VITAMIN A CONTENT IN THE TRADITIONALLY PRESERVED INDIGENOUS VEGETABLES: A CASE STUDY OF KORU LOCATION, NYANDO DISTRICT.

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other university.

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To my dear parents, Paul and Hulder, whom I owe a lot in life.
My brothers Steve, Ben and husband Eliud.

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ABSTRACT

In Koru Location indigenous vegetables grow well during the rainy season but remain scarce in the dry season. The indigenous vegetables are usually preserved and stored for use during the dry season. However, vitamin A deficiency is still a problem in the area affecting children of six years of age and below. The present study investigated the methods used in preserving indigenous vegetables and determined the beta-carotene and thus vitamin A content in them.

Field data on types of indigenous vegetables grown, the extent of their preservation and the methods used for preservation were collected through interviews using a semi-structured questionaire administered to a sample of 60 women residing in the study area, as well as through observation. Beta-carotene content in the preserved vegetables was determined using a spectrophometric procedure. Beta-carotene was extracted in an organic solvent, purified by passing through a column and absorbance read at 451nm.

The results showed that eleven types of indigenous vegetables are grown in Koru Location out of which five types, namely cowpea leaves, spider herb, bush okra, black nightshade and pumpkin leaves are usually preserved for use during the dry season. Sixty three percent of women are involved in the preservation of vegetables. There was a significant difference in the age of mothers who preserved vegetables and those who did not, with mothers of over 46 years preserving vegetables more than younger mothers (p=0.0005).

The methods used to preserve vegetables included sun drying, fire drying and fermentation. Sun drying of vegetables takes one to three days depending on the amount of sunshine available and the pre-treatment method of the samples. The sun dried vegetables are kept for a period of up to 8 months though the majority of mothers keep them for 6 months (55%). Fermented vegetables are kept for a shorter time (maximum of 7 days).

The sun dried indigenous vegetables contain significantly lower amounts of beta-carotene as compared with fresh vegetables (p=0.002). The fresh vegetables lost between 29-74% of their beta-carotene content on sun drying. After 6 months of storage there was a further significant decrease in the beta-carotene content in the sun dried and stored vegetables (p=0.003), losing about 62-68%. However, solar drying was found to retain more beta-carotene in the vegetables than sun drying (p=0.001).

It can be concluded that the indigenous vegetables grown and preserved in Koru Location contain high amounts of beta-carotene (provitamin A) that can be used to prevent vitamin A deficiency. The preserved vegetables retain very low concentrations of beta-carotene after 6 months of storage.

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LIST OF ABBREVIATIONS USED

CC	-	Column Chromatography
FAO	-	Food and Agriculture Organization
GoK	-	Government of Kenya
GTZ	-	German Technical Cooperation
HPLC	-	High Performance Liquid Chromatography
ILSI	-	International Life Sciences Institute
KENGO	-	Kenya Environment Non-Governmental Organization
NGO	-	Non-Governmental Organization
TLC	-	Thin-Layer Chromatography
UNICEF	-	United Nations Children's Education Fund
VAD	-	Vitamin A Deficiency
WHO	-	World Health Organization

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND INFORMATION

Plants are essential for human existence as the direct source of the staple foodstuffs in form of their seeds, fruits, leaves and tubers. Indigenous leafy vegetables play an important role in the traditional diets of most rural African societies. A number of indigenous vegetables such as the spider herb, bush okra, amaranth, jute, black nightshade and cowpea leaves are usually consumed in Kenya. These indigenous vegetables are a good source of beta-carotene, a precursor of vitamin A, minerals and plant protein (Maundu et al., 1999).

Vitamin A in the human diet is derived from preformed vitamin A (retinol) and from carotenoids that are synthesized in plants. Human beings convert a considerable proportion of the carotenoids in the foods they eat into vitamin A. Carotenoids are dark red crystalline compounds that give a deep yellow-pink coloration to plants such as carrots. The carotenoid colour is usually masked in dark green plants by chlorophyll. Beta-carotene is one of the carotenoids that is widely distributed in nature and has the highest vitamin A activity (Robinson et al., 1986). Others include alpha-carotene and cryptoxanthin. Dark green leafy vegetables are a good source of beta-carotene, which is a provitamin A compound. Provitamins are substances which occur in foods and are capable of conversion into vitamins in the body (precursors of vitamins). A great majority of green leafy vegetables are rich in provitamin A carotenoids (Passmore and Eastwood, 1986). In the body carotenoids are converted into vitamin A.

Vitamin A is a pale-yellow, viscous fat-soluble compound which is fairly heat stable but easily destroyed by oxidation, especially at high temperatures and in the presence of air, light especially ultraviolet radiation, acid or in rancid fats (Burton and Foster, 1988).

Over the years, vitamin A has been identified to be responsible for several interrelated physiologic function such as vision, membrane structure and function, epithelial tissue integrity, growth and differentiation of tissue, bone growth and reproductive function (Burton and Foster, 1988). In vision, a deficiency of the vitamin leads to a condition known as night blindness and when severe it may cause xerophthalmia whereby the cornea of the eye becomes dry and subsequently thickened (Fox and Cameron, 1984).

Other functions of carotenoids include food colorants, absorbers of light energy, oxygen transporters and physiological functions such as anticancer, antiaging and treatment of photosensitivity diseases (Tee, 1992).

The major source of vitamin A in developing countries comes from carotenoids in plant foods. However, due to seasonality of availability of plant foods, adequate levels of vitamin A are not met in many people's diets. For example, during the rainy season there are plenty of green leafy vegetables, which act as good sources of provitamin A carotenoids. The vegetables become scarce during the dry season and this is when there are a lot of cases of vitamin A deficiency (FAO, 1995). The adverse effects of vitamin A deficiency include night blindness and poor immune response in children, pregnant and lactating women. Vitamin A deficiency is also associated with increased morbidity and mortality among pre-school children. Recent evidence shows that improving the vitamin

A status of deficient children can increase their chances of survival by more than 23% (McLaren and Frigg, 2001). Further, vitamin A can have important effects on maternal mortality and can protect infants from effects of maternal to child transmission of HIV (West et al., 1999).

The strategies used to control VAD are the supply of vitamin A doses to the affected community, food fortification programs and intervention programs aimed at increasing local production and consumption of vitamin A-rich foods. The use of periodic oral dosage of vitamin A is an effective means of controlling xerophthalmia, but it is expensive and may not reach the required target groups since the most vulnerable children are the most difficult to reach. Similarly, although food fortification is usually a cheap and most effective method of controlling xerophthalmia, the poverty-stricken population may be unable to afford the food (Nyambaka, 1996). Underwood (1989) has emphasized that although periodic dosing programs are beneficial, focus should be on approaches that foster practical solutions attainable through better utilization of available foods and other resources. Therefore, efforts to promote the consumption of indigenous dark green leafy vegetables and fruits remain a major element of controlling VAD (McLaren and Frigg, 2001).

A number of countries in Africa including Botswana, Kenya, Namibia, Uganda, Zambia and Zimbabwe experience dry seasons and thus there is shortage of vegetables. In these countries indigenous vegetables such as the spider herb, cowpea leaves, black nightshade, *Crotalaria ochroleuca* and the bush okra are normally preserved by sun drying. This helps to cater for their scarcity during the dry season (Schippers, 2000). Many parts of Kenya too, especially Eastern, Coast, Rift Valley and Nyanza provinces experience long dry seasons in a year, which interferes with the availability of dark green indigenous vegetables, thus the people's food system. Koru Location, of Nyando District in Nyanza Province is one such area that experiences a long dry season and where a number of households are known to preserve indigenous vegetables.

Scarcity of vegetables during dry seasons result in inadequate intake of vitamin A rich foods. This together with the presence of severe illness and low awareness and knowledge about proper nutrition has attributed to the presence of vitamin A deficiency in many areas (Roberts, 2000). One way of availing vegetables all year round is through preservation. Among the Luos in Nyanza Province, sun drying of vegetables is a common practice where vegetables such as the spider herb, cowpea leaves and *Brassica carinata* are preserved (Maundu et al., 1999). The drying is done when vegetables are in plenty. Sometimes the vegetables can be dried by the use of fire.

The main purpose of drying or dehydration is to extend the shelf life of foods by reducing water activity. However, sun drying destroys nutritional content, especially the beta-carotene content in these vegetables. This is because beta-carotene is unstable to light and oxygen. Therefore, there is need to determine the levels of beta-carotene that remains and thus vitamin A value in the sun-dried vegetables. This is important when developing better policies, including adoption of other methods of preservation such as solar drying or better feeding habits so as to improve the family's nutritional status throughout the year.

Fermentation is another important means of food preservation common throughout the world. It involves the growth of desirable organisms to cause the competitive disappearance of undesirable spoilage or pathogenic organisms. Foods such as milk, meat and vegetables are preserved by this process (Wood, 1985). In Asia, the preparation of fermented food is a widespread tradition. *Gundruk*, a fermented and dried vegetable product is important for ensuring food security for many Nepali communities especially in remote areas. One of the disadvantages of the traditional process of *gundruk* is the loss of 90% of the carotenoids during sun drying (Azam-Ali, 1998). In western Kenya, the black nightshade is one of the indigenous vegetables that is fermented. The vegetable is first boiled in water, after which the water is replaced with milk and boiled again for a short time. The resulting product is compressed and left to ferment and dry for a few days where it solidifies and turns almost black in colour (Schippers, 2000).

1.2 STATEMENT OF THE PROBLEM

Vitamin A deficiency is a serious public health problem in many developing countries today. Inadequate vitamin A in the diet is basically manifested through a set of symptoms known as xerophthalmia, which causes failing sight and eventual blindness if left untreated. Children between six months and six years are the major victims of this deficiency. The World Health Organization (WHO) estimates that half a million children go blind every year from xerophthalmia and several millions more exhibit other symptoms of vitamin A deficiency (WHO, 1982; Buyckx, 1991).

Vitamin A deficiency in Kenya has been identified through field nutritional surveys and clinical research and is a common nutritional problem (Orinda, 1990). However, some symptoms of this vitamin deficiency can go unnoticed due to the complex interaction of infections with various types of malnutrition and deficiency diseases (Bennet and Maneno, 1986). A national micronutrients survey conducted in Kenya from February to July 1994 revealed that severe vitamin A deficiency was most prevalent in Kisumu, Kisii and Bungoma districts where sixty six percent of the deficient children are found (UNICEF/GoK, 1995). Kisumu has since been divided into Nyando and Kisumu District. Koru Location, the study area lies in Nyando District.

The majority of people in Koru Location grow different types of indigenous vegetables which are a good source of beta-carotene, a precursor of vitamin A. But this area experiences a long dry season such that during this time the indigenous vegetables are unavailable. A number of households in this location preserve the vegetables when in plenty using the common traditional methods such as sun drying and fermentation. However, much of the beta-carotene is lost in such processes because the compound is easily oxidized. It is therefore important to determine the beta-carotene content that remains and thus vitamin A value in the traditionally preserved indigenous vegetables. This will serve as a basis for formulating better policies such as introducing better techniques that preserve higher levels of beta-carotene in the vegetables or starting nutritional education activities to improve families' nutritional status all the year round.

1.3 PURPOSE OF THE STUDY

The main purpose of this study was to investigate the traditional methods used to preserve indigenous vegetables in Koru Location and to determine the vitamin A content in the preserved vegetables.

1.4 OBJECTIVES

The specific objectives of the study were therefore:

- To determine the prevalence of vitamin A deficiency among children in Koru Location.
- To identify the indigenous vegetables that are grown in Koru Location, Nyando District.
- To assess the extent to which preservation of these indigenous vegetables is done in the study area.
- To examine the traditional methods used to preserve these indigenous vegetables.
- To determine the beta-carotene and thus vitamin A content of the traditionally preserved indigenous vegetables.

1.5 HYPOTHESES

The study hypotheses were:

- There is a relationship between the vitamin A content in the preserved indigenous vegetables and the preservation methods.
- There is a relationship between the extent of preservation and the unavailability of vegetables.

1.6 ASSUMPTIONS

The study assumed that:

- Vitamin A deficiency can be minimized during the dry season through preservation of indigenous vegetables.
- Indigenous vegetables are commonly preserved in regions experiencing long dry seasons.
- Many communities in Kenya use locally available dark green indigenous vegetables as sources of their vitamin A.

1.7 SIGNIFICANCE OF THE STUDY

The findings of the study are useful because they provide information on the indigenous vegetables grown in the study area that form the source of nutrients for the community and on the extent of vegetable preservation going on in the area. It also provides useful information on the levels of beta-carotene and thus vitamin A content in traditionally preserved indigenous vegetables. This is of great benefit to the Ministry of Agriculture, Ministry of Health and to Non Governmental Organizations (NGOs) interested in preventing vitamin A deficiency in regions that are prone to drought. The extent of vitamin A deficiency prevalence is useful to policy makers and other interested partners in coming up with intervention strategies to combat vitamin A deficiency. The effects of preservation treatment procedures on beta-carotene content in the vegetables is important to food technologists and nutritionists. Lastly, the study contributes to the field of knowledge in foods and nutrition and forms the basis for future research in the area.

1.8 LIMITATIONS

The study focused on indigenous leafy vegetables locally grown and preserved in Koru Location, Nyando District. Therefore, any generalizations of the study findings to other areas should be done with caution.

The fresh and preserved vegetable samples were collected during different seasons although their beta-carotene contents were compared directly. The indigenous vegetables preserved by the community were collected in April and May 2001 while the fresh vegetables were collected in September 2001.

1.9 OPERATIONAL DEFINITION OF TERMS

Beta-carotene: It is a provitamin A carotenoid (precursor of vitamin A) found in plant foods.

Provitamins: Substances which occur in food and are not themselves vitamins but are capable of conversion into vitamins in the body.

Vitamin A: It is a pale-yellow, viscous, fat-soluble compound found in animal foods.

Dehydration: This is the application of heat under controlled conditions to remove water normally present in food by evaporation.

Sun drying: Dehydration process in which vegetables are laid on flat surfaces in the sun and turned regularly to dry.

Solar drying: A dehydration process in which the principal source of energy is derived from the enhancement of the sun's radiation. It provides higher air temperatures and improved drying rates of vegetables.

Indigenous vegetables: Vegetables that have been taken from the wild or semi wild state and have been planted in small plots at the homestead or in farms for home consumption.

1.10 DESCRIPTION OF VARIABLES

The independent variable in this study is the type or method of preservation used. This is because the method of preservation can be manipulated to determine its effects on the vitamin A content of the indigenous vegetables. The vegetables are also independent variables.

The dependent variables are the vitamin A contents in the indigenous vegetables.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter reviews the literature related to the present study. The major components discussed are:

- The types of indigenous vegetables;
- Methods of vegetable preservation;
- Vitamin A: its sources, importance in the body, absorption and deficiency; and
- The methods of analysing pro-vitamin A carotenoids.

2.2 TYPES OF LEAFY INDIGENOUS VEGETABLES

Leafy indigenous vegetables play an important role in traditional diets in rural and urban areas of Kenya. They form a substantial proportion of the diets of most low-and middle–class Kenyans. For rural Kenyans, the vegetables are inexpensive, easily accessible and excellent sources of micronutrients such as vitamin A, minerals and plant protein (Maundu, et al., 1999). A sizeable number of vegetables such as the pumpkin leaves, spider herb, jute, amaranth, black nightshade and cowpea leaves are usually grown in small plots at the homestead called kitchen gardens or in farms for home consumption. Table 2.1 shows some indigenous and cultivated green leafy vegetables grown in Kenya and their beta-carotene (provitamin A) content. The most common and widely grown vegetables are discussed below.

Table 2.1. Some wild and cultivated green leafy vegetables from Kenya and their Beta-Carotene Content.

Indigenous vegetable		Beta carotene content (µg/100 g wet weight)	
Botanical name	Common name	Range	Mean
Amaranthus species	East African Spinach	3,750-4,750	4,416
Amaranthus hybridus	East African Spinach	6,750-8,750	7,415
Crotalaria brevidens	-	6,250-7,750	7,000
Gynandropsis gynandra	Spider herb	15,500-16,750	15,916
Vigna Unguiculata	Cowpea leaves	6,250-8,250	7,416
Cucurbita maxima	Pumpkin leaves	7,750-9,000	8,375
Solanum nigrum	Black nightshade	7,500-7,750	7,625
Cucurbita species	Pumpkin	7,875-9,125	8,291
Beta vulgaris	Swiss chard	4,875-7,375	6,125
Manihot utilissima	Cassava	12,125-16,750	14,437
Phaseolus vulgaris	Bean	9,500-11,225	10,665
Brassica olerecea	Kale	7,625-9,000	8,312
Corchorus olitorius	Bush okra	8,250-9,000	8,750
Solanum tuberosum	Potato (Irish)	10,825-11,520	11,260
Colacasia esculenta	Cocoyam	9,500-9,952	9,700
Erucastrum arabica	-	7,500-7,750	7,625
Galinsoga perviflora	-	7,250-7,563	7,375

Source: Klaui and Bauernfeind, 1981; Gomez, 1981

2.2.1 Amaranthus Species

Amaranths are among the most commonly used leafy vegetables in Kenya and the rest of Africa. They have a high nutritional value because of the high levels of essential micronutrients like beta carotene, vitamin C, iron and calcium (Schippers, 2000). The common species are:

♦ ***Amaranthus dubius***

This is an erect branched herb up to 1 meter or more, resembling the spiny amaranth, but without spines. It has ridged stems and simple leaves with conspicuous veins underneath. Its flowers are born in clusters, in the axils and in terminal branched heads or spikes. The fruit produced is covered by bracts and bracteoles, which are the more visible structures of the flowering part. The seeds are black and shiny.

Plate 2.1 ***Amaranthus dubius.***

The plant grows in most tropical parts of the world and is usually found in most sub-humid parts of Kenya. It is a common herb in most towns in Kenya and is commonly found on cultivated land, roadsides and floodplains. Leaves and tender shoots are used as a vegetable, sometimes cooked with more bitter vegetables such as *Gynandropsis gynandra* and *Solanum nigrum*, or used as a popular choice for improving the taste of many traditional leafy vegetables (Maundu et al., 1999).

- ***Amaranthus hybridus***

Amaranthus hybridus also called Chinese spinach, spiny amaranth and spleen amaranth is an erect branched herb usually 40 – 80cm. Its stems are green or tinted red and ridged while its leaves are simple, alternate, green or tinted red with a lamina up to 15cm or more and a long petiole. Flowers are borne in clusters in green, yellow, red or occasionally purple axillary and terminal spikes.

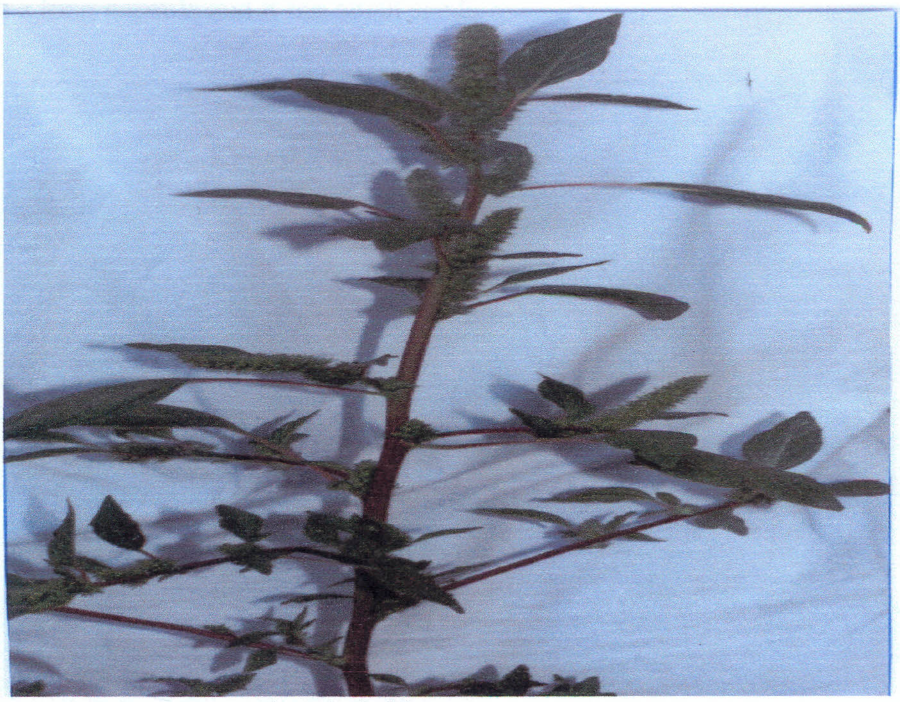

Plate 2.2 ***Amaranthus hybridus.***

Its seeds are shiny black or cream. It is widespread in tropical and subtropical regions of the world and widely distributed in humid to sub-humid areas in Kenya, mainly as a weed of cultivation in degraded land and built-up areas, along rivers, roadsides and forest edges. Leaves and young shoots are used as a vegetable. This is the commonest and the most widely used species in wetter regions. Much of it is picked from the wild or occasionally it is spared when found growing as a weed. In some parts of Kenya, especially in the west, the species is cultivated in small home gardens. The vegetable is very tasty and its large leaves make it very popular (Maundu et al., 1999).

2.2.2 *Brassica carinata*

Brassica carinata, also called the Ethiopian cabbage, is an erect herb, often branched, up to 1.2 meters or more high. Its leaves are pinnately lobed and smaller compared to those of other brassicas. Its flowers are yellow and borne in a long terminal inflorescence. Its fruit is a long capsule and it has small seeds.

Plate 2.3 ***Brassica carinata..***

It is grown in many parts of the world with several cultivars. In Kenya it is mainly grown in Nyanza and Western Provinces, especially by the Luo and Luhyia communities. It prefers fertile places such as abandoned cattle enclosures. Its leaves are used as a vegetable and is popular among the Luo. Here, the leaves are cooked as a vegetable or mixed with those of *dek* (*Gynandropsis gynandra*), boiled, made into lumps, dried in the sun and stored in a clay pot (*agulu*) as a dry-season food (Maundu et al., 1999). In other parts of Africa such as Malawi, the leaves are mixed with those of *Solanum nigrum* and *Gynandropsis gynandra* during cooking (Schippers, 2000). The cooked vegetable has a characteristic sharp odour and is not bitter (Maundu et al., 1999).

2.2.3 *Corchorus olitorius*

Corchorus olitorius, also called the jute or bush okra is an erect woody herb usually 0.5 to 1.2 meters high but may reach a height of up to 2.5 meters on cultivation. Its leaves are short stalked, ovate to elliptic and margin serrated. It has yellow flowers. It is widespread in Kenya in seasonally flooded areas, flood plains, at the edges of lakes, dams and marshes. The leaves are widely used as a vegetable in Kenya and the rest of Africa. It is normally cooked with other coarse vegetables such as *Gynandropsis gynandra* and cowpea leaves as it is slippery. When cooked with cowpea leaves, milk and butter, it is given to lactating mothers among the Luo (Maundu et al., 1999). The leaves are a good source of protein, starch, vitamins A and C and minerals such as calcium, phosphorus and iron. The leaves are sometimes sun dried, pounded to flour and stored for significant periods(FAO, 1988).

2.2.4 *Crotalaria ochroleuca*

Crotalaria ochroleuca is an erect herb having stems ribbed with ascending branches. The leaves are divided into three narrow leaflets. It has yellow flowers with very conspicuous purple veins.

Plate 2.4 *Crotalaria ochroleuca.*

It is cultivated for its leaves in Nyanza and Western provinces. It grows in seasonally flooded areas, flooded plains, swamp edges and in cultivated land. The vegetable is slightly bitter and is normally cooked with milk or other vegetables such as cowpea to counteract bitterness (Maundu et al., 1999). Crotalaria leaves contain high levels of provitamin A and calcium (Schippers, 2000).

2.2.5 *Cucurbita maxima*

Cucurbita maxima, also known as the pumpkin is a trailing or climbing plant. Its stems have tendrils, are angled and have prickly hair. Its leaves are coarsely hairy, light green, up to 10 cm long. The plant has yellow flowers (Maundu et al. 1999).

Plate 2.5 ***Cucurbita maxima***

It has long been widely grown in Kenya and other parts of Africa for home consumption. Both the fruit and leaves are eaten in Kenya. Pumpkins have an advantage over other vegetables in that the fruits can be stored for up to 6 months before being consumed and can play an important role in maintenance of nutritional levels during the long dry season, when few fresh vegetables are available. The leaves may be dried and stored for 6 months (Schippers, 2000).

2.2.6 *Gynandropsis gynandra*

Gynandropsis gynandra, also called the spider herb is an erect herb, usually 0.5 to 1.0 meters high. Its stem is hairy and rather oily. Its leaves are on long stalks usually divided into 3, 5 and 7 leaflets. It has white or pink flowers.

Plate 2.6 *Gynandropsis gynandra.*

The leaves are widely used as a vegetable in Kenya, especially in the western and coastal regions. Leaves are cooked and eaten along with *ugali,* a paste made from finger millet or maize flour. Since the leaves are bitter they are usually cooked with other vegetables such as cowpea or amaranth among the Luo. Sometimes milk is added to the vegetables and preferably left overnight in a pot to reduce bitterness. The leaves are preserved by mixing with those of *Kandhira* (*Brassica carinata*), boiled, made into lumps, dried in the sun and stored in a clay pot as a dry-season food (Maundu et al., 1999). The leaves are also blanched, or simply chopped and sun dried for use in times of scarcity (FAO, 1988). The sun-dried leaves are stored in a tight fitting container and kept in a well-ventilated and dry place for up to 6 months (Schippers, 2000). The leaves are rich in vitamin A and C, with medium levels of calcium, magnesium, iron and a protein content, 3.5 – 6% (FAO, 1988).

2.2.7 *Solanum nigrum*

Solanum nigrum, also called the black nightshade, is an erect herbaceous plant with ridged soft stems.

Plate 2.7 *Solanum nigrum*

It is widely distributed in Kenya and is commonly found as a weed in cultivated fields. Its leaves do best during and just after the rains. The leaves are widely used as a vegetable in Kenya, normally cooked with amaranth among the Luo. As the vegetable is bitter, some people prefer not to use salt (Maundu et al., 1999). The leaves are high in vitamins A and C and are a moderate source of minerals. The leaves are sometimes sun-dried (FAO, 1988).

2.2.8 *Vigna unguiculata*

Vigna unguiculata, also called the cowpea is an erect, trailing or climbing herb with three leaflets.

Plate 2.8 *Vigna Unguiculata.*

It is cultivated all over Kenya and in several countries in Africa as a vegetable. Both leaves and seeds are used as food, cooked alone or with other types of vegetables. When the leaves are cooked with corchorus leaves, milk or butter it is served to breast-feeding mothers among the Luo. Cowpea leaves may be dried whole or chopped and stored for several months for use during dry seasons (Maundu et al., 1999; Schippers, 2000).

2.3 METHODS OF VEGETABLE PRESERVATION

2.3.0 Introduction

Seasonality is a major barrier to enjoying the benefits of the presence of fruits and vegetables in many developing countries. Surpluses of fruits and vegetables are often lost due to inadequate processing and preservation techniques. Post-harvest losses are usually high especially for micronutrient-rich foods which are perishable. After a few days of storage, green vegetables lose substantial amount of vitamin C and carotenoids. At the household level practical and often neglected preservation methods exist to increase year-round access to micronutrients. In areas experiencing long dry spells, leafy vegetables are normally preserved by sun drying. Improved drying technologies such as solar drying retain high quantities of the nutrients in dried products, such as carotene (FAO/ILSI, 1997). Other methods such as fermentation are also used though the preservation period is much shorter. In this section preservation will be looked at under dehydration, fermentation, and other methods.

2.3.1 Dehydration

Dehydration is the application of heat under specific conditions to remove water present in food by evaporation (Miller, 1986). Dehydration reduces the moisture content in the food to prevent the growth of microorganisms that cause food spoilage. Dried foods can be kept at ambient temperatures for long periods and thus provide nutrients when fresh produce is not available (FAO, 1995). The common dehydration methods, primarily solar and sun drying which are simple, inexpensive technologies in terms of both capital input and operating costs can be adequate among communities living in regions that have a suitable dry season after harvesting food crops (Hui, 1992).

2.3.1.1 Sun Drying

Since ancient times sun drying has been the most common method of preserving vegetables. In sun drying, the foodstuff is spread on a flat surface in the open air and exposed to the drying action of the sun. Variations on this technique include hanging the foodstuff from the eaves of buildings or from trees or gathering the harvest in bundles in the fields (Hui, 1992).

Spreading vegetables on the bare ground or on mats is usually avoided to prevent contamination by dust and insects. Instead raised trays or racks are preferred when drying vegetables. The trays are usually perforated to permit the maximum flow of air around the drying surface and are loaded with no more than 6 kilograms of vegetables per square metre. These vegetables are spread in an even layer and are stirred or moved about at least every hour during the first drying period. This speeds up drying and improves the quality of the finished product. Shade drying, which is when the drying rack is placed in a shaded position is also carried out if it is necessary to prevent discolouration or to conserve nutrients. Shade drying is more dependent on air movement through or over the drying vegetables. Therefore, the drying rack is positioned to take maximum advantage of any winds. In dry air conditions with ample circulation, shade drying can be accomplished almost as quickly as sun drying (Spiers and Coote, 1986).

Sun drying however changes the surface characteristics of food such as reflectivity and colour and destroys the vitamins such as vitamin A or carotene and vitamin C. Large differences in reported data on the nutritive value of dried foods are due to wide variations in the preparation procedures, the drying temperatures and presence or exclusion of light (Hui, 1992).

Sun drying of indigenous leafy vegetables is practised in several African countries: Botswana, Kenya, Malawi, Namibia, Uganda, Zambia and Zimbabwe (Schippers, 2000). Some regions in these countries have been reported to experience dry seasons during which vegetables become scarce. The dried vegetables act as a source of food during the dry season. The vegetables that are sun dried in these countries include amaranth, spider herb, cowpea leaves, pumpkin leaves, black nightshade, bush okra and *Crotalaria achroleuca* (Katende, 1999; Schippers, 2000; Tredgold, 1990).

A study carried out in Western Kenya and the lake region revealed that the common method of preserving indigenous vegetables in times of plenty was sun drying (Chweya and Eyzaguirre, 1999). Experienced women are usually involved. The common procedure is that these women place vegetables on trays without cutting and blanching and dry them in open sunshine until the moisture content is low enough to prohibit bacterial growth. In Bungoma District, a KENGO (Kenya Environment Non-Governmental Organization) project sun dries indigenous vegetables and incorporates them in porridge flour, as a weaning food (Mathenge, 1997). Among the Luo in Nyanza

Province, sun drying is used to preserve indigenous leafy vegetables such as the spider herb, *Brassica carinata* and cowpea leaves (Maundu et al., 1999).

2.3.1.2 Solar Drying

Solar drying is an improved method of sun drying in which solar energy is collected to heat air in a cabinet that in turn dries the foodstuff. The principle source of energy for drying is derived from the enhancement of the sun's radiation. Compared to sun drying, solar drying provides higher air temperatures and consequential lower relative humidities which are conducive to improved drying rates and a lower final moisture content of the dried crop (Spiers and Coote, 1986). Solar dryers may improve the nutrient content in dried products and retain higher quantities of carotene than are retained by sun drying (FAO/ILSI, 1997). The solar drying of beta-carotene-rich fruits and vegetables is an effective, inexpensive low-level technology for preserving vitamin A. The technology has found a wide application in many countries such as in Haiti, Niger, Tanzania and the Dominican Republic where fruits and vegetables are dried (Linehan, 1993). In these countries, members of local women's groups are successfully trained to perform drying tasks and market the dried products to generate income. Solar dried fruits and vegetables are particularly attractive as a source of vitamin A for children and act as a source of food during the drought season (Linehan, 1994; Jefremords, 1995).

Various solar dryers have been developed and tested by the Tanzania Food and Nutrition Centre and two models are in use (Mgoba, 1993; Mulokozi et al., 2000). The first model, affordable by women groups, consist of a black polyethylene sheet stretched over a box on wooden legs. The black sheet filters ultraviolet light, which destroys nutrients such as carotenes during drying. The drier is portable, enabling women to position it in such a way as to maximize trapping solar energy at different times in the day. Leaves are placed in a ventilated drawer inside the box. The other model is made of mud brick in which heat retention is enhanced by the thickness and poor heat conduction of the brick walls thereby contributing to its drying effectiveness. However, the drier is prone to deterioration over time even though the outer walls are coated with used motor oil to reduce rain damage. A similar simple mud brick solar drier has been developed by FAO for Sahelian countries (FAO/ILSI, 1997). Both dryers perform equally well in drying vegetables, producing approximately 1.5 kilograms of dried vegetables if thinly spread to facilitate faster drying. It takes about four hours to dry amaranth leaves on a sunny day, and six hours for sweet potato leaves. The dryers are used predominantly for dark green leafy vegetables but are also suitable for drying mangoes, papaya, pumpkins and yellow/orange sweet potatoes. The vegetables dried in the enclosed solar dryers have been found to contain considerably higher concentrations of beta-carotene than those sun dried the traditional way in the open air (Mulokozi et al., 2000).

In Kenya, not much has been done on solar drying of fruit and vegetables. It is a new technology that has been made fairly expensive for the rural people. However, the German Technical Cooperation (GTZ) has tried to facilitate this technology in Kilifi, Mwingi, Kitui, Mbeere, Makueni, Embu and Tharaka Nithi districts where farmers are trained to solar dry bananas, tomatoes, guavas, mangoes, pawpaws and different vegetables. They intend to extend this project to Nyanza and Western provinces (King'ori, 1997).

Cheap and simple solar dryers constructed using readily available materials should be developed and promoted for use by households in rural areas of Kenya such as Koru location to preserve indigenous vegetables when they are in plenty. This will make the vegetables available during the dry season and will be a way of retaining as much carotene in the vegetables as possible.

2.3.2 Fermentation

Fermentation is defined as a desirable process of biochemical modification of primary food products brought about by microorganisms and their enzymes. It is purposely carried out to enhance properties such as taste, aroma, shelf life, texture and nutritional value (FAO/WHO, 1996). It is an important traditional household technology in many parts of the world, especially in areas where preservation techniques such as cold storage (refrigeration) or hot-holding cannot be used or are lacking. Lactic acid fermentation at the household level is a natural process brought about by the lactic acid bacteria present in raw food or those derived from a shorter culture. The common denominator of lactic acid fermentation of vegetables is that salt is added in varying quantities. Many lactic acid bacteria have a better tolerance to salt than most pathogenic bacteria. Salt is also effective in protecting the product against some spoilage bacteria and in the case of vegetable fermentation it makes fermentable sugars available by osmotic extraction of juices (FAO/WHO, 1996).

Fermented foods are popular throughout the world and in some regions make a significant contribution to the diet of millions of individuals. In Asia, the preparation of fermented foods is a widespread tradition. A fermented and dried vegetable product, *gundruk,* is important for ensuring food security for many Nepali communities especially in remote areas (Azam-Ali, 1998). In the preparation of *gundruk*, the lactic acid bacteria are not given any assistance to multiply but fermentation depends on the natural selection of lactic acid producing organisms without adding salt. However, once the organisms start to colonise the leaves, they proliferate rapidly and soon form the optimum conditions required for growth. The process is very simple and can be carried out at home with minimum equipment or effort. The dried product can be stored in airtight containers for several months. One of the disadvantages of the traditional process of *gundruk* is the high loss of the carotenoids, probably during sun drying. However, improved methods of drying might reduce the vitamin loss (Azam-Ali, 1998).

Fermentation of vegetables is not very common in Kenya. In western Kenya, some vegetables such as the black nightshade are fermented. The vegetable is first boiled in water, after which the cooking water is replaced with milk and boiled again for a short time. The resulting product is compressed and left to ferment and dry for a few days where it solidifies and turns almost black in colour. The 'cake' is now ready and can be cut into slices and eaten. It is served with cassava or a similar food (Schippers, 2000).

2.3.3 Other Preservation Methods

The other preservation methods that are used commercially involve use of high and low temperature processes. High temperature preservation methods, which are controlled processes include canning, aseptic processing, pasteurization and blanching. Pasteurization is a low order, time and temperature dependant heating process that destroys all pathogens present in the food, reduces the bacterial load in the case of milk and eggs, and reduces yeast and mould count in the case of beer, wine and fruit juice to extend their shelf life. Blanching is another low-order heat process used primarily as a pretreatment step in freezing to destroy enzymes while canning is done to wilt and cleanse tissue and expel tissue gas (Mathlouthi, 1986).

Low temperature preservation methods include refrigeration and freezing. Refrigeration helps to keep foods at a low temperature and prevents their spoilage. Freezing is achieved through both low temperatures to inhibit microbial growth and rates of reactions, and the reduction in water content as a result of ice crystallisation. The shelf life of frozen foods can range from 3 months to a year or longer (Mellor, 1978).

2.4 VITAMIN A

2.4.1 Sources of Vitamin A and carotenoids

Vitamin A or retinol is a pale-yellow, fat-soluble compound, which has the structure shown below:

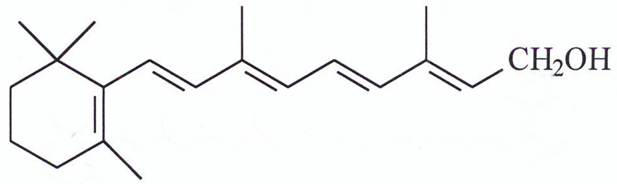

Fig. 2.1: The Structure of Vitamin A

Vitamin A is an unsaturated alcohol and behaves like other alcohols. It has been synthesized and is now produced industrially on a fairly large scale for the enrichment of margarine (Fox and Cameron, 1984; McLaren and Frigg, 2001).

Vitamin A is found in animal tissues. Fish liver oils are the most concentrated source. Consumption of cod liver oil or halibut liver oil is a simple way of ensuring that a sufficient supply of vitamin A is obtained (Williams, 1989). Milk and milk products are good sources of vitamin A as well as eggs (Fox and Cameron, 1984).

Vegetables contain no vitamin A as such but pigments called carotenoids are present which are converted to vitamin A in the walls of the small intestines during absorption, making vegetables to have considerable vitamin A activity. Several carotenoids exist in vegetables but the most common and important is beta-carotene, while others include lycopene, alpha-carotene and gamma-carotenes. Carotenoids, which are vitamin A active are referred to as provitamin A. Beta-carotene is a red solid which was first isolated from carrots owing its name to this source. Solutions of beta-carotene are yellow in colour and it is used for colouring magarine. Beta-carotene is present in green leafy vegetables, in carrots and in yellow fruits such as apricots. Table 2.2. shows the main sources of vitamin A activity in the diet. The molecular structure of beta-carotene is twice that of the vitamin A structure as shown below.

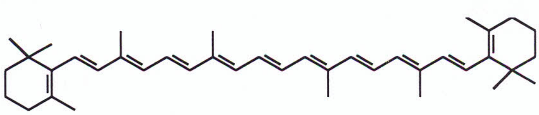

Fig. 2.2: The Structure of β-Carotene

It might be expected that when one molecule of beta-carotene is converted into vitamin A by the body two molecules of the latter would be produced. However, the conversion is not as efficient and beta-carotene is only about one sixth as effective as retinol (Fox and Cameron, 1984). Other provitamin A carotenoids present in vegetable foods are converted to retinol even less efficiently and may be taken as having half the activity of beta-carotene (Fox and Cameron, 1984). A recent study by Khan and West (1999) suggests that the conversion factors for plant carotenoids from yellow-orange fruits and from green leafy vegetables should be 12:1 and 28:1 respectively.

Table 2.2: Average values of vitamin A activity of foods

Food	Retinol equivalents (µg per 100g food)
Foods supplying retinol	
Halibut-liver oil	900,000
Shark-liver oil	180,000
Cod-liver oil	18,000
Herring	45
Sardines (canned)	30
Liver of ox	17,270
Beef, mutton, pork	0-4
Butter	995
Magarine	900
Cheese	420
Eggs	140
Milk	40
Foods supplying carotene	
Red palm oil	20,000
Carrots	2,000
Green leafy vegetables (spinach)	1,000
Tomatoes	117
Bananas	33

Source: Fox and Cameron, 1984; McLaren and Frigg, 2001

2.4.2 Importance of Vitamin A in the Body

The different functions of vitamin A in humans can be broadly grouped under four headings:

a) Vision,

b) Bone growth,

c) Reproduction and

d) Maintenance of epithelia

2.4.2.1 Role of Vitamin A in Vision

The best understood function of vitamin A is related to the maintenance of normal vision in dim light. The retina of the eye contains two kinds of light receptors: the rods, which produce a photosensitive pigment, rhodopsin or visual purple for vision in dim light and the cones which produce lodopsin or visual violet for vision in bright light and color vision (Robinson et al., 1986). When light hits the retina, rhodopsin splits into two parts, opsin and retinal. In the dark the two components recombine to form rhodopsin again. Normally there is more than enough retinal in the pigment layer behind the rods and cones to ensure constant adjustments to variances in light. When the body is deficient in vitamin A, less retinal is available for formation of visual purple. The rods and cones then become increasingly sensitive to light changes, which cause night blindness. This condition can usually be cured rapidly by an injection of vitamin A (retinol), which is readily converted into retinal and then into rhodopsin. The cone of the retina contains another pigment, visual violet, which influences color vision and the ability to see in bright light. Vitamin A (retinol) is also required as a component of this pigment although there is no evidence that vitamin A can cure color blindness (Williams, 1989).

2.4.2.2 Role of Vitamin A in Bone Growth

Vitamin A is essential for normal skeletal and tooth development. It has been observed for some time that vitamin A deficiency is associated with retarded growth, but the precise mechanisms remains unclear (Robinson et al., 1986). With a deficiency of vitamin A, bones do not grow in length and the normal remodeling process does not take place. Vitamin A contributes in an essential way to the growth of skeletal and soft tissues, probably through an effect on protein synthesis, mitosis (cell division) or stability of cell membranes (Williams, 1989).

2.4.2.3 Role of Vitamin A in Reproduction

Studies in experimental animals have shown that vitamin A is essential for spermatogenesis in the male and normal estrous cycle in the female. If vitamin A is not available to the animal during fetal development, many malformations result (Robinson et al., 1986) including glandular degeneration and sterility. In tests with animals fed with only retinoic acid as a source of vitamin A, the lack of retinol and retinal produced sterility and testicular degeneration in males and aborted or malformed offspring in females (Williams, 1989).

2.4.2.4 Role of Vitamin A in the Maintenance of Epithelia

Vitamin A has a vital role in the formation and maintenance of healthy functioning epithelial tissue, which forms the body's primary barrier of infections (Burton and Foster, 1988). The epithelium includes not only the skin but also the mucous membrane lining the ocular and oral cavities and the gastrointestinal, respiratory and genitourinary tracts. The physiologic function of vitamin A in maintaining the integrity of epithelial tissue provides the basis for current research relating vitamin A (retinoids and carotenoids) to cancers of epithelial origin. Without vitamin A the epithelial cells become dry and flat and gradually harden to form keratin, a process called keratinization. Keratin is a protein that forms dry, scale-like tissue such as nails and hair. When the body is deficient in vitamin A, many epithelial tissues may undergo keratinization. This increases the susceptibility to severe infections of the eye, the nasal passages, the sinus, middle ear, lungs and generourinary tract (Robinson et al., 1986; Williams, 1989).

2.4.3 Vitamin A Absorption, Transport, Storage and Utilization

Vitamin A enters the body in two forms: as the preformed vitamin A from animal sources and as the precursor provitamin A carotenoids from plants (Burton and Foster, 1988). Unless the diet is rich in liver, eggs, butterfat, or fish-liver oils, all of which contain large amounts of vitamin A, much of the vitamin is ingested in the form of its carotenoid precursors, of which beta-carotene is the most efficient (Robinson et al., 1986).

Bile salts, pancreatic lipase and fat aid in the absorption of vitamin A and provitamin A carotenoids by the body. Bile aids in the absorption of vitamin A, as it does in other fat-related substances, since it serves as a vehicle of transport through the mucosal wall of the small intestine. First, the major dietary form of preformed vitamin A, long-chain fatty acid esters of retinol are hydrolyzed by an enteric lipase before absorption. Clinical conditions affecting the biliary system such as obstruction of the bile ducts, infectious hepatitis and cirrhosis of the liver hinder vitamin A absorption. The fat-splitting enzyme pancreatic lipase is necessary for initial hydrolysis in the upper intestine of fat emulsions or oil solutions of the vitamin. This enzyme is not required for absorption of a water soluble synthetic form of the vitamin. Therefore, in conditions where secretion of pancreatic lipase is curtailed, such as in cystic fibrosis, the water-soluble form would be preferred (Williams, 1989). Some fat in the intestine, simultaneously absorbed is needed for the absorption of vitamin A. When a diet is low in fat, the absorption of vitamin A and carotenes is seriously impaired. Dietary fat has been shown to increase the absorption of beta-carotene from dark green leafy vegetables in children (Olson, 1996). The simultaneous presence of vitamin E in the intestinal tract prevents the oxidation of vitamin A that would otherwise occur.

Other factors that impair the absorption of vitamin A as well as carotenoids include some drugs, chronic diarrhoea, pancreatitis, severe protein-energy malnutrition and infestation with ascaris, hookworm and schistosoma. Protein-energy malnutrition reduces carotenoid utilization in the body (WHO, 1982). Age is another factor that affects vitamin A absorption. For example, in the newborn infant, especially the premature infant, absorption is poor. With advancing age, the elderly person may experience increasing difficulties with absorption. Chronic use of mineral oil as a laxative also hinders vitamin A absorption (Robinson et al., 1986).

The efficiency of absorption of carotenoids from plant food is between 50% and 60% depending on bioavailability. Bioavailability is the fraction of an ingested nutrient that is available for utilization in normal physiologic functions or for storage. The absorption of carotenoids decreases at high intakes of carotene. On a high fibre diet, excretion of carotene is increased and the bioavailability of beta-carotene is reduced (Machlin, 1991).

The route of absorption of vitamin A and carotene parallels that of fat. In the intestinal mucosa all the retinol from both preformed animal sources and from plant carotene conversion, is re-esterified with long-chain fatty acids. Incorporated into the chylomicrons, it enters the blood stream via the lymphatic system and is carried to the liver for storage and distribution as needed to the cells. In the liver, the retinol is stored as retinyl esters in lipid droplets. These are then hydrolyzed and free retinol is bound to a carrier protein, retinol-binding protein (RBP), for delivery to cells. In serum, this carrier-retinol compound and the carrier protein alone has a high affinity for another plasma protein called transthyretin and a complex is formed between the two substances (Williams, 1989).

2.4.4 Vitamin A Deficiency

Vitamin A deficiency (VAD), which refers to any state in which the vitamin A status is subnormal, is still a serious public health problem in many developing countries today. Inadequate vitamin A in the diet results in the set of symptoms known as xerophthalmia, which causes failing sight and eventual blindness if left untreated. Children between six months and six years are the major victims of vitamin A deficiency. It is estimated that almost 250 million in developing countries are at risk of VAD of whom 2.83 million are clinically deficient (FAO/ILSI, 1997). The World Health Organization, (WHO) today estimates that half a million children go blind every year from xerophthalmia and several millions more exhibit other symptoms of vitamin A deficiency. (Buyckx, 1991). Two thirds of these children die each year of infectious diseases because VAD impairs their resistance to common infections.

A national micronutrients survey conducted recently in Kenya revealed that severe vitamin A deficiency is most prevalent in many parts of the country, with Kisumu, Kisii and Bungoma districts accounting for the highest percent (66%) of the deficient children (UNICEF/GoK, 1995). Sub-clinical cases of VAD are prevalent in drought prone areas and densely populated regions in Western Kenya due to limited availability and consumption of vitamin A-rich foods during dry seasons (Orinda, 1990; FAO, 1995).

2.4.5 Epidemiological factors of VAD

VAD has been described as the most widespread and serious nutritional disorders to afflict mankind (WHO, 1982). The problem has remained largely unchecked and continues to be the cause of a high toll in blindness and death among young children. The epidemiology of the problem is, however, rather complex. The factors involved may be considered in terms of a host-environment-agent interrelationship, as in other diseases or disorders (Tee, 1992). Some of these factors are discussed below.

2.4.5.1 Host factors

Host related factors are those factors in the individual that contribute to his being vitamin A deficient. Age is considered predominant among all of the host factors involved. Young children constitute the most vulnerable age group, and the most serious eye lesions commonly occur in them. This is related to their relatively high vitamin A requirements for growth, increased needs due to the frequent occurrence of infections, low intake of milk from undernourished mothers and failure to supplement carotene-poor staples with dark green leaves and other rich sources (Mclaren, 1981). There appears to be evidence that males are more susceptible to xerophthalmia. This is said to be true for all stages of ocular lesions, all ages and in many countries. However, reasons for the sex difference are unclear although it could be more cultural than biologic (Tee, 1992).

2.4.5.2 Agent Factors: The Diet

Vitamin A deficiency is highly prevalent in communities where the dietary staple is rice, with little or no consumption of animal foods, dark green leafy vegetables, or of yellow/orange fruits and vegetables. This is also true for communities dependent on cassava, white potato, or other carbohydrate dense foods that are virtually devoid of vitamin A and carotenoids. Vitamin A deficiency is a condition found in poor socioeconomic environments where foods from animal sources are too expensive and carotenes from plant sources are of paramount importance. However, due to ignorance and/or neglect, even these cheaper sources of vitamin A are very often not adequately utilized especially by children. Hence, it is common to find "poverty in the midst of plenty," and the destruction of eyes by xerophthalmia in environments where carotene-rich green leaves are abundant (Tee, 1992). Unsatisfactory early childhood feeding practices have an important bearing on the development of vitamin A deficiency. Xerophthalmia is rarely reported among breastfed infants and seldom reported in children who continue to be breastfed in the second year. However, this is not to be so in many countries since the mothers themselves tend to be undernourished, with a very low vitamin A status and consequently the milk produced has a low concentration of the vitamin. Early weaning of children to an inadequate diet of rice, cereals and tubers worsen the situation (Underwood, 1984).

2.4.5.3 Environmental Factors

Where xerophthalmia endemicity is extremely high, the disease tends to occur all year round with less seasonal variations. On the other hand, where the incidence rate drops, vitamin A deficiency appears highly seasonal. The deficiency is associated with, among other things, particular seasons in which precipitating factors occur, such as dry periods when the supply of fresh fruits and vegetables is scarce (Tee, 1992).

2.4.5.4 Bioavailability of beta-carotene from plant foods

The efficiency of absorption of carotenoids from plant foods is between 50% and 60% depending on bioavailability. Bioavailability is the fraction of an ingested nutrient that is available for utilization in normal physiologic functions or for storage (Machlin, 1991). A study by Khan and West (1999) found out that absorption and conversion of carotenoids from plant foods was much lower than the conventional conversion of 6:1. Carotenoids from orange fruits were better absorbed than those from green leafy vegetables. The study therefore suggests that the conversion factors for plant carotenoids from yellow and orange fruits and from green leafy vegetables should be 12:1 and 28:1, respectively.

Some studies have shown that the stability of beta-carotene in plants is affected by the cooking procedures. The study by Tabekha (1999) found out that mild heating of beta-carotene rich foods resulted in only 10% loss of beta-carotene while prolonged heating resulted in 50-80% loss.

A number of factors have been found to affect the bioavailability of provitamin A carotenoids from plant foods. When a diet is low in fat, the absorption of Vitamin A and carotenes is seriously impaired (Williams, 1989). Dietary fat has been shown to increase the absorption of beta-carotene from dark green leafy vegetables in children (Olson, 1996; Takyi and Owusu, 1999). The consumption of dark green leafy vegetables (cassava and kapok leaves) in the presence of added fat (sheabutter, 10%) enhanced both bioavailability of carotenoids in the leaves and the retinol status. Similarly another study conducted by Chandrasekhar (1999), reported that amaranthus and pumpkin leaves cooked in shallow fat had a mean beta-carotene absorption of 61.7% and 72.5% respectively in humans. Mulokozi (1999) has also found out that the use of red palm oil and sunflower oil improves the bioavailability of beta-carotene in green leafy vegetables. A high fibre diet increases excretion and reduces biovailability of the beta-carotene. The absorption of carotenoids is also decreased with high intakes of carotene (Machlin, 1991).

The vitamin A status of a subject is also important because the poorer the vitamin A status, the more the retinol concentrations increase in response to an improved dietary intake. In a study carried out by Russel (1999) in Phillipines to determine whether foods rich in provitamin A carotenoids improve vitamin A status in malnourished children, carotenoid-rich vegetables were found effective in providing vitamin A to children. Environmental factors such as the presence of parasites reduce the absorption of beta-carotene, therefore prevention of ascaris infection through deworming is important to improve the bioavailability of beta-carotene from dark green vegetables (Persson, 1999).

2.5 METHODS OF ANALYSING PRO-VITAMIN A CAROTENOIDS

The analysis of carotenoids is often complicated because of their instability whereby they have a tendency to readily undergo isomerization and oxidation reactions due to their being photo- and thermo-labile. Conditions such as working in dim lights, in an inert atmosphere and at low temperature, and using purified solvents are necessary in all procedures. A pre-requisite in the analysis of caretonoids is the preliminary sample treatment in order to release, isolate and extract the compounds from the food matrix. Although there are many procedures for the pre-treatment of plant materials available, they follow basic steps. The blended, or if dry, the ground sample is extracted with an organic solvent, mainly hexane (or petroleum ether) mixed with acetone or diethyl ether, filtered and the residue re-extracted several times. Some procedures may involve a saponification step to remove chlorophyll, fats and esters (Nyambaka, 1996).

A wide variety of separation, and detection and quantification procedures are used in the studies of carotenoids. The earliest method for the separation of carotenoids was the counter-current distribution method in which various fractions of carotenoids such as hydrocarbons, and hydroxyl derivatives were obtained in the liquid-liquid partitioning. The method is not popular due to the high cost of equipment and to the prolonged exposure of carotenoids which may lead to formation of artefacts (Nyambaka, 1996).

Chromatography is the most important technique for separating and purifying carotenoids. Column chromatography (CC), or open-column chromatography, involves the use of an open column packed with an adsorbent and a solvent which flows by gravitational force. There are many adsorbents used in the separation of carotenoids, with the common ones being CaO, $CaCO_3$, $Ca(OH)_2$, $MgCO_3$, MgO, $ZnCO_3$ and Al_2O_3. Selection of adsorbents to use depend on the types of carotenoids being separated. Columns packed with MgO are widely used in many methods for the separation of vegetable carotenoids ever since the adsorbent was introduced in the official methods of provitamin A analysis in 1955 (AOAC, 1984). Hyflo Super Cel or celite is mixed with the absorbent as a filter aid to improve the slow flow rate.

Thin-layer chromatography (TLC) has been successfully applied to carotenoid separation and identification. The method permits rapid and sharp separation and is generally applied on a micro or semi-micro scale, detecting compounds at trace levels. The adsorbents mostly used are the basic oxides and carbonates which are normally mixed with binders such as calcium sulphate, kieselguhr and starch. For identification and quantification, the adsorbent with separated carotenoid is scrapped from the plate directly into the eluent, filtered and then analysed (Nyambaka, 1996).

High-performance liquid chromatography (HPLC) is a column chromatographic method in which column packing materials have been highly developed in the form of very small particles of uniform size, shape and porosity, and the solvent delivered at high pressure from a pump that ensures uniform flow. In most HPLC analyses the columns used are the pre-packed ones, especially in reversed phase chromatography. The sample is introduced into the solvent system (mobile phase) flowing at a particular rate, and is separated at the tightly packed column. The separated compounds are passed on to the detector where they are monitored and recorded in form of a chromatogram (Nyambaka, 1996). HPLC is widely used in the analysis of vegetable carotenoids for pro-vitamin A determination as well as for complete carotenoid investigation (Gross, 1991).

Several methods are used for the identification of carotenoids. The standard method of carrying out the quantitative determination of carotenoids is by spectrophotometry where the extinction coefficient of the compound at a given wavelength in a particular solvent is used. The method normally requires a chromatographically pure compound and enough quantity to be detected. Petroleum ether and hexane are the solvents commonly used in the determination of carotenes, while more polar solvents are used for xanthophylls. The method has been used in the determination of total carotenoids in fruits and vegetables (Brubacher et al., 1985).

Quantitative determination in HPLC analysis is attained by use of the comparison of the peak area or peak heights of the authentic standards with those of the samples. The method can only be used if the detector response is proportional to the extinction coefficient, obtained from the calibration curve. HPLC identification of the carotenoids is based on the retention times as well as co-chromatography with standards (Nyambaka, 1996).

2.6 SUMMARY

Vitamin A is an important vitamin in the human body. It has several functions, among them being vision, bone growth, reproduction and maintenance of the epithelia. Vitamin A per se is obtained only from animal food sources, while the vitamin A precursors are supplied in abundance by the dark green and deep yellow vegetables and fruits. In developing countries where sources of vitamin A comes from provitamin A carotenoids, seasonality is a major barrier to obtaining adequate levels of vitamin A in the diet because availability of fruits and dark green indigenous vegetables is interfered with. Some communities preserve foods like green leafy indigenous vegetables by sun drying for use in times of scarcity because they have a high vitamin A activity. This destroys the beta-carotene and thus vitamin A content in the vegetables. Proper methods of preserving vegetables are available and these can be used so that the carotenoids are less destroyed.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

The main aim of this study was to investigate preservation methods of indigenous vegetables in Koru location of Nyando District and determine the vitamin A content in the preserved vegetables. The methodology employed to facilitate this investigation is discussed below.

3.2 DESCRIPTION OF THE STUDY AREA

Koru Location is located in Nyando District, Nyanza province, Western Kenya. Nyando District is a new district curved out of the former Kisumu District. It covers 1,280 km^2 and has 6 divisions: Muhoroni, Miwani, Nyando, Awasi, Lower Nyakach and Upper Nyakach. Koru location lies in Muhoroni division together with other locations namely Tamu and Mnara. The location has three sub-locations: Nyando, Homa-Lime and Koru Central.

The climate in Koru Location is extremely erratic and unpredictable. The long rains begin in late March and lasts for about two months. Thereafter, a dry season continues until the short rainy season in August, which lasts for barely one month followed by another long dry spell. Availability of food, especially the green leafy vegetables during the dry periods is a major problem in the area.

3.3 DESCRIPTION OF RESEARCH DESIGN

The study was carried out in two phases: phase one entailed field work and phase two laboratory work. Therefore, the study encompassed both a descriptive survey and an experimental research design.

3.3.1 Descriptive Survey

The descriptive survey sought to find out the different types of indigenous vegetables grown by the community in Koru Location, the methods used to preserve them and their dietary intake during the dry season. This information was obtained using an interview guide and by observation. The survey also formed the basis for selecting the vegetable samples for the experimental work.

3.3.2 Experimental Research Design

The preserved vegetable samples were obtained from households that did the preservation. These samples, both dried and fermented were kept in opaque airtight plastic containers and brought to the laboratory. The fermented vegetables were kept frozen while the dry samples were kept in a cool dark place until the time of analysis. The vitamin A content of the dried and fermented vegetables was analyzed in duplicate at the Kenyatta University, Department of Chemistry research laboratory.

Fresh leafy vegetables were obtained from household gardens when they were ready and in plenty i.e. during the harvesting season. These vegetables were kept in black perforated polythene bags and brought to the laboratory. The samples were first blanched in boiling water to prevent further oxidation of beta-carotene and divided into three portions; one for analysis, one for sun drying and one for solar drying. Laboratory preservation of the fresh vegetables was necessary in order to compare the beta-carotene content in them and those preserved by the community. The vitamin A content in the fresh, sun dried and solar dried vegetables were then analyzed. Vitamin A content was analysed using a column chromatographic separation and ultraviolet-visible (UV-VIS) detection procedure.

3.4 SAMPLE SELECTION

Koru was purposively selected because it is a region that experiences two dry seasons and incidences of vitamin A deficiency. It is also a region where indigenous vegetables do very well during the rainy season, but remain scarce in the dry season.

Koru location has three sub-locations: Nyando, Homa-Lime and Koru Central and each of the sub-locations has 4 villages, making a total of 12 villages. Each village has approximately 50 households, giving a total of 600 households. Two villages were randomly selected out of the 4 villages in each sub-location to give a total of 6 villages. A list of the households in the six villages randomly selected was obtained from the Chief's office. Out of 300 households from the six villages selected, 60 households were selected by systematic random sampling, 10 in each village. This represents 10 percent of the total households in the study area. The sampling interval used was 5 and every k^{th} case was selected for inclusion in the study. The mother in each of the selected households was interviewed. Figure 3.2 shows a sampling procedure flowchart.

Indigenous leafy vegetables that were analysed for their vitamin A content were purposively selected from the list of vegetables grown and preserved in Koru.

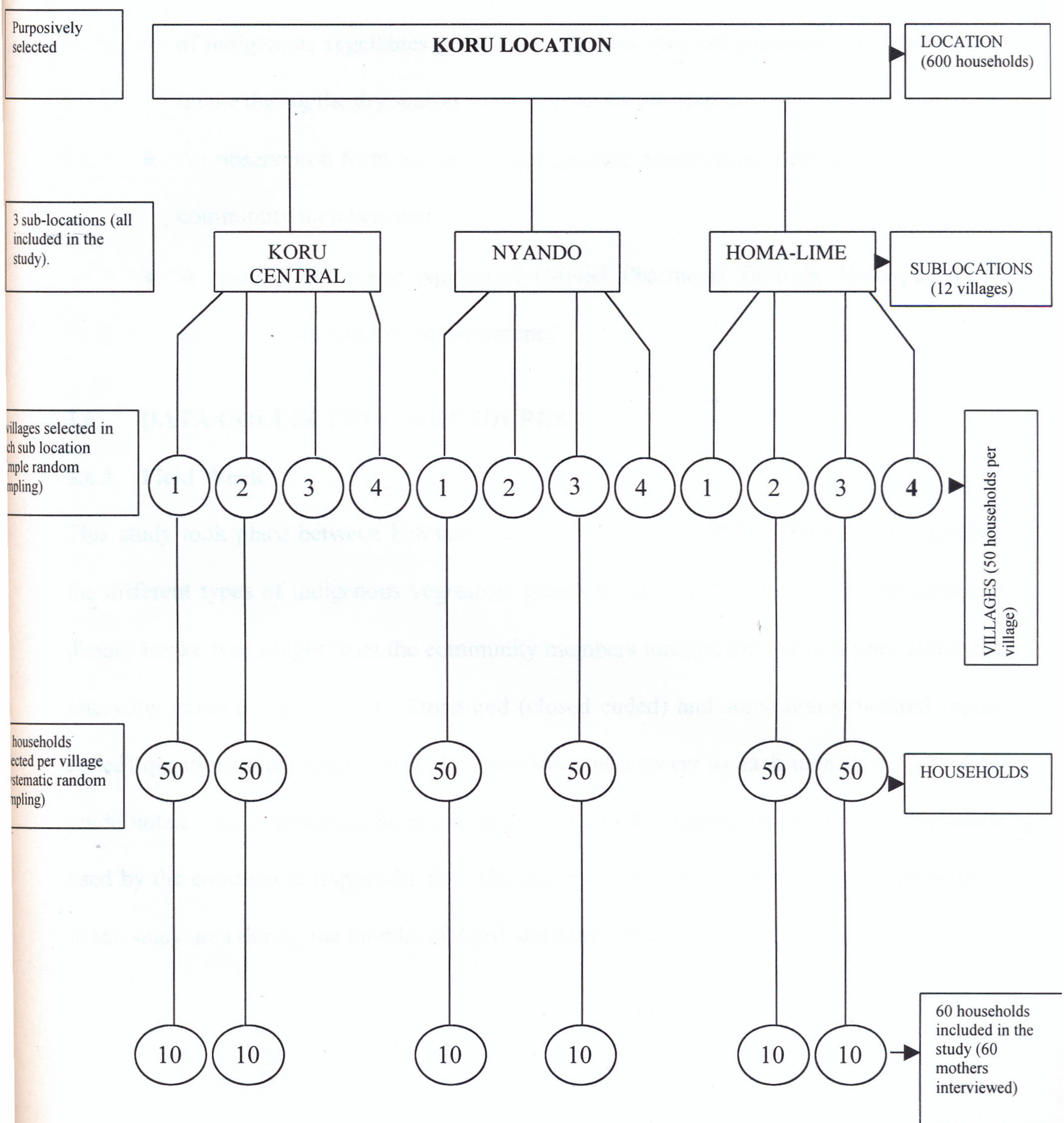

Fig. 3.2: Sampling Procedure

3.5 INSTRUMENTS FOR DATA COLLECTION

The study used three instruments as follows:

- A semi-structured interview guide for obtaining information on the different types of indigenous vegetables grown in Koru, how they are preserved and their dietary intake during the dry season when vegetables are scarce.
- An observation form for recording vegetable preservation methods as used by the community members and
- A spectrophotometric equipment (Model Pharmacia Biotech, Novaspec II) to measure absorbance of beta-carotene.

3.6 DATA COLLECTION PROCEDURES

3.6.1 Field Work

This study took place between February 2001 and September 2001. Information regarding the different types of indigenous vegetables grown in Koru, their preservation methods and dietary intake was sought from the community members through the use of a semi structured interview guide (Appendix A). Structured (closed ended) and some non-structured (open-ended) questions were used during the interview and answers to each item in the interview guide noted. An observation form was used to record the process of vegetable preservation used by the community (Appendix B). The preservation of vegetables was done by mothers in the study area during the months of April and May, 2001.

3.6.2 Laboratory Work

A laboratory experimental procedure was used to determine the levels of beta-carotene, and thus, vitamin A values in samples of the indigenous leafy vegetables collected from the field. Both fresh and preserved forms of the indigenous leafy vegetables were analyzed.

3.6.2.1 Sample preparation

The fresh raw vegetable samples collected from Koru were thoroughly washed under tap water and then destalked and all inedible parts removed before shredding. The samples were then blanched for 1-3 minutes in boiling water (96 Deg Centigrade) and divided into three portions: one for laboratory analysis, one for solar drying and another for sun drying. Fresh samples that were not analysed on the same day were kept frozen until use.

The vegetables were solar dried using a solar drier model similar to the one used by Mulokozi et al. (2000). The model is shown in Plate 3.1. Samples were thinly spread on a ventilated tray and the drawer closed. The black polyethylene sheet prevented the vegetables coming into direct contact with the sunrays. The drying process took six to eight hours.

Sun drying of vegetables was done alongside solar drying. Vegetables were spread on a ventilated tray and exposed to the sun until dry. The drying process was much shorter (4 hours). The solar dried and sun dried samples were stored in hard polythene bags, nitrogen flashed in, then sealed tightly to prevent any oxygen getting in.

Plate 3.1: Solar Drier

3.6.2.2 Determination of Beta-Carotene

- **Chemicals/Reagents**

β-Carotene standard (Type IV) and Butylated hydroxytoluene (BHT) were obtained from Sigma Company, England. Ascorbic acid, sodium chloride, potassium hydroxide, anhydrous sodium sulphate, magnesium oxide and Hyflosupercel were analar grade obtained locally from Kobian Chemical Company, Nairobi. Acetone, Ethanol and Petroleum ether were Analar grade and were also obtained locally from Kobian but were distilled first before use.

- **Standard solutions**

5 mg encapsulated beta-carotene crystalline was dissolved in petroleum ether and made to 100 ml to give 50 μg/ml β-carotene standard solution. The solution was kept in frozen condition. Working solutions were prepared by diluting portions to appropriate concentrations.

- **Analysis**

The extraction procedure followed was that by Nyambaka and Ryley (1996) with some modifications. For fresh vegetables, twenty-five grams of the blanched samples were homogenised by blending with 50ml of water containing 0.5% ascorbic acid for 5 minutes. Five grams of the resultant mixture was extracted with 50ml of acetone–petroleum ether mixture (3:2) containing 0.5% butylated hydroxytoluene (BHT) by shaking with an electric flask shaker (Model, Griffin) at a moderate speed for 10 minutes. The mixture was carefully decanted into a separating funnel and the residue re-extracted until it was colourless (three extractions were found to be sufficient). The combined extracts were then saponified by adding 25ml of a saturated solution of potassium hydroxide (KOH) in ethanol to the mixture, shaken lightly and allowed to stand for 15 minutes before being washed with 100ml of 10% sodium chloride solution followed by three portions of 100ml distilled water to remove acetone. The extract was then dried over anhydrous sodium sulphate and evaporated to near dryness in a rotary evaporator at 30^0C.

The residue was then passed through a column containing magnesium oxide and hyflo super-cel mixture (1:1). Petroleum ether containing 0.5% BHT was continuously added through the column and the eluate collected in a 100 ml volumetric flask until the eluate was colourless. After making to a final volume of 100ml, the absorbance of beta-carotene at 451 nm was determined using a UV-visible absorption spectrophotometer (Model, Pharmacia Biotech, Novaspec II). A calibration graph of absorbance versus the concentration of the beta-carotene standard solutions was used to determine the concentration of the various vegetable samples. Due to the risk of oxidation and isomerization of carotenes, analysis was performed in dimmed lights at room temperature.

For the dry vegetable samples, 0.5g of finely ground material was used for extraction. Five millilitres of distilled water was added to the sample, allowed to stand for 10 minutes and then extracted following the above procedure. All samples, fresh and dried were analyzed in duplicate.

- **Determination of moisture content**

1 gram of dried/fresh vegetable material was weighed and placed in a crucible. This was put in an oven at 105^0C for at least 3 hours. The dry weight of the vegetables was then taken. The moisture content in the vegetables was calculated using both the initial weight of vegetables before drying and the final weight after drying as shown below.

$$\frac{\text{Initial Weight} - \text{Final Weight}}{\text{Initial Weight}} \times 100$$

The calculation of beta-carotene content in the vegetables was based on the dry matter content of the vegetables.

3.7 PRE-TESTING THE INSTRUMENT

3.7.1 Interview Guide

Pre-testing before field study was done to ensure that the items in the instruments had the same meaning to all the respondents. Pre-testing was done on the interview schedules using six respondents in the study area to find out whether the questions were appropriate for the respondents. The six respondents used in the pre-test were not included in the final study. The questions were found to be appropriate and thus used for interviewing the 60 women sampled in the study.

3.7.2 Laboratory Analysis

A solution of beta-carotene was scanned on a spectrophotometer to determine where its absorption was highest. The highest absorbance was recorded at 451 nanometres (nm) in petroleum ether.

3.8 DATA ANALYSIS

The quantitative data collected were analyzed using SPSS. Tables and graphs were used to present and illustrate the results from field interviews and experimental analysis. Percentages, frequencies and means were used to present results. The Pearson product moment correlation, r, as well as regression analysis were used to test the relationship between the absorbance and concentration of the beta carotene standard solutions. T-test was used to test the significant difference between two variables, such as the method of vegetable preservation and the levels of Vitamin A in the vegetables. Chi-square was used to test the relationship between the age of mothers and vegetable preservation.

The raw data constituting field notes and information from the interviews were analyzed qualitatively. These were reconstructed and re-written in this report.

To calculate the concentration of beta-carotene in the dried and fresh vegetable samples the formula below was used:

$$X\ (\mu g/g) = \frac{X\ (\mu g)}{\text{Weight of Sample (g)}}$$

Where X is the weight or concentration of beta-corotene in the sample. The weight of the sample is based on the dry weight.

The vitamin A value in the dried and fresh vegetables was calculated by dividing their beta-carotene content by 6 as approved by WHO/FAO (1988).

CHAPTER 4

RESULTS AND DISCUSSION

4.1 INTRODUCTION

The study investigated the indigenous leafy vegetables grown in Koru Location of Nyando District and how they are preserved as a measure of improving food security, and particularly as a means of fighting vitamin A deficiency (VAD).

The results of the study are presented and discussed under the following sub headings:

1. Extent of Vitamin A deficiency (VAD) in Koru Location
2. Sociodemographic and socioeconomic information
3. Food system in the area
4. Indigenous leafy vegetables grown
5. Preservation of indigenous vegetables
6. Source of vegetables during the dry season
7. Beta-carotene (Provitamin A) content of preserved indigenous vegetables

4.2 EXTENT OF VITAMIN A DEFICIENCY

Prevalence of vitamin A deficiency among children less than 6 years of age was obtained from biochemical and clinical assessment data on children who visited Koru Mission Hospital in the study area from January to September 2001. The data was kindly availed by the hospital doctors. An average of 94 children were visiting the hospital per month within that period. The clinical observation was on the cases of night blindness, bitot's spots and keratomalacia as in Table 4.1 while biochemical sample (blood serum) were analysed by doctors at the hospital for the level of serum retinol in order to detect subclinical vitamin A deficiency (VAD). The results, given in Tables 4.1 and 4.2 indicate that vitamin A deficiency is a major problem among children especially those under 6 years of age in Koru Location.

Table 4.1 No. (%) of cases of Nightblindness, Bitot spots and Keratomalacia in children in Koru

Month (2001)	No. of children observed	Nightblindness cases	Bitot spots cases	Keratomalacia/ Cornea Ulceration cases
January	102	1 (0.98%)	4 (3.92%)	1 (0.98%)
February	94	1 (1.06%)	4 (4.26%)	2 (2.13%)
March	97	2 (2.06%)	4 (4.12%)	2 (2.06%)
April	88	2 (2.27%)	4 (4.55%)	2 (2.27%)
May	90	2 (2.22%)	4 (4.44%)	2 (2.22%)
June	95	2 (2.11%)	4 (4.21%)	2 (2.11%)
July	99	3 (3.03%)	4 (4.04%)	2 (2.02%)
August	93	3 (3.23%)	4 (4.30%)	2 (2.15%)
September	91	3 (3.30%)	4 (4.40%)	2 (2.19%)

Source: Koru Mission Hospital Records

Table 4.2: The number (percentage) of children with < 10 μg/dl and 10-19 μg/dl serum retinol levels in Koru

Month (2001)	No. of children observed	No. of children with serum retinol <10 μg/dl	No. of children with serum retinol (10-19 μg/dl)
January	102	9 (8.82%)	26 (25.49%)
February	94	7 (7.45%)	24 (25.53%)
March	97	9 (9.28%)	30 (30.92%)
April	88	6 (6.82%)	24 (27.27%)
May	90	5 (5.56%)	21 (23.33%)
June	95	5 (5.26%)	22 (23.15%)
July	99	7 (7.07%)	24 (24.24%)
August	93	6 (6.45%)	20 (21.51%)
September	91	4 (4.39%)	16 (17.58%)

Source: Koru Mission Hospital Records

Table 4.1 shows cases of night blindness, bitot's spots and keratomalacia in the study area. During the study period, an average of 2 children (2.25%) had night blindness, 4 children (4.25%) had Bitot's spots and 2 children (2.01%) had keratomalacia. One child was diagnosed to have night blindness in January. The number remained constant up to March when a new case was reported. Another new case of night blindness was diagnosed in July and the number remained constant up to September. Four cases of Bitot's spots were reported in January and the number remained constant up to September, suggesting that no new cases were reported. In the case of keratomalacia, one child was diagnosed with it in January, a new case came in February and the number remained constant up to September. The WHO (1982) criteria proposes that VAD becomes a serious community health problem if among children below 6 years of age at least 1% have nightblindness, 0.5% have Bitot's spots and 0.01% have keratomalacia. From this criteria, Koru Location experiences serious

VAD. However, WHO (1996) revised the limits and considered VAD mild when less than 1% of the children have nightblindness, moderate when more or equal to 1% but less than 5% of children have nightblindness and severe when greater than 5% of children have nightblindness. From the cases of nightblindness in Table 4.1 vitamin A deficiency was moderate in the area.

During the period of observation, that is, the first nine months of the year 2001, an average of six children (6.73%) had serum retinol levels less than 10 μg/dl and 23 children (24.34%) had serum retinol levels between 10 – 19 μg/dl. The serum retinol levels of less than 10 μg/dl in 5% of the children and between 10 – 19 μg/dl in 15% of the children in an area indicates severe deficiency of vitamin A (WHO, 1982). It is therefore evident that vitamin A deficiency is a severe problem in the area. A more recent criteria for determining whether vitamin A deficiency (VAD) is a public health problem in an area uses the serum retinol levels of below 20 μg/dl in more than 20% of surveyed children of between 7 and 71 months to indicate severe VAD (WHO, 1996). Using this criteria, it is evident that VAD is a serious problem in the area.

The results in Table 4.1 and 4.2 clearly indicate that the prevalence of VAD from clinical examination is much lower than from biochemical examination. This clearly shows that subclinical VAD is difficult to diagnose using clinical methods but can be determined biochemically or cytologically (UNICEF/GoK, 1995).

Various studies conducted in Kenya have shown that VAD is a serious public health problem. A longitudinal study carried out in Machakos reported clinical signs of VAD, with bitot spots and conjuctival xerosis observed among 3.5% and 6% respectively in children below 6 years (Stephenson et al., 1979). Other studies done in Machakos have reported 1.4% cases of nutritional blindness (Sinabulya, 1976) and a similar proportion as having bitot spots among children aged below 15 years (Dijkhuizen, 1981). Clinical signs for vitamin A deficiency among preschool children have also been reported in Turkana and Kitui (Jansen and Alnwick, 1979). A biochemical survey conducted in South Nyanza District in 1993 indicated a VAD prevalence of 13% for the < 10 μg/dl serum retinol and 45% for the >10-19μg/dl serum retinol indicating that VAD is a serious public health problem in this area (UNICEF/GoK, 1995).

The national micronutrient survey conducted in Kenya in 1994 showed that VAD is a major problem in many districts including Baringo, Bungoma, Garissa, Kitui, Kisumu, Kisii, Kwale, Mandera, Mombasa and South Nyanza (UNICEF/GoK, 1995). It was observed that 66.4 percent of all vitamin A deficient children came from 3 districts, namely Bungoma, Kisii and Kisumu. In Kisumu 17% of the total children surveyed had serum retinol less than 10 μg/dl, and 14.2% had serum retinol levels between 10 and 19 μg/dl. In Kisii 26.2% had serum retinol levels less than 10 μg/dl and 11.6% had serum retinol levels of 10 to 19 μg/dl. In Bungoma 22.9% of children had serum retinol levels less than 10 μg/dl and 11.0% had serum retinol levels between 10 to 19 μg/dl (UNICEF/GoK, 1995). At the time of the survey Koru Location in Nyando District was still under Kisumu District. The proportion of children with serum retinol levels less than 10 μg/dl in the three districts was very high in relation to the criteria set by WHO (1982) and WHO (1996).

The factors which are associated with VAD include dietary deficiency, age, infectious disease, maternal education, socioeconomic status and seasonality. There is abundant evidence that breastfeeding is highly protective against xerophthalmia (Sommer and West, 1996). This may be partly due to the regular supply of preformed vitamin A in the mother's milk. Further, breastfeeding lowers the rate of infections as compared with artificially fed children. However, inadequate dietary intakes of vitamin A among lactating mothers leads to low vitamin A content in breast milk (McLaren and Frigg, 2001). Lack of animal foods such as meat and eggs and also fruits and vegetables in the diet of children is associated with VAD. The situation is made worse during the long dry season when fruits and vegetables are lacking. This is clearly evident in Table 4.2 where the number of children with serum retinol levels less than 20 μg/dl is higher in January, February, March and July as compared to the other months. This is the time that the area experiences a dry season.

It is generally agreed that preschool children are the most vulnerable group to VAD (Sommer and West, 1996). The requirements for growth of the younger children tend to be greater, while the body stores for micronutrients tend to be lower. The diet of the vulnerable child also tends to be more restrictive and limited during infancy or just after weaning than later on in life. Infections have an additional adverse nutritional impact at this age. A high prevalence of diseases (diarrhoea, lower respiratory tract infections, measles, intestinal parasites) increase the risk of VAD (McLaren and Frigg, 2001).

It was confirmed from Koru Mission Hospital staff that the children suffering from VAD who visit the hospital are given vitamin A tablets and mothers are advised to give children foods rich in vitamin A such as meats, eggs and indigenous green leafy vegetables that are available in the area. Mothers are also encouraged to breastfed their children and consume foods rich in vitamin A.

4.3 SOCIODEMOGRAPHIC AND SOCIOECONOMIC INFORMATION

Koru Location in Nyando District of Nyanza Province has three sub-locations with a total of 12 villages. Six villages from the three sub-locations were randomly selected for interview. Ten households were randomly selected from each village, making a total of 60 households (Table 4.3).

Table 4.3: The villages sampled in the Study

Sub-Location	Villages	Households	Cumulative %
Koru Central	Ogwedhi	10	16.7
	Ziwani	10	33.3
Nyando	Awendo	10	50.0
	Oyani	10	66.7
Homa-Lime	Ruke	10	83.3
	Kaoga	10	100
Total		**60**	

Each household, which consisted of a mother, father and children, had its size ranging from three (3) to seven (7) members (Table 4.4). However, the average size was five (5). All the households interviewed had both parents.

Table 4.4: Household Size of Respondents in Koru

Household size	Frequency	Total	Percent
3	2	6	3.3
4	11	44	18.3
5	25	125	41.7
6	19	114	31.7
7	3	21	5.0
Total	**60**	**310**	**100**

From the households sampled, there were 43 children who were 6 years of age and below, representing 13.87% of the population. This is the age that is more susceptible to vitamin A deficiency. This is because the requirements of growth for young children tend to be greater while the body stores for micronutrients tend to be lower (McLaren and Frigg, 2001).

The ages of mothers interviewed in the study ranged from 19 years to 69 years, with the distribution shown in Table 4.5. However, most of the mothers (67%) were aged between 30 and 50 years.

Table 4.5: Age distribution of mothers interviewed in Koru

Age Bracket	Frequency
< 30	5
31-40	18
41-50	22
51-60	9
61-70	6

Koru Location is predominantly inhabited by the Luo ethnic community with the other tribes constituting a very small percentage. Out of 60 mothers interviewed in the study 59 (98.3%) were Luos and one was a Luhya. The other tribes living in the area are Kalenjins and Kikuyus but their number is small.

A great majority of people in Koru depend on agriculture which is virtually the only occupation and source of their livelihood. Sugar cane is the main cash crop grown by a few people. The other crops grown such as maize, millet, sorghum, beans, cassava, irish potatoes, sweet potatoes, groundnuts, bananas, lemons and different types of indigenous vegetables are predominantly for subsistence but some are also sold out. Animals such as sheep, goats, cows and chicken are also reared. These animals and their products such as milk and eggs are usually sold in exchange for money.

4.4 FOOD SYSTEM IN THE AREA

Production of food crops in Koru Location is mainly done on a subsistence basis. A variety of crops are grown in this region including maize, millet, sorghum, beans, cassava, Irish potatoes, sweet potatoes, groundnuts, bananas, lemons and different types of indigenous vegetables. The crops act as a source of food for the inhabitants of this region. When in plenty, these crops are sold in exchange for money. However, in many households, maize, millet, sorghum, beans and indigenous vegetables are dried and stored for use in times of food scarcity.

4.4.1 The indigenous Leafy Vegetables

A large number of indigenous vegetables are grown in Koru Location although some are grown by less than 50 percent of the population (Table 4.6).

Table 4.6: Indigenous vegetables and number of households growing them in Koru Location

Indigenous Vegetables Grown				
Botanical name	**Common name**	**Local name**	**No. of households (Frequency)**	**Percent**
Vigna unguiculata	Cowpea leaves	*Bo*	60	100
Solanum nigrum	Black nightshade	*Osuga*	60	100
Gynandropsis gynandra	Spider herb	*Dek*	60	100
Corchorus olitorius	Bush okra/jute	*Apoth*	54	90
Crotalaria achroleuca	*Mito*	*Mito*	53	88.3
Amaranthus dubius	Amaranth	*Ododo*	36	60
Brassica carinata	Ethiopian cabbage	*Kandhira*	31	51.7
Cucurbita maxima	Pumpkin leaves	*Susa*	13	21.7
Amaranthus hybridus	Amaranth	*Alikra*	4	6.7
-	Amaranth	*Apiwo*	1	1.7
-	Amaranth	*Odongo oer*	1	1.7

Eleven types of indigenous vegetables are grown in the area, and out of these seven are the most common types since they are grown by at least 50 percent of the population. These vegetables include cowpea leaves, black nightshade, spider herb, bush okra, *Crotalaria ochroleuca, Amaranthus dubius* and the Ethiopian cabbage. Pumpkin leaves are grown by a small percentage of the people (21.7%). Among the four species of amaranths grown, *Amaranthus dubius* is grown by a large percentage (60%) of the people. The other three species are grown by less than 10% of the people.

Amaranths, cowpea leaves, black nightshade and pumpkin leaves are grown and do well in the whole country whereas *Brassica carinata*, *Gynandropsis gynandra, Corchorus olitorius* and *Crotalaria ochroleuca* do well in Western and Nyanza Provinces (Maundu et al., 1999). The vegetables are good sources of beta-carotene, a provitamin A compound (Table 2.1).

The indigenous leafy vegetables grown in Koru are often inter-cropped and rarely occupy a significant proportion of the farm. They occupy areas around the house together with bananas, maize, cassava and sorghum. Availability of vegetables is highest shortly after the onset of the rainy seasons when tender plants are uprooted for use and sale. The long rains in Koru begin in late March and lasts for two months. The vegetables are usually harvested in mid-April to June. Thereafter there is a short dry period before the short rainy season that begins in mid August and lasts for a month. This is followed by a long dry season beginning from November to March. The supply of indigenous vegetables drops considerably during the dry periods (Table 4.7).

Table 4.7 indicates that the harvesting of indigenous vegetables is done from April to June and from August to October while little harvesting is done from November to March and in July. In May all households get vegetables. When harvesting is low people buy vegetables or use the preserved ones. However, one mother out of the 60 interviewed harvested vegetables all year round. She lives near the River Nyando and is able to irrigate her vegetable garden during the dry season.

Table 4.7: Number of people (percent) harvesting indigenous dark green vegetables in each month

Month	No. of people	Percentage
January	1	1.7
February	4	6.7
March	4	6.7
April	48	80.0
May	60	100.0
June	42	70.0
July	2	3.3
August	36	60.0
September	55	91.7
October	19	31.7
November	1	1.7
December	1	1.7

The availability and consumption of green leafy vegetables depend on seasonal changes and this affects the nutritional status of the population. Although these vegetables are usually plentiful during wet seasons, they remain scarce or in some cases disappear totally during dry seasons. Because of their high beta-carotene (provitamin A) value, increasing the availability and utilization of green leafy vegetables can minimise or alleviate VAD in developing countries (Nyambaka, 1996). This can be done by preserving vegetables or by irrigation farming so that they are available during the dry season.

4.5 PRESERVATION AND STORAGE OF THE INDIGENOUS VEGETABLES

The study established that preservation of indigenous vegetables is a common practice, perhaps because the region experiences a long dry season. Out of the 60 mothers interviewed, 38 of them (63.3%) were preserving vegetables in one way or another. Preservation is basically done by mothers, perhaps because women are the ones involved in feeding the family and hence are more desperate when vegetables are scarce during the dry season. However, the preservation of vegetables is strongly related to the age of women in that women of over 46 years of age are more involved in preservation activities than younger women (Table 4.8).

Table 4.8: Relationship between the age of mothers and vegetable preservation

Age (years)	Response on Preserving vegetables		
	Yes (%)	No (%)	Total (%)l
19 – 35	3	10	13
36 – 45	14	9	23
46 – 69	21	3	24
Total	**38**	**22**	**60**

$\chi^2 =$ 15.17 df = 2 p value = 0.0005

A chi-square test done on the above statistics showed that there was a significant difference between the age of mothers who preserved vegetables and those who did not (p = 0.0005). Mothers of over 46 years preserve vegetables more than younger mothers, a trend that implies that with time preservation of vegetables will cease. The art of preservation is therefore not passed over to the younger generation. This may account for the rising cases of malnutrition and VAD in the area, and in many parts of Kenya and third world countries in general. Commercialisation of the processing technology might help to sustain the methods.

4.5.1 Methods of Preserving Vegetables

Out of the eleven types of indigenous vegetables grown in the area, only five types are preserved. These are cowpea leaves, spider herb, black nightshade, pumpkin leaves and bush okra. Cowpea leaves are preserved by a majority of the mothers, with over 80% while the other vegetables are preserved by relatively fewer mothers (Table 4.9).

Table 4.9: The types of indigenous vegetables and the number of households preserving them in Koru

Vegetable	No. of mothers preserving	Percentage of those preserving
Cowpea leaves	33	86.84
Spider herb	8	21.05
Black nightshade	5	13.16
Bush okra	5	13.6
Pumpkin leaves	3	7.89

The traditional preservation methods that are used in the community are sun drying, fire drying and fermentation. All the 38 mothers who were involved in vegetable preservation used sun drying while 12 mothers preserved by fermentation. One mother sometimes preserved her vegetables by fire drying. Cowpea leaves are mostly preserved by sun drying whereas the spider herb is mostly fermented. Out of 38 mothers preserving vegetables by sun drying, 23 (60.53%) preserved one type of vegetable, 14 (36.84%) preserved two types of vegetables and 1 (2.63%) preserved three types of vegetables.

4.5.1.1 Treatment and Drying Procedure

The procedure employed by mothers to dry vegetables varied quite a lot. After harvesting, vegetables are selected and washed in clean water. Thereafter, some mothers chop the vegetables and blanch them in boiling water before sun drying while others dry the vegetables after blanching them whole. Some however chop and dry the vegetables without blanching while others dry them whole without blanching. There are also mothers who add *magadi (*bicarbonate*)* or salt to vegetables prior to sun drying to help in maintaining the colour of the vegetables and prevent spoilage. These different approaches to vegetable treatment can be grouped into ten different procedures. These are:

1. Washing and drying whole vegetables in the sun. This was done on the cowpea leaves, black nightshade, spider herb and bush okra.
2. Chopping and sun drying. This was done on the pumpkin leaves.
3. Chopping, adding of salt and then sun drying. This was done on the cowpea leaves and black nightshade.
4. Blanching whole and sun drying. It was done on the spider herb and cowpea leaves.
5. Blanching whole, making into balls and sun drying. This was done on the spider herb.
6. Blanching whole and drying near the fireplace. It was done on the spider herb.
7. Blanched whole in boiling water to which *magadi* is added then sun drying. This was done on pumpkin leaves.

8. Blanching whole, adding some salt to the vegetable and then sun drying. This was done on the cowpea leaves.
9. Chopping, blanching and sun drying. It was done on the cowpea leaves.
10. Chopping, blanching in boiling water to which *magadi* soda is added and sun drying. This was done on the cowpea and pumpkin leaves.

In sun drying, the treated vegetables are laid and spread on mats made out of reeds called *"par"* and exposed to the sun to dry. The drying period was between 1 and 3 days depending on the amount of sunshine available and the treatment procedure used. Table 4.10 shows the number of households sun drying vegetables in different durations.

Table 4.10: The number of households sun drying vegetables in different periods in Koru

Duration (days)	Households	Percentage
1	3	7.9
2	23	60.5
3	12	31.6
Total	**38**	**100**

The majority of the households dry vegetables for two days. The blanched vegetables dried faster than those that were not blanched. The unblanched chopped vegetables dried faster than those that were whole and not chopped. The bicarbonate treated vegetables also dried faster than those that were treated with salt. The vegetables dried near the fireplace took a short time to dry. The dried products are then put in large clay pots and stored for between four to eight months.

The drying of green leafy vegetables and their preservation is a common practice in Africa and elsewhere. It is a means of reducing waste of highly perishable vegetables and ensuring their availability all year round (Nyambaka, 1996). Sun drying of vegetables is currently done in a number of African countries such as Botswana, Kenya, Namibia, Uganda, Zambia and Zimbabwe. In these countries the indigenous leafy vegetables commonly sun-dried include cowpea leaves, pumpkin leaves, bush okra, spider herb, *Crotalaria ochroleuca* and *Solanum nigrum* (Schippers, 2000). These are the same vegetables that are preserved in Koru Location and the rest of Nyanza Province (Maundu et al., 1999).

The sun drying technology, which is the process that reduces the water activity and hence slows down the enzymes and microorganisms growth, is inexpensive and convenient. However, the quality of the sun dried products is usually low due to exposure to the sun that heats up the material causing internal temperatures to rise without regulation and destroying colour, nutrients especially vitamins and flavour. Sun drying also suffers from the effects of contamination with dirt, dust and insect infestation. The quality of sun died products may generally be acceptable although improvements are possible (Nyambaka, 1996).

Solar dehydration, a process which combines sun drying with temperature control and the regulation of air flow has been found to improve quality of sun dried products. The products are heated with warm air moving across it without direct sunlight and drying temperatures are usually less than 40^0C (Kordylas, 1990).

4.5.1.2 Fermentation

Fermentation is usually done to improve the flavour of vegetables although such vegetables can be preserved for at most a week. The vegetables that are mostly fermented by the mothers include spider herb, pumpkin leaves and cowpea leaves. The process involves blanching the vegetables in boiling water after being chopped or while whole for about one hour. The boiling water is then drained and the vegetables fried in fat with onions and tomatoes. Cream, milk and home made ghee is added to the vegetables and cooked for a few minutes. The vegetable is then left to ferment for two days after which it can be consumed. The fermented products can be kept for up to 7 days.

Fermented foods are popular throughout the world. *Gundruk* is a fermented and dried vegetable product that is important for ensuring food security for many Nepali communities especially in remote areas (Azam-Ali, 1998). The dried product can be stored in airtight containers for several months. A disadvantage of the traditional process of *gundruk* is the loss of 90% of the carotenoids, probably during sun drying. Improved methods of drying might reduce the vitamin loss.

In Western Kenya, black nightshade is the most common indigenous vegetable that is fermented. The vegetable is first boiled in water for half an hour after which the cooking water is replaced with milk and boiled again for a short time. The resulting product is compressed and left to ferment and dry for a few days where it solidifies and turns almost black in colour. The vegetable is then ready for serving together with cassava or a similar food (Schippers, 2000).

4.5.2 Storage of Preserved Vegetables

A good majority of people in the study area depend on dried vegetables during the dry season. When completely dry, the vegetables are usually stored differently by different households. A large percentage of the mothers (73.7%) store the dried vegetables in a large, clean dry clay pots, called *dak*, covered with a clay lid or *tao*. The lid is then sealed with cow dung to ensure that the vegetables retain dryness for several months, as well as limit excess oxygen getting in. The other containers used are clean plastic buckets and manila bags (Table 4.11). Storage of dried indigenous leafy vegetables in clay pots is a common practice among the Luo and the vegetables are used as a dry season food (Maundu et al., 1999).

Table 4.11: Containers used to store dried indigenous vegetables

Container Type	Households using it	Percentage
Large clay pot with a clay lid	28	73.7
Plastic buckets	9	23.7
Manila bags	1	2.6
Total	**38**	**100**

The preserved vegetables are usually stored for between four to eight months. The storage period covers the expected dry seasons before the next harvest. Table 4.12 shows the frequency of storage period against the households that preserve vegetables. A majority (55.3%) of mothers keep dried vegetables for 6 months.

Table 4.12: The length of storage of preserved vegetables in relation to the percentage of preserving households

Months	Households preserving	Percentage
4	1	2.6
5	6	15.8
6	21	55.3
7	3	7.9
8	7	18.4
Total	**38**	**100**

A number of reports indicate that dried indigenous vegetables can be stored for up to 6 months (Schippers, 2000;Katende, 1999; FAO, 1988). Maundu et al. (1999) asserts that dried indigenous vegetables can last for several months.

4.6 SOURCE OF VEGETABLES DURING THE DRY SEASON

Availability of fresh vegetables in Koru is usually a problem during the dry season although, some households use fresh vegetables. Thirty five percent of people buy fresh vegetables from the market, 13.33 percent use their own preserved vegetables and 50 percent use both their own preserved vegetables and fresh vegetables bought from the market during the dry season (Table 4.13). A number of other countries in Africa such as Botswana, Kenya, Uganda, Namibia, Zimbabwe, Zambia and Malawi are reported to use dried vegetables during the dry season (Schipppers, 2000; Katende, 1999; Tredgold, 1990; Williamson, 1975). This confirms that preservation of vegetables by drying is a common practice in Africa.

Table 4.13: Source of vegetables during the dry season

Source	Frequency	Percentage
Market	21	35.00
Own preserved vegetables	8	13.33
Own preserved and market	30	50.00
Own fresh vegetables	1	1.67
Total	**60**	**100**

One mother out of 60 did not have a problem with getting fresh vegetables all year round. She lives near river Nyando and is able to irrigate her farm during the dry season. From her produce, she even provides a number of households with fresh vegetables during the dry season.

In Western Kenya, vegetable production is mostly rain-fed. During the dry season, people adopt certain strategies to meet their vegetable needs (Nekesa and Meso, 1997). This includes farming along riverbanks where supplementary watering can be done, as one mother in the study area does. Those whose farms do not border rivers grow cucurbits (pumpkin leaves) which are drought resistant and once established are harvested all year round (Nekesa and Meso, 1997).

4.6.1 Dietary Intake of Vegetables during the Dry season

The consumption of fresh vegetables during the dry season on a daily basis is low, since they are hardly available. Preserved vegetables are therefore mostly consumed. Out of the 60 mothers interviewed, only 5 consume fresh vegetables on a daily basis whereas 31 consume preserved vegetables on a daily basis. The number of species of indigenous vegetables available during the dry season is reduced from 11 to 4. The vegetables are cowpea leaves, black nightshade, spider herb and bush okra and are the ones mainly consumed during this season. Cowpea leaves however are consumed well in both preserved and fresh form. The other vegetables are mostly consumed fresh, indicating that although these vegetables are preserved, the quantities are usually low (Table 4.14). The consumption of these vegetables in the fresh or preserved form is either once per week, month or occasionally due to scarcity. The other foods that are largely consumed during the dry season are beans and/or *omena* with *ugali*.

The diet consisting of dark green leafy vegetables is more valuable because the vegetables contain more beta-carotene (provitamin A), vitamin C, protein, calcium and iron. These vegetables constitute the major source of vitamin A (IFPP, 1989). A nutritional survey carried out in Kenya reported vitamin A adequacy to be below 60% of the minimum daily requirements (Bodhal et al., 1969). Similarly, recent statistics show that carotene from vegetables contribute 68% of dietary vitamin A on a worldwide basis and 82% in developing countries (FAO/ILSI, 1997). In spite of the abundance of carotene in the world, vitamin A deficiency is still a serious problem. Inadequate dietary intake of vitamin A in developing countries could be attributed to the unavailability of vegetables during the dry season, poor cooking method, diet composition and cultural habits among others (Simpson et al., 1981). The seasonality pattern of prevalence of vitamin A deficiency concur with availability pattern. This suggests that intake is near adequate during the rainy season and very low during the dry season

Table 4.14: The extent of consumption of fresh and preserved vegetables during the dry season

Vegetable Type	Form	Consumption Pattern		
		Frequency	Number	Percentage consuming
Cowpea leaves	Preserved	Everyday	28	52.8
	Preserved	Once a week	5	9.4
	Fresh	Everyday	2	3.8
	Fresh	Once a week	18	34.0
Spider herb	Preserved	Everyday	1	1.9
	Preserved	Once a week	7	13.0
	Fresh	Once a week	40	74.0
	Fresh	Once a month	6	11.1
Black nightshade	Preserved	Everyday	1	1.9
	Preserved	Once a week	3	5.6
	Preserved	Once a month	1	1.9
	Fresh	Everyday	1	1.9
	Fresh	Once a week	36	66.7
	Fresh	Once a month	12	22.2
Pumpkin leaves	Preserved	Once a week	3	25.0
	Fresh	Once a week	5	**41.7**
	Fresh	Once a month	4	33.3
Bush okra	Preserved	Everyday	1	2.0
	Preserved	Once a week	4	8.0
	Fresh	Everyday	2	4.0
	Fresh	Once a week	39	78.0
	Fresh	Once a month	4	8.0
Ethiopian cabbage	Fresh	Once a week	4	15.4
	Fresh	Once a month	11	42.3
	Fresh	Occasionally	11	42.3
Mito	Fresh	Once a week	6	13.0
	Fresh	Once a month	36	78.3
	Fresh	Occasionally	4	8.7
Amaranthus dubius (*Ododo*)	Fresh	Once a week	3	8.6
	Fresh	Once a month	24	68.6
	Fresh	Occasionally	8	22.9
Amaranthus hybridus (*Alikra*)	Fresh	Once a month	3	75.0
	Fresh	Occasionally	1	25.0
Odongo oer (Amaranth)	Fresh	Once a month	1	100
Apiwo (Amaranth)	Fresh	Once a month	1	100

4.7 BETA-CAROTENE (PROVITAMIN A) CONTENT OF PRESERVED VEGTABLES

4.7.1 Method of Analysis

Figure 4.1 shows the curve of wavelength against absorbance of beta-carotene in petroleum ether obtained when absorbance of a beta-carotene standard solution was measured between 300 and 500 nm. The maximum absorbance was observed at 451 nm and this was used for analysis.

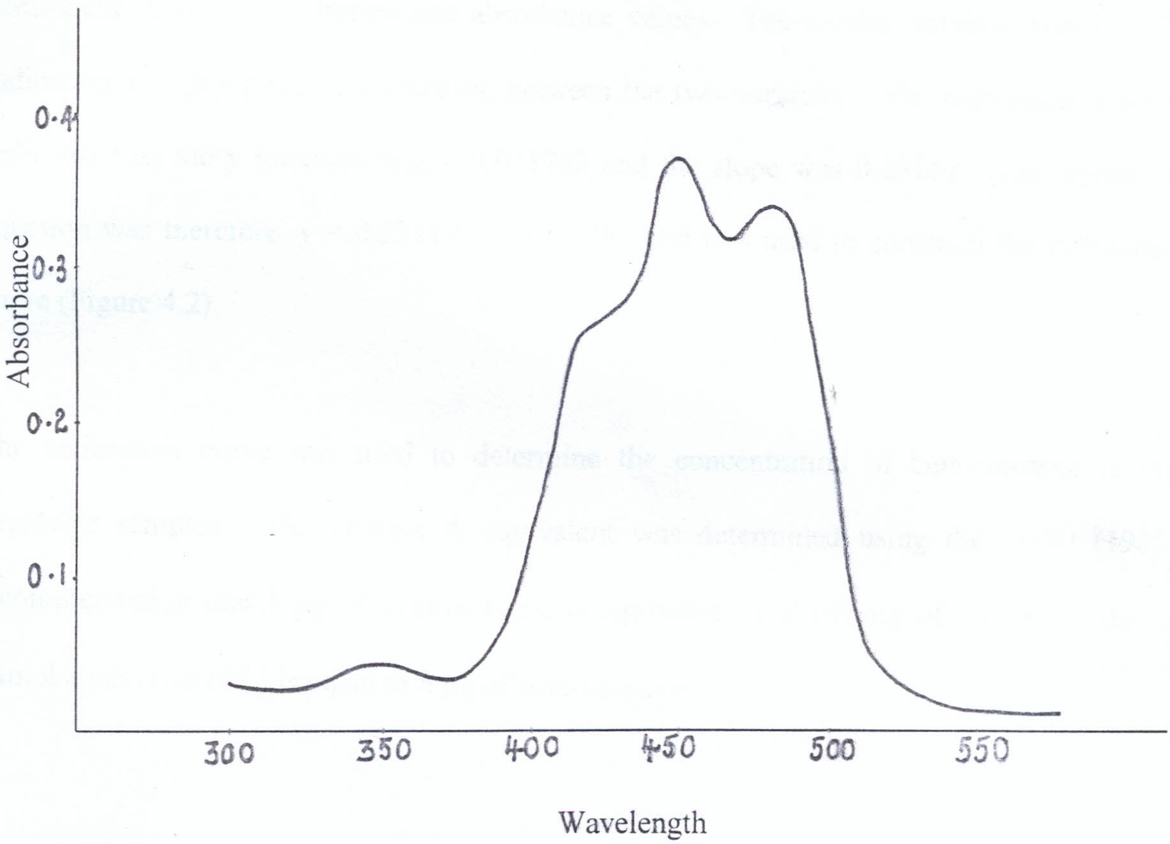

Figure 4.1: Wavelength spectrum of beta-carotene in petroleum ether

A calibration graph of absorbance versus different concentrations of beta-carotene standard solutions was also determined. Table 4.15 gives the absorbance values obtained and these were used to construct the calibration graph (Fig. 4.2).

Table 4.15: Concentration against absorbance of beta-carotene standard

Concentration (μg/ml)	0	1	2	3	4	5
Absorbance	0	0.207	0.451	0.681	0.904	1.154

A correlation analysis was done to determine the Pearson's product moment correlation coefficient, r, for concentration and absorbance values. The r-value obtained was 0.9997, indicating a highly positive correlation between the two variables. The regression analysis indicated that the y intercept was – 0.011762 and the slope was 0.23117. The regression equation was therefore, $y = 0.23117x - 0.011762$ and was used to construct the calibration curve (Figure 4.2).

The calibration curve was used to determine the concentration of beta-carotene in the vegetable samples. The vitamin A equivalent was determined using the WHO (1988) recommendation that 1 μg of beta-carotene is equivalent to 0.167 μg of retinol, or that 1 retinol equivalent (RE) is equal to 6 μg of beta-carotene.

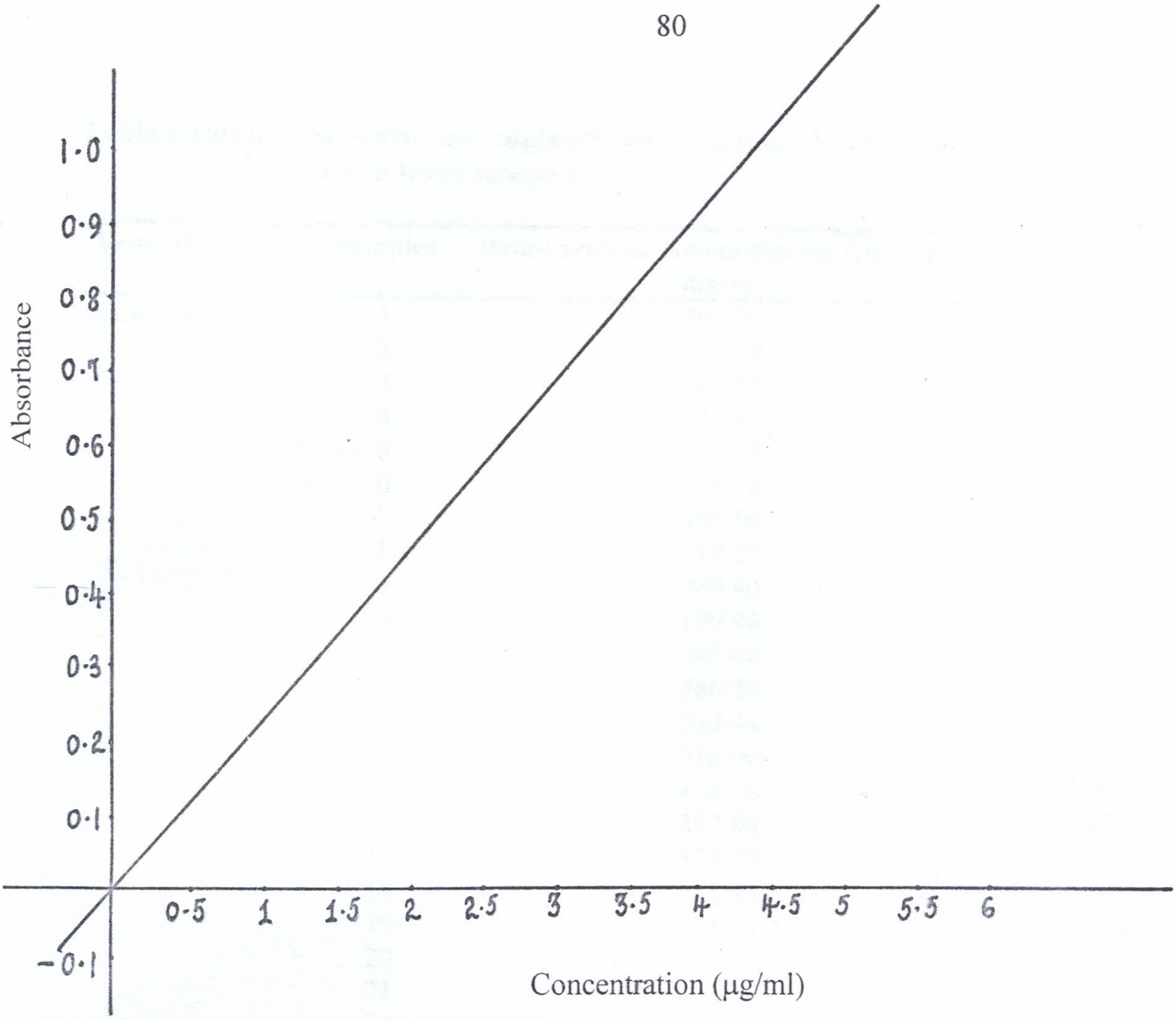

Figure 4.2: **Calibration graph of beta-carotene**

4.7.2 Beta-carotene (Provitamin A) Content of Community's Preserved Vegetables

4.7.2.1 Dried Vegetables

Tables 4.16(a) and 4.16(b) give the concentration of beta-carotene and vitamin A value of the preserved vegetables collected from different households in the study area. Cowpea leaves is preserved by most households and has the largest samples (Table 4.16a). The other vegetables are preserved by few households (Table 4.16b).

Table 4.16(a): Beta-carotene content* and vitamin A value of different sun dried cowpea leave samples

Vegetable	Samples	Beta-carotene concentration (µg/g) dry matter	Vitamin A Equivalent
Cowpea leaves	1	807.26	134.54
	2	328.19	54.70
	3	383.87	63.98
	4	474.87	79.15
	5	312.93	52.16
	6	288.18	48.03
	7	484.59	80.77
	8	410.07	68.35
	9	469.80	78.30
	10	199.96	33.33
	11	346.40	57.73
	12	360.26	60.04
	13	389.44	64.91
	14	316.00	52.67
	15	433.28	72.21
	16	387.86	64.64
	17	377.77	62.96
	18	753.35	125.56
	19	431.00	71.83
	20	385.22	62.20
	21	402.39	67.07
	22	389.12	64.85
	23	492.17	82.03
	24	372.69	62.12
	25	372.58	62.10
	26	310.22	51.70
	27	403.84	67.31
	28	417.60	69.60
	29	361.47	62.25

* Mean of duplicate analysis

Table 4.16(b): Beta-carotene content* and vitamin A value of other sun dried indigenous vegetables

Vegetable	Samples	Beta-carotene concentration (μg/g) dry matter	Vitamin A Value
Spider herb	1	866.65	144.44
	2	322.08	53.68
	3	405.49	67.58
	4	621.49	103.58
	5	459.65	76.61
	6	271.22	45.20
	7	458.53	76.42
	8	265.05	44.18
Black nightshade	1	377.01	62.84
	2	661.54	110.26
	3	589.65	98.28
	4	339.32	56.55
	5	290.09	48.35
Bush okra	1	172.80	28.80
	2	182.74	30.46
	3	160.69	26.78
	4	205.64	34.27
	5	190.02	31.67
Pumpkin leaves	1	432.43	72.07
	2	424.94	70.82
	3	317.43	52.91

* Mean of duplicate analysis

The concentration of beta-carotene in the sun dried cowpea samples collected from the field ranged from 199.96-μg/g dry matter to 807.26 μg/g dry matter. The mean concentration was 409.05 μg/g dry matter. Some of the concentration values in Table 4.16(a) are similar to those reported by Nyambaka (1996) who obtained a mean concentration of 499 μg/g dry matter and a range of between 411-568 μg/g dry matter in sun dried cowpea leaves.

Fresh samples of cowpea leaves collected from Koru location were analysed for their beta-carotene content and found to have a mean of 507.30 μg/g dry matter. The fresh samples were also sun dried and solar dried in order to investigate the effect of drying. The sun dried samples had a mean concentration of 299.38 μg/g dry matter while the solar dried ones had a mean of 420.40 μg/g dry matter (Table 4.20). However, these values are quite different from those obtained in community sun dried samples, perhaps due to different harvesting seasons and extent of leaf maturity. The fresh vegetables were picked in September, 2001 whereas the community's preserved vegetables were collected in April and May, 2001. The fresh cowpea samples also had very soft leaves, indicating that they were less mature than the sun dried samples collected from the field and this could have led to their having lower levels of beta-carotene on sun drying.

The beta-carotene levels in fresh cowpea samples are comparable to values reported in literature. Nyambaka (1996) reported a mean value of 691 μg/g dry matter in blanched fresh cowpea leaves, Maeda and Salunkhe (1981) reported a value of 686 μg/g dry matter and Gomez (1981) reported a mean value of 632μg/g dry matter. Klaui and Bauernfeind (1981) obtained a value of 498μg/g dry matter and Pepping et al. (1988) obtained 400μg/g dry matter.

The concentrations of beta-carotene in other vegetables also varied widely (Table 4.16b). The concentration in the spider herb ranged from 265.05μg/g dry matter to 866.65μg/g dry matter. The average concentration was 458.77 μg/g dry matter. The mean concentration in the fresh vegetables was 1048.48 μg/g dry matter and in sun dried was 682.56 μg/g dry matter indicating a 65% retention (Table 4.20). Nyambaka (1996) obtained a mean value of 990μg/g dry matter in fresh and blanched spider herb, while Gomez (1981) obtained 477 μg/g dry matter and Klaui and Bauernfeind (1981) reported a value of 692μg/g dry matter.

The beta-carotene concentration in the preserved black nightshade ranged from 290.09 μg/g to 661.54 μg/g dry matter with a mean concentration of 451.52 μg/g dry matter. The levels of the fresh vegetable samples was 717.08 μg/g dry matter and of sun dried was 427.63 μg/g dry matter (Table 4.20).

The concentration of beta-carotene in preserved bush okra ranged from 160.69 μg/g dry matter to 205.64μg/g dry matter, with a mean concentration of 182.38 μg/g dry matter. The levels of the fresh blanched leaves had a mean of 503.42 μg/g dry matter which dropped to 131.87 μg/g dry matter after sun drying. Generally, the bush okra has the lowest beta-carotene concentration after sun drying compared to the other four vegetables. The vegetable is a very soft vegetable and is wilt sensitive. Gomez (1981) reports that plant materials which are wilt sensitive experience high losses of beta-carotene due to damage of the tissues by heat during blanching and drying.

The beta-carotene concentration in preserved pumpkin leaves ranged from 317.43 μg/g dry matter to 432.43μg/g dry matter, with a mean of 391.6 μg/g dry matter. The fresh leaves collected from Koru had a mean concentration of 548.26 μg/g dry matter and 386.47 μg/g dry matter after sun drying (Table 4.20).

The variation in beta-carotene content in the plant foods is brought about by the differences in sample varieties, part of the plant consumed, stage of maturity, soil fertility, climate or geographical site of production, harvesting and post-harvesting handling, processing and storage conditions (Rodriguez-Amaya, 1993; Gross, 1991; Pepping et al., 1988). The differences in the beta-carotene levels in the community's preserved vegetables could be attributed to some of these factors, especially variety of samples, maturity of the leaves, duration of sun drying and the method of preparation prior to sun drying. The preserved indigenous vegetables especially cowpea leaves, black nightshade, bush okra and spider herb varied in leaf size. Some had large leaves whereas others had small leaves.

The vegetables were also harvested at different times which could have led to the differences in the beta-carotene levels. This was clearly seen in the fibre content of the leaves, especially cowpea leaves, where some had less fibre content while others had more (from determination of moisture content). The vegetables with more fibre content were more mature than those with less fibre. Nyambaka (1996) noted that the use of more mature cowpea leaves retains higher amounts of beta-carotene, even when undergoing severe processing conditions such as sun drying. This may explain why samples 1 and 18 with concentrations of 807.26 μg/g dry matter and 753.35 μg/g dry matter respectively in Table 4.16a had higher levels of beta-carotene after sun drying.

The average concentration of beta-carotene in the commonly consumed sun dried vegetables is shown in Table 4.17. Four vegetables have high levels of beta-carotene as displayed in Figure 4.3. The vitamin A values of these vegetables indicate that they are still major sources of vitamin A in the diet. If some 10-20g of dried cowpea leaves are added to a child's meal they will provide 681-1363 μg RE. This is within the safe levels of vitamin A intake which is between 400 and 600 μg RE per day for children and 600 and 850 μg for adults (WHO/FAO, 1988). However, recent literature have shown that bioavailability of beta-carotene from green leafy vegetables is equivalent to biological activity of 0.0357 (1μg retinol ≡ 28 μg beta-carotene). When this is the case vitamin A intake will not be sufficient. Hence, the amount required to be added to the child's meal is 30-40g of dry vegetable.

Table 4.17: The average concentration* of beta-carotene in the sundried vegetables

Vegteble	N	Average beta-catoene concentration (μg/g dry matter)	Vitamin A Equivalent
Cowpea leaves	29	409.05	68.18
Spider herb	8	458.77	76.46
Black nightshade	5	451.52	75.25
Bush okra	5	182.38	30.40
Pumpkin leaves	3	391.60	65.27

* Mean of duplicate analysis

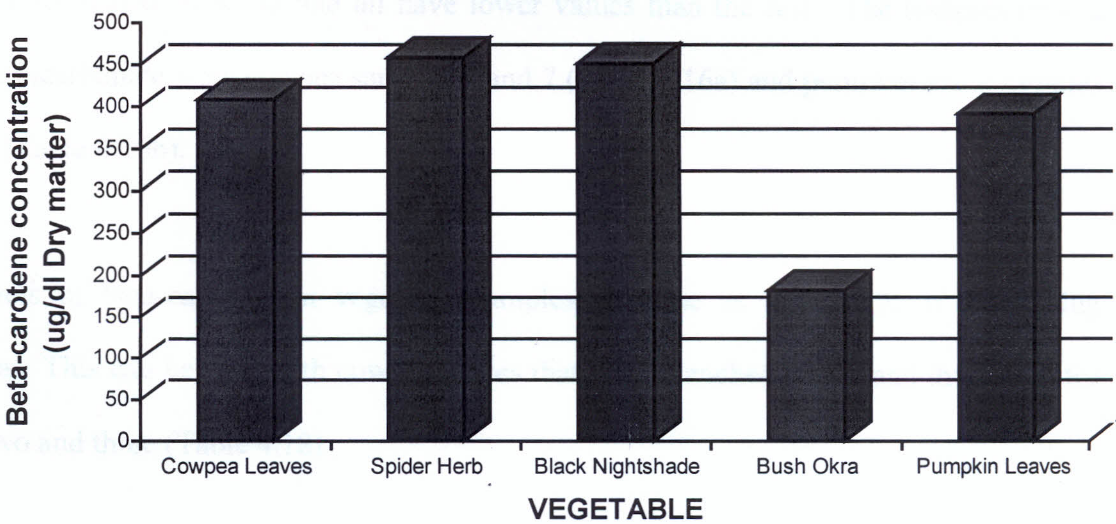

Fig. 4.3: Average concentration of beta-carotene in different sun dried vegetables

The post harvest handling and processing of vegetables could have also contributed to the variations in the results. Ten different procedures of vegetable preparation before sun drying were recorded in the study and are discussed in section 4.5.1.1.

Plant materials which are wilt sensitive experience higher losses of beta-carotene due to the damage of the tissues by heat during blanching and drying (Gomez, 1981). This explains why the levels of beta-carotene in a vegetable like the bush okra, a very soft vegetable is very low after sun drying (Table 4.16b and Figure 4.3). Nyambaka (1996) noted that treatment of vegetables with bicarbonate of soda (*magadi*) and salt lowered the beta-carotene level in dehydrated products. Products treated with common salt experienced the highest rate of deterioration. Some dried vegetables collected from households in Koru were treated with salt and others with *magadi (*bicarbonate*)* and this could have led to low beta-carotene concentration. Salt and magadi accelerate oxidation of beta-carotene in the vegetables Cowpea samples 5, 6, 10, 14 and 26 (Table 4.16a) and black nightshade sample 5 (Table 4.16b) were treated with salt and all have lower values than the rest. The samples treated with the bicarbonate were cowpea samples 4 and 7 (Table 4.16a) and pumpkin leave samples 1 and 2 (Table 4.16b).

The levels of beta-carotene in vegetable samples decrease as the length of sun drying increases. This can be seen with cowpea leaves that were blanched whole and then dried for a day, two and three (Table 4.18).

Seven (7) vegetables were dried for one day and these had an average concentration of 419.84 μg/g dry matter, 5 were dried for 2 days and had an average of 360.35 μg/g dry matter and 3 were dried for 3days and had an average of 303.78. A correlation analysis gave an r-value of –1.000. This indicates a perfect negative correlation between the beta-carotene concentration in the vegetables and the number of days of sun drying. As the days of sun drying increased the beta-carotene concentration in the vegetables reduced. This was also observed in the spider herb samples (Table 4.16b). Samples 1, 4, 5 and 7 were dried for one day, samples 2 and 3 were dried for two days while samples 6 and 8 were dried for three days. For the bush okra (Table 4.16b) samples 4 and 5 were dried for one day whereas samples 1, 2 and 3 were dried for two days. Samples 2 and 3 for the black nightshade were dried for a day while 1, 4 and 5 were dried for two days. The pumpkin leave samples 1 and 2 were dried for a day while 3 was dried for two days (Table 4.16b).

Table 4.18: The effect of the duration of sun drying on the beta-carotene concentration* in preserved cowpea leaves

Duration of sun drying (Days)	Sample	Concentration (μg/g Dry Matter)
1	1	383.87
	2	474.87
	3	469.80
	4	389.44
	5	433.28
	6	385.22
	7	402.39
2	8	328.20
	9	346.40
	10	360.26
	11	377.77
	12	389.12
3	13	312.93
	14	288.18
	15	310.22

* Mean of duplicate analysis

The loss of beta-carotene in processed foods is attributed to oxidative degradation and isomerization of beta-carotene. The extent of these degradative process is influenced by the severity of the drying conditions and nature of plant material (Nyambaka, 2001). The occurrence of oxidation reaction depends on the presence of oxygen, metals, enzymes, unsaturated lipids, exposure to light, type and physical state of carotenoid present, severity of treatment, packaging material and storage condition (Rodriguez-Amaya, 1999). Beta-carotene is susceptible to effects of ultraviolet radiation from the sun which may induce photo-oxidation (Nyambaka, 1996). This could explain why exposing the vegetables for several days in the sun leads to a reduction in the beta-carotene content.

4.7.2.2 Fermented Samples

The beta-carotene concentration in the fermented samples of the spider herb collected from households in the study area ranged from 372.98 μg/g dry matter to 404.08 μg/g dry matter (Table 4.19).

Table 4.19: Beta-carotene concentration* of fermented spider herb

Sample	β-carotene concentration (μg/g dry matter)	Vitamin A value (μg/g)
1	404.08	67.35
2	392.67	65.45
3	372.98	62.16

* Mean of duplicate analysis

The average beta-carotene concentration in the fermented spider herb was however 389.91 μg/g dry matter. Compared to the beta-carotene concentration in the fresh spider herb (1048 μg/g dry matter) it can be noted that over 62% of the beta-carotene was lost during the fermentation process. A similar sample when sun-dried retained about 65% of beta-carotene content. This could be attributed mainly to prolonged heating of the vegetables. The vegetables were boiled for up to two hours and were re-heated before use. Prolonged heating of vegetables results in the loss of 50-80% of the beta-carotene in the vegetables while mild heating loses 10% of beta-carotene (Tabekha, 1999).

4.7.3 Effect of the Drying Procedures (Sun Drying and Solar Drying) on Beta-Carotene Content in Indigenous Vegetables

The sun-drying of vegetables is known to result in the loss of the beta-carotene content. This was noted when the levels of beta-carotene in the fresh vegetable samples were compared with the sun-dried samples (Table 4.20 and Figure 4.4). Table 4.20 shows the levels of beta-carotene in the fresh, sun dried and solar dried vegetable samples. Fresh vegetables were collected from the field and divided into three portions. The first portion was used to determine the concentration while other portions were sun-dried and solar-dried.

Table 4.20: Beta-carotene content* of green leafy vegetables (μg/g) blanched then processed with different drying methods

Vegetable	Fresh (μg/g DM)	Solar Dried μg/g DM (% retained)[1]	Sun Dried μg/g DM (% retained)[1]
Bush okra	503.42	**276.58 (55%)**	131.87 (26%)
Pumpkin leaves	548.26	473.28 (86%)	386.47 (71%)
Kandhira	780.07	573.53 (74%)	467.17 (60%)
Spider herb	1048.48	854.63 (82%)	682.56 (65%)
Black nightshade	717.08	642.30 (90%)	427.63 (60%)
Cowpea leaves	507.30	420.40 (83%)	299.38 (59%)
Amaranth	650.38	448.11 (69%)	320.23 (49%)
Mito	668.10	572.76 (86%)	437.58 (66%)

* Mean of duplicate analysis
1. Percent of beta-carotene retained is based on amount of beta-carotene in blanched fresh sample

The amounts of beta-carotene in fresh and blanched vegetables were compared with those of dried samples using the traditional open-air direct sun method and the improved enclosed solar drier. Samples dried in the enclosed solar drier retained more beta-carotene content (between 55 percent and 90 percent) than those dried using the traditional open-air direct sun drying method (between 26 percent and 71 percent). The highest proportion of beta-carotene was retained in the samples of black nightshade, pumpkin leaves, *mito*, cowpea leaves and the spider herb. These vegetables lost about 10 to 18 percent on solar drying and 29 to 41 percent on sun drying (Figure 4.4). The levels of beta-carotene in solar dried vegetables and the sun dried ones compare closely with the levels reported by Mulokozi et al. (2000). Fifty six percent to ninety percent beta-carotene retention was reported in enclosed solar dried indigenous vegetables while 49 percent to 65 percent beta-carotene retention was reported in the open-air sun dried vegetables. The vegetables that retained a high beta-carotene content in the above study were *ngwiba*, cowpea leaves and *mganani*.

A significant test (t-test) indicated that there was a significant reduction in the content of beta-carotene in the vegetables after solar-drying ($p=0.001$) and after sun drying ($p=0.002$) at the 95% confidence level. The two preservation methods of solar drying and sun drying lead to significantly different concentrations of beta-carotene in the preserved vegetables ($p<0.05$). Sun drying lost more beta-carotene than solar-drying. This is clearly shown in Figure 4.4.

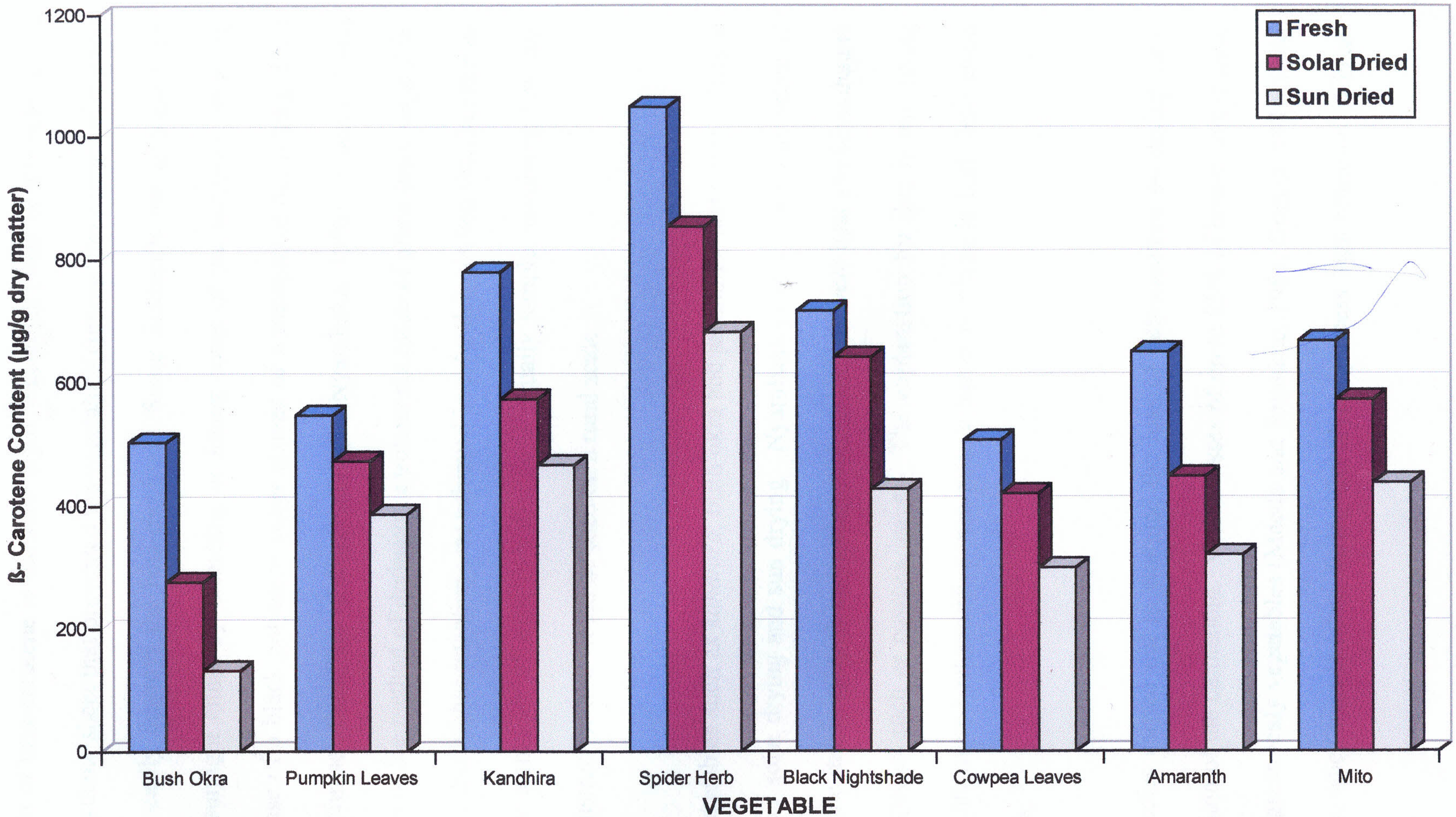

Fig. 4.4: The effect of sun- and solar-drying on beta-carotene content in indigenous vegetables

The higher levels of beta-carotene in the solar dried vegetables could be attributed to the use of black polythene sheet that prevented the vegetables coming into contact with direct sunlight, which easily destroys the beta-carotene. Some foodstuffs are affected when dried in direct sunlight either by bleaching or losing some of the nutrients especially vitamins. The use of a black polythene cover instead of a transparent one during direct solar drying minimises the effect of direct sunlight (Nyambaka, 1996). Gomez (1981) studied the effect of the method of drying on carotene retention of green leafy vegetables and demonstrated that higher retention was achieved in solar dehydration than in open-air sun drying. The technique of solar dehydration is usually simple, involving low cost materials and construction and would be used on a rural scale.

Wilt sensitive vegetables such as *kandhira*, bush okra and amaranth, had lower values of beta-carotene after solar drying and sun drying. Nyambaka (1996) noted high losses of beta-carotene in the Italian spinach and spring cabbage, which were heat sensitive than in the heat stable species such as cowpea leaves. The explanation for this is that young immature leaves are more heat sensitive than mature leaves resulting in high destruction of the carotenoids.

A number of studies carried out to examine the loss of beta-carotene on drying have shown low retention of the carotenoid. Varied losses of up to 95% of beta-carotene have been reported in green leafy vegetables (Maeda and Salunkhe, 1981; Gomez, 1981; Park, 1987). However, when care is taken during the drying process high retention of beta-carotene can be achieved in the dried vegetables and hence making high contribution to the total dietary intake of provitamin A (Nyambaka, 1996).

4.7.4 Effect of Storage on Concentration of Beta-Carotene in Preserved Vegetables

The preserved vegetables collected from Koru Location were stored in sealed plastic bags in a dry, dark area at room temperature and analysed after six months to investigate whether there was a significant reduction in the beta-carotene concentration. Figure 4.5 and Table 4.21 indicate the extent of the change in the amount of beta-carotene in four types of vegetables. The concentration of beta-carotene in cowpea leaves is an average of six samples sun dried by the community while that of the black nightshade, spider herb, and bush okra are an average of two samples each. The percentage retention of beta-carotene in the dried vegetables ranged from 31.93% to 38.16%. The highest retention was in cowpea leaves, though not significantly different from others.

A t-test showed that the concentration of beta-carotene in the sun dried vegetables declined significantly after six months of storage ($p=0.003$). The change was significant for cowpea leaves ($p=0.032$) and bush okra ($p=0.029$) but not for the black nightshade ($p=0.237$) and spider herb ($p=0.437$). There were large inter-vegetable variations that could have caused these effects. For example, the addition of salt and sodium bicarbonate during vegetable preparation could have caused some of the carotenoid loss. In addition, the presence of oxygen in the dried samples enhances the oxidation reaction hence destruction of beta-carotene.

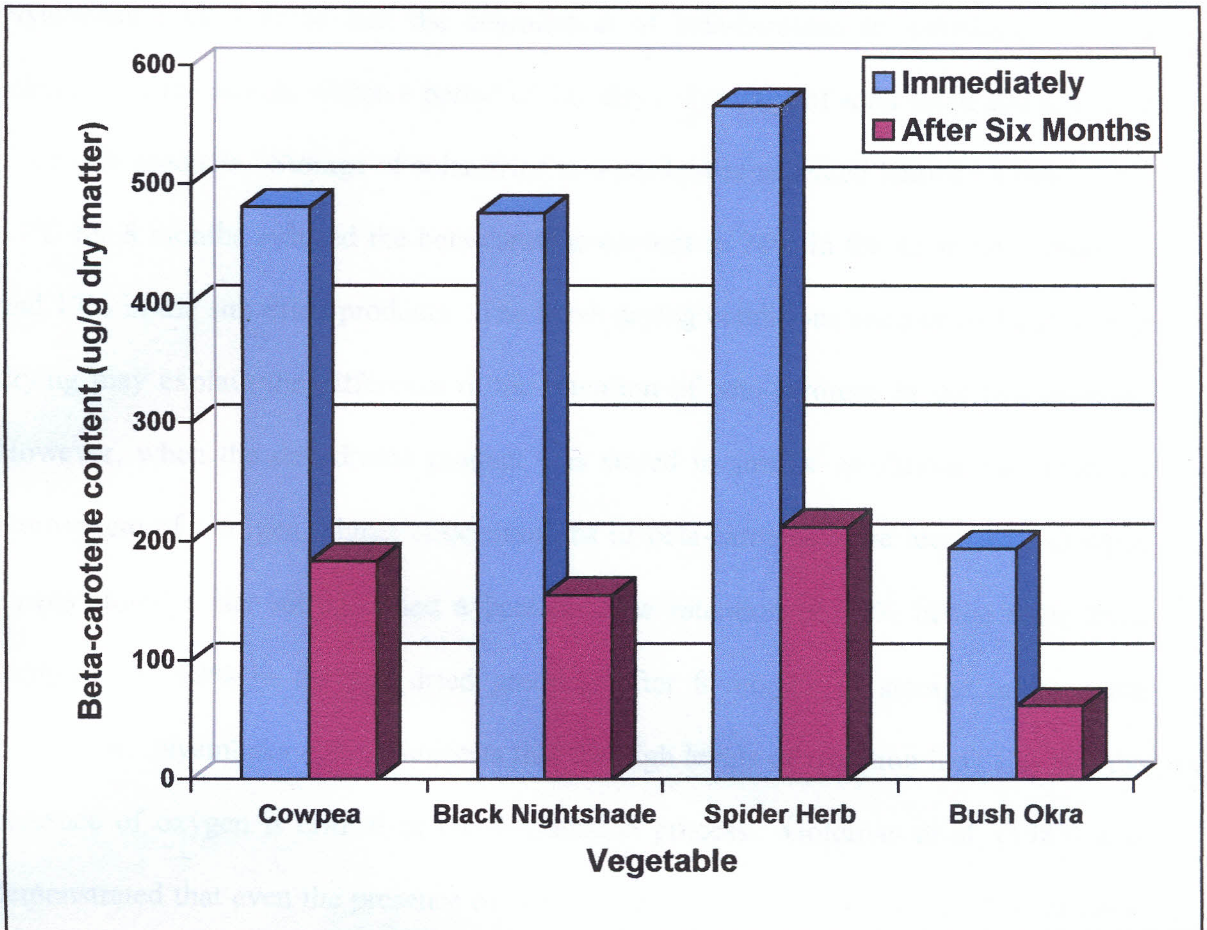

Fig. 4.5: Effect of storage on concentration of beta-carotene in preserved vegetables

Table 4.21: The effect of storage on beta-carotene content* in some dried indigenous vegetables

Vegetable	n	Beta-carotene concentration (µg/g Dry Matter)		Vitamin A Equivalent
		Initial amounts	After 6 months (% retention)	
Cowpea leaves	6	480.85	183.51 (38.16%)	30.59
Black nightshade	2	475.81	155.24 (32.63%)	25.87
Spider herb	2	565.85	212.34 (37.53%)	35.39
Bush okra	2	194.19	62.01 (31.93%)	10.33

* Mean of duplicate analysis

Nyambaka (1996) noted that the degradation of beta-carotene in dehydrated cowpea leaves occurred rapidly within a period of 120 days of storage of solar dried and sun dried vegetable products. Storage of solar dried cowpea leaves in sealed laminated bags at 18-23^{0}C for 8 months reduced the beta-carotene content to 24% in the solar dried products and 17% in the sun dried products. The harsh drying conditions encountered during sun drying may explain the difference in the retention of beta-carotene in the two samples. However, when the dehydrated product was stored in similar conditions but under an atmosphere of nitrogen, higher concentrations of beta-carotene were recorded. Cowpea leaves stored under nitrogen had a beta-carotene retention of 78% in the solar dried samples and 68% in the sun dried products after 8 months of storage in the same conditions. Nyambaka (1996) suggests that the high levels of retention indicates that the presence of oxygen is critical in the degradation process. Goldman et al. (1983) also demonstrated that even the presence of 1-2% oxygen produces a significant loss of beta-carotene.

The high rates of degradation of beta-carotene in dehydrated green leafy vegetables with storage can be explained by a combination of interrelated factors. The rate of carotenoid loss depends upon the concentration of oxygen, moisture content, temperature, presence of lipids, presence of antioxidants, enzyme activity, presence of ultraviolet light, presence of transition metals, location within the food matrix and structure and extent of reaction (Rodriguez-Amaya, 1999; Okos et al., 1992; Karel, 1980).

Dehydrated products/foods require packaging that excludes water vapour and oxygen if the stability of the nutrients and the general quality is to be maintained. Laminates incorporating aluminium such as polythene-aluminium-polyester bags, which give a barrier for oxygen and moisture are the best. However, such bags are expensive to use for ordinary packaging. Use of oxygen absorbers such as iron fillings in ordinary packages may reduce oxygen concentration in packed dehydrated foods (Nyambaka, 1996).

4.7.5 The Effect of Different Treatment on the Beta-Carotene Concentration in Solar- and Sun-Dried Cowpea Leaves

Fresh cowpea leaves were treated differently before solar and sun drying so as to investigate the effect on beta-carotene content. The results are indicated in Table 4.22. The solar dried samples retained more beta-carotene than the sun dried. Blanching before dehydration resulted into higher retention of beta-carotene than when samples are not blanched. Similarly, high levels of beta-carotene were lost when vegetables were chopped before drying. The values of beta-carotene in the vegetables that were dried whole were higher compared to those that were chopped before drying. The use of salt and bicarbonate (*magadi*) during blanching also reduced the beta-carotene content in the dried vegetables. More beta-carotene was lost when samples were blanched in salty water as compared with those blanched in bicarbonate treated water.

Table 4.22: The effect of different treatment on the beta-carotene content* in solar-and sun-dried cowpea leaves

Treatment	Concentration (μg/g Dry Matter)	
	Sun dried	Solar dried
Fresh whole	322.78	394.29
Fresh chopped	207.33	327.87
Blanched whole	401.79	499.06
Chopped and blanched	287.96	398.07
Blanched whole in salty water	116.77	192.66
Blanched whole in water with *magadi*	362.64	406.92

* Mean of duplicate analysis

Nyambaka (1996) noted that the treatment of vegetables with bicarbonate of soda and common salt lowers the beta-carotene level in dehydrated products. Products with common salt showed the highest rate of beta-carotene deterioration. The high rate of destruction of beta-carotene in these products could be attributed to the presence of iodine in the salt, which encourages oxidation. However, Speck et al. (1977) and Arya et al. (1979) reported that salt treatment before dehydration significantly improved colour, texture, flavour, reconstitution and carotenoid stability in carrots. According to Nyambaka (1996) the treatment of cowpea leaves with bicarbonate of soda showed a slight loss of beta-carotene.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

Vitamin A deficiency is a problem in Koru location of Nyando district as it is in many other regions of Kenya. Children under six years of age and lactating mothers are the most affected. 6.73% of children in Koru were reported to have serum retinol levels of less than 10 μg/dl while 24.34% had serum retinol levels between 10 – 19 μg/dl. Clinically, 2.25% of children were diagnosed to have night blindness, 4.25% had bitot's spots while 2.01% had keretomalacia. This statistics show that vitamin A deficiency is highly prevalent in the area. The cases of vitamin A deficiency were found to be high during the months of January, February, March, and July as compared to the other months. This is the period when fruits and vegetables are scarce. This confirms that children do not consume enough green leafy indigenous vegetables during this time. On the other hand children could be consuming the vegetables but the bioavalability of beta-carotene (provitamin A) from them is low. This also indicates that children do not have enough storage of vitamin A in the body suggestive of inadequate intake even when vegetables are plenty.

In Koru location eleven different types of indigenous vegetables are grown which do very well during the rainy season and form a major part of the people's diets. The fresh indigenous vegetables contain considerable amount of beta-carotene (provitamin A). The fresh spider herb contains the highest amount of beta carotene (1048 μg/g dry matter) and the bush okra contains the lowest level, 503 μg/g dry matter. These vegetables can be used in preventing vitamin A deficiency in the region. The other vegetables with high amounts of beta-carotene when fresh are the black nightshade, *kandhira* (Ethiopian cabbage), amaranth, *mito* (*crotalaria achroleuca*), cowpea leaves, bush okra and pumpkin leaves

Five types of indigenous vegetables are preserved to cater for their scarcity during the dry season. Sixty three percent of mothers preserve vegetables with older mothers of over 46years being involved more. This has negative implications in that with time vegetable preservation will cease.

The common methods used to preserve vegetables were sun drying and fermentation. Sun drying of indigenous vegetables was found to cause significant losses of beta-carotene ($p = 0.002$) mainly due to oxidation. The vegetables lost 29 – 74 percent of their beta-carotene after sun-drying. Although mothers sun-dry the vegetables and consume them during the dry season, children might still be vitamin A deficient because the levels retained in the vegetables after sun drying are low. Solar drying, an alternative method that was used resulted into higher retention of beta-carotene than sun drying. Inspite of the low retention of beta-carotene in the sun dried vegetables, the contribution which these vegetables can make to the total dietary intake of provitamin A should not be underestimated.

The sun-dried vegetables could be kept for a period of up to eight months, but the majority of the mothers keep them for only six months. During storage indigenous vegetables were found to lose substantial amounts of beta-carotene, losing 62 to 68 percent of their beta-carotene content ($p = 0.003$). This is due to the presence of oxygen in the storage containers that induces the oxidation process. This indicates that preserved vegetables need to be stored for a shorter period or if they are to be stored for longer periods, methods that reduce the amount of oxygen in storage containers should be used. Use of oxygen absorbers such as iron filings in storage containers such as the large clay pots and plastic buckets may help.

5.2 RECOMMENDATIONS

Based on the above conclusions the following are recommended:

- Mothers in Koru Location need to be encouraged to feed their children with green leafy indigenous vegetables both during the wet and dry seasons. The vegetables can be consumed in the fresh and dry forms. The spider herb should be consumed more as it has higher levels of beta-carotene. This might help minimise cases of vitamin A deficiency in children.
- Although 5 types of indigenous vegetables are preserved in the region the other 6 indigenous leafy vegetables identified in the region contain high amounts of beta-carotene (provitamin A) and should be promoted for preservation in the area.
- The bush okra, which is one of the 5 vegetables preserved in the area is not good for preservation since it loses much of its beta-carotene due to its being very soft. This needs to be discussed with mothers in this region. Much of the vegetable needs to be consumed in the fresh form.

- Solar dehydration, which is a better method of preserving vegetables, needs to be promoted in the area. Women need to be encouraged to solar dry vegetables on a commercial basis and sell them in cities and towns. This might increase intake as well as income.

- Use of oxygen absorbers such as iron filings in storage containers such as clay pots and plastic buckets may reduce oxygen concentration in packed dried vegetables. This should be looked into and will be a way of keeping vegetables for a longer period of time and still maintain as much beta-carotene in the vegetables as possible

- Apart from vegetables, sweet potatoes are also grown in the region, which are a good source of beta-carotene (provitamin A). This should be promoted for consumption especially during the dry season as a means of diversifying the sources of vitamin A.

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APPENDIX A

INTERVIEW GUIDE FOR THE MOTHERS.

Location ____________________

Sub-Location ____________________

Village ____________________

Household Code ____________________

SECTION I

DEMOGRAPHIC INFORMATION

Mother's Name: ____________________

1. How old are you? ____________________
2. Which ethnic group do you belong to? ____________________
3. How many people live in your house/home? ____________________
4. What is the composition of these members in your household and their ages?

Relationship (e.g. husband, wife, son, etc.)	Age
1.	
2.	
3.	
4.	
5.	
6.	
7.	
8.	
9.	
10.	

SECTION II

VEGETABLES GROWN AND PRESERVATION METHODS

5. Which types of indigenous vegetables do you grow?

____________ ____________ ____________ ____________

____________ ____________ ____________ ____________

6. Do you get these vegetables throughout the year?

   Yes ____________ No ______________

7. Which months of the year do you harvest these vegetables?

   _______________ _________________ ________________

8. Do you ever preserve these vegetables and why?

   Yes __________ No _________

   Why? ____

9. Which vegetables do you preserve?

   __________ ___________ _____________

10 Which preservation method do you use?

   Sun drying ____________ Solar drying __________

   Fermentation __________ Other _______________

11 Who does the preservation?

   Mother __________ Son __________ Maid __________

   Father __________ Daughter __________Other __________

12 What is your source of vegetables during the dry season?

   Market _________________________________

   Own preserved vegetables __________________

   None ___________________________________

13 How long do the vegetables take to be preserved? _____________

14 How do you store the preserved vegetables? _________________

15 How long can the preserved vegetables last? _________________

16 Apart from indigenous vegetables which other crops do you grow?

   ____

SECTION III

1. DIETARY INTAKE OF INDIGENOUS VEGETABLES DURING DRY SEASON.

Vegetable	Preserved/ Fresh	Frequency of consumption			Rarely or Occasionally eaten	Estimated amount in household measures
		Everyday	Once a week	Once a month		

2. Which other foods do you eat during the dry season?

____

APPENDIX B

OBSERVATION GUIDE

Location ____________________ Sub-Location____________________

Village ______________________ Household ______________________

1. Type of indigenous vegetables to be preserved ______________________
2. Preparation of vegetables before drying ____________________________
3. Method used for preserving vegetables_____________________________
4. Material used for drying vegetables ________________________________
5. How long the vegetables take to dry ________________________________
6. How vegetables are stored after drying _____________________________