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Effects of various processing methods on proximate composition, minerals and Beta-carotene content of two local carrot varieties

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DECLARATION

I, the undersigned, declare that this thesis is my original work and has not been presented for any degree in this or any other institution and that all sources of materials used in this thesis have been duly acknowledged.

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This thesis has been submitted for examination with my approval as a University advisor. In addition, I declare that this thesis is the original work of my student and has been done under my supervision.

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ABSTRACT

Vitamin A deficiency is a public health problem in Ethiopia. It affects vision, growth, tissue differentiation, reproduction and immune system. Carrot varieties are known to contain high amount of β-carotene which is the major precursor of Vitamin A. This study was designed to determine β-carotene and changes in nutrient composition after various methods of processing (Roasting, boiling, Roasting + boiling and powdering) on two local varieties of carrot variety. Atomic Absorption Spectroscope and colorimeter were used for the analysis of minerals and High Performance Liquid Chromatography was used for β-carotene determination. The proximate (moisture, ash, fiber, fat, carbohydrate, protein, and mineral (Zinc, Potassium, Iron, Magnesium, Phosphorus and Calcium) content in raw carrot varieties and corresponding processing methods were determined. In addition, β-carotene level was determined. The β-carotene level ranged from 8824µg/g (Chantenay) to 1933.3µg/g and 8900µg/g (Nantes) to 2466.6µg/g. There was significant difference ($p < 0.05$) between the two varieties and among the different processes in β-carotene contents. Nantes variety found to be high in β-carotene. Moisture content, 89%-91.8%, 88.5-90.4%, crude protein, 0.18-1.7%, 0.51%-1.53%, crude fat, 0.35%-0.54%,0.22%-0.61%, crude fiber 1.23%-1.06%,1.3%1.06%,and total ash ranged 1.9%-0.8%, 1.9%-0.8%, carbohydrate 8.01%-3.39% 8.9%-4.2% for both Chantenay and Nantes, respectively. Similarly, the range of iron, 0.34-1.29, 0.3-1.26 magnesium, 10.2-12.1, 9-11.4 potassium, 198-318, 215-352 zinc, 0.2, 0.2-0.4 calcium 30-31, 30.6-32.3 and phosphorous19.9-33, 20-33 mg/100g were for both Chantenay and Nantes respectively. Thus processing specially boiling + roasting significantly affected the Beta-carotene, protein, ash, fat and iron, magnesium content of both varieties though Nantes carrot varieties were found to be better than Chantenay in terms of retention of proximate composition, minerals and β-carotene content after the various thermal processing methods. On the other hand, powdering did not significantly affect the proximate composition, minerals and Beta-carotene content of both Chantenay and Nantes varieties. The study revealed that both Nantes and Chantenay carrot varieties can provide adequate amount of beta carotene to fulfill the daily requirements. Hence consumption of moderately processed; especially boiled and powdered carrots is preferred intervention in fighting Vitamin A deficiency.

Key words Beta-carotene, Chantenay, Nantes

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ABBREVIATIONS

AAS: Atomic Absorption Spectroscope

ANOVA: Analysis of Variance

AOAC: Association of Official Analytical Chemists

BHT: Butylated hydroxytoluene

CSA: Central Statistical Agency of Ethiopia

EDHS: Ethiopian Demographic Health Survey

SNNPR: Southern Nations, Nationalities and People's Region

ENNS: Ethiopian National nutrition strategy

FAO: Food and Agricultural Organization

Fe: Iron

FSV: Fat soluble vitamin

GDP: Growth and development plan

HCL: Hydrochloric Acid

HFP: Homestead food production

HPLC: High-performance liquid chromatography

IU: International Unit

IUNS; International Union of Nutritional Sciences

KOH: Potassium hydroxide

LSD: Least Significant Difference

MDD: Micronutrient deficiency

NNP: National Nutrition Program

RDA: Recommended Dietary Allowances

RNI: Recommended nutrition intakes

SPSS: Statistical package for service solution

VAD: Vitamin A Deficiency

WHO: World Health Organization

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1. INTRODUCTION

1.1. Back ground

Micronutrient deficiency is a global problem even much bigger than protein energy malnutrition. More than two billion people are affected globally by hidden hunger particularly due to the deficiency of vitamin A, iodine, iron and zinc. Most of these people live in low income countries and are typically deficient in more than one micronutrient (WHO/UNICEF, 2006). Inadequate dietary intake is a primary cause of vitamin A deficiency in developing countries (Adem et al., 2012). Besides the increased risk of mortality, vitamin A deficiency limits growth, weakness immunity, causes blindness and impairs the normal development of healthy skin and tissues (WHO/FAO, 2006). Vitamin A deficiency predisposes an estimated 100 million Africans to a higher risk of visual impairment and blindness (WHO, 2006).

Vitamin A malnutrition is one of the major public health problems that is being investigated in Ethiopia since 1958 (Getachew and Mohammed, 2012). Postmus (1958) reported that 9% of girls and 2.2% of boys out of seven thousand preschool and school-aged children had Bitot's spots, a disease symptom due to vitamin A deficiency. The Ethiopian Nutrition Institute also revealed that overall national rate of Bitot's spots was 1%, i.e. about six to eight million Ethiopian children under six years of age were at risk of vitamin A deficiency (Demissie, 2014). The prevalence was 1.6% in pastoral, 1.1% in grain crops based and 0.4% in cash crop based areas. De Sole (1987) also reported a 5% prevalence of Bitot's spots among children in southern Ethiopia. Micronutrient baseline surveys conducted by World Vision Ethiopia in ten rural districts of Ethiopia further showed that 6.4% of the 1246 children aged 6 to 71 months and 7.5% of the 3003 children aged between 6 and 14 years had Bitot's spots (Balcha, 2011). The prevalence is 2 to 15 folds greater than the World Health Organization (WHO) cut-off point (0.5%) for public health significance. Hence, micronutrient malnutrition, vitamin A deficiency in particular, continues to be one of the major public health problems in Ethiopia.

The three-pronged approach to reducing the hidden hunger, including Vitamin A deficiency involves: short-term supplementation; medium-term food fortification; and a long-term focus on balanced nutrition (dietary diversification). It has been estimated that nutrition-specific interventions like fortification that only tackle the immediate causes of undernutrition (UNICEF 1990), such as poor breastfeeding practices or vitamin and mineral deficiencies, can only reduce global levels of chronic undernutrition by one-third and child mortality by one-quarter (UNICEF 1990). Without efforts to address the underlying causes of malnutrition through nutrition-sensitive approaches – such as agriculture, food systems, education and employment, the global problem will not be resolved.

Carrot production is one of the best sources of pro vitamin A, beta carotene. Carrot is one of the major vegetable crops cultivated worldwide (Rubatzky et al., 1999). The domesticated types are divided into two groups: (1) the Eastern or Asian carrots, with mainly purple and yellow roots; and (2) the Western carrots, with mainly orange roots. Carrots are the single most important source of dietary pro-vitamin A carotenoids in the world; USA, accounting for 30% of the total vitamin A available to consumers (Simon, 1992). Thus, carrots have acquired worldwide acceptance due to their high pro-vitamin A content, acceptable taste, ease of production, and relatively long storage life at low temperature. They are well adapted to mid and high altitude areas, both under irrigation and rain fed conditions in many parts of Ethiopia (IAR, 1979).

Carrots have been one of the most important means used to mitigate vitamin A deficiency. Carrot roots are a rich source of carotenoids, precursors of vitamin A. The carotenoids contained in the edible portion of carrots can range from 6000 to more than 54,000 µg per 100 g (Simon and Wolff, 1987).According to USDA (2010), 100g of carrot contains 8824µg. Carrots, are mainly consumed in urban areas of the country which is about 15% of the population. However, their value as an important source of vitamin A is not well exploited in the country due to lack of awareness among the majority of the Ethiopian rural population (Getachew and Mohammed, 2012).

Thermal processing affects carrot quality as measured by sensory and instrumental methods (Simon, 1985). Color is an important quality attribute of processed carrots. Orange color intensity is related to carotenoids content (Simon, 1985), and loss of orange color intensity is diminished by carrot processing (Bao and Chang, 1994). Degradation of carotenoids in carrots varies according

to preservation technique and processing conditions (Simon and Lindsay, 1983; Bao and Chang, 1994). Processing reduced total carotenoids content in sliced carrots 8–12% in one study (Simon and Lindsay, 1983), while others reported a slight increase in β-carotene after processing (Paulus and Saguy, 1980). The increase could be a result of release of carotenoids and other pigments from cell components at the beginning while reduction could be attributed to severe treatment.

Nutritional concerns have been arising as the Ethiopian way of cooking is believed to have impacts on the micronutrient content (especially vitamin A) of carrots. The overall objective of the present study is therefore, to evaluate the influence of cooking, roasting, roasting + boiling/cooking and powdering on the proximate composition, minerals content and vitamin A (beta carotene) content of the two local carrot varieties. The study will also explore the importance of micronutrient composition of carrot in varietal selection or in promoting nutrition sensitive agriculture.

1.2. Statement of the problem

Deficiency of vitamin A is of crucial importance as a worldwide nutritional problem, in the developing countries. In these areas, the diet is composed primarily of such items as rice, wheat, maize, and tubers, which contain far from adequate amounts of vitamin A precursors (Erdman et.al 1982). The most common cause of Vitamin A deficiency is insufficient dietary intake of Vitamin A, which is normally found in animal source foods as preformed Vitamin A (or retinol) and in plant source foods as Pro-vitamin A (Souganidis et al., 2013).

In Ethiopia, Micronutrient deficiency is a major contributor to childhood morbidity and mortality. Children can receive micronutrients from foods, fortified food, and direct supplementation. Severe vitamin A deficiency (VAD) can cause eye damage. VAD can also increase the severity of infections such as measles and diarrheal diseases in children and cause slow recovery from illness (Mofokeng, 2013). Vitamin-A-deficiency is a serious public health problem in Ethiopia. National prevalence rates of 1.7% for Bipots spots and 0.8% of night blindness among mothers. Nationally, 37.7% of children had deficient serum retinol levels (Demissie et al., 2014).

The primary cause of vitamin A deficiency is inadequate dietary consumption of vitamin A and/ or suboptimal use of the nutrient in the body. A number of secondary factors contribute to insufficient dietary intake of vitamin A. Inadequate production of vitamin A-rich foods, lack of income to purchase, unavailability of vitamin A-rich foods in markets, a large family size, high maternal parity levels, low level of maternal education, low levels of awareness of the importance of vitamin A, and illness are some secondary factors that are presumed to contribute to inadequate consumption of vitamin A in developing countries (Tsegaye et al., 2009).

Addressing the global challenge of micronutrient deficiency requires the need for many strategies both short and long-term sustainable approaches. In addition to micronutrient supplementation and fortification, promoting food based approach is important to enable adequate intakes of micronutrients by much of the population. Nutrition sensitive agriculture provide a comparatively inexpensive, cost effective, sustainable and long term means of delivering micronutrients to the poor (Thompson 2011). However, currently implementing strategy in Ethiopia is supplementation of vitamin A capsule for children 6 to 59 months of age which is expensive and not sustainable

when compared to food based approach (personal communication with Wolayta Sodo woreda office of Agriculture and office of health).

To add to this problem, the way carrots, the major sources of β-carotene are handled, stored, transported and cooked have a very significant effect on the availability of the micronutrient precursor. Of these factors, cooking is the major one affecting the micronutrient content of the carrots in Ethiopian dishes.

2. OBJECTIVES

2.1 General Objective

To determine the influence of Boiling, Roasting, Boiling + Roasting and Powdering on the proximate composition, minerals and β-carotene content of the two local carrot varieties, Nantes and Chantenay, grown in Ethiopia.

2.2 Specific objectives

- To determine proximate composition and their changes during processing of two carrot varieties.
- To analyze mineral compositions of both varieties of carrots produced in Ethiopia
- To determine the level of β-carotene content in two carrot varieties, as influenced by different processing methods.

2.3 Hypothesis

The proximate composition, calcium, magnesium, zinc, phosphorus, potassium and iron contents and beta-carotene of Nantes and Chantenay carrot varieties which are locally growing in Ethiopia are not significantly influenced by various processing methods.

2.4 Significance of the Study

This work has the following importance, among many more;

- It increases knowledge and awareness of the public on effects of processing techniques on the micronutrients, especially vitamin A, content in their dishes,
- Increases the knowledge and awareness of the public on varietal selection for various types of dish for a maximum nutritional benefit.
- It recommends institutes and organizations working towards varietal improvement, to include nutritional analysis as part of varietal improvement and release/adaptation of carrot varieties,
- It helps in increasing awareness of the community to follow appropriate processing of carrot for optimum nutritional benefit.

3. LITERATURE REVIEW

3.1 Vitamin A

Vitamin A is an essential nutrient that is required in small amounts by humans for the normal functioning of the visual system, the maintenance of cell function for growth, epithelial cellular integrity, immune function and reproduction (WHO, 1995), Dietary requirements for vitamin A are normally provided as a mixture of preformed vitamin A (retinol), which is present in animal source foods, and pro-vitamin A carotenoids, which are derived from foods of vegetable origin and which have to be converted into retinol by tissues such as the intestinal mucosa and the liver in order to be utilized by cells. Foods derived from plants provide carotenoids, some of which can be converted into vitamin A. The carotenoids with the greatest vitamin A precursor is beta carotene which can be split into form retinol in the intestine and liver (Whitney and Rady, 2008).

In Foods,

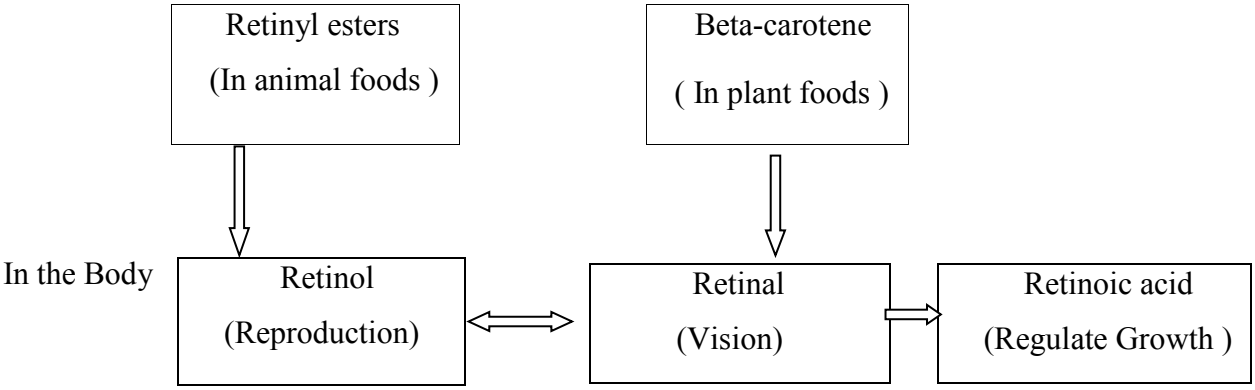


Figure 1: Conversion of Vitamin A precursors to Vitamin A (Whitney and Rady, 2008)

Carotenoids are a class of closely related natural pigments synthesized by plants. Their main function is to absorb light during photosynthesis and provide protection against photosynthesization. Over 600 different carotenoids have been identified and approximately 40 of these occur in common food sources including carrot. Beta-carotene, alpha-carotene, lutein, beta-crypoxanthin and lycopene are the most common carotenoids found in plasma. Some of these carotenoids, such as beta-carotene, alpha carotene and beta-cryptoxanthin, are metabolized in the

small intestine and function as precursors of vitamin A. However, other carotenoids, such as lycopene and lutein, are devoid of pro-vitamin A activity (Yeung and Laquatra, 2003).

The beta-carotene content of carrot varies with the growing conditions and post-harvest storage of the food. The bioavailability and bio conversion of pro-vitamin A carotenoids can be influenced by various factors such as the digestibility of the food, molecular linkage, amount of carotenoids consumed in meal, matrix in which the carotenoids is incorporated, intake of dietary fat type for fat soluble vitamins and amount of fiber, alcohol, nutritional status of the individual as well as genetic and host related factors (Jim and Truswell, 2002).

3.2 Metabolism

Dietary sources of vitamin A that are retnyl ester and retinol from certain animal tissue and beta-carotene from certain plants are hydrolyzed in the intestinal mucosa, releasing retinol and free fatty acids. Retinol derived from esters and from the cleavage and reduction of carotenes is re-esterifies to long chain fatty acids in the intestinal mucosa and secreted as a component of chylomicrons into the lymphatic system. Retnyl esters contained in chylomicrons remnants are taken up by and stored in the liver. Retinol is released from the liver when it is needed and transported to the extra hepatic tissues by the plasma retinol binding protein. The complex attaches to specific receptors on the surface of the cells of peripheral tissues (Harvey and Ferrier, 2011).

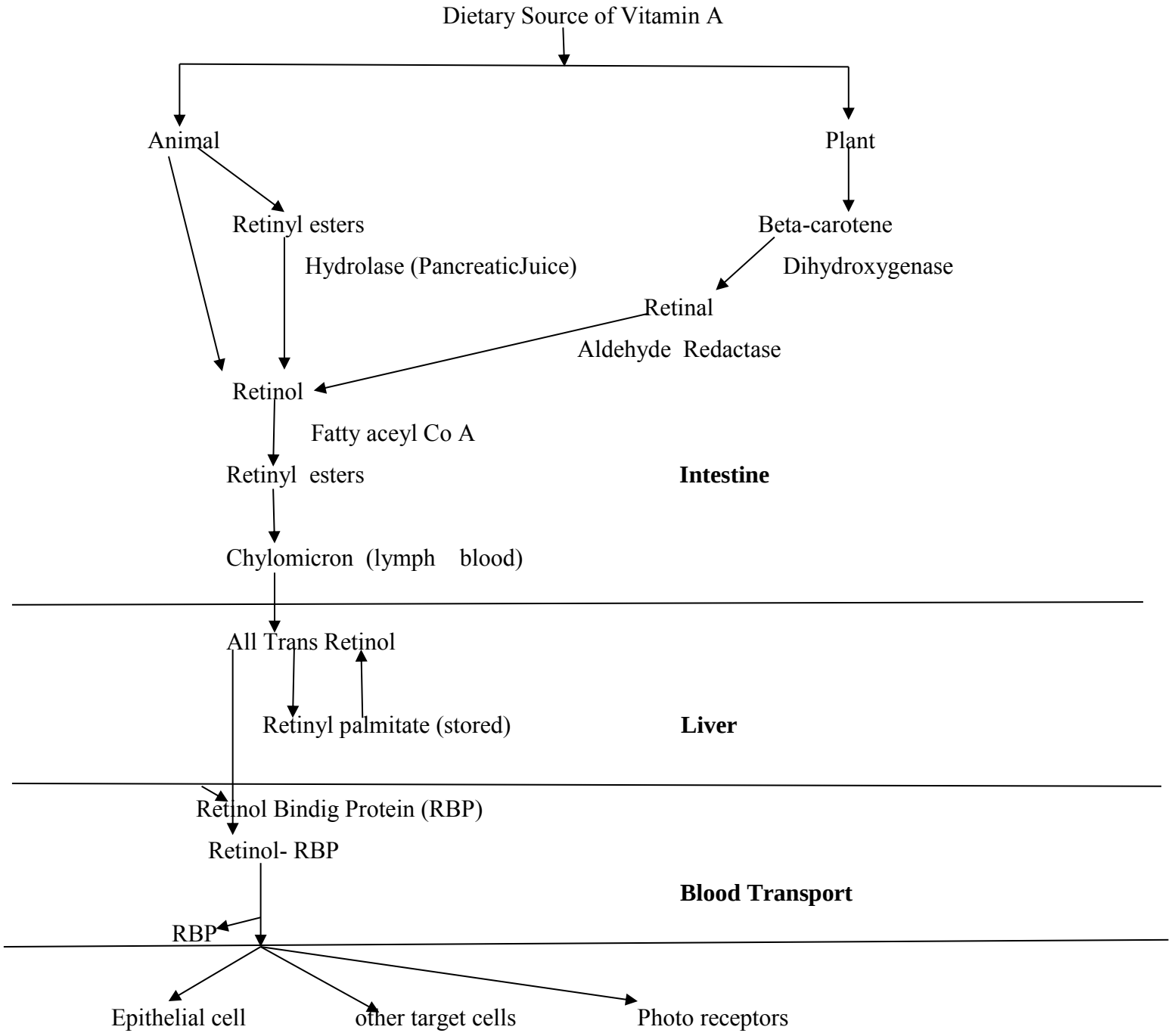


Figure 2: Scheme of Vitamin A Metabolism (Harvey and Ferrier, 2011)

3.3 Biological significance of Vitamin A

Vitamin A and its precursor, pro-vitamin A such as β-carotene, have diverse role and profound effect on health. Its major roles are promoting vision, participating in protein synthesis and cell differentiation, marinate the health of epithelial tissues and it is as anti-infective vitamin ,because its required for normal functioning of the immune system (WHO/FAO,2004). Whitney and Rady (2008) reported that the three forms of Vitamin A carry out specific functions. Retinal is active in vision and it's also an intermediate in the conversion of retinol to retinoic acid. Retenoic acid acts like a hormone, regulating cell differentiation, growth and embryonic development. Retinol supports reproduction and it is a major transport and storage form of Vitamin A.

Beta- carotene and other carotenoids are also potent antioxidants and important physiological modulators (Yeung and Laquatra, 2003).Antioxidants have proven to be effective in fighting free radicals, highly unstable compounds that are formed when oxygen combines with certain substances. Free radicals can damage the basic structure of cells and thus lead to chronic diseases such as cardiovascular disorder and cancer and accelerate the aging process. Thus, β-carotene and other carotenoids protect oxidation and free radical damage by quenching singlet oxygen (Sesso et al.,2004).

3.4 Prevalence of Vitamin A deficiency

As vitamin A deficiency affects visual function, indicators of vitamin A status have traditionally relied on changes in the eye, specifically night blindness and xerophtalmia (FAO/WHO, 1999). Globally 190 million children under the age of five years old are vitamin A deficient, Africa having one of the highest prevalence, at 44% (WHO,2009).Vitamin A deficiency is the cause for 1.2-1.3 million children and significant numbers of women to die ,and 4.4 million children and 6.2 million women suffer from xerophtalmia (SCN,2004). In the developing world, prevalence rates in this age group range from 15% up to as high as 60%, with Latin America, the Eastern Mediterranean and the Western Pacific being at the low end of this range, and Africa and South-East Asia occupying the high end (WHO, 2005).

Vitamin A deficiency is public health problem in Ethiopia. In Ethiopia pregnant women, infants and young children are most susceptible for Vitamin A deficiency and sadly, its deficiency affects about 7.7 million children and results in an estimated 50,000 deaths each year (FMoH, 2011).

The prevalence of night blindness is also high among pregnant women in many poor regions of the world, with rates varying between 8% and 24% (WHO, 2005). Night blindness tends to be accompanied by a high prevalence of low concentrations of retinol in breast milk (<1.05μmol/l or 30μg/dl). According to WHO criteria greater than 1% prevalence of night blindness in children aged 24–71 months, or the presence of serum retinol concentrations of less than 0.70μmol/l in 10% or more of children aged 6–71 months indicates a public health problem (WHO, 2005). It has been suggested recently that a prevalence of night blindness of more than 5% in pregnant women should be added to the list of criteria that signify a public health problem (WHO, 2005).

The problem of vitamin A deficiency (VAD) is global. Vitamin A deficiency is the cause for 1.2-1.3 million children and significant numbers of women to die, and 4.4 million children and 6.2 million women suffer from xerophtalmia (SCN, 2004).

It is also major nutritional concern in poor societies, especially in lower income countries. The main underlying cause of VAD as a public health problem is a diet that is chronically insufficient in vitamin A that can lead to lower body stores and fail to meet physiologic needs (e.g. support tissue growth, normal metabolism, resistance to infection). A poor diet and infection frequently coexist and interact in populations where VAD is widespread. In such settings, VAD can increase the severity of infection which, in turn, can reduce intake and accelerate body losses of vitamin A to exacerbate deficiency (WHO, 2005).

3.5 Risk factors of Vitamin A deficiency

Usually, vitamin A deficiency develops in an environment of ecological, social and economical deprivation, in which the key risk factors for vitamin A deficiency are diet which are low in sources of vitamin A (i.e. dairy products, eggs, fruits and vegetables), poor nutritional status, and high rate of infections, in particular, measles and diarrheal diseases (Bartholemew and Ogden, 1989).

The best sources of vitamin A are animal source foods, in particular, liver, eggs and dairy products, which contain vitamin A in the form of retinol, i.e. in a form that can be readily used by the body. It is not surprising then that the risk of vitamin A deficiency is strongly inversely related to intakes of vitamin A from animal source foods. In fact, it is difficult for children to meet their requirements for vitamin A if their diet is low in animal source foods (Haile-Meskel, 2011), especially if their diet is also low in fat. Fruits and vegetables contain vitamin A in the form of carotenoids, the most important of which is β-carotene. In a mixed diet, the conversion rate of β-carotene to retinol is approximately 12:1 (higher, i.e. less efficient than previously believed). The conversion of the other pro-vitamin-A carotenoids to retinol is less efficient, the

corresponding conversion rate being of the order of 24:1 (Navara, 2004). Various food preparation techniques, such as cooking, grinding and the addition of oil, can improve the absorption of food carotenoids (Navara, 2004). Synthetic beta carotene in oil, which is widely used in vitamin A supplements, has a conversion rate to retinol of 2:1, and the synthetic forms of β-carotene that are commonly used to fortify foods, a conversion rate of 6:1 (Navara, 2004).

3.6 Recommended intake

Daily nutritional needs in vitamin A for different class ages were evaluated by FAO/WHO to tackle vitamin A deficiency. The mean requirement intake to prevent xerophtalmia in the absence of clinical or sub-clinical infection that expressed as µg retinol. This intake should account for the proportionate bioavailability of performed vitamin A (about 90%) and pro-vitamin A carotenoids from a diet that contains sufficient fat (10g daily) whereas the recommended safe level intake is the average continuing intake of vitamin A to permit adequate growth and other vitamin A dependent functions and to maintain an acceptable total body reserve of the vitamin (WHO/FAO, 2004). The WHO/FAO recommended safe intake is presented in Table 1 below. As the body can derive vitamin A from various retinoid and carotenoids, its contents in foods and its recommendations are expressed as retinol activity equivalents (RAE) (Whitney and Rady, 2008).

Table 1: Estimated mean requirement and safe level of intake for vitamin A, by group

Group	Age	Mean requirements (µg RE/day)	Recommended safe intake (µg RE/day)
Infants and children	0-6 months	180	375
	7-12 mo	190	400
	1-3 years	200	400
	4-6 years	200	450
	7-10 years	250	500
Male	11-12	500	1000
	13-15	600	1000
	Adult(15)	600	1000
Adolescent	10-18 years	330-400	600
Adults: Female	19-65 years	270	500
	65+ years	300	600
Male	19-65 years	300	600
	65+years	300	600
Pregnant women	-	370	800
Lactating mother	-	450	850

Source WHO/FAO, 2004

3.7 Vitamin A Deficiency in Ethiopia

Vitamin A deficiency is observed to increase the severity of infections such as measles and diarrheal diseases in children and slow recovery from illness. Vitamin A is found in breast milk, other milks, liver, eggs, fish, butter, red palm oil, mangoes, papayas, carrots, pumpkins, and dark green leafy vegetables. The liver can store an adequate amount of the vitamin for four to six months. Periodic dosing (usually every six months) of vitamin A supplements is one method of ensuring that children at risk do not develop VAD (CSA, 2011). Therefore, VAD is a major public health problem in Ethiopia, associated with annual deaths of nearly 40 thousand children (MOH, 2011).

Vitamin A is essential micronutrient for proper functioning of the immune system proving the vitamin A status of children increase their resistance to disease, and thus in Ethiopia were diarrhea, acute respiratory infection, and measles are among the major cause of child mortality, improve vitamin A status will play critical role in reducing young children mortality.

3.8 Strategies for the control of micronutrient malnutrition

Globally there are short and long term strategies to combat micronutrient deficiency that are supplementation, and food- base approaches such as food diversification, fortification (exogenous fortification and bio fortification). Food- base approaches promote the consumption of foods that are naturally rich in micro nutrient or are enriched foods through fortification (Thompson and Amoroso, 2011).

Supplementation is the term used to describe the provision of micronutrients, usually in the form of pills, capsules or syrups. It has the advantage of being capable of supplying an optimally amounts of a specific nutrients in a highly absorbable form to control in individuals or population groups that have been identified as being deficient (Allen, 2006).Although supplementation has saved many lives and much suffering has been avoided as a result of these efforts ,it is a short term emergency measure. It fails to recognize the root cause of micronutrient

deficiency and to assist communities and households to feed and nourish themselves adequately (Ruel, 2012).Supplementation usually requires the procurement and purchase of micronutrients in relatively expensive pre-package form and effective distribution system .It cannot provide the overall long term economic benefits and sustainability that food base approaches can deliver (Allen, 2006).

Dietary diversification is a long term strategy that complements supplementation and fortification programs. It refers to a variety of strategy that aim to increase the production, availability and access to foods rich in micronutrients and bioavailability of micronutrients from the diet. Dietary diversification can be achieved through horticultural approaches such as home gardens, behavioral change and improved methods of food preparation and improved methods of food preparation and preservation that minimize the loss of micronutrients (Ruel, 2012).

Exogenous fortification is adding of essential vitamins and minerals to foods which are regularly consumed as flour, salt, sugar and cooking oil (Nuss and Tanummihardijo, 2011). In many situations, this strategy can lead to relatively rapid improvements in the micronutrients status of a population, and at a very reasonable cost, especially if advantage can be taken of existing technology and local distribution networks (Allen,2006).

Biofortification is the process of breeding nutrients into crops through conventional and transgenic methods (Saltzman et al., 2014).It is a promising strategy for combating hidden huger that provides a sustainable, long term strategy for delivering micronutrient comparatively inexpensive and cost effective way to rural populations in developing countries who may have limited access to diverse diets, supplements and commercially fortified foods. Unlike the continual financial outlays required for supplementation and commercial programs, a onetime investment in plant breeding can yield micronutrient rich planting materials for farmers to grow for years to come (Thompson and Amoroso, 2014).

Farm-based approaches can also assist farmers and empower the community. Studies have shown that children from a family with developed gardens consume 1.6 times more vegetables and have a lower risk of night blindness than children without such gardens. Production and consumption of vegetables and fruits was one of the strategies used in the program (Balcha, 2001). Carrots have been one of the most important means used to mitigate vitamin A deficiency (Velgouse,& Dize,2000).

Projects conducted in Asia and Africa involving gardening and small animal husbandry has been shown to increase dietary diversity and nutritional content of home diets, improve total dietary vitamin A intake, and reduce the risk of VAD-associated xerophtalmia (Velgouse and Dize,2000). This intervention is useful in circumstances beyond the household's control, economic upheaval, political unrest, or an increase in agricultural prices since increased home food production can increase year-round availability and establish continuous access to nutritious foods (Velgouse, & Dize, 2000).

Carrot roots are a rich source of carotenoids such as β-carotene, which is, precursor of vitamin A. The carotenoids contained in the edible portion of carrots can range from (60–540 ppm) in

100g (Simon and Wolff, 1987). Carrots are the single most important source of dietary pro-vitamin A carotenoids in the USA, accounting for 30% of the total vitamin A available to consumers (Simon, 1992).

3.9 Stability of pro-vitamin A carotenoids

Most vegetables are commonly cooked before being consumed. It is known that cooking induces significant changes in chemical composition, influencing the concentration and bioavailability of bioactive compounds in vegetables. However, both positive and negative effects have been reported depending upon differences in process conditions and morphological and nutritional characteristics of vegetable species (Nicoli et al.,1999; Bernhardt and Schilic, 2006).

Pro-vitamin A carotenoids are easily destroyed by exposure to light, during processing, heating and storage (Rodriguez-Amaya, 1997). Whatever the processing method carotenoids retention decrease with longer processing time, higher processing temperature, and cutting of the food (Rodriguez-Amaya and Kimura, 2004).

Heat treatment is one of the processes in the production of carrot puree, causing texture changes and loss of numerous nutrients. In the case of carrots, these changes primarily affect carotenoids, which are very sensitive to intensive heat treatment. During hydrothermal processing, carotenoids undergo oxidation and isomerization. These processes lead to color changes in carrot products, a decrease in their value as a source of vitamin A, or even to the formation of oxidized derivatives deteriorating their organoleptic properties. It was found that β-carotene forms are characterized by lower (even by 50%) activity of vitamin A (Lessin et al., 1997). Comparatively, the pro-vitamin A carotenoids are more stable to light and oxidation than retinol. This may be due to the location of the carotenoids within the plant tissues. However, heat treatment which disintegrates tissue, if coupled with exposure to oxygen, light and acid, can result in the destruction of the pro-vitamin A carotenoids. In addition, heat, acid and light have been reported to cause isomerization of vitamin A and carotenoids (Zechmeister, 1962). This isomerization is due to the conversion of the all-trans isomers to the cis isomers. The all-trans isomers of the carotenoids predominate in the fresh tissues because they have the most stable configuration. The cis isomers

have been reported to have lower biological potencies than all-trans isomers (Zechmeister, 1949); thus, isomerization can lead to a reduction in available vitamin A.

The structure and textural properties of fruit and vegetable tissues are dependent, largely, on the cell wall (Klockeman et al 1991). Hence, Cooking-induced softening of carrots is due to an initial loss of turgor (Greve et al 1994a). An analysis of interactions between carotenoids and insoluble dietary fiber shows that the amount of carotenoids bound with this fraction decreases during hydrothermal processing. It was found that in raw carrots from 52% to 64% of β-carotene are bounded with insoluble dietary fiber. Hydrothermal processing causes a significant decrease in the amount of carotenoids bounded with this fraction, and the greatest changes were observed during heat treatment (Julitta et al.,2003).

Moisture can be removed from the roasted food rapidly once the oil temperature reaches the boiling point of water. The color and flavour can be better preserved in Vacuum-roasted food, because the food is heated at lower temperature and oxygen content and good retention of nutrients. Thermal processing alter the properties of carrots by the degradation of some of their components, such as starch and protein (Edgar and Murakami,1997).

3.10 Carrot production in Ethiopia

Currently, about 12,345.8 t of carrot is produced in Ethiopia on 2,215 ha of land (CSA, 2014/15). Although the production trend is not consistent from year to year, the production of carrots has doubled between 2008/9 and 2010/11 mainly due to increasing urbanization and the recognition of carrots as an income and nutrition source. Farmers in Hararghe area also generate foreign currency from exporting carrots to neighboring Djibouti and Somalia. Moreover, foreign currency income obtained from exporting fresh or chilled carrots increased from a mere 581 USD in 1997 to 517,172 USD in 2014 (ARARI, 2015). In addition, a significant number of individuals get their income from brokering, trading (wholesale or retail), and transporting carrots.

Carrots are produced in a wide range of agro-ecologies from the lowlands to the highlands of Ethiopia. They are frost tolerant and have become one of a few alternative crops that can be grown in the frost prone highlands around 3000 masl. They grow in well drained alluvial and sandy loam

soils but not in heavy clay and water-logged soils. Carrots are usually grown on small plots in the backyards of town and peri-urban dwellers for family consumption; however, some farmers grow carrots on up to 0.25 to 1 ha as a means of income. Carrots can be grown throughout the year if rain and irrigation water is available. In highlands that get bimodal rain fall, two cycles of carrots can be produced based solely on rain. These are the short rainy season (*Belg*, March to May) and the long rainy season (*Meher*, June to September). The third cycle is also possible between October and March with irrigation water. Tables 2 and 3 respectively show trend and major production areas in Ethiopia.

Table 2: Carrot production in Ethiopia from 2008-2014/15

Year	No of holders	Area (ha)	Production (MT/Ha)	Productivity (MT/Ha)
2014/15	117649	2214.9	18229.3	6.7
2013/14	15032	2712.7	12345.8	5.6
2012/13	205637	2100	13466.6	6.4
2011/12	149484	1400	10000	7.1
2010/11	137052	946.7	6694.1	7.1
2009/10	134358	1071.2	6881.5	6.4
2008/9	138208	1741.0	17.9	10.3

Source: CSA, 2014/15

Table 3: Major carrot production areas and seasons in Ethiopia

Region	**Major production area (kebele)**	**Altitude**	**Season**	**Planting time**	**Harvesting time**
Oromia	Alefwaja,AlefTijosiro,Tifolebusole	1800-3000			
Arsi Shirka Woreda			Meher	July	Sep
			Belg	March	June
			Irrigated	Oct	Jan
Arsi Bokogi	Lemu mirt,Enkolo,Lemu Dimu	2500-2800	Meher	July-oct	
			Belg	March	June
			Irrigated	Sept-dec	
Arsi Enkole wabe	Lemu kare,Teji wolkite	>3000	Meher	May/jun	Sep
			Belg	Mar/Apr	July
East Harerge	Haramaya,Kombolcha	1900-2000	Meher	June	Sep
			Irrigated	Sep-Nov	Dec-Mar
Amhara	North shewa	2200-2700	Meher	June	Sep-Oct
			Belg	Feb-mar	June
	Debre brehane borale ,melka		Irrigated	Sep-oct	Dec-Mar
Addis Ababa	Akakikality, Nifasesilk, Kolfe,Gulele	2000-2200	Meher	June	Sep/Oct
			Irrigated	Oct-mar	Jan-June
Tigray					
East Tigray/ganta afsthun	Dibla, Sasun, Smret	n.d	Meher	Mid Aug	Mid Dec
			Irrigated	1st week of Oct	Mid Jan

Region	Major production area (kebele)	Altitude	Season	Planting time	Harvesting time
South east Tigray /Enderta	Ararto,Cheelekot,Diba	n.d	Irrigated	1st week of Dec	Mid Mar
South Tigray Enda Mekoni	Embhazti,Simret,Shimta	2500-2800	Meher	3rd week of June	End Sep
			Irrigated	1st week of June	Mid March
SNNPR	Hadiya (Lemu,Hosanna) Wolayta (Sodo Zuriya) Murcharie (Benchi Magi,Gurage) Sidama (Wendo Genet)and Gedeo zones	1800-2000	Belg Meher	April August	August Dec/Jan

Source: CSA, 2014/15

Remarks n.d : No document

3.11 Variety adaptation

Study conducted by various researchers showed that carrots were a popular crop in Hararghe, eastern Ethiopia. Farmers were producing and saving their own seeds of carrot. However, roots from the local seeds lacked uniformity and quality. As a result, seeds of eight varieties were imported from Kenya and a variety trial was initiated at the College of Agriculture at the then Alemaya College of Agriculture (now Haramaya University) in early 1960s (Sirk, 1992). Among the eight varieties tested Nantes and Chantnay gave good root yields. Nantes had the best quality roots and became very popular in Hararghe. Chantnay was also well accepted (Kidane-Mariam, 1969). Simret (1994) reported that from adaptation trials undertaken at various agro-ecological zones between 1983 and 1988, Nantes and Chantnay gave a root yield of 19.6 and 21.7 t/ha in the

highlands (2201 to 3000 masl), 23.2 and 24.1 t/ha in the mid-altitudes (1701 to 2200 masl), and 21.2 and 19.7 t/ha in the lowlands (500 to 1700 masl), respectively.

The result indicted that both varieties were suited to mid-altitude areas while Chantenay was more suited to high altitudes than lowlands and the vice-versa was true for Nantes. Hence, as the result of variety adaptation trials, Nantes and Chantnay were recommended to be grown in various parts of Ethiopia as it shown in Table 3 at different seasons of the year.

The characteristics of the two varieties are:

- Nantes has orange colored and cylindrical roots with a blunt end and strong leaves. It is in high demand among farmers for its good adaptation in highlands and high market demand for its good color, thick and long roots and sweet taste. These are 6-7" (15-18cm) cylindrical carrots, with blunt tips. Nantes carrots perform better in heavier, rockier soils where other carrot types twist and fork. They're less likely to form pithy cores when left in the field than Chantenay carrots (Figure 3).
- Chantnay has shorter roots than Nantes, with broad 1 ½- 3" (4-8cm) crowns tapering quickly to a rounded point 6" (15cm) away, yellowish orange in color and a sharp tip. It has a long shelf life and is suitable for long distance. Before Nantes varieties were developed, these cone-shaped carrots were the only choice for gardeners growing carrots in heavy or rocky soils (Figure 3).



Figure 3: Nantes (Left) Chantenay (Right) Carrots

3.12 Provitamin A carotenoids in carrots

Carrots, sweet potatoes, and green leafy vegetables are major contributors of pro-vitamin A in diet (Bureau et.al, 1986). The color of carrot root is the result of various pigments that serve as intermediate products in the carotenoids pathway (Koch and Goldman 2005). Table 4 shows six carotenes which have been reported in carrots (Simon and Wolff 1987). Figure 4 also shows the common geometric isomers and all-trans beta carotene. The major pigments responsible for orange and yellow color of the roots are α- and β-carotene. B-carotene often represents 50% or more of the total carotenoids content (Rubatzky et al. 1999).

Table 4: Carotenoids with vitamin A activity carrots (Simon and Wolff 1987)

Compound	Relative potency
Beta-carotene	100
Alpha-carotene	53
Gamma-carotene	43
Crypoxanthin	57
Lycopene	0
Zeaxanthin	0

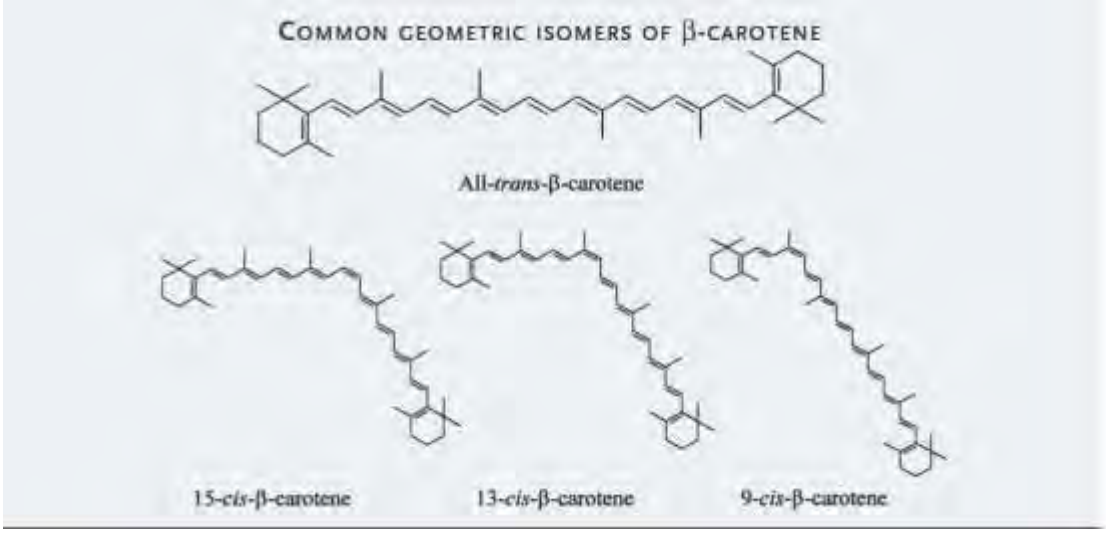


Figure 4: Carotenoids with vitamin A activity carrots (Simon and Wolff 1987)

Carotenoids concentrations of fruits and vegetables are affected by factors such as:

- cultivar/variety;
- part of the plant consumed;
- uneven distribution of the carotenoids in a given food sample;
- stage of maturity;
- Climate/geographic site of production;
- Harvesting and postharvest handling; and
- Processing and storage (Bureau et.al, 1986).

3.13 Nutrients other than carotenoids in carrot

Fruits and vegetables are important sources of water soluble sugars, protein and fiber. They also contain range of micronutrients such as vitamin Iron, Magnesium, Potassium, Phosphorus, Zinc, calcium, Copper, Sodium, Manganese, Calcium, and Sodium, (Olalude et al.,2015). Carrots have been one of the most important means used to mitigate vitamin A deficiency (Velgouse, and Dize, 2000).

Table 5: proximate composition and minerals composition of carrot per 100g

Carrot	
Proximate (g)	
Protein	0.93
Carbohydrate by difference	9.58
Fiber total	2.8
Sugars Total	4.74
Sucrose	3.59
Glucose	0.59
Fructose	0.55
Minerals (mg)	
Calcium	33
Iron	0.3
Magnesium	12
Phosphorus	35
Potassium	320
Sodium	69
Zinc	0.24
Copper	0.05
Manganese	0.14

Source: USDA,2010 National Nutrient Database for Standard Reference

3.13.1 Potassium

Gopalan et al. (1991) have reported 53 mg/ 100 g of phosphorus in a carrot which was boiled at 100^{o}c for 20 minutes. Winiarsk and Nowak (2008) reported 0.97 mg/g and 0.52mg/g of potassium in juice made of carrot and apples and carrot and banana respectively. The values reported by Holland et al. (1991) for phosphorus was 25 mg/100 g. USDA (2010) National Nutrient Database for Standard Reference reported 35 mg/100g.

3.13.2 Iron

The standard set by The United States Department of Agriculture (USDA) Nutritional nutrients data base for standard reference offers iron composition of carrot 0.3mg/100g (USDA, 2010). Gopalan et al. (1991) have reported iron 2.2 mg/100 g. The values reported by Holland et al. (1991) showed that iron 0.4 mg/100 g,. Kulshrestha (2008) reported that powder carrot is a good source of iron1.26mg/100g. Olalude (2015) analyzed the physico-chemical of carrot juice and came up with the result of 1.67mg/100g.

3.13.3 Magnesium

Carrots are a good source of minerals like Magnesium. Gopalan et al (1991). Holland et al. (1991 have reported 9mg/g of Magnesium in Roasted carrot.Winiarsk and Nowak (2008) reported 0.06 mg/g and 0.05mg/g of potassium in juice made of carrot and apples and carrot and banana respectively. The United States Department of Agriculture (USDA) Nutritional nutrients data base for standard reference offers nutrients compositions of carrot which 10mg/100g.

3.13.4 Calcium

Holland et al (1991) reported 34 mg/100 g content of calcium in processed carrot the standard set by Ethiopian food composition reported 31 mg/100g of calcium (ENHRI,1997). USDA (2010) set 33mg/100g. Holland et al (1991) reported Calcium 34 mg/100 g. in processed carrot.

3.13.5 Zinc

Holland et al. (1991) reported 0.2 mg/ 100 g of Zinc in juice made of carrot and apples and carrot and banana respectively. Zinc deficiency is a public health problem, and is associated with poor growth, decreased immune function, increased susceptibility to and severity of infections, adverse outcomes of pregnancy, and neurobehavioral abnormalities (Sandberg 2002; Melaku et al., 2005).

3.13.6 Phosphorus

The values reported by Holland et al. (1991) for phosphorus in the carrot was 25 mg/100 g. .Gopalan et al (1991) have reported 53 mg/ 100 g of phosphorus. USDA (2012) reported the phosphorus standard is 35 mg/100g of raw carrot.

4. MATERIALS AND METHODS

4.1 Study Setting

The analysis of proximate composition was conducted in Addis Ababa University (AAU), Centre for Food science and Nutrition. Beta- Carotene determination was done at the Ethiopian Conformity Assessment Enterprise (ECAE) and Mineral analysis was conducted at Debre Zeit Agricultural Research Center and Horticoop Ethiopia.

4.2 Sample Collection

Samples of Nantes and Chantnay varieties of carrots (5 kilograms each) were collected from local farmers of Soddo Zuria woreda of Wolayta zone in SNNPR with the help of high level agriculture experts and carrot researcher from Debre Zeit Agricultural Research Center. The area was selected because the farmers in this woreda are surplus carrot producers and they also produce both Nantes and Chantenay varieties.

4.3 Sample preparation

Carrots from each variety were bought from the market. The samples were then placed inside paper bags (avoiding light) and stored under chilled conditions at 2-5°C, until analyzed (within 1week). All carrots were thoroughly washed with tap water and discolored spots, if present, scraped before analysis. Each carrot type was extracted, and the analytes from three samples of the original carrot batches were measured.

4.4 Treatment of the samples

Based on most common carrot processing methods employed in Ethiopia, (cooking or boiling, Roasting and one more which was less practiced (powdering), various treatments were employed to the samples. Samples from both varieties were subjected to the different processing methods that imitated the real traditional methods like cooking (boiling in water at boiling point for 50 minutes at 97^0C), Roasting (using commonly used Niger seed oil for 30 minutes at 170^0C), and powdering (drying in shed and then pounding). This level of heat and timing was selected to simulate the real cooking practice in the area (based on an assessment done in the study area on community members' practices).

The samples which were collected were grinded by using lab grinder Model: CIT-FW-100. The grinded powders of carrot samples were sieved through 1mm sieve. These sieved powders were collected and packed in paper bags (ISO, 1981). All analyses were done by using analytical grade chemicals and regents.

Beta carotene was determined using High Performance Liquid Chromatography (HPLC), minerals such as Iron, calcium, magnesium, zinc contents of each processed carrots were analyzed using AAS. Phosphorus and Potassium were analyzed using Colorimetric technique.



Figure 5: Chantenay (Left) and Nantes carrot Varieties. Above peeled, below Boiled

Carrots collected

↓

Washing and rinsing with distilled water

↓

Trimming and Peeling



↓

Slicing (1cm×1cm×1cm)



↓

Processing (Boiling, Roasting, Roasting + Boiling and Powdering)



↓

Various Analysis Techniques for proximate composition, Beta carotene (HPLC) and minerals (Calorimeter and AAS)



Figure 6: Sample preparation flow diagram

4.5 Proximate Analysis

4.5.1 Moisture

Moisture of the seed flours were determined according to AOAC (2000). The empty aluminum dish and its lid were dried in drying oven at 100^0C for 1h and cooled in a desiccator. The dried and cooled dish together with the lid was weighed. About 5g of the prepared carrot samples (raw, roasted, boiled, boiled+roasted and powdered) were weighed and dried in drying oven with air circulation at 105^0C for 3hrs, cooled in a desiccator and then weighed. The amount of moisture was calculated by using the following formula. The result is shown in Table 6.

$$\text{Moisture} = W_2/W_1 \times 100\%$$

Where: W1= weight (g) of sample

W2=loss of weight (g)

4.5.2 Ash

The ash content was determined by AOAC (2000) using the official method 923.03.The cleaned crucible with its lid were dried in a muffle furnace at 5500C for 1h and cooled in a desiccator for 30 min. Aut 5g of the prepared carrot samples (raw, roasted, boiled, boiled+roasted and powdered) were weighed with and without lid and charred on a hot plate until the smokes disappeared. The charred sample was put in the muffle furnace at 550^0C and ashed for 3hrs and then left in the muffle overnight. The ashed sample was cooled in a desiccator for 1h and weighed when it cools. The amount of ash was calculated by using the following formula. The result is shown in Table 6.

$$\text{Ash \%} = W_2/W_1 \times 100\%$$

Where: W1= weight (g) of sample

W2=weight (g) of ash

4.5.3 Crude protein

Protein content was determined according to AOAC (2000) using the official method 979.09. In a cleaned Tecator flask, 0.5g of sample was weighed, 6mL of concentrated sulphuric acid (AR) was added and allowed to stand for 24hrs. After 24 hrs 3.5mL of H_2O_2 (30%) was added step by step. When the violent reaction stopped it was shacked and left in the rack. Three g of accelerated reagent (a mixture of copper sulphate pentahydrate and anhydrous potassium sulphate) was added and left for 15 minutes. The mixture was digested in a digest stove (HYP-1008 eight holes) at 370^0C for 4hrs. After digestion it was cooled in the hood on the rack, 25mL of distilled water was added to dissolve the precipitate, 25 mL of 40% NaOH was added to the digested sample and placed in the distiller (KDN-102F, nitrogen analyzer distillation device). 25mL of H_3BO_3 (saturated solution), 25mL of distilled water and 3 drops of methyl red were added in the 250mL conical flask and placed in the distiller (KDN-102F, nitrogen analyzer distillation device). In the distillation when about 150-200mL distillate was collected it was titrated with 0.1 N HCl and the amount of HCl was recorded. The amount of protein was calculated by using the following formula and the result is shown in Table 6.

$$\text{Crude protein \%} = \frac{V_2 - V_1 \times N \times 14.01 \times 6.25}{10\ W}$$

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

V2= volume (ml) of hydrochloric acid solution required for the test sample

N= normality of hydrochloric acid

W= weight of sample

14.01= equivalent weight of nitrogen

6.25= Nitrogen to protein conversion factor

4.5.4 Crude fat

The crude fat was extracted according to AOAC (2000) official method 4.5.01.The cleaned flask (cylinder) and boiling chips was dried in the drying oven at 1000C for 1h, cooled in the desiccators for 30min and weighed. Two grams of sample was weighed in thimble containing fat free cotton. The thimbles were placed in the thimble holders, 50mL of petroleum ether (boiling range of 60-900C) was poured in the flask, the thimble was immersed in the petroleum ether (in the flask) and heated at 800C in the fat determinator (SZC-C fat determinator) for 1hr, hanged the thimble and heated at the same temperature for 2hrs and then the solvent was recovered for 15 min. The heater was switched off, the flask was dried in the drying oven at 900C for 30 min, cooled in the desiccators for 15 min and then weighed the flask with the extract. The amount of extractable fat was calculated by using the following formula and the result is shown in Table 6.

Weight of fat (W_f)= W_a-W_b

Where: W_a = weight of extraction flask after extraction

W_b = weight of extraction flask before extraction

$$\text{Crude fat content (\%)} = \frac{W_f \times 100}{W}$$

Where: W = Weight of the sample

4.5.5 Crude fiber

Crude fiber analysis was conducted using the method of AOAC (2000) official method 962.09. About 1.5g sample was transferred into a 600 ml beaker and about 200 ml 1.25% sulfuric acid was added and boiled for 30 minutes. Recording took place by placing a watch glass over the mouth of the beaker. After 30 minutes heating by gently keeping the level constant with distilled water, 20 ml of 28% KOH was added and again boiled gently for further 30 minutes, and then the solution was filtered through sintered glass crucibles. Subsequently, washing was conducted with hot distilled water, 1% sulfuric acid, 1% NaOH solution and finally with acetone.

Then, filtered and dried it in the electric oven (memmert 854 Schwabach, West Germany) at 130ºC for 2hrs. Furthermore, it was cooled at room temperature for 30 minutes in a desiccator and weighed, then transferred it to crucible to muffle furnace (GALLENKAMP, Model FSL 340-0100, U.K.) for 30 minute ashing at 550^0C. Finally, it was cooled again in a desiccator and re-weighed. The crude fiber content was determined by using the formula and the result is shown in Table 6.

$$\text{Crude fiber content (\%)} = \frac{(W_1 - W_2) \times 100}{W_3}$$

Where, W_1 = crucible weight after drying

W_2 = crucible weight after ashing

W_3 = weight of sample

4.5.6 Crude carbohydrate

The crude carbohydrate was calculated by difference method. The mathematical expression is as follows:

Crude carbohydrate (%) = 100-(%crude fiber + % crude protein + % crude fat +% total ash + moisture)

4.6 Minerals

Calcium, zinc, magnesium and iron were determined using atomic absorption spectrophotometer method of AOAC (2000).). The ash obtained after dry ashing at 550^0C was treated with 5 ml of 6N HCl to wet it completely and carefully dried on a low temperature hot plate. 7 ml of 3N HCl was added and the dish was heated on the hot plate until the solution just boils. It was cooled and filtered through a Whatman filter paper in to a 50mL volumetric flask. Again seven ml of 3N HCl was added to the dish and heated until the solution just boils. Finally, cooled and filtered into the

volumetric flask. For the determination of calcium, lanthanum chloride (1% w/v) was added to both standards and samples to suppress interference from phosphorus. Using atomic absorption spectrophotometer (Varian, spectra-10/20, Australia) a calibration curve was prepared by plotting the absorption or emission values against the metal concentration in mg/100g. Reading was taken from the graph, which depicted the metal concentrations that correspond to the absorption or emission values of the samples and the blank. The metal contents were calculated by using the following formula.

$$\text{Metal Content (mg/100g)} = (a-b)b/100\times W$$

Where: W = weight of samples (g)

V = volume of extract (ml)

a = concentration of sample solution (µg/ml)

b = concentration of blank solution (µg/ml)

- **Determination of phosphorus and Potassium**

The ash obtained after dry ashing at 550 0C was treated with 5 ml of 6N HCl to wet it completely and carefully dried on a low temperature hot plate. 7.5 ml of 3N HCl was added and the dish was heated on the hot plate until the solution just boils. Then, it has been cooled and filtered. Again, 7.5 ml of 3N HCl was added to the dish and heated until the solution just boils. Finally, cooled and filtered into the 50mL volumetric flask and then filled with distilled water. Five ml of the sample dilution, 0.5 mL molybdate reagent and 0.20 mL aminonaphtholsulphonic acid reagent were added into a test tube and let stand for 10 minutes. The absorbance at 660 nm was read using spectrophotometer (BECKMAN, DU-64, and Japan) against distilled water. The standard (As) was prepared by mixing standard phosphorous solution, molybdate reagent and aminonaphtholsulphonic acid. The blank (AB) was prepared by mixing molybdate reagent, aminonaphtholsulphonic acid and deionized water. The concentration of phosphorus was calculated first by subtracting the blank from all other reading and by using the following formula:

Mg p/100g = Abs-blank/slope×S.wt

Where: S.wt=weight of sample

Abs= absorbance

The molybdate reagent was prepared by taking 75 ml of 10 N H_2SO_4 in a 250 mL volumetric flask and dissolving 6.25 g of ammonium molybdate in a beaker in about 50 mL water and then transferring the beaker solution into the volumetric flask. The aminonaphtholsulphonic acid reagent was prepared by dissolving 100 mg of 1, 2, 4 aminonaphtholsulphonic acid in 39 mL of sodium bisulphate solution, and then adding 1 Ml of sodium sulphite solution. Sodiumbisulphite15 % and Sodium sulphite 20 % solution was prepared by dissolving 7.5 gm sodiumbisulphite in 50 mL of water and 2 gm sodium sulphite in 10 mL of water respectively. The standard phosphorous solution was prepared by dissolving 438.8 mg of KH_2PO_4 (water free) in some water in a 100 mL volumetric flask, adding 1 mL conc. H_2SO_4 and diluting to the mark with water. The standard curve was made by taking 0.1, 0.2, 0.4, 0.6, 0.8 and 1.0 mL of the standard solution and diluting to 100mL.

The Potassium content of both the Nantes and Chantenay carrots were determined by a flame photometer (Jenway PFP7, UK) after digesting representative 2g sample with diluted (1:1) nitric acid (Osborne and Voogt, 1978).

4.7 Beta Carotene Analysis

4.7.1 Reagents and standards

All Chemicals used in the analysis of beta-carotene were HPLC grade. Acetone, petroleum ether, acetonitrile, methanol, ethyl acetate, triethylamine, DMSO (Dimethyl Sulfoxide) were used. An analytical standard of beta-carotene (Sigma-Aldrich, St. Louis, MO, USA) was used to calibrate and quantify the beta-carotene. All chemicals such as, concentrated nitric acid (HCl), de ionized water for metal analysis were of analytical grade and all glassware were soaked overnight in 10 % (v/v) nitric acid, rinsed with distilled water for about three times and dried before using.

4.7.2 Beta carotene standard preparation

The standard was prepared using crystal form of 95% HPLC grade beta carotene type II produced by sigma Aldrich stock solution was prepared 30µg/ml in DMSO (Dimithyl Sulfoxide).

4.7.3 Extraction and partition

The analysis was done based on the method described by Rodriguez-Amaya and Kumar (2004) under low light conditions. Extraction and partition were carried out under a hood and dark conditions.

Acetone were used in this method because it readily available and easily penetrates food tissues well .0.1% BHT was added as a solvents. Exactly 2.5 g of carrot samples was taken and sufficient deionized water (about 10ml) was added to cover the surface, and then allowed to stand for 30 minutes. About 20ml of cold acetone was added and left to stand for 15 minutes. Then the solution was filtered using whatmann No. 4 on a Buchner funnel. The solid was placed in a mortar, ground well with the pestle, about 50 ml of cold acetone (acetone refrigerated for 2 hours) was added ,and that was grounded again with the pestle to extract the carotene .It was filtered through the same funnel and collected in the same flask . The mortar, pestle funnel and residue were rinsed with small amounts of acetone; the rinse was received in the flask will extract. The extraction was repeated until the residue become colorless.

The extract was partitioned between petroleum ether (PE) and water in a separating funnel. About 20 ml of petroleum ether was placed in a separator funnel then one third of the extract and 300ml of deionized water were added. The deionized water was slowly added down the wall of the separator funnel to minimize emulsion. The aqueous lower phase was discarded. The partitioning was repeated for the rest portions of the extract sequentially. After the third portion was partitioned, the PE layer was washed three times with deionized water to remove acetone. In the last washing, it was discarded the lower phase as completely as possible without discarding any of the upper phase.

The upper phase was collected by passing it through small funnel with anhydrous sodium sulphate (about 15 g) to remove residual water in 50 ml round flask for analysis. Glass wool was used to

plug the funnel to hold the sodium sulfate. The funnel was washed with small amount of petroleum ether collecting the washing into the flask.

4.7.4 HPLC Analysis of Beta carotene

The extracted sample collected in 50 ml round bottom flask from separetory funnel was concentrated in a rotary evaporator T $\leq 35^0$c and dried under nitrogen gas then, re-dissolved using 1ml of acetone. Finally, the solution was filtered using 0.22µm PTFE syringe filter and injected into HPLC.

Beta-carotene analysis was performed using Aglient 1260 infinity series consists of quatrinary pump, auto sampler, and column thermostat and chemstation software. The beta carotene were separated on Monomeric C18 column: waters Spherisorb ODS 2 (2µm, 4.6 ×250mm) operated at a flow rate of 0.5ml/min. Three mobile phases were used and they were mixture of acetonitrile, methanol, ethyl acetate with 0.05% triethylamine. The gradient elution program was set as follows 95:5:0 to60:20:20 in 20minutes, staying the proportion until40 minutes, then to 20:20:40 in 20 lipids re-equilibration was for 15 minutes. The column temperature was 30^0c and the wavelength of UV visible was 450nm.The injection volume was 10µl. The beta carotene content was calculated using the formula:

$$C_x\,(\mu g/g) = \frac{Ax \times Cs\left(\mu\frac{g}{ml}\right) \times \text{Total Volume of extract (ml)}}{As \times \text{Sample Weight (g)}}$$

Where: C_X is concentration of carotenoids of sample

A_x is peak area of carotenoids of sample

C_s is concentration of the standard

A_s is peak area of the standard

- **Retention**

Retention was calculated using apparent retention. Apparent retention is defined as the ratio of the nutrient content in the cooked food to the nutrient content in the raw food, expressed on a dry basis (Murphy et al., 1975). The following is the formula:

$$\text{Apparent retention \%} = \frac{\text{Nutrient content per g of cooked food}}{\text{Nutrient Content per g of raw food.}} \times 100\%$$

4.7.5 Recovery Experiment for beta carotene Analysis

The recovery was used to determine the method accuracy. Accuracy is the degree of average measurement with an accepted reference. In this study the accuracy of the technique was evaluated in terms of % recovery values between 70% and 120% were considered as acceptable range.

$$\text{Recovery} = \frac{\text{Conc.Spiked sample _un spiked sample}}{\text{Conc.Analyte added (spiked)}} \times 100\%$$

The recovery was performed by spiking sample with known amount of beta carotene standard (1µg/ml) and analyzed as per the method and the results were compared to determine the effect of the matrix on the accuracy of the analysis. The method recovery was 76.4% which is within the acceptable range.

4.7.6 Limit of Detection

Detection is the lowest concentration of analyte in the sample that can be detected, not necessarily quantified under stated experimental conditions. The method of detection is defined as the concentration value of the studied compound for which the signal (S) to noise (N) ratio is higher than three (S/N>3) (FDA,1994).In this study the instrument detection limit was performed by preparing serial dilution of beta carotene standard for 0.07µg/ml,0.06µg/ml and 0.05µg/ml and run each of them seven times. The signal (S) to noise (N) ratio greater than three (S/N>3) was obtained for 0.07µg/ml.

4.8 Data Processing and Analysis

Determination of Vitamin A as pro-vitamin beta carotene and major minerals (iron, Magnesium, calcium, zinc) in the two variously processed carrot varieties were done in triplicate using HPLC, AAS respectively and calorimeter for phosphorus and Potassium; respectively. Data were analyzed using statistical software SPSS version 20.0 and subjected to analysis of independent t-test, ANOVA and least significant difference (LSD). P-value of <0.05 was considered to be significant.

5. RESULTS AND DISCUSSION

The effects of processing (Roasting, boiling, boiling + roasting and powdering) on the nutrient compositions and levels of beta-carotene. Carrots of local varieties that were obtained from local farmers in Wolayta zone, Soddo Woreda.

5.1 Proximate composition

The proximate compositions of processed and raw carrots was shown in the Table 6. Moisture content of both varieties of carrots ranged between 89 - 91.8 to Chantenay and 88.5 - 90.2 for Nantes. Accordingly, the total ash content of the processed and raw carrots of the two varieties ranged between 0.88 - 1.9 to 0.9 - 1.9 for Chantenay and Nantes, respectively. Protein content of raw carrot ranged from 1.23 - 0.18 for Chantenay and Nantes ranged between 1.53 - 0.51.

The fat content of both varieties of carrots which were raw and processed were significantly different ($p<0.05$). Crude fiber content of the two varieties which were processed and raw were not significantly different ($p<0.05$). The carbohydrate content for Chantenay ranged between 6.7 - 3.39 and 7.6 - 4.29 for Nantes .The results of fiber and moisture are significantly different between the two varieties of carrots which submitted to the same processes.

Results are expressed as $\pm$ SD under each table.

Table 6: Proximate composition of raw and differently processed carrots

Samples analyzed	Raw		Boiled		Roasted		Boiled +Roasted		Powder	
	Chantenay	Nantes	Chantenay	Nantes	Chantenay	Nantes	Chantenay	Nantes	Chantenay	Nantes
Protein	1.72 ±0.7^{a}	1.53±0.1^{a}	0.4±0.03^{b}	0.73±^{b}	0.66±0.41^{b}	0.33±.15^{b}	0.18±0.02^{c}	0.61±0.0^{c}	1.71±0.2^{a}	1.4±0.2^{a}
CHO, by difference	5.35±56^{a}	6.58±1.3^{a}	4.85±2.4^{b}	5.47±0.9^{b}	6.77±1.9^{a}	7.39±0.32^{a}	4.68±0.5^{b}	5.48±1.4^{b}	88.88±4.1^{c}	89.43±0.6^{c}
Fiber	1.1±0.4^{a}	1.2±0.5^{a}	1.23±0.3^{a}	1.3±00^{a}	1.13±0.3^{a}	1.28±0.1^{a}	1.13±0.5^{a}	1.31±0.01^{a}	1.06±0.4^{a}	1.06±0.3^{a}
Moisture	90.6±1.5^{a}	89.4±0.4^{a}	91.4±0.1^{a}	90.4±1.17^{a}	89±3.6^{a}	88.5±5.6^{a}	91.8±0.3^{a}	90.2±1.3^{a}	7.25±5.2^{b}	6.97±05^{b}
Ash	0.88±0.0^{a}	0.9±0.0^{a}	1.9±0.0^{b}	1.9±0.0^{b}	1.9±0.06^{b}	1.89±0.01^{b}	1.8±0.01^{b}	1.9±0.0^{a}	0.8±0.04^{a}	0.8±0.3^{a}
Fat	0.35±0.1^{a}	0.39±01^{a}	0.22±0.0^{b}	0.2±0.0^{b}	0.54±0.0^{c}	0.61±0.0^{c}	0.41±0.01^{a}	0.5±0.1^{c}	0.3±0.2^{a}	0.34±0.2^{a}

Values with the same row followed by different superscripts are significantly different at $P < 0.05$.

5.1.1 Moisture

The result was analyzed and this result showed that the moisture content is 89% for raw Chantenay and 88.5 for raw Nantes and the different processes increase the moisture content except powdering which ranged between 6.97% for Nantes and 7.25% for Chantenay. the result agrees with the study conducted in Nigeria showed 91.000 ± 0.265 which indicates that carrot contained much water which will help in healthy hydration of the body system, in transport of nutrient, elimination of waste and body temperature regulation (Olalude, 2015).

The moisture content of powdered carrot varies from 8.6 to 8.9% in studies by Anon 1952; Howard et al. 1962; Gill and Kataria (1974) which agreed with the result found in this study 8.8±5.2% -8.7.3%.

Gopalan et al. (1991) have reported the chemical constituents of carrot with moisture content of 86%, the values reported by Holland et al. (1991) also revealed that the moisture content of Roasted carrots contain an average 88.8% in which the result agreed with the finding of the present study.

5.1.2 Ash

The total ash content of raw carrots for both varieties was found to be 0.88% and 0.9% Chantenay and Nantes respectively. The trends of the results showed an increment in ash content as it is processed differently except powdering which resulted 0.8% for Chantenay and 0.82% for Nantes. The results agree with the Ethiopian food composition estimate which was reported to range between 0.9 - 1.9 (ENRHI, 1997).

Almeida.M, 1997 reported in the range of 1.2 to 1.09 for raw 0.21-0.41 for boiled ash content. These variations are due to variation in the soils, climate and genetic variation. When we compare the processing there was no significance difference ($p>.0.05$) in the total ash content.1.9, 1.9, 1.8, 0.8 for Chantenay and 1.9, 1.89, 1.9, 0.8 for Nantes when it's boiled, roasted, boiled + roasted and powdered, respectively. Olalude, (2015) reported ash content of 1.333 ± 0.153% which is lower than the results found in this result.

5.1.3 Protein

The protein content of both carrot varieties Chantenay and Nantes, ranged between 1.23%-0.18% to 1.53% - 0.51%. In a study conducted in Brazil the protein content of raw carrots of different varieties ranged 1.01 -1.26 % (Almeid.M, 1997) which agreed with the values found in this study.

The result in this study also agreed with the result expressed in Ethiopian food composition table which ranged between 0.40-1.7% (ENRHI, 1997). The composition of protein reduced as the carrots subjected to different treatments (1.23% to 0.18% for Chantenay) and (1.53 % to 0.51% for Nantes).

The variations in protein content may be attributed to the variety, soil and agronomic practices. The investigation further indicated that processing methods significantly reduce ($P<0.05$) the crude protein content as compared to raw carrot. There were 1.23% to 0.18% for Chantenay and 1.53 % to 0.51% for Nantes reduction in the protein content of roasted, boiled, and roasted + boiled, powdered respectively. The observed reduction in protein content of roasted, boiled, roasted + boiled samples might be due to leaching out of some amino acids (the sulfur containing amino acids) and heat denatured the protein (Bhatty, et al., 2000).

5.1.4 Crude fat

There is a tendency of an increment in fat contents of both carrot varieties which are subjected to different processes including roasted, and boiling + roasting. Crude fat of 0.367% of fat was reported by Olalude (2015) which is in agreement with the finding of this result which ranged between 0.35 -0.39 for both raw Chantenay and Nantes.

All values of boiled and powdered carrots of Chantenay and Nantes ranged between 0.2 - 0.3 for Chantenay and 0.22-0.34 for Nantes. The results agree with the values in the Ethiopian food composition which range between 0.2-0.4 (ENRHI, 1997).

5.1.5 Crude fiber

The content of fibers in carrots of the two varieties ranged between1.1-1.23% for Chantenay and 1.06 – 1.31%. Katherine (1991) boiled samples have crude fiber contents of 1.5% which were

exceed the result found in this study. Olalude (2015) reported that crude fiber % 1.167 ±0.153 which agreed with the result in this finding. Almeida, (1997) has also reported the fiber content of boiled carrots to be1.65%-2.41%, which was greater than from both varieties of carrot in this study submitted to the same treatments which have lesser fiber contents. There was a trend of increasing in fiber content when both species of carrot varieties submitted to different treatments. This is may be cooking resulted in increased solubilization of pectin and arabinogalactan (Katherine and james, 1991; Nawirska and Kwasniewska (2005).

5.1.6 Crude carbohydrate

The edible portion of carrots contains about 10% carbohydrate s having soluble carbohydrates ranging from 6.6 to 7.7 g/100 g and protein from 0.8 to 1.1 g/100 g in 4 carrot cultivars (Howard et al., 1962). Raw carrots of both varieties Chantenay and Nantes have crude carbohydrate 6.7 % and 7.6% which was comparable to the finding of Olalude (2015) reported a lesser value, which was 6.1%.

Due to the processing methods there was increasing and decreasing effect on the content of crude carbohydrate. There were 3.39 % for Chantenay 5.3% for nantes,5.4% Chantenay 6.8% Nantes 5% Chantenay 4.29% Nantes for and 8.01 % chantney,8.9% Nantes ,both decreased in crude carbohydrate content of boiled, Roasted, and Roasted+ boiled respectively. Loss in carbohydrate during roasting and boiling might be due to leaching of soluble carbohydrates like sugars into the cooking water (Esenwah and Ikenebomeh (2008).

- **Percentage losses in Proximate composition as compared to raw Carrots**

Proximate composition has been significantly affected by thermal processing of both Chantenay and Nantes carrots. As can be seen from figure 6 below, Chantenay varieties are the most affected by the thermal processes showing up to 90% loss in protein especially during roasting + boiling and 77% during boiling. The smallest reduction in all proximate compositions was observed in powdering of both Chantenay and Nantes carrots. An exception if the high/significant loss in moisture content of the powdered carrots showing up to 90% reduction.

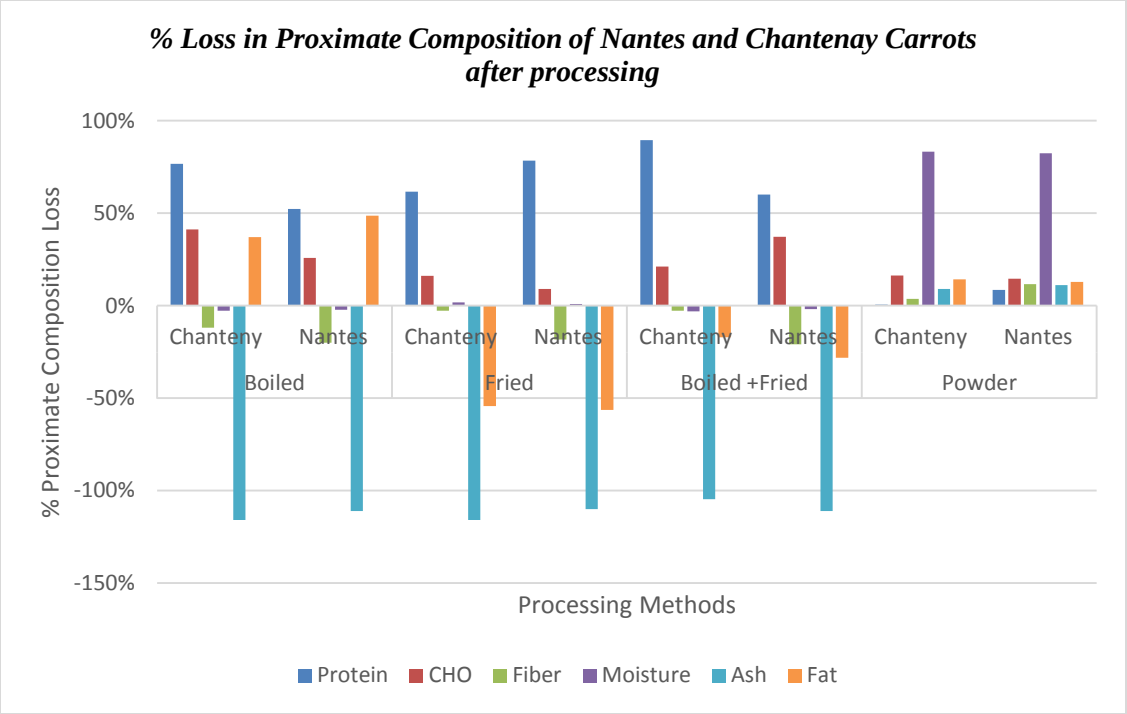


Figure 7: Percentage Loss of Proximate Composition after Various Processing Methods

Figure 6 also shows that an increase in ash and fat contents of both Nantes and Chantenay carrot varieties during thermal processing especially roasting and roating + boiling. This could be attributed to the fact that the oil used in roasting might have added to the dry matter and fat content of the samples.

5.2 Mineral composition in raw and processed carrots

The mineral content of raw and processed of Chantenay and Nantes carrots is presented in Table 7. There was a loss of zinc in Chantenay when it was boiled and boiled and roasted. Leaching as a result of the boiling is responsible for the losses in both. The loss was in boiled and Roasted which ranged between 0.2±0.0 – ND to 0.4±00- 0.19±0.0. Iron was ranged between 1.4±0.4-0.34±0.0 for Chantenay and Nantes respectively. Magnesium were increased in the process of Roasting in the Chantenay ($p>0.05$). Potassium also increases in all processes the result ranged between 203.3±5.7 to 318.3±2.8. Calcium content of both varieties ranged between 30.3±6.6 -31±3.6 to 31± 6.6 -31 ± 2.6 Chantenay and Nantes respectively. The phosphorus content of both varieties are not significantly different ($p>0.05$) for the carrot varieties which were raw and powder.

Table 7: Fe, Mg, K, Ca, P, Zn content of processed and raw carrots (mg/100 g)

Samples analyzed	Raw		Boiled		Roasted		Boiled +Roasted		Powder	
	Chantenay	Nantes	Chantenay	Nantes	Chantenay	Nantes	Chantenay	Nantes	Chantenay	Nantes
Iron	1.29±0.0^{a}	1.26±0.6^{a}	0.4±0.0^{b}	0.3±0.02^{b}	1.0 ±0.4^{a}	1.1±0.2^{a}	0.34±0.0^{b}	0.32±0.0^{b}	1.2±0.0^{a}	1.2±0.0^{a}
Magnesium	10.36±1.5^{a}	9.16±0.5^{a}	9.9±0.2^{a}	8.8±1.2^{a}	12.1±0.2^{b}	12.9±0.1^{b}	10.9±0.2^{a}	9.9±0.1^{a}	10.2±0.1^{a}	9±0.9^{a}
Potassium	203.3±5.7^{a}	215±5^{b}	201±10^{a}	212±6.42^{a}	313.9±2.3^{b}	227.2±7.7^{b}	208.3±2.8^{a}	219±2.5^{b}	198.±1.1^{a}	212±8.7^{b}
Calcium	31±4a	30. ±2.6^{a}	31±3.6^{a}	28.9.±2.5^{a}	30.3±6.6^{a}	32.3±2.5^{a}	31±00^{a}	31.3±4^{a}	30.3±6.6^{a}	30.6±1.5^{a}
Phosphorus	33±0.0^{a}	33±1^{a}	19.96±0.0^{b}	20±0.2^{b}	19.9±0.04^{b}	19.83±0.0^{b}	32.9±00^{a}	33±33^{a}	33±0.0^{a}	32.9±0.0^{a}
Zinc	0.2±0.0^{a}	0.4±00^{b}	ND	0.2±0^{a}	ND	0.19±0.0^{a}	ND	0.3±0.0^{b}	0.2±0.0^{a}	0.4±0.0^{b}

Values with the same row followed by different superscripts are significantly different ($P < 0.05$).

- **Iron**

Gopalanet al. (1991) have reported iron 2.2 mg/100 g which exceed the amount found in this study which were ranged between 1.29-0.34 mg/100 g for Chantenay and 1.2-0.3 mg/100g. the values reported by Holland et al. (1991) showed that iron 0.4 mg/100 g, which agreed with the result of which were boiled Chantenay 0.4mg/100g ,the result for both Chantenay and Nantes which were boiled +Roasted 0.34mg/100g ,0.32mg/100g respectively agreed with the standard set by The United States Department of Agriculture (USDA) Nutritional nutrients data base for standard reference offers nutrients compositions of carrot 0.3mg/100g (USDA,2010).

Singh and Kulshrestha (2008) reported that powder carrot is a good source of iron 1.26mg/100g which agreed with the result of this finding 1.2 mg/100g for Chantenay and 1.26mg/100g for Nantes.

Iron is a micro nutrient that is most often deficient in developing countries, with children and women of reproductive age especially at risk of such deficiencies (Melaku et al., 2005). Its deficiency cause anemia and the symptoms recognized by low blood iron level, small number of red blood cells and low blood hemoglobin values (de Ferra, et al., 1997). Iron deficiency is common only among children and pre-menopausal women. Great care must be taken not to take too much iron, as excess amounts are stored in the body's tissues, and adversely affect the body's immune function, cell growth and heart health (wadlaw and Insel, 1996).

Low content and bioavailability of iron in the typical cereal-based diet is a major cause of iron deficiency (Sandberg, 2002).In developing countries iron deficiency, due to poor bioavailability, retards normal brain development in infants and affects the success of pregnancy by increasing premature deliveries, as well as morbidity of mother and child at around child birth. It also affects working capacity, thus impairing socio-economic development as well (Malenganisho et al., 2007).

- **Magnesium**

The magnesium content of Chantenay and Nantes which were subjected to different treatments have no significant difference $p>0.05$. The result of both varieties of carrots of raw and boiled 10.36mg/100g, 9.16mg/100g for Chantenay and 10.2mg/100g ,9 mg/100g for Nantes agreed with the standard set by USDA,(2010) which 12mg/100g and 10mg/100g. Mg is associated with abnormal irritability of muscle and convulsions and excess Mg with depression of the central nervous system (Budavari, 1997).

- **Potassium**

Potassium content of the two varieties of carrots are significantly different $p<0.05$. Different processed significantly affects the potassium content of the two varieties of carrots. The values reported by Holland et al. (1991) the potassium content of processed carrot 240 mg/ 100 g which agreed with the results which were found in this study which ranged between 203.3mg/100g -312 mg/100g for Chantenay and 215mg/100g -332mg/100g for Nantes. This might be due to variation in soil, climate and genetic variation.

Potassium is an electrolyte that dissolves in cellular fluid along with calcium and sodium and conducts electricity. Adequate potassium intake is essential for muscle contraction and a steady heart rhythm. An adult, need 4,700 milligrams of potassium each day (Roger et al., 2011).
Low potassium intake in the United States is considered a major contributor to the prevalence of hypertension and CVD, with the percentage of attributable risk (PAR) for low potassium intake at 17% for hypertension (systolic BP [SBP] >140 mm Hg) (Geleijnse et al,2003) . In the United States, increased potassium intake alone would decrease the number of adults with known hypertension by 17% and would increase life expectancy by 5.1 years for over 12 million Americans (Roger et al., 2011).

Hypertension mortality was documented at 54,707 for 2008, and hypertension was mentioned as an underlying cause for mortality for about 300,000. Conservatively, an increase in potassium intake could save over half a million lives over the next decade. Potassium is important effort to prevent kidney disease, stroke, and cardiovascular disease (Kristal and paul,2013).

- **Calcium**

Calcium content of the two varieties of carrots are not significantly different $p>0.05$.Different treatments boiling, Roasting, boiling+Roasting did not affects the composition of the calcium in Chantenay and Nantes significantly. Holland et al. (1991) reported Calcium 34 mg/100 g content of calcium which agreed with the result of this finding which were ranged between 30.3mg/100g -31mg/100mg for Chantenay 31mg/100g -32.3 mg/100g. It also agreed with the standard set by Ethiopian food composition 31 mg/100g (ENHRI,1997).USDA (2010) set 33mg/100g.

- **Phosphorus**

The phosphorus content of raw carrots of Chantenay and Nantes ranged between 33mg/100g -19.9mg/100g to 32.9mg/100g -20mg/100g respectively. Gopalan et al. (1991) have reported 53 mg/ 100 g of phosphorus which exceed with the finding of this research whereas, the values reported by Holland et al. (1991) for phosphorus was 25 mg/100 g which is greater than the result for the two processes which were boiled and Roasted in the finding of this study. The result of this study agreed with the USDA,(2012) standard which is 35 mg/100g.

Phosphorous (or phosphate) is part of the phospholipids, an essential functional component of cellmembranes, and is part of high energy phosphate compounds like e.g. adenosine triphosphate (ATP) and creatine phosphate, the biological energy conservation molecule which is essential to all vital processes. Phosphorus is also an essential component of hydroxyapatite, the main structural bone mineral. Deficiency of phosphorus is common in malnourished children and severe hypophosphatemia is associated with increased mortality in kwashiorkor (Manary et al., 1998).

Phosphorus deficiency is also likely to cause rickets-like bone changes in malnourished children. Phosphorous is likely to be a limiting nutrient in treatment of children. Absorption of dietary phosphorus is high (55-70%), relatively independent of dietary composition, and does not appear to be up-regulated at low intakes. (Golden, 2009).

- **Zinc**

The zinc content of boiled and Roasted for both varieties of Chantenay and Nantes are significantly different $p<0.05$.The values ranged between 0.2mg/100g to 0.19-0.4mg/g respectively. Both processes results significant amounts of losses. This loss might be due to

leaching. Holland et al. (1991) reported 0.2 mg/ 100 g which agreed with the result of Chantenay. Zinc is an essential trace mineral that is a component of over 200 enzymes and is known to be necessary for normal collagen synthesis and mineralization of bones, and is involved in vital processes such as mitosis, synthesis of DNA and protein, and gene expression and activation (Walingo, 2009).

Deficiency of Zn is highly prevalent in developing countries, but also in vulnerable groups with high requirements in industrialized countries, such as women of fertile age, infants and adolescents (Sandberg, 2002).

Approximately one third of children in low-income countries are stunted (Walingo, 2009). Zinc deficiency is presumed to be the underlying cause of stunting and delayed sexual maturation. Zinc supplementation increases linear growth in stunt children which suggests that these high rates of stunting may be due in part to zinc deficiency (Walingo, 2009).

Zinc nutritional status influences the absorption, transport and utilization of vitamin A. The enzyme that plays a major role in the oxidative conversion of retinol to retinal is zinc dependent, and may be adversely affected in zinc deficiency (Adeyeye et al., 2000).

- **Percentage Losses in Mineral Content as Compared to Raw Carrots**

The percentage loss in minerals content of both Nantes and Chantenay carrots under various processing methods was calculated taking raw carrots as controls. Zinc is the most affected mineral during thermal processing exhibiting 60% to 100% loss in both Chantenay and Nantes varieties. Iron and Phosphorus were also significantly affected showing more than 50% loss in all thermal processing methods especially in boiling and roasting + boiling. Magnesium and Potassium were the least affected demonstrating less than 10% loss and even some insignificant increase in roasting. This, in part could be attributed to the addition of these minerals from the niger seed (*Guizotia abyssinica (L.f) CASS*)) oil that was used to roast the carrots. Please refer to figure 7 below.

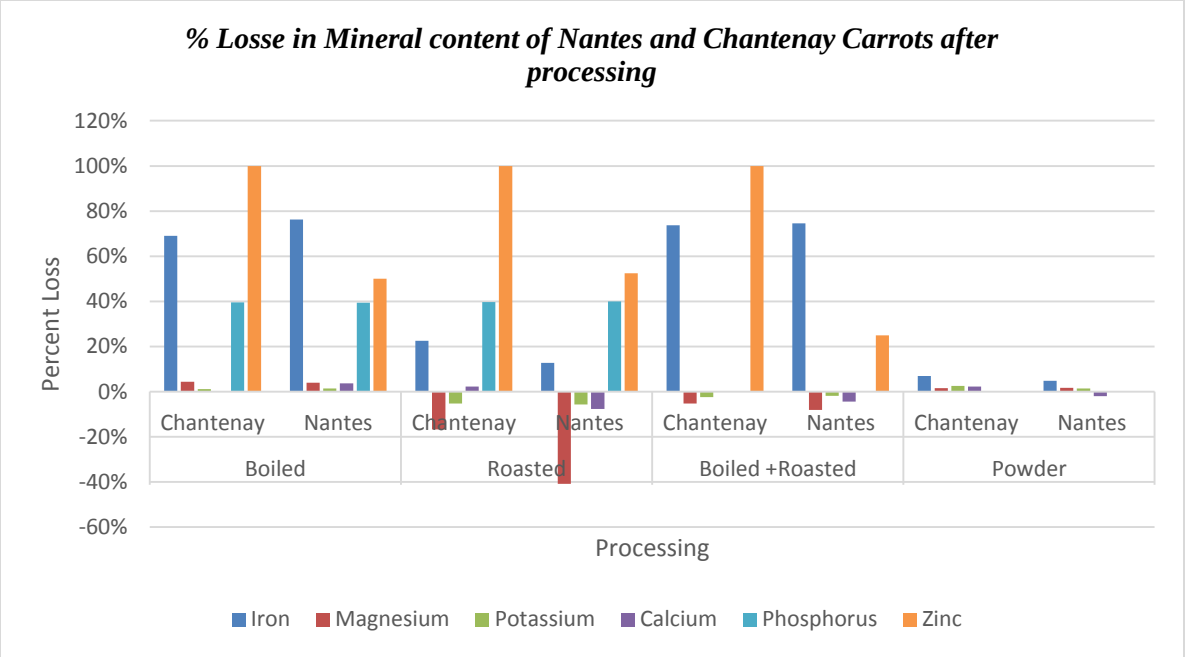


Figure 8: Percentage Loss of Mineral Content after Various Processing Methods

The least loss in minerals content was observed in powdered form of both Nantes and Chantenay carrots. The reduction in minerals content of both carrot varieties as a function of the powdering process is insignificant (1% to 7%).

5.3 Beta-carotene composition

The results of analysis of beta-carotene composition of raw and processed carrot varieties are presented in Table 8. The beta-carotene content in the Chantenay which were went through different treatments range from 8824.0 µg/g to 1933.3 µg/g. The β-carotene content in the Nantes which were processed in the same way as the Chantenay range from 8900.00 ±0.00µg/g to 2466.6 ± 57.73 µg/g. Different processing methods affects the β-Carotene content between the two varieties in a significant amounts and Statistically there was significant difference ($P<0.05$) between the two carrot varieties which were subjected to the same treatments in their beta-carotene content and significance difference among each treatments within the group also observed.

Table 8: Beta-carotene content of processed and raw carrots µg/g

Beta carotene	Chantnay	Nantes
Raw	8824.0 ± 21.6 [a]	8900.00 ±0.00[b]
Boiled	4173 ± 64.29[c]	5600.0 ±0.00[d]
Roasted	3566.6 ± 57.3[e]	3206 ± 11.54[f]
Boiled + Roasted	1933.3 ± 57.7[g]	2466.6 ± 51.3[h]
Powder	6183.3 ± 70.3[i]	8400.0 ± 0.00[j]

[a-b] Values with the same row followed by different superscripts are significantly different (P<0.05).

Carrots are a globally important vegetable crop providing a source of important nutritional compound including pro-vitamin through their carotenoids content and have been one of the most important means used to mitigate vitamin A deficiency (Simon and Wolff, 1987). Carrot roots are a rich source of carotenoids, precursors of vitamin A. The carotenoids contained in the edible portion of carrots can range from 6000 to more than 54,000 µg per 100 g, (60–540 ppm) (Simon and Wolff, 1987).The color of carrot root is the result of various pigments that serve as an intermediate products in the carotenoids path (Koch and Goldman,2005). The major pigments responsible for orange and yellow color in carrot i.e. chantey and Nantes are α-carotene and β-carotene. The β-carotene often represent 60 % or more of total carotenoids content (Rubatzky etal., 1999). Higher β-carotene were found in raw Nantes of this study (8900.00 ± 0.00µg/g) than Chantenay (8824.0 ± 21.6).

The United States Department of Agriculture (USDA) Nutritional nutrients data base for standard reference offers nutrients compositions of raw carrot 8285.00 µg/100g (USDA,2010) in which both results 8824.00 ±21.6 and 8900.00 ±0.00 respectively exceed with the standard set by USDA this is due to factors such as cultivar, stage of maturity, geographic site of production, processing and storage (Bureau et al,1986).

Alteration or loss of carotenoids i.e. Beta-carotene during processing and storage of foods occurs through physical removal, geometric isomerization, and enzymatic or non-enzymatic oxidation. In home preparation, losses of carotenoids generally increase in the following order: microwaving <

steaming < boiling. Deep Roasting and substantial losses of carotenoids (Rodriguez-Amaya, 2002).

Whatever the processing method β-carotene retention decreases with longer processing time, higher processing temperature, and cutting of carrot; as a result of enzymatic activity and oxidation (Rodriguez-Amaya, 2002). A study conducted in Kenya revealed that powdering retain 127.8mg/100g of β-carotene (Mwangi.K,2009).

The evaluation of β-carotene content of dehydrated powder carrots in India 23.9 mg/100g (krishan, 2011). Singh and Kulshrestah (2008) reported carrot powder is a good source of beta-carotene. In this study boiling +Roasting significantly affected the beta-carotene content of both varieties Chantenay and Nantes 1933.3±57.7 µg/100g, 2466.6±51.3 µg/100g respectively.

- **Percentage losses in Beta Carotene Content of Nantes and Chantenay Carrots as compared to raw Carrots**

This study showed that beta carotene is greatly affected by thermal processing methods. Figure 8 shows the percentage losses of beta carotene content as a function of the various treatments or processing methods. The highest level of loss in beta carotene content is shown in both Chantenay and Nantes varieties that were roasted + boiled. Chantenay and Nantes carrots that undergo roasting + boiling lost 78% and 72% respectively. Nantes carrots that were boiled and roasted lost 37% and 64% respectively while Chantenays that undergo same process lost 53% and 60% of their beta carotene content. The least level of beta carotene loss was observed in powdered carrots. Powdered Chantenay carrots lost 30% while Nantes lost only 6% of their beta carotene content.

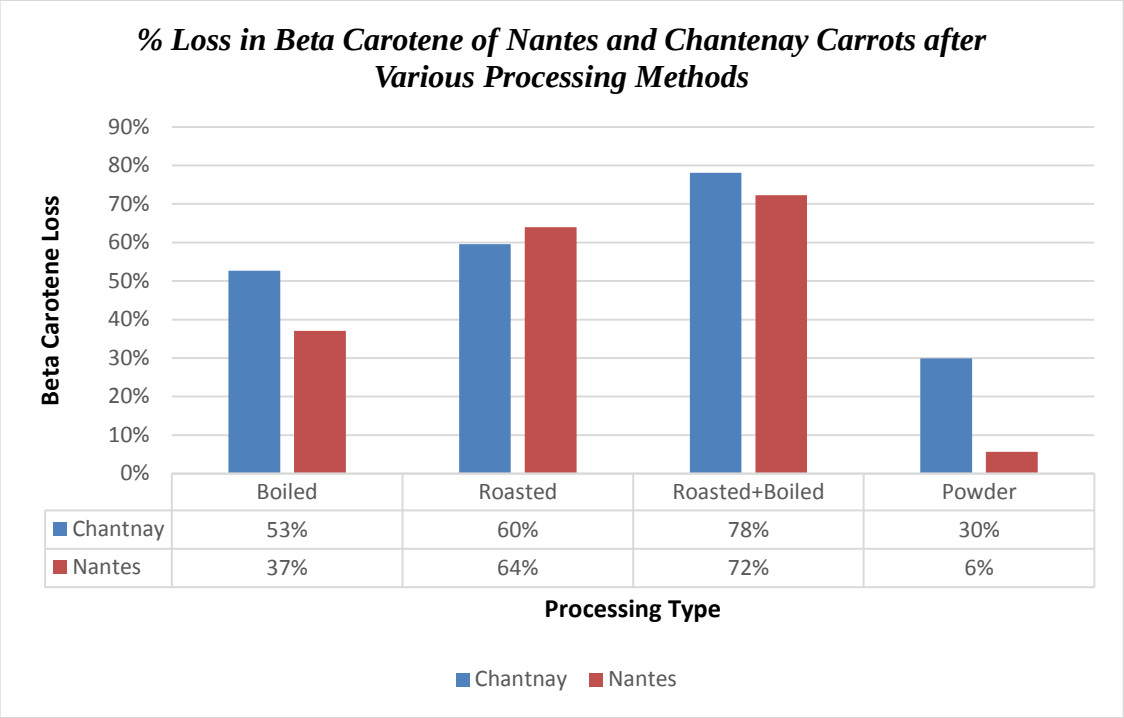


Figure 9: Percentage Loss of Beta Carotene after Various Processing Methods

6. CONCLUSION

This study clearly revealed that, Nantes is the type of carrot varieties which contains higher amounts of beta-carotene proximate composition, and minerals such as Fe, K, Ca, and Z in quantities than Chantenay. Beta carotene content was found to be significantly higher in treated Nantes than Chantenay carrot varieties; hence Nantes carrots are preferably better for the types of treatments in this study.

According to the Dietary reference intakes series, National Academies Press2005,by the National Academies of Sciences Infants daily requirements ranged between 400-500µg/day, children ranged between 300-400µg/day, for both males and females ranged between600-900µg/day, pregnant and lactating women ranged between 750-1300µg/day.

The beta carotene contents of both varieties are sufficient enough to support to optimal health. In order to combat vitamin A deficiency carrot is an important step to recommending and promoting the food to consumer.

The study also demonstrated, powdering is a better method which causes less loss of beta carotenes, proteins carbohydrates, fibers, ashes and fats except moistures which is greater loss in both Chantenay and Nantes.

The study indicates that the minerals in all the carrots varieties varies when subjected to different treatments there is loss of iron when it undergoes boiling, roasting and boiling + roasting. Magnesium is significantly affected during the above processes. Potassium is significantly increased when it's boiled, roasted, and boiled + roasted in both varieties of carrots probably due to release from cell components as a result of the treatment. Calcium is not significantly different in different treatments, Phosphorus is affected significantly by boiling and roasting

This study as well reported that all the samples contain less amount of zinc. There was a significant amount of zinc lost during boiling and roasting.

7. RECOMMENDATIONS

1. Agriculture sector specialists should play their role to enhance the production and accessibility of Nantes and/or Chantenay varieties based on the specific nutritional and shelf life requirements of a farming community.
2. Optimization of cooking temperatures and time to find optimum processing condition may need further study.
3. The Nutrition sensitive agricultural practices that enhance the coverage and effectiveness of nutrition-specific interventions should be promoted. All stakeholders who work on combating VAD should take their part to increase the knowledge and awareness of the public on available carrot varietal selection for various types of dish for maximum nutritional benefits.

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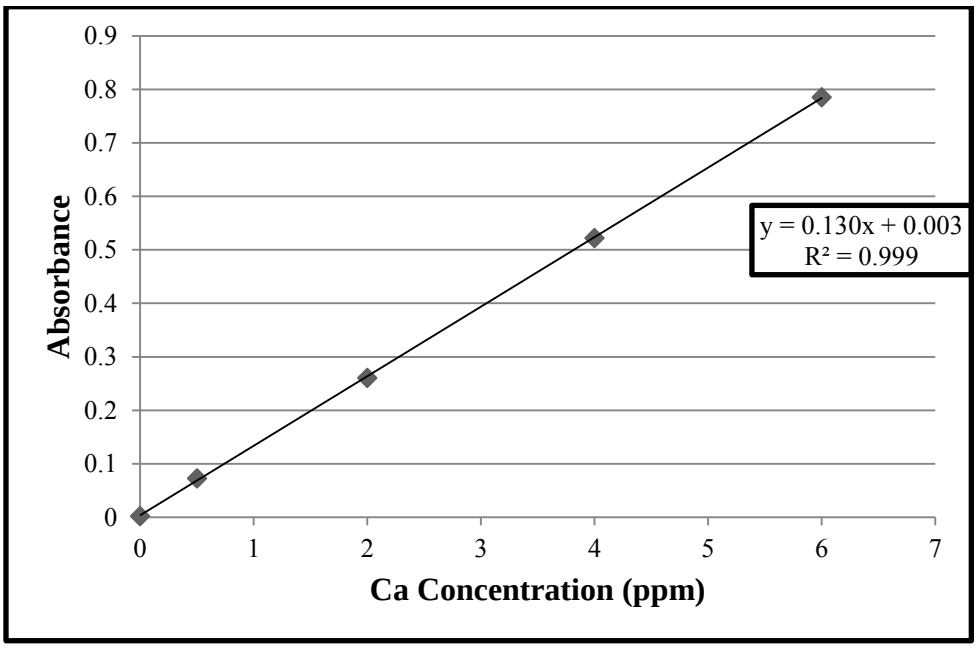
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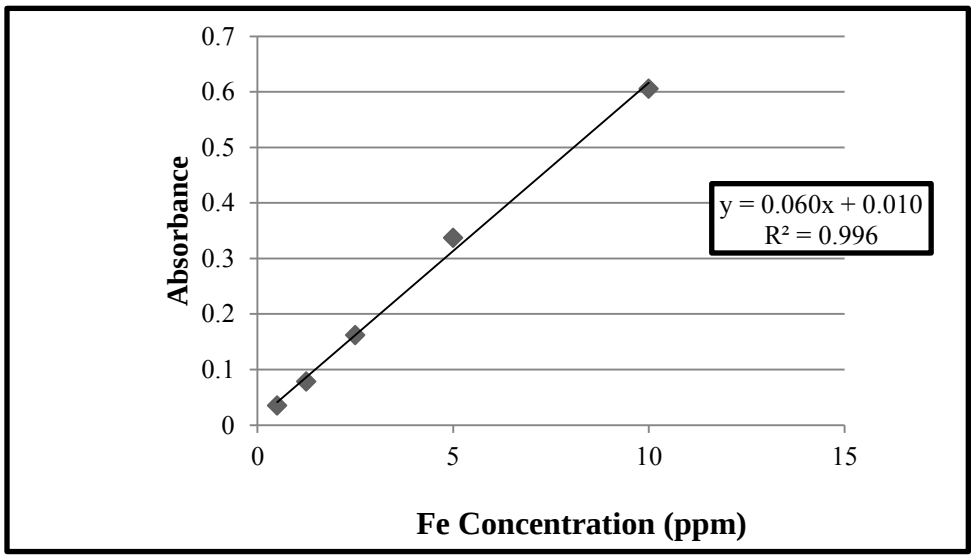
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APPENDICES

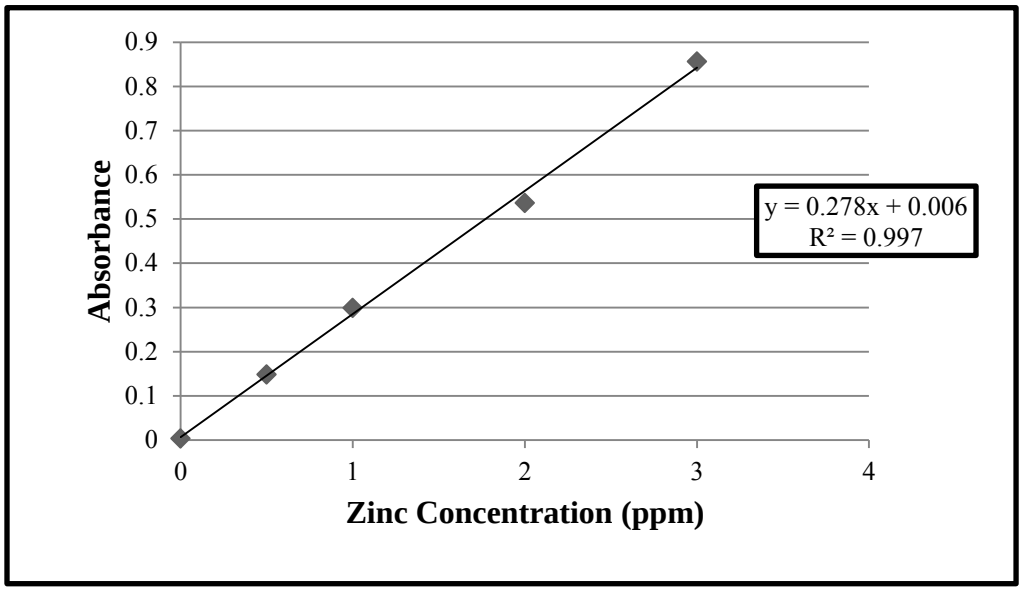
Appendix 1. Calibration Curve for Calcium



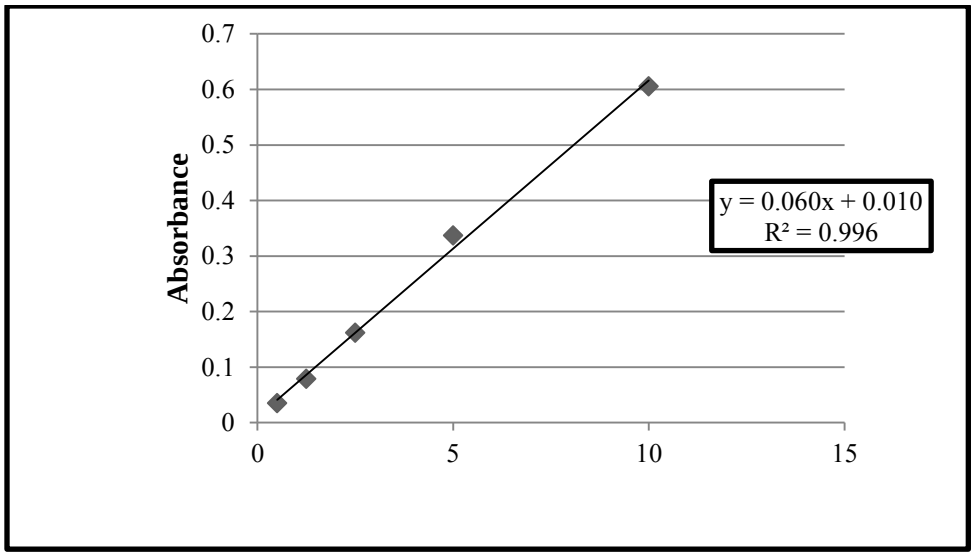
Appendix 2. Calibration Curve for Iron



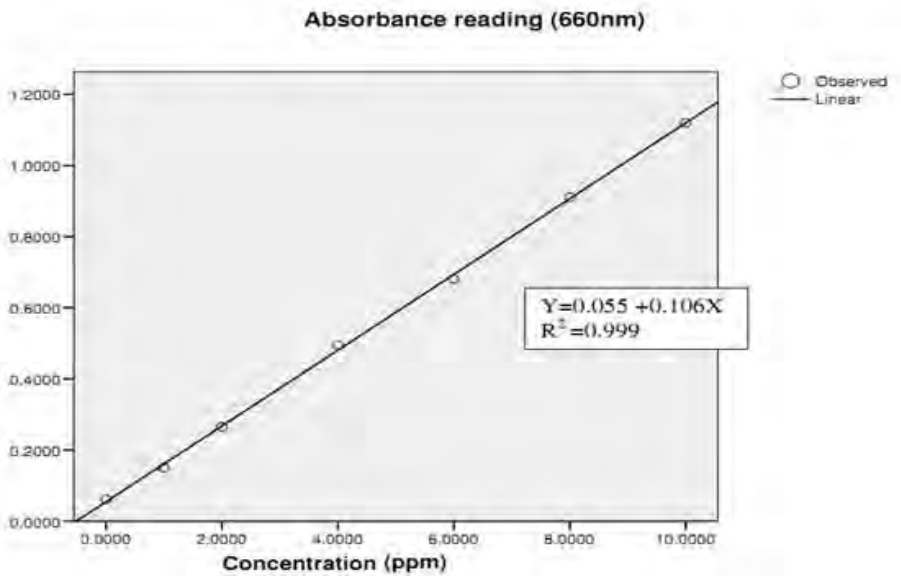
Appendix 3. Calibration Curve for Zinc



Appendix 4: calibration curve for Magnesium (ppm)



Appendix 5. Calibration curve potassium



Appendix 6. Calibration curve Phosphorus

