STANDARDISATION AND QUALITY EVALUATION OF MILLET BASED COMPOSITE NUTRIMIXES FOR ADOLESCENTS

By

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THESIS

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DECLARATION

I, hereby declare that the thesis entitled "**Standardisation and quality evaluation of millet based composite nutrimixes for adolescents**" is a bonafide record of research work done by me during the course of research and the thesis has not previously formed during the basis for the award to me of any degree, diploma, associate ship, fellowship or other similar title, of any other University or Society.

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CERTIFICATE

Certified that the thesis entitled **"Standardisation and quality evaluation of millet based composite nutrimixes for adolescents"** is a bonafide record of research work done independently by **Mrs. Reshma T. R.** under my guidance and supervision and that it has not been previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

TITLE OF PLATES

LIST OF APPENDICES

INTRODUCTION

1. INTRODUCTION

Adolescence, the second decade of life is a transitional period in the life cycle. It is a bridging phase between childhood and adulthood characterised by significant physical, psychological and social changes.

According to WHO (2015), adolescent period is defined as the age group between 10 and 19 years. The total world population is 7 billion in that 1.2 billion are adolescents. Out of one in six of the world's population, are adolescents aged 10 to 19.

Adolescence is characterised by changes associated with puberty that typically take place during the early adolescent years. The unique characteristics of the adolescent age is the sudden growth and development of the child that involves a sequence of hormonal and physical changes, including both sexual maturation and physical growth (Janesick *et al.,* 2014). Adolescents of growing age need proper nutritional care not only to promote growth but also for maintaining their optimum health and nutritional status. Provision of adequate dietary energy, macro and micro nutrients for growth and development should be the principle determinant of the diet of adolescence (Dwyer *et al*., 2014).

The vagaries in food and nutritional security of a country is reflected through the health and nutritional status of their youth. Adolescents remained in the world especially in developing countries as a largely neglected, nutritionally vulnerable group. The appalling picture of global adolescent health revealed that 1.2 million adolescents died in 2015 that comes over 3000 every day mostly from preventable or treatable causes (UNICEF, 2016). The major nutritional problems affecting adolescent group were malnutrition and iron deficiency anaemia. Apart from this other micronutrient deficiencies prevalent in adolescence, include deficiencies of vitamin A, vitamin D, calcium, zinc and iodine (Babu *et al*., 2016) In India, prevalence of anemia among adolescent girls is 90 per cent and 63.25 per cent adolescents had body mass index less than normal (Rahman *et al*., 2015). The prevalence of vitamin A deficiency among adolescents was 47 per cent (Ahmed and Hassan, 2015). These nutritional problems can be overcome by supplementation of diets with food formulations using low cost, locally accessible food stuffs.

Dietary supplements in different forms like health mixes, health drinks, capsules and other preparations combined with normal intake have shown improvement in health and provided targeted nutrients for body (Sherleker and Udipi, 2006). Composite flour technology makes it possible to blend, mix or fortify one food material with others (Noorfarahzilah *et al.,* 2014). So that the resulting composite mix is not only of better nutritional quality but also have necessary attributes for consumer acceptance.

Millets have been termed as super foods as they are immensely rich in phytonutrients and micro minerals which are vital for the nutritional security. Millets has been identified as poor man's crops, which grow in adverse climatic conditions and possess many nutritional and therapeutic properties. Millets are small seeded with different varieties such as pearl millet, finger millet, proso millet, kodo millet, foxtail millet, little millet and barnyard millet (Kaur *et al.*, 2012). India is the largest producer of different kinds of major and minor millets. The nutritive value of millets are superior to rice and wheat with respect to protein and phytochemicals. Millets contain carbohydrates (60-70%), proteins (7-11%), fat (1.5-5%), and crude fibre (2-7%) and are also rich in vitamins and minerals. They are excellent source of vitamin B, magnesium and antioxidants (Singh *et al.*, 2012). Processing technologies for improving nutritional characteristics of millets increase the digestibility, absorption and reduce anti-nutritional factors (Saritha and Singh, 2016). Even though millets have enough potential to contribute to food and nutritional security, they still remains as underutilised.

Composite food mixes can be developed with millets to provide adequate protein and also to use as concentrated source of energy, iron, folic acid and other specific nutrients particularly the micronutrients.

The present study entitled 'Standardisation and quality evaluation of millet based composite nutrimixes for adolescents' was proposed to develop composite nutrimixes using millets suitable for adolescents and to evaluate organoleptic, nutritional and storage qualities of the developed nutrimixes. The study also aims to assess the suitability of the nutrimixes for the preparation of different food products.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Literature pertaining to the study entitled "Standardisation and quality evaluation of millet based composite nutrimixes for adolescents" is reviewed under the following headings.

2.1 Adolescence – The period of transition

2.2 Health status of adolescents in India

2.3 Nutritional requirements of adolescents

2.4 Significance of nutrimixes

2.5 Role of millets in nutritional security

2.1 Adolescence – The period of transition

Nutritional wellbeing and health status of a community are the critical factors in determining national development. The most precious human resource in every country is the young generation. Human genetic potential has to be maximised to achieve developmental goals of a community. Adolescence is a critical period in lifespan with characteristic developmental epoch during which children become adults. The word adolescence comes from the Latin verb "Adolescere" which means to grow into maturity. According to WHO (2001), adolescence period is defined as the age group between 10 and 19 years. Adolescence is the time of growth from the immaturity of childhood into the maturity of adulthood (Adler, 2005). Department of Health and Human Services (2014) specified adolescence as ages of 10 years to 19 years and bridges the gap between present generation and the next. American Academy of Pediatrics (2015) indicate that adolescence as the years between 11-21, and U.S. Sivagurunathan *et al.* (2015) also identified adolescents as the young people aged between 10 to 19 years.

The total world population is 7 billion, among that 1.2 billion are adolescents (UNICEF, 2011). World Population Monitoring Bureau (2012) reported that, in world

1.6 billion persons are aged between 12- 24 among that, 721 million are adolescents (12-17 years), and 850 million were considered as youth (18-24 years).

India has the largest adolescent population in the world. As per Census 2011, the Indian population was 1210.19 million in that, 586.47 million (49.5%) are females and 623.72 million (50.5%) are males. Among this, 28.8 per cent were adolescent girls and 30 per cent were adolescent boys. In Kerala, the total population is 333.87 million comprising 173.66 million (51.7%) females and 160.21 million (48%) males. In that 24.8 per cent was adolescent girls and 21.7 per cent was adolescent boys (GOI, 2011).

The adolescence period was classified into three stages based on growth characteristics. Age between 10 -11 was considered as pre adolescence, 11-14 as early adolescence, 14-16 as mid adolescence and 17-20 as late adolescence (Jayanthini, 2000). Steinberg (2002) observed that sub-stages of adolescence was early (10 to 13 years), middle (14 to 18 years) and late (19 to 22 years) adolescence. Nienstein *et al.* (2009) designated 10 to 13 years as early adolescence, 14 to 16 years as middle adolescence and 17 to 21 years as late adolescence.

Adolescence is the dynamic period marked through physiologic, psychosocial and also cultural transitions. Adolescence is also a period of stress and strain, characterised by physical, mental and hormonal changes. It is the period of transition between childhood and adulthood, which is characterised by rapid body changes resulting from physical changes, including both sexual maturation and physical growth, emotional, mental, and social development (Mulugeta *et al.*, 2009). The unique characteristics of adolescent age is the sudden growth and development of the child (Casey *et al.*, 2010). These transitions include onset of puberty, development of adult identity and changes in socio economic dependence to relative independence (Steinberg, 2014). Janesick *et al.* (2014) reported that adolescence undergoes reproductive maturation and physical growth during the transition to adulthood.

The major physical changes include, increase in height and weight, genital development, pimple and acne formation (Singh, 2010). Soliman *et al.* (2014) reported that in adolescence age, linear growth increased markedly for both sexes.

The growth of adolescence girls happens earlier than adolescence boys. Adolescence girl forms the crucial segment of the population (Raman, 2002). Changes in body composition of adolescence girls is characterised by alterations in both the quantity and distribution of fat. Physical changes like wider pelvic structure and breast were triggered by changing levels of estrogen, testosterone and growth hormone (Diamanti and Core, 2012). In adolescent boys, a noticeable increase in height and weight, change in body proportion with marked widening of shoulders and chest were observed. The voice becomes deep and tone change. Development of hair on legs, chest, face and underarms etc were the major changes in boys.

Similarly, Marshall *et al.* (2002) reported that the peak height velocity for girls was 9cm/ year at age of 12 and total gain in height of 25cm during the pubertal period. Boys attain height peak velocity of 10.3cm/ year later than girls. During tannel genital stage they gain 28cm height. The height was approximately 5cm/year for both males and females in pre-pubertal stage. In pubertal stage, the yearly height increase to 8.3 cm in females and 9.5 cm in males (Soliman *et al.,* 2014)

Peak weight gain was obtained within 3 to 6 months in females and by approximately 3 months in males and it slows around the time of menarche, but weight gain was increased again in late adolescence. Adolescent males gain an average weight of 9 kg per year during puberty (Barnes *et al*., 2000). Tanner (2000) reported that, during adolescence 50 per cent of the adult body weight was gained and more than 90 per cent of adult skeletal mass has been obtained in 18 years of age. According to Soliman *et al*. (2014) peak weight velocity for boys was 9kg/year and for girls, it was 8.3kg/year at the age of 12. Weight gain results from increased muscle development in boys and body fat in girls. During adolescence weight velocity increases from 3 kg/year to 9kg/ year.

Biological development during adolescence affects psycho-social development. Adolescence is the stage which is considered as the most beautiful phase of one's life filled with lots of imagination, aspiration zeal and potential outburst (Eddy, 2005). Teenagers develop a stronger recognition for their own personal identity and self-esteem. An increased awareness of sexuality and heightened consciousness about physical appearance are fundamental psycho social tasks during adolescence (Barr *et al.,* 2004). Cognitive development was increased in early adolescence which is dominated by egocentrism, concrete thinking and impulsive behavior (Wilson *et al.,* 2005). Hormonal changes are predisposing behavioural and personality changes during adolescent age (Singh, 2010).

2.2 Health status of adolescents in India

Adolescent's health is of paramount importance because health status of adolescents determines the health status in their adulthood. Adolescence is generally considered as a healthy period in life cycle but many diseases visible in adult hood have their roots in adolescence.

Inadequate nutrition is the major cause for morbidity and failure in achieving full genetic potential by adolescence and children (Begum, 2001). It affects their physical growth and development and lead to functional impairment, disability, diminished productivity and increased susceptibility to infection (WHO, 2005). Malnutrition results from excess or imbalance of nutrients among adolescence, create long lasting effect on the growth, development and physical fitness of a person (Amy, 2010).

Malnutrition was prevalent among adolescents due to unhealthy eating habits and higher use of mass media that was 88.2 per cent among adolescent girls and 71.5 per cent among adolescent boys. It plays an important role in selecting their food habits and life style pattern (UNICEF, 2013). Priyadarshini *et al.* (2013) reported that, adolescence (11 to 17 years) in Chennai, was highly influenced by unhealthy eating habits and mass media and author found that, 90% eat either food or snacks while watching TV, 82% buy food products and snacks based on advertisement, 59% skipped outdoor activities for TV, 42% follows diet and 42% exercise to get the body like their favorite media personality. Television viewing in childhood and adolescence is associated with overweight, poor fitness, smoking and raised cholesterol in adulthood.

The major nutritional problems affecting adolescence group was under nutrition and iron deficiency anaemia. Apart from this other micronutrient deficiencies that are prevalent in adolescence, include deficiencies of vitamin A, vitamin D, calcium, zinc and iodine (Babu *et al.*, 2016).

Undernutrition is a major problem in adolescence which is associated with lean body mass and deficiencies in muscle strength and work capacity. According to WHO (2004) adolescents were graded based on BMI, which include grade 3 chronic energy deficiency (BMI <16kg/m^2), grade 2 chronic energy deficiency (BMI 16-16.9 kg/m^2), grade 1 chronic energy deficiency (17-18.49 kg/m^2), normal (18.5-24.99 kg/m^2), over weight (25-29.99kg/m^2) and obese (>30 kg/m^2). National Nutrition Monitoring Bureau (2011) reported that 66 per cent of adolescents (14-17 years) were undernourished. In India, one third of adolescent boys and girls have chronic energy deficiency (Kishore, 2011). Suma (2012) found that 27 per cent of adolescence in India, were having moderate chronic energy deficiency, 21 per cent with mild chronic energy deficiency, 22 per cent obese grade 1, 15 per cent were low weight and 9 per cent belong to grade 2.

Singh *et al.* (2014) conducted a study among adolescence of age 10-19 and found that the prevalence of underweight, stunting and thinness was 32.8 per cent, 19.5 per cent and 26.7 per cent respectively. Maximum prevalence of malnutrition was observed in early adolescence (28% - 47%). Similarly, Latesh and Garg (2015) conducted a study to assess the prevalence of malnutrition among adolescent girls and found that the mean height, weight and BMI was 159.45cm, 50.3kg and 19.77kg/m^2 respectively which were significantly ($p<0.05$) lower than Indian reference standards.

Rahman *et al.* (2015) found that in India, 63.25 per cent adolescence had body mass index less than normal. Prevalence of undernutrition was higher among adolescent girls (36.75%), and overweight was observed among adolescent boys (1.25 %). Based on BMI, prevalence of chronic energy deficiency among girls was 21.25 per cent (Grade I), 7.25 per cent (Grade II) and 8.25 per cent (Grade III). Chronic energy deficiency grade I, II and III among boys was 21.75, 1.5 and 3.25 per cent respectively. Severe malnutrition was high among girls (8.25%) compared to boys (3.25%).

Ghosh *et al.* (2013) reported that, malnutrition is a major health problem in developed and developing countries and observed many nutritional deficiencies among adolescence which lead to impaired cognitive development. Tribal adolescence have lower BMI than non-tribal adolescents.

Nutritional anaemia is a major micronutrient deficiency problem in India among adolescence. According to the National Family Health Survey (NFHS, 2006) in India, 56 per cent adolescent girls and 30 per cent adolescent boys suffer from anaemia. Anaemia is the condition when the haemoglobin level was decreased to lower extreme from the normal range (Lal and Pankaj, 2011). Globally anaemia affects 1.62 billion people, in that 69.4 million are adolescence. Africa and Asia account more than 85 per cent of the absolute anaemia burden. More than half of adolescents aged between 15 and 19 are anaemic (NFHS, 2012).

Anaemia is classified on the basis of haemoglobin level in to mild, moderate and severe. The haemoglobin levels >12 .0 g/dl for non anaemic,10-11.9g/dl for mild, 8.0- 9.9g/dl for moderate and < 7.9 was considered as severe (WHO, 2001). Suma (2012) conducted a study among adolescents and found that, majority (99 %) were suffering from various forms of anaemia, which include, moderate anaemic (49 %), mild anaemic (46 %) and severe anaemic (4 %).

Hemoglobin is the part of red blood cells that gives blood its red color and enables the red blood cells to carry oxygenated blood throughout your body

(Deshpande *et al.,* 2013). Iron deficiency anaemia causes impaired growth, developmental delay, decrease physical activity, behavioral abnormalities, impaired cognitive function and school performance in adolescence. Iron needs are increased during adolescence for rapid growth and it is essential for the synthesis of hemoglobin. Low levels of iron, folate, vitamin B_{12}, vegetarian diet, poverty, unawareness, attainment of menarche, history of worm infestation and low socio economic status are epidemic factors of anemia (Thomas *et al.*, 2015).

Alem *et al.* (2013) reported that, 2 billion peoples are iron deficient. Majority (75 %) of anaemia is related to iron deficiency, followed by folate and vitamin B_{12} deficiencies. Abhishek and Deepika (2015) conducted a study among rural adolescent girls in India and found that prevalence of anaemia was 40 per cent and the hemoglobin level ranged from 6g/dl to11.9g/dl. Prevalence of anaemia was higher among late adolescence (14-16 yrs) than early adolescence (10- 13yrs). Similarly, Biradar *et al.,* (2015) reported a high prevalence (21 %) of anaemia among the adolescent girls in India.

Vitamin A deficiency is prevalent among children and adolescence worldwide. The deficiency will increase the risk of illness, impaired growth, development, vision and immune system (Ruel, 2001). Ahmed and Hasan (2015) reported that, the risk of vitamin A deficiency was extended in early childhood and adolescence.

Agarwal *et al.* (2014) reported that, vitamin A deficiency was observed among school going adolescent girls with the symptoms like bitot's spot and conjuctival xerosis. The author also found that the prevalence of vitamin A deficiency was higher among adolescents in age group 15-19 years (48.77 %) as compared to 10-14 years of age group (41.63 %). It was higher among males (43.7 %) when compared to females (43.3 %).

West (2006) reported that people with serum retinol concentrations of less than 20μg/dL are considered vitamin A deficient, and less than 10μg/dL are considered severely deficient. In moderate deficiency, vitamin A concentration was 15.55µg/dL for adolescent girls and 15.74µg/dL for adolescent boys (Yunuza *et al.,* 2015).

Vitamin D is essential for calcium and phosphorus metabolism and the immune system (Gordon *et al.*, 2004). Other functions of vitamin D include intestinal calcium absorption, maintaining calcium homeostasis, bone development and skeletal integrity.

Severe vitamin D deficiency was observed rarely and mild deficiency was common. But the prevalence of vitamin D deficiency in adolescence is considerably high in many countries. Different factors cause vitamin D deficiency including lack of sunlight exposure, pigmented skin, and less time spent outdoors, because of hot weather, and lower vitamin D intake (Soliman, 2014).

Gordon *et al.* (2004) assessed the prevalence of vitamin D deficiency among adolescents and found that, 24 per cent adolescents were deficient in vitamin D and 4.6 per cent adolescents were severely deficient. Muhairi *et al.* (2013) conducted a study among adolescents to assess the prevalence of vitamin D deficiency and found that, 19.7 per cent were vitamin D deficient (serum 25OHD level ≤15 ng/mL) and 45.4 per cent were vitamin D insufficient (serum 25OHD level ≤20 ng/ml). The prevalence was high among adolescent girls (28%) than boys (10%).

Calcium is an essential mineral for maintaining bone health and help in bone mineralisation and rigidity especially during adolescence. This will prevent the chances of osteoporotic risk and bone fracture (Uma and Heidi, 2004). It also participates in fibrin formation during the blood coagulation process and regulate the muscle contraction through regulating actin and myosin contractility by protein troponin (Bueno and Czepielewski, 2008).

During the adolescence growth spurt, 45 per cent of adult skeletal volume is formed and bone mineral content is increased at a rate of 8.5 per cent per year. Daily dietary calcium intake of 1300mg/day for adolescence, will increase the bone accretion rate at 6 per cent. This will translate to optimal bone status at menopause and it will act against osteoporosis (Bhatia, 2008). Daniela *et al.* (2016) found that 86.6 per cent of adolescence does not meet the recommended dietary allowances.

Iodine deficiency result from inadequate dietary intake and it cause a wide spectrum of diseases, which include impaired mental function, goitre, hypothyroidism and cretinism (Rawal and Kedia, 2011). Iodine is essential for normal mental and physical wellbeing of humans. Iodine is an essential component of the thyroid hormones, tetraodothyronine and triodothyronine and it is necessary for normal growth, development and metabolism during pregnancy, infancy and throughout life (Caldwell *et al.*, 2013). Workie *et al.* (2017) reported that, the overall prevalence of goitre was 351 (48.9%), with 36.9 per cent grade 1 goitre and 11.9 per cent grade 2 goitre. The prevalence of vulnerable goitre was high among adolescents (60.9 %).

Zinc deficiency is a serious health problem in many communities especially among adolescents because of pubertal growth spurt (Mahmoodi and Kimiaga, 2001). Zinc is essential for human health and growth because it has structural and functional role in multiple enzyme system that are involved in physical growth, immunological and reproductive functions (Manjula *et al.*, 2006).

Consequently zinc deficiency affects physical growth and may deteriorate health status and increase the risk of severity of a variety of infectious diseases. Nearly half of the world's population is at risk due to inadequate zinc intake (Kawade, 2011). Serum zinc level <74µg/dl for male children and <70 µg/dl for female children above 10 years of age was considered as zinc deficiency (Kapil *et al.*, 2011).

Fesharakinia *et al.* (2009) reported that the mean serum zinc level was 87.7 (±32.7) µg/dl and the overall prevalence was 28.8 per cent among adolescents. Abunada *et al.* (2013) conducted a study among adolescents (12-15years) to assess the zinc deficiency and he found that, overall prevalence of serum zinc deficiency was 42.5 per cent. The prevalence was high among adolescent girls (47.7 %) than boys (37.2 %)

2.3 Nutritional requirements of adolescence

Nutritional requirements varies in different phases of life. The requirements of a nutrient are defined as, the amount of absorbed nutrients that is necessary to fulfill its physiological functions in the body (ICMR, 2010).

Adolescent age is remarkable due to its increased demands for vital nutrients. Inadequate diet intake during this age leads to stunted growth and delayed sexual maturation (Stang and Story, 2005). At this period they require planned diet, affection, guidance, proper monitoring and motivation (Mulugeta *et al.*, 2009). Dwyer (2014) observed that with the rapid changes in body composition during adolescence, nutrient demand also increases. The author also pointed out that adolescent period is nutritionally significant than any other time in life cycle.

Energy needs for growth are higher during adolescence compared to earlier childhood, which exceed 10 per cent of the total energy requirements. It varies according to age and sex and daily activities (Heald and Gong, 2005). The maximum consumption of calories was estimated around 2330 Kcal on average for girls between 13 to 15 years of age, and 2440 Kcal for the age group of 16 to 17 years. The caloric requirements increase upto 2750 Kcal for boys of 13 to 15 years of age, due to the pubertal spurt, and 3020 Kcal until the end of the growth period (16- 17 years age) (ICMR, 2010). Spear (2002) observed that requirements of energy and protein has a positive correlation with growth pattern than with chronological age.

The daily requirement of protein was 54.3 g to 61.5 g for adolescent girls between the age group 13 to 17 years and for adolescent boys it was 51.9 g to 55.5 g (ICMR, 2010). Protein is essential for the maintenance of existing tissue and deposition of lean mass. Protein requirement reach at the peak level during pubertal growth spurt (11-14 in girls and 15-18 in boys) (Evans, 2015).

The human body requires dietary fat and essential fatty acids for normal growth and development. The dietary guidelines recommend 30 per cent of calories should come from fat, in which calories from saturated fat should not be more than 10 per cent in the diet of adolescence. According to Alaimo *et al.* (2001) intake of total fat and saturated fat exceed recommendations due to life style changes among adolescence.

Vitamin A plays a vital role in normal vision, reproduction, growth, and immune function (Russell, 2001). To ensure adequate body stores of vitamin A, adolescents must consume 4800 μg as the daily requirements (ICMR, 2010).

Vitamin E is well known for its antioxidant properties, which become increasingly important as body mass expands during adolescence. The RDA for vitamin E for 9-13 year old adolescents is 11 mg/day and 15mg/day for 14-18 year old (ICMR, 2010).

Vitamin C is involved in the synthesis of collagen and other connective tissues. In India, adolescence (86-98 per cent) had adequate dietary intakes of vitamin C (Jayanthini, 2000). The RDA for vitamin C is 40 mg/day for adolescent boys and girls (ICMR, 2010).

Adolescence have increased requirements for folate during puberty as it plays an integral role in DNA, RNA and protein synthesis (Jayanthini, 2000). The RDA for folate is 150μg/day for 13-15 year olds and 200 μg/day for 16-17 year olds (ICMR, 2010)

Calcium needs are higher during adolescence (10-20 years) due to rapid increase in the mineralisation of bone. An intake of calcium is 1300mg/ day is sufficient for adolescents (10-18) (Brown and Prinstein, 2011). ICMR (2010) recommended 800mg of calcium for both adolescent boys and girls. Female acquire 37 per cent of skeletal mass from age 11-15. Adequate intake of calcium prevent osteoporotic conditions in adolescence (Mahan and Raymond, 2016)

The increased iron requirement during adolescence, is due to the expansion of blood volume and subsequent increase in hemoglobin synthesis. ICMR (2010) recommended 27 mg of iron for adolescent girls (13-15) and it decreased to 28 mg for the age group between 16-17 years. For adolescent boys the iron requirement is around 32-28 mg for the age group between 13-17. Girls need to ensure adequate intake of iron as they lose 0.5mg/ day by way of menstruation. Iron lost not replaced in the body may predispose to iron deficiency anaemia. Iron is also needed for the synthesis of myoglobin which is involved in muscle growth. The additional requirement of iron during adolescence for the growth spurt, expansion of blood volume and increase in Hb concentration would be 12 µg/kg for boys and 16 µg/kg for girls (Srilakshmi, 2010).

Zinc is associated with more than 100 specific enzymes and is vital for protein formation. Zinc is important in adolescence for proper growth and sexual maturation. Zinc deficiency in adolescence cause growth failure and delayed sexual development. During rapid growth and hormonal changes among adolescents the serum zinc levels decline (Donovon and Gibson, 2005). The daily recommended allowance of zinc for adolescents was 11 mg (13-15 year old) and 12 mg for (16-17 year old) (ICMR, 2010).

Dietary fibre is important for normal bowel function and aid in prevention of various life style diseases. Adequate fibre intake reduces serum cholesterol levels, blood sugar levels and also reduce the risk of obesity (Williams *et al.*, 2010).

To attain adequate nutrients, the adolescence must consume a balanced diet. The food consumption pattern is changing all over the world towards energy dense, high fat, high sugar and salt, processed and ready to eat foods (Morland *et al.*, 2012). Changing the food consumption pattern cause adverse effect on the public health status and there is increased prevalence of deficiency disorders and other degenerative diseases (Arora and Mathur, 2014).

ICMR (2010) recommended that the adolescent girls in the age group between 13-15 have to take 330g of cereals and millets, 60g of pulses, 500ml of milk and milk products, 100g of each roots and tubers, green leafy vegetables and fruits, 200g of other vegetables, 25g of sugar and 40g of fat. For adolescent boys, the recommended intake per day is 420g of cereals and millets, 75g of pulses, 500ml of milk and milk products, 150g of roots and tubers, 100g of green leafy vegetables and fruits, 200g of other vegetables, 20g of sugar and 45g of fat.

The adolescent girls in the age group between 16-18 have to take 330g of cereals and millets, 75g of pulses, 500ml of milk and milk products, 200g of roots and tubers, 100g of green leafy vegetables and fruits, 200g of other vegetables, 25g of sugar and 35g of fat. For adolescent boys, the recommended intake per day is 450g of cereals and millets, 90g of pulses, 500ml of milk and milk products, 200g of roots and tubers and other vegetables, 100g of green leafy vegetables and fruits, 30g of sugar and 50g of fat (ICMR, 2010).

2.4 Significance of nutrimixes in combating malnutrition

Malnutrition has many adverse effects on human health, especially when it occur during growing period. The major micronutrient deficiencies of adolescence living in developing countries include deficiencies of iron, vitamin A and iodine (Ahmed *et al.*, 2005). Adolescents require high nutrient intake to maintain the growth and development (Akhter and Sandhya, 2013). Micronutrient deficiencies can adversely affect the health of adolescents which can be prevented by supplementation, food fortification, bio-fortification or programs for increasing the production of nutrient dense food (Korkalo *et al.*, 2015). Food formulations using low cost, locally available food stuff is one of the strategies to improve the health status of vulnerable communities.

Supplementary foods in the form of health mixes, health drinks and other preparations combined with normal intake have shown improvement in health and provided targeted nutrients for body. They are given in various forms (Sherleker and Udipi, 2006). Supplementation through food formulations is an effective way to improve the health status and also for combating malnutrition and deficiency diseases (Sangeetha and Premakumari, 2010).

Technology of composite flour makes to blend, mix and fortify one food with other ingredient. So that the resulting fortified mix has both nutritional quality and consumer acceptance (Noorfarahzilah *et al.,* 2014).

Complementary food supplements can be defined as food based mixes that can be consumed in addition to the diet to increase the nutritive value. It is equivalent to food fortification and increase the essential nutrients from food (Nestel *et al.*, 2003). Nutrimix is an instant food which are good supplements of essential vitamins and minerals to achieve recommended dietary intake (Tilakaratne *et al.,* 2015)

Supplementation of cereal based products with millets has become popular due to nutritional and economic advantages (Karuppasamy *et al.,* 2014). Food mixes are developed to supply protein of high biological value and to utilise concentrated sources of specific nutrients.

CPCRI (2006) developed amrutham nutrimix for children using wheat, soya chunks, bengal gram and ground nut which provide 391 Kcal of energy, 69.47 g of carbohydrate, 16.14 g of protein, 5.44 g of fat, 191.23 mg of calcium and 8.9 mg of iron.

Aneena and James (2015) developed a health mix (Teen Plus) for adolescents using malted ragi flour, whole cereals, pulses, milk solid and nuts, which provide 398 Kcal of energy, 43.5 g of carbohydrate, 10.65 g of protein, 336 mg of calcium and 6.1 mg of iron. The mix was also rich in vitamins like carotene (9.86 μg), thiamin (0.263 mg), riboflavin (0.241 mg), niacin (3.33 mg) and folic acid (21.63 μg).

According to Zaheeruddin (2011) low cost composite flour nutrimix prepared using pearl millet, barley and whey protein concentrate had the maximum protein content (25.88 g) and carbohydrate (60.98 g).

Angel and Devi (2014) developed iron rich health mix using locally available iron rich foods like garden cress seeds, rice flakes, roasted bengal gram dhal, bajra, samai and jaggery to combat anaemia. The prepared health mix (50g) provided 183.75 Kcal of energy, 4.72 g of protein, 10.61 mg of iron and 36.7 mg of calcium and was highly acceptable. The author reported that after supplementation, the mean haemoglobin level raised from 8.23 to 11.11mg/dl.

According to Shudhodhan (2012) nutrimix fortified with zinc and iron using pearl millet, whey protein concentrate, skimmed milk powder and sugar, provided 80.79 Kcal of energy, 80.79 g of carbohydrate, 14.64 g of protein, 8.29 mg of iron, 4.64 mg of zinc and 193.47 mg of calcium. It was highly acceptable and shelf stable for two months.

Devi and Samundeswari (2013) developed a health mix using ragi, soyabean, ground nut and jaggery, which supplied 104.8 Kcal of energy, 3.88 g of protein, 3 g of fat, 41 mg of calcium and 1.2 mg of iron. The study also revealed that there was a significant increase in haemoglobin level, serum protein level, height, weight and overall health status after supplementation of the mix.

A millet mix was developed by Malar and Narayanan (2013) using pearl millet, finger millet and barnyard millet which provided high protein (14.2 g), fat (6.6 g), energy (455 Kcal), crude fibre (1.2 g), carbohydrate (76.3 g), calcium (124.0 mg), phosphorus (368.0mg) and iron (6 mg).

Gupta (2014) developed nutrimix based on oatmeal, pear, cow pea, maize, bengal gram dal and sanwa millet in different propotions, which provided 315 Kcal of energy, 43.5g of carbohydrate, 14.4g of protein, 4.48mg of iron and 30.4mg of calcium.

Saritha and Patterson (2014) developed a sea food health mix powder using juvenile fish powder with other ingredients like millet, pulses, rice, maize, cardamom etc. It had high amount of protein (48.02 g) and minerals like calcium (1341.21 mg), iron (108.06 mg), phosphorus (28.91 mg), sodium (104.23 mg) and potassium (110.20 mg). The mix was used to prepare sea food health mix milk, sea food health mix curd, sea food health mix sweet balls and *mirche* balls.

Radhapriya and Lakshmi (2015) developed health mix to improve bone health by using low cost and locally available indigenous foods like ragi, soya, wheat, milk powder, sesame seeds, oats and flax seed. The developed mix provided 420 Kcal of energy, 51 g of carbohydrate, 19 g of protein, 5.85 g of fat and 3.08 g of crude fibre. The mix was rich in vitamin and minerals like calcium (440 mg), iron (5.5 mg), phosphorus (330 mg), thiamin (0.8 mg), riboflavin (0.25 mg), niacin (6.6 mg), pantothenic acid (1.0 mg), pyridoxine (0.3 mg) and folic acid (97 mcg).

Parvathy *et al.* (2015) developed a health mix using cereals, pulses and millets in different proportions which provided 17.08 g of protein, 4.05 g of fibre, 20.68 mg of calcium, 244 mg of phosphorus and 7.57 mg of iron. The developed mix was shelf stable, highly acceptable and was suitable for the preparation of snacks.

An iron rich health mix was prepared by Angel and Devi (2015) using rice flakes, wheat, roasted bengal gram, gingelly seeds and jaggery. Highly acceptable sweet balls using the mix was prepared and supplemented to anaemic adolescent girls and observed an increase in haemoglobin level was from 8.77 to 9.75 per cent.

A nutrimix was developed based on brown rice and mung bean and fortified with dehydrated muringa leaves and pumpkin powder in different combinations. It contained 28 per cent protein, 14 per cent fibre and 43 per cent carbohydrate and had high amount of vitamin A (Tilakaratne *et al.*, 2015).

Herbal hypolipidemic health mix was prepared using roasted parboiled rice flour, green gram dal, *arjuna*, cinnamon and fenugreek. The herbal mix (100g) provided 74.75 g of carbohydrate, 12.92 g of protein and 7.13 g of dietary fiber. The mix had antioxidant property, because it contain vitamin A (29.8 IU), vitamin E (0.57 mg), vitamin C (0.16 mg), selenium (11.2 mg), copper (193.4 μg), zinc (529.2 μg), iron (2531 μg) and manganese (810.7 μg). The health mix was found to be suitable for hyperlipidemic patients (Borkotoky and Sarma, 2016).

Manjula *et al.* (2017) developed herbal health mix with penny wort leaves to mitigate micronutrient malnutrition. Health mix was prepared using whole wheat, ragi, bajra, foxtail millet, soy, green gram dal, cocoa powder, sugar, dates and cardamom. The developed health mix was high in protein (12.98 g), vitamin A (156.7 IU) and vitamin C (15.6 mg).

Nasheeda (2006) developed a multipurpose convenient mix from banana flour. The health mix provide energy (381.20 Kcal), protein (16.63 g), calcium (308.33 mg) and iron (3.33 mg). Raj (2011) developed a weaning mix using grain amaranth and ragi and found that it provide 16.66 g of protein, 2 g of crude fibre, 77.07 g of carbohydrate, 349.60 mg of calcium, 350. 69 mg of phosphorus and 10.64 mg of iron.

Usharani and Lakshmi (2015) developed functional food mix using bengal gram, black gram, carrot, tomato, cauliflower, pepper, cumin seeds, red chillies and amla powder. The prepared mix contained 333 Kcal energy, 59.81 g carbohydrate, 15.75 g protein, 8.16 g fibre, 419 mg calcium, 3.9 mg iron, 460 μg β- carotene and 23.83 mg vitamin C.

Krishnamoorthy *et al.* (2013) formulated a multi millet mix by incorporating finger millet, foxtail millet, proso millet, little millet and kodo millet. The *idli* prepared from the mix contain energy (424 Kcal), protein (15.1 g), fat (5.2 g), crude fibre (3.8 g), carbohydrate (72 g), calcium (128 mg) and Iron (3.40 mg). *Dosa* contained energy (429.8 Kcal), protein (15.8 g), fat (9.8 g), crude fibre (3.95 g), carbohydrate (69 g), calcium (114 mg) and Iron (3.42 mg).

Tanya *et al.* (2013) developed a malt drink mix by incorporating fruits like banana and papaya into pearl millet and bajra. Papaya incorporated mix contained 8.5 g of protein, 3.9 g of fat, 5.5 g of crude fibre and banana incorporated mix contained 8.45 g of protein, 5.4 g of fat, 2.6 g crude fibre. This malt mix was recommended as health food for all age groups.

Guddad and Bharati (2014) formulated multigrain mixes using ragi, rice, wheat, green gram dhal and soya bean and highly acceptable *laddu* and *thepla* were prepared out of the developed mix

Sharon (2010) developed probiotic fermented food mixture using banana, defatted soya flour, green gram flour and fruit pulp and found that the probiotic mix provide 9.29 g of protein, 6.45 mg of iron and 68.17 mg of calcium. Shilpa *et al.* (2015) developed probiotic food mix using locally available ingredients such as Italian millet flour, wheat flour, soya flour, skimmed milk powder, roasted bengal gram dal powder. The protein, fat, crude fibre, carbohydrate, energy, calcium, phosphorus, iron and zinc content of the developed composite probiotic functional mix were 18.10 g, 5.70 g, 3.47 g, 58.77 g, 359 Kcal, 107.10 mg, 343.22 mg, 5.66 mg and 2.03 mg per 100 g, respectively.

Lakshmi (2011) developed tempeh flour mix using green gram, cowpea, soybean, rice and wheat. The prepared mix provide protein (43.15 g), fat (20.87 g), calcium (331.25 mg), iron (8.03 mg), phosphorus (601.36 mg) and zinc (4.82 mg). Jayasingh *et al.* (2016) developed nutritionally superior and low cost seaweed soup mix powder using vegetables, legumes, cereals and seaweed extracts such as agar and carrageenan. The prepared mix contain 11.3 per cent protein, 2.4 per cent fat, and 64.54 per cent carbohydrate.

Hyder *et al.* (2007) developed a multiple micronutrient fortified beverage for adolescence and found that the supplementation of fortified beverage for 6 months increased the weight, MUAC, BMI, haemoglobin level and serum retinol level. The use of multiple micronutrient fortified beverage could reduce prevalence of anaemia, and improved the micronutrient status and growth.

Sowjanya and Manjula (2016) developed instant mix with dehydrated green leafy vegetables. The ingredients are ragi, wheat, pepper, dehydrated drum stick leaves and spinach leaves. The *dosa* prepared from the mix provided energy (310.54 Kcal), carbohydrate (45.47 g), protein (7.73 g), fat (1.46 g) and iron (3.09).

Gayatri and Agarwal (2016) developed antihyperglycemic and antihyperlipidimic nutrimix beneficial for diabetic patients. Highly acceptable products like *idly*, *chapatti*, soup and curry were prepared by incorporating developed nutrimix.

Surekha *et al.*, (2013) prepared low glycaemic index noodles from barnyard millet flour by incorporating sago flour, pulse flour, bengal gram and dried green leafy vegetables and found that incorporation of millets increased the nutrient content. Kumar *et al.* (2015) prepared sorghum flour based functional biscuit by incorporation of finger millet and refined wheat flour and the product contain high amount of protein (14 g) and crude fibre (1.88 g).

Deshmukh and Yenag (2016) developed a composite flour bread by incorporating little millet and wheat flour as the major ingredients. The prepared composite flour bread had good amount of protein (10.15 g) and carbohydrates (76.35 g). Geetha *et al.*, (2016) developed foxtail millet based multi grain extruded food product, using foxtail millet flour, rice flour, chick pea flour and flax seed flour. The product have good nutritional profile and sensory attributes.

Vijaykumar e*t al.* (2010) prepared a composite flour by using kodo millet, barnyard millet, wheat flour and defatted soya flour for preparation of noodles. The author found that the mean glycaemic index and load was lower than branded noodles. Kadam and Maheswari (2015) developed a composite flour for preparing *rotti* and *chapatties* using wheat flour, little millet flour, soy bean and methi leaves powder. The developed flour had higher amount of protein (15.37 g), carbohydrate (74.2 g) and crude fibre (2.056 g). Sambavi *et al.* (2015) developed composite flour for preparing cookies using 50 per cent of foxtail millet and wheat flour The selected composite flour provide high amount of protein (14 %), fat (5.7%) and crude fibre (0.07 %).

2.5. Role of millets in nutritional security

Nutrition security means access by all people at all times to the adequate utilisation and absorption of nutrients in food, in order to be able to live a healthy and active life (FAO, 2011). Millets are a treasure house of micronutrients. Developing millet based complementary foods to the poorer sections of the society meeting the nutritional needs is an effective strategy to combat malnutrition. Dietary diversification through location specific traditional crops like millets must be encouraged both at national and household level for improving household food security (Hariprasanna *et al.*, 2014).

Millets has been identified as poor man's crops, which grow in adverse climatic conditions and possess many nutritional and therapeutic properties. Millets are small seeded with different varieties such as pearl millet, finger millet, proso millet, kodo millet, foxtail millet, little millet and barnyard millet. (Kaur *et al.*, 2012). Millet has many nutritious and health benefits such as preventing cancer and cardiovascular diseases, reduce tumor incidence, lower blood pressure, risk of heart disease, cholesterol and rate of fat absorption, delaying gastric emptying and supplying gastrointestinal bulk (Gupta and Nagar, 2012). Singh and Raghuvanshi (2012) reported that millets contain carbohydrates (60-70%), proteins (7-11%), fat (1.5-5%), and crude fibre (2-7%) and provide vitamins and minerals. They were excellent sources of vitamin B, magnesium, antioxidants and also a good source of minerals like manganese, phosphorus and iron. Millet proteins provide essential amino acids except lysine and threonine but are relatively high in sulphur containing amino acids methionine and cysteine. B complex vitamins like niacin, folate, riboflavin, and thiamine are present in millets that play a key role in energy synthesis in the body (Moreno *et al.,* 2013).

Millet were popular food for patients having chronic diseases especially diabetes and obesity (Rao and Muralikrishna, 2001). Millets have low glycaemic index which is mainly due to development of resistant starch during heating and cooling (Veena *et al.*, 2005). Millet will decrease the blood glucose level and improve the lipid profile. Lipid level was improved by decreasing the triglycerides, LDL and VLDL cholesterols and increase the HDL level. Millet products have high satiety value and will not make crave for foods in between meals, which solve the problems of constipation.

Devi *et al.*, (2011) reported that, millets were rich in dietary fibre (18%) and phenolic compounds (0.3 to 3 %) and possess several health benefits such as anti-diabetic, anti-tumerogenic, atherosclerogenic effects, antioxidant and antimicrobial properties. It will protect against mucosal ulceration, epithelilisation, increased synthesis of collagen, activation of fibroblast and mast cells.

The total production of millet grains was 762712 metric tons in world and India was the top producer of millet grains 43.85 per cent (334500 tons) (FAO, 2011). Millets are underutilised and neglected crop because of lower cooking quality and low bioavailability of millets. Traditionally millets are processed by malting which improves its digestibility, sensory and nutritional qualities as well as pronounced effect in the lowering the anti-nutrients. Through appropriate processing technologies, these problems can be solved and make them valuable as food for poor families to combat malnutrition and important source of income. These techniques improve nutritional characteristics of millet and increase the digestibility, absorption and reduce anti-nutritional factors (Amadou *et al.*, 2013 and Sarita and Singh, 2016).

Millets are nutritionally superior to cereals, but their utilisation is very less. Blending of millets with other ingredients is a possible way for their proper utilisation (Singh *et al.*, 2005). Development of health foods using millets and their commercialisation received attention to promote the millets among the urban population apart from traditional rural consumers (Hariprasanna *et al.*, 2014).

Jaybhaye *et al.* (2014) found that addition of millets changed the physico-chemical, nutritional and functional characteristics of various food products like macroni, vermicelli, noodles and pasta are prepared using refined wheat flour, were replaced by composite flours from millets. Health mix prepared from millets is considered as a healthy food and it contain adequate amount of protein, low fat and high fibre

Devi and Samundeswari (2013) developed an iron rich health mix in the form of sweet *laddu* using ragi, soyabean, ground nut and jaggery and supplemented for preschool children to assess their nutritional status. Twenty five gram of health mix in mid-morning daily for two months was given. After supplementation, the mean height increased from 17.16cm to 18.61cm and in control group height was from 17.37cm to 17.46cm. As per percentage of weight for age, the experimental group and control group of 5 years initially belonged to grade I and grade II degree of malnutrition and after supplementation, the grade of malnutrition positively changed from grade II to grade I and from grade I to normal which indicates the effect of supplementation on nutritional status of the supplemented group.

Ugare *et al.* (2014) reported the effect of barnyard millet in lowering the blood glucose level. Reference carbohydrate and test meal equivalent to 50 g carbohydrate were administered separately to the volunteers. The feeding intervention of 28 days revealed a significant reduction in glucose (139.2 to 131.1mg/dl), LDL-C (from 167.7 to 162.9 mg/dl), VLDL-C (from 24.0 to 23.2 mg/dl), ratio of TC: HDL (from 4.7 to 4.6) and LDL: HDL (from 3.2 to 3.1) in the experimental diabetic groups.

Khader and Maheswari (2012) developed a malted food using ragi and found its effect on the nutritional status of preschool children, pregnant and lactating mothers. Significant increase was observed in weight of preschool children and lactating women after supplementation. Hemoglobin level in pregnant and lactating women significantly increased after supplementation. Considerable reduction (50%) in the incidence of PEM, vitamin A, B vitamins, vitamin C and iron deficiency symptoms in experimental groups and decrease in morbidity rate upto 50 per cent was observed.

Sarada and Mridula (2016) developed a millet pulse ladoo using jowar, ragi, soya, roasted bengal gram, ghee, jaggery and it was supplemented to children's for 45 days and found the differences in anthropometric parameters. After supplementation a gradual increase in weight (83.40kg to 84.43kg), height (10.16cm to 10.96cm), MUAC (14.32cm to 14.72cm). Similarly, Nazni (2010) developed weaning biscuits using ragi. After supplementation the mean height changed from 12.14cm to 12.69cm, weight from 79.31cm to 79.98cm and a gradual increase was observed in the cognitive development.

Preethi and Mohankumar (2015) developed iron and zinc rich food supplement using little millet and supplemented to anaemic girls (8 years). There was a significant increase in the anthropometric parameters when compared with the control group. The mean Body Mass Index value of the children supplemented with the formulated cookies came above the standard value. There was a significant improvement in the biochemical parameters ($p<0.005$). The score for cognitive development also improved after the supplementation study.

Thathola *et al.* (2010) developed low glycemic index (GI) foxtail millet biscuits (GI = 50.8) and *burfi,* a sweet product (GI = 37.5), for diabetic patients. Significant reduction was recorded in serum glucose (23%), serum cholesterol (6%), serum LDL (20%) and GHb (16.5%), and a slight decrease in serum triglycerides and VLDL. Serum HDL increased significantly by 23 per cent. Almost similar results were observed for foxtail millet *burfi* as for foxtail millet biscuits. Similar results was reported by Choi *et al.* (2014) for foxtail millet incorporated foods.

Itagi *et al.* (2013) developed little millet composite mix to test, glyco-lipemic responses among 6 non diabetic and 9 type 2 diabetics with four week feeding intervention. Marked reduction in plasma triglycerides was 18.57% and increase in HDL-cholesterol was 7.14% among experimental non diabetic group was noted. The significant difference in plasma glucose was observed in the experimental and control groups after intervention. The triglycerides reduced significantly in the non-diabetics.

The glycaemic index (GI) of foxtail millet *dosa* was 59.25 and rice *dosa* was 77.96. There was a significant reduction ($P<0.001$) in the postprandial glucose level of patients who consumed a millet-based *dosa* when compared to those who consumed a rice based *dosa.* No significant reduction was observed in the fasting glucose levels (Narayanan *et al.*, 2016).

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The present study entitled 'Standardisation and quality evaluation of millet based composite nutrimixes for adolescents' was proposed to develop composite nutrimixes using millets for adolescents and to evaluate organoleptic, nutritional and storage qualities of the developed nutrimixes. The study also aimed to assess the suitability of the nutrimixes for the preparation of different food products. The materials used and the methods adopted for the study are given under the following headings.

3.1. Collection and processing of raw ingredients

3.2. Standardisation of millet based composite nutrimixes

3.3. Organoleptic qualities

- 3.3.1. Selection of judges
- 3.3.2. Preparation of score card

3.4. Quality evaluation of millet based composite nutrimixes

- 3.4.1. Nutritional qualities
- 3.4.2. Organoleptic qualities
- 3.4.3. Selection of composite nutrimixes

3.5. Quality evaluation of selected nutrimixes

- 3.5.1. Chemical and nutritional qualities
- 3.5.2. Organoleptic qualities
- 3.5.3. Microbial enumeration
- 3.5.4. Peroxide value
- 3.5.5. Insect infestation

3.6. Preparation of products from the selected composite nutrimixes

3.7. Cost of production of nutrimixes

3.8. Statistical analysis

3.1 Collection of raw ingredients

Finger millet and barnyard millet were selected as the major ingredients for developing composite nutrimixes. Flax seeds and garden cress seeds were used as the functional ingredients at 5 per cent and 10 per cent levels. Other ingredients used were whole wheat flour, skimmed milk powder, defatted soya flour, garden cress seed, flax seed and sugar. All the ingredients were collected from wholesale market.

The collected millets were cleaned, washed and malted. The procedure adopted for malting was standardised. Millets were soaked in water for varying time period of 4hr (T_1), 6hr (T_2), 8hr (T_3), 10hr (T_4), 12hr (T_5), 14hr (T_6), 16hr (T_7)and 18hr (T_8), to obtain optimum germination of millets with maximum organoleptic qualities. The germination time was fixed at 24 hrs. Details regarding the standardisation of soaking time is presented in Table 1.

3.1.1. Standardisation of soaking time

Table 1: Details regarding the soaking time of millets

Treatments	Soaking time (hours)
T_0	0
T_1	4
T_2	6
T_3	8
T_4	10
T_5	12
T_6	14
T_7	16
T_8	18

The organoleptic qualities of the malted millet flours were assessed and the treatments with maximum organoleptic qualities were selected.

Cleaning
↓
Soaking (10 hours)
↓
Germination (24 hours)
↓
Drying (40ºC)
↓
Powdering and sieving in 40 mesh size

3.2 Standardisation of millet based composite nutrimixes

Millet based composite nutrimixes were prepared using malted ragi flour and malted barnyard millet flour as major ingredients and also in different combinations.

Twenty five per cent of the total ingredients were fixed as protein source (PS) (wheat flour- 10 per cent, defatted soya flour -10 per cent, skimmed milk powder – 5 per cent) so as to provide protein in the developed nutrimixes. Five per cent sugar was used in all treatments. The functional ingredients like garden cress seed powder and flax seed powder was incorporated separately at 5 per cent and 10 per cent levels in all the treatments.

The details of treatments used to standardise the millet based composite nutrimixes are given in Table 2.

Table 2: Details regarding the standardisation of millet based composite nutrimixes

(MRF – Malted ragi flour, MBF – Malted barnyard millet flour, GCS – Garden cress seed powder, PS- Protein source, S- Sugar)

The experiment was repeated using flax seed powder (FSP) as the functional ingredient instead of Garden Cress Seed (GCS).

Treatments	Combinations
1	65%MRF+25%PS+5%S+ 5%GCS
2	60%MRF+25%PS+5%S+10%GCS
3	65%MBF+25%PS+5%S+5%GCS
4	60%MBF+25%PS+5%S+10%GCS
5	60%MRF+25%PS+5%S+5%MBF+5%GCS
6	55%MRF+25%PS+5%S+5%MBF+10%GCS
7	55%MRF+25%PS+5%S+10%MBF+5%GCS
8	50%MRF+25%PS+5%S+10%MBF+10%GCS
9	50%MRF+25%PS+5%S+15%MBF+5%GCS
10	45%MRF+25%PS+5%S+15%MBF+10%GCS
11	45%MRF+25%PS+5%S+20%MBF+5%GCS
12	40%MRF+25%PS+5%S+20%MBF+10%GCS
13	40%MRF+25%PS+5%S+25%MBF+5%GCS
14	35%MRF+25%PS+5%S+25%MBF+10%GCS
15	35%MRF+25%PS+5%S+30%MBF+5%GCS
16	30%MRF+25%PS+5%S+30%MBF+10%GCS
17	30%MRF+25%PS+5%S+35%MBF+5%GCS
18	25%MRF+25%PS+5%S+35%MBF+10%GCS
19	25%MRF+25%PS+5%S+40%MBF+5%GCS
20	20%MRF+25%PS+5%S+40%MBF+10%GCS
21	20%MRF+25%PS+5%S+45%MBF+5%GCS
22	15%MRF+25%PS+5%S+45%MBF+10%GCS
23	15%MRF+25%PS+5%S+50%MBF+5%GCS
24	10%MRF+25%PS+5%S+50%MBF+10%GCS
25	10%MRF+25%PS+5%S+55%MBF+5%GCS
26	5%MRF+25%PS+5%S+55%MBF+10%GCS
27	5%MRF+25%PS+5%S+60%MBF+5%GCS

Preparation of nutrimixes

Blending of raw ingredients in different proportions

↓

Pre-gelatinised with water (100g/250ml water for 10 minutes)

↓

Dried in cabinet drier (60°C) for 10 h

↓

Powdered

3.3. Quality evaluation of millet based composite nutrimixes

3.3.1. Nutritional qualities

The nutritional qualities of the formulated millet based composite nutrimixes were computed for nutrients like energy, carbohydrate, protein, fat, fibre, vitamins (carotene, thiamin, riboflavin, niacin) and minerals (calcium and iron). Nutrient content of the developed nutrimixes was calculated based on nutritional values of raw ingredients per 100 g as suggested by Gopalan *et al.* (1989).

3.3.2. Organoleptic evaluation

Organoleptic evaluation was conducted by preparing porridges with the developed nutrimixes using score card with nine point hedonic scale by a panel of fifteen judges.

3.3.2.1 Selection of judges

A series of organoleptic trials were carried out using simple triangle test at laboratory level to select a panel of fifteen judges as suggested by Jellinek (1985).

3.3.2.2 Preparation of score card

Score card was prepared using total six quality attributes such as appearance, colour, flavour, texture, taste and overall acceptability for organoleptic evaluation of millet based composite nutrimix. Each of the above mentioned qualities were assessed by a nine point hedonic scale. The prepared score card are presented in Appendix I.

3.3.3 Selection of millet based composite nutrimixes

Out of 54 treatments, two composite nutrimixes one each from GCS and FSP combination were selected based on the computed nutritive value and acceptability scores obtained for different quality attributes for further studies.

A relative ranking was conceived for assessing various nutrient parameters like energy, carbohydrate, protein, fat, fibre, calcium, iron, carotene, thiamin, riboflavin, niacin and vitamin C. The rank order was given in a relative way with highest value given as one, then there afterwards stepped down on rank order. A reverse rank order was followed in the case of fat. The total scores were recorded for all the nutrients mentioned. The combination which gives the least ranking score is the best treatment on the basis of nutrient content.

3.4 Quality evaluation of selected nutrimixes

The selected millet based composite nutrimixes were packed in polyethylene laminated aluminium pouches and kept for four months under ambient conditions. Chemical, nutritional, organoleptic and keeping qualities of stored nutrimixes were analysed initially and also during second and fourth month of storage.

3.4.1 Chemical and nutritional qualities

3.4.1.1 Moisture

Moisture content of the nutrimixes were estimated by the method of A.O.A.C. (1980). To determine the moisture content five gram of sample was taken in a petridish and dried at 60- 70°C in a hot air oven, cooled in a desiccator and weighed. The process of heating and cooling was repeated till constant weight was achieved. The moisture content of the sample was calculated from the loss in weight during drying

$$\text{Moisture content (\%)} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100$$

3.4.1.2 Energy

The energy content of nutrimixes were computed according to Gopalan *et al.* (1982) and expressed as kilocalories. The energy present in sample were calculated using the suggested formula below.

Energy (Kcal) = (4×protein) + (4×total carbohydrate) + (9×fat)

3.4.1.3 Starch

Starch content of the nutrimixes were estimated colorimetrically using anthrone reagent as suggested by Sadasivam and Manickam (1992). Weighed 0.5g of the sample and extracted with 80 per cent ethanol to remove sugars. Residue was repeatedly extracted with hot 80 per cent ethanol to remove the sugars completely. The residue was dried over a water bath and added five milliliter water and 6.5ml of 52 per cent perchloric acid and extracted in the cold for 20 minutes. Centrifuged the sample and re-extracted with fresh perchloric acid. The supernatant made upto one milliliter with water and added four milliliter of anthrone reagent, heated for 8 minutes, cooled and read the OD at 630 mm.

A standard graph was prepared using serial dilution of standard glucose solution. From the graph, glucose content of the sample was estimated.

3.4.1.4 Total carbohydrate

The carbohydrate content of selected nutrimixes was estimated by method suggested by Sadasivam and Manickam (1992). The 20 mg of sample was hydrolysed with 5 ml of 2.5N HCl for 3 hours and cooled to a room temperature. The residue was neutralised with solid sodium carbonate until effervescence ceases. The volume was made upto 100 ml and centrifuged. The supernatant (0.2 ml) was made up to one milliliter and then 4 milliliters of anthrone reagent was added and heated for eight minute, cooled rapidly and intensity of green to dark colour was read at 630 nm. A standard graph was prepared using standard glucose at serial dilution. From the standard graph, the amount of total carbohydrate present in sample was estimated and expressed in gram per 100 g of sample

3.4.1.5 Protein

The protein content of selected nutrimixes was estimated using Lowry's method given by Sadasivam and Manickam (1992). The sample (5 mg) was extracted using 5 – 10 ml of buffer (Tris Buffer GR – Tris Hydroxymethyl Amino methane) and centrifuged. The 0.1ml of supernatant was taken in test tube and 5 ml alkaline copper solution was added to the test tube. Mixed well and allowed to stand for 10 minutes. Then 0.5ml of Folin-Ciocalteau Reagent was added and incubated at room temperature in the dark for 30 minutes. The developed blue colour was read at 660 nm. A standard graph was prepared using alkaline copper solution and Folin-Ciocalteau reagent at serial dilution. From the standard graph, the amount of total protein present in sample was estimated and expressed in g per 100g of sample.

3.4.1.6 Total fat

The fat content of selected nutrimixes was estimated using the method given by Sadasivam and Manickam (1992). Five grams of sample was taken in a thimble and plugged cotton. The material was extracted with petroleum ether for six hours without interruption by gentle heating in a soxhlet apparatus. Extraction flask was then cooled and ether was removed by heating and weight was taken. The fat content was expressed in gram per 100g of the sample.

3.4.1.7 Crude fibre

The crude fibre of selected nutrimixes was estimated using method given by Sadasivam and Manickam (1992). Two grams of dried and powdered sample was boiled with 200 ml of 1.25 per cent sulphuric acid for thirty minutes. It was filtered using muslin cloth and washed with boiling water. The residue was again boiled with

200 ml of 1.25 per cent of sodium hydroxide for 30 minutes. Repeated the filtration through muslin cloth and residue was washed with 25ml of boiling 1.25 per cent of sulphuric acid, 50 ml of water and 25 ml of alcohol. Then obtained residue was taken in ashing dish (W_1) dried at 130^0c for 2 hours. Cooled the dish in a desiccator and weight (W_2). The residue was again ignited in muffle furnace at 600^0c for 30 minutes, cooled in a desiccator and reweight (W_3).

$$\text{Percentage of crude fibre} = \frac{\text{Loss in weight on ignition } (W2 - W1) - (W3 - W1)}{\text{Weight of the sample}} \times 100$$

3.4.1.8 Calcium

The calcium content of selected nutrimixes was estimated by Atomic Absorption Spectrophotometric method using diacid extract prepared from the sample (Perkin – Elmer, 1982). One gram of the sample was predigested with 10ml of 9:4 mixtures of nitric acid and perchloric acid and made up to 100 ml and used directly in Atomic Absorption Spectrophotometer for the estimation of calcium and expressed in mg per 100 g of the sample.

3.4.1.9 Iron

The iron content of selected nutrimixes were estimated using Atomic Absorption Spectrophotometric method using diacid extract prepared from the sample (Perkin – Elmer, 1982). One gram of the sample was predigested with 10ml of 9:4 mixtures of nitric acid and perchloric acid and made up to 100 ml and used directly in Atomic Absorption Spectrophotometer for the estimation of iron and expressed in mg per 100 g of the sample.

3.4.1.10 Zinc

The zinc content of selected nutrimixes were estimated using Atomic Absorption Spectrophotometric method using diacid extract prepared from the sample

(Perkin – Elmer, 1982). One gram of the sample was predigested with 10ml of 9:4 mixtures of nitric acid and perchloric acid and made up to 100 ml and used directly in Atomic Absorption Spectrophotometer for the estimation of zinc and expressed in mg per 100 g of the sample.

3.4.1.11 Phosphorus

The phosphorus content was analysed colorimetrically which gives yellow colour with nitric acid and vandate molybdate reagent. Five ml of predigested aliquot, 5 ml of nitric acid and vandate molybdate reagent was added and made up to 50 ml with distilled water. After 10 minutes, the optical density was read at 420 nm. A standard graph was prepared using serial dilution of standard phosphorus solution. The phosphorus content was expressed in mg $100g^{-1}$.

3.4.1.12 *In vitro* starch digestibility

Starch digestibility was estimated as suggested by Satterlee *et al.* (1979). One gram of sample in 100 ml water was gelatinised and boiled for one hour and filtered. One ml of the gelatinised solution was taken and one ml of the enzyme solution (saliva diluted with equal quantity water) was added. The mixture was incubated at 37°C for 1-2 hours. The reaction was stopped by adding one ml of sodium hydroxide. Later the glucose was estimated by the method of Somoygi (1952).

3.4.1.13 *In vitro* protein digestibility (IVPD)

The method proposed by Sadasivam and Manickam (1992) was used to determine IVPD. A multi enzyme system, consisting of a mixture of porcine pancreatic trypsin type IX, bovine pancreatic chymotrypsin type II, and porcine intestinal peptidase grade III was used. Food mixtures and distilled water were used to prepare 50 ml of an aqueous protein suspension (6.25 g protein/1) with pH adjusted to 8.0, while stirring in a water bath at 37° C. The multi enzyme system was maintained in an ice bath. Five ml of aliquots of the multi enzyme solution were added with stirring to the water suspension at 37° C. The rapid pH drop was recorded automatically over a 10 minutes period using pH meter. IVPD was calculated from the equation IVPD = 210.46 – 18.10X, where X = pH after 10 minutes.

3.4.1.14 *In vitro* availability of minerals

The sample was extracted with 0.03 N hydrochloric acid by shaking the contents at 37°C for 3 hours. The clear extract obtained after filtration with whatsman No.42 filter paper was oven dried at 100°C and wet acid digested. The amount of the HCl extractable calcium, phosphorus, iron, potassium and zinc in the digested sample were determined by the methods as described the estimation of minerals.

$$\text{Mineral extractability} = \frac{\text{Mineral extractability in 0.03 N HCl}}{\text{Total mineral}} \times 100$$

3.4.2. Organoleptic qualities

The organoleptic qualities of the stored nutrimixes were conducted as per the procedures discussed in 3.3.2.

3.4.3. Microbial enumeration

The millet based composite nutrimix were evaluated for the presence of bacteria, yeast and fungi initially and during second and fourth month of the storage period. The methods used for analysing microbes were serial dilution and plate count method suggested by Agarwal and Hasija (1986). Ten gram of sample was added to 90 ml of sterile water and shaken for 20 minutes. From that one ml of solution was transferred to a test tube containing 9 ml of sterile water to get 10^{-2} dilution and similarly 10^{-3}, 10^{-4}, 10^{-5} and 10^{-6} dilutions were also prepared. Enumeration of total micro flora was carried out using Nutrient agar media for bacteria, potato dextrose agar media for fungi and Sabouraud's dextrose agar media for yeast, which was prepared from Himedia Lab, Mumbai. The dilution for bacteria was 10^{-6}, for yeast 10^{-3} and for fungi 10^{-3}.

3.4.4. Peroxide value

Peroxide value of selected nutrimixes were estimated to find the rate of rancidity during storage. It was estimated by the procedure given by Sadasivam and Manickam (1992). One gram of sample was taken in a boiling tube and to that one gram of potassium iodide and 20ml solvent mixture (glacial acetic acid and chloroform) was added. The tube was placed in boiling water for 30 second and transferred the contents to a conical flask containing 20 ml of 5 per cent potassium iodide solution. The tubes were washed twice with 25 ml water and collected in a conical flask. This was titrated against N/500 sodium thiosulphate solution until yellow colour disappears. Later 0.5 ml of starch solution was added and titrated till the appearance of blue colour. A blank solution was also prepared and peroxide value was calculated and expressed in milliequivalent per kg of the sample.

3.4.5. Insect infestation

Nutrimixes were sieved and observed under microscope for assessing the presence of storage insects.

3.5 Preparation of products from the selected composite nutrimixes

Different food products was prepared namely sweet *laddu,* health drink and *pakkoda* from the selected two composite nutrimixes. The organoleptic evaluation was conducted among 30 adolescents to get the best products from the millet based composite nutrimixes. The procedure adopted for the preparation of different products are presented in Appendix II.

3.6 Cost of production

Cost of millet based composite nutrimixes were estimated based on the expenses needed for the preparation of the products. The cost of production was computed based on the market price of procured ingredients used for preparation of products. The cost was calculated for 100g of the product and compared with similar products available in the market.

3.7 Statistical analysis of data

The scores of organoleptic evaluation were assessed by Kendall's coefficient of concordance (W). The data of nutritive value were assessed by scoring method. The biochemical observations were tabulated and data analysed by using independent t test.

RESULTS

4. RESULTS

The results pertaining to the study entitled "Standardisation and quality evaluation of millet based composite nutrimixes for adolescents" are presented under the following headings.

4.1 Stanadardisation of malting of millets

4.2 Standardisation of millet based composite nutrimixes

4.2.1. Nutritional qualities of nutrimixes

4.2.2. Organoleptic qualities of nutrimixes

4.3. Nutritional qualities of selected nutrimixes

4.4. Quality evaluation of selected composite nutrimixes on storage

4.4.1. Nutritional qualities

4.4.2. Organoleptic qualities

4.4.3. Shelf life qualities

4.5. Preparation of products from the selected composite nutrimixes

4.5.1 Organoleptic evaluation

4.6. Cost of production of nutrimixes

4.1 Stanadardisation of malting of millets

Ragi and barnyard millet were selected as the major ingredients, for developing composite nutrimixes. The selected millets were malted for improving the nutritional and organoleptic qualities. Malting procedure was standardised for both ragi and barnyard millet separately. Optimum germination of millets with maximum organoleptic qualities were assessed based on varying time of soaking. Alltogether there were 9 treatments, and the ungerminated millet flour (T_0) was kept as control. The germination time was fixed at 24 hours. Millets were soaked in water for varying time period of 4hr (T_1), 6hr (T_2), 8hr (T_3), 10hr (T_4), 12hr (T_5), 14hr (T_6), 16hr (T_7)and 18hr (T_8). After germination the seeds were dried at 60°C for 8 hours and powdered to get a uniform flour. A porridge was prepared using standard procedure suggested by Nasheeda (2006) and the organoleptic qualities were evaluated.

4.1.1 Organoleptic qualities of malted millet flours

The mean scores and the mean rank scores obtained for different quality attributes of malted millet flours are presented in Table 3. Prepared malted ragi and malted barnyard millet flour was presented in Plate 1. and Plate 2.

Based on the organoleptic scores of malted ragi flour, the mean score for the appearance ranged from 7.55 (T_0) to 7.97 (T_4 and T_5) with mean rank score from 2.81 to 6.56. In malted barnyard millet flour, highest mean score for appearance was obtained for T_4 (8) and the lowest for T_0 (7.76).

For colour, the mean score and mean rank score ranged from 7.31 (T_0) to 7.84 (T_4) and 2.56 to 6.25 respectively in malted ragi flour. In malted barnyard millet flour, the highest mean score and mean rank score of colour was for T_4 (7.76 and 6.30) followed by T_7 (7.73 and 6.07) and T_5 (7.63 and 5.27)

The mean score for flavour of malted ragi flour ranged from 7.02 (T_0) to 7.55 (T_4) with the mean rank scores from 3.50 to 6.38. In malted barnyard millet flour, the highest mean scores for flavour was obtained for T_4 (7.5) followed by T_5 and T_3 (7.13).

In the case of texture, the mean scores and mean rank scores ranged from 7.02 (T_0) to 7.68 (T_4) and 2.25 to 7.31 respectively in malted ragi flour. In malted barnyard millet flour the highest mean scores and mean rank for texture was 7.16 (T_4) followed by 7.03 (T_5) and 7 (T_3 and T_7).

For taste and overall acceptability, the highest mean score was obtained for the treatment T_4 (7.6) and lowest for T_0 (6.35) in malted ragi flour. In malted barnyard millet flour, the highest mean score for taste was obtained for the treatment T_4 (7.4) followed by T_5 (6.76) and T_2 (6.16). The mean scores for overall acceptability of

T_0

T_1

T_2

T_3

T_4

T_5

T_6

T_7

T_8

Plate 2. Malted barnyard millet flour with varying soaking time

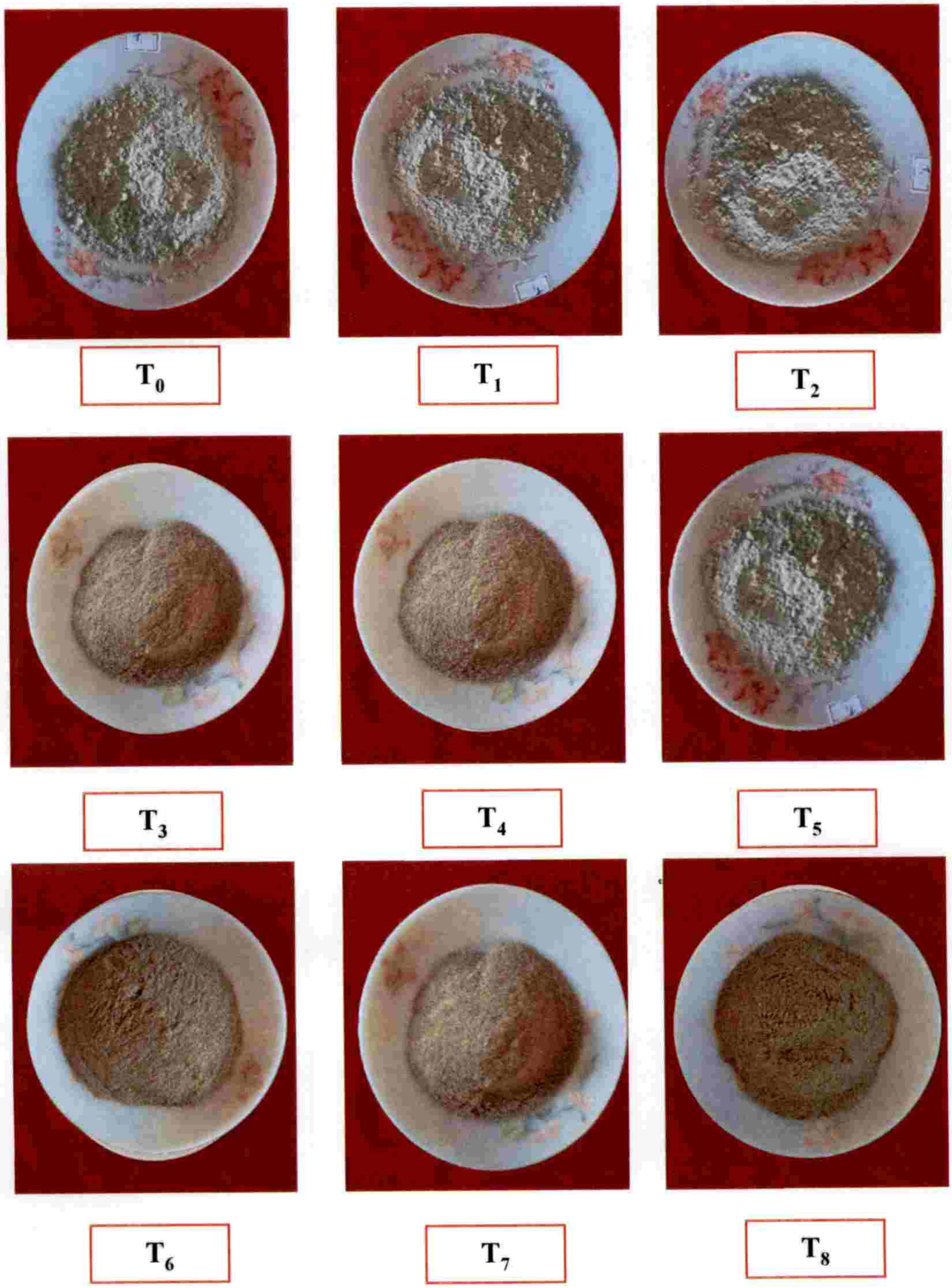


Plate 1. Malted ragi flour with varying soaking time

Table 3: Organoleptic qualities of malted millet flours

Treatments	Appearance		Colour		Flavour		Texture		Taste		Overall Acceptability	
	MRF	MBF	MRF	MBF	MRF	MBF	MRF	MBF	MRF	MBF	MRF	MBF
T_0	7.55 (2.81)	7.76 (4.17)	7.31 (2.56)	7.5 (4.30)	7.02 (3.50)	6.4 (2.07)	7.02 (2.25)	6.56 (3.60)	6.35 (2.22)	5.2 (1.73)	6.8 (2.47)	5.9 (2.40)
T_1	7.75 (4.38)	7.9 (5.10)	7.71 (5.06)	7.56 (4.83)	7.11 (3.81)	6.6 (2.90)	7.48 (5.62)	6.76 (4.37)	6.66 (3.22)	5.63 (2.80)	7.06 (3.66)	6.0 (2.57)
T_2	7.77 (4.56)	7.83 (4.53)	7.80 (5.88)	7.56 (4.77)	7.35 (5.31)	7.00 (4.97)	7.44 (5.09)	6.83 (4.50)	6.82 (3.72)	6.16 (4.47)	7.15 (4.25)	6.43 (4.90)
T_3	7.8 (5.00)	7.86 (4.83)	7.82 (5.03)	7.6 (5.07)	7.28 (4.59)	7.13 (5.90)	7.48 (5.44)	7 (5.57)	7.17 (5.84)	6.5 (6.17)	7.44 (5.97)	6.63 (5.83)
T_4	7.97 (6.56)	8.00 (5.70)	7.84 (6.25)	7.76 (6.30)	7.55 (6.38)	7.5 (7.63)	7.68 (7.31)	7.16 (6.43)	7.6 (7.25)	7.4 (8.63)	7.72 (7.69)	7.66 (8.50)
T_5	7.97 (5.22)	7.96 (5.67)	7.82 (4.84)	7.63 (5.27)	7.51 (6.09)	7.13 (5.70)	7.28 (3.66)	7.03 (5.60)	7.31 (6.19)	6.76 (6.93)	7.27 (5.09)	6.8 (6.63)
T_6	7.84 (5.28)	7.86 (4.83)	7.73 (5.03)	7.53 (4.47)	7.24 (4.47)	7.06 (5.33)	7.41 (4.56)	6.9 (4.87)	6.93 (4.09)	6.4 (5.33)	7.15 (4.44)	6.63 (5.97)
T_7	7.88 (5.88)	7.9 (5.10)	7.83 (5.53)	7.73 (6.07)	7.35 (4.97)	7.06 (5.33)	7.51 (5.78)	7 (5.40)	7.31 (6.56	6.03 (4.10)	7.38 (6.12)	6.16 (3.87)
T_8	7.81 (5.31)	7.9 (5.07)	7.82 (4.81)	7.46 (3.83)	7.42 (5.88)	7.03 (5.17)	7.46 (5.28)	6.86 (4.67)	7.2 (5.84)	6.16 (4.83)	7.27 (5.28)	6.26 (4.33)
Kendall's W	0.201 *	0.149*	0.173*	0.162*	0.151*	0.458*	0.320*	0.214*	0.422*	0.640*	0.339*	0.606*

MRF – Malted ragi flour, MBF malted barnyard millet flour,
Values in parentheses are mean rank scores based on Kendall's W *-Significance at 1 % level
T_1- Control, T_2 – 4 hrs soaking, T_3 – 6 hrs soaking, T_4 – 8 hrs soaking, T_5 – 10 hrs soaking, T_6 – 12 hrs soaking, T_7 – 14 hrs soaking, T_8 – 16 hrs soaking, T_9 – 18 hrs soaking

malted barnyard millet flour was found to be highest in T_4 (7.66) with mean rank score of 8.5.

Based on the organoleptic scores of both malted ragi flour and malted barnyard millet flour, treatment T_4 obtained the highest scores for all parameters like appearance, colour, flavor, texture, taste, and overall acceptability. A significant agreement among judges was observed for the all quality attributes of malted ragi flour and malted barnyard millet flour prepared by soaking for 10hrs and germinated for 24 hrs

Hence, T_4 (soaking in water for 10hrs and germination for 24 hrs) was found to be the best treatment to get optimum malting with maximum organoleptic qualities.

4.2 Standardisation of millet based composite nutrimixes

Millet based composite nutrimixes were standardised by using varying proportions of malted ragi flour and barnyard millet flour. Two functional ingredients like garden cress seed powder and flax seed powder were also added separately in 5 per cent and 10 per cent levels. Other ingredients were kept in a fixed proportion. Totally 54 treatments were tried, in that 27 treatments were incorporated with garden cress seed powder and another 27 treatments with flax seed powder. The treatments done are detailed in section 3.3.

4.2.1 Nutritional qualities of composite nutrimixes

Nutritional qualities of 27 nutrimixes per 100g were assessed separately for treatments based on garden cress seeds and flax seeds. Assessment of nutritional qualities was based on computation of nutritive value of raw ingredients.

4.2.1.1 Nutritional qualities of nutrimixes incorporated with garden cress seed

Twenty seven treatments of millet based composite nutrimixes incorporated with garden cress seeds were prepared (Plate 3) and the nutrient qualities were calculated. The details regarding the computed nutritive value of millet based nutrimixes incorporated with garden cress seeds are furnished in Table 4.

The highest energy content was observed in T_2 (317.52 Kcal) followed by the treatments T_6 (316.12 Kcal), T_4 (315.72 Kcal) and T_8 (314.72 Kcal). The lowest energy content of 285.72 Kcal was observed in treatment T_{26}. For the rest of the treatments energy content was in the range of 293.02 Kcal to 313.32 Kcal. The rank order was given based on relative ranking method in which rank one was assigned for the highest value.

In the case of carbohydrates, T_1 had the highest carbohydrate content of 61.26 g followed by the treatments T_5 (60.94g 100 g^{-1}), T_7 (60.61g 100 g^{-1}) and T_9 (60.28g 100 g^{-1}). Carbohydrate content was low in the treatments T_{26} (55.73g 100 g^{-1}), T_{24} (56.06g 100 g^{-1}) and T_{22} (56.39g 100 g^{-1}). In other treatments, carbohydrate content is varied from 56.39g 100 g^{-1} to 59.96g 100 g^{-1}.

The highest protein content was observed in the treatment T_2 (16.22g 100 g^{-1}) and followed by T_6 (16.17g 100 g^{-1}), T_8 (16.1g 100 g^{-1}) and T_{10} (15.16g 100 g^{-1}). The lowest protein content was observed in T_3 (14.61g 100 g^{-1}). The other treatments also provided adequate amount of protein in the range of 14.66g 100 g^{-1} to 16.00g 100 g^{-1}.

In the case of fat, lowest score were considered as the desirable quality and hence the combination with lower values for fat was ranked high. So, for fat, T_1, T_2, T_7 and T_9 obtained rank order of 1, 2, 3, 4 respectively. Treatments T_3 (10.09g 100 g^{-1}) and T_4 (10.47g 100 g^{-1}) obtained high crude fibre content, in T_1 (3.59g 100 g^{-1}) the lowest fibre content was observed in other treatments in the range of 4.05g 100 g^{-1} to 9.59g 100 g^{-1}.

The nutrimixes were found to be rich in vitamins and minerals. Treatments T_1, T_2 and T_6 had a high calcium content of 319.68mg 100 g^{-1}, 318.03mg 100 g^{-1} and 303.58mg 100 g^{-1} respectively. The iron content was highest in T_4 (24.02mg 100 g^{-1}) followed by T_{26} (22.35mg 100 g^{-1}) and T_{24} (21.6mg 100 g^{-1}), with lowest calcium content in T_1 (9.47mg 100 g^{-1}).

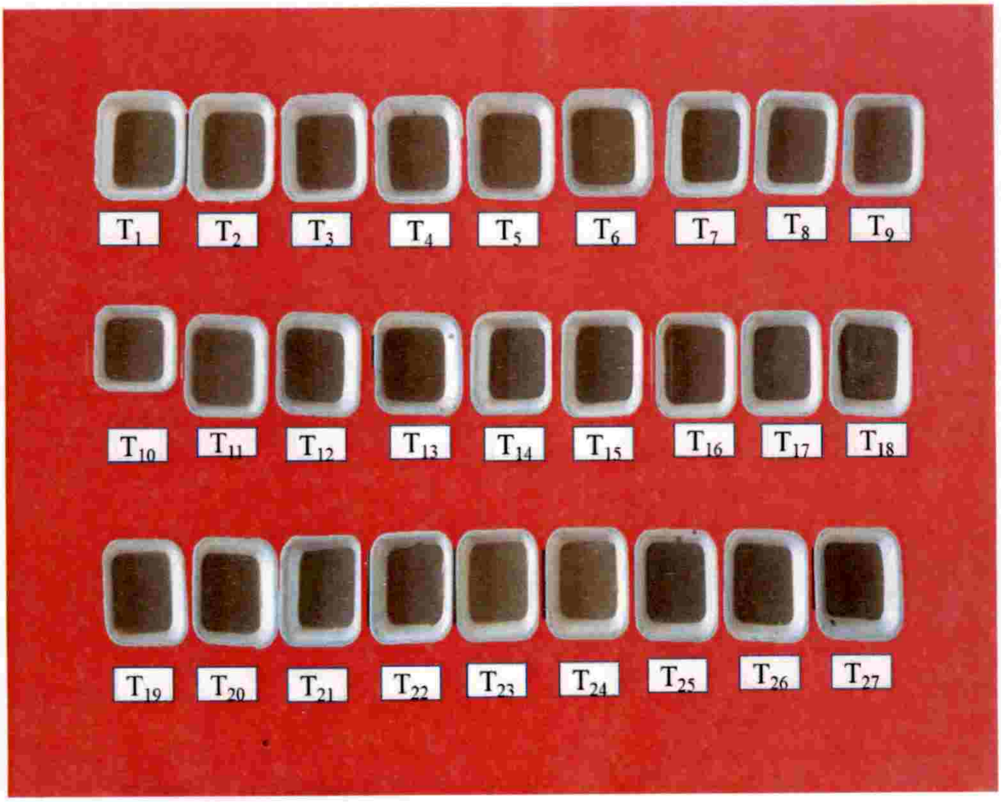


Plate 3. Garden cress seeds incorporated millet based composite nutrimixes

Table 4: Nutritional qualities of nutrimixes incorporated with garden cress seed (100g)

Treat-ments	Energy (Kcal)	CHO (g)	Protein (g)	Fat (g)	Fibre (g)	Calcium (mg)	Iron (mg)	Carotene (µg)	Thiamin (mg)	Riboflavin (mg)	Niacin (mg)	Total Score
1	311.22 (7)	61.26 (1)	15.32 (14)	2.37 (1)	3.59 (27)	318.03 (2)	9.47 (27)	74.15 (1)	0.44 (3)	0.29 (14)	2.23 (27)	124
2	317.52 (1)	59.31 (7)	16.22 (1)	3.53 (8)	3.79 (26)	319.68 (1)	14.27 (20)	73.4 (2)	0.45 (1)	0.31 (1)	2.89 (22)	90
3	293.02 (26)	57.04 (22)	14.61 (27)	4.64 (21)	10.09 (2)	108.73 (27)	19.02 (7)	58.55 (27)	0.38 (27)	0.16 (27)	4.24 (5)	218
4	315.72 (3)	58.69 (11)	15.87 (8)	5.87 (27)	10.47 (1)	127.58 (25)	24.02 (1)	59.9 (25)	0.41 (17)	0.30 (8)	4.96 (1)	127
5	309.82 (9)	60.94 (2)	15.27 (15)	2.54 (2)	4.09 (25)	301.93 (4)	10.2 (26)	72.95 (3)	0.44 (5)	0.29 (15)	2.38 (26)	132
6	316.12 (2)	58.99 (9)	16.17 (2)	3.7 (10)	4.29 (24)	303.58 (3)	15.01 (18)	72.2 (4)	0.45 (2)	0.31 (2)	3.04 (20)	96
7	308.42 (11)	60.61 (3)	15.21 (16)	2.72 (3)	4.59 (23)	285.83 (5)	10.94 (25)	71.75 (5)	0.43 (7)	0.28 (16)	2.54 (25)	139
8	314.72 (4)	58.65 (13)	16.1 (3)	3.88 (12)	4.79 (22)	287.48 (6)	15.74 (16)	71 (6)	0.44 (4)	0.31 (3)	3.2 (18)	107

Figures in parenthesis indicate the total rank scores

Contd.

9	307.02 (13)	60.29 (4)	15.16 (17)	2.89 (4)	5.09 (21)	269.73 (8)	11.67 (24)	70.55 (7)	0.43 (9)	0.28 (17)	2.69 (24)	148
10	313.32 (5)	58.34 (14)	16.06 (4)	4.05 (14)	5.29 (20)	271.38 (7)	16.48 (14)	69.8 (8)	0.44 (6)	0.30 (4)	3.35 (16)	112
11	305.62 (15)	59.96 (5)	15.1 (18)	3.07 (5)	5.59 (19)	253.63 (10)	12.41 (23)	69.35 (10)	0.42 (11)	0.28 (18)	2.85 (23)	157
12	311.92 (6)	58.01 (16)	16 (5)	4.23 (16)	5.79 (18)	255.28 (9)	17.21 (12)	68.6 (9)	0.43 (8)	0.30 (5)	3.51 (14)	118
13	304.22 (17)	59.64 (6)	15.05 (19)	3.24 (6)	6.09 (17)	237.53 (12)	13.14 (22)	68.15 (11)	0.42 (13)	0.28 (19)	3.00 (21)	163
14	310.52 (8)	57.69 (18)	15.95 (6)	4.4 (18)	6.29 (16)	239.18 (11)	17.95 (10)	67.4 (12)	0.43 (10)	0.30 (6)	3.66 (11)	126
15	302.82 (19)	59.30 (8)	15.00 (20)	3.42 (7)	6.59 (15)	221.43 (14)	13.88 (21)	66.95 (13)	0.42 (15)	0.28 (20)	3.16 (19)	171
16	309.12 (10)	57.36 (20)	15.90 (7)	4.58 (20)	6.79 (14)	223.08 (13)	18.68 (8)	66.2 (14)	0.42 (12)	0.30 (7)	3.82 (10)	135
17	301.42 (20)	58.99 (10)	14.94 (21)	3.59 (9)	7.09 (13)	205.33 (16)	14.61 (19)	65.75 (15)	0.41 (18)	0.28 (21)	3.31 (17)	179
18	307.72 (12)	57.03 (23)	15.84 (9)	4.75 (22)	7.29 (12)	206.98 (15)	19.42 (6)	65 (17)	0.42 (14)	0.30 (9)	3.97 (8)	147

Figures in parenthesis indicate the total rank scores

Contd.

19	300.02 (21)	58.66 (12)	14.88 (22)	3.77 (11)	7.59 (11)	189.23 (18)	15.35 (17)	64.55 (16)	0.41 (20)	0.28 (22)	3.47 (15)	185
20	306.32 (14)	56.71 (24)	15.78 (10)	4.93 (23)	7.79 (10)	190.88 (17)	20.15 (5)	63.8 (18)	0.41 (16)	0.30 (10)	4.13 (6)	153
21	298.62 (22)	58.33 (15)	14.83 (23)	3.94 (13)	8.09 (9)	173.13 (20)	16.08 (15)	63.35 (19)	0.40 (22)	0.27 (23)	3.62 (13)	194
22	304.92 (16)	56.39 (25)	15.73 (11)	5.1 (24)	8.29 (8)	174.78 (19)	20.89 (4)	62.6 (20)	0.41 (19)	0.29 (11)	4.28 (4)	161
23	297.22 (23)	58.00 (17)	14.77 (24)	4.12 (15)	8.59 (7)	157.03 (22)	16.82 (13)	62.15 (21)	0.40 (24)	0.27 (24)	3.78 (12)	202
24	303.52 (18)	56.06 (26)	15.67 (12)	5.28 (25)	8.79 (6)	158.68 (21)	21.62 (3)	61.4 (22)	0.41 (21)	0.29 (12)	4.44 (3)	169
25	295.82 (24)	57.68 (19)	14.72 (25)	4.29 (17)	9.09 (5)	140.93 (23)	17.55 (11)	60.95 (23)	0.39 (25)	0.27 (25)	3.93 (9)	240
26	285.72 (27)	55.73 (27)	15.62 (13)	5.45 (26)	9.29 (4)	142.58 (24)	22.35 (2)	60.2 (24)	0.41 (23)	0.29 (13)	4.59 (2)	185
27	294.42 (25)	57.35 (21)	14.66 (26)	4.47 (19)	9.59 (3)	124.83 (26)	18.28 (9)	59.75 (26)	0.39 (26)	0.27 (26)	4.09 (7)	214

Figures in parenthesis indicate the total rank scores

Vitamins like thiamin (0.45mg 100 g^{-1}) and riboflavin (0.31mg 100 g^{-1}) were found to be high in T_2 and niacin (4.96mg 100 g^{-1}) was high in T_4. Highest carotene was observed in T_1 (74.15μg 100 g^{-1}) and T_2 (73.4μg 100 g^{-1}) and lowest in T_3 (58.55μg 100 g^{-1}).

Based on the relative ranking method, the total ranks were computed and found that T_2, T_6 and T_8 obtained rank scores of 90, 96 and 107 which indicate that they are nutritionally superior nutrimixes. Among these, T_2 was found to be nutritionally superior with 317.52 Kcal of energy, 59.31 g 100 g^{-1} of carbohydrate, 16.22 g 100 g^{-1} of protein, 3.52 g 100 g^{-1} of fat, 3.79 g 100 g^{-1} of fibre, 319 mg 100 g^{-1} of calcium and 14.27 mg 100 g^{-1} of iron. With respect to nutritional qualities, both T_6 and T_8 were also found to be on par with T_2. It was found to be have 316.12 Kcal and 314.72 Kcal of energy, 58.98 g 100 g^{-1} and 58.66 g 100 g^{-1} of carbohydrate, 16.17 g 100 g^{-1} and 16.11 g 100 g^{-1} of protein 3.7 g 100 g^{-1} and 3.87 g 100 g^{-1} of fat 4.29 g 100 g^{-1} and 4.79 g 100 g^{-1} of fibre, 305.58 mg 100 g^{-1} and 287.48 mg 100 g^{-1} of calcium 5.83 mg 100 g^{-1} and 6.57 mg of iron 100 g^{-1} in T_6 and T_8 respectively.

Treatments like T_{23}, T_{25} and T_{27} obtained rank scores of 202, 240 and 214 and which indicate that they are nutritionally lower compared to other treatments.

4.2.1.2 Nutritional qualities of nutrimixes incorporated with flax seeds

Twenty seven treatments of flax seeds incorporated nutrimixes were prepared (Plate 4) and the nutrient composition was computed. Nutritional qualities of millet based composite nutrimixes incorporated with flax seeds (100 g) are furnished in Table 5.

The treatment T_2 contain high amount of energy (325.12 Kcal), followed by treatments T_6 (323.72 Kcal), T_4 (323.32 Kcal) and T_8 (322.32 Kcal). Lower energy content was seen in T_3 (296.82 Kcal) and T_{27} (298.22 Kcal). Other treatments also provided adequate energy in the range of 299.62 Kcal to 320.92 Kcal.

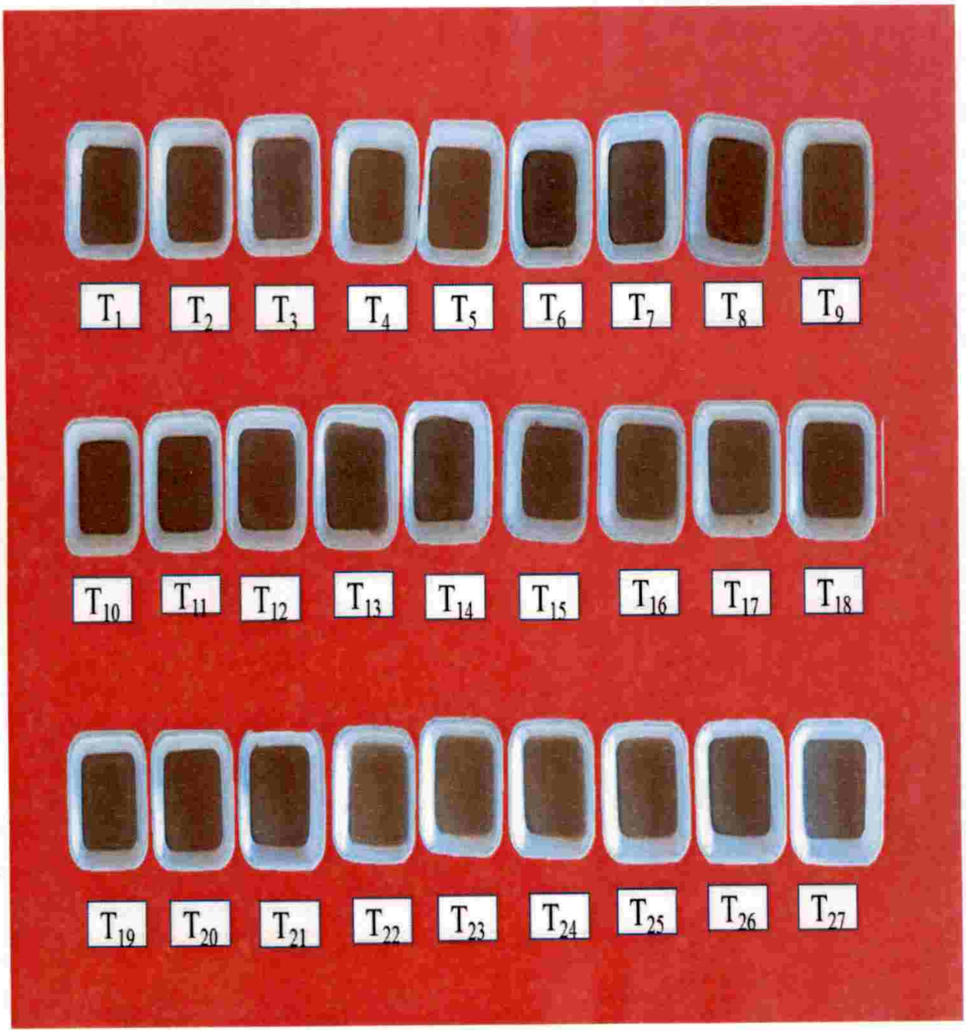


Plate 4. Flax seeds incorporated millet based composite nutrimixes

Carbohydrate content was the highest in T_1 (61.06 g 100 g^{-1}), followed by T_5 (60.73 g 100 g^{-1}), T_7 (60.40 g 100 g^{-1}) and T_9 (60.08 g 100 g^{-1}) and the lowest carbohydrate content was found in T_{26} (55.33 g 100 g^{-1}). Rest of the treatments had carbohydrates in the range of 55.65 g 100 g^{-1} to 59.76 g 100 g^{-1}. The protein content of 15.72 g was observed in the treatment T_2, followed by T_6 (15.66 g 100 g^{-1}), T_8 (15.610 g 100 g^{-1}) and T_{10} (15.56 g 100 g^{-1}). The lowest protein content of 14.06 g 100 g^{-1} was found in T_4. Other treatments contain protein in the range of 14.36 g 100 g^{-1} to 15.50 g 100 g^{-1} respectively. The fat content of flax seed incorporated nutrimixes ranged from 2.99 g 100 g^{-1} (T_1) to 10.19 g 100 g^{-1} (T_4). The highest fibre content was noticed in T_4 (10.19 g 100 g^{-1}) followed by T_3 (9.95 g 100 g^{-1}) and T_{27} (9.45 g 100 g^{-1}), and the lowest in T_1 (2.99 g 100 g^{-1}).

Vitamin and mineral content of the nutrimixes were assessed. Highest amounts of calcium was found in T_1 (307.68 mg 100 g^{-1}), T_2 (298.98 mg 100 g^{-1}) and T_5 (291.58 mg 100 g^{-1}) and the lowest in T_3 (98.38 mg 100 g^{-1}). The highest iron content was found in T_4 (14.29 mg 100 g^{-1}) followed by T_3 (14.16 mg 100 g^{-1}), T_{27} (13.42 mg 100 g^{-1}) and T_{25} (12.69 mg 100 g^{-1}). Thiamin content was high in T_1 (0.43 mg 100 g^{-1}) whereas riboflavin was high in T_4 (0.30 mg 100 g^{-1}). Niacin was found to be the highest in T_3 (3.58 mg 100 g^{-1}) and the lowest in T_2 (1.56 mg 100 g^{-1}) Carotene content was in the range of 58.7 μg 100 g^{-1} to 74.3 μg 100 g^{-1} with highest in T_1 (74.3 μg 100 g^{-1}) and followed by T_2 (73.7 μg 100 g^{-1}) and T_5 (73.1 μg 100 g^{-1}).

When the total rank scores were computed, treatments like T_7, T_1 and T_2 obtained rank scores of 110, 115 and 116 respectively, which indicated that these treatments are superior in nutritional qualities compared to other treatments. Among different treatments, T_7 was considered as the best nutrimix, with respect to nutritional qualities because it provided 315.02 Kcal of energy, 60.40 g of carbohydrate, 15.07 g 100 $g^{-1}$of protein, 3.34 g 100 $g^{-1}$of fat, 4.45 g 100 g^{-1} fibre, and 275.48 mg 100 g^{-1} of calcium and 6.07 mg 100 g^{-1} of iron. Both T_1 and T_2 were also found to be on par with

Table 5: Nutritional qualities of nutrimixes incorporated with flax seed (100g)

Treat-ments	Energy (Kcal)	CHO (g)	Protein (g)	Fat (g)	Fibre (g)	Calcium (mg)	Iron (mg)	Carotene (µg)	Thiamin (mg)	Riboflavin (mg)	Niacin (mg)	Total Score
1	312.22 (14)	61.06 (1)	14.96 (15)	2.99 (1)	3.45 (27)	307.68 (1)	4.6 (26)	74.3 (1)	0.42 (1)	0.26 (4)	1.56 (25)	116
2	325.12 (1)	58.9 (8)	15.72 (1)	4.79 (12)	3.51 (26)	298.98 (2)	4.54 (27)	73.7 (2)	0.41 (4)	0.25 (6)	1.56 (26)	115
3	296.82 (27)	56.83 (22)	14.36 (26)	5.27 (17)	9.95 (2)	98.38 (27)	14.16 (2)	58.7 (27)	0.37 (26)	0.24 (24)	3.58 (1)	201
4	323.32 (3)	57.72 (16)	14.05 (27)	7.13 (27)	10.19 (1)	106.9 (26)	14.29 (1)	60.2 (25)	0.35 (26)	0.30 (1)	3.47 (2)	155
5	313.62 (12)	60.73 (2)	15.02 (14)	3.17 (2)	3.95 (25)	291.58 (3)	5.34 (24)	73.1 (3)	0.42 (2)	0.26 (3)	1.72 (23)	114
6	323.72 (2)	58.58 (10)	15.67 (2)	4.96 (14)	4.01 (24)	282.88 (4)	5.28 (25)	72.5 (4)	0.41 (6)	0.25 (8)	1.71 (24)	119
7	315.02 (10)	60.41 (3)	15.07 (13)	3.35 (3)	4.45 (23)	275.48 (5)	6.07 (22)	71.9 (5)	0.42 (3)	0.26 (2)	1.87 (21)	110
8	322.32 (4)	58.25 (12)	15.61 (3)	5.14 (16)	4.51 (22)	266.78 (6)	6.01 (23)	71.3 (6)	0.41 (8)	0.25 (10)	1.87 (22)	132

Contd.

Figures in parenthesis indicate the rank scores

9	310.82 (16)	60.08 (4)	14.91 (16)	3.52 (4)	4.95 (21)	259.38 (7)	6.81 (20)	70.7 (7)	0.41 (5)	0.26 (5)	2.03 (19)	125
10	320.92 (5)	57.93 (14)	15.56 (4)	5.31 (18)	5.01 (20)	250.68 (8)	6.75 (21)	70.1 (8)	0.40 (10)	0.25 (13)	2.02 (20)	141
11	309.42 (18)	59.76 (5)	14.85 (17)	3.70 (5)	5.45 (19)	243.28 (9)	7.54 (18)	69.5 (9)	0.41 (7)	0.25 (7)	2.18 (17)	131
12	319.52 (6)	57.6 (17)	15.5 (5)	5.49 (19)	5.51 (18)	234.58 (10)	7.48 (19)	68.9 (10)	0.40 (12)	0.25 (15)	2.18 (18)	149
13	308.02 (19)	59.43 (6)	14.80 (18)	3.87 (6)	5.95 (17)	227.18 (11)	8.28 (16)	68.3 (11)	0.40 (9)	0.25 (9)	2.34 (15)	137
14	318.12 (7)	57.28 (19)	15.45 (6)	5.66 (20)	6.01 (16)	218.48 (12)	8.22 (17)	67.7 (12)	0.39 (14)	0.25 (17)	2.33 (16)	156
15	306.62 (20)	59.11 (7)	14.74 (19)	4.05 (7)	6.45 (15)	211.08 (13)	9.01 (14)	67.1 (13)	0.40 (11)	0.25 (11)	2.49 (13)	143
16	316.72 (8)	56.95 (21)	15.39 (7)	5.84 (21)	6.51 (14)	202.38 (14)	8.95 (15)	66.5 (14)	0.39 (15)	0.25 (12)	2.49 (14)	155
17	305.22 (21)	58.78 (9)	14.69 (20)	4.22 (8)	6.95 (13)	194.98 (15)	9.75 (12)	65.9 (15)	0.39 (13)	0.25 (14)	2.65 (11)	151
18	315.32	56.63	15.34	6.01	7.01	186.28	9.69	65.3	0.38	0.24	2.64	169

Figures in parenthesis indicate the rank scores

Contd.

	(9)	(23)	(8)	(22)	(12)	(16)	(13)	(16)	(18)	(20)	(12)	
19	303.82 (22)	58.46 (11)	14.63 (21)	4.40 (9)	7.45 (11)	178.88 (17)	10.48 (10)	64.7 (17)	0.39 (16)	0.25 (16)	2.80 (9)	159
20	313.92 (11)	56.3 (24)	15.28 (9)	6.19 (23)	7.51 (10)	170.18 (18)	10.42 (11)	64.1 (18)	0.38 (20)	0.24 (22)	2.8 (10)	176
21	302.42 (23)	58.13 (13)	14.58 (22)	4.57 (10)	7.95 (9)	162.78 (19)	11.22 (8)	63.5 (19)	0.38 (17)	0.25 (18)	2.96 (8)	166
22	312.52 (13)	55.98 (25)	15.23 (10)	6.36 (24)	8.01 (8)	154.08 (20)	11.12 (9)	62.9 (20)	0.37 (22)	0.24 (25)	2.95 (9)	185
23	301.02 (24)	57.81 (15)	14.52 (23)	4.75 (11)	8.45 (7)	146.68 (21)	11.95 (6)	62.3 (21)	0.38 (19)	0.25 (19)	3.11 (6)	172
24	311.12 (15)	55.65 (26)	15.17 (11)	6.54 (25)	8.51 (6)	137.98 (22)	11.89 (7)	61.7 (22)	0.37 (23)	0.24 (26)	3.11 (7)	190
25	299.62 (25)	57.48 (18)	14.47 (24)	4.92 (13)	8.95 (5)	130.58 (23)	12.69 (4)	61.1 (23)	0.37 (21)	0.24 (21)	3.27 (4)	181
26	309.72 (17)	55.33 (27)	15.12 (12)	6.71 (26)	9.01 (4)	121.88 (24)	12.63 (5)	60.5 (24)	0.37 (26)	0.24 (27)	3.26 (5)	197
27	298.22 (26)	57.16 (20)	14.41 (25)	5.10 (15)	9.45 (3)	114.48 (25)	13.42 (3)	59.9 (26)	0.37 (24)	0.24 (23)	3.42 (3)	193

Figures in parenthesis indicate the rank scores

T_7 in nutritional qualities. Treatments T_1 and T_2 were also nutritionally good and provided adequate amount of energy (312.22 Kcal, 315.12 Kcal), carbohydrate (61.05 g 100 g^{-1}, 58.02 g 100 g^{-1}), protein (14.96 g 100 g^{-1}, 15.72 g 100 g^{-1}), fat (2.09 g 100 g^{-1}, 4.07 g 100 g^{-1}), fibre (3.45 g 100 g^{-1}, 3.51 g 100 g^{-1}), calcium (307.68 mg 100 g^{-1}, 298.98 mg 100 g^{-1}) and iron (4.6 mg 100 g^{-1}, 4.54 mg 100 g^{-1})

Treatments T_3, T_{26} and T_{27} have obtained ranking scores of 201, 197 and 193 respectively, which indicate that these were lower in nutritional qualities compared to others.

4.2.2 Organoleptic evaluation of the standardised nutrimixes

Porridges were prepared by the millet based composite nutrimixes and were evaluated organoleptically for various quality attributes like appearance, colour, flavor, texture, taste and overall acceptability.

4.2.2.1 Organoleptic evaluation of millet based composite nutrimixes incorporated with garden cress seeds

The mean scores and the mean rank scores obtained for different quality attributes of millet based composite nutrimixes incorporated with garden cress seeds are presented in Table 6.

The mean scores for the appearance were ranged from 8.3 to 8.6 and the mean rank scores from 10.67 to 17.10. The highest mean score was obtained for the treatment T_1, T_2, T_7, T_8, T_9, T_{11} and the lowest score for T_{21}, T_{22}, T_{23}, T_{24}, T_{25}, T_{26}, T_{27}. With respect to colour T_{24}, T_{25}, T_{26}, T_{27} obtained the high mean score of 8.8 (23.40) and a lowest score of 7.8 (7.9) for T_{15}.

For flavour highest mean score of 7.4 (16.23) was shown by T_{24}, T_{25}, T_{26} and T_{27} with the lowest score of 7.06 (8.77) by T_4. The mean score and mean rank score of texture varied from 7.3 to 8.8 and 5.43 to 24.27 respectively and the highest score was obtained for T_{23}, T_{24}, T_{25}, T_{26} and T_{27} and lowest for T_5.

Table 6: Organoleptic qualities of nutrimixes incorporated with garden cress seeds

Treatments	Appearence	Colour	Flavour	Texture	Taste	Overall acceptability
1	8.3 (10.67)	7.9 (9.13)	7.2 (13.57)	7.6 (8.70)	6.6 (3.57)	7.2 (13.57)
2	8.3 (10.67)	7.9 (9.13)	7.3 (14.43)	7.6 (8.70)	6.8 (5.93)	7.3 (14.43)
3	8.4 (12.47)	8.4 (19.30)	7.3 (14.90)	8.1 (16.77)	7.4 (14.63)	8.0 (14.90)
4	8.4 (13.80)	7.9 (9.13)	7.06 (8.77)	7.5 (7.53)	6.6 (5.40)	6.9 (8.77)
5	8.4 (13.80)	7.9 (9.13)	7.2 (11.93)	7.3 (5.43)	6.8 (6.03)	7.13 (11.93)
6	8.5 (15.60)	8.4 (19.30)	7.4 (15.77)	8.3 (20.23)	7.4 (14.33)	8.2 (15.77)
7	8.3 (10.67)	7.9 (9.13)	7.2 (11.93)	7.6 (8.93)	6.7 (4.97)	7.7 (11.90)
8	8.3 (10.67)	7.9 (9.13)	7.2 (11.93)	7.6 (8.93)	7.0 (7.47)	7.4 (11.90)
9	8.3 (10.67)	7.9 (9.13)	7.2 (13.57)	7.6 (9.93)	7.4 (13.73)	7.2 (13.57)
10	8.2 (9.60)	7.9 (9.13)	7.2 (13.27)	7.4 (5.93)	7.2 (11.60)	7.2 (13.27)
11	8.3 (10.67)	7.9 (9.13)	7.2 (13.27)	7.4 (5.93)	7.2 (11.60)	7.2 (13.27)
12	8.4 (13.80)	7.9 (9.13)	7.2 (13.27)	7.5 (7.53)	7.2 (11.60)	7.1 (13.27)
13	8.4 (13.80)	7.9 (9.13)	7.2 (13.27)	7.6 (9.53)	7.0 (8.47)	7.1 (13.27)
14	8.4 (13.80)	8.1 (12.80)	7.2 (13.27)	7.6 (9.93)	7.0 (8.47)	7.1 (13.27)
15	8.4 (13.80)	7.8 (7.90)	7.2 (13.27)	7.5 (7.53)	7.3 (8.47)	7.4 (13.27)

Contd.

16	8.4 (13.80)	7.9 (9.37)	7.2 (14.90)	7.7 (11.37)	7.7 (12.77)	7.6 (13.27)
17	8.4 (15.33)	8.2 (15.63)	7.3 (13.27)	7.8 (12.57)	7.6 (18.57)	7.7 (14.90)
18	8.5 (15.33)	8.2 (15.63)	7.2 (14.90)	8.0 (16.37)	7.5 (16.83)	7.4 (13.27)
19	8.5 (15.33)	8.2 (15.63)	7.3 (14.60)	8.1 (17.40)	7.6 (15.90)	7.7 (14.90)
20	8.5 (17.10)	8.2 (15.63)	7.2 (14.60)	8.2 (17.40)	7.6 (17.83)	7.9 (14.90)
21	8.6 (17.10)	8.2 (15.63)	7.3 (16.23)	8.3 (19.47)	7.8 (19.10)	7.8 (14.60)
22	8.6 (17.10)	8.2 (15.63)	7.3 (16.23)	8.8 (20.13)	7.6 (17.13)	8.2 (14.60)
23	8.6 (17.10)	8.6 (21.47)	7.3 (16.23)	8.8 (24.27)	8.4 (23.67)	8.5 (16.23)
24	8.6 (17.10)	8.8 (23.40)	7.4 (16.23)	8.8 (24.27)	8.6 (24.60)	8.5 (16.23)
25	8.6 (17.10)	8.8 (23.40)	7.4 (16.23)	8.8 (24.27)	8.7 (25.37)	8.5 (16.23)
26	8.6 (17.10)	8.8 (23.40)	7.4 (16.23)	8.8 (24.27)	8.6 (24.60)	8.5 (16.23)
27	8.6 (17.10)	8.8 (23.40)	7.4 (16.23)	8.8 (24.27)	8.7 (25.37)	8.5 (16.23)
Kendalls W	0.313**	0.716**	0.194**	0.836**	0.810**	0.194**

Values in parenthesis are mean rank scores based on Kendall's W which was significant at 1% level

With respect to taste, the highest score of 8.7 (25.37) was obtained for T_{27} and T_{25} followed by T_{26} and T_{24} (8.6). The overall acceptability had mean score and mean rank from 6.9 (T_4) to 8.5 (T_{23} to T_{27}) and 8.77 to 16.23 respectively.

Based on Kendall's value a significant agreement among judges was observed for the all quality attributes of nutrimix incorporated with garden cress seeds.

4.2.2.2 Organoleptic evaluation millet based composite nutrimixes incorporated with flax seed

The mean scores and the mean rank scores obtained for different quality attributes of millet based composite nutrimixes incorporated with flax seed are presented in Table 7.

Twenty seven treatments of nutrimixes incorporated with flax seed were subjected to organoleptic evaluation. For appearance, nutrimixes obtained mean rank scores ranging from 4.10 (T_8) to 21.07 (T_7) with the mean score from 7.55 to 8.64. For colour, the highest mean scores was obtained by T_{23} (8.86), followed by T_7 and T_{22} (8.66)

In case of flavour, the highest mean score of 8.37 was obtained for the treatment T_7 and T_{13}. The mean score for texure differs from 7.02 (4.00) to 8.80 (24.7). The highest score was obtained for T_{22} (8.8) and T_{23} (8.8) and lowest for T_8 (6.35) and T_9 (7.31).

For taste, the mean score and mean rank scores ranged from 6.35 to 8.6 and 3.60 to 24.17 respectively. The highest score for taste was obtained for T_7 (8.55) followed by T_{13} (8.53) and T_{15} (8.48) and lowest in T_8 (6.35).

The overall acceptability obtained a mean score and mean rank score ranging from 6.80 to 8.53 and 4.07 to 24.10 respectively. Treatment T_{23} (8.53) obtained highest mean score followed by T_{27} (8.48) and T_{15} (8.35) and the lowest score in T_8 (6.8).

Table 7: Organoleptic qualities of nutrimixes incorporated with flax seeds

Treatments	Appearance	Colour	Flavour	Texture	Taste	Overall Acceptability
1	7.8 (7.27)	7.68 (8.37)	7.28 (9.10)	7.48 (8.87)	7.17 (9.53)	7.4 (10.53)
2	7.97 (10.07)	7.84 (10.60)	7.55 (11.73)	7.68 (12.03)	7.6 (13.53)	7.72 (13.77)
3	8.35 (10.90)	7.97 (12.23)	8.13 (19.50)	7.95 (14.20)	7.95 (17.27)	7.93 (18.80)
4	8 (10.70)	7.75 (8.80)	7.62 (13.67)	7.08 (4.63)	7.06 (8.01)	7.15 (7.47)
5	7.75 (7.23)	7.71 (9.13)	7.11 (7.17)	7.48 (8.93)	6.66 (4.97)	7.06 (5.63)
6	7.77 (7.37)	7.8 (10.03)	7.35 (10.80)	7.44 (8.63)	6.8 (6.17)	7.1 (7.13)
7	8.64 (21.07)	8.66 (23.40)	8.37 (22.17)	8.55 (22.70)	8.55 (23.53)	8.15 (20.0)
8	7.55 (4.10)	7.31 (4.03)	7.02 (6.37)	7.02 (4.00)	6.35 (3.60)	6.8 (4.07)
9	7.77 (8.13)	7.68 (8.33)	7.44 (11.30)	7.28 (6.10)	7.31 (10.57)	7.27 (8.17)
10	7.84 (7.73)	7.73 (8.97)	7.24 (7.63)	7.41 (7.83)	6.9 (8.73)	7.15 (7.63)
11	7.88 (9.23)	7.75 (9.53)	7.35 (9.40)	7.51 (9.03)	7.31 (11.27)	7.38 (10.03)
12	7.84 (8.30)	7.68 (8.43)	7.42 (10.23)	7.46 (8.60)	7.2 (9.97)	7.27 (8.27)
13	8.4 (17.63)	8.53 (20.40)	8.37 (21.83)	8.4 (20.17)	8.53 (23.37)	8.35 (22.03)
14	8.31 (14.37)	8.22 (15.57)	8.22 (20.83)	8.26 (18.37)	8.26 (20.57)	8.2 (20.13)
15	8.6 (20.30)	8.55 (21.01)	8.53 (24.67)	8.55 (22.83)	8.48 (22.93)	8.35 (22.17)
16	8.53 (19.33)	8.46 (20.40)	7.4 (12.63)	8.33 (19.97)	7.46 (12.67)	8.2 (20.50)

Contd.

17	8.46 (18.10)	7.93 (11.63)	7.2 (10.10)	7.33 (7.37)	6.86 (5.73)	7.13 (8.70)
18	8.33 (16.20)	7.93 (11.63)	7.2 (10.10)	7.6 (10.57)	6.73 (5.10)	7.0 (5.30)
19	8.2 (13.60)	7.93 (11.63)	7.26 (10.87)	7.4 (7.70)	7.26 (10.17)	7.26 (8.50)
20	8.6 (20.43)	8.26 (17.27)	7.33 (11.73)	8.26 (18.90)	7.8 (15.87)	7.93 (16.80)
21	8.6 (20.43)	8.26 (17.27)	7.33 (11.77)	8.33 (19.87)	7.66 (14.33)	7.8 (14.60)
22	8.6 (20.43)	8.66 (23.10)	7.4 (12.97)	8.8 (24.70)	8.46 (22.37)	8.26 (21.00)
23	8.6 (20.43)	8.86 (25.23)	7.4 (12.97)	8.8 (24.70)	8.6 (24.17)	8.53 (24.10)
24	8.15 (11.70)	8.01 (12.01)	8.08 (19.33)	7.93 (14.50)	7.73 (14.47)	7.82 (15.43)
25	8.24 (13.57)	8.17 (14.93)	7.93 (17.10)	7.93 (14.20)	8.06 (18.40)	7.97 (17.37)
26	8.28 (14.63)	8.17 (15.73)	8.33 (21.97)	8.35 (19.77)	8.06 (21.30)	8.31 (20.93)
27	8.51 (18.73)	8.37 (18.37)	8.26 (20.70)	8.33 (18.88)	8.35 (21.43)	8.48 (22.93)
Kendall's W	0.489**	0.521**	0.471**	0.700**	0.732**	0.696**

Values in parenthesis are mean rank scores based on Kendall's W which was significant at 1% level

Based on Kendall's value a significant agreement among judges was observed for the all quality attributes of nutrimix incorporated with flax seed.

4.2.3 Selection of nutrimixes based on quality attributes

Millet based composite nutrimixes incorporated with garden cress seed and flax seed were standardised separately. From this, one best composite nutrimix each from garden cress seed (nutrimix-GCS) and flax seed (nutrimix-FSP) were selected based on nutritional as well as organoleptic qualities for further studies (Plate 5).

Among various treatments of nutrimix-GCS T_2, T_6 and T_8 were found to be nutritionally superior nutrimixes. Based on relative ranking given with respect to nutritional qualities, T_2, T_6 and T_8 obtained rank order of 90, 96 and 107 respectively

In nutrimix-GCS nutritionally superior treatments like T_2, T_6 and T_8 obtained higher scores for all parameters. Treatment T_2 obtained the highest mean score of 8.3 for appearance, 7.9 for colour, 7.3 for flavour, 8.1 for texture, 7.4 for taste and 8.0 for overall acceptability. Treatment T_6 obtained higher scores for all parameters like appearance (8.5), colour (8.4), flavor (7.4), texture (8.4), taste (7.4) and overall acceptability (8.3). Treatment T_8 also obtained acceptable scores of 8.3, 7.9, 7.2, 7.6, 7.0 and 7.4 for appearance colour, flavour, texture, taste and overall acceptability respectively. A significant agreement among judges for the all quality attributes was observed in nutrimix-GCS. Hence, considering the superior nutritional and organoleptic qualities, T_6 (55%MRF+25%PS+5%S+5%MBF+10%GCS) was found to be the best combination among nutrimixes-GCS.

Among 27 treatments of FSP nutrimix, T_7, T_5 and T_2 obtained a total rank of 110, 114 and 115 respectively. With respect to organoleptic scores, T_7 obtained highest scores for all parameters like 8.64 for appearance, 8.66 for colour, 8.37 for flavor, 8.55 for texture, 8.55 for taste and 8.15 for overall acceptability. Treatment T_1 and T_2 also obtained acceptable scores for appearance (7.8 and 7.97), colour (7.68 and 7.84), flavour (7.28 and 7.55), texture (7.48 and 7.68), taste (7.17 and7.6) and overall

Nutrimix-GCS

Nutrimix-FSP

Plate 5. Selected millet based composite nutrimixes

acceptability (7.4 and 7.72). A significant agreement among judges was observed for the all quality attributes in nutrimix-FSP. Hence considering the superior nutritional and organoleptic qualities, T_7 (55%MRF+ 25%PS+ 5%S+ 10%MBF+ 5%FSP) was selected as the best treatment among nutrimixes-FSP.

Thus two treatments T_6 and T_7 from nutrimix-GCS and nutrimix-FSP respectively were selected for further studies.

4.3. Nutritional qualities of selected nutrimixes

The nutritional qualities like moisture, energy, starch, total carbohydrate, protein, fat, crude fibre, calcium, iron, phosphorus and zinc of selected millet based composite nutrimixes were estimated and are presented in Table 8.

Table 8: Nutritional qualities of selected nutrimixes

Nutrients	Treatments		t value
	Nutrimix-GCS	Nutrimix-FSP	
Moisture (%)	2.39	2.45	12.728^{NS}
Energy (Kcal)	346.87	354.61	5.457^{NS}
Starch (g 100^{-1})	85.87	83.23	38.921^{NS}
Carbohydrate (g 100^{-1})	63.37	62.83	1.775^{NS}
Protein (g 100^{-1})	15.67	14.91	29.435^{NS}
Fat (g 100^{-1})	3.41	4.85	24.696^{NS}
Fibre (g 100^{-1})	5.87	7.81	9.429^{NS}
Calcium (mg 100^{-1})	189.43	175.70	25.600^{NS}
Iron (mg 100^{-1})	17.77	15.94	2.982^{NS}
Zinc (mg 100^{-1})	3.26	3.80	3.718^{NS}
Phosphorus (mg 100^{-1})	154.10	145.23	4.457^{NS}
NS- non significant			

The nutritional qualities of selected nutrimixes were analysed. Compared to nutrimix-FSP, nutrimix-GCS obtained highest nutrients for energy (346.8 Kcal), starch (85.87 g 100 g^{-1}), carbohydrate (63.37 g 100 g^{-1}), protein (15.67 g 100 g^{-1}), calcium (189.43 mg 100 g^{-1}), iron (17.77 mg 100 g^{-1}), zinc (3.26 mg 100 g^{-1}) and phosphorus (154.10 mg 100 g^{-1}) and low moisture (2.39 %) and fat (3.41 g 100 g^{-1}). The nutrimix-FSP contain 354.6 Kcal energy, 83.23 g 100 g^{-1} of starch, 62.83 g 100 g^{-1} of carbohydrate, 14.9 g 100 g^{-1} of protein, 4.85 g 100 g^{-1} of fat, 7.81 g 100 g^{-1} of fat, 175.70 mg 100 g^{-1} of calcium, 15.94 mg 100 g^{-1} iron, 3.80 mg 100 g^{-1} of zinc and 145.23 mg 100 g^{-1} phosphorus. There was no significant difference in nutritional qualities observed between the nutrimixes.

4.4 Quality evaluation of selected composite nutrimixes during storage

The selected millet based composite nutrimixes namely nutrimix-GCS and nutrimix-FSP were packed in polyethylene laminated aluminium pouches. The packed nutrimixes were stored under ambient condition for four months and evaluated the biochemical, nutritional, organoleptic and storage qualities initially and during second and fourth month of storage.

4.4.1. Nutritional and biochemical qualities during storage

Nutritional qualities like moisture, energy, starch, carbohydrate, protein, fat, fibre, calcium, iron, zinc, phosphorus, *in vitro* protein digestibility, *in vitro* starch digestibility, *in vitro* availability of minerals like calcium, iron, zinc and phosphorus were analysed initially and also during storage period and details are given below.

4.4.1.1 Moisture

Moisture content of the food material is an important factor which affects the physical and chemical qualities of food. Moisture content of selected millet based composite nutrimixes were estimated and is presented in Table 9.

The initial moisture content was 2.39 per cent in nutrimix-GCS. During storage period, the moisture content increased to 2.48 per cent and after 4 months of storage it again increased to 2.61 per cent. Initial moisture content of nutrimix-FSP was 2.45 per cent and it increased during the second and fourth month of storage to 2.56 per cent and 2.68 per cent respectively. Compared to GCS incorporated nutrimix, moisture content of flax seed incorporated nutrimix was lower over the fourth month storage period.

As per t value there was no significant difference between the moisture content of nutrimix-GCS and nutrimix-FSP. The relative per cent increase of moisture over the previous stage of observation was calculated and found that the relative change was apparently small.

Table 9: Changes in moisture content of selected nutrimixes during storage

Treatments	Moisture content (%) during storage		
	Initial month	Second month	Fourth month
Nutrimix-GCS	2.39	2.48 (3.76)	2.61 (5.24)
Nutrimix-FSP	2.45	2.56 (3.98)	2.68 (4.71)
t value	12.728 ^{NS}	44.548 ^{NS}	1.533 ^{NS}
NS - Non-significant			

Figures in parenthesis indicates per cent relative change over the previous month

4.4.1.2. Energy

Energy content of selected millet based composite nutrimixes were estimated and is presented in Table 10.

Initial energy content of nutrimix-GCS was 346.87 Kcal and nutrimix-FSP was 354.61 Kcal. During the second and fourth month of storage, energy content of nutrimix-GCS decreased to 336.43 Kcal and 328.64 Kcal respectively. Energy content of nutrimix-FSP decreased to 330.58 Kcal at the end of storage period.

The difference in energy content among nutrimix- GCS and nutrimix-FSP was statistically non-significant. The relative per cent decrease of carbohydrate over the previous stage of observation was apparently small.

Table 10: Changes in energy content of selected nutrimixes during storage

Treatments	Energy content (g 100 g^{-1}) during storage		
	Initial month	Second month	Fourth month
Nutrimix-GCS	346.87	336.43 (3.00)	328.64 (2.31)
Nutrimix-FSP	354.61	347.34 (2.05)	330.58 (4.82)
t value	5.457 ^{NS}	5.597 ^{NS}	1.109 ^{NS}
NS - non significant			

Figures in parenthesis indicates per cent relative change over the previous month

4.4.1.3 Starch

Starch content of selected millet based composite nutrimixes were estimated and are presented in Table 11.

Starch content was found to be high in nutrimix-GCS than nutrimix-FSP. Initial starch content of nutrimix-GCS was 85.87 g 100 g^{-1} and it decreased in second and fourth month to 84.13 g 100 g^{-1} and 83.55 g 100 g^{-1} respectively. Nutrimix-FSP have the initial starch content of 83.23 g 100 g^{-1} and decreased to 81.91 per cent at the end of storage period.

The difference in starch content among nutrimix GCS and FSP was statistically non-significant. The relative per cent decrease of starch over the previous stage of observation was apparently small.

Table 11: Changes in starch content of selected nutrimixes during storage

Treatments	Starch content (g 100 g^{-1}) during storage		
	Initial month	Second month	Fourth month
Nutrimix-GCS	85.87	84.13 (2.02)	83.55 (0.68)
Nutrimix-FSP	83.23	82.55 (0.81)	81.91 (0.77)
t value	38.921 ^{NS}	39.229 ^{NS}	6.182 ^{NS}
NS -Non-significant			

Figure in parenthesis indicates per cent relative change over the previous month

4.4.1.4 Total carbohydrate

Carbohydrate content of selected millet based composite nutrimixes were estimated and are presented in Table 12.

Carbohydrates are the concentrated source of energy. Initially, nutrimix-GCS contain 63.37 g 100 g^{-1} carbohydrate and during second month of storage which reduced to 62.03 g 100 g^{-1} and in fourth month it reduced to 60.75 g 100 g^{-1}. In the case of nutrimix-FSP, initially it was 62.83 g 100 g^{-1} and the end of storage period it was reduced in to 58.81 g 100 g^{-1}.

There was no significant difference between the carbohydrate content of nutrimix-GCS and nutrimix-FSP. The relative per cent decrease of carbohydrate over the previous stage of observation was apparently small.

4.4.1.5 Protein

Protein content of selected millet based composite nutrimixes were estimated and presented in Table 13.

Nutrimix-GCS had 15.67 g 100 g^{-1} protein initially and during the second and fourth month of storage it decreased to 14.47 g 100 g^{-1} and 14.08 g 100 g^{-1} respectively.

Nutrimix-FSP contain 14.91 g 100 g^{-1} protein, initially and it decreased to 14.67 g 100 g^{-1} and 14.26 g 100 g^{-1}

There was no significant difference between the protein content initially and during the second and fourth month of storage. The relative per cent decrease of protein over the previous stage of observation was apparently small.

Table 12: Changes in carbohydrate content of selected nutrimixes during storage

Treatments	Carbohydrate content (g 100 g^{-1}) during storage		
	Initial month	Second month	Fourth month
Nutrimix-GCS	63.37	62.03 (2.11)	60.75 (2.06)
Nutrimix-FSP	62.83	61.51 (2.10)	58.81 (4.38)
t value	1.775^{NS}	1.108 ^{NS}	4.373 ^{NS}
NS- Non-significant			

Figure in parenthesis indicates per cent relative change over the previous month

Table 13: Changes in protein content of selected nutrimixes during storage

Treatments	Protein content (g 100 g^{-1}) during storage		
	Initial month	Second month	Fourth month
Nutrimix-GCS	15.67	14.47 (7.65)	14.08 (2.69)
Nutrimix-FSP	14.91	14.67 (1.60)	14.26 (2.79)
t value	29.435 ^{NS}	4.189 ^{NS}	3.368 ^{NS}
NS-Non-significant			

Figures in parenthesis indicates per cent relative change over the previous month

4.4.1.6 Total fat

Total fat content of selected millet based composite nutrimixes were estimated and presented in Table 14.

Initially the fat content of nutrimix-GCS was 3.41 g 100 g^{-1} and it decreased to 3.37 g 100 g^{-1} and 3.25 g 100 g^{-1} in the second and fourth month respectively. Initial fat content of nutrimix-FSP was 4.85 g 100 g^{-1} and it decreased in second and fourth month of storage to 4.73 g 100 g^{-1} and 4.25 g 100 g^{-1} respectively.

The difference in fat content of selected nutrimixes was statistically non-significant based on t test. The relative per cent decrease of fat over the previous stage of observation was apparently small.

Table 14: Changes in fat content of selected nutrimixes during storage

Treatments	Fat content (g 100 g^{-1}) during storage		
	Initial month	Second month	Fourth month
Nutrimix-GCS	3.41	3.37 (1.17)	3.25 (3.56)
Nutrimix-FSP	4.85	4.73 (2.47)	4.25 (10.14)
t value	24.696 ^{NS}	108.775 ^{NS}	58.835 ^{NS}
NS- Non-significant			

Figures in parenthesis indicates per cent relative change over the previous month

4.4.1.7 Fibre

Fibre content of selected millet based composite nutrimixes were estimated and presented in Table 15.

The fibre content of nutrimix-GCS was 5.87 g 100 g^{-1} initially and it decreased to 5.58 g 100 g^{-1} in second month and to 5.34 g 100 g^{-1} in fourth month of storage period. In the case of nutrimix-FSP, 7.81 g 100 g^{-1} of fibre decreased to 7.67 g 100 g^{-1} and to 7.64 g 100 g^{-1} during the end of storage period.

There was no significant difference in fibre content of both nutrimixes. The relative per cent decrease of fibre over the previous stage of observation was apparently small.

Table 15: Changes in fibre content of selected nutrimixes during storage

Treatments	Fibre content (g 100 g^{-1}) during storage		
	Initial month	Second month	Fourth month
Nutrimix-GCS	5.87	5.58 (4.94)	5.34 (4.30)
Nutrimix-FSP	7.81	7.67 (1.79)	7.64 (0.39)
t value	9.429^{NS}	15.568^{NS}	30.450^{NS}
NS - Non-significant			

Figures in parenthesis indicates per cent relative change over the previous month

4.4.1.8 Calcium

Calcium content of selected millet based composite nutrimixes were estimated and presented in Table 16.

Calcium content of the nutrimix-GCS and nutrimix-FSP was 189.43 mg 100 g^{-1} and 175.70 mg 100 g^{-1} respectively. During second month of storage, calcium decreased 187.20 mg 100 g^{-1} in nutrimix-GCS and to 168.83 mg 100 g^{-1} in nutrimix-FSP. At the end of storage period, it again decreased to 185.66 mg 100 g^{-1} and 167.43 mg 100 g^{-1} in nutrimix GCS and FSP respectively.

In nutrimix-GCS and nutrimix-FSP, there was no significant difference observed with respect to calcium content. The relative per cent decrease of calcium over the previous stage of observation was calculated and found that the relative change was apparently small.

Table 16: Changes in calcium content of selected nutrimixes during storage

Treatments	Calcium content (mg 100 g^{-1}) during storage		
	Initial month	Second month	Fourth month
Nutrimix-GCS	189.43	187.20 (1.17)	185.66 (0.82)
Nutrimix-FSP	175.70	168.83 (3.91)	167.43 (0.82)
t value	25.600 ^{NS}	50.724 ^{NS}	61.156 ^{NS}
NS-Non-significant			

Figure in parenthesis indicates per cent relative change over the previous month

4.4.1.9 Iron

Iron content of selected millet based composite nutrimixes were estimated and presented in Table 17.

Initial iron content of the nutrimix-GCS and nutrimix-FSP was 17.77 mg 100 g^{-1} and 15.94 mg 100 g^{-1} respectively. During the storage period of second month, iron content of nutrimix-GCS and nutrimix-FSP decreased to 16.45 mg 100 g^{-1} and 15.05 mg 100 g^{-1} and in the fourth month it again decreased to 15.49 mg 100 g^{-1} and 14.67 mg 100 g^{-1} respectively.

There was no significant variation in nutrimix-GCS and nutrimix-FSP in terms of iron content. The relative per cent decrease of iron over the previous stage of observation was apparently small.

4.4.1.10 Zinc

Zinc content of selected millet based composite nutrimixes were estimated and are presented in Table 18.

In nutrimix-GCS, the initial zinc content was 3.26 mg 100 g^{-1} and it was high in nutrimix-FSP (3.80 mg 100 g^{-1}). During storage period of second month and fourth month the zinc content of nutrimix-GCS decreased to 2.87 mg 100 g^{-1} and to 2.11 mg

100 g^{-1} respectively. In nutrimix FSP, zinc content decreased to 3.58 mg 100 g^{-1} and to 2.85 mg 100 g^{-1}.

There was no significant variation in the zinc content among the selected nutrimixes. The relative per cent decrease of zinc over the previous stage of observation was apparently small.

Table 17: Changes in iron content of selected nutrimixes during storage

Treatments	Iron content (mg 100 g^{-1}) during storage		
	Initial month	Second month	Fourth month
Nutrimix-GCS	17.77	16.45 (7.42)	15.49 (5.83)
Nutrimix-FSP	15.94	15.05 (5.58)	14.67 (2.52)
t value	2.982 ^{NS}	8.475 ^{NS}	3.013 ^{NS}
NS- Non-significant			

Figures in parenthesis indicates per cent relative change over the previous month

Table 18: Changes in zinc content of selected nutrimixes during storage

Treatments	Zinc content (mg 100 g^{-1}) during storage		
	Initial month	Second month	Fourth month
Nutrimix-GCS	3.26	2.87 (11.96)	2.11 (26.48)
Nutrimix-FSP	3.80[a]	3.58 (5.78)	2.85 (20.39)
t value	3.718 ^{NS}	10.631 ^{NS}	15.543 ^{NS}
NS- Non-significant			

Figures in parenthesis indicates per cent relative change over the previous month

4.4.1.11 Phosphorus

Phosphorus content of selected millet based composite nutrimixes were estimated and are presented in Table 19.

Initially nutrimix-GCS contain 154.10 mg 100 g^{-1} of phosphorus and nutrimix-FSP contain 145.23 mg 100 g^{-1}. After storage, phosphorus content of nutrimix-GCS decreased to 147.80 mg 100 g^{-1} and further to 135 mg 100 g^{-1}. Same trend observed in nutrimix-FSP also, the phosphorus content decreased to 136.30 mg 100 g^{-1} to 121.99 mg 100 g^{-1} after storage.

The variation in phosphorus content in both nutrimixes were statistically non-significant. The relative per cent decrease of phosphorus over the previous stage of observation was apparently small.

Table 19: Changes in phosphorus content of selected nutrimixes during storage

Treatments	Phosphorus content (mg 100 g^{-1}) during storage		
	Initial month	Second month	Fourth month
Nutrimix-GCS	154.10	147.80 (4.08)	135.00 (8.66)
Nutrimix-FSP	145.23	136.30 (6.14)	121.99 (10.49)
t value	4.457 ^{NS}	3.768 ^{NS}	3.768 ^{NS}
NS - Non-significant			

Figures in parenthesis indicates per cent relative change over the previous month

4.4.1.12 *In vitro* starch digestibility

In vitro starch digestibility of selected nutrimixes were estimated and are presented in Table 20.

Nutrimix-GCS has significantly higher starch digestibility than nutrimix-FSP in the storage period. *In vitro* starch digestibility of nutrimix-GCS was 96.17 per cent and it decreased during storage to 95.24 per cent and further to 94.13 per cent. In the case of nutrimix-FSP initial value of *in vitro* starch digestibility was 94.83 per cent. During the second and fourth month of storage it decreased in to 93.35per cent and 91.88 per cent respectively.

In vitro phosphorus values of nutrimix-FSP and nutrimix-GCS are statistically non-significant during storage period. The relative per cent decrease of *in vitro* digestibility of starch over the previous stage of observation was apparently small.

Table 20: Changes in *In vitro* starch digestibility of selected nutrimixes during storage

Treatments	*In vitro* starch digestibility (%) during storage		
	Initial month	Second month	Fourth month
Nutrimix-GCS	96.17	95.24 (0.96)	94.13 (1.16)
Nutrimix-FSP	94.83	93.35 (1.56)	91.88 (1.57)
t value	2.527 ^{NS}	10.657 ^{NS}	17.456 ^{NS}
NS- Non-significant			

Figure in parenthesis indicates per cent relative change over the previous month

4.4.1.13 *In vitro* protein digestibility

In vitro protein digestibility of selected millet based composite nutrimixes were estimated and are presented in Table 21.

In vitro digestibility of protein was 89.82 per cent in nutrimix-GCS initially which reduced to 88.47 and to 87.87 per cent during second and fourth month respectively. *In vitro* protein digestibility of nutrimix-FSP was 90.66 per cent and reduced to 89.87 and 88.12 per cent during storage period. Digestibility of protein was high in nutrimix-FSP compared to nutrimix-GCS.

During storage period there was no significant difference between the nutrimix-GCS and nutrimix-FSP. The relative per cent decrease of *in vitro* digestibility of protein over the previous stage of observation was apparently small.

Table 21: Changes in *In vitro* protein digestibility of selected nutrimixes during storage

Treatments	*In vitro* protein digestibility (%) during storage		
	Initial month	Second month	Fourth month
Nutrimix-GCS	89.82	88.47	87.27
Nutrimix-FSP	90.66	89.87	88.12
t value	4.878 ^{NS}	7.444 ^{NS}	7.089 ^{NS}
NS -Non-significant			

Figures in parenthesis indicates per cent relative change over the previous month

4.4.1.14 *In vitro* mineral availability

4.4.1.14.1 Calcium

In vitro availability of calcium in selected millet based composite nutrimixes were estimated and are presented in Table 22.

During storage a gradual decrease was observed in the *in vitro* availability of calcium in nutrimixes. Calcium availability of the nutrimix-GCS and nutrimix-FSP was 76.50 per cent and 74 per cent respectively. During second month calcium availability decreased to 67.56 per cent in nutrimix-GCS and 68.20 per cent in nutrimix-FSP and at the end of storage period it was again decreased into 59.30 and 61.10 per cent respectively.

As per t value there was no significant difference between the nutrimix-GCS and nutrimix-FSP. The relative per cent decrease of *in vitro* availability of calcium over the previous stage of observation was apparently small.

Table 22: Change in *in vitro* availability of calcium in selected nutrimixes during storage

Treatments	*In vitro* calcium (%) during storage		
	Initial month	Second month	Fourth month
Nutrimix-GCS	76.50	67.56 (11.68)	59.30 (12.22)
Nutrimix-FSP	74.00	68.20 (0.07)	61.10 (10.41)
t value	2.981 ^{NS}	0.700 ^{NS}	3.530 ^{NS}
NS - Non-significant			

Figures in parenthesis indicates per cent relative change over the previous month

4.4.1.14.2 *In vitro* iron availability

In vitro availability of iron in selected millet based composite nutrimixes were estimated and are presented in Table 23.

Initial availability of iron in nutrimix-GCS and nutrimix-FSP varied from 73.83 per cent and 63.80 per cent and showed a significant difference among the compositions. During storage period the iron content of nutrimix-GCS and nutrimix-FSP decreased to 71.46 per cent and 61.00 per cent respectively.

In vitro availability of iron in both nutrimix GCS and FSP was statistically non-significant during storage period. The relative per cent decrease of *in vitro* availability of iron over the previous stage of observation was apparently small.

Table 23: Changes in *in vitro* availability of iron in selected nutrimixes during storage

Treatments	*In vitro* iron (%) during storage		
	Initial month	Second month	Fourth month
Nutrimix-GCS	73.83	72.80 (1.39)	71.46 (1.84)
Nutrimix-FSP	63.80	62.43 (2.14)	61.00 (2.29)
t value	40.587 [NS]	77.750 [NS]	20.887 [NS]
NS - Non-significant			

Figures in parenthesis indicates per cent relative change over the previous month

4.4.1.14.3 *In vitro* zinc availability

In vitro availability of zinc in selected millet based composite nutrimixes were estimated and presented in Table 24.

In nutrimix-GCS, the initial availability of zinc content was 68.12 per cent and it was high in nutrimix-FSP (68.66 per cent). During the storage period of second month and fourth month the availability of zinc decreased in nutrimix-GCS to 67.82 per cent and to 66.52 per cent respectively. In the case of nutrimix-FSP zinc availability decreased to 67.06 and to 65.83 per cent by the end of storage period.

The variation in *in vitro* zinc availability for both nutrimix GCS and FSP was statistically non-significant during storage period. The relative per cent decrease of *in vitro* availability of zinc over the previous stage of observation was apparently small.

4.4.1.14.4 *In vitro* phosphorus availability

In vitro availability of phosphorus in selected millet based composite nutrimixes were estimated and are presented in Table 25.

Nutrimix-FSP was observed to have high *in vitro* availability of phosphorus (65.60 %) compared to nutrimix-GCS (63.23 %). After storage, phosphorus content of nutrimix-FSP decreased from 63.70 to 67.46 per cent. Same trend was observed in nutrimix-GCS, in which phosphorus content decreased from 63.70 to 61.46 per cent.

As per t value, there was no significant variation between in nutrimix-GCS and nutrimix-FSP during storage period. The relative per cent decrease of *in vitro* availability of phosphorus over the previous stage of observation was apparently small.

Table 24: Changes in *in vitro* availability of zinc in selected nutrimixes during storage

Treatments	*In vitro* zinc (%) during storage		
	Initial month	Second month	Fourth month
Nutrimix-GCS	68.12	67.82 (0.44)	66.52 (1.91)
Nutrimix-FSP	68.66	67.06 (2.33)	65.83 (1.83)
t value	6.079 ^{NS}	8.165 ^{NS}	3.826 ^{NS}
NS- Non-significant			

Figures in parenthesis indicates per cent relative change over the previous month

Table 25: Changes in *in vitro* availability of phosphorus in selected nutrimixes during storage

Treatments	*In vitro* phosphorus (%) during storage		
	Initial month	Second month	Fourth month
Nutrimix-GCS	63.23	61.06 (3.43)	59.53 (2.50)
Nutrimix-FSP	65.60	63.70 (2.89)	61.46 (3.51)
t value	5.511 ^{NS}	24.982 ^{NS}	4.800 ^{NS}
NS -Non-significant			

Figure in parenthesis indicates per cent relative change over the previous month

4.4.2 Organoleptic evaluation of selected nutrimixes during storage

The organoleptic qualities of nutrimix-GCS and nutrimix-FSP were evaluated initially and also during second and fourth month of storage period. The result pertaining to the organoleptic evaluation are given as follows.

The mean scores for different organoleptic qualities of nutrimix GCS and FSP are presented in Table 26.

The mean score for the appearance of nutrimix GCS and FSP was 8.75 and it decreased to 8.26 in nutrimix-GCS and 8.45 in nutrimix-FSP during the second month of storage. At the end of storage period, mean scores for appearance again decreased to 7.17 and 7.68 in nutrimix-GCS and nutrimix-FSP respectively.

For colour, the mean score obtained was 8.62 for both nutrimixes. During the second month, the colour of nutrimix-GCS decreased to 8.22 and in fourth month it was 7.13. In nutrimix-FSP, during second and fourth month of storage the colour decreased to 8.06 and 7.4 respectively.

Nutrimix-GCS obtained lower mean score for flavour (7.86) than nutrimix-FSP (8.4). A decreasing trend in organoleptic qualities was observed during storage period. The mean scores for flavour of nutrimix-GCS and nutrimix-FSP decreased to 6.62 and 7.06 respectively at the end of storage period.

Nutrimix-GCS obtained lower mean score for flavour (7.86) than nutrimix-FSP (8.4). A decreasing trend in organoleptic qualities was observed during storage period. The mean scores for flavour of nutrimix-GCS and nutrimix-FSP were decreased to 6.62 and 7.06 respectively at the end of storage period.

A mean score of 8.51 was observed for nutrimix-FSP for texture initially and during second and fourth month of storage period, the score decreased to 8.17 to 7.65 respectively. The mean score for texture of nutrimix-GCS was 8.11 initially and 7.77 and 7.26 during second and fourth month respectively. The maximum mean score for taste was noticed in nutrimix-FSP (8.47) initially. On the second and fourth month of storage the mean scores decreased to 8.26 and 8.00 respectively. The mean scores for

Table 26: Mean scores for the organoleptic qualities of selected nutrimixes

Treatments	Appearance			Colour			Flavour		
	Months of storage								
	Initial	2nd month	4th month	Initial	2nd month	4th month	Initial	2nd month	4th month
Nutrimix-GCS	8.75	8.26	7.17	8.62	8.22	7.13	7.86	7.77	6.62
Nutrimix-FSP	8.75	8.45	7.68	8.62	8.06	7.4	8.4	7.7	7.06

Treatments	Texture			Taste			Overall acceptability		
	Months of storage								
	Initial	2nd month	4th month	Initial	2nd month	4th month	Initial	2nd month	4th month
Nutrimix-GCS	8.11	7.77	7.26	8.26	8.06	7.97	7.8	7.4	7.00
Nutrimix-FSP	8.51	8.17	7.65	8.47	8.26	8.00	8.2	8.08	7.4

Nutrimix-GCS -Garden cress incorporated nutrimix, nutrimix-FSP – Flax seed incorporated nutrimix taste was lower in nutrimix-GCS (8.26) than nutrimix-FSP initially. Mean score was then decreased during storage period into 8.06 (2nd month) and 7.97 (4th month).

The mean score for overall acceptability was high in nutrimix-FSP initially (8.2) and also during second (8.08) and fourth (7.4) month of storage. Slightly lower overall acceptability was observed for nutrimix-GCS with a mean score of 7.8 initially, 7.4 and 7.00 during second and fourth month of storage period.

4.4.3 Shelf life qualities

The selected nutrimix-GCS and nutrimix-FSP were evaluated for the microbial qualities, peroxide value and insect infestation initially and during the second and fourth month of storage.

4.4.3.1. Microbial qualities

Nutrimixes incorporated with garden cress seed and flax seed were evaluated for bacteria, fungi and yeast initially and during second and fourth month of storage period and the result pertaining to microbial enumeration are given in Table 27.

Table 27: Microbial evaluation of selected nutrimixes

Treatments	Microbial enumeration								
	Bacteria (10^6 cfu/g)			Fungi (10^3 cfu/g)			Yeast (10^3 cfu/g)		
	Initial	Second month	Fourth month	Initial	Second month	Fourth month	Initial	Second month	Fourth month
Nutrimix-GCS	ND	0.21	1.52	ND	ND	0.35	ND	ND	ND
Nutrimix-FSP	ND	0.39	1.49	ND	ND	0.99	ND	ND	ND

ND – Not detected

As revealed in table 27, initially the bacterial count was not detected in both nutrimixes. During second month of storage, bacterial count was detected in nutrimixes. In nutrimix-GCS the bacterial count was 0.21 x 10^6 cfu/g and in nutrimix-FSP it was 0.31 x 10^6 cfu/g. On the fourth month of storage the bacterial count in nutrimix-GCS increased to 1.52 x 10^6 cfu/g and to 1.49 x 10^6 cfu/g in nutrimix-FSP.

Fungal count was not detected initially and during second month in both nutrimixes. On the fourth month of storage fungal count was observed in nutrimix-GCS (0.35 x 10^3 cfu/g) and in nutrimix-FSP (0.99 x 10^3 cfu/g.)

Yeast count was not observed in nutrimix-GCS and nutrimix-FSP throughout the storage period.

4.4.3.2 Peroxide value

Peroxide value indicate the evidence of rancidity of unsaturated fats and oils present in foods. Peroxide value of nutrimixes were analysed initially and during second and fourth month of storage period. In nutrimix-GCS and nutrimix-FSP, the peroxide value were not detected initially and throughout the storage period.

4.4.3.3 Insect infestation

Insect infestation of the selected nutrimixes were evaluated initially and during the second and fourth month of storage. Presence of insect and storage pests were not detected throughout the period of storage.

4.5 Quality evaluation of products from the selected nutrimixes

Three products namely *pakkoda, laddu* and health drink were prepared using selected nutrimixes. These products were evaluated organoleptically for different quality attributes like appearance, colour, flavour, texture, taste and overall acceptability. The organoleptic evaluation was conducted among a group (n=30) of adolescents (age 15-17 years). The results of organoleptic evaluation of the products are presented in this section.

Organoleptic qualities of *pakkoda*, *ladoo* and health drink prepared from nutrimix-GCS and nutrimix-FSP are presented in Table 28.

4.5.1 Organoleptic evaluation of the *pakkoda* prepared from nutrimixes

The mean score for the appearance of *pakkoda* prepared from nutrimix-GCS was 7.86 and for *pakkoda* prepared from nutrimix-FSP was 7.61. With respect to colour, the mean score of 7.30 was obtained for *pakkoda* prepared from nutrimix-GCS and 7.41 for *pakkoda* from nutrimix-FSP. For flavour, the mean score of 7.36 and 7.50 was obtained for *pakkoda* prepared from nutrimix-GCS and nutrimix-FSP respectively. Highest mean score for taste (8.43) and texture (8.33) was obtained for *pakkoda* prepared from nutrimix-GCS. For overall acceptability, *pakkoda* prepared from nutrimix-GCS had high mean score of 8.36 whereas *pakkoda* prepared from nutrimix-FSP was 7.82.

A significant variation was observed among the sensory attributes of *pakkoda* prepared from nutrimix-GCS and nutrimix-FSP. The *pakkoda* prepared from selected nutrimixes is presented in Plate 6.

4.5.2 Organoleptic evaluation of the *laddu* prepared from nutrimixes

The highest mean score for appearance was obtained for *laddu* prepared from nutrimix-FSP (8.20) than *laddu* prepared from nutrimix-GCS. For colour, the mean score of 7.40 was obtained for *laddu* from nutrimix-GCS and 7.84 for *laddu* from nutrimix-FSP. Mean scores for flavour was 6.86 and 7.60 respectively for nutrimix-GCS and nutrimix-FSP. For taste and texture, the highest mean score of 7.96 and 8.07 was obtained for *laddu* prepared from nutrimix-FSP and that for *laddu* prepared from nutrimix-GCS was 7.83 and 7.66 respectively. The overall acceptability was also high in nutrimix-FSP *laddu* (7.90) than nutrimix-GCS *laddu* (7.73).

Nutrimix-GCS *Pakkoda*

Nutrimix-FSP *Pakkoda*

Plate 6. *Pakkoda* prepared from selected nutrimixes

Nutrimix-GCS *Laddu*

Nutrimix-GCS *Laddu*

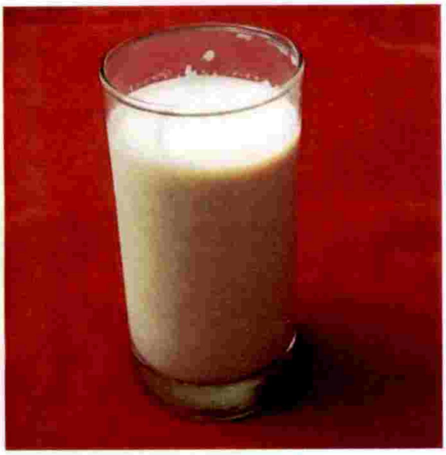
Plate 7. *Laddu* prepared from selected nutrimixes

4.5.3 Organoleptic evaluation of the health drink prepared from nutrimixes

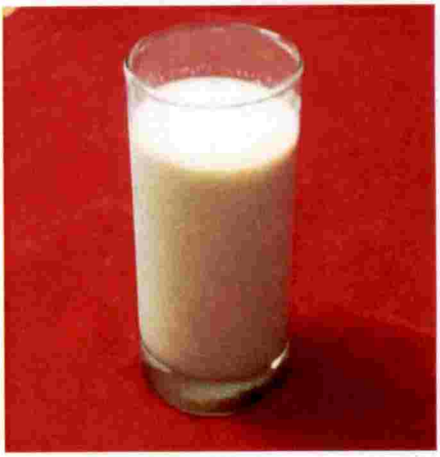
Health drink prepared from nutrimix-FSP obtained highest mean score for parameters like appearance (8.65), colour (8.63), flavour (8.30), taste (8.23) and overall acceptability, except texture (8.50). Health drink prepared from nutrimix-GCS obtained the mean score of 8.26 for appearance, 8.43 for colour, 8.13 for flavour, 7.96 for taste, 8.53 for texture and 8.43 for overall acceptability. There was a significant variation observed in the sensory attributes of health drink prepared from nutrimix-GCS and nutrimix-FSP. The health drink prepared from selected nutrimixes is presented in Plate 8.

Table 28: Organoleptic evaluation of the products prepared from nutrimixes

Treatments	Sensory attributes					
	Appearance	Colour	Flavour	Taste	Texture	Overall acceptability
Nutrimix-GCS *pakkoda*	7.86	7.30	7.36	8.43	8.33	8.36
Nutrimix-FSP *pakkoda*	7.61	7.41	7.50	7.63	7.68	7.82
Nutrimix-GCS *laddu*	7.64	7.40	6.86	7.83	7.66	7.73
Nutrimix-FSP *laddu*	8.20	7.84	7.60	7.96	8.07	7.90
Nutrimix-GCS health drink	8.26	8.43	8.13	7.96	8.53	8.43
Nutrimix-FSP health drink	8.65	8.63	8.30	8.23	8.50	8.53



Nutrimix-GCS health drink



Nutrimix-FSP health drink

Plate 8. Health drink prepared from selected nutrimixes

4.6. Nutritional qualities of the developed nutrimixes (100g) in comparison with RDA for adolescents

The amount of nutrients provided by 100g of nutrimixes was compared with the RDA of adolescents in the age group between13-15 was presented in Table 29.

The comparison with the amount of nutrients provided by nutrimixes with daily dietary requirements of adolescents boys between the age group 13-15 was indicate that, garden cress incorporated nutrimix provided 12.61 per cent of energy (346.87 Kcal), 28.85 per cent of protein (15.67 g $100g^{-1}$), 7.57 per cent of fat (3.41 g $100g^{-1}$), 23.67 per cent of calcium (189.43 mg $100g^{-1}$), and 55.53 per cent of iron (17.77 mg $100g^{-1}$). Similarly the flax seed incorporated nutrimix provided 12.89 per cent of energy (354.61 Kcal), 27.45 per cent of protein (14.91 g $100g^{-1}$), 10.77 per cent of fat (4.85 g $100g^{-1}$), 21.96 per cent of calcium (175.70 mg $100g^{-1}$) and 49.81 per cent of iron (15.94 mg $100g^{-1}$).

In the case of adolescents girls (13-15), the garden cress incorporated nutrimix provide 14.88 per cent of energy (346.87 Kcal), 30.19 per cent of protein (15.67 g $100g^{-1}$), 8.52 per cent of fat (3.41 g $100g^{-1}$), 23.67 per cent of calcium (189.43 mg $100g^{-1}$), 65.81 per cent of iron (17.77 mg $100g^{-1}$) and the flax seed incorporated nutrimix provide 15.21 per cent of energy (354.61 Kcal), 28.72 per cent protein (14.91 g $100g^{-1}$), 12.12 per cent fat (4.85 g $100g^{-1}$), 21.96 per cent calcium (175.70 mg $100g^{-1}$) and 59..03 per cent of iron (15.94 mg $100g^{-1}$).

4.7 Cost of production of selected nutrimixes

The cost of production of selected nutrimixes are given in Table 30. Cost of production was calculated based on cost of raw ingredients, labour charges, fuel charges and electricity charges.

Table 29: The amount of nutrients provided by nutrimixes in comparison with RDA for adolescents

Nutrients	Boys (13-15 years)			Girls (13-15 years)		
	RDA	Per cent of requirement of RDA met by Nutrimix-GCS	Per cent of requirement of RDA met by Nutrimix-FSP	RDA	Per cent of requirement of RDA met by Nutrimix-GCS	Per cent of requirement of RDA met by Nutrimix-FSP
Energy (Kcal)	2750	346.87 (12.61)	354.61 (12.89)	2330	346.87 (14.88)	354.61 (15.21)
Protein (g)	54.3	15.67 (28.85)	14.91 (27.45)	51.9	15.67 (30.19)	14.91 (28.72)
Fat (g)	45	3.41	4.85 (10.77)	40	3.41 (8.52)	4.85 (12.12)
Calcium (g)	800	189.43 (23.67)	175.70 (21.96)	800	189.43 (23.67)	175.70 (21.96)
Iron (g)	32	17.77 (55.53)	15.94 (49.81)	27	17.77 (65.81)	15.94 (59.03)

Table 30: Cost of production of selected nutrimixes

Treatments	Cost (Rs/Kg)
Nutrimix-GCS	315.87
Nutrimix-FSP	295.20

The cost of production of nutrimix-GCS was Rs. 315.87/kg and that of nutrimix-FSP was Rs. 295.20/kg.

DISCUSSION

5. DISCUSSION

The discussion pertaining to the study entitled "Standardisation and quality evaluation of millet based composite nutrimixes for adolescents" is presented in this section under the following headings.

5.1. Standardisation of malting of millet flour

5.2. Nutritional and organoleptic qualities of millet based composite nutrimixes.

5.3. Quality attributes of selected nutrimixes

5.4. Changes in the quality attributes of selected nutrimixes on storage

5.5. Organoleptic qualities of products developed with the selected nutrimixes

5.1 Standardisation of malting of millet flour

Malting is an inevitable process in the development of health foods. Malting of millet grains can be used as a technique to prepare nutrient rich food formulations suitable for infant formulas, complementary food products and composite flours or food blends (Ahmed *et al.*, 2013). Malting of millets increases the nutritional quality of the products, cause biochemical modification and decreases the anti-nutritional factors. Malting and germination of millets generally improves the sensory qualities, bioavailability of nutrients and digestibility of nutrients and hence it is an appropriate strategy in food processing (Platel *et al.*, 2010).

Ogbonna *et al.* (2012) reported that malting technique can be used to enhance effectively the nutritional status of vulnerable groups. Hassan *et al.* (2006) reported that soaking, germination, malting and dry heating can be effective to reduce the anti-nutritional factors like phytic acid, tannins and polyphenols. Malting improved the *in vitro* protein (14% to 26%) and starch (86% to 112%) digestibility in pearl millet (Archana and Kawatra, 2001).

In the present study, both ragi flour and barnyard millet flour prepared with 10 hrs soaking followed by 24 hrs germination was highly acceptable based on sensory parameters like appearance (7.97 and 8), colour (7.84 and 7.76), flavour (7.55 and 7.5), texture (7.68 and 7.16), taste (7.6 and 7.4) and overall acceptability (7.72 and 7.66). By varying the time of soaking (4, 6, 8, 10, 12, 14, 16 and 18 hrs) optimum germination with maximum organoleptic qualities was observed. In millets malted after 4 to 8 hrs of soaking, a uniform germination was not observed. Optimum germination without off odour was obtained in millets soaked for 10 hrs. Uniform sprouting was also observed in millets soaked for 10 hrs. For those soaked for more than 10 hrs, off flavour development was noticed.

Sharma *et al.* (2015) reported that 10 hrs of soaking increased the vitamin C content with a gradual decrease in the anti-nutritional factors, and prolonged time of soaking adversely affected the nutritional composition. Kajihausa *et al.* (2014) reported that the protein content of the flour was increased with increase in soaking time from an initial value of 26.09 per cent to 45.64 and 48.70 per cent for 8 to 12 hrs soaking time respectively and then decreased as time of soaking increased. In the present study, optimum germination with maximum organoleptic qualities were observed at 24 hrs of germination. Germination time is a significant parameter which influence nutritional and organoleptic qualities of malted millets.

Swami *et al.* (2013) reported that as germination time increases from 8 to 24 hrs, the protein content of finger millet malt increased from 14 per cent to 17.5 per cent. The malt prepared at 24 hrs germination time had the highest protein content and other nutritional factors. Soaking and germination process significantly reduced the polyphenolic contents in millets and legumes. Naveena and Bhaskarachary (2013) recommended that soaking and 24 hrs germination was helpful in minimising various polyphenols from 32 – 62 per cent during processing.

The mean scores for overall acceptability of malted barnyard millet flour and malted ragi flour are represented in Figure 1 and 2 respectively.

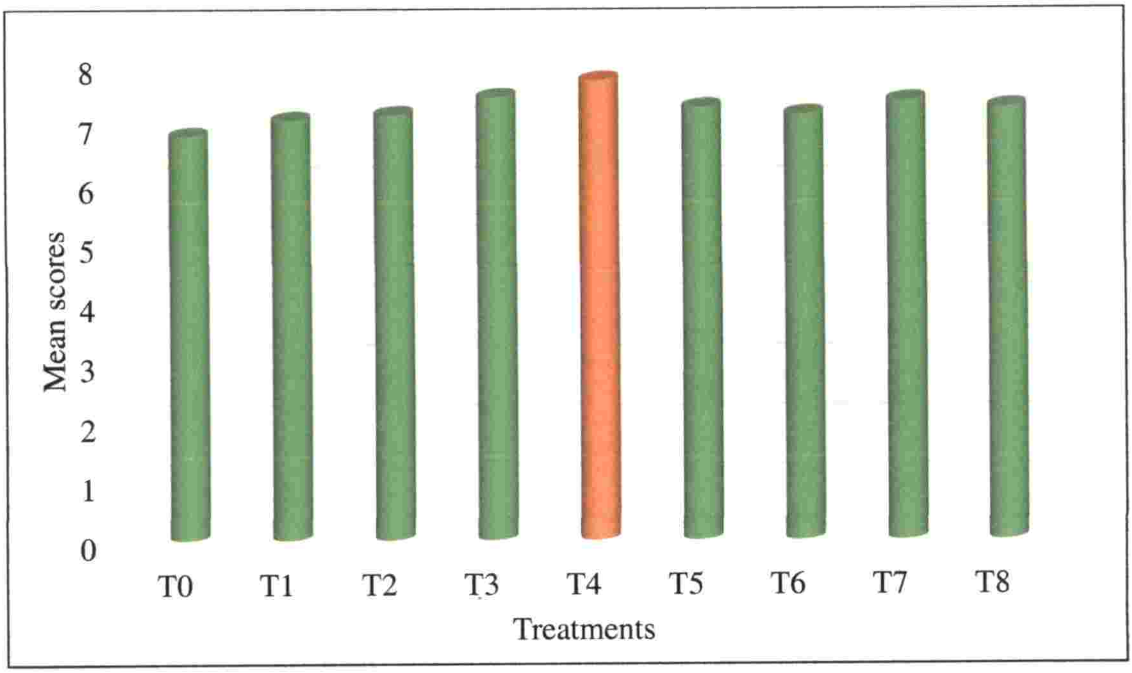


Figure 1: Mean scores for overall acceptability of malted ragi flour

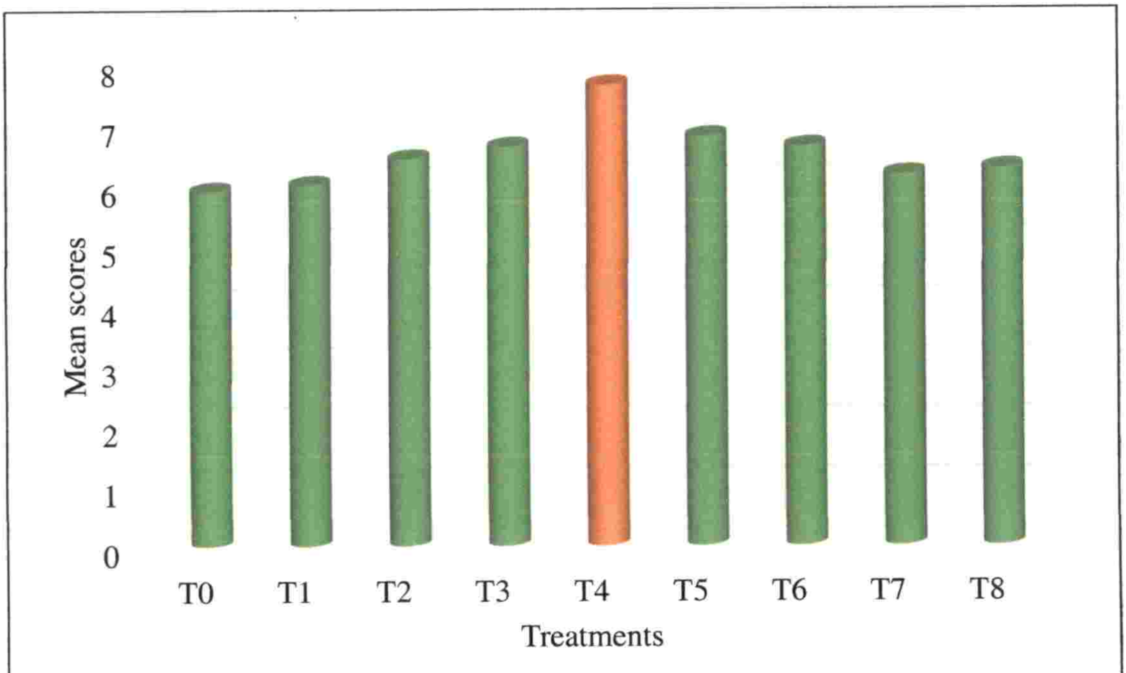


Figure 2: Mean scores for overall acceptability of malted barnyard millet flour

5.2. Nutritional and organoleptic qualities of millet based nutrimixes

5.2.1 Nutritional qualities

Nutritional qualities of the both garden cress seed flour incorporated nutrimixes (GCS) and flax seed powder incorporated nutrimixes (FSP) were assessed based on computation of nutritive value of raw ingredients. The various nutrients like energy, carbohydrate, protein, fat, crude fibre, calcium, iron, vitamin A, thiamin, riboflavin and niacin were calculated and scored based on relative ranking method.

Among 27 treatments of nutrimixes-GCS standardised, the highest energy content observed was 317.52 Kcal (T_2) and in nutrimixes-FSP it was 325.12 Kcal (T_2). Both these mixes contain 60 per cent of malted ragi flour and 10 per cent of garden cress seed flour. Energy content increased with the increasing incorporation of malted flour in the complementary processed foods. Fikiru *et al.* (2016) evaluated the effect of blending ratio of malted barley, maize, and roasted pea flour on complementary food quality and sensory acceptability and found that energy content of the complementary foods increased from 364.4 to 371.0 Kcal/100g as the ratio of malted flour increased. Similar result (376.23–376.27 Kcal/100 g) was reported by Hussain *et al.* (2012) who formulated complementary food from malted wheat and lentil composite flour.

Carbohydrate content of nutrimixes-GCS and nutrimixes-FSP ranged from 61.26 g 100^{-1} to 55.73 g 100^{-1} and 61.06 g 100^{-1} to 55.23 g 100^{-1} respectively. In the present study, the highest carbohydrate content was observed in malted ragi flour incorporated with 65 per cent in both nutrimix-GCS (T_1) and nutrimix-FSP (T_1). Pragya *et al.* (2016) reported that total carbohydrate content of finger millet was in the range of 72 to 79.5 per cent and after malting, it increased in the range of 73.7 to 83.1 per cent. The carbohydrate content of nutrimixes increased with increase in proportion of malted flours (Hall *et al.*, 2006). Fikiru *et al.* (2016) reported that, the carbohydrate contents in the complementary food processed ranged from 68.9 to 74.1 per cent. The highest carbohydrate content was observed in the blended ratio of 68 per cent maize, 20 per cent pea and 12 per cent malted barley. The lowest carbohydrate content was seen in the blended ratio of 55 per cent maize, 35 per cent pea and 10 per cent malted barley.

The protein content of the developed nutrimixes was in the range of 14 per cent to 16 per cent. The highest protein content was observed in T_2 in both nutrimix-GCS (16.22 g 100 g^{-1}) and nutrimix-FSP (15.72 g 100 g^{-1}). There was no considerable variation observed between nutrimixes-GCS and FSP, because both nutrimixes contain around 60 per cent of malted millet flour (either ragi or barnyard millet). Finger millet (7.3 g 100 g^{-1}) and barnyard millet (6.2 g 100 g^{-1}) do not have much variation in protein content (Gopalan *et al.*, 1986). In all nutrimixes a fixed quantity of protein source (25 %) was incorporated. Whole wheat flour (10 %), defatted soya flour (10 %) and skimmed milk powder (5 %) was used as the protein source. According to Gibson and Hotz (2001), blending of cereal-based foods and their processing methods can improve the protein content of the flour. Malting also enhanced digestibility and protein content with an increase in some amino acids such as lysine, tryptophan and methionine (Noorfarahzilah *et al*,. 2014). Lohia and Udipi (2015) developed a complementary food mix using malted flour and fermented flour and found that malted complementary food mix contain high protein (11.5g 100 g^{-1}).

Fat content of nutrimixes-GCS was ranging from 2.37 g 100 g^{-1} to 5.87 g 100 g^{-1} and in nutrimixes-FSP it varied from 2.99 g 100 g^{-1} to 7.13 g 100 g^{-1}. Garden cress is rich in linolenic acid which enhanced the amount of fat in all food preparation (Chetana and Sunkireddy, 2011). Jain and Grover (2017) developed garden cress incorporated *chikki,* and found that fatty acid compositions was increased in garden cress *chikki.* Gambus *et al.* (2004) found that addition of 10-13 per cent flaxseed in bread enhanced the linolenic acid content. Mervat *et al.* (2015) reported that, 10 per cent incorporation of full fat flax seed powder in composite flour increased the fatty acid composition than defatted flax seed powder. The fat content was high in barnyard millet (4.7 g/100g) compared to finger millet (1.3 g/100g) (Ahmed *et al.*, 2013) as a result, increasing the propotion of barnyard millet increased the fat content of the developed nutrimixes also. The functional ingredients used in the nutrimixes such as garden cress seeds and flax seeds also contain high amount of fat. So varying proportion of functional ingredients also changed the fat content.

The fibre content of nutrimix-GCS and nutrimix-FSP were in the range of 5.87 g 100 g^{-1} to 10.47 g 100 g^{-1} and 3.45 g 100 g^{-1} to 10.19 g 100 g^{-1} respectively. The fibre content was high in nutrimixes with 65 per cent incorporation of malted barnyard millet flour. Barnyard millet contain 13 per cent total dietary fibre with 4.66 and 8.18 per cent of soluble and insoluble fractions (Veena, 2004). Surekha *et al.* (2013) reported that barnyard millet flour incorporated cookies had the highest fibre (7.08 mg/100g) content than vegetable cookies.

Among 27 treatments, calcium content was high in T_1 (nutrimix-FSP) and T_2 (nutrimix-GCS). Both T_1 and T_2 contain 60 – 65 per cent ragi in their basic combination. Finger millet is rich in calcium which helps in strengthening bones and calcium content of finger millet ranged from 262 to 487 mg 100 g^{-1} with mean value of 320.8 mg 100 g^{-1} (Singh and Raghuvanshi, 2012). Kaur *et al.* (2016) developed composite flour in different variations and the calcium content of 10 per cent, 20 per cent and 30 per cent incorporation of finger millet was 163.66 mg 100 g^{-1}, 188.15 mg 100 g^{-1} and 219.33 mg 100 g^{-1} respectively.

Among various nutrimixes developed, nutrimixes-GCS (T_4) obtained the highest amount of iron (24.02 mg 100 g^{-1}) and among nutrimixes-FSP, the highest iron content was observed in T_4 (14.29 mg 100 g^{-1}). Barnyard millet contain 18.6 mg 100 g^{-1} of iron (Veena *et al.*, 2005). In T_4, the amount of barnyard millet was 60 per cent and incorporation of garden cress seeds a further increased the iron content in GCS nutrimix to 24.02 mg 100 g^{-1}. Singh and Mishra (2014) developed two types of composite flours, one by incorporating barnyard millet with wheat flour (CF_1) and second one was finger millet and pearl millet with wheat flour (CF_2). The iron content was high in CF_1 (3.8 mg 100 g^{-1}) compared to CF_2 (3.2 mg 100 g^{-1}). Rani and Sucharitha (2016) developed iron rich *laddu* incorporating garden cress seed and found

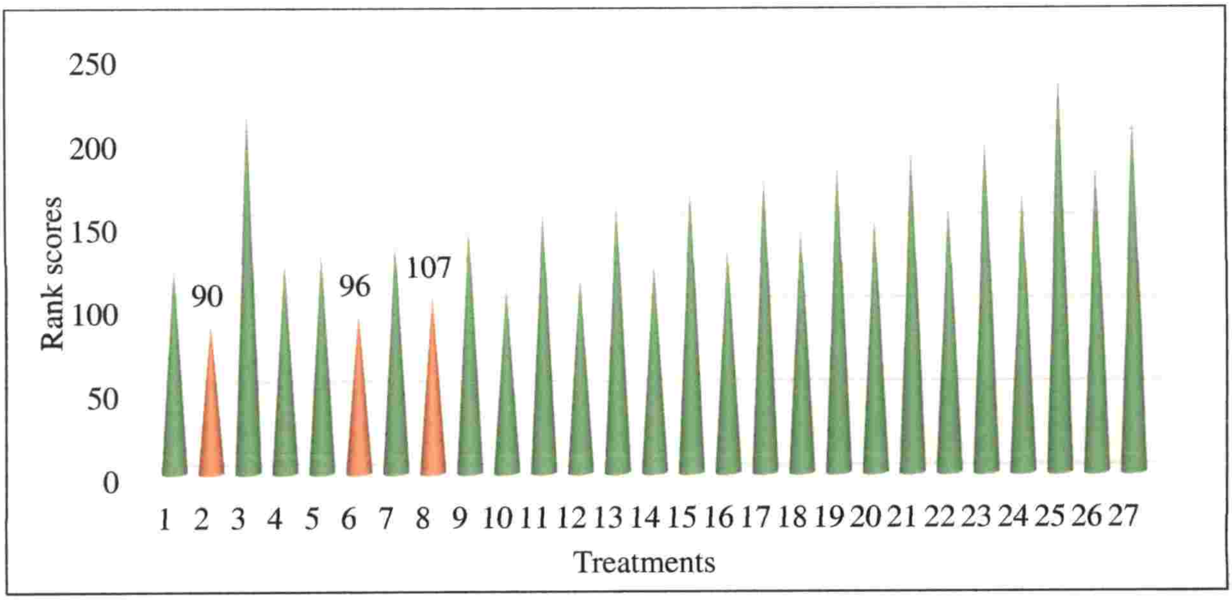


Figure 3: Nutritional qualities of composite nutrimixes-GCS

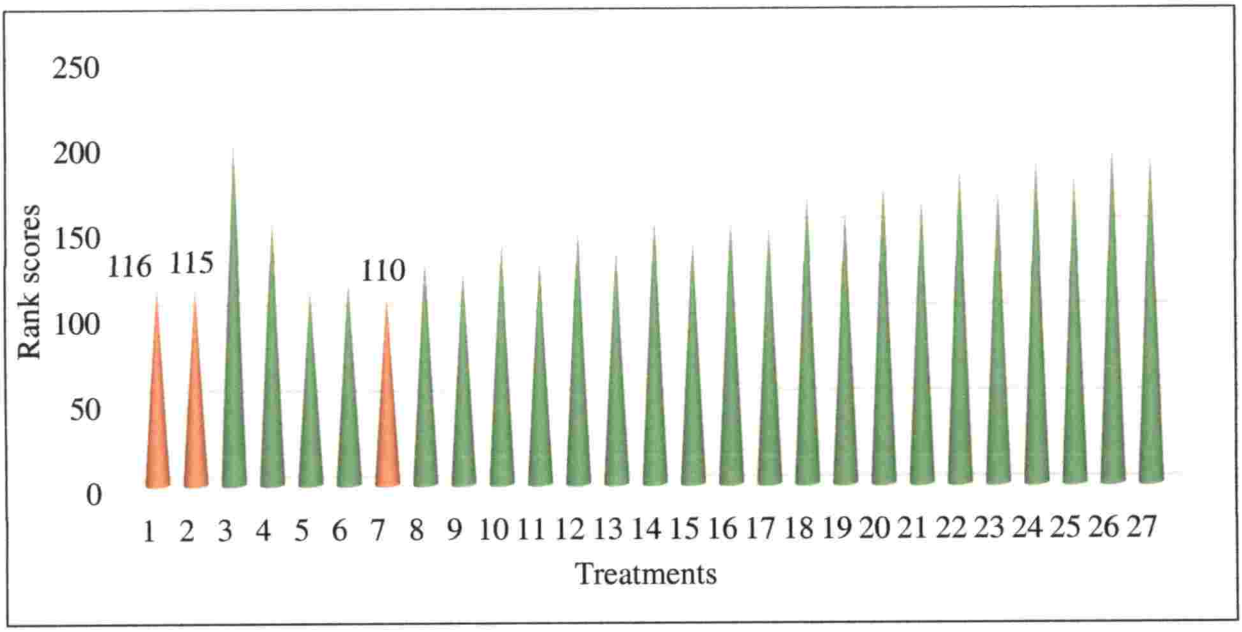


Figure 4: Nutritional qualities of composite nutrimixes-FSP

that 15 per cent incorporation of garden cress seed increased the iron content (16.01 mg 100 g^{-1}) in products.

Vitamins like carotene, thiamin was high in nutrimixes-GCS and FSP. Finger millet contain 42µg 100 g^{-1} of carotene and 0.42 mg 100 g^{-1} of thiamin. Among GCS nutrimixes, highest contents of thiamin (0.45 mg 100 g^{-1}) and riboflavin (0.31 mg 100 g^{-1}) was observed in T_2. So, nutrimixes incorporated with 65 per cent malted ragi flour showed higher carotene and thiamin content. In the case of niacin, nutrimixes incorporated with malted barnyard millet flour obtained higher amounts, because barnyard millet contain 4.3 mg 100 g^{-1} of niacin (Saleh *et al.*, 2014).

The total relative rank score for nutritional qualities of GCS nutrimixes and FSP nutrimixes are represented in Figure 3 and 4 respectively.

5.2.2 Organoleptic qualities

Organoleptic evaluation of the developed nutrimixes were assessed based on organoleptic scores. The selected nutrimixes were highly acceptable based on the parameters like appearance, colour, flavour, taste and overall acceptability.

Among twenty seven treatments of both nutrimixes-GCS and FSP, nutrimixes incorporated with higher per cent of barnyard millet flour obtained comparatively higher scores for appearance and colour than nutrimixes incorporated with malted ragi flour. Nazni and Karuna (2016) developed barnyard incorporated rusk and muffin in different proportions (20 % and 25 %). Twenty five per cent incorporation of barnyard millet flour rusk had highest score for appearance (7.85) and colour (7.57). Similar result was obtained in barnyard millet flour incorporated muffin also. Nishad *et al.* (2017) developed a multi millet based health drink and found that health drink with 15 per cent barnyard millet flour obtained highest score of 8.7 for overall acceptability. Malted ragi flour impart chocolate brown colour and it provided acceptable appearance and colour to the product. Verma and Patel (2013) developed ragi based composite flour, the product prepared were dark in colour, nutritionally superior and was highly acceptable by the consumers.

Organoleptic parameters like flavour and texture obtained higher score of 7.06 to 7.4 and 7.3 to 8.8 respectively in nutrimixes-FSP than the mean scores obtained for nutrimixes-GCS. This may be due to the high viscosity and peculiar flavour of garden cress seed powder. Similar result was reported by Mohite *et al.* (2012), garden cress seed powder act as a thickening agent, so the higher incorporation of garden cress seed powder affected the consistency of nutrimix. Patil *et al.* (2015) developed biscuits incorporated with garden cress seeds in varying proportions of 10, 15 and 20 per cent. The parameters like flavour and texture was decreased in 15 per cent and 20 per cent garden cress seed powder incorporated products than those incorporated with 10 per cent GCS powder. The texture and overall acceptability of garden cress seed products was significantly affected by increased level of garden cress seed powder (Singh *et al.*, 2015). Yareshimi and Hiremath (2017) developed value added products by incorporating 5 and 10 per cent roasted garden cress seeds. Five per cent incorporated seeds obtained higher scores for texture and flavour for *laddu* (7.95 and 7.90), biscuit (7.75 and 7.85), *pappad* (7.75 and 8.25) and soup (7.80 and 7.95). Mohite *et al.* (2012) did organoleptic evaluation of health drink and observed that health drink prepared with three per cent of processed garden cress seed powder scored highest (8.75) compared to other drinks of lower concentration (1-5% w/v) of garden cress seed powder.

Sasikumar (2013) developed *roti* incorporated with flax seed in different proportion and found that 40 per cent incorporated *roti* was highly acceptable based on organoleptic scores. Gaggat *et al.* (2014) reported that products incorporated with 5 per cent flax seed powder were highly acceptable with a mean score of 5 in seven point hedonic scale. Saxena and Vashishth (2016) developed value added products incorporated with flax seed powder at different levels of 10, 20, 30 and 40 per cent. The products like muffin and *khakra* incorporated with 10 per cent flax seed powder obtained overall score of 4.4 and *thepla* and *mathri* incorporated with 40 per cent flax seed had a mean score of 4.8 in five point hedonic scale.

Taste and overall acceptability was high in nutrimixes incorporated with higher proportion of malted barnyard millet flour both in nutrimixes-GCS and nutrimixes-FSP. It was mainly due to the suitability of barnyard millet attributed with respect to its odourless nature and bland taste. The taste was acceptable without any pronounced bitter taste and could blend well with other food accompaniments and ingredients (Veena *et al.,* 2004). The author developed roti with 100 per cent of barnyard millet flour and found that it was highly acceptable than other combinations. Vijaykumar *et al.,* (2010) developed noodles with 20 per cent barnyard millet flour which obtained higher scores of 4.8 for taste than 10 per cent incorporated noodles (4.4). Similar results was reported by Vijaykumar and Mohankumar (2011) who developed *dosa* by incorporating barnyard millet in different proportions and 30 per cent incorporation of millet flour obtained higher score of 4.9 for taste than 10 per cent of millet flour (4.4). Surekha *et al.* (2013) who developed barnyard millet incorporated cookies with 100 per cent barnyard millet flour was found to be highly acceptable and highest mean score was obtained for the parameters like colour (4.40), flavour (4.40), taste (4.30) and overall acceptability (4.40).

The mean score for overall acceptability were higher for treatments T_{22} to T_{27} in both nutrimixes. But nutritional qualities were high in T_2, T_6 and T_8 in nutrimixes-GCS and T_1, T_2 and T_3 nutrimixes-FSP based on relative ranking scores. The organoleptic scores of these nutritionally superior nutrimixes obtained a mean score of above 7 for all parameters. So among nutritionally superior nutrimixes, those with maximum organoleptic qualities were selected for further studies. Hence, from 27 nutrimixes-GCS and nutrimixes-FSP, T_6 (55%MRF+ 25%PS+ 5%S+5%MBF+10%GCS) and T_7 (55%MRF+25%PS+5%S+10%MBF 5%FSP) were selected based on nutritional as well as organoleptic qualities.

5.3. Quality attributes of selected nutrimixes

The selected nutrimixes (nutrimix-GCS and nutrimix-FSP) were analysed for the major and minor nutrients to determine the actual nutritional qualities. The moisture content of nutrimix-GCS and nutrimix-FSP was 2.39 and 2.45 per cent respectively. Usharani and Lakshmi (2013) developed a functional food mix in different variations and the moisture content was ranging from 3.07 – 3.43 per cent. Guddad and Bharati (2014) developed a multigrain flour mix which had 3.60 per cent moisture. Kumar *et al.* (2015) developed a composite flour using finger millet, sorghum flour and soya flour and obtained a moisture content of 2.81 per cent. Sambhavi *et al.* (2015) reported that 4.60 per cent of moisture was present in foxtail millet based composite flour.

In the present study, the energy content of nutrimix-GCS was 346.87 Kcal and of nutrimix-FSP it was 354.61 Kcal. Angel and Devi (2014) developed iron rich health mix using finger millet and the mix provide 367 Kcal of energy. Surekha *et al.* (2013) developed barnyard millet health mix and 100 g of health food provide 382 Kcal of energy. Jose (2005) developed a complementary food mix for infants using ragi, rice and pulses in different proportions which provide higher energy value of 392 Kcal. Chappalwar (2013) developed a composite flour using ragi, oats and wheat flour provided 315 Kcal of energy, which was slightly low compared to the energy value observed in nutrimixes developed in the present study.

The starch content of nutrimix-GCS was 85.87 g 100 g^{-1} and in nutrimix-FSP was 83.23 g 100 g^{-1}. Similar results was reported by Sharon (2012) where a banana based probiotic food mixture was developed and the initial starch content was 66.94 g 100 g^{-1}. Shukla and Srivastava (2014) developed a composite flour using finger millet and wheat flour and the starch content was found to be 63.02 g 100 g^{-1}. Murugkar *et al.* (2013) developed multi nutrient mix using malted finger-millet and sprouted green gram and found that it was high in starch content (69.53 g 100 g^{-1}).

Nutrimix-GCS contain 63.37 g 100 g^{-1} carbohydrate and in nutrimix-FSP it was 62.83 g 100 g^{-1}. CPCRI (2006) developed amrutham nutrimix for children using wheat, soya chunks, bengal gram and ground nut which provided 69.47 g 100 g^{-1} of carbohydrates. Low cost composite flour nutrimix prepared using pearl millet, barley and whey protein concentrate had the maximum carbohydrate of 60.98 g 100 g^{-1} (Zaheeruddin, 2011). Banu *et al.* (2012) developed multigrain composite mixes which had carbohydrates in the range of 56 to 61 per cent. Kumar *et al.* (2015) developed health drink powder in various combinations using malted finger millet flour and found that carbohydrate content was ranging from 69.99 g 100 g^{-1} to 72.50 g 100 g^{-1}.

The protein content in nutrimix-GCS was 15.67 g 100 g^{-1} and 14.91 g 100 g^{-1} in nutrimix-FSP. Proso-millet based convenience mix for infants and children was developed by Srivastava *et al.* (2001) which provided 14.32 g 100 g^{-1} protein. Saggu and Sundaravalli (2013) developed a value added iron rich spirulina millet mix flour which had 16.07 g protein per 100g. Srilatha and Rajini (2015) developed *navadhanya* health mix using different cereals and pulses and found that it provided 17.85 g 100 g^{-1} of protein per 100 g 100 g^{-1}. Aneena and James (2015) developed a health mix for adolescents using ragi, rice, wheat and soya flour which contain 18 mg of protein per 100 g.

The fat content present in nutrimix-GCS was 3.41 g 100 g^{-1} and in nutrimix-FSP was 4.85 g 100 g^{-1}. Krishnaja (2011) developed a functional food mix using ragi and barley as the major ingredients and the fat content observed was 1.88 g per 100 g. Radhapriya and Lakshmi (2015) developed health mix incorporated with flax seed and the fat content obtained was 5.85 g in 100g. Choudhary and Gupta (2017) developed a mix using amaranth seeds, wheat flour, refined wheat flour and garden cress seeds which had 3.23 g 100 g^{-1} of fat. Khader and Maheswari (2014) developed amylose rich malt mixes using ragi and wheat and the prepared mix provided 2.27 g 100 g^{-1} of fat. Usharani and Lakshmi, 2013 developed health mix and the fat content was ranging from 3.00 g 100 g^{-1} to 3.41 g 100 g^{-1}

The fibre content was slightly high in nutrimix-FSP (7.81 g 100 g^{-1}) than nutrimix-GCS (5.87 g 100 g^{-1}). Usharani and Lakshmi (2013) developed functional food mixes which provided fibre in the range of 7.97 to 8.17 g 100 g^{-1}. Krishnaja (2011) developed a functional food mix using ragi in different combinations and the fibre content was ranged from 3.3 g 100 g^{-1} to 4.0 g 100 g^{-1}. Parvathy *et al.* (2015) developed a novel health drink from millets which contain fibre (4.05 g 100 g^{-1}).

The calcium content of the nutrimix-GCS and nutrimix-FSP was 189.43 mg 100 g^{-1} and 175.70 mg 100 g^{-1} respectively. Parvathy *et al.* (2015) found that 198.68 mg 100 g^{-1} of calcium was present in novel health mix from millets. Usharani and Lakshmi (2013) observed that 180 mg 100 g^{-1} of calcium was found in functional food mix. Aneena and James (2015) reported that 337 mg 100 g^{-1} of calcium was present in ragi based health mix.

The iron content of the nutrimix-GCS and nutrimix-FSP was 17.77 mg 100 g^{-1} and 15.94 mg 100 g^{-1} respectively. Angel and Devi (2015) developed iron rich health mix which provided 10 mg of iron per 50 g. Aneena and James (2015) developed health mix using ragi for adolescents which provided 7 mg of iron.

In nutrimix-GCS, the zinc content was 3.26 mg 100 g^{-1} and in nutrimix-FSP it was 3.80 mg 100 g^{-1}. Aneena and James (2015) developed teen plus health mix using ragi for adolescents and it provided 1 mg of zinc from 100 g of health mix. According to Shudhodhan (2012) nutrimix fortified with zinc and iron using pearl millet, whey protein concentrate, skimmed milk powder, sugar and provided 4.64 mg of zinc per 100g.

Nutrimix-GCS contain 154.10 mg 100 g^{-1} of phosphorus and nutrimix-FSP contain 145.23 mg 100 g^{-1}. Usharani and Lakshmi (2013) developed a functional food mix and it provided 168 mg 100 g^{-1} of phosphorus. Radhapriya and Lakshmi (2014) developed a health mix to improve bone health and it provided 330 mg 100 g^{-1} of phosphorus.

5.4. Changes in quality attributes of selected nutrimixes on storage

The selected nutrimix-GCS and nutrimix-FSP were packed in polyethylene laminated aluminium pouches and kept for storage under ambient conditions and analysed for moisture, energy, starch, carbohydrate, protein, total fat, fibre, calcium, iron, zinc, phosphorus, *in vitro* digestibility of starch and protein and *in vitro* availability of minerals

5.4.1 Nutritional qualities of nutrimixes during storage

The initial moisture content of nutrimix-GCS and nutrimix-FSP were 2.39 per cent and 2.45 per cent respectively. During 2^{nd} and 4^{th} month of storage the moisture content of GCS nutrimix was increased to 2.98 per cent and 3.21 per cent and in FSP it was 2.56 per cent and 3.00 per cent respectively (Figure 5). Raj (2011) developed a weaning food mix using grain amaranth and ragi and found that during 3 months of storage moisture content was increased from 2.53 per cent to 3.93 percent. Usharani and Lakshmi (2013) developed a functional food mix and the moisture content was ranging from 3.07 – 3.43 per cent. The moisture content of composite flour blends during storage varied from 8.41 to 10.20 in the polyethylene bags for a period of 3 months (Khadam, 2014). This increase in moisture content may be attributed due to the increase in relative humidity in ambient storage conditions after storage (Smith and Hui, 2004). Increasing the moisture content was dependent on the interactive effect of storage temperature and storage period (Obadina *et al.* 2016). Multimixes have hygroscopic nature and they absorb moisture from atmosphere. In the present study, there was no relative difference in moisture content during storage. This indicate that the developed nutrimixes obtained good moisture barrier with the polyethylene laminated aluminium pouches.

Initial energy content of nutrimix-GCS was 346.87 Kcal and nutrimix-FSP was 354.61 Kcal. The nutrimix-GCS have energy content of 336.43 Kcal in 2^{nd} month of storage and 328.64 Kcal in 4^{th} month, and in nutrimix-FSP it was 347.34 Kcal and

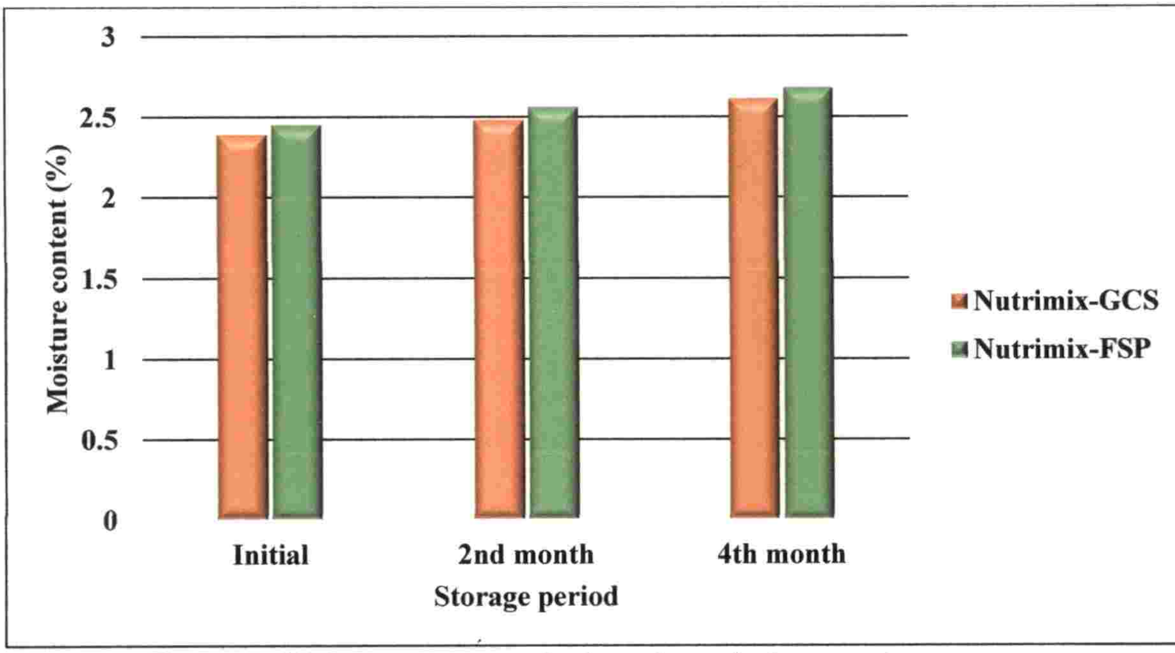


Figure 5: Moisture content of selected nutrimixes on storage

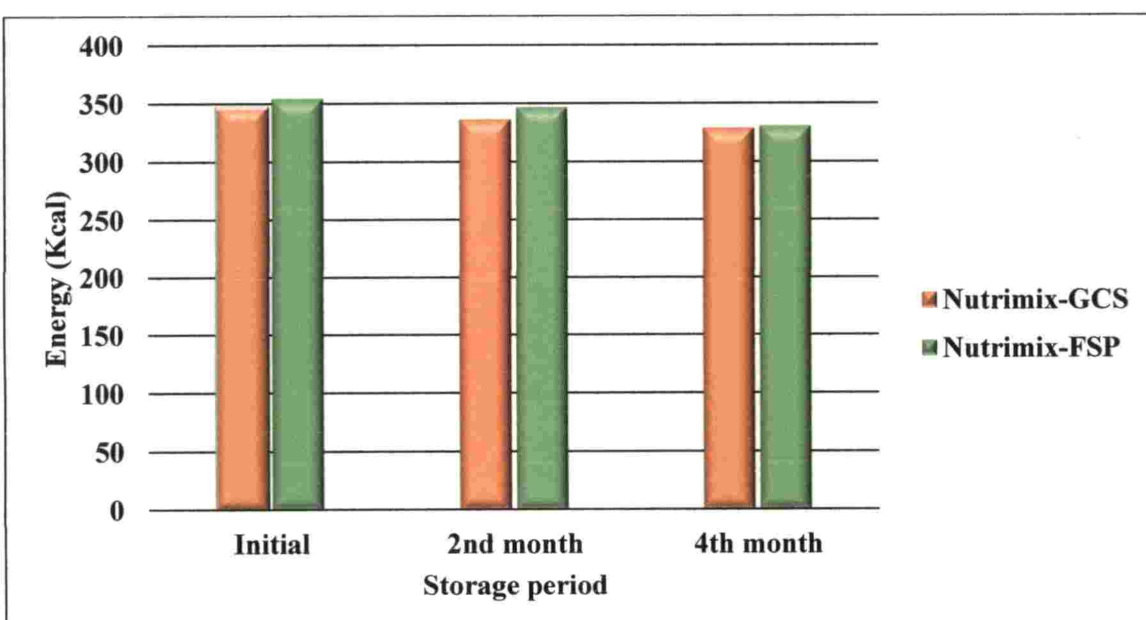


Figure 6: Energy content of selected nutrimixes on storage

330.58 Kcal respectively. During the storage period a gradual decrease in the energy content was observed (Figure 6). Khader and Maheswari (2015) developed amylose rich malted mix using ragi, green gram and milk powder and it provided 376 Kcal of energy. Radhapriya and Lakshmi (2014) developed a health mix incorporated with 50 per cent of ragi flour and found that during storage the energy content decreased from 336 Kcal to 318 Kcal.

The total energy content was calculated based on the energy produced by 1g of carbohydrate (4 Kcal), protein (4 Kcal) and fat (9 Kcal). The decrease in energy content during the storage period was mainly due to the decrease the carbohydrate, protein and fat content during storage.

Starch content of nutrimix-GCS and nutrimix-FSP were 85.87 g 100 g^{-1} and 83.23 g 100 g^{-1} initially which decreased to 84.13 g 100 g^{-1} and 82.55 g 100 g^{-1} respectively during second month of storage. By the end of 4^{th} month of storage, both nutrimix-GCS and nutrimix-FSP obtained a starch content of 83.55 g 100 g^{-1} and 81.91 g 100 g^{-1} respectively. Banu *et al.* (2012) developed multi grain composite nutrimix and reported the starch content of nutrimix was 76 g 100 g^{-1} and observed a gradual decrease during storage. Lakshmi (2011) reported that a gradual decrease in the starch content from 49.38 g 100 g^{-1} to 46.68 g 100 g^{-1} during the 6^{th} month of storage. The changes in starch content during storage was represented in Figure 7.

During germination the starch content was decreased due to the action of hydrolytic enzymes, which convert starch molecule in to carbohydrates. The decrease in starch content during storage may be due to the conversion of starch to simple sugars (Sarabhai, 2012).

Carbohydrates are the concentrated sources of energy. A gradual decrease in carbohydrate was observed during storage in nutrimix-GCS from 63.37 g 100 g^{-1} to 60.73 g 100 g^{-1} and in nutrimix-FSP 62.83 g 100 g^{-1} to 58.81 g 100 g^{-1}. Raj (2011) developed a weaning food mix using grain amaranth and finger millet and observed a gradual decrease in the carbohydrate content from 74.66 g 100 g^{-1} to 71.01 g 100 g^{-1}

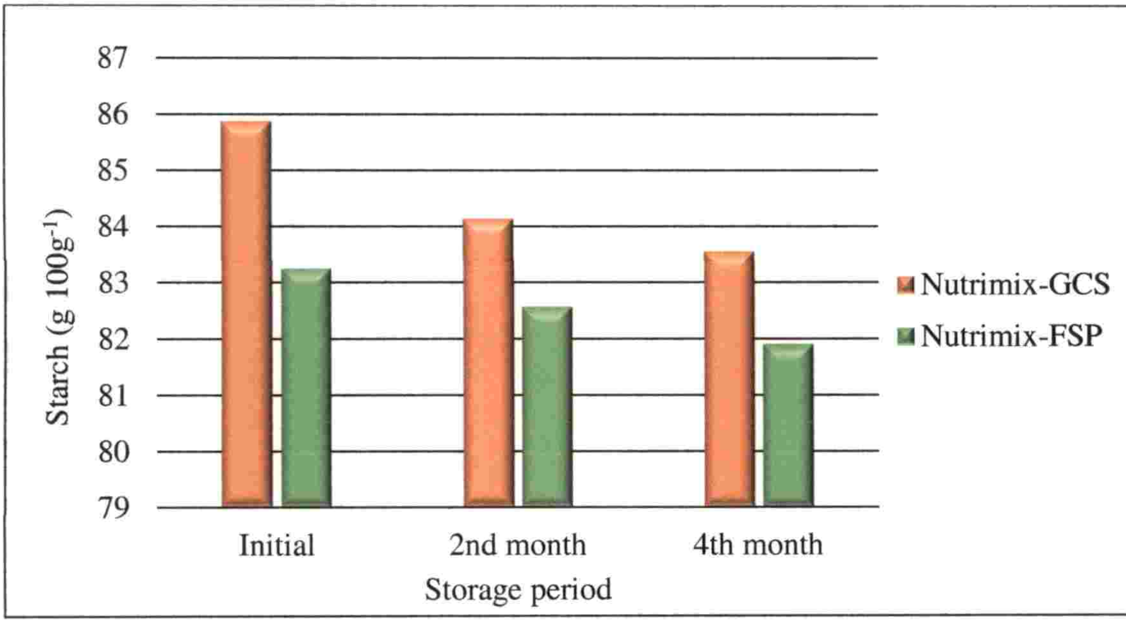


Figure 7: Starch content of selected nutrimixes on storage

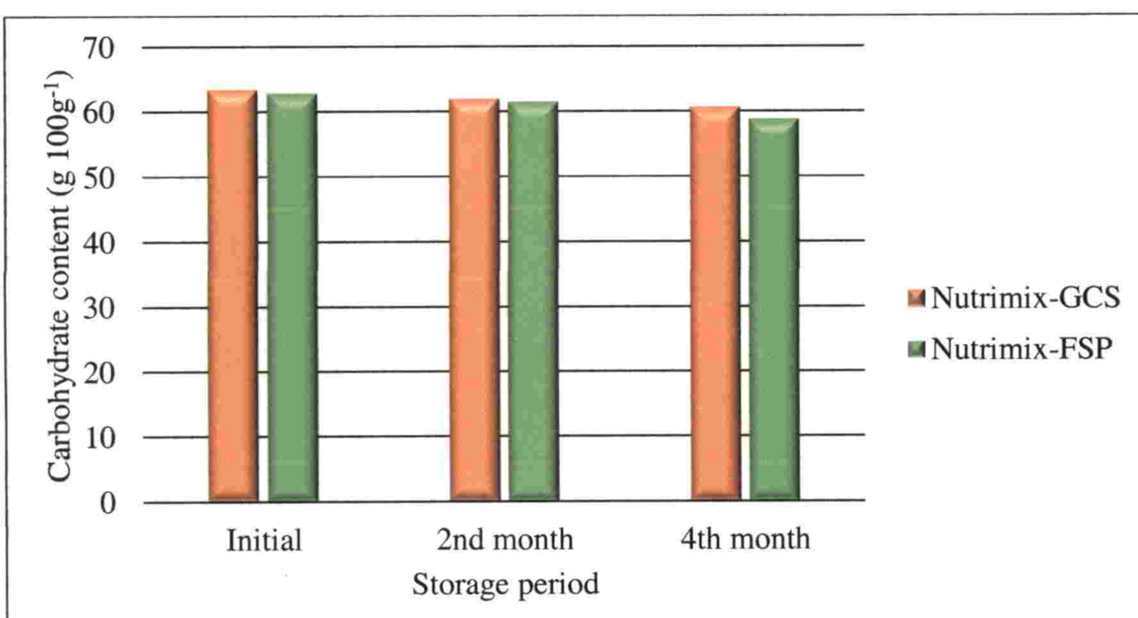


Figure 8: Carbohydrate content of selected nutrimixes on storage

during storage. Similar results was reported by Choudhary and Jood (2013) Where observed a decrease in carbohydrate content in composite flour prepared from millets, sorghum, cowpea and green gram during storage. The changes in carbohydrate content during storage is represented in Figure 8.

Bolarinwa *et al.* (2013) developed a composite flour using millets, sorghum, cowpea and green gram and observed a gradual decrease in the carbohydrate content from 78.18 g 100 g^{-1} to 68.56 g 100 g^{-1} during storage. The increase in the moisture uptake and microbial load throughout the storage period might have lead to decrease in the carbohydrate content (Ojinnaka *et al.* 2009). Raj (2011) reported that hydrocarbon loss in flour during storage decreased the carbohydrate content.

Initially, the protein content in nutrimix-GCS and nutrimix-FSP was 15.67 g 100 g^{-1} and 14.91 g 100 g^{-1}. During the second month, nutrimix-GCS had 14.47 g 100 g^{-1} protein and in nutrimix-FSP had 14.61 g 100 g^{-1} protein, and during fourth month of storage it was further reduced to 14.08 g 100 g^{-1} and 14.26 g 100 g^{-1} respectively. The changes in protein content during storage is represented in Figure 9. Sarabhai (2012) developed rice based fermented food mix with 4.27 per cent protein, which decreased to 3.92 per cent during the storage period. The similar results were reported by Raj (2011) also. Parvathy *et al.* (2015) developed a health mix using cereals, pulses and millets in different proportions which had a protein content of 17.08 g during storage and it was decreased to 15.58 g 100 g^{-1}. Pandey (2005) developed a malted health mix using jack fruit seed flour and found that it was rich in protein 19.25 g 100 g^{-1} and a slight decrease to 19.13 g 100 g^{-1} was observed during storage.

The protein content decreased during storage period. This might be associated with the absorption of moisture from the storage atmosphere that further accelerated microbiological growth. The microbes utilise the proteins present in food stuff for their proliferation (Adams and Moss, 2005). Similarly, increase in the moisture content might have initiated the proteolytic activity that will lead to protein degradation (Danuta and Malgorzata, 2009). Germination, malting and fermentation has been

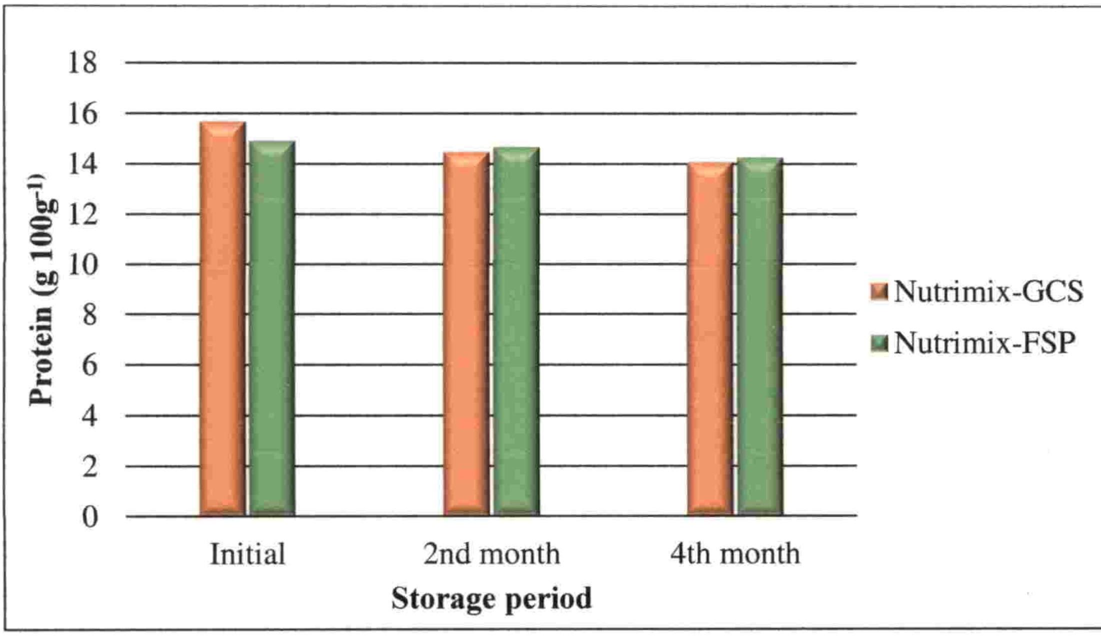


Figure 9: Protein content of selected nutrimixes on storage

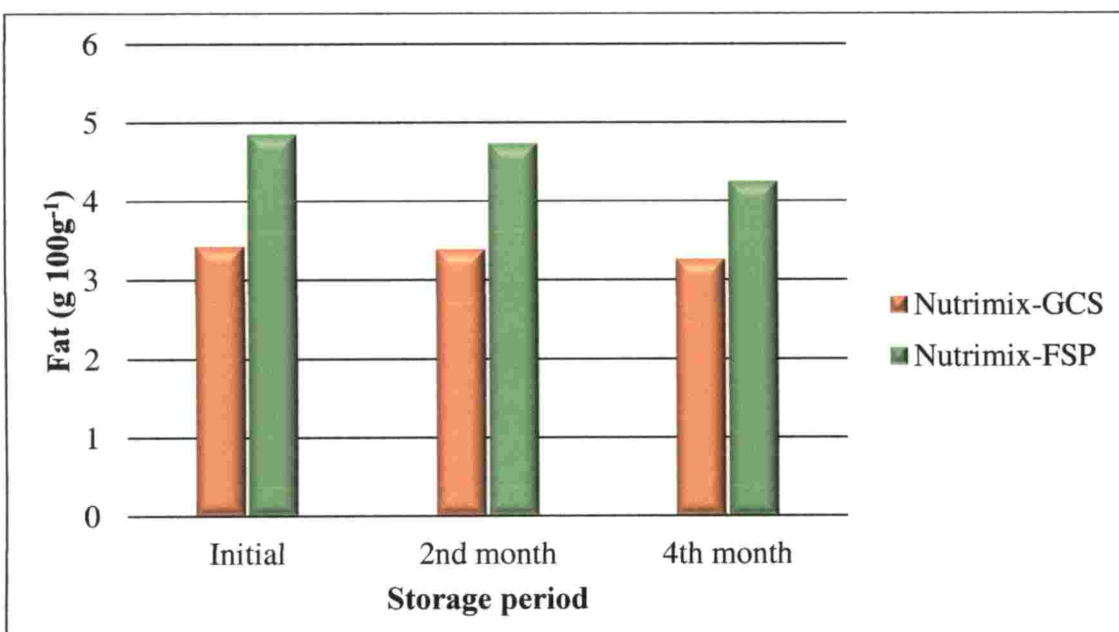


Figure 10: Fat content of selected nutrimixes on storage

reported to improve the protein content and quality of food products (Fesharakinia et al., 2009). Tiwari and Awasti (2014) reported that protein content decreased during storage due to maillard reaction between amino acid and sugar molecule and the process was accelerated due to increase in the moisture content.

The initial fat content in nutrimix-GCS was 3.41 g 100 g^{-1} and in nutrimix-FSP it was 4.85 g 100 g^{-1}. During the storage period, the fat content in both nutrimixes decreased to 3.25 g 100 g^{-1} and 4.25 g 100 g^{-1} respectively. The changes in fat content during storage is represented in Figure 10. Pandey (2005) developed malted health mix using jackfruit seed and it contain 4.61 g 100 g^{-1} of fat during storage which decreased to 4.10 g 100 g^{-1}. Raj (2011) developed amaranth based weaning mix with a fat content of 2 g 100 g^{-1} which was decreased to 1.60 g 100 g^{-1} during third month of storage. Similar results was reported by Sarabhai (2011) a functional food mix developed from ragi.

The decrease in fat content might be associated with the relative humidity of the storage conditions, which could have stimulated the activity of lipase and splits up fat into free fatty acids and glycerol resulting in reduction in total fat content of the product (Akhtar *et al.*, 2005).

The initial fibre content of nutrimix-GCS and nutrimix-FSP was 5.87 g 100 g^{-1} and 7.81 g 100 g^{-1} respectively. During second month fibre content in nutrimix-GCS was 5.58 g 100 g^{-1} and in nutrimix-FSP it was 7.67 g 100 g^{-1}. By the end of storage period it further decreased to 5.34 g 100 g^{-1} and 7.64 g 100 g^{-1} respectively. The changes in fibre content during storage is represented in Figure 11. Banu *et al.* (2012) developed multi- whole grain mix formulated by using cereals, millets, pulses and nuts and the mix was rich in fibre 11.7 per cent and it was reduced to 9.25 in the fourth month of storage. Kabari and Giami (2015) developed biscuit from composite flour and the fibre content decreased from 2.1 per cent to 1.7 per cent after 60 days of storage. Khader and Maheswari (2015) developed amylose rich malted mix using malted ragi

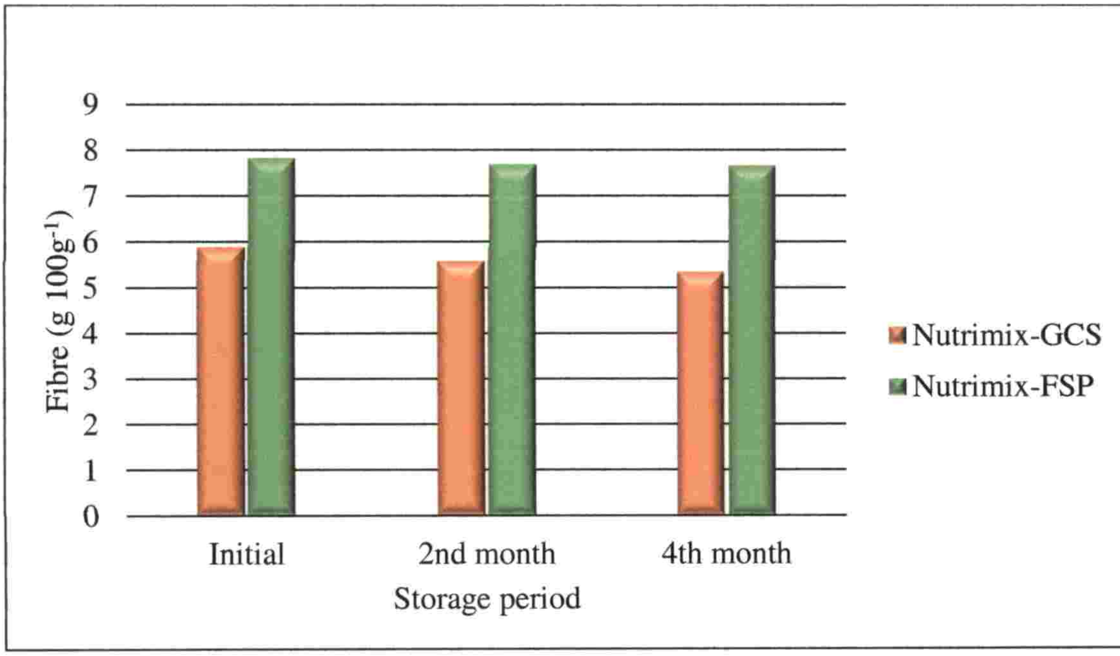


Figure 11: Fibre content of selected nutrimixes on storage

flour, whole wheat flour, green gram, milk powder and sugar which provided 4.05 g 100 g^{-1} of fibre initially then decreased to 3.58 g 100 g^{-1} during storage.

Agbemafle *et al.* (2014) reported that during storage period, degradation occurred in hemicellulose and other structural polysaccharide materials in composite flour.

During storage period, calcium decreased from 187.20 mg 100 g^{-1} to 185.66 mg 100 g^{-1} in nutrimix-GCS and 168.83 mg 100 g^{-1} to 167.43 mg 100 g^{-1} in nutrimix-FSP (Figure 12). Krishnaja (2014) found that calcium content of functional food mix reduced from 472 mg 100 g^{-1} to 425.4 mg 100 g^{-1}.

Iron content was high in both nutrimix-GCS (17.77 mg 100 g^{-1}) and nutrimix-FSP (15.94 mg 100 g^{-1}) and it was decreased in storage period to 15.49 mg 100 g^{-1} and 14.67 mg 100 g^{-1} respectively (Figure 13). Raj (2011) also observed a reduction in iron content in weaning mix during storage from 10.64 g 100 g^{-1} to 10.48 g 100 g^{-1}.

Nutrimix-GCS contain 3.26 mg of zinc and in nutrimix-FSP it was 3.80 mg 100 g^{-1} and it was decreased to 2.11 and 2.85 mg 100 g^{-1} during storage (Figure 14). Gaddam *et al.* (2016) reported that zinc content in complementary health food was decreased from 3.57 g 100 g^{-1} to 3.54 g 100 g^{-1} during storage the storage period.

Phosphorus content of nutrimix-GCS was decreased from 147.80 mg 100 g^{-1} to 136.30 mg 100 g^{-1} and in nutrimix-FSP from 135 mg 100 g^{-1} to 121.99 mg 100 g^{-1} (Figure 15). Krishnaja (2014) found that phosphorus content of functional food mix was reduced from 472 mg 100 g^{-1} to 425.4 mg 100 g^{-1} and 141 mg 100 g^{-1} to 109 mg 100 g^{-1}.

Lakshmi (2011) developed a soup mix and analysed the changes in micronutrients and found that during 6 months of storage period a gradual decrease was observed in calcium (261.87 mg 100 g^{-1} to 259.35 mg 100 g^{-1}), iron (2.97 mg 100 g^{-1} to 2.90 mg 100 g^{-1}), zinc (3.57 mg 100 g^{-1} to 3.54 mg 100 g^{-1}) and phosphorus (268.77 mg 100 g^{-1} to 259.69 mg 100 g^{-1}). Josheela *et al.* (2014) developed a weaning mix for pre-schoolers using little millet which provided 169.593 mg 100 g^{-1} of calcium

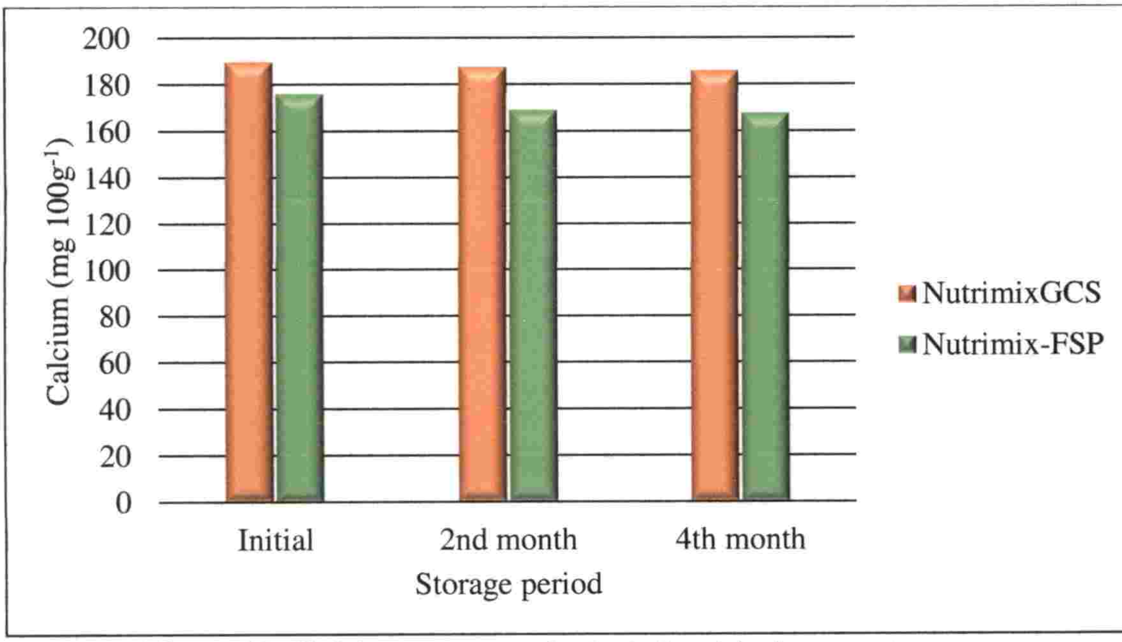


Figure 12: Calcium content of selected nutrimixes on storage

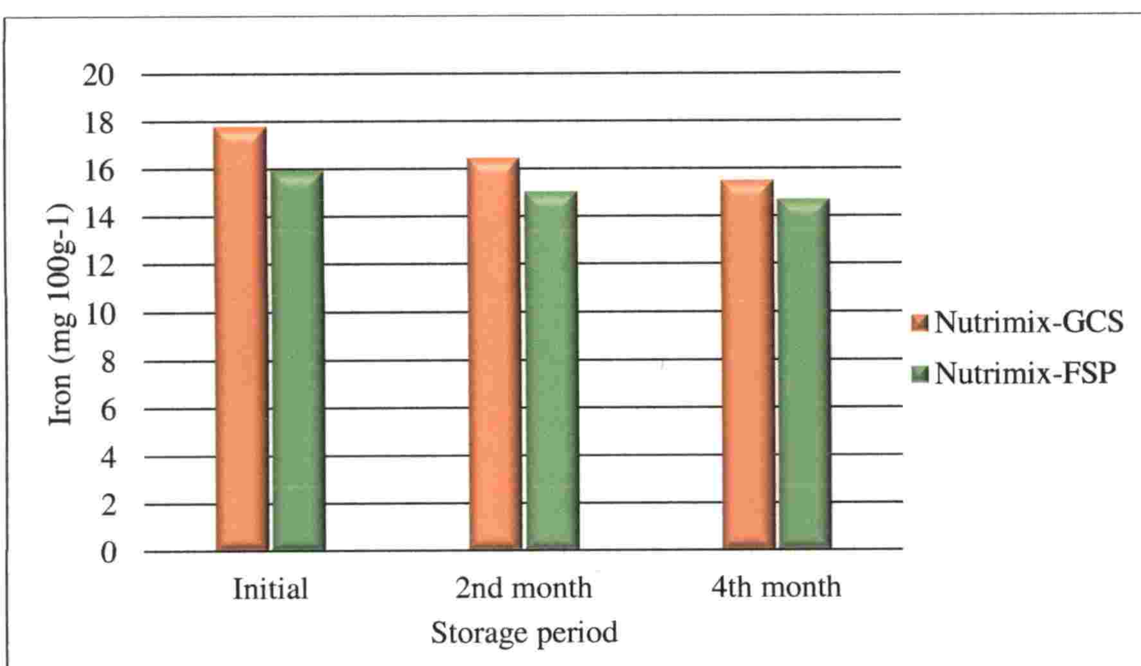


Figure 13: Iron content of selected nutrimixes on storage

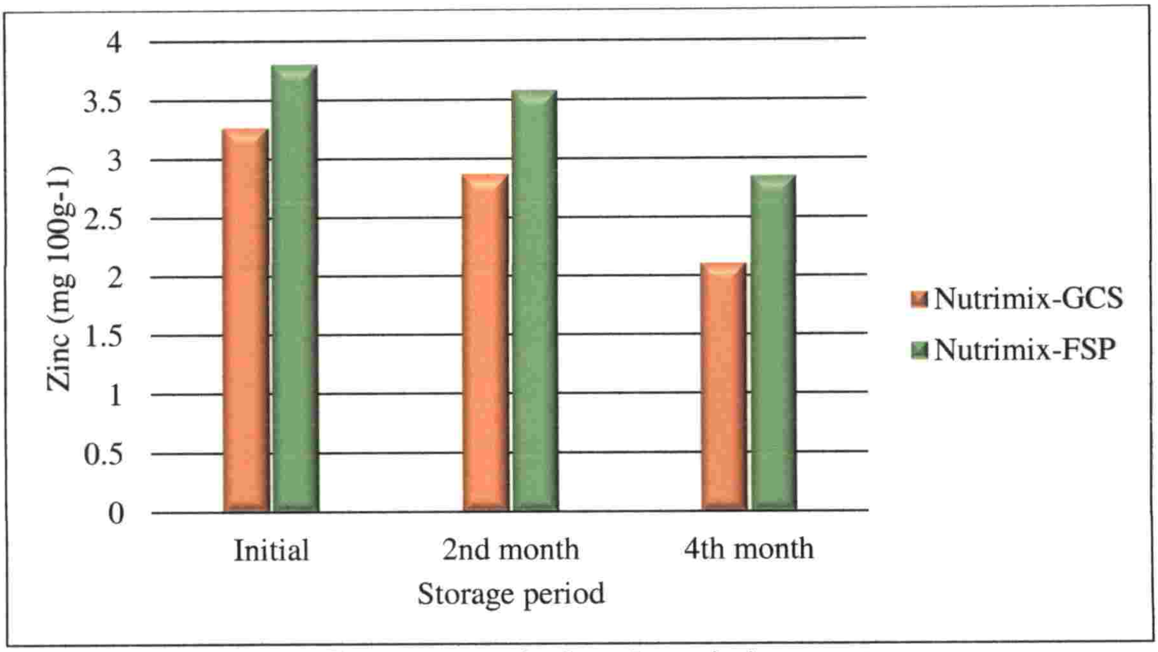


Figure 14: Zinc content of selected nutrimixes on storage

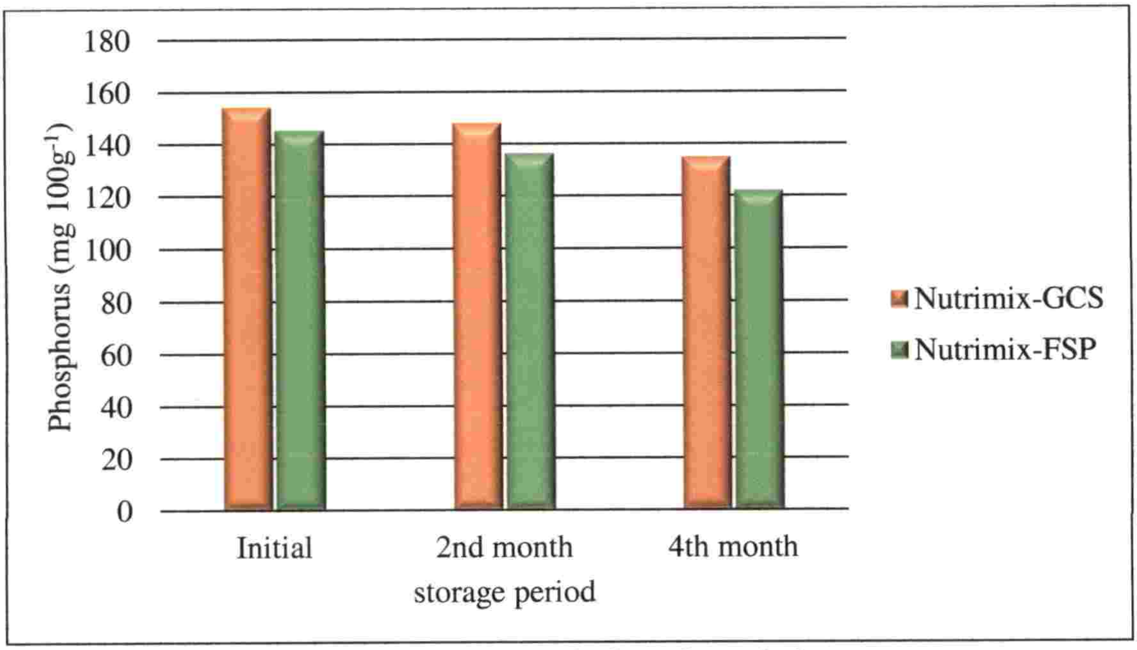


Figure 15: Phosphorus content of selected nutrimixes on storage

and 17.82 mg 100 g^{-1} of iron and during storage it decreased to 158.98 mg 100 g^{-1} and 15.78 mg 100 g^{-1} respectively.

In the present study, *in vitro* starch digestibility in nutrimix-GCS was 96.17 per cent and in nutrimix-FSP was 94.83 per cent and it was decreased during storage to 94.13 per cent and 91.88 per cent respectively. In initial month *in vitro* protein digestibility of nutrimix-GCS was 89.82 per cent and nutrimix-FSP was 90.66 per cent and the end of storage it decreased to 87.27 per cent and 88.12 per cent. Different processing techniques improved the *in vitro* digestibility of protein and starch. Archana *et al* (2001) reported that, malting of pearl millet improve the *in vitro* protein (14- 26 per cent) and *in vitro* starch digestibility (86-116 per cent), similar result was reported by Khetarpaul and Chauhan (2002). The changes in *in vitro* starch and protein are represented in Figure 16 and 17 respectively.

During storage period the digestibility of starch and protein decreased. This may be due to the decrease in protein and starch content during storage. Huchchannanavar (2014) developed a composite mix and the IVPD was 85.3 per cent, and observed that the addition of defatted soy flour and skimmed milk powder and pulse flour which might have increased the IVPD in composite flour. Banu *et al.* (2012) developed multi grain composite nutrimix and reported the *In-vitro* starch digestibility of nutrimix was 76 per cent. Raj (2011) reported that, initial IVSD of weaning mix was 96.92 per cent which was gradually decreased during storage to 93.47 per cent. IVPD of weaning mix was 90.45 per cent which decreased to 89.70 per cent during the storage period. Guddad and Bharati (2014) developed cereal based health mix and the IVSD of mix was ranging from 61.4 per cent to 63 per cent and IVPD ranged from 88.10 per cent to 91.53 per cent.

In the present study *in vitro* availability of minerals like calcium, iron, zinc and phosphorus was almost similar in both nutrimix-GCS and nutrimix-FSP. nutrimix-GCS, had *in vitro* availability of calcium (76.50 to 56.30 per cent), iron (73.83 to 71.46 per cent), zinc (68.12 to 66.52 per cent) and phosphorus (63.23 to 59.53 per cent).

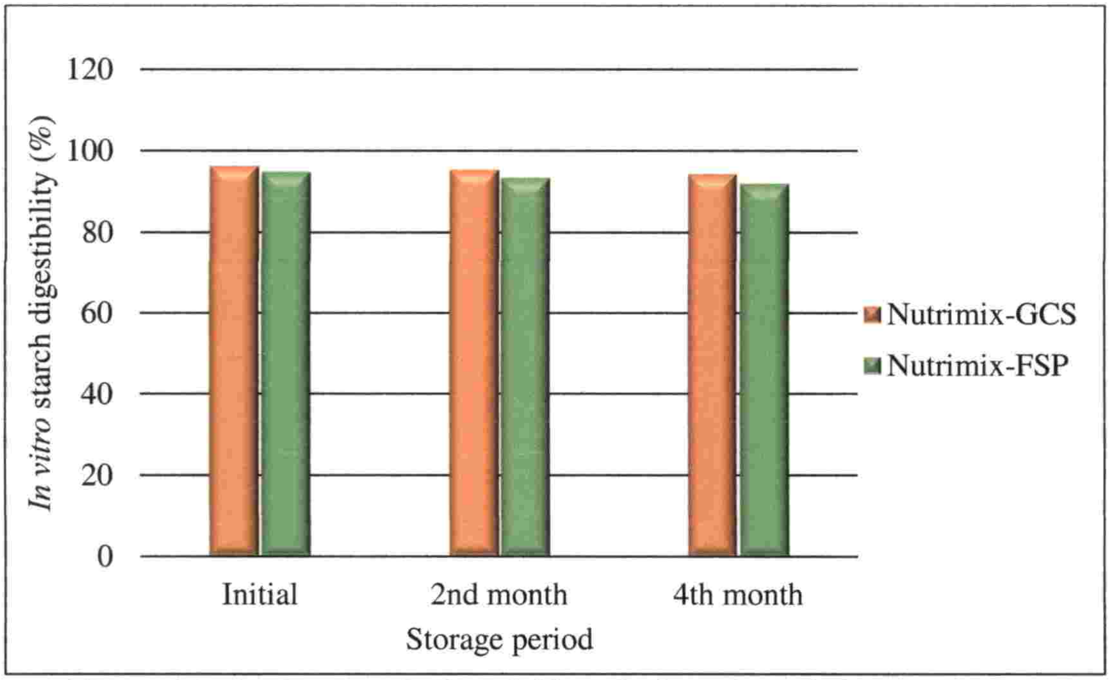


Figure 16 : *In vitro* starch digestibility of selected nutrimixes on storage

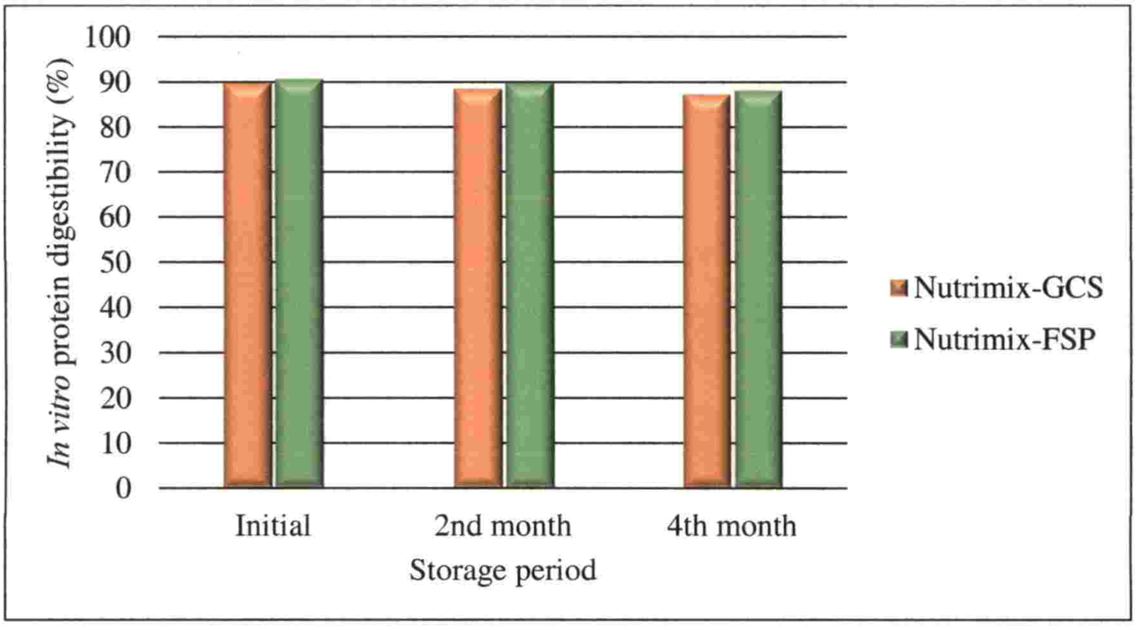


Figure 17 : *In vitro* protein digestibility of selected nutrimixes on storage

Nutrimix-FSP, had high availability of mineral like calcium (74.00 to 61.10 per cent)), iron (63.80 to 61.00 per cent), zinc (68.66 to65.83 per cent) and phosphorus (65.60 to 61.46 per cent). Elizabete *et al.* (2008) developed a multi mix and the bioavailability of calcium was 75.1 per cent and for iron it was 48.9 per cent. Phytic acid and phytate are present in millets, phytate can form complexes with minerals leading to decreased availability of these nutrients in the digestive tract (Nadeem, 2010). A significant reduction of mineral content during soaking and germination was observed by Appukuttan (2010). The changes in the *in vitro* availability of minerals are represented in Figure 18, 19, 20 and 21.

5.4.2. Organoleptic evaluation

Different parameters like appearance, taste and mouth feel decided the acceptance of food (Srilakshmi, 2010). The selected millet based composite nutrimixes were evaluated organoleptically during storage period. The initial organoleptic score obtained for nutrimix-GCS was 8.75 for appearance, 8.62 for colour, 7.86 for flavour, 8.11 for texture, 8.26 for taste and 7.8 for overall appearance. Nutrimix-FSP also obtained higher scores for appearance (8.75), colour (8.62), flavour (8.4), texture, (8.17), taste (8.47) and overall acceptability (8.2). During storage a gradual decrease was observed in the organoleptic scores of nutrimixes. Lohekar and Arya (2014) developed a food mix using ragi, soy flour and garden cress seeds. The product was stored in polyethylene laminated aluminium pouches and observed a decrease in organoleptic scores during storage in both nutrimix-GCS and nutrimix-FSP. But a higher organoleptic scores was obtained after 6 months. Saranya and Praveena (2014) developed a malt drink mix using bajra and packed in HDPE and laminated pouches. Sensory scores showed a decreasing trend in overall acceptability of the products during storage. Guddad and Bharati (2014) also reported that organoleptic scores was decreased during storage, but it was highly acceptable upto 180 days of storage.

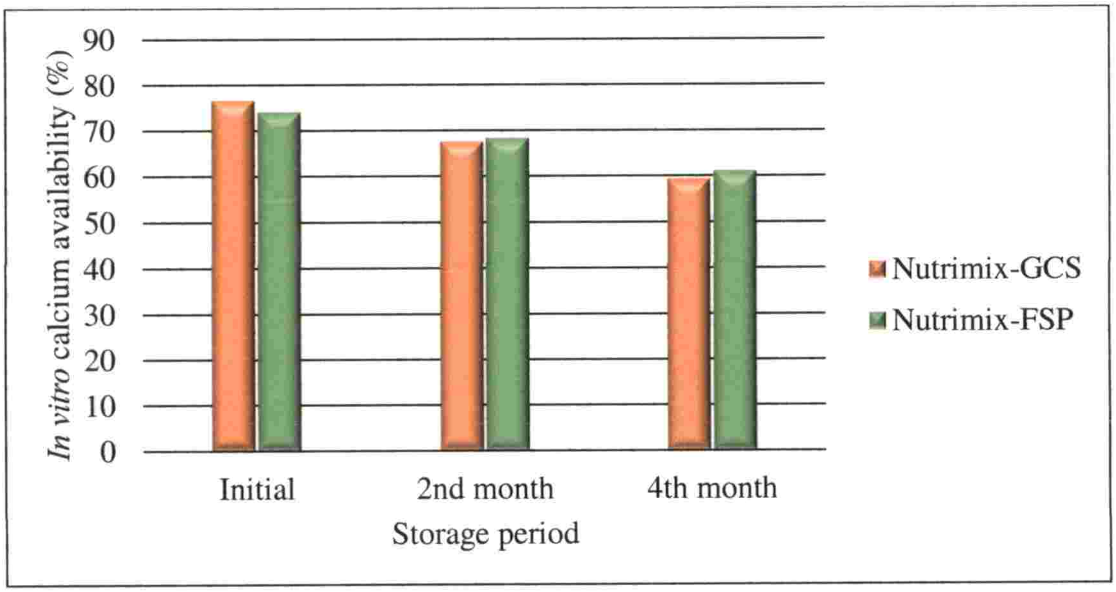


Figure 18: ***In vitro*** **calcium availability of selected nutrimixes on storage**

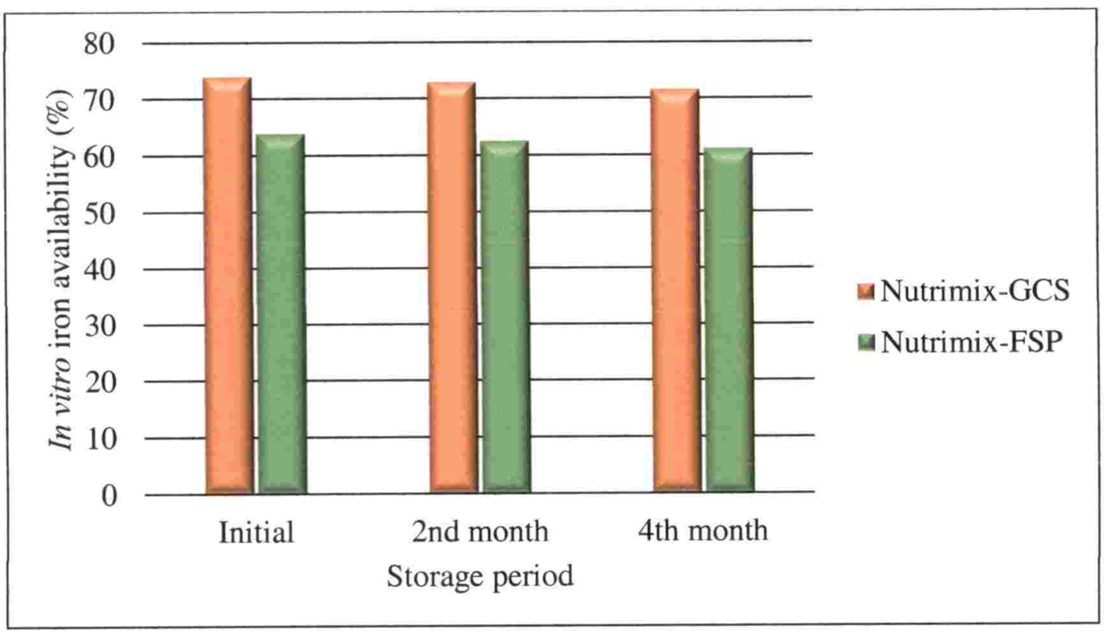


Figure 19: ***In vitro*** **iron availability of selected nutrimixes on storage**

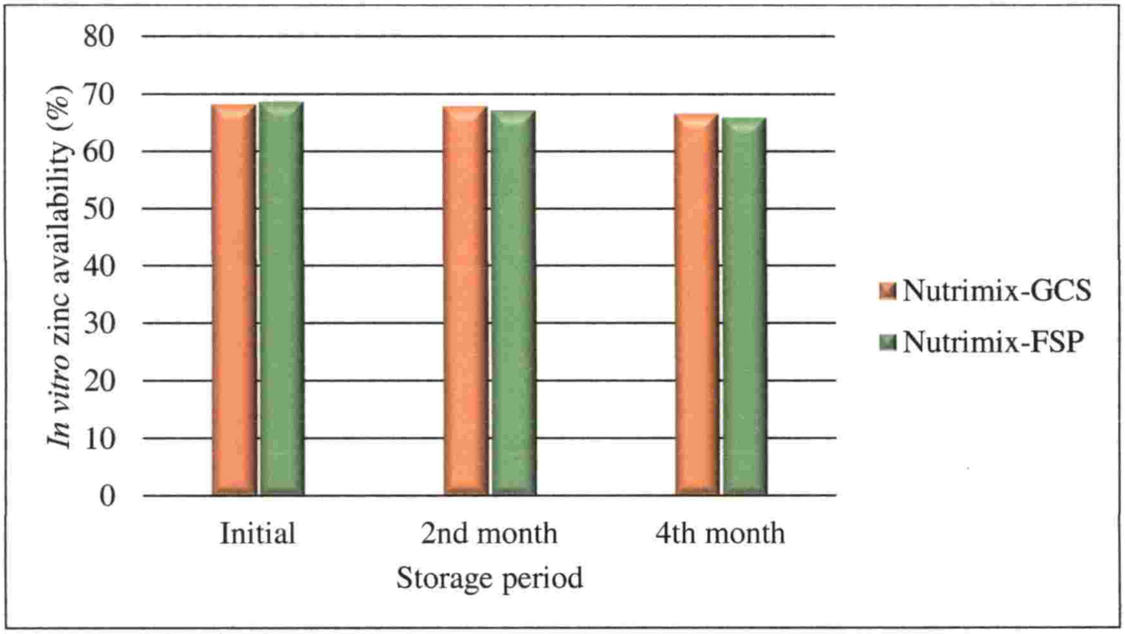


Figure 20 : *In vitro* zinc availability of selected nutrimixes on storage

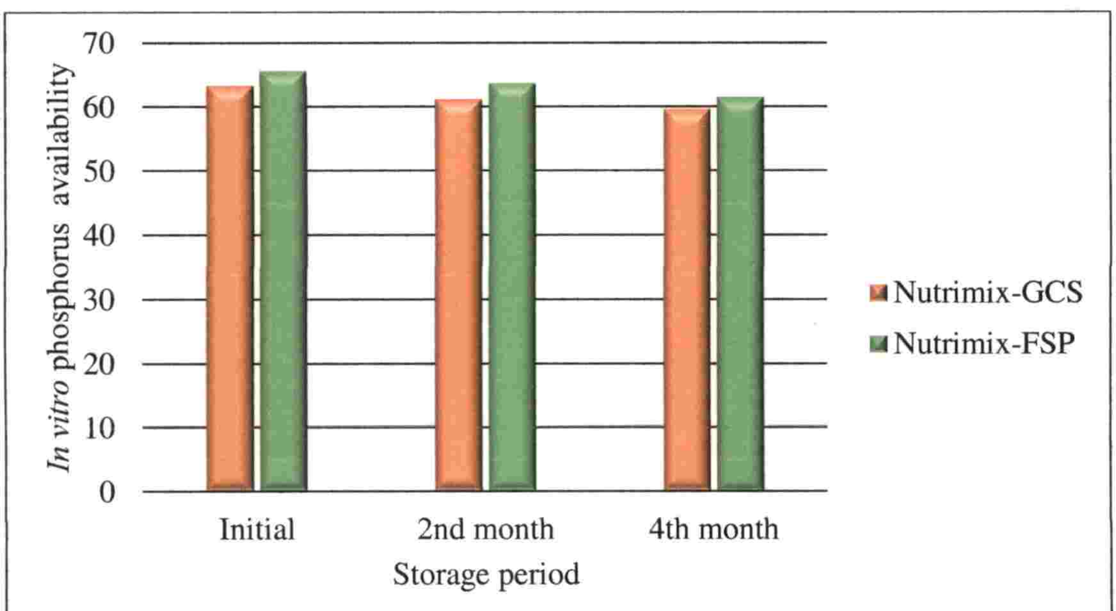


Figure 21 : *In vitro* Phosphorus availability of selected nutrimixes on storage

5.4.3. Shelf life qualities

Microbial enumeration (bacteria, yeast and fungi) was carried out in nutrimixes during storage period. Initially the bacterial growth was not detected and in 2^{nd} and 4^{th} month of storage, bacterial count of 0.21 x 10^6 cfu/g and 1.52 x 10^6 cfu/g respectively was observed in nutrimix-GCS. In nutrimix-FSP, bacterial count was 0.39 x 10^6 cfu/g and 1.49 x 10^6 cfu/g respectively during 2^{nd} and 4^{th} month of storage. The fungi colonies (0.369 x 10^3 cfu/g in nutrimix-GCS and 0.99 x 10^3 cfu/g in nutrimix-FSP was detected only during 4^{th} month of storage. Yeast count was not observed throughout the storage study. A gradual increase in moisture content was observed during storage. High moisture content, temperature of storage, pH, relative humidity and type of food, greatly influenced the microbial growth (Galeas, 2014). Spoilage by microorganism cause development of off odour and off taste and reduces the shelf life of the product (Ameh, *et al.* 2015).

Saranya (2012) reported that growth of bacteria and fungi were not observed up to second month in the developed health mix. Raj (2011) observed the initial bacterial count of 0.33 x 10^6 cfu/g, after 3 months it was increased to 3.33 x 10^6 cfu/g. The yeast (1.66 x 10^3 cfu/g to 2.33 x 10^3 cfu/g) and fungi (0.33 x 10^3 cfu/g to 3.66 x 10^3 cfu/g) colonies were also observed during storage period. Krishnaja (2012) developed a fuctional food mix and observed little growth of bacterial and fungi colonies up to 4^{th} month of storage, after the bacterial growth was with in safe limits. In the present study also, the microbial growth observed was within permissible limits.

Peroxide value is the clear indication of rancidity content. At moisture content greater than 12 per cent, risk of fat oxidation and development of rancidity increases. Peroxide value depends on temperature, time and light, measures the extent of primary oxidation of oils. In the present study, peroxide value was not detected upto fourth month of storage period. That may be due to the lower moisture content and effectiveness of laminated pouches in preventing oxidation. Similar results was reported by Saranya (2012), not peroxide content was detected till 3^{rd} month of storage in soup mixes. Krishnaja (2014) developed a functional food mix and not observed peroxide value upto fourth month of storage. In fifth (0.22 meq/kg) and sixth (0.23 meq/kg) month peroxide content was reported.

Insect infestation was not observed initially and during second and fourth month of storage period. The mixes after storage were of free flowing without any lump formation and caking of the flour. These may be due to the low moisture content and storage of mixes in the polyethylene laminated aluminium pouches which had high moisture barrier. Stored flours are favorable food source for insects, providing the essential elements required for continued growth and development. High moisture content in flours also accelerates the insect infestation (Butt *et al.* 2009). Keskin and Oskaya (2015) suggested that less than 9 per cent moisture content showed no insect attack in wheat flour. In the present study, the moisture content was less than 9 per cent.

5.5. Organoleptic evaluation of the products prepared from nutrimixes

The organoleptic evaluation of *pakkoda, ladoo* and health drink was conducted among 30 adolescents and obtained higher organoleptic scores in the range of 7 to 8.7 for all parameters like appearance, colour, flavour, taste, texture and overall acceptability. *Pakkoda, laddu* and health drink prepared from nutrimix-GCS obtained the overall acceptability scores of 8.36, 7.73, 8.43 and for nutrimix-FSP it was 7.82, 7.90 and 8.53 respectively. The mean scores for the organoleptic evaluation of products prepared using nutrimixes are represented in Figure 22, 23 and 24

Malathi *et al.* (2014) developed ribbon *pakkoda* from ragi and barnyard millet flour which were highly acceptable and obtained mean scores of 7.6 and 8.01 respectively. Subhasree *et al.* (2015) developed different food products from *amrutham* nutrimix. *Pakkoda* prepared from nutrimix was highly acceptable with a mean score of 4.96 (appearance), 4.96 (colour), 4.76 (texture), 4.8 (flavour), 4.76 (taste) and 4.84 (overall acceptability). Saggu and Sundaravalli (2015) developed spirulina and finger

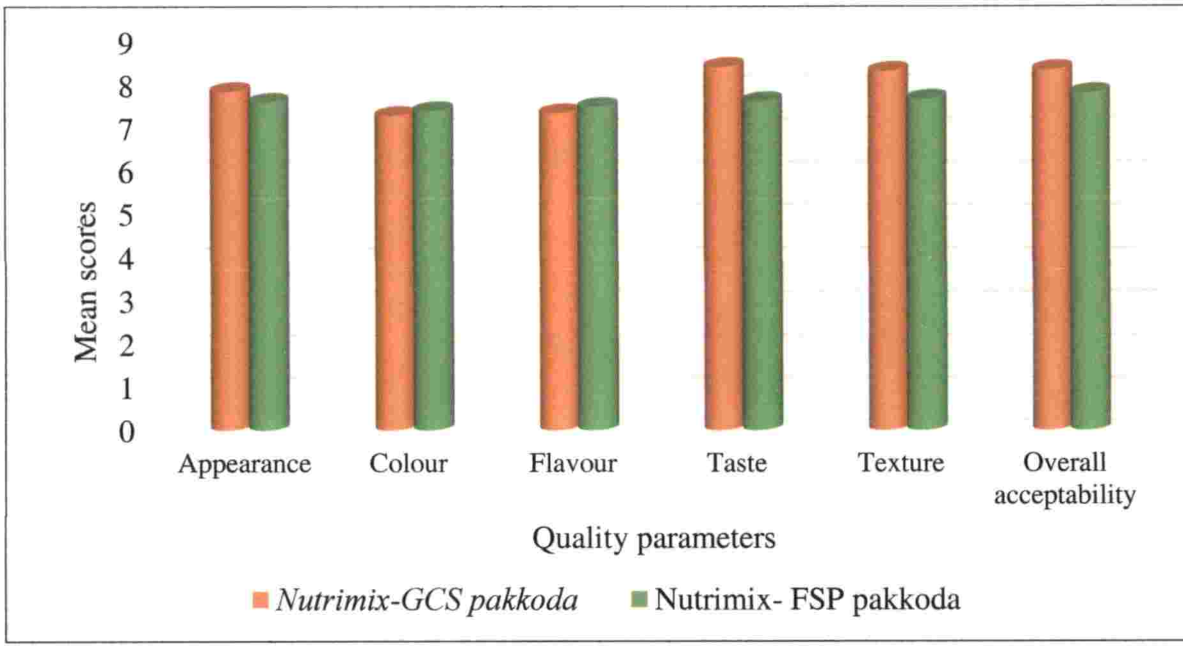


Figure 22 : Mean scores for organoleptic evaluation of nutrimixes incorporated *Pakkoda*

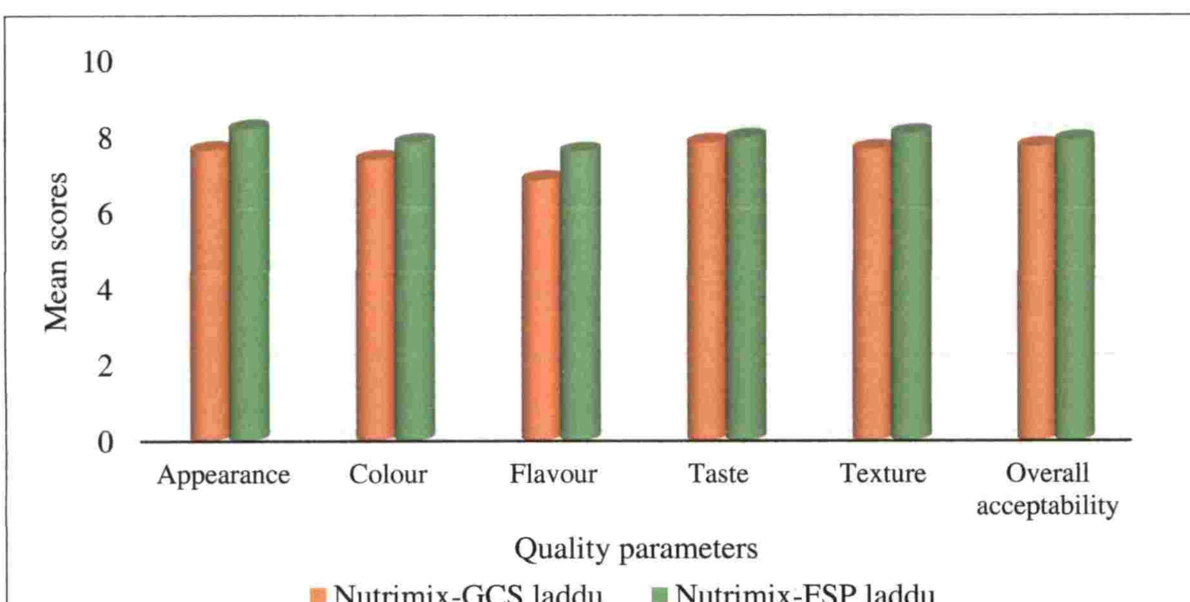


Figure 23 : Mean scores for organoleptic evaluation of nutrimixes incorporated *laddu*

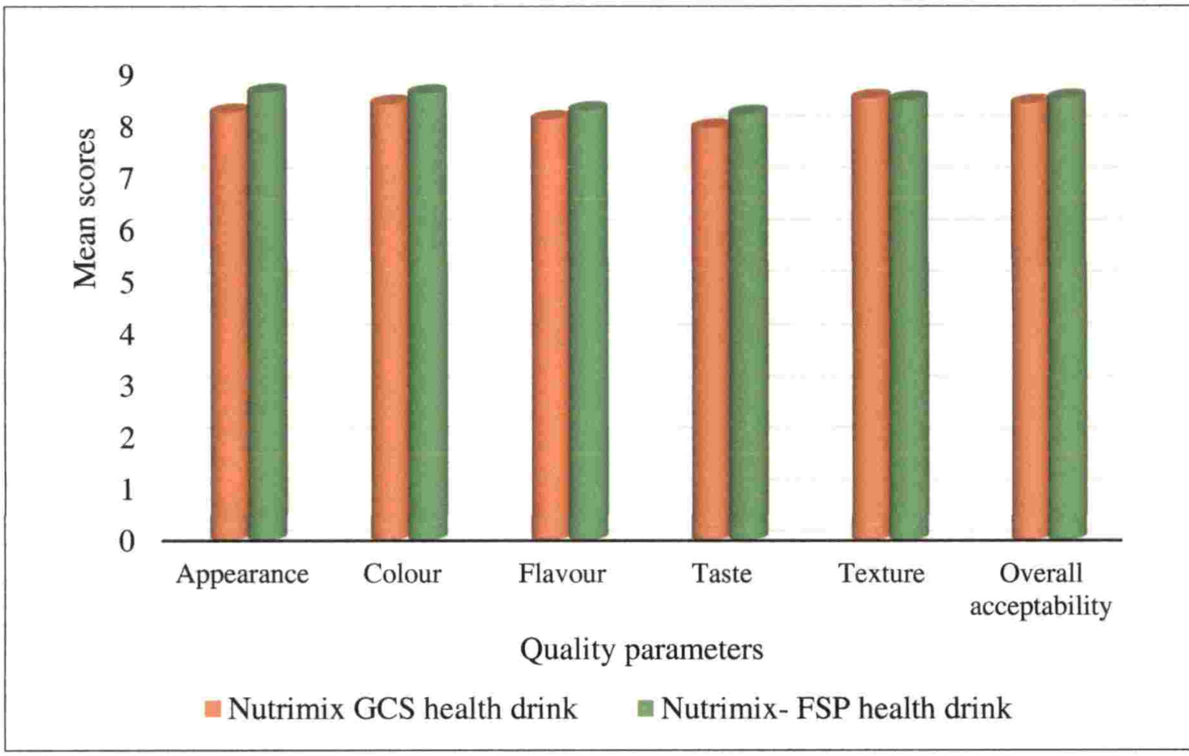


Figure 24 : Mean scores for organoleptic evaluation of nutrimixes incorporated health drink

millet mix flour and developed different food products. The nutrimix incorporated *Pakkoda* was highly acceptable with a mean score of 8.2.

Devi and Samundeeswari (2013) developed a health mix and supplemented in the form of *laddu* for pre-schoolers and was highly acceptable with a mean score 7.53. Khader and Maheswari, (2015) developed *laddu* from amylose rich malt mix and obtained higher scores based on 5 point hedonic scale for appearance (4.65), colour (4.70), flavour (4.80), taste (4.82), texture (4.85) and overall acceptability (4.90). Similarly Srilatha and Rajini (2015) developed *laddu* from *navadhanya* health mix and was found to be highly acceptable (8.2). Similarly, Chaudhary and Gupta (2017) developed *laddu* from iron rich health mix and obtained higher score of 7.80 for overall acceptability.

Kumar *et al.* (2013) developed a health drink powder using finger millet and obtained mean score of 6.8 for colour and appearance, 7.6 for flavour, 7.9 for mouth feel and 7.43 for overall acceptance. Parvathi *et al.* (2015) developed health drink from millets. The overall composite score for the health mix was at 8.3. Scores for each of the individual attributes for health drink ranged from 8.3 to 8.6. The sensory evaluation of millet based health drink revealed that it was highly acceptable and preferable to the consumers. Aneena and James (2015) developed a health mix for adolescents using ragi. The health drink prepared from health mix was highly acceptable with a mean score of 9.

5.6. Nutritional qualities of the developed nutrimixes (100g) in comparison with RDA for adolescents

The garden cress incorporated nutrimix provided 12-14 per cent of energy, 28-30 per cent of protein, 23 per cent of calcium, and 55-65 per cent of iron for both boys and girls between the age group of 13-15 years of age . Similarly the flax seed incorporated nutrimix provided 12-15 per cent energy, 27-28 per cent protein, 21 per cent of calcium and 49-59 per cent of iron.

Angel and Devi (2014) developed an iron rich health mix which provide 8-10 per cent of energy, 16-18 per cent of protein, 65-75 per cent of iron, 9-12 per cent of calcium. Similarly, Kumar *et al.* (2013) developed a malted health drink powder using finger millet and the percentage of daily dietary requirements of protein was ranging from 14-17 percent and the calcium content was from 47-57 per cent.

Hence, from this study it is clear that malted millet flours can be blended well along with protein sources like skimmed milk powder and defatted soya flour to formulate nutritionally superior composite flour mixes. Various functional ingredients which are rich in micronutrients like garden cress seeds and flax seeds also can be incorporated in minimum quantities to the mixes so as to obtain multi mixes of high organoleptic qualities. The developed nutrimixes (100g) will provide 12-14% of energy, 28-30% of protein, 23% of calcium, 55-65% of iron of the total daily requirement for adolescents. The nutrimixes were found to be suitable for the preparation of different food products. The developed nutrimixes were shelf stable and retained nutritional as well as organoleptic qualities up to 4 months of storage. These nutrimixes can be utilised for combating micronutrient deficiencies among adolescents and can be popularised among vulnerable communities.

SUMMARY

6. SUMMARY

The present study entitled 'Standardisation and quality evaluation of millet based composite nutrimixes for adolescents' was proposed to develop composite nutrimixes using millets for adolescents. Nutrimixes were prepared with different combinations of ragi, barnyard millet, whole wheat flour, defatted soya flour, skimmed milk powder and the two functional ingredients garden cress seed and flax seed. The study aimed to evaluate organoleptic, nutritional and storage qualities of the developed nutrimixes. The study also assessed the suitability of the nutrimixes for the preparation of different food products.

The major ingredients, ragi and barnyard millet were malted by standardising the soaking time and germination time. Soaking time of 10 hrs and germination time of 24 hrs was found to be the optimum conditions for malting in order to get malted millet flour with organoleptic qualities.

The millet based composite nutrimixes were standardised by using malted ragi flour and malted barnyard millet flour as major ingredients and also in different combinations. Twenty five per cent of the total ingredients were fixed as protein source (PS) (wheat flour- 10%, defatted soya flour -10%, skimmed milk powder - 5%) so as to obtain minimum protein content in the developed nutrimixes. The functional ingredients like garden cress seed powder and flax seed powder was incorporated separately at 5 per cent and 10 per cent levels in all the treatments. Totally fifty four treatments for standardising the nutrimixes, 27 treatments are prepared with the functional ingredient garden cress seeds and other 27 treatments with flax seeds.

Millet based composite nutrimixes incorporated with garden cress seeds and flax seeds were standardised separately. From this, one best composite nutrimix each from garden cress seeds (nutrimix-GCS) and flax seeds (nutrimix-FSP) were selected based on nutritional as well as organoleptic qualities for further studies.

With respect to the organoleptic qualities nutrimix-GCS, T_6 obtained higher scores for all parameters like appearance (8.5), colour (8.4), flavor (7.4), texture (8.4), taste (7.4) and overall acceptability (8.3). Based on the computed nutritive value, T_6 provided 316.12 Kcal of energy, 58.99 g carbohydrate, 16.17 g of protein, 3.7 g of fat, 4.29 g of fibre, 303.58 mg of calcium and 15.01 mg of iron. Among nutrimix-FSP, T_7 was considered as the best nutrimix because it provided 315.02 Kcal of energy, 60.41 g 100 g^{-1} of carbohydrate, 15.07 g 100 g^{-1} of protein, 3.35 g 100 g^{-1} of fat, 4.45 g 100 g^{-1} fibre, and 275.48 mg 100 g^{-1} of calcium and 6.07 mg 100 g^{-1} of iron and based on the organoleptic qualities T_7 obtained higher scores for all parameters like 8.64 for appearance, 8.66 for colour, 8.37 for flavor, 8.55 for texture, 8.55 for taste and 8.15 for overall acceptability.

The selected millet based composite nutrimixes were packed in polyethylene laminated aluminium pouches and kept for four months under ambient conditions. Chemical, nutritional, organoleptic and keeping qualities of stored nutrimixes were analysed initially and also during second and fourth month of storage.

The moisture content was 2.39 per cent in nutrimix-GCS and 2.45 per cent in nutrimix-FSP. During storage it increased to 2.56 per cent and 3.00 per cent respectively. Initial energy content of nutrimix-GCS was 346.87 Kcal and of nutrimix-FSP was 354.61 Kcal and in fourth month of storage the energy content of nutrimixes decreased to 336.43 Kcal (nutrimix-GCS) and 328.64 Kcal (nutrimix-FSP). Starch content was found to be high in nutrimix-GCS than nutrimix-FSP. Initial starch content of nutrimix-GCS was 85.87 g 100 g^{-1} and it was decreased in second and fourth month to 84.13 g 100 g^{-1} and 83.55 g 100 g^{-1}respectively. In nutrimix-FSP starch content was 83.23 g 100 g^{-1} initially, which decreased to 82.55 g 100 g^{-1} and 81.91 g 100 g^{-1} during second and fourth month of storage respectively.

Initially, nutrimix-GCS contain 63.37 g 100 g^{-1} of carbohydrate and in the case of nutrimix-FSP, it was 62.83 g 100 g^{-1} finally it was decreased to 62.03 g 100 g^{-1} (GCS) and 58.81 g 100 g^{-1} (FSP). In the case of protein nutrimix-GCS had 15.67 g 100

g^{-1} protein and nutrimix-FSP contain 14.91 g 100 g^{-1} initially and finally it decreased to 14.47 g 100 g^{-1} and 14.26 g 100 g^{-1} respectively.

Initially the fat content of nutrimix-GCS was 3.41 g 100 g^{-1} and it decreased to 3.25 g 100 g^{-1} and of nutrimix-FSP was 4.85 g 100 g^{-1} and it then decreased to 4.25 g 100 g^{-1} respectively. The fibre content of nutrimix-GCS was 5.87 g 100 g^{-1} initially and it decreased to 5.34 g 100 g^{-1} in fourth month of storage period. In nutrimix-FSP also fibre content (7.81 g 100 g^{-1}) decreased by the end of storage period (7.64 g 100 g^{-1}).

Initially the GCS and nutrimix-FSP contained high amount of minerals like calcium (189.43 mg 100 g^{-1} and 175.70 mg 100 g^{-1}), iron (17.77 mg 100 g^{-1} and 15.94 mg 100 g^{-1}), zinc (3.26 mg 100 g^{-1} and 3.80 mg 100 g^{-1}) and phosphorus (154.10 mg 100 g^{-1} and 145.23 mg 100 g^{-1}). A gradual decrease in mineral content was observed during storage.

In vitro starch digestibility of nutrimix-GCS was 96.17 per cent and in nutrimix-FSP was 94.83 per cent initially and it was decreased during storage to 94.13 per cent and 91.88 per cent respectively. *In vitro* digestibility of protein was 89.82 percent in nutrimix-GCS and 90.66 per cent in nutrimix-FSP and it was decreased to 87.87 per cent and 88.12 per cent during storage period.

In vitro availability of calcium (76.50 % and 74 %), iron (73.83 % and 63.80 %), zinc (68.12 % and 68.66 %) and phosphorus (65.60 % and 63.23 %) was high in nutrimix-GCS and nutrimix-FSP and it was decreased during storage period.

During storage, the scores of organoleptic evaluation decreased but it was acceptable by the panel judges. Nutrimix-FSP was highly acceptable than nutrimix-GCS based on organoleptic scores.

In second month, bacterial count was 0.21 x 10^6 cfu/g in nutrimix-GCS and in nutrimix-FSP it was 0.31 x 10^6 cfu/g. On the fourth month of storage the bacterial count was 1.52 x 10^6 cfu/g in nutrimix-GCS and 1.49 x 10^6 cfu/g in nutrimix-FSP. In fourth month of storage, fungal count was observed in nutrimix-GCS (0.35 x 10^3 cfu/g) and in nutrimix-FSP (0.99 x 10^3 cfu/g). Yeast count was not observed in nutrimix-GCS and nutrimix-FSP throughout the storage period.

Peroxide value and the presence of insect and storage pests were not detected throughout the period of storage.

In the present study, the selected nutrimixes were used for the preparation of different food products like *laddu*, *pakkoda* and health drink. The overall score of nutrimix-GCS and nutrimix-FSP *pakkoda* was 8.36 and 7.82 respectively. For *laddu*, nutrimix-GCS and nutrimix-FSP obtained the overall score of 7.73 and 7.90. Health drink prepared with the developed nutrimixes were obtained highest score for both Nutrimix-GCS health drink (8.43) and nutrimix-FSP health drink (8.53)

From the present study, it is clear that millet based composite nutrimixes can be developed with high nutritional quality and acceptability. Functional ingredients like garden cress seeds and flax seeds can be used up to 10 per cent to develop acceptable nutrimix formulations and enhance their nutritional qualities. The prepared nutrimixes were nutritionally superior with high amount of carbohydrate, protein, calcium, iron, fibre and it was highly digestible with high mineral availability. So it can be considered as a food supplement for adolescents which contain essential nutrients for the growth and development of adolescents. The product was microbiologically safe, shelf stable for minimum 4 months of storage in polyethylene laminated aluminum pouches. The developed nutrimixes are suitable for food preparations.

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APPENDICES

APPENDIX I

Score card for the organoleptic evaluation of nutrimixes

Name:

Date:

Parameters	Treatments																										
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Appearance																											
Colour																											
Flavour																											
Texture																											
Taste																											
Overall acceptability																											

9 point hedonic scale

Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like or dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

Signature

APPENDIX II

Score card for the organoleptic evaluation of products prepared from nutrimixes

No	Parameters	Treatments	
		Nutrimix-GCS *pakkoda*	Nutrimix-FSP *pakkoda*
1	Appearance		
2	Colour		
3	Flavour		
4	Texture		
5	Taste		
6	Overall acceptability		

9 point hedonic scale

Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like nor dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

Signature

Score card for the organoleptic evaluation of products prepared from nutrimixes

No	Parameters	Treatments	
		Nutrimix-GCS *laddu*	Nutrimix-FSP *laddu*
1	Appearance		
2	Colour		
3	Flavour		
4	Texture		
5	Taste		
6	Overall acceptability		

9 point hedonic scale

Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like nor dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

Signature

Score card for the organoleptic evaluation of products prepared from nutrimixes

No	Parameters	Treatments	
		Nutrimix-GCS health drink	Nutrimix-FSP health drink
1	Appearance		
2	Colour		
3	Flavour		
4	Texture		
5	Taste		
6	Overall acceptability		

9 point hedonic scale

Like extremely	**9**
Like very much	**8**
Like moderately	**7**
Like slightly	**6**
Neither like nor dislike	**5**
Dislike slightly	**4**
Dislike moderately	**3**
Dislike very much	**2**
Dislike extremely	**1**

Signature

APPENDIX III

1. Procedure adopted to prepare *pakkoda*

Ingredients	Quantity (g)
Nutrimix powder	50
Gram flour	35
Chilli powder	5
Asafoetida powder	5
Salt	5
Oil	For frying

Procedure

1. Prepare dough with health mix powder, gram flour, chilli powder, asafoetida powder and salt.

2. Heat oil for deep frying.

3. Press the dough in ribbon shape by using a mould and deep fry in oil.

2. Procedure adopted to prepare *laddu*

Ingredients	Quantity (g)
Nutrimix powder	50
Gram flour	15
Coconut	10
Sugar	10
Cardamom	2
Ghee	3
Cashew nut	5
Raisins	5

Procedure

1. Roast nutrimix powder, gram flour and coconut for 10 minutes.

2. Add powdered sugar and cardamom, and mix together.

3. Fry cashew nuts and raisins in hot ghee. Add into the blended mixture.

4. Take small portions of the mixture and roll into balls.

3. Procedure adopted to prepare health drink

Ingredients	Quantity (g)
Nutrimix	5
Sugar	5
Milk	100ml

Procedure

1. To the boiled milk add nutrimix and sugar. Mix well until it dissolves.

STANDARDISATION AND QUALITY EVALUATION OF MILLET BASED COMPOSITE NUTRIMIXES FOR ADOLESCENTS

By

RESHMA T. R.

(2015-16-001)

ABSTRACT OF THE THESIS

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KERALA, INDIA

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ABSTRACT

Adolescence is a transitional period in the life cycle which is characterised by significant physical, psychological and social changes. Adolescents need proper nutritional care not only to promote growth but also to maintain their optimum health and nutritional status. The major nutritional problems affecting adolescents are weight abnormalities and micronutrient deficiencies. Composite nutrimixes can be developed with millets to provide adequate energy, protein, iron, folic acid and other micronutrients. Hence, the present study entitled 'Standardisation and quality evaluation of millet based composite nutrimixes for adolescents' was carried out to develop composite nutrimixes using millets for adolescents and to evaluate organoleptic, nutritional and storage qualities. The study also aimed to assess the suitability of the nutrimixes for the preparation of different food products.

Millet based composite nutrimixes were prepared from malted ragi flour (MRF) and malted barnyard millet flour (MBF) as major ingredients at different combinations. Twenty five per cent of the total ingredients were fixed as protein source (PS) (wheat flour- 10 per cent, defatted soya flour -10 per cent, skimmed milk powder – 5 per cent) and 5% sugar was also added in all treatments. The functional ingredients like garden cress seed powder (GCS) and flax seed powder (FSP) was incorporated separately at 5 per cent and 10 per cent level in different treatments. The organoleptic qualities and nutritional qualities were evaluated for 27 treatments of nutrimixes incorporated with garden cress seeds and flax seeds separately. Among various garden cress seed powder incorporated nutrimixes, the combination of 55%MRF+ 5%MBF+ 10%GCS was selected as the best nutrimix (Nutrimix-GCS) based on nutritional and organoleptic qualities. Similarly, among flax seed powder incorporated nutrimixes, the combination of 55%MRF+ 10%MBF+ 5%FSP was selected as the best treatment (Nutrimix- FSP).

The selected millet based composite nutrimixes (GCS and FSP) were packed in laminated aluminium pouches and subjected to storage studies under ambient condition

for a duration of four months. Chemical, nutritional, organoleptic and microbial qualities of stored nutrimixes were analysed initially and during second and fourth month of storage.

The nutrimix-GCS contain 346.87 kcal of energy, 85.87g 100 g^{-1} of starch, 63.37g 100 g^{-1} of carbohydrate, 15.67g 100 g^{-1} of protein, 3.41g 100 g^{-1} of fat and 5.87g 100 g^{-1} of fibre. The nutrimix- FSP had 354.61 kcal of energy, 83.23g 100 g^{-1} of starch, 62.83g 100 g^{-1} of carbohydrate, 14.91g 100 g^{-1} of protein, 4.85g 100 g^{-1} of fat and 7.81g 100 g^{-1} of fibre. Nutrimix-GCS and nutrimix-FSP contain high amount of minerals like calcium (189.43 mg 100 g^{-1} and 175.70 mg 100 g^{-1}), iron (17.77 mg 100 g^{-1} and 15.94 mg 100 g^{-1}), zinc (3.26 mg 100 g^{-1} and 3.80 mg 100 g^{-1}) and phosphorus (154.10 mg 100 g^{-1} and 145.23 mg 100 g^{-1}). *In vitro* starch digestibility of nutrimix-GCS and nutrimix-FSP was 96.17 per cent and 94.83 per cent respectively. *In vitro* digestibility of protein was 89.82 percent in nutrimix-GCS and 90.66 per cent in nutrimix-FSP. *In vitro* availability of calcium (76.50 % and 74 %), iron (73.83 % and 63.80 %), zinc (68.12 % and 68.66 %) and phosphorus (65.60 % and 63.23 %) was high in both nutrimixes.

The total microbial count observed in both nutrimixes were within permissible limits till the end of storage. Peroxide value and insect infestation were not detected throughout the storage. In the present study, *laddu*, *pakkoda* and health drink were prepared by incorporating nutrimixes. These products were highly acceptable among adolescents (14-15years) and obtained a mean scores above 7 for all treatments.

The developed nutrimixes (100g) will provide 12-14% of energy, 28-30% of protein, 23% of calcium, 55-65% of iron of the total daily requirement for adolescents. The nutrimixes were found to be suitable for the preparation of different food products. The nutrimixes were shelf stable up to 4 months of storage in laminated aluminum pouches. These nutrimixes can be utilized for combating micronutrient deficiencies among adolescents and can be popularised among vulnerable communities