1. INTRODUCTION

Micronutrients play a central part in metabolism and in the maintenance of tissue function. Micronutrients are life sustaining nutrients that are needed only in small quantities for effective functioning of brain, the immune system, reproduction and energy metabolism but their deficiency make a considerable negative impact on health and learning abilities (Chaudhary, Pareek, & Sharma, 2011). There is growing interest in the role of the micronutrients (essential trace elements and vitamins) in optimizing health and in prevention or treatment of disease. Micronutrients are most important in global public health terms; their lack represents a major threat to the health and development of population worldwide. Their deficiency results in devastating public health problem affecting people throughout the socio economic spectrum. Children are frequently the victims of micronutrient deficiencies and failure to overcome micronutrient deficiency in a sustainable fashion jeopardizes a nation’s future (Baltussen, Knai, & Sharma, 2004).

Micronutrient deficiency is better known as hidden hunger because it is often ignored and underappreciated as there are no visible or physical symptoms of deficiency until later in life. Hidden hunger is a chronic lack of essential vitamins and minerals, with potentially devastating effects despite the fact that people often don’t realize that they are suffering from hidden hunger. For example, a lack of vitamin A can impair the immune system and make children more vulnerable to diseases such as measles, diarrhea, and malaria. Lack of iron can cause anemia in women and children. A fetus or infant that suffers from iodine deficiency may become mentally impaired (Arlappa et al., 2011).

The World Health Organization identified Iron, Vitamin A and Iodine as the “Big 3” that affect at least one-third of the world’s population. World Health Organization estimated that Micronutrient deficiency ranked among the top ten leading causes of death in developing countries. In the developing country like India serious deficiency disorders particularly micronutrient deficiencies associated with Vitamin A, Iron and Iodine are encountered due to dietary insufficiency (Ramakrishnan, 2002).
Micronutrient deficiencies are widespread in the industrialized nations, but even more so in the developing regions of the world (Calton, 2010). In developing countries, where poverty prevails, deep rooted traditions, taboos and false beliefs have imprisoned the people; the serious deficiency disorders of micronutrients and its impact are more acute and profound. The sequelae of micronutrient deficiencies are profound and include premature death, poor general health, blindness, growth stunting, mental retardation, learning disabilities and low work capacity (Hettiarachchi, Lianage, Wickremasinghe, Hilmers, & Abrahams, 2006). It can affect all age groups, but young children and women of reproductive age tend to be among those most at risk of developing micronutrient deficiencies (Budhathoki, Shah, Bhurtyal, Amatya, & Dutta, 2008). Micronutrient deficiency has many adverse effects on human health, not all of which are clinically evident. Thus, in addition to the obvious and direct health effects, the existence of micronutrient deficiency has profound implications for economic development and productivity, particularly in terms of the potentially huge public health costs and the loss of human capital formation (Wimalawansa, 2013).

Almost one third of children in developing countries are affected to some degree by Vitamin A deficiency, which impairs their growth, development, vision and immune function, and in extreme cases leads to blindness and death (Khaliq, Rahman, Rizvi, & Afzal, 2008). Iron deficiency, which leads to anemia, is well recognized as the most common dietary deficiency in the world (including developed countries), affecting mostly children and women of reproductive age. It is estimated that more than half of all pregnant women in the world and at least one third of preschoolers suffer from anemia, and many more are iron deficient to some degree. Hence, it can be concluded that Iron deficiency is harmful at all ages (Kalaivani, 2009). In infants, it impairs physical growth, cognitive development and immunity; at school age it affects school performance; at adulthood it causes fatigue and reduced work capacity; and among pregnant women, anemia may cause fetal growth retardation or low birth weight, and is responsible for a large proportion of maternal deaths (World Health Organization, 2004). Nutritional iodine deficiency is a geochemical environmental problem. Iodine Deficiency continues to pose a serious threat to the health, well being, economic productivity and advancement of several hundred million people throughout the world.
The sad reality is that people living in iodine deficient environment and consuming only locally grown food suffer from reduced mental abilities and are at a considerable risk of producing cretins as offspring. All these conditions have profound implications for the individual and the family and impose significant economic burden on the community at large (Singh, 2007).

In India, micronutrient deficiency is a major nutritional problem which is responsible for about 40-50 percent of the infant’s deaths. In India, 40-60 percent of pre-school children, 25-30 percent of women in their reproductive age and 50 percent of the women in late pregnancy suffer from micronutrient deficiency (Singh et al., 2007). Therefore, it can be concluded that Micronutrient deficiency especially of Vitamin A and Iron poses a serious threat to the health of vulnerable groups of population (Rai, Hirai, Abe, & Ohno, 2002). Globally, night blindness affects 5.2 million pre school age children and 9.8 million pregnant women, which corresponds to 0.9 per cent and 7.8 per cent of the population at risk of VAD (Vitamin A Deficiency), respectively (Administrative Committee on Coordination/Standing Committee on Nutrition, 2004).

Iron deficiency is the most common nutritional disorder in the world. The numbers are staggering: as many as 4-5 billion people, 66-80 percent of the world’s population, may be iron deficient; 2 billion people over 30 percent of the world’s population are anemic mainly due to iron deficiency, and in developing countries, frequently exacerbated by malaria and worm infections (World Bank, 1993; Garica & Mason, 1992; Mothercare, 1992).

Iodine deficiency disorders are a world wide major public health problem. These affect a large segment of populations in all continents of our planet and have been with us from generation; more than 1.5 billion people all over the world are at risk of Iodine Deficiency Disorders (Singh, 2007).

Therefore, the control of micronutrient deficiencies is an essential part of the overall effort to fight against hunger and malnutrition. Countries need to adopt and support a comprehensive approach that addresses the cause of micronutrient deficiency
Introduction

(Food and Agriculture Organization, 2012). Actions that promote an increase in the supply, access, consumption and utilization of an adequate quantity, quality and variety of foods for all population groups should be supported. The aim is for all people to be able to obtain from their diet; all the nutrients; they need to enjoy health and productive life (Andersson, Petersson, & Sidenvall, 2007). There are two basic approaches to meet all the requirements are based on Medicinal supplementation and Food Based Approach (Singleton, Orthofer, & Lamuela-Raventos, 1999).

Various National and International Organizations like ICDS, DWCD, CARE and WFP, considering the gravity of the problem have plunged themselves in the goal of solving the micronutrient deficiency. Government of India has also introduced several programmes to combat these deficiencies. But despite of planning so many alternative strategies and taking so many important steps to reduce micronutrient deficiency, the present nutritional scenario reflects that the nutritional goals to be achieved by 2010 remain as unfulfilled promises and demands for some more practical alternative strategy is realized (Arlappa et al., 2011). Despite of all good intentions and relevant programmes being in place, the nutritional and health status of our vulnerable section is not very encouraging. The developing world has yet to experience relief from the consequential effects of micronutrient deficiency, particularly from lack of Vitamin A and Iron (Simopoulos & Gopalan, 2003).

The medicinal approach for combating micronutrient deficiencies especially of Vitamin A and Iron is less popular because of lower acceptability of medicines by subjects because of the related side effects of gastrointestinal tract like diarrhea, nausea etc. Number of studies have also reported that accidental over dose of iron containing medicinal supplements may cause fatal poisoning in children younger than 6 years (Khademloo, Ajami, Khallilian, & Motamed, 2008; Saha, Chant, & McGrath, 2007; Adsul, Desai, Gawde, & Balliga, 2005). Symptoms of overdose of vitamin A include severe headache, tiredness, dizziness, mental/mood changes such as irritability, depression, loss of appetite, dark urine, severe stomach/abdominal pain (Onakapoya, Wider, Pittler, & Ernst, 2011; West, Klemm, & Sommer, 2010; Villamor & Fawzi, 2005; World Health Organization, 2002; World Health Organization, 2001). This indicated to a clear need for a “FOOD BASED APPROACH” which can provide not
only one nutrient but different micronutrients and many organizations are now laying stress on this approach (Simopoulous & Gopalan, 2003).

World Health Organization also advocates the use of “Food Based Approach” in facing the problem of micronutrient deficiency. Food based approaches are working as a tool to prevent micronutrient deficiencies. The most sustainable approaches to increasing the micronutrient status of populations are food based approaches, which include food production, dietary diversification and food fortifications as well as value addition at commercial and household levels. Food based interventions focus on food – natural, processed, fortified, or in combination – as the primary tool for improving the quality of diet and for overcoming and preventing micronutrient deficiencies (Chaudhary, Pareek, & Sharma, 2011).

The basis of this approach is to increase the production and consumption of foods, especially those rich in micronutrients, as well as their absorption and utilization in the body. These approaches are aimed at increasing the intake of micronutrients, programmes that deliver micronutrient supplements often provide the fastest improvement in the micronutrient status of individuals or targeted populations groups (Vijayaraghavan, 2002). The Food and Agricultural Organization of the United Nations is committed to placing food based strategies for preventing micronutrient deficiencies high on the development policy agenda and urges all parties to speed up their wider implementation. Therefore various organizations are now laying stress on “FOOD BASED APPROACHES (Elizabeth & Raj, 2008).

Government need to make cost effective efforts to improve the food supply and the diets of vulnerable group. Such actions should be seen as an investment in human resource development and nation-building. Micronutrient deficiency usually occurs when diets lack variety and therefore, vitamins and minerals needed to prevent micronutrient deficiency which present in a variety of foods (Ahmed, Jabbar, & Ehui, 2000). Policies and programmes need to be developed and implemented to ensure better year round access to and consumption of an adequate variety and quantity of good quality, safe, micronutrient rich foods. Food based approaches are working as a tool to prevent micronutrient deficiencies. These are defined as ‘a preventive and
comprehensive strategy that uses food as a tool to overcome micronutrients deficiencies and ensures a supply of small quantities of micronutrients on a continuous ongoing basis with an aim to provide micronutrients through natural dietary sources (Kidala, Greiner, & Gebre-Medhin, 2000). The objective of the food based approach is to ensure that people get micronutrients in sufficient quantity through their daily diet. A number of researches have been done in this direction and has given positive results (Raghuramulu, Nair, & Kalyansundaram, 2003; Bamji, Rao, & Reddy, 2003; Sri Lakshmi, 2003; Gopalan, Ramasastri, & Balasubramanian, 2003; Adfule, 2002; World Health Organization, 2001; Park & Park, 2000).

The time and effort to implement the strategy offer the potential for long lasting benefits. They are preventive, cost effective and sustainable and can be adapted to different cultural and dietary traditions and locally feasible approaches. They are broad based, aimed to improve the overall quality of the diet of a population; they can address multiple nutrient deficiencies simultaneously. It builds partnerships among government, consumer group, the food industry and other organizations to achieve the shared goal of overcoming micronutrient deficiency. The risk of toxicity is minimized because the amounts of nutrients consumed are within normal physiological levels (Lucca, Hurrell, & Potrykus, 2001; Mulokozi, Mselle, Mgoba, Muyagabuso, & Ndossi, 2000).

Increased availability of micronutrient rich foods, along with increased educational and marketing activities, can greatly increase consumption of these foods among vulnerable groups. Dietary diversification, food fortification and nutrition and health education are all included in the food based approach. Food based rather than drug based approach is a proper answer to the problem of micronutrient deficiency – as indeed to the problem of under nutrition in general. Hence, various steps have been taken by Karnataka State Agro Corn Product Ltd (KSACPL), NIN, CFTRI, ICMR are all making an ongoing effort to produce low cost nutritional supplements enriched with micronutrients to control micronutrient deficiencies.
Introduction

A number of studies have been conducted to highlight beneficial effect of value addition through locally available micronutrient rich food and one such product is Green Leafy Vegetables. The Micronutrient Initiative group (Canada), The International Nutritional Anemia Consultative Group, (Washington) and World Health Organization are now emphasize on the consumption and production of green leafy vegetables and are laying stress on introduction of new crops and promoting the use of more varied diet and dietary diversification (Vijayaraghavan, 2002; Vijayaraghavan, Nayak, & Ramana, 1997).

Many types of greens are consumed all over the country. The commonly consumed greens are palak, amaranthus, fenugreek, drumstick, mint etc. The green leafy vegetables are rich source of beta carotene, iron, calcium, vitamin C, riboflavin and folic acid. These greens are inexpensive and it is advisable to include at least 50 gram of green leafy vegetables in one’s diet. They contain all important nutrients required for growth and maintenance of health. Green leafy vegetables must be consumed by children, pregnant and nursing women to obtain much needed beta carotene, iron and calcium. This is particularly so on a predominantly cereal based diets of the poor who suffer from the dietary deficiency of these nutrients (Gopalan, Ramasastri, & Balasubramanian, 2003). Hence, use of green leafy vegetables must be encouraged in the country like India where the diet is mostly cereal based.

According to the estimates of the National Horticulture Board the national production of vegetables stood at 72.83 million from a cropped area of 5.6 million hectare in 1997, with India taking second position in the world (Manmohan, 2000). The green revolution with its increased global caloric output is said to have contributed to micronutrient deficiency afflicting more than 40 percent of the world’s population (Singh et al., 2007). Agricultural interventions to increase the supply and dietary intake of iron from plant foods are not popular (Ruel, 2001). Many people are unaware of the nutritional value of green leafy vegetables and many may regard them as inferior (Steyn, Oliver, Winter, Burger, & Nesamvuni, 2001b). Lack of popularity and availability were given as possible reasons for the low consumption of green leafy vegetables (Menemyane, Venter, Vorster, & Steyn, 2005).
In India, various types of under-utilized foods are available but are not utilized to the extent they should be in spite of their high nutritive value. Green Leafy Vegetables are good source of micronutrients but are often under-utilized. Looking into the prevalence of high level of micronutrient deficiency among vulnerable section, utilization of under-utilized foods can be explored to overcome the nutritional disorders (Sheela, Nath, Vijayalakshmi, Yankanchi, & Patil, 2004). In nature, there are many underutilized greens of promising nutritive value, which can nourish the ever increasing human population. Now a day, underutilized foods are gaining importance as a means to improve the nutritional status. Green Leafy Vegetables occupy a unique place among vegetables because of their color, flavor and health benefits. It plays an important role in the diet as they provide essential micronutrients and minerals. Being highly seasonal, there is a glut of these leaves in the market during the peak season resulting in reduced price and leading to losses to the growers (Adfule, 2002).

Green leafy vegetables are a store house of many micronutrients and they occupy an important place in the diets of millions of people in India. Green leafy vegetables are rich source of vitamin A, iron and other micronutrients, they are even cheap in cost but because of lack of nutrition education and their perishable nature, people are unaware of their rich composition (Gupta & Prakash, 2011). In a country like India, where most of the people are engulfed in poverty and can’t afford the expensive food products and suffer from various deficiency diseases there is an immediate need to identify cheap and easily available source rich in iron, vitamin A and other micronutrients and green leafy vegetable can be one of them (Joshi & Mehta, 2010). Green leaves are found to be an excellent source of minerals like iron, selenium, copper, zinc and also of antioxidants like carotene and ascorbic acid (Kowsalya & Sangeetha 1999). Since green leafy vegetables supply not only iron but also vitamin C and folic acid, hence there increased consumption can play a role in control of anemia. Green leafy vegetables are offers a cheap but rich source of a number of micronutrients and other phytochemicals having antioxidant properties (Tarwadi & Agte, 2003).

The biggest nutrient contribution of green leafy vegetables is towards total vitamin A intake. Vitamin in plant foods is present in the form of Pro vitamin A carotenoids, mostly of beta carotene (Faber, Jaarsveld, & Laubscher, 2007a). Pro
vitamin A carotenoids achieve vitamin A activity when they are converted to retinol in the body. Green leafy vegetables are good sources of Pro vitamin A carotenoids. It is generally accepted that 6 µg of beta carotene equals to 1 retinol equivalent (RE) of vitamin A activity or 1 µg retinol. The net bioavailability of beta carotene in green leafy vegetable seems to be lower than previously thought (De Pee et al., 1988). Nevertheless, consumption of cooked and pureed green leafy vegetable was shown to have beneficial effect on improving vitamin A status (Haskell et al., 2005; Haskell et al., 2004; Takyi, 1999). A study was done by Faber, Venter, & Benade, (2002b) showed that home gardens that focused on green leafy vegetable and yellow/orange fleshed vegetables improved children’s vitamin A status in South Africa.

A study done on African children of 2-5 year old, it was found that for children consuming green leafy vegetables, these vegetables contributed 19 to 39 percent of total iron intake (Faber, Jaarsveld, & Laubscher, 2007a). However, availability of iron from green leafy vegetables can be influenced by many factors: oxalates, tannins and ascorbic acid being the important ones. The in vitro availability of iron from commonly consumed green leafy vegetables in India was found to be 2.8 to 4.6 percent. The availability of iron did not increase with the increase in ascorbic acid content of green leafy vegetable but there was a trend towards decreased bioavailability of green leafy vegetables containing large amounts of oxalates (Chawla, Saxena, & Seshardi, 1988). Therefore, an attempt was made to study the effect of processing on the nutrient content of green leafy vegetables.

Green leafy vegetables contain high amount of moisture and are not good source of calories and are highly perishable. Augmenting utilization and avoiding wastage calls for employing suitable preservation techniques that are user friendly and sustainable at the commercial and household level. Although there are number of techniques by which we can improve the nutritive quality, reduce the content of inhibitors like oxalate, phytate and shelf life of green leafy vegetables and ensure their consumption on daily basis. Preservation techniques can prevent huge wastage as well as make them available in the lean season at remunerative prices. Vegetables can be therefore processed and preserved by simple traditional inexpensive methods like blanching and dehydration (Joshi & Mehta, 2010; Mepba, Eboh, & Banigbo, 2007).
BLANCHING stops all life processes, inactivates enzymes, fixes green color and removes certain harsh flavors common in green leafy vegetables (Mepba, Eboh, & Banigbo, 2007). DEHYDRATION is one of the simplest method of preserving the green leafy vegetables. In dehydration, the moisture content of the food is reduced and the growth of microorganisms in the dried food is retarded. Removal of moisture from green leafy vegetables is the key to enhance their shelf life and dehydration works on the same principle (Gupta, Sehgal, Singh, & Singh, 2012). Dehydration simultaneously combines heat and mass transfer. It reduces the water availability in food products to such an extent to minimize qualitative and quantitative deterioration of foods by reducing rates of chemical reactions. It is one of the oldest methods of food preservation and an important food processing technique (Lima, Queiroz, & Nebra, 2002). Dehydration not only facilitates reduction in the bulk of fresh material, easy transport because of reduced weight and volume but also increases availability of food throughout the year (Gupta, Sehgal, Singh, & Singh, 2012).

Dried green leafy vegetables have been consumed traditionally especially in many parts of Asia and Africa. Seasonal shortage of green leafy vegetables has been reported in many African countries and thus green leafy vegetables are dried traditionally for use during seasons of shortage. Pumpkin and cowpea leaves are traditionally dried in Zambia. Leaves of tete (Amaranthus hybridus), soko (Celosia argentina) and labagba (Solanum mudiflorum) are commonly used for drying in south western parts of Nigeria (Gupta & Prakash, 2009).

Sreemulu (1980) from Tanzania and Ifon & Bassir (1980) from Nigeria highlighted that dehydrated green leafy vegetables to be a good source of micronutrients, while analysis of dehydrated green leafy vegetables by Faboya (1983) clearly indicated that they are rich source of minerals. An advantage of using dehydrated green leafy vegetable is that they can be easily incorporated in different food products. Dehydrated curry leaf powder was successfully incorporated into extruded maize product in Andhra Pradesh (Bhavani & Devi, 1996). Scientists from Defense Food Research Laboratory, India, have undertaken studies on effect of blanching and dehydration of green leafy vegetables, so as to find their utility as leaf vegetables based curry mixes to be used as part of rations. Among the vegetables
studies, Chakota and Fenugreek leaves had better color and vitamins (carotenoids and vitamin C) retention and found suitable as a natural vitamin supplement for use in curry mixes (Premvalli, Majumdar, & Madhura, 2001).

Blanching of green leaves help in reducing the anti nutrient content of leaves and dehydration makes green leafy vegetables equivalent to legumes in their nutrient content (Joshi & Mehta, 2010). Dehydration also makes them a concentrated source of vitamins and minerals and thus they become a very suitable “NATURAL FORTIFICANT”. In addition to increasing variety in the menu and reducing wastage, dehydrated vegetables are simple to use and have a longer shelf life than fresh vegetables. The dried leaf powder can then be incorporated in various recipes in acceptable proportion (Joshi & Mehta, 2010). In this way we can ensure the consumption of micronutrient rich green leafy vegetables on daily basis.

Thus the present research was an effort to use food as a major tool to overcome micronutrient deficiency particularly in case of school going children (7-9 years), especially of Iron and Vitamin A, and to use the less utilized green leafy vegetables as the cheap and easily available food source to combat micronutrient deficiency with the following objectives.

OBJECTIVES OF THE STUDY:

- To perform nutritional estimation of selected fresh green leaves.
- To perform nutritional estimation of Blanched dehydrated and Non Blanched dehydrated green leafy vegetables.
- To formulate recipes by incorporating different proportions of dry leafy powder and perform their organoleptic evaluation.
- To assess and compare the effect of various cooking methods on micro nutrient content of both control and most accepted recipes.
- To study the shelf life of most accepted recipes
- To calculate cost and nutritive value of most accepted products.