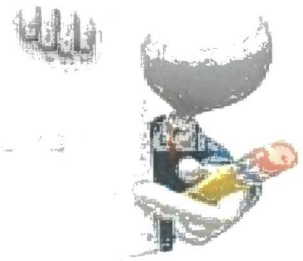

Introduction

I INTRODUCTION

Micronutrient deficiencies are a significant cause of malnutrition and associated ill health among populations in developing countries (Dhakar *et al.*, 2011). Also known as 'hidden hunger', micronutrient deficiency at the subclinical level causes poor general health and decreased school and work performance occur with an increased mortality risk. In May 2008, the Copenhagen Consensus Expert Panel consisting of top economists including Nobel Laureates considered 30 options and ranked the provision of micronutrients as the world's best investment for development. In a recent publication by the World Health Organization (WHO), it is estimated that approximately 25 per cent of the population worldwide suffers from anaemia, two billion people have an insufficient iodine intake (WHO, 2008; 2009) and 0.9 and 7.8 per cent of the preschool and pregnant population are at risk of vitamin A deficiency respectively (WHO, 2009).

Together with vitamin A and zinc deficiencies, iron deficiency has the largest documented disease burden among micronutrients (WHO, 2009a). According to the World Hunger and Poverty Facts and Statistics (2012), iodine deficiency disorders affect over 740 million people, 13 per cent of the world's population. Iodine deficiency is the most prevalent cause of brain damage in the world (WHO, 2009) with fifty million people having some degree of mental impairment caused by iodine deficiency disorders.

The importance of eliminating micronutrient malnutrition has long been recognized by India's policy makers and is well reflected in the country's policy documents like the National Nutrition Policy and the National Nutrition Plan of Action. The three major micronutrient deficiencies of public health significance are vitamin A deficiency, iron deficiency anaemia and iodine deficiency disorders (Horton *et al.*, 2008). According to the recent NNMB report (2006), the prevalence of anaemia in India was found to be 78, 75, 70 and 67 per cent among the lactating women, pregnant women, adolescent girls and preschool children respectively. Bitot's spot (0.8%) is still above the WHO cut off points (0.5%) and the overall prevalence of total goitre is still four

per cent. According to Bhat *et al* (2008), about 200 million people in India live at risk of iodine deficiency disorders, whereas more than 71 million people are suffering from goitre and other disorders related to iodine deficiency and 38 million newborns per year are at risk of mental impairment because of iodine deficiency.

Micronutrient deficiency undermines the potential of billions of people worldwide, limiting both their physical and mental growth during the vital years of childhood. Consequently, a series of global goals and a large amount of donor and national resources have been directed at such micronutrient deficiencies and India is ranked third in the world after Nepal and Bangladesh with 47 per cent of the children suffering from malnutrition with dire consequences of morbidity, mortality, productivity and economic growth (Eleventh Five Year Plan, 2011-12). Around the world, at least two billion people live with vitamin and mineral deficiencies (Micronutrient Initiative, 2009).

Known clinical outcomes of micronutrient deficiencies include impaired growth and cognitive development, poor birth outcomes, anaemia, cretinism, and blindness (De-Regil *et al.*, 2011). Iron deficiency if left uncorrected, leads to anaemia of increasing severity, reduced work capacity, diminished learning ability and increased susceptibility to infections. Vitamin A deficiency results in progressive damage in the eye, eventually leading to blindness. Secondary effects include impaired resistance to infection, reduced physical growth, ill health and mortality (Edem, 2009). The Micronutrient Initiative (2009) has estimated that at least two children in the world die every minute of every day because they have not received the protection that vitamin A supplementation can provide. The consequences of iodine deficiency beyond physical manifestation of goitre include reduced cognitive development and function, severe mental and neurological impairments.

Micronutrient deficiencies are a major obstacle to socio-economic development in many countries. They have an immense impact on the health of the population. These deficiencies contribute to a vicious cycle of malnutrition, underdevelopment and poverty affecting already underprivileged

groups. Solving micronutrient malnutrition may therefore be seen as a precondition for rapid and sustainable development. Poverty is often at the root of micronutrient malnutrition and is also linked to inadequate access to food, sanitation and safe water and lack of knowledge about safe food handling and feeding practices (Latham *et al.*, 2011).

The primary causes of micronutrient malnutrition are inadequate intake of micronutrient rich foods and impaired absorption or utilization of nutrients in these foods which may be due to infection or parasitic infestation, which also increase metabolic needs for many micronutrients. Micronutrient deficiency can also result from excessive loss of nutrients from the body, increased requirements during special physiologic conditions, or a combination of these factors.

Though the WHO has constructed a large pool of information on children's weights, heights and ages, data on most other specific indicators of nutritional outcomes, such as wasting or micronutrient deficiencies, are still insufficient. Working on this point shall help to identify appropriate intervention points by providing a complete picture of the food situation as possible (Bassett and Nelson, 2010). Infants and children are the most vulnerable groups to micronutrient malnutrition requiring high vitamin and mineral intake for rapid growth relative to the amount of food they consume (De-Regil *et al.*, 2011). Children in developing countries have, in general, a more monotonous diet and may have a higher risk of micronutrient deficiencies (Eilander *et al.*, 2010).Their diets generally provide insufficient amounts of key micronutrients to meet their nutritional needs, and the inclusion of animal-source foods to fill the nutrient gap may not be practical (WHO, 2005).

Since micronutrient deficiencies often coexist and synergistic effects of micronutrients on physical functions may indirectly affect cognition, supplementing children with multiple micronutrients could have greater advantages over single micronutrient supplementation (Eilander *et al.*, 2010).The three immediate methods to address the issue and impacts of micronutrient deficiency are growing staple food crops that are rich in micronutrients, food-based micronutrient interventions (fortifying), and

nutritionally balanced school feeding programs (food-based approaches) with the third being the most widespread intervention (Bhutta, 2008). This method has also been shown to be among the most cost effective global development efforts (Horton, 2008).

The introduction of micronutrient rich complementary foods and fortified foods in the diets of the children are vital to prevent the development of deficiencies. Unfortunately, this dietary gap is often unmet in socio-economically disadvantaged children, either due to the poor nutritional quality of the complementary diet and the unavailability and/or unaffordability of micronutrient rich foods, including commercially prepared fortified cereals. Although various approaches exist, dietary improvement becomes the most logical and sustainable strategy to prevent micronutrient deficiencies. Improving the diet is of paramount importance since it contributes to improvement in overall nutritional status. Attention hence needs to be shifted from supplementation and fortification to the implementation of such food based programmes.

Micronutrient supplementation is a highly cost-effective intervention for child health and reduces all cause mortality among children by nearly one quarter. Well developed supplementation programs provide a reliable source of micronutrients for children in the face of economic instability and rising food prices (Semba *et al.*, 2010).

Commodities for reducing child malnutrition should be chosen on the basis of nutritional needs, program circumstances, availability of constituents and likelihood of impact. Efforts have to be made to achieve these objectives through dietary and nutritional interventions. Using an expensive, currently usually imported, commercial product, as the main food to prevent malnutrition, is undesirable and unsustainable (Latham *et al.*, 2011).

Horticulture crops, particularly fruits and vegetables, are known worldwide as the cheapest and sustainable sources of vitamins and minerals (Wispelwey and Deckelbaum, 2010). The nearly ubiquitous consumption of cereals all over the world gives cereals an important position in international

nutrition. Among these, red rice (*Oryza sativa*) is the partially hulled rice which has a red husk. With a nutty flavour, red rice has a high nutritional value, due to the fact that the germ of the rice is left intact. Whole wheat (*Triticum aestivum*) is known for its rich content of manganese, phosphorous, potassium, zinc, thiamine and folate. Rice flakes (*Oryza sativa*) are tasty flakes that are produced using parboiled rice grains which is both a cereal and a healthy ingredient for various types of vegetarian dishes and the most commonly used iron rich food (ICMR, 1989).

Sorghum (*Sorghum vulgare*) and pearl millet (*Pennisetum typhoideum*) grains are nutritionally comparable or even superior to major cereals owing to higher levels of protein with more balanced amino acid profile, energy, vitamins, micronutrients such as iron and zinc, insoluble dietary fibre, and phytochemicals and sorghum is a potential source of nutraceuticals (Taylor, 2006). Pearl millet bran contains a high proportion of soluble dietary fiber and could be used in an ideal snack (Kaur *et al.*, 2012). Finger millet (*Eleusine coracana*) is the richest in calcium content, about 10 times that of rice and wheat. They are highly nutritious, non-glutinous and non acid forming foods and hence are soothing and easy to digest.

Groundnut (*Arachis hypogaea*) is the world's third most important source of vegetable protein of high biological value (Fernandes *et al.*, 2010). Lotus stem (*Nelumbium nelumbo*), an under exploited food in Tamil Nadu is high in iron, vitamins B and C, along with potassium, copper, phosphorous and manganese. Ponnanganni (*Alternanthera sessilis*), a green leafy vegetable is a good source of β carotene, vitamin C and proved to be beneficial to the eyes (Chandra, 2009).

Sustained benefits have been observed in nutritional status through supplementation of micronutrients by many clinical trials. Long-term effects of early intervention evident in terms of school performance, attendance, cognitive and psychological functioning have also been reported by several studies (Black *et al.*, 2011). Recent recommendations from the American Academy of Paediatrics focus on complementary foods suggesting that strategies are necessary to make micronutrient rich complementary foods

available in countries where the risk of deficiencies are high (Baker and Greer, 2010).

The burden of disease experienced by school age children is large and very little attention has been paid to the health aspects for these school aged children. The NNMB (2001) has reported that child malnutrition in school going children is responsible for 22 per cent of the country's burden of diseases. Community based nutrition programmes have an important role in ensuring wide and timely coverage of key health services, such as immunization. School premises can provide excellent opportunities to provide health and nutrition preventive services to children, whether for curative or preventive child health care (Rai *et al.*, 2009).

Parent education interventions and counselling programmes can improve children's cognitive, social and emotional development and school readiness. Quality in early child development programmes can be maximised through design, curriculum, practise for parents, training for childcare, monitoring and assessment, governance, and supervision. Parenting interventions promote parent-child interactions to improve responsiveness in feeding children, increase attachment, and encourage children's development, care, and feeding. Parenting education and support can be effectively delivered through home visits, community groups, regular clinic visits media or in combination with other components (Aboud and Akhter, 2011).

There exists a considerable gap in the diets of the community in terms of micronutrient intake and one of the reasons behind this could be the inadequate knowledge of nutrition resulting in poor diet choices and lack of dietary diversity. Ramanathapuram district has been underdeveloped in terms of health and nutrition of the residents. In spite of the existing National Prophylaxis Programme in India, micronutrient deficiency still exists. Further, not many studies have been done on the micronutrient nutrition among the populations of Ramanathapuram district. The Eleventh Five Year Plan of the Government of India (2011-12) has pointed out that there are innumerable gaps in the existing nutrition related interventions, micronutrient malnutrition is

not being addressed in a comprehensive manner. Hence the need for the present study.

The **specific objectives** of the present study are: To

- Assess the prevalence of micronutrient deficiency disorders among the various age groups of Ramanathapuram district.
- Estimate the subclinical levels of micronutrient deficiency through biochemical assessment.
- Develop micronutrient rich products incorporating natural food sources that are cost effective and nutrient dense.
- Develop education module for combating micronutrient deficiency.
- Study the impact of dietary interventions on micronutrient status of school going children.