba* (185.5 µg/g).

**Table 9: Effect of growing conditions on vitamin A µg/g) content for four species of wild vegetables**

Vegetable species	Treatments					SE	Significance
	Forest	Improved	Tree	Banana	Open Space		
<i>Launaea cornuta</i>	225.1 <sup>e</sup>	326.0 <sup>c</sup>	480.6 <sup>a</sup>	467.7 <sup>b</sup>	287.4 <sup>d</sup>	10.1	***
<i>Bidens pilosa</i>	236.4 <sup>b</sup>	349.1 <sup>a</sup>	392.0 <sup>a</sup>	397.0 <sup>a</sup>	337.5 <sup>a</sup>	10.1	***
<i>Basella alba</i>	250.5 <sup>d</sup>	297.3 <sup>b</sup>	339.3 <sup>a</sup>	279.6 <sup>c</sup>	185.5 <sup>e</sup>	10.1	***
<i>Solanum scabrum</i>	455.7 <sup>a</sup>	226.3 <sup>d</sup>	234.9 <sup>c</sup>	218.8 <sup>e</sup>	291.2 <sup>b</sup>	10.1	***
<b>Significance</b>	***	***	***	***	***		

Within rows, least squares means with common superscript are not significantly different ( $P > 0.05$ ).

Significance: NS, not significant; \*,  $P < 0.05$ ; \*\*,  $P < 0.01$ ; \*\*\*,  $P < 0.001$  and SE, standard error of mean

#### 4.4.3.2 Differences in vitamin A content within species and between the growing conditions

Moreover, it can be observed from Table 9 that *Launaea cornuta* has the highest vitamin A content (480.6 µg/g), under tree shade, followed by banana shade (467.7 µg/g), improvised shade (326.3 µg/g), open space (287.4 µg/g) and forest (225.1 µg/g).

Unfortunately, in the literature there is no comparable information on vitamin A content in *Launaea cornuta* grown under the five growing conditions.

Also, the Table shows that *Bidens pilosa* had the highest vitamin A content (397.0 µg/g) under banana shade, followed by tree shade (349.1 µg/g), open space (337.5 µg/g). The least was forest growing conditions (236.4 µg/g).

*Basella alba* had the highest vitamin A content (339.3µg/g) under tree shade growing conditions, followed by improvised shade (297.3µg/g), banana shade (279.6µg/g), forest (250.5µg/g) and the lowest – open space (185.5µg/g).

It can be observed in Table 9 that *Solanum Scabrum* performed well under forest growing conditions with vitamin A content (455.7 µg/g) followed by (291.2 µg/g) obtained from open space and (226.3 µg/g) under improvised shade. Banana shade had the lowest vitamin A content (218.8µg/g). These findings differ from those reported by Weinberger and Msuya (2004) that *Solanum Scabrum* had the highest β – carotene content (75.4 µg/g). However, β – carotene content of *Solanum Scabrum* reported by Mwajumwa *et al.*, (1991) (100.0 µg/g) is lower than the values from this study. Variations within the same species between the five growing conditions could probably be due to differing soil characteristics or soil organic matter, which, in turn determines soil fertility.

Therefore, from the study outcomes the information obtained may be used to compile an inventory that will be used in future to characterize the conducive growing conditions, which will produce quality wild vegetables with enhanced nutrient values, especially those matching or even surpassing the forest growing conditions in order to ensure sustainability and conservation of biodiversity of the forests.

#### 4.4.4 Effect of growing conditions (shade) on calcium content (mg/100g) for four species of wild vegetables

##### 4.4.4.1 Differences in calcium content between species and within the growing conditions

Difference in calcium content between species and within the growing conditions is presented in Table 10. The Table shows that *Solanum Scabrum* and *Basella alba* had the highest calcium contents (448.2 mg/100g each) under forest growing conditions, followed by *Bidens pilosa* (342.7mg/100g). The lowest was *Launaea cornuta* (283.8 mg/100g).

Also, the table shows that under improvised shade growing conditions, *Solanum Scabrum* had the highest calcium content (351.8 mg/100g) followed by *Launaea cornuta* (342.3 mg/100g), *Bidens pilosa* (158.7 mg/100g) and the lowest, *Basella alba* (111.7 mg/100g).

Further, it can be observed that under tree shade growing conditions, *Bidens pilosa* had the highest calcium content (228.0 mg/100g), followed by *Solanum Scabrum* (221.5 mg/100g), *Launaea cornuta* (197.5 mg/100g) and the lowest, *Basella alba* (106.5 mg/100g).

Furthermore, under banana shade, *Bidens pilosa* had the highest calcium content (575.7 mg/100g), followed by *Solanum Scabrum* (206.2 mg/100g), *Basella alba* (106.6 mg/100g) and the lowest, *Launaea cornuta* (58.6 mg/100g).

Also, Table 10 shows that under open space growing conditions *Launaea cornuta* had the highest calcium content (324.3 mg/100g), followed by *Bidens pilosa* (313.7 mg/100g), *Solanum Scabrum* (281.4 mg/100g), *Basella alba* (70.8 mg/100g). The lowest was *Basella alba* (70.8 mg/100g). Variations within the different species between in the same growing conditions are again exhibited. Unfortunately, in the literature there is no comparable

information on moisture content in wild vegetables grown under the five growing conditions.

**Table 10: Effect of growing conditions on calcium content (mg/100g) for four species of wild vegetables**

Vegetable	Treatments					SE	Significance
species	Forest	Improvised	Tree	Banana	Open		
					Space		
<i>Launaea cornuta</i>	283.8 <sup>c</sup>	342.3 <sup>a</sup>	197.5 <sup>d</sup>	58.6 <sup>e</sup>	324.3 <sup>b</sup>	2.7	***
<i>Bidens pilosa</i>	342.7 <sup>b</sup>	158.7 <sup>e</sup>	228.0 <sup>d</sup>	575.7 <sup>a</sup>	313.7 <sup>c</sup>	2.7	***
<i>Basella alba</i>	448.2 <sup>a</sup>	111.7 <sup>b</sup>	106.5 <sup>b</sup>	106.6 <sup>b</sup>	70.8 <sup>c</sup>	2.7	***
<i>Solanum scabrum</i>	448.2 <sup>a</sup>	351.8 <sup>b</sup>	221.5 <sup>d</sup>	206.2 <sup>e</sup>	281.4 <sup>c</sup>	2.7	***
Significance	***	***	***	***	***		

Within rows, least squares means with common superscript are not significantly different ( $P > 0.05$ ).

Significance: NS, not significant; \*,  $P < 0.05$ ; \*\*,  $P < 0.01$ ; \*\*\*,  $P < 0.001$  and SE, standard error of mean

#### 4.4.4.2 Differences in calcium content within species and between the growing conditions

Moreover, it can further be observed in Table 10 that *Launaea cornuta* had the highest content (342.3 mg/100g) under improvised shade growing conditions, followed by open space (324.3 mg/100g), forest (283.8 mg/100g) and the lowest, banana shade (58.6 mg/100g). These findings differ from those reported by Lyimo *et al.*, (2003) that *Launaea cornuta* contained calcium content of 256.2 mg/100g. The differences in calcium content could be attributed to differing growing conditions and soil fertility, depending on available organic matter.

Also, *Bidens pilosa* had the highest calcium content ( 575.7 mg/100g) under banana shade, followed by forest growing conditions (342.7 mg/100g), open space (313.7 mg/100g), tree

shade (228.0 mg/100g) and the lowest (158.7 mg/100g). These findings differ from those reported by Lyimo *et al.*, that *Bidens pilosa* had calcium content of 66.5 mg/100g).

Table 10 also shows that *Basella alba* had the highest calcium content (448.2 mg/100g) under forest growing conditions, followed by improvised shade (112.7 mg/100g), banana shade and tree shade (106.6 and 106.5 mg/100g) respectively and the least, under open space growing conditions (70.8 mg/100g). In comparison, other studies carried out by Lyimo *et al.*, (2003) showed different calcium contents (250.0 mg/100g). The differences could be due to the differing growing conditions.

It can also be observed from Table 10 that *Solanum Scabrum* had the highest calcium content (448.2 mg/100g) under forest conditions, followed by improvised shade (351.8 mg/100g), open space (281.4 mg/100g), tree shade (221.5 mg/100g), and the least, banana shade (206.2 mg/100g). These findings differ from those reported by Lyimo *et al.*, (2003) for *Solanum Scabrum* (66.8 mg/100g).

Therefore, from the study outcomes the information obtained may be used to compile an inventory that will be used in future to characterize the conducive growing conditions, which will produce quality wild vegetables with enhanced nutrient values, especially those matching or even surpassing the forest growing conditions in order to ensure sustainability and conservation of biodiversity of the forests.

#### **4.4.5 Effect of growing conditions (shade) on zinc content (mg/100g) for four species of wild vegetables**

##### **4.4.5.1 Differences in zinc content between species and within the growing conditions**

Difference in zinc content between species and within the growing conditions is presented in Table 11. The table shows that *Launaea cornuta* had the highest zinc content (1.9

mg/100g) under forest growing conditions, followed by *Bidens pilosa* (1.0mg/100g); *Basella alba* and *Solanum Scabrum* had the lowest(0.7mg/100g each)

Also it can be observed in Table 11 that *Solanum Scabrum* has the highest zinc content (4.1mg /100g) under improvised shade growing conditions followed by *Launaea cornuta* (0.5 mg/100g ), *Bidens pilosa* (0.4 mg/100g) and the lowest was *Basella alba* zinc content (0.3 mg/100g). Further, Table 11 reported that *Launaea cornuta* and *Bidens pilosa* had the highest zinc content under tree shade growing condition followed by *Solanum Scabrum* (1.1 mg/100g), *Basella alba* had the lowest zinc content (0.5 mg/100g))

Furthermore, *Solanum Scabrum* under banana shade growing condition had higher zinc content (9.1 mg/100g) followed by *Launaea cornuta* (1.3 mg/100g), *Bidens pilosa* has zinc content (0.7 mg/100g), the lowest *Basella alba* (0.3 mg/100g) The variation between the species is expected. Table 11 also shows that *Bidens pilosa* has higher zinc content (9.7 mg/100g) under open space, followed by *Basella alba* (9.1 mg/100g), *Solanum Scabrum* (1.9 mg/100g) and the lowest zinc content (0.8 mg/100g).

**Table 11: Effect of growing conditions on zinc content (mg/100g) for four species of wild vegetables**

Vegetable species	Treatments					SE	Significance
	Forest	Improved	Tree	Banana	Open Space		
<i>Launaea cornuta</i>	1.9 <sup>a</sup>	0.5 <sup>d</sup>	1.9 <sup>a</sup>	1.3 <sup>b</sup>	0.8 <sup>c</sup>	0.1	***
<i>Bidens pilosa</i>	1.0 <sup>c</sup>	0.4 <sup>c</sup>	1.9 <sup>b</sup>	0.7 <sup>c</sup>	9.7 <sup>a</sup>	0.1	***
<i>Basella alba</i>	0.7 <sup>b</sup>	0.3 <sup>b</sup>	0.5 <sup>b</sup>	0.3 <sup>b</sup>	9.1 <sup>a</sup>	0.1	***
<i>Solanum scabrum</i>	0.7 <sup>d</sup>	4.1 <sup>b</sup>	1.1 <sup>d</sup>	9.1 <sup>a</sup>	1.9 <sup>c</sup>	0.1	***
<b>Significance</b>	***	***	***	***	***		

Within rows, least squares means with common superscript are not significantly different ( $P > 0.05$ ).

Significance: NS, not significant; \*,  $P \leq 0.05$ ; \*\*,  $P < 0.01$ ; \*\*\*,  $P < 0.001$  and SE, standard error of mean

#### 4.4.5.2 Differences in zinc content within species and between the growing conditions

It can be observed in Table 11 that *Launaea cornuta* has the highest zinc content (1.9 mg/100g) under forest and tree shade growing conditions, followed by banana shade growing condition (1.3 mg/100g) and open space had the zinc content (0.8 mg/100g), lowest zinc content (0.5 mg/100g) under improvised shade growing conditions

The results in Table 11 shows that *Bidens pilosa* has the highest zinc content (9.7 mg/100g) under open space, followed by tree shade growing condition (1.9 mg/100g), forest growing condition (1.0 mg/100g), banana shade zinc content (0.7 mg/100g) and the lowest, improvised shade (0.4 mg/100g)

Also I can be observed in Table 11 that *Basella alba* had higher zinc content (9.1mg/100g) under open space, followed by forest growing conditions (0.7 mg/100g), and tree shade growing conditions (0.5 mg/100g), The lowest zinc content was (0.3 mg/100g each) under improvised and banana shade growing conditions. *Solanum scabrum* has highest zinc content (9.1 mg/100g) under banana shade followed by improvised shade (4.1 mg/100g),

open space has zinc content (1.9 mg/100g) and tree shade has zinc content (1.1 mg/100g). Lowest zinc content (0.7 mg/100g) under forest growing conditions.

These findings are differing to some growing conditions from those reported by Weinberger and Msuya (2004) that zinc content in *Solanum scabrum* (0.88mg/100g). Other studies with findings comparable to the current study include Kinabo *et al.*, (2004) reported contents of Zn in *Solanum scabrum* to be 0.57 mg/100 g edible portion, which is lower than those observed in the current study. This means that the variation between the growing conditions is expected.

Therefore, from the study outcomes the information obtained may be used to compile an inventory that will be used in future to characterize the conducive growing conditions, which will produce quality wild vegetables with enhanced nutrient values, especially those matching or even surpassing the forest growing conditions in order to ensure sustainability and conservation of biodiversity of the forests.

#### **4.4.6 Effect of growing conditions (shade) on vitamin A content (mg/100g) for four species of wild vegetables**

##### **4.4.6.1 Differences in iron content between species and within the growing conditions**

Difference in iron content between species and within the growing conditions is presented in Table 12. It can be observed that *Bidens pilosa* had the highest iron content (32.7mg/100g) under forest growing conditions, followed by *Launaea cornuta* (3.6mg/100g); both *Basella alba* and *Solanum* had the lowest (1.0 mg/100 each).

Further, *Solanum scabrum* had highest iron content (25.1mg/100g) under improvised shade, followed by *Bidens pilosa* (25.1mg/100g) and *Basella alba* and *Launaea cornuta* had the lowest zinc content (4.4 and 4.2mg/100g) respectively.

Furthermore, it can be observed from table 13 that *Bidens pilosa* had the highest iron content (20.6 mg/100g), trees shade, followed by *Solanum scabrum* (8.5 mg/100g) and *Basella alba* (5.6 mg/100g), *Launaea cornuta* had the lowest iron content (1.3 mg/100g). Although growing condition is the same, vegetables differ genetically the variation should be expected.

The results in Table 12 shows that *Bidens pilosa* had the iron content (52.4 mg/100g), under banana shade growing conditions, followed by *Launaea cornuta* (13.5 mg/100g), *Basella alba* (12.2 mg/100g) *Solanum scabrum* had the lowest iron content (1.4 mg/100g). Also the result in Table 12 shows that *Bidens pilosa* had the iron content (10.1 mg/100g), under open space, followed by *Solanum scabrum* (5.8 mg/100g), and *Basella alba* (1.4 mg/100g). The lowest was *Launaea cornuta* (0.8 mg/100g).

**Table 12: Effect of growing conditions on iron content (mg/100g) for four species of wild vegetables**

Vegetable species	Treatments					SE	Significance
	Forest	Improvised	Tree	Banana	Open Space		
<i>Launaea cornuta</i>	3.6 <sup>b</sup>	4.2 <sup>b</sup>	1.3 <sup>c</sup>	13.5 <sup>a</sup>	0.8 <sup>d</sup>	0.4	***
<i>Bidens pilosa</i>	32.7 <sup>b</sup>	25.1 <sup>c</sup>	20.6 <sup>d</sup>	52.4 <sup>a</sup>	10.1 <sup>e</sup>	0.4	***
<i>Basella alba</i>	1.0 <sup>d</sup>	4.4 <sup>c</sup>	5.6 <sup>b</sup>	12.2 <sup>a</sup>	1.4 <sup>d</sup>	0.4	***
<i>Solanum scabrum</i>	1.0 <sup>d</sup>	29.4 <sup>a</sup>	8.5 <sup>b</sup>	1.4 <sup>d</sup>	5.8 <sup>c</sup>	0.4	***
<b>Significance</b>	***	***	***	***	***		

Within rows, least squares means with common superscript are not significantly different ( $P > 0.05$ ).

Significance: NS, not significant; \*,  $P < 0.05$ ; \*\*,  $P < 0.01$ ; \*\*\*,  $P < 0.001$  and SE, standard error of mean

#### 4.4.6.2 Differences in iron content within species and between the growing conditions

Similarly, it can be observed in the table that *Launaea cornuta* had the highest iron content (13.5 mg/100g) under banana shade, followed by forest growing conditions (3.6 mg/100g), improvised shade (4.2 mg/100g), tree shade conditions (1.3 mg/100g), and the lowest iron content (0.8 mg/100g) under open space. These findings differ from those reported by Lyimo *et al.*, (2003) that iron content in *Launaea cornuta* was (2.7 mg/100g). Therefore the different amounts of iron in *Launaea cornuta* could be due to different growing conditions.

Further, it can be observed in table 12 that *Bidens pilosa* had the iron content (52.4 mg/100g), followed by forest growing conditions (32.7 mg/100g), improvised shade, (25.1 mg/100g), and tree shade conditions (20.6 mg/100g), lowest was (10.1 mg/100g), under open space growing conditions. These findings differ highly from those reported by Lyimo *et al.*, (2003) that iron content (2.2 mg/100g).

Furthermore, it can be observed that *Basella alba* had the highest iron content (12.2 mg/100g) followed by tree shade growing conditions (5.6 mg/100g), improvised shade conditions (4.4 mg/100g), open space growing conditions (1.4 mg/100g), lowest iron

content observed under forest growing conditions. These findings also differ fairly from those reported by Lyimo *et al.*, (2003) that iron content (4.0 mg/100g).

Moreover, it can be observed in Table 12 that *Solanum scabrum* had the highest iron content (29.4 mg/100g), under improvised shade, followed by tree shade growing conditions (8.5 mg/100g), open space growing conditions (5.8 mg/100g), banana shade (1.4 mg/100g) and the lowest (1.0 mg/100g), under forest conditions. (2.5 mg/100g). These findings are differing to some growing conditions from those reported by Weinberger and Msuya, (2004) that iron content in *Solanum scabrum* (15.9mg/100g). Other studies with findings comparable to the current study include Kinabo *et al.*, (2004) reported contents of iron in *Solanum scabrum* to be 6.1 mg/100g, which is lower than those observed in the current study. This means that the variations on iron contents within species between the growing conditions is expected.

Therefore, from the study outcomes the information obtained may be used to compile an inventory that will be used in future to characterize the conducive growing conditions, which will produce quality wild vegetables with enhanced nutrient values, especially those matching or even surpassing the forest growing conditions in order to ensure sustainability and conservation of biodiversity of the forests.

#### **4.4.7 Effect of growing conditions (shade) on vitamin A content (mg/100g) for four species of wild vegetables**

##### **4.4.7.1 Differences in protein content between species and within the growing conditions**

Difference in protein content between species and within the growing conditions is presented in Table 13. It can be observed that *Solanum scabrum* had the highest protein content (6.4 mg/100g) under forest conditions, followed by *Launaea cornuta*, *Bidens*

*pilosa* and *Basella Alba* (0.4 mg/100g each). Probably *Solanum scabrum* was obtained in a growing condition with high organic matter.

Also *Bidens pilosa* had the highest protein content (2.4 mg/100g) under improvised shade, followed by *Solanum scabrum* (1.8 mg/100g), and *Basella alba* (1.6 mg/100g) and the lowest was *Launaea cornuta* (1.2 mg/100g).

Further, it can be observed from Table 13 that *Bidens pilosa* had the highest protein content (3.3 mg/100g), under tree growing conditions, followed by *Solanum scabrum* (1.8 mg/100g), *Launaea cornuta* (1.6 mg/100g) and the lowest, *Basella alba* (0.2 mg/100g)

Table 12 also shows that *Bidens pilosa* had the highest protein content (6.3 mg/100g) under banana growing conditions, followed by *Solanum scabrum* (3.3 mg/100g), *Basella alba* (2.9 mg/100g) and the least, *Launaea cornuta* (0.3 mg/100g).

The table also shows that, *Bidens pilosa* had the highest protein content (6.5 mg/100g), under open space growing conditions, followed by *Basella alba* (3.3 mg/100g), *Solanum scabrum* (1.5 mg/100g) and the lowest, *Launaea cornuta* (1.4 mg/100g).

The nutrient values among the studied species may vary with soil fertility, plant age and type (i.e. variant or species). For example, it was found that the leaf protein content of *Solanum scabrum* was dependent on the age of the plant. Moreover the availability of nitrogen in the soil increases the amount of ascorbic acid and protein while decreasing the calcium content in the leaves (Jennifer and Chweya 1997). This probably explains the reason for the higher amount of vitamin C and crude protein of *Solanum scabrum*.

**Table 13: Effect of growing conditions on crude protein content (mg/100g) for four species of wild vegetables**

Vegetable species	Treatments					SE	Significance
	Forest	Improvised	Tree	Banana	Open Space		
<i>Launaea cornuta</i>	0.4 <sup>d</sup>	1.2 <sup>c</sup>	1.6 <sup>a</sup>	0.3 <sup>d</sup>	1.4 <sup>b</sup>	0.04	***
<i>Bidens pilosa</i>	0.4 <sup>d</sup>	2.4 <sup>c</sup>	3.3 <sup>b</sup>	6.3 <sup>a</sup>	6.5 <sup>a</sup>	0.04	***
<i>Basella alba</i>	0.4 <sup>d</sup>	1.6 <sup>c</sup>	0.2 <sup>e</sup>	2.9 <sup>b</sup>	3.3 <sup>a</sup>	0.04	***
<i>Solanum scabrum</i>	6.4 <sup>a</sup>	1.8 <sup>c</sup>	1.8 <sup>c</sup>	3.3 <sup>b</sup>	1.5 <sup>d</sup>	0.04	***
<b>Significance</b>	***	***	***	***	***		

Within rows, least squares means with common superscript are not significantly different ( $P > 0.05$ ).

Significance: NS, not significant; \*,  $P < 0.05$ ; \*\*,  $P < 0.01$ ; \*\*\*,  $P < 0.001$  and SE, standard error of mean

#### 4.4.7.2 Differences in protein content within species and between the growing conditions

Further to the observations above, Table 13 also shows that *Launaea cornuta* had the highest protein content (1.6 mg/100g), under tree shade, followed by open space (1.4 mg/100g), improvised shade (1.2 mg/100g), forest growing condition (0.4 mg/100g), and the lowest, and banana shade growing conditions (0.3 mg/100g). These findings differ from those reported by Lyimo *et al.*, (2003) that protein content is higher (4.6 mg/100g). The difference in protein content might be caused by different in growing conditions.

As it can be observed from Table 13, *Bidens pilosa* had the highest protein content (6.5mg/100g) under open space growing conditions, followed by banana shade (6.3 mg/100g), tree shade (3.3 mg/100g), improvised shade (2.4 mg/100g) and the lowest, forest growing conditions (0.4 mg/100g). These findings differ from those reported by Lyimo *et al.*, (2003), protein content of *Bidens pilosa* was (0.7 mg/100g) since these are five different growing conditions, and variation within a species is expected.

Further, it can be observed from Table 13 that *Basella alba* had the highest protein content (3.3 mg/100g), under open space, followed by banana shade growing conditions (2.9 mg/100g), improvised shade (1.6 mg/100g), forest growing conditions (0.4 mg/100g), and

the lowest protein content (0.2 mg/100g), under tree shade growing conditions. These findings are lower in protein content compared with those reported by Lyimo *et al.*, (2003), which showed the protein content of 5.0 mg/100g; these might be caused by variations between different growing conditions.

Furthermore, it can be observed from the table that, *Solanum scabrum* had the highest protein content (6.4 mg/100g) under forest growing conditions, followed by banana shade (3.3 mg/100g), improvised and tree shade growing conditions (1.8 mg/100g each) and the lowest, open space growing conditions (1.5 mg/100g). These findings differ from those reported by Lyimo *et al.*, (2003) for *Solanum scabrum* (1.0 mg/100g). The variation could be due to the differences in soil fertility and locations in which the studies were carried out.

Therefore, from the study outcomes the information obtained may be used to compile an inventory that will be used in future to characterize the conducive growing conditions, which will produce quality wild vegetables with enhanced nutrient values, especially those matching or even surpassing the forest growing conditions in order to ensure sustainability and conservation of biodiversity of the forests.

#### **4.4.8 Effect of growing conditions (shade) on crude fibre content (mg/100g) for four species of wild vegetable**

##### **4.4.8.1 Differences in crude fibre content between species and within the growing conditions**

Difference in crude fibre content between species and within the growing conditions is presented in Table 14. It can be observed that *Solanum scabrum* had the highest crude fibre content (1.5 mg/100g), under forest growing conditions, followed by *Launaea cornuta* (0.7 mg/100g), and the lowest crude fibre *Bidens pilosa* and *Basella alba* (0.6 mg/100g each).

Also the results in Table 14 shows that *Solanum scabrum* had the highest crude fibre content (1.4 mg/100g) under improvised shade growing conditions, followed by *Bidens pilosa* (1.3 mg/100g), and the lowest crude fibre content, *Launaea cornuta* and *Basella alba* (0.6 mg/100g each). Unfortunately in the literature there is no comparable information on wild vegetables grown under improvised shade conditions.

The results in Table 14 also shows that *Bidens pilosa* and *Solanum scabrum* have crude fibre content (1.3 mg/100g each), under tree shade growing conditions, followed by *Basella alba* (1.1 mg/100g) and the lowest crude fibre, *Launaea cornuta* (0.9 mg/100g). It can be observed in the Table 14 that under banana shade growing conditions *Solanum scabrum* had the crude fibre content (1.7 mg/100g), followed by *Launaea cornuta* and *Bidens pilosa* (1.5 mg/100g), the lowest crude fibre, *Basella alba* (0.9 mg/100g).

Further, as it can be observed in the Table 14 that *Basella alba* had the highest crude fibre content (1.8 mg/100g), under open space conditions, followed by *Bidens pilosa* (1.6 mg/100g), *Solanum scabrum* (0.7 mg/100g) and the lowest crude fibre, *Launaea cornuta* (0.5 mg/100g).

**Table 14: Effect of growing conditions on crude fibre content (mg/100g) for four species of wild vegetables**

Vegetable species	Treatments					SE	Significance
	Forest	Improvised	Tree	Banana	Open Space		
<i>Launaea cornuta</i>	0.7 <sup>c</sup>	0.6 <sup>c</sup>	0.9 <sup>b</sup>	1.5 <sup>a</sup>	0.5 <sup>d</sup>	0.03	***
<i>Bidens pilosa</i>	0.6 <sup>c</sup>	1.3 <sup>b</sup>	1.3 <sup>b</sup>	1.5 <sup>a</sup>	1.6 <sup>a</sup>	0.03	***
<i>Basella alba</i>	0.6 <sup>d</sup>	0.6 <sup>d</sup>	1.1 <sup>b</sup>	0.9 <sup>c</sup>	1.8 <sup>a</sup>	0.03	***
<i>Solanum scabrum</i>	1.5 <sup>b</sup>	1.4 <sup>b</sup>	1.3 <sup>b</sup>	1.7 <sup>a</sup>	0.7 <sup>c</sup>	0.03	***
<b>Significance</b>	***	***	***	***	**		

Within rows, least squares means with common superscript are not significantly different ( $P > 0.05$ ).

Significance: NS, not significant; \*,  $P < 0.05$ ; \*\*,  $P < 0.01$ ; \*\*\*,  $P < 0.001$  and SE, standard error of mean

#### **4.4.8.2 Differences in Crude fibre content within species and between the growing conditions**

Furthermore, it can be observed from the Table 14 that *Launaea cornuta* had the highest crude fibre content (1.5 mg/100g), under banana shade, followed by tree shade (0.9 mg/100g), forest growing conditions (0.7 mg/100g), improvised shade (0.6 mg/100g), and the lowest (0.5 mg/100g) under open space growing conditions. These findings differ from those reported by Lyimo *et al.*, (2003) that crude fibre content (1.2 mg/100g). Variability in crude fibre content might be caused by different in growing. As shown in table 14, it can be observed that *Bidens pilosa* had the highest crude fibre content (1.6 mg/100g), under open space growing conditions, followed by banana shade conditions (1.5 mg/100g), improvised shade and tree shade conditions (1.3 mg/100g each), and lowest crude fibre content (0.6 mg/100g), under forest growing conditions. These findings differ from those reported by Lyimo *et al.*, (2003), *Bidens pilosa* (1.6 mg/100g). Open space growing conditions are in agreement with. The variation could be due to differences in soil fertility and locations in which the studies were carried out.

Similarly, it can be observed in Table 14 that *Basella alba* had the highest crude fibre content (1.8 mg/100g), under open space conditions, followed by tree shade conditions (1.1 mg/100g), banana shade growing conditions (0.9 mg/100g), and the lowest crude protein content were under forest conditions and improvised shade (0.6 mg/100g each). These findings differ from those reported by Lyimo *et al.*, (2003) that crude fibre content in *Basella alba* (1.5 mg/100g). Variability in crude fibre content might be caused by different in growing.

Moreover, it can be observed in Table 14 that *Solanum scabrum* had the highest crude fibre content (1.7 mg/100g), under banana shade growing conditions, followed by forest growing conditions (1.5 mg/100g), improvised shade conditions (1.4 mg/100g), tree shade conditions (1.3 mg/100g) , and lowest crude fibre content (0.7 mg/100g), under open space growing conditions. In comparison with other in literature, Lyimo *et al.*, (2003) reported that the fibre content in *Solanum scabrum* to be 0.8 mg/100g, which is lower than those observed in the current study.

Therefore, from the study outcomes the information obtained may be used to compile an inventory that will be used in future to characterize the conducive growing conditions, which will produce quality wild vegetables with enhanced nutrient values, especially those matching or even surpassing the forest growing conditions in order to ensure sustainability and conservation of biodiversity of the forests.

### **Limitations**

In this study soil type and characteristics were not studied, which could contribute to variations observed in this study. However, since samples were taken in the same village from different locations and pooled according to environment conditions, it is assumed that the soil type effect could not confound the results. Consequently, these results reveal that there was no single environmental condition that was highly favourable for all species, but instead each of the studied wild vegetable species had its own favourable condition. It can be concluded that the observed variations in moisture contents could be due to different physiological requirements of the studied vegetables. However, the variations in moisture content of the same species under different conditions manifest the possible essential differences in respective characteristics of the conditions.

## CHAPTER FIVE

### 5.0 CONCLUSION AND RECOMMENDATIONS

#### 5.1 Conclusion

Indigenous knowledge on this study in the community living around Balangai Forest Reserve showed that the fresh leaves are the edible portion for all vegetables recorded. There is little variation in the method of preparation for consumption. Dried vegetables are often stored for consumption during the dry season when few indigenous vegetables are available.

Among the studied 15 indigenous wild vegetables identified in the study area, four species that were the most preferred were: *Solanum scabrum*, *Bidens pilosa*, *Launaea cornuta* and *Basella alba*

The study demonstrates that wild vegetables have high nutritional potential, and their nutritional value is greater than that of some of the species from the forest as presented in Tables 7 to 14. With respect to their mineral content, these wild vegetables may offer a better nutritional potential than exotic vegetables. The study also shows that most of farmers in Kweminyasa and Mahange villages were already cultivating more than one species of wild vegetables in their home garden, also growing of specific species of wild vegetables has increased rather than declined.

The cultivated species in all growing conditions appear to perform well or better in maintaining nutrients compared to species in forest growing conditions. This means that farmers can domesticate wild vegetables in order to get important nutrients thus conserving the forest as a resource for germplasm.

However, great variations of the eight nutrients studied were noticed for the four wild vegetable species collected from four growing conditions (Improvised, Tree, Banana shade and Open space) whereby Forest condition was the control. Therefore, while it is absolutely critical to select specific species, it is also important to consider the growing condition where the wild vegetable is obtained.

Therefore, from the study outcomes the information obtained may be used to compile an inventory that will be used in future to characterize the conducive growing conditions, which will produce quality wild vegetables with enhanced nutrient values, especially those matching or even surpassing the forest growing conditions in order to ensure sustainability and conservation of biodiversity of the forests.

## **5.2 Recommendations**

On the basis of the main findings of this study, the following recommendations are made:

- (i) Wild vegetables have been given low priority in most research and development programs. Little is known about the indigenous cultivation techniques (for those cultivated), knowledge and utilization, extent and structure of genetic variation, potential for crop improvement through domestication, selection and/or breeding. Thus, it is important to have relevant studies undertaken and indigenous knowledge documented in order to help counter food insecurity.
- (ii) An important practical implication of this study is that the analysis done on the four species of wild vegetables can be used to capture the role of wild vegetables in diets and that it is essential to pay attention to their contemporary use in nutrition and food security assessments.

- (iii) Further, areas such as, community forests, national parks and reserves where the wild vegetables have been afforded a degree of statutory protection could be used to specifically safeguard wild species used as vegetables by local people through cultivation of wild vegetables by providing them with farming and nutrition education for processing and preservation of wild vegetables.
- (iv) That more research is needed to come up with data on variations within wild vegetable species and soil type, as these were not exhaustively explored.
- (v) The study has provided the growing conditions in which identified wild vegetables had the best outcomes of nutrient content. These are being recommended for adoption (see Table 15).

**Table 15: Nutritional values of domesticated wild vegetables and a growing condition in which each performed best**

S/N	Nutrient	Species name	Value	Growing condition
1	Moisture <sup>1</sup> (g/100g)	<i>Solanum scabrum</i>	81.7	Banana shade
2	Vitamin (mg/100g)	<i>Launaea curnuta</i>	3.1	Tree shade
3	$\beta$ -carotene ( $\mu$ g/g)	<i>Launaea curnuta</i>	480.6	Tree shade
4	Calcium(mg/100g)	<i>Bidens pilosa</i>	575.7	Banana shade
5	Zinc (mg/100g)	<i>Bidens pilosa</i>	9.7	Open space
6	Iron (mg/100g)	<i>Bidens pilosa</i>	52.4	Banana shade
7	Crude protein mg/100g	<i>Bidens pilosa</i>	6.5	Open space
8	Crude fibremg/100g	<i>Basella alba</i>	1.8	Open space

## REFERENCES

- Abbiw, D. K. (1997). Diversity and Traditional uses of African Vegetables. *In: Traditional African Vegetables: Proceedings of the IPGRI International Workshop on Genetic Resources of Traditional Vegetables in Africa: Conservation and Use* ICRAF-HQ, Nairobi. (L. Guarino ed.), Institute of Plant. Genetic and Crop Plant Research, Rome., Italy. pp 29-30.
- Abukutsa-Onyango. M.O., A.N. Muriithi, K. Ngamau, V. Anjichi, S.G. Agong, A. Fricke, B. Hau and H Stützel. 2005. *Proceedings of the Third Horticulture Workshop on Sustainable Horticultural Production in the Tropics*, 26th - 29th November 2003. Maseno University, MSU, Maseno, Kenya 13-18pp.
- AOAC, 2000. *In: W. Horwitz (Ed.), Official Analytical Chemists, 17th Edition, Method: 985.29, 986.11, 974.24. AOAC. International, Washington, DC: In Journal of food composition and analysis, Volume 17, Issues 3-4, June to August 2004, 311-320 pp.*
- Asfaw, Z. (1997). Conservation and use of traditional vegetables in Ethiopia. *In: Traditional African Vegetables. Proceedings of the IPGRI International Workshop on Genetic Resources of Traditional Vegetables in Africa: Conservation and Use.* ICRAF-HQ, Nairobi. (L. Guarino ed) Institute of Plant Genetic and Crop Plant Research,, Rome., Italy 57-63 pp.

- Bowman, B.A. and Russel, R.M. (eds) (2001). Influence of body water and blood volume on thermoregulation and exercise performance in the heat. *In: Present knowledge in nutrition.* 27:167-218. International Life Sciences Institute (ILSI) Washington, DC. 805 pp.
- Bujulu, E and Matee.J.J (2005) A Survey on Production and Consumption of traditional leafy vegetables in Arusha region, Tanzania: *In Proceedings of the Third Horticulture Workshop on Sustainable Horticultural Production in the Tropics*, 26th - 29th November 2003.Maseno University,MSU ,Maseno, Kenya. . 102 pp
- Chweya, J.A. and Eyzaguirre, P.B.(eds) (1999). The biodiversity of traditional leafy vegetables. International Plant Genetic Resources Institute, Rome, Italy 20 pp.
- Edmonds, Jennifer M. and James A. Chweya. (1997.) Black nightshade *Solanum scabrum* L. and related species. Promoting the conservation and use of underutilized and neglected crops. 15. Institute of Plant Genetics and Crop Plant Research, Gatersleben/International Plant Genetic Resources Institute, Rome, Italy. 66-69 pp.
- Ezekwe, M.O., Thomas, R. A. and Membrahtu, T. (1999). Nutritive characterization of purslane accessions as influenced by planting date. *Plant Foods for Human Nutrition* (Dordrecht), 54(3): pp. 183-191.
- FAO, (1988). Traditional food plants. *FAO Food Nutr. Paper* 42. FAO, Rome, Flora of Tropical East Africa, Kew Botanic Gardens, UK pp. 593.

- Fawusi, M.O.A., D.P. Ormrod and A. Eastham. (1983). Influence of temperature on the growth of *Solanum scabrum* and *Amaranthus hybridus*. *Scientia Hort.* 18:305-311.
- Flyman, M.V. and Afolayan, A.J. (2006). The suitability of wild vegetables for alleviating human dietary deficiencies. [\*South African Journal of Botany\*](#). 72(4): 492-497.
- Flyman, M.V. and Afolayan, A.J. (2007). Effect of plant maturity on the mineral content of the leaf *Momordica balsamina* L and *Vigna unguiculata* subsp. *Sesquipedalis* (L) Verdc. 11pp.
- Geissler, P.W.; S.A. Harris; R.J. Prince; A. Olsen; R.A. Odhiambo; H. Oketch-Rabah; P.A. Madiega; A. Anderson; and P. Mølgaard, (2002). Medicinal plants used by Luo mothers and children in Bondo district, Kenya (In) *Journal of Ethnopharmacology* 83, 39-54 pp.
- Humphry, C.M., Clegg, M.S., Keen, C.L. and Grivetti, L.E. (1993). Food diversity and drought survival. The Hausa example.-*Int. J. pp Food Sci. Nutr.* 44: 1-16.
- Johansson, L. (2001). Ten million trees later. Land use change in the West Usambara Mountains. The soil erosion and Agroforestry Project in Lushoto District. 1981-2000. 163 pp.

- Keding, G., Weinberger, K., Swai, I., Mndiga, H. (2007). Diversity, traits and use of traditional vegetables in Tanzania. Technical Bulletin No. 40. Shanhua, Taiwan: AVRDC—The World Vegetable Center. 53 pp.
- Kerkhof .P. (1990). Agroforestry in Africa. Panos Institute, London, UK. 216pp.
- Kimiywe, J., Mbithe, D., Waudo, J. and Maundu, P. (2008) Utilization and Medicinal Value of Indigenous Leafy Vegetables Consumed in Urban and Peri-Urban Nairobi, In: *African Journal of Food and Agriculture and Development* 7. (4): 7.
- Kimura M, and Rodriguez-Amaya DB.(2003) Carotenoid composition of hydroponic leafy vegetables / *Agric Food Chem.* 51;2603-2607.
- Kinabo, J., Mnkeni, A., Nyaruhucha, C.N.M., Msuya, J. and Ishengoma, J. (2004). Nutrients content of foods commonly consumed in Iringa and Morogoro regions. Proceedings of the 2<sup>nd</sup> Collaborative Research Workshop on Food Security, TARP II SUA Project. Morogoro, 28–30 May 2003. Nairobi Vol. 7 (4): 6-9.
- Kothari, C.R. (2004) Research methodology: Methods and techniques. Second edition New Age International Publishers, New Delhi. pp 172- 175.
- Lyimo, M. Temu, R.P.C. and Mugula, J.K. (2003). Identification and nutrient composition of indigenous vegetables of Tanzania. Kluwer Academic Publishers, the Netherlands. *Plant Foods for Human Nutrition* 58: 85–92.

- Mathenge, L. (1997). Nutritional value and utilization of indigenous vegetables in Kenya. In: *Traditional African Vegetables: Proceedings of the IPGRI International workshop on Genetic Resources of Traditional Vegetables in Africa: Conservation and Use*. ICRAF-HQ, Nairobi. (L. Guarino ed.) Institute of Plant Genetic and Crop Plant Research, Rome, Italy. pp. 76-77.
- Maundu, P.M., Ngugi, G.W. and Kabuye, C.H.S. (1999). Traditional Food Plants of Kenya. Kenya Resources Centre for Indigenous Knowledge (KENRIK), National Museums of Kenya, Nairobi. pp. 1-258.
- Michele Spina, Massimiliano Cuccioloni, Luca Sparapani, Stefano Acciarri, Anna Maria Eleuteri, Evandro Fioretti, Mauro Angeletti, (2007). Comparative evaluation of flavonoid content in assessing quality of wild and cultivated vegetables for human consumption [Journal of the Science of Food and Agriculture](#) [Volume 88, Issue 2](#), Pages 294-304pp.
- Midmore, D.J., Vera, N. and Venkataraman, R. (1991). "Household gardening projects in Asia: past experience and future directions." *Technical Bulletin* No. 19. Asian Vegetable Research and Development Center. 28 pp.
- Modi, A., Modi, M. and Hendricks, S. (2006). Potential role for wild vegetables in household food security: a preliminary case study in Kwazulu-Natal. In: *African Journal of Food and Agriculture and Development* 6. (1): 6-7.

- Mwajumwa, L.B.S, Kahangi, M.E. and Imungi, J.K. (1991). The prevalence and nutritional value of some Kenyan indigenous leafy vegetables from three locations of Machakos district. *Ecology of Food and Nutrition* 26:275–280.
- Nordeide, M.B., Hatløy, A., Følling, M., Lied, E. and Oshaug, A. (1996). Nutrient composition and nutritional importance of green leaves and wild foods in an agric. district, Koutiala, in Southern Mali. *Int. J. Food Sci. Nutr.* pp 47, 455-468.
- Ogoye-Ndegwa, C. and Aagaard-Hansen, J. (2003). Traditional gathering of wild vegetables among the Luo of western Kenya-a nutritional anthropology project. *In: Ecology of Food and Nutrition*. Taylor and Francis Group. pp. 69-89.
- Ohiokpehai, O. (2003). Promoting the nutritional goodness of traditional food products. *Pakistan Journal of Nutrition* 2 (4): 267 – 270.
- Okafor, J.C. (1997). Conservation and use of traditional vegetables from woody forest species in south-eastern Nigeria. *In: Traditional African Vegetables. Proceedings of the IPGRI International Workshop on Genetic Resources of Traditional Vegetables in Africa: Conservation and Use*. ICRAF-HQ, Nairobi. (L. Guarino ed.), Institute of Plant Genetic and Crop Plant Research, Rome. pp. 31-38.
- Olsen A. and Nielsen B. S.,(1999). Undersogelser af lægeplanter benyttet af Luo folker I Kenya. ("Investigations of Medicinal Plants Used by the Luo of Kenya"). Dissertation in Danish. Royal Danish School of Pharmacy. 58 (8) 595-602 pp.

- Pisarikova, B., Peterka, J., Trckova, M., Moudry, J., Zraly, Z. and Herzig, I., (2007). The content of insoluble fibre and crude protein of the above-ground mass of *Amaranthus cruentus* and *A. hypochondriacus*, 349 pp.
- Rumm, E B, Ascherio, A. and Giovannuoli E, (1997) Vegetable, fruits and cereal fibre intake and risk of coronary heart disease among the man. 275; 447-51.
- SAS, (2001). Statistical Analysis System. User's guide, version 8.2 SAS Institute, INC Carry. Nc. USA. 496 pp.
- Shackleton, S.E., Dzerefos, C.M., Shackleton C.M. And Mathabela, F.R (1998). Use and trading of wild edible herbs in central lowveld savannah region, South Africa. *Econ. Bot* (52), 251-259.pp.
- Shemdoe,R.S.(2004). Local knowledge on Ecosystem management practices and Human plague Problem in Western Usambaras Tanzania. 30 pp.
- Singh, M. (1971). Influence of shade on the growth performance of *Solanum scabrum* L. *Journ. Indian Bot. Soc.* 50(2):194-200 pp.
- UNESCO (1999). People and plant Handbook: source for applying ethnobotany to conservation and community development. Issue No 5 Pp. 11.
- UNESCO, (1997). Conservation and Utilization of Indigenous Medicinal Plants and Wild Relatives of Food Crops. Nairobi. 57-63 pp.

Vainio\_Matilla, K. (2000). Wild vegetables used by Sambia in the Usambara Mountains, NE Tanzania. – *Ann. Bot. Fennici* 37: 57-67.pp.

Weinberger, K. and Msuya, J. (2004). Indigenous vegetables in Tanzania – significance and prospects. Shanhua, Taiwan: AVRDC – The World Vegetable Centre, Technical Bulletin No. 31, AVRDC Publication 04-600.70pp.

## APPENDICES

### Appendix 1: Structured questionnaire:

#### Baseline Survey on Knowledge of Wild Vegetables in Lushoto district

#### I. PERSONAL DATA OF THE INFORMANTS

Name: ..... Date .....

Age ..... Gender.....M/F

Marital status..... Name of the village.....

#### II GENERAL QUESTIONS

1. Do you use wild vegetables?.....Yes/No?

2. Which ones do you prefer? Cultivated vegetables or wild ones?

(i). Cultivated vegetables

(ii.) Wild vegetables

3. Which wild vegetables are consumed more in your household? (i)

..... (ii)..... (iii)

..... (iv).....

4. How do you prepare the wild vegetables for food? Leaves are:

(i) Chopped and boiled in water

(ii) Fried in cooking oil

(iii) Boiled and mixed with groundnuts or coconut milk

(iv) Cooked in soup with meat

(v) Fried in cooking oil after sun drying

(vi) Used as salad

(vii) Other ways

5 Do you preserve wild vegetables? .....If 'Yes', how do you preserve?

.....  
 .....

6. How do you process your wild vegetables before preserving them?

(i) Drying in the sun

(ii) Blanching and sundrying

(iii) Boiling then sundrying

7. Do you store wild vegetables? .....If 'Yes', how do you store?

.....  
 .....

8. Do you cultivate wild vegetables? ..... If 'Yes', under which conditions?

i. Shade

ii. Open space

iii. Intercropped

iv. Other

8. When are the wild vegetables available? (Seasons of availability)

January

April

July

October

February

May

August

November

March

June

September

December

9. Do these wild vegetables have any other uses? ..... If 'Yes', what are they? (i)

.....

(ii).....

(iii).....

10. For the wild vegetables you have identified for food and or for sale, what are their threatening pests and diseases?

Wild vegetable of Interest	Pest(s)	Disease(s)

11. Seriousness of the pests and diseases (for sustainable production and utilization)

i. Very serious

ii. Serious

iii. Mild

iv. Not serious

12. Are there local ways to control pests and diseases of cultivated wild vegetables that you know? .....If 'Yes' what are they?

(i) .....

(ii).....

(iii) .....

13. If no, then how do you control them?

(i).....

(ii).....

(iii).....

**THANK YOU FOR YOUR COOPERATION**

**Appendix 2: Proximate composition analysis**

<b>Parameter (%)</b>	<b>Samples</b>															
<b>Moisture Content</b>																
<b>Protein</b>																
<b>Vitamin C</b>																
<b>Crude Fibre</b>																
<b>Vitamin A</b>																
<b>Iron</b>																
<b>Calcium</b>																
<b>Zinc</b>																

**Analysis done by** .....

**Position**.....

**Name of Laboratory** .....

**Date**.....