INTRODUCTION

India stands at a very vulnerable position with one of the highest prevalence of undernutrition in the world in spite of improvement in food availability and poverty alleviation. In addition to it, numerous determinants play a role in its causation. Malnutrition in children is more an interplay of female illiteracy, ignorance about nutritional needs of infants and young children and poor access to health care. The interplay of these determinants and their complementary effect makes it difficult to isolate one key factor in causing undernutrition.

The UN ranks India in the bottom quartile of countries by under-1 infant mortality (53rd highest), and under-five child mortality (78 deaths per 1000 live births). Infancy is the most critical and vulnerable period. Protein-energy malnutrition is essentially a syndrome that occurs during the crucial transitional phase of child’s life from breast milk to other types of foods. During this period, children need nutritionally balanced, calorie-dense complementary foods in addition to mother’s milk because of the increasing nutritional demands of the growing body (Sajilata et al. 2002; Umeta et al. 2003).

The under-five years population of India stands at a staggering 112.8 million (Census-India, 2011). However, despite all the advances in health, education and agriculture sectors as well as vast improvements in the country’s economy, India as of 2011, unfortunately figures in the list of countries that had made insufficient progress towards meeting the Millennium Development Goal (UNICEF, 2013). The recently released data from NFHS-4 indicates that the proportion of under 5 year children who are stunted (i.e. too short for age) has fallen from 48.0 percent in 2005-06 to 38.4 percent in 2015-16. Similarly, the proportion of under 5 year children who are underweight (i.e. too thin for age) has gone down from 42.5 percent to 35.7 percent between 2005-06 and 2015-16. However, the proportion of children who exhibit wasting (i.e. too thin for height) has increased from 19.8 percent to 21.0 percent between NFHS-3 and NFHS-4.
According to National Family Health Survey-4 data (2016), only 55 percent children of India are able to receive exclusive breast feeding for the first six months of life and only 42.7 per cent get good, timely and appropriate complementary feeding after six months along with continued breast feeding.

The first year of the life is characterized by rapid growth and changes in body composition with most healthy infants doubling their birth weight by six months and tripling it by one year of age. To meet the demands for growth and development, an adequate intake of energy and a wide variety of nutrients are required. Malnutrition in early childhood has serious, long-term consequences because it impedes motor, sensory, cognitive, social and emotional development. Malnourished children are less likely to perform well in school, have lowered resistance to disease which consequently stifles development and more likely to grow into malnourished adults, at greater risk of disease and early death.

Most growth faltering occurs between the ages of six and 24 months when the child is no longer protected by exclusive breastfeeding and is more exposed to disease and infection through contaminated food or water. Even a child adequately nourished after 24 months of age is unlikely to recover growth ‘lost’ in the first two years as a result of malnutrition.

Protein energy malnutrition is a serious problem in developing countries where a growing population and lack of agricultural development results in a limited supply of high quality protein to the general populations. About 60% of all deaths among children less than five years of age are directly or indirectly attributed to malnutrition. About two-third of these deaths are associated with inappropriate feeding practices and occur during the first year of life. Poor feeding practices during infancy and early childhood, resulting in malnutrition, contribute to impairment of cognitive and social development, poor school performance and reduced productivity in later life (NFHS-3, 2009). PEM is a critical problem with many determinants playing a role in causing this vicious cycle of undernutrition.

One of the key reasons for undernutrition in early life is the faulty and sub-optimal infant and young child feeding practices, which is further compounded by factors such as low birth weight and repeated episodes of illnesses like diarrhea and
acute respiratory infections. The first two years of life provide a critical window of opportunity for ensuring appropriate growth and development of children through optimal feeding.

Early initiation of breastfeeding, exclusive breastfeeding for the first six months of life followed by continued breastfeeding for up to two years and beyond with adequate complementary foods after completion of six months of age is the most appropriate feeding strategy for infants and young children.

Although breast feeding is the best choice for feeding the infant, it meets nutritional requirements of growing infant only up to six months. Thereafter, complementary feeding becomes a necessity for the optimum development of an infant. However, the capacity of a complementary diet to meet the protein and energy requirements of infants depends on its nutritional quality as well as its dietary bulk. This can be achieved through legume supplementation of cereal-based complementary foods. However, their role appears to be limited because of several factors including low protein and starch digestibility, poor mineral bioavailability and high anti-nutritional factors.

Complementary feeding, i.e. introduction of foods other than milk to an infant's diet, is a major step in the development of food behavior, it represents a critical stage from both nutritional and behavioural standpoints, likely to affect the infant's growth and health (Greer et al., 2008; Morgan et al., 2004; Zutavern et al., 2008 and Sloan et al., 2008).

Traditionally complementary foods are liquids and semi-solids which are later replaced by foods eaten by older family members. In some cases these types of foods can be filling and yet not meet the child’s nutrient needs. The shifting from breast milk to solid food is based on the infants’ nutrient requirements for growth, physiological maturation, developmental stages and cultural influences. Complementary feeding practices are considerably different in various parts of the world and whether these diverse patterns confirm to what is optimal is unknown.

Most of the requirement of complementary foods is being met through commercially produced complementary foods prepared by various processes which
are either complicated or too expensive as drum drying and extrusion cooking. Complementary foods, thus prepared are excellent and meet the maximum requirements of the infant. However, these marketed products are too expensive for the target groups who need such a product in developing countries.

Therefore, it is need of the society to develop ways and means of developing economic but nutritionally excellent products within the reach of wider population. The basic bulk raw materials should be locally available staple grains. The process or technology of production should not be sophisticated and it should be highly adaptable. The complementary food formulae should be nutritionally well-balanced in terms of proteins, fats, energy and essential vitamins and minerals. The fibre content should be low or within the permitted limits. It should be pre-cooked or instant so that it can be fed to babies as a soft product by simple stirring in hot or boiling water. It should be microbiologically safe and should have good storage stability.

According to WHO (2003), appropriate complementary diet is one which produce a gruel or porridge that is neither too thick for the infant to consume nor so thin that energy and nutrient density are reduced.

Several traditional food processing and preparation methods can be used at the household or small scale level to enhance the bio-availability of micro nutrients in the agricultural produce based food products. These methods include thermal processing (roasting, parching), mechanical processing, soaking, fermentation, germination and malting. These methods improve the bio-availability of micro nutrients by enhancing the enzymatic activity and decrease or removal of anti-nutritional factors in the prepared formulations.

The locally available agricultural produce as wheat, rice, millets, chick pea and green gram dhal are not costly, and the simple, traditional processing technique can be used to develop easily prepared/available, nutritious, tastier, safer and cost effective complementary foods. Cereal grains and legume seeds usually contain high amounts of anti-nutrients viz. tannin and phytic acid. These bind strongly to minerals and trace elements, such as iron, zinc, copper, calcium and can thereby reduce their bioavailability. Minerals and trace elements are of special importance in infant nutrition for the rapidly growing child.
In the recent years, there has been an increasing recognition of the importance of millets as the substitution for major cereals with respect to protein, energy, vitamins and minerals. In addition, these are rich source of dietary fibre, phytochemicals and micronutrients and hence, they are rightly termed as “nutri-cereals”. Millets are unusually drought resistant and consequently there is progressive increase in the use of these grains as a human food staple. Millet grains survive in arid, hot environments in which more widely used cereals would not thrive. Hence, its production and importance is growing concurrently with global warming.

Sorghum (Sorghum bicolor, L. Moench) is one of the most important crops in the world and is one of the four major food grains of our country after wheat, rice and maize. It is a staple food for millions of poor rural people in Asian and African countries. It has many common names around the world. Sorghum is called great millet, kafir corn, or guinea corn in Western parts of Africa. Other names are jowar (India), kaolian (China) and milo (Spain), (U. S. Grains Council, 2008). It is often referred to as “coarse grain”.

According to Dicko (2005), the protein content in whole sorghum grain is in the range of 7 to 15%. Starch is the main component of sorghum grain, followed by proteins, non-starch polysaccharides and fat. The average energetic value of whole sorghum grain flour is 356 kcal/100g.

Sorghum is rich in mineral content but its nutritional quality is dictated mainly by its chemical composition: presence of considerable amounts of anti-nutritional factors such as tannin, phytic acid, polyphenol and trypsin inhibitors that are undesirable. Hence, elimination or inactivation of such anti-nutritional compounds is absolutely necessary to improve the nutritional quality of sorghum, and effectively utilize its full potential as human food, by using simple household technologies like fermentation or germination (Gilani et al. 2005).

Traditional methods of processing like germination and fermentation are known to have positive effects on the digestibility of sorghum and thus can be used to improve its nutritional quality. Sprouting seeds contain high protein, low unsaturated fatty acids, low carbohydrate and vitamin compared with the ungerminated seeds.
Mineral content such as phosphorus, calcium, zinc and copper are higher in sprouts as the hydrolysis of phytic acid by the phytase enzyme activated during germination.

Due to inadequate knowledge, ignorance on the nutritional and health benefits of sorghum, it is categorized as low nutritional value and a food for the poor but the traditional methods of processing are known to have positive effects on its nutritional quality.

Currently there is an increasing preference among consumers for foods that contain not only traditional nutrients but also provide other compounds that are beneficial to health and well-being. Food systems that feed the world must be changed in ways that will ensure that balanced nutrient supplies are available continuously to all children in adequate, affordable amounts. Even though commercial complementary foods are available, most of them are priced beyond the reach of the majority of the population in less-developed countries like India. These foods are mostly manufactured using high technology and are sold in sophisticated packaging.

There is a need for economic complementary foods which can be prepared easily at home and in community kitchens from locally available raw materials such as sorghum. Use of simple processing technology that is within the reach of the general public in developing countries and does not require sophisticated equipment for formulating complementary mixes is to be encouraged. Such foods can be more nutritious than commercial brands. Increasing work participation of women both in urban and rural areas also has made it necessary that instant foods are available at home for feeding of infants and young children.

Sorghum, the white variety (CSV-23), being locally available, produced in surplus amount and nutritious on the other hand, can be used for preparation of complementary food mixes at home level. White sorghum contains low tannin content due to the absence of a pigmented sub-coat.

Till now sorghum has been used in the food preparations for the adults, animal fodder, alcoholic beverages, industrial applications, etc. There is a need to popularize its use for infant foods by applying several processing techniques and improving its nutritive value and thus formulating a home-based complementary food mix.
So with this view the present study entitled as “Designing of complementary food mixes based on Sorghum (Sorghum bicolor, L. Moench)” was planned with the following objectives:

1. To design complementary food mixes based on sorghum using different processing methods.

2. To evaluate the organoleptic properties, nutritional profile and physico-chemical properties of developed complementary food mixes.

3. To assess the shelf-life of developed complementary food mixes.