PHYSICO-CHEMICAL AND FUNCTIONAL PROPERTIES OF LITTLE MILLET (*Panicum miliare*), DEVELOPMENT AND EFFICACY OF LITTLE MILLET BASED SPORTS FOOD

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1. INTRODUCTION

Millets are a group of cereal crops, cultivated around the world in a wide range of soils and climate, for food and fodder. The word 'mil' refers to thousands of grains that can be held in a handful, indicating the small size of the grains. The group includes millets such as little millet (*Panicum miliare*), foxtail millet (*Setaria italica*), proso millet (*Panicum miliaceum*), kodo millet (*Paspalum scrobiculatum*), barnyard millet (*Echinochloa frumentacea*) and finger (*Elusine coracana*) millet.

These crops are of special importance in semiarid regions because of their short growing seasons and tolerance to adverse climatic conditions and drought hardy. They require lower inputs in terms of fertilizers, pesticides and insecticides, hence eco-friendly. Millets are one of the oldest foods known to humans and possibly the first cereal grain to be used for domestic purposes (Sharma, 2006). Traditionally millets were considered as poor man's food and were consumed by primitive tribes. These are still preferred for sustainable agriculture. Millets have served as emergency food during food shortages as they can be stored under ordinary conditions. Production of millets can be found from tropics, with rainfall averaging over 1200mm per year, to steppes of Siberia with rainfall averaging less than 300mm. In India, the area under production of minor millets is 2.4 m ha. with a production of 2.7 m tones of which minor millets excluding finger millet is cultivated in an area of 1.0 m ha. with a production of 0.53 m tonnes and productivity of 530 kg/ha. (Anon., 2008).

The role of millets as food grain has been declining over years with increasing availability of rice, wheat and maize after the green revolution. Government policies which do not promote cultivation and consumption, together with difficulty in processing of these grains and shift to cultivation of cash crops have contributed to the neglect of millets under the modern agricultural production systems. This has also caused further marginalization of the farming regions where these crops are grown and the farmers who have been traditionally depending on these crops for their food security and income.

Interestingly, it is being now realized that the millets have importance as health foods, largely due to their nutraceutical components. Millets are being recognized as potential future crops because of relatively high dietary fibre, antioxidants, micronutrients, sulphur containing amino acids and essential fatty acids besides macro nutrients.

Little millet (*Panicum milaire*) is one of the minor millet and called by several names such as *Save/ savi* in Kannada, *Kutki* in Hindi, *Samai* in Tamil, *Sama* in Telugu, *Sava* in Marathi and *Chama* in Malayalam. Its cultivation is seen in India up to altitudes of 2100 m. The crop is well known in Karnataka, Andra Pradesh, Tamil Nadu, Maharashtra, Jharkhand, Madhya Pradesh, Orissa and Gujarat.

Little millet exhibit diversified use as food, feed and fodder. The grain compares well with other cereals. It is a fair source of protein (7.70 to 16.50 %), fat (2.45 to 9.04 %), carbohydrates (62.50 to 76.30 %), an excellent source of dietary fibre (15.90 to 18.10 %) with good amount of soluble (3.15 to 5.70%) and insoluble (10.20 to 14.95 %) fractions (Kulkarni *et al*., 1992, Hadimani and Malleshi, 1993 and Itagi, 2003).

Little millet has been utilized for production of various value added products apart from the traditional food preparations. Weaning foods, bakery products, fried snacks and therapeutic foods are among the few to be mentioned (Itagi, 2003, Hemalatha, 2008, Kurahatti *et al*., 2010 a and b). Diversified utilization and designing of health foods for different population can increase the demand for this nutritious grain.

Today, sports has become one of the most challenging and competitive profession in the world. Sports involve national sentiments and pride. With advancement of many training centers and encouraging support from the government, sports as a profession is gaining importance in India.

Training improves performance in sports. While this is undoubtedly necessary, it is now increasingly realized that nutrition is equally important. Concerning sports performance, it is commonly recognised that besides, genetics and physical training, the nutritional status of an athlete substantially determines his or her potential to excel in sports (Burke, 2001).

The influence of nutrition on health, body weight and body composition, substrate availability and ultimately sports performance is being accepted. It is the position of the American Dietetic Association, Dietitians of Canada, and the American College of Sports Medicine that physical activity, athletic performance, and recovery from exercise are enhanced by optimal nutrition. These organizations recommend appropriate selection of foods and fluids, timing of intake, and supplement choices for optimal health and exercise performance (Anon., 2009).

Sports nutrition is the application of science of nutrition to performance enhancement in sports. Nutrition and the dietary requirements for sporting events require careful programming. The body requires food not only for energy but also for anabolic and repetitive processes. The link between overtraining and a depressed immune state and recovery are being addressed through nutrition. A poor or inadequate diet can lead to fatigue, irritability, and sometimes to eating disorders such as anorexia.

Individuals who seek to boost physical performance rely on proper diet and increased training. The growing awareness of the synergy between diet and physical activity has fueled an expanding interest in the valuable role that nutrition can play in achieving one's genetic potential in physical performance.

Whatever the sport, it is essential for an athlete to have his or her body working at peak efficiency. Nutrition is an integrated part of an athlete's regimen.

The first component to optimize training and performance through nutrition is to ensure that the athlete is consuming enough calories to offset energy expenditure. People who participate in a general fitness program (e.g., exercising 30 - 40 minutes per day, 3 times per week) can generally meet nutritional needs following a normal diet, because their caloric demands from exercise are not too great. However, athletes involved in moderate levels of intense training (e.g., 2-3 hours per day of intense exercise performed 5-6 times per week) or high volume intense training (e.g., 3-6 hours per day of intense training in 1-2 workouts for 5-6 days per week), the caloric needs may be 50 – 80 Kcals/kg body weight/day (Leutholtz and Kreider, 2001). For elite athletes, energy expenditure during heavy training or competition may be enormous (Kreider, 1991).

Maintaining an energy deficient diet during training often leads to significant weight loss (including muscle mass), illness, onset of physical and psychological symptoms of overtraining, and reductions in performance. Additionally, female athletes have been reported to have a high incidence of eating disorders. Consequently, it is important for the sport nutrition specialist working with athletes to ensure that athletes are well-fed and consume enough calories to offset the increased energy demands of training and maintain body weight. Although this sounds relatively simple, intense training often suppresses appetite and/or alters hunger patterns so that many athletes do not feel like eating (Berning, 1998). Some athletes do not like to exercise within several hours after eating because of sensations of fullness and/or a predisposition to cause gastrointestinal distress. Further, travel and training schedules may limit food availability and/or the types of foods the athletes are accustomed to eating. Care should be taken to plan meal times in concern with training as well as make sure athletes have sufficient availability of nutrient dense foods throughout the day for snacking between meals (e.g., drinks, fruit, carbohydrate/protein bars, etc).

For this reason, sport nutritionists often recommend that athletes should consume 4-6 meals per day and snack in between meals in order to meet energy needs. Use of nutrient dense energy bars and high calorie carbohydrate/protein supplements provides a convenient way for athletes to supplement their diet in order to maintain energy intake during training.

The second component to optimizing training and performance through nutrition is to ensure that athletes consume the proper amounts of carbohydrate, protein and fat in their diet. Athletes involved in moderate and high volume training need greater amounts of carbohydrate and protein in their diet to meet macronutrient needs. Carbohydrate recommendations for athletes range from 6 to 10 g/kg (2.7 to 4.5 g/lb) body weight per day (Sherman *et al*., 1998 and Leutholtz and Kreider, 2001). Carbohydrates maintain blood glucose levels during exercise and replace muscle glycogen. The amount required depends upon the athlete's total daily energy expenditure, type of sport, sex and environmental conditions. Preferably, the majority of dietary carbohydrate should come from complex carbohydrates.

However, since it is physically difficult to consume that much carbohydrate per day when an athlete is involved in intense training, many nutritionists and sport nutrition specialist recommend that athletes consume concentrated carbohydrate juices/drinks and/or consume high carbohydrate supplements to meet carbohydrate needs. There has been considerable debate regarding protein needs of athletes (Tarnopolsky, 1999 and Kreider, 1999). It is generally recommended that athletes involved in moderate amounts of intense training consume 1 – 1.5 g/kg/day of protein (50 – 225 g/day for a 50 – 150 kg athlete) while athletes involved in high volume intense training consume 1.5 – 2.0 g/kg/day of protein (Kreider and Kleiner, 2000). If an insufficient amount of protein is obtained from the diet, an athlete would be in negative nitrogen balance which can increase protein catabolism and slow recovery. Over time, this may lead to lean muscle wasting and training intolerance. Therefore, care should be taken not only to make sure the athlete consumes enough protein in the diet but also that the protein is of high quality.

The dietary recommendations of fat intake for athletes are similar to or slightly greater than those recommended for non-athletes in order to promote health. Maintenance of energy balance, replenishment of intramuscular triacylglycerol stores and adequate consumption of essential fatty acids are of greater importance among athletes and allow for somewhat increased intake. This depends on the athlete's training state and goals. Fat intake should range from 20 to 35 per cent of total energy intake. Consuming < 20 per cent of energy from fat does not benefit performance. Fat, which is a source of energy, fat soluble vitamins, and essential fatty acids, is important in the diets of athletes. High-fat diets are not recommended for athletes.

Athletes who restrict energy intake or use severe weight-loss practices, eliminate one or more food groups from their diet, or consume high or low-carbohydrate diets of low micronutrient density are at greatest risk of micronutrient deficiencies. Athletes should consume diets that provide at least the Recommended Dietary Allowance (RDA) for all micronutrients. In general, no vitamin and mineral supplements are required if an athlete is consuming adequate energy from a variety of foods to maintain body weight. A multivitamin/mineral supplement may be appropriate if an athlete is dieting, habitually eliminating foods or food groups, is ill or recovering from injury, or has a specific micronutrient deficiency. Single-nutrient supplements may be appropriate for a specific medical or nutritional reason (e.g., iron supplements to correct iron deficiency anemia).

Now, more than ever, there is an increased demand for accurate sport nutrition information. Proper nutrition helps athletes at all levels to prevent injury, enhance recovery from exercise, achieve and maintain optimal body weight, improve daily training workouts, and maintain overall good health. Keeping up with sport nutrition can be an overwhelming task. In India, the sports performance is not optimum compared with other countries. One of the several reasons is lack of sound sports nutrition principles. Though the food consumption of sportsmen is better than the sedentary men, the protein energy ratio of the diet is not satisfactory. Hence the mere increase of nutrients is not enough to improve the sports performance.

Little millet has no characteristic flavour unlike other minor millets and can blend well with other ingredients. One possible strategy for extending the utilisation of this nutritious grain is to blend with mixture of ingredients in an acceptable way. Composite mix is a mixture of various foods or ingredients which bring about improvement in nutritional composition and quality by mutual supplementation. This, apart from providing optimum proportion of nutrients, is a convenient ready to use product for sports persons, who cannot afford to spend time searching for right kind of food. They can also carry it to places and prepare easily. In this context, formulation of acceptable, easy to consume, user friendly, natural food based product with good shelf life under ambient conditions and having optimum combination of nutrients for the sportsman is the need of the hour. The present investigation is directed to formulate little millet based food to enhance the sports performance, with following objectives.

1. To study the physicochemical and functional properties of little millet genotypes
2. To develop little millet based sports food, evaluate its nutrient composition and shelf life
3. To characterise the sensory profile of developed sports food
4. To test the efficacy of developed sports food on the performance of sports persons
5. To study the market viability of developed sports food

2. REVIEW OF LITERATURE

Little millet is one of the minor millets which are cultivated in difficult production environments like low rainfall and periodic drought. The nutritive value of millets can be compared with staple cereals like rice and wheat. The relevant literature on little millet and other millets with reference to physico-chemical and functional properties, development of millet based composite mixes and supplementary impact of millet based foods are reviewed in this chapter. The literature pertaining to nutritional profile of sportsman and effect of food supplementation on their performance are also critically reviewed and presented.

2.1 Physico- chemical properties of minor millets

Little millet is one among the minor millets; the group also includes foxtail millet, proso, barnyard and kodo millet. These millets are very small in size unlike other food grains. The minor millets have been studied for their physical, chemical and nutritional qualities.

2.1.1 Physical properties of minor millets

One of the important factors which contribute to product quality in terms of appearance is the colour of the grain, which is determined by the presence of pigments. Variation in colour within the species is common, which is evident in almost all minor millets.

Lorenz (1983) reported that the colour of dehulled proso millet varieties ranged from creamy white to very dark brown. The dehulled little millet was reported to be white and foxtail millet was dark yellow in colour (Itagi, 2003). Veena *et al.* (2005) revealed that the dehulled grains of barnyard millet varieties ranged from dull cream to brownish colour. Thus, genetic variation in seed colour was evident in millets.

The thousand grain weight of little millet varieties was reported to be ranging from 1.90 to 2.7 g. Little millet was relatively smaller compared to other minor millets (Malleshi, 2002). Broad genotypic studies on 20 foxtail millet varieties indicated thousand grain weights to be ranging between 1.20 to 3.10 g. Barn yard millet varieties were relatively smaller than kodo millet varieties, with values ranging between 2.7 to 4.0 g and 4.2 to 5.0 g respectively. Proso millet was relatively big seeded with thousand grain weight ranging between 5.4 to 6.9 g (Hadimani and Malleshi, 1993, Srivastava and Batra, 1998, Itagi, 2003 and Veena *et al.*, 2005).

The little millet recorded lowest seed volume compared to other minor millets with values ranging between 1.30 to 2.50 ml/1000 grains. The seed volumes of foxtail, barnyard and kodo millet varieties were reported to be 1.50 to 3.50, 1.50 to 5.80, 2.80 to 3.60 ml/1000 grains, respectively. Proso millet was observed to be more consistent in seed volume with values ranging between 3.80 to 4.10ml/1000 grains (Hadimani and Malleshi, 1993, Srivastava and Batra, 1998, Itagi, 2003 and Veena *et al.*, 2005).

Density of grains is one of the important parameters determining dehulling and milling performance. The density of little millet was found to be ranging between 1.21-1.46 g/ml. While the density of foxtail and barnyard millet were recorded to be 1.18 and 1.42 g/ml and 1.07-1.40 g/ml, respectively. (Mandhyan *et al.*, 1987, Hadimani and Malleshi, 1993, Srivastava and Batra, 1998, Itagi 2003 and Veena *et al.*, 2005).

2.1.2 Chemical composition of minor millets

Grains are the storehouse of many chemical components including nutrients, phyto-chemicals and non-nutritive functional constituents. The nutritive value of millets is comparable to other cereals with slightly higher content of protein and minerals (Gopalan *et al.*, 2007).

Varietal differences in nutrient composition within the species of minor millets were reported by several investigators. Studies indicated that little millet genotypes recorded a moisture content of 8.56 to 12.34 per cent. It was also reported that proso millet recorded a high moisture content ranging from 10.60 to 15.00 per cent, followed by foxtail millet, kodo millet and barnyard millet with values of 10.7, 11.5, 10.2 and 9.53 per cent, respectively (Kulkarni *et al.*, 1992, Kulkarni and Naik, 1999 & 2000, Itagi, 2003, Veena *et al.*, 2005).

Studies have indicated that the protein content of little millet ranged from 7.7 to 12.5 per cent. The protein content in foxtail, kodo, proso and barnyard millet were reported to be ranging between 9.70-13.70, 8.50-10.50, 9.00-10.50 and 9.50-12.00 per cent, respectively with varietal differences within species as reported by several investigators (Kulkarni *et al*., 1992, Hadimani and Malleshi, 1993, Mogra *et al*., 1998, Kulkarni and Naik, 1999 and 2000, Itagi, 2003, and Veena *et al*., 2005).

With respect to fat content of minor millets, little millet recorded 2.0 to 5.4 per cent fat, with varietal differences. The fat content of foxtail millet (2.1-5.2%), kodo millet (1.1-3.3%), proso millet (2.1 to 5.2%) and barnyard millet (3.20-9.84%) was reported by several investigators (Kulkarni *et al*., 1992, Hadimani and Malleshi, 1993, Mogra, 1998, Kulkarni and Naik, 1999 and 2000, Itagi, 2003, and Veena *et al*., 2005,).

Millets in general are considered as a good source of crude fibre (Gopalan *et al*., 2007). Little millet was reported to contain crude fibre in the range of 1.2 to 7.6 per cent. The crude fibre content reported in foxtail millet was 2.7 to 5.4 per cent, proso millet was 5.51 per cent, kodo millet was 6.3 per cent and barnyard millet was 5.35 to 7.90 per cent (Kulkarni *et al*., 1992, Mogra *et al*., 1998, Kulkarni and Naik, 1999 and, 2000, Itagi, 2003 and Veena *et al*., 2005).

Krishnakumari and Thayumanavan (1998) studied the characteristics of starches of minor millets. The scanning electron microscope pictures of starch granules resembled those of rice starch granules, with a size of 0.8 to 10.0 µm. The little millet starch granule was spherical with a size ranging between 1.0 to 9.0 µm. Several granules showed deep indentation caused by protein bodies. Barnyard millet possessed highest gelatinisation temperature (84.9°C) followed by kodo (82.8°C), little (79.3°C), foxtail (78.8°C) and proso millet (75.8°C).

A wide variation in starch content of minor millet varieties was observed in foxtail millet (50.7-56.0%), proso millet (51.9-54.0%), kodo millet (47.5-50.25%) and barnyard millet (50.4-55.34%). The starch content in one variety of little millet was 55.00 per cent (Malleshi and Desikachar, 1985). Veena *et al*., (2005) documented a starch content ranging between 51.52 and 59.55 per cent in nine varieties of barnyard millet.

Becker and Lorenz (1978) determined the saccharide composition of proso millet and foxtail millet varieties. Sucrose was the major saccharide (0.48-1.12%) followed by raffinose (0.04-0.12%). Maltose and maltotriose were not detected.

Millets in general are rich in dietary fibre content. Little millet is reported to have a total dietary fibre content of 15.90 per cent. In which the soluble dietary fibre content was 5.70 per cent and insoluble dietary fibre was 10.20 per cent. It was reported that barnyard millet recorded a highest proportion of soluble dietary fibre of about 5.90-6.50 per cent (Hadimani and Malleshi, 1993 and Veena *et al*., 2005). Proso and foxtail millets were shown to contain lowest proportions of soluble fractions of dietary fibre (4.4 and 3.4 %, respectively) as reported by Hadimani and Malleshi,1993.

Lorenz (1983) observed that the tannin content of the dehulled proso millet varieties ranged from 0.023 to 0.034 per cent catechin equivalent and dehulling reduced tannin levels by 65-80 per cent. Kulkarni *et al.* (1992) analysed the tannin content of five minor millets and reported that little millet contained 147.76 mg tannin. Highest tannin content was recorded in kodo millet (167.10 mg), followed by proso millet (156.65 mg), foxtail millet (129.29 mg) and Barnyard millet (102.96 mg). The phytate content of proso millet varieties was 0.18 to 0.27, and a reduction of 27-53 per cent in phytates upon dehulling was reported by Lorenz (1983).

A study conducted by National Institute of Nutrition on mineral and trace elements of six varieties each of little millet and barnyard millet revealed that the mean ionisable iron content was 1.78 and 1.42 mg/100 g, respectively. Relatively higher concentration of zinc, copper and chromium in little millet and a higher concentration of calcium, phosphorous, manganese and magnesium were recorded in barnyard millet (Anon., 1983). Kulkarni *et al.* (1992) reported similar values for ionisable iron contents in little (1.76 mg), foxtail (0.56 mg), proso (1.47 mg), kodo (1.50 mg) and barnyard (1.38 mg) millets.

A significant variation in calcium content of five minor millets was recorded with values ranging from 12.36 to 29.17 mg/100 g and little millet was reported to contain 12.36 mg calcium (Kulkarni *et al*., 1992). Veena *et al*., (2005) reported that the calcium and iron content of barnyard millet varieties ranged from 17.1-32.7 and 1.2-1.5 mg/100, respectively.

2.2 Development and nutritional evaluation of millet based composite foods

Blending of millets with other ingredients is of paramount importance to improve the nutrient composition and protein quality in addition to providing convenience by facilitating the possibility of 'balanced diet in a single dish'. Several studies pertaining to development, nutrient composition and nutritional quality of minor millet based composite foods are reviewed here.

Gahlawat and Sehgal (1994) developed and evaluated the mixes using different cereals (rice, foxtail millet and barnyard millet), green gram and jaggery at the proportion of 70:30:25. The mixes contained 10.2-13.7 g protein, 1.0-1.87 g fat, 2.9-3.7 g ash, 1.0-1.27 g crude fibre, 357 to 374 Kcal energy and 14.42 to 15.33 mg of iron.

The evaluation of protein digestibility of four weaning blends developed by Griffith *et al*. (1998) using pearl millet, teff, cowpea and peanut at 60:40 ratio of cereal and legume / oilseed showed significant variation among the weaning blends. The peanut formulations with pearl millet (51.2-56.1 %) and teff (52-56.8 %) were having 13.8 per cent higher *in vitro* protein digestibility (IVPD) than cowpea based blends (43.9-50.0 and 43.9-52.0 %, respectively). The fermented blends had better digestibility compared to unprocessed blends, indicating that processing methods improved IVPD by 12-14 per cent.

Suma (1998) developed roasted and malted weaning mixes using amaranth grain and foxtail millet (70:30). Results indicated that malted mix had lower viscosity (560 cpu) when compared to roasted mix (3520 cpu). The viscosity of roasted food reduced significantly (1800 cpu) with addition of 5 per cent amylase rich food. Roasted mix had higher protein (14.79 %), fat (4.75 %) and ash (2.24 %), lower fibre (1.73 %) and carbohydrate (71.79 %) when compared to malted mix (14.15, 4.15, 2.22, 2.05 and 72.16 %, respectively). The keeping quality of the mixes in aluminum boxes at ambient temperature revealed that increase in moisture (4.7 to 7.6%) and peroxide value (0 to 3.5 meq/ kg fat) of roasted mix from 0 to 8th week of storage was less when compared to malted mix (5.29 to 8.59% moisture and 0 to 2.9 meq/kg fat peroxide value) from 0 to 5th week of storage.

Pathak and Srivastava (1998) formulated foxtail millet based mixes in combination with fenugreek seeds and legumes. The mixes packed in polythene bags for one month at room temperature revealed non-significant differences in overall acceptability of food products. The products when evaluated for the glycemic response in normal and diabetic subjects revealed a reduction in blood glucose levels.

Eight multi-mixes from maize, sorghum, cowpea, soybean, yam, cocoyam, plantain and sweet potato at the ratio of 65:30:05 (cereal: legume: starchy staple) were formulated by Nnam (2000). Nutrient analysis revealed that soybean in combination with sorghum or maize had higher amounts of protein (20.03 to 23.0%), fat (7.67-7.74%), crude fibre (2.46-3.71%) and calcium (70.06-81.69 mg/100g). Maize in combination with soybean and plantain and sorghum with cowpea and plantain contained higher amount of iron (3.66 mg/100g). Though all the mixes contained adequate amounts of most of the essential amino acids, they were reported to be limiting in methionine. Blending cowpeas with maize produced a higher protein score than blending cowpeas or soybeans with sorghum. The mix with cowpea, maize and sweet potato had the highest protein score.

Srivastava *et al.* (2001) developed proso millet based malted and popped convenience mixes along with soybean and peanut flours, in the ratio of 70:15:15 popped mix contained significantly higher amounts of fat (5.43 g/100 g), protein (15.98 g/100g) and energy (336 Kcal/100g) compared to malted mix (5.0, 14.35 g and 328 Kcal per 100 g, respectively). The PER of malted mix (2.13) was higher compared to popped mix (1.88) as against the casein diet (2.50) as control.

Weaning foods using malted flour of foxtail millet (30%), barnyard millet (30%), roasted soy flour (25%) and skim milk powder (15%) were formulated by Thathola and Srivastava (2002). The mix contained 18.37, 40, 9.0, 0.41 and 60.89 per cent of protein, total ash, crude fat, crude fibre and carbohydrate, respectively. Further weaning mix was fortified with multivitamin – mineral mixture to meet PFA standards. The mix stored in an airtight plastic container for four months was liked on par with fresh sample in overall acceptability by trained panel of judges.

Vanalli (2003) developed sports food based on sorghum, soybean, sugar and skimmed milk powder (40:20:25:15) which had 18 per cent energy from protein. The product had very good sensory scores and stored well for more than three months in polythene cover at ambient conditions.

Malted and roasted supplementary mixes were formulated by Banakar (2005) using cereals (sorghum, rice and finger millet), pulses (soybean, greengram), oilseed (peanut) and dehydrated amaranthus leaves. Malted supplementary food had significantly higher solubility (26.38%) and dispersability (70.06%) compared to roasted (21.00 and 66.48%, respectively). Malted supplementary food with or without amylase rich food recorded significantly higher viscosity compared to roasted supplementary food. Malted supplementary food was found to have significantly higher IVPD (76.13%) compared to roasted food (69.96%).

Multimixes were developed and nutritionally evaluated by Ijirotimi *et al.* (2006) using sorghum and pigeon pea at different proportion i.e., 90:10 (SP1), 80:20 (SP2), 70:30 (SP3), 60:40 (SP4) and 50:50 (SP5), respectively. With the increase in proportion of pigeon pea an increase was recorded in crude protein and crude fibre with a simultaneous decrease in carbohydrate content. Mixes contained 12.7-21.9 g protein, 2.3-2.6 g fat, 1.4-2.2 g crude fibre, 5.8-6.5 g ash and 58.3-71.8g carbohydrate. The biological evaluation revealed that animals fed with SP2 had higher weight gain followed by those with SP3. Keeping control as 100, higher BV (110.7) and true nitrogen digestibility (121.8) were recorded in SP2 while maximum PER (92.8) and NPU (116.1) were registered in SP3 and SP5, respectively.

Kurahatti *et al.* (2010a) developed little millet (50%) based composite mix with green gram dhal (20%), Bengal gram dhal (15%) and peanut (10%). To enhance micronutrients *viz*., iron, calcium and β-carotene, dehydrated amaranthus and chakramuni leaves were incorporated in powder form at 5 per cent level. The mix had 5.3 per cent swelling power and 15.6 per cent solubility. When the porridge from the mix was organoleptically evaluated, the mix received the scores between 7 and 8 on 9 point scale. The millet based mix compared well with multigrain supplementary food in sensory scores and nutritive value. The mix contained 357 K cal of energy, 14.6 g protein, 7.5 g of fat, 8 g of fiber, 57.5 g of carbohydrate, 7.4 g of iron, 65 mg of calcium and 313 µg of β-carotene.

Composite mixes were developed using 50 per cent little millet or cereals (wheat, rice and sorghum), 35 per cent pulses (green gram and bengal gram dhal), 10 per cent oilseed (peanut) and five per cent green leafy vegetables (amaranthus or chakramuni) by employing roasting and dehydration techniques by Kurahatti *et al.* (2010b). Out of six formulations, four mixes had amaranthus or chakramuni leaves and two had garden cress seeds as a source of micronutrients. All the mixes were highly accepted. The protein quality evaluation revealed that the green leafy vegetable incorporated mixes had higher total scores in little millet and multigrain mix with amaranthus (38.13-39.78, respectively). Methionine was the limiting amino acid with a chemical score ranging from 38 to 61 per cent. Little millet based mixes had higher NPV (8.17-8.28) compared to multigrain based mixes (5.61-6.09). The protein digestibility of little millet based mix with amaranthus was 64.5 per cent.

2.3 Nutritional status of sportsman

Nutritional status of the sportsman is one of the most important factors affecting optimal sports performance. Hence, physical fitness and training levels are very much dependent on nutritional status of sports personnel.

Wan-Nudri *et al.* (1996) determined the anthropometric measurements and body composition of selected Malaysian national athletes. A total of 84 male athletes from 10 different types of sports and 24 female athletes from five types of sports were studied. The mean body weights of male and female athletes were 68.8 kg and 58.0 kg, respectively.

The male athletes from weight lifting team and female athletes from basket ball team were heavier (110.1 kg and 61.4 kg respectively). The mean heights of male and female athletes were 1.73 and 1.66 m, respectively. The athletes from basket ball team were tallest (male 1.88 m and female 1.70m) among the groups. The mean BMI and body fat of male athletes were 22.9 kg/m^2 and 13.8 per cent respectively while, for females 20.9 kg/m^2 and 24.7 per cent respectively.

The nutritional status and adequacy of diet of 50 male long distance athletes from Coimbatore were studied by Ramaswamy and Roosevelt (1997). The mean height and weight of athletes (170.26 cm and 59.98 kg, respectively) were higher than NNMB data.

Greene *et al.* (1998) studied the anthropometric and performance measures for 54 female and 61 male high school basket-ball players. Performance measures included the vertical jump, shuttle run and sprint. The male subjects were taller and heavier, while female had a significant higher percentage of body fat. Males were able to jump significantly higher, shuttle run and sprint faster than female subjects.

Nutritional status of 63 elite female athletes (16-21 years) of India was determined by recording BMI and hemoglobin level. The BMI values ranged from 16.8 to 23.0, whereas mean hemoglobin level of middle distance runners was 11.6 mg/100 ml, in sprinters and jumpers it was 10.4 mg/100 ml and 9.0 mg/100 ml respectively (Goswami and Mathur, 1999).

Chandrasekaran and Easwaran (2000) evaluated the nutritional and physical fitness status of selected Service athletes from Pune. The height and weight of 75 subjects belonging to various sports groups were recorded. The body composition, nutrient intake, hemoglobin and aerobic capacity of 30 athletes (10 each from marathon, cross country and walk disciplines) were studied. Results revealed that all the athletes had normal BMI except the athletes belonging to marathon and basketball events who had low weight normal BMI. None were found to be obese. The walk athletes had lowest body fat (6.90%) and hence the highest lean body mass (59.04 kg) compared to other groups. Ninety per cent of marathon and cross country athletes had acceptable body fat where as 70 per cent of walk athletes were lean. A positive correlation existed between hemoglobin level and the VO_2 max of athletes. The cross country athletes had highest hemoglobin level (16.5 g/dl) and VO_2 max (4.26 l/min).

Nutritional status of 18 male and 12 female trained athletes from Dharwad city (age 16-20 years) was studied by Kavitha *et al.* (2001). The mean height, weight, mid arm circumference were high in male athletes (168.63 cm, 56.25 kg and 83.60 cm, respectively) than female athletes (157.25 cm, 46.80 kg and 78.47 cm, respectively) where as triceps skin fold thickness was found higher in female athletes (9.35 mm) than male athletes (7.45 mm). However both were taller and heavier when compared to Indian standards.

Tsunawake *et al.* (2003) evaluated the body composition and cardio respiratory function (VO_2max and O_2debt max) measured by the treadmill exercise test in Japanese women's volleyball team (n=12) and basketball team (n=11). The mean values of the height and body weight were 168.7 cm and 59.7 kg in the volleyball players and 166.5 cm and 58.8 kg in the basketball players. The mean body fat was 18.4 per cent in the volleyball players and 15.7 per cent in the basketball players. No significant difference was observed in any measured item of the physique, skin fold thickness, or body composition between the volleyball players and basketball players. The VO_2max and O_2deb max were 22 per cent and 28 per cent higher in the basketball players (56.7 ml/ kg/ min and 134.3 ml/ kg, respectively) than in the volleyball players (46.5 ml/ kg/ min and 103.2 ml/ kg, respectively).

Chatterjee *et al.* (2005) assessed the nutritional and motor performance of adolescent football players (n=12) and sprinters (n=12) of Kolkata city. The height of football players (159.76 cm) was significantly higher than sprinters (150.22 cm). The agility, hand muscle strength and strength endurance of sprinters (9.54 sec, 35.58 kg and 2.78 min, respectively) was better than football players (10.16 sec, 26.71 kg and 2.42 min, respectively). There was no significant difference between two groups for weight, leg muscle power and speed. The nutrients intake and hemoglobin concentration of sprinters was higher than football players.

The nutritional profile and performance assessment of sportsman and women (aged 18-22 years) practicing athletics (n=16), cricket (n=21), volleyball (n=15) and football (n=19) in Hyderabad was carried out by Jose and Chandrasekhar (2009).

The results revealed that male athletes were taller and heavier than female athletes. However, all the groups were below the WHO standards. It was observed that cricket players had lowest and volleyball players had highest values for all anthropometric parameters. The mean hemoglobin levels of subjects were satisfactory except for cricketers (12.3 and 11.3 g/dl for male and female, respectively). The athletes recorded highest hemoglobin values (14.3 g/dl). Intake of all the nutrients was above the RDA values for males than females except for the energy intake of female players. The mean cardiovascular efficiency score of male athletes (86.3) was highest and that of female cricketers (51.1) the least.

Sugasri and Premakumari (2010) studied the nutritional status and athletic performance of adolescent female (n=95) athletes at Coimbatore. The weight, BMI and skin fold thickness of subjects was 51.75 kg, 20.6 kg/m^2 and 12.8 mm, respectively. Mean nutrient intakes for energy, protein and fat were higher in day scholars (2591 K cal, 56.5 g and 23.0 g, respectively) than those residing in hostel (2284 Kcal, 52.4 g and 21.3 g, respectively). Similar trend was observed for micronutrients. The cardiovascular efficiency score was higher in day scholars (49.0) compared to hostellites (47.7). While there was no significant difference in the values for blood pressure (116/76 vs. 117/76 mm of Hg) and resting heart rate (65.7 vs. 65.9) in the two groups. The hemoglobin and blood glucose levels were higher in day scholars (11.5 g/dl and 116.9 mg/dl, respectively) than hostellites (11.2 g/dl and 112.8 mg/dl, respectively). The endurance of the day scholars was better than the hostellites as measured by treadmill test (14.38 vs. 13.39 min), ergometer test (18.55 vs. 18.20 min) and athletic event test (3.47 vs. 3.56 min).

Hence, anthropometric indices are good indicators of nutritional status of sports men. A well balanced nutrient dense diet helps an athlete to achieve a good physique in terms of height, weight, BMI, fat free mass etc. and also better performance in sports.

2.4 Dietary and nutrient intake of sports persons

Individual athletes differ in their nutritional requirements because of age, size, sex and nature of the sports activity. The first component to optimize training and performance through nutrition is to ensure that the athlete is consuming enough calories to offset energy expenditure. Energy needs of athletes are very high as they expend tremendous amount of energy. Energy yielding macronutrients are to be taken in right proportion to have good physique and better performance.

Micronutrients play important role in energy production, hemoglobin synthesis, and maintenance of bone health, adequate immune function and protection of body against oxidative damage. As the rates of the metabolic processes increase during physical activity, an adequate supply of micronutrients is needed to promote optimal performance.

Nutritional intake of 63 elite female athletes (16-24 yrs) was found by Goswami and Mathur (1999). The energy intake of subjects ranged from 3854 Kcal in sprinters to 4126 Kcal in throwers, but significant differences existed between groups. The protein intake ranged from 121.9 g in throwers to 156.1 g in sprinters.

Nutritional intake of 18 male and 12 female trained athletes (16-20 yrs) of Dharwad city was assessed by Kavitha *et al.* (2001). The nutrient intakes were less than the recommendations. The mean intake of energy, protein, fat and carbohydrate were higher in male athletes (2972 Kcal, 90 g, 125 g and 338 g) than female athletes (2371 Kcal, 67 g, 91 g and 320 g respectively). The micronutrient intake was significantly higher in male athletes when compared to female athletes. Riboflavin (50%), niacin (35%), retinol (40%), vitamin-C (28%) and iron (< 28%) intake was less when compared to intake of thiamine and calcium which was more than 60 per cent.

The nutritional status of national volleyball players (n=14) of Iran was assessed by Zareie (2003). The dietary intake of carbohydrate, protein and fat were 49, 10 and 41 per cent of total energy intake, respectively. The dietary intakes were less than the RDA for macro nutrients. The intakes of vitamins B_1, B_2, B_3 and C were more and vitamins B_6, B_{12} and E were less than RDA. Among minerals the intakes of magnesium and zinc were less while iron, sodium and potassium were more than RDA. Food frequency information showed that the consumption of vegetables and dairy products especially milk was low.

Hassapidou *et al.* (2003) studied the dietary intake of 15 Greek basket-ball players for each athletic season. Athlete's mean energy intake decreased from the transitional to the training season, and during competitive season most athletes were not in energy balance. Their mean protein intake varied from 11 per cent of energy intake during the transitional season to 16 per cent during the competitive season. Carbohydrate provided 41-53 per cent of energy intake where as fat intake ranged from 32-48 per cent, indicating a diet high in fat and low in carbohydrate compared to the recommendations. Dietary intakes varied among the athletes but in general they had an unbalanced nutrition.

Schroder *et al.* (2004) studied the dietary habits of 55 elite Spanish basket-ball players. Energy consumption among these athletes (17.7 MJ/day) was high in comparison to other elite team sport athletes. Further, the intakes of protein, fat, saturated fatty acids, mineral and most vitamins exceeded the RDA, whereas, intakes of carbohydrate and vitamin-E failed to meet the guidelines.

Kelkar *et al.* (2006) evaluated the dietary nutrient composition of 78 sportsmen (18-25yrs) belonging to varied sports discipline viz., runners (n=20), boxers (n=21), weight lifters (n=21) and wrestlers (n=15) in Pune. The runners, boxers and weight lifters obtained 55-60 per cent, 12-15 per cent and 20-30 per cent of calories from carbohydrate, protein and fat respectively. The proportion of nutrients was in accordance with the recommendations. While, the wrestlers obtained 34, 15.5 and 49 per cent of calories from carbohydrate, protein and fat, respectively which did not adhere to the recommendations.

Martin *et al.* (2006) studied the nutritional practices and activity patterns of elite female soccer players from England (n=16). Results indicated that energy intake was low (1904 Kcal) in relation to recommendations for soccer players. Energy expenditure (2154 Kcal) was not significantly different from intake, indicating achievement of energy balance. Carbohydrate (53.8 %), protein (16.8 %) and fat (28.8 %) intakes were in line with recommendations. With the exception of vitamin A and iron, all micronutrient intakes were higher than the RDA.

The nutrient intake of 32 basketball players from Dharwad city revealed that the mean per cent adequacy for nutrients was lower than the recommendations for all nutrients. More than 80 per cent adequacy was recorded for protein (86%), folic acid (96%), potassium (97%) and zinc (92%). The adequacy for iron (42%) was very low (Asha *et al*., 2009).

In many studies it was observed that, the macronutrient intakes of athletes were below the recommendation, which is one of the most hindering factor that may contribute to poor endurance capacity and poor sports performance. Hence, energy and macronutrient needs, especially carbohydrate and protein, must be met for optimal peak performance.

2.5 Endurance capacity of sports person

Endurance capacity is the time to exhaustion during exercise of constant intensity. It is ability against fatigue, and it enables the sportsmen to perform effectively without getting tired and to recover quickly. Nutritional intake and endurance capacity are very much dependent on each other because, for energy production in the exercising muscle, an individual needs both adequate amount of glycogen stores in the muscle, and continuous supply of oxygen in the body, for such mechanism, a sportsman needs to develop a sound aerobic capacity, which enables the body to maximize the oxygen uptake and helps in continuous supply of oxygen during energy production in exercising muscles.

2.5.1 Carbohydrate loading and endurance capacity

Carbohydrate loading is a strategy involving changes to training and nutrition that can maximize muscle glycogen stores prior to endurance competition. This is also known as glycogen loading, glycogen super compensation or carbohydrate super compensation. Carbohydrate loading can enhance endurance performance by allowing the sportsman to run at their optimal pace for a longer period.

The technique was originally developed in the late 1960's and typically involved a 'depletion phase' involving 3-4 days of hard training plus a low carbohydrate diet. This was then followed immediately by a 3-4 day 'loading phase' involving rest combined with a high carbohydrate diet.

The combination of the two phases was shown to boost muscle carbohydrate stores beyond their usual resting levels. A modified version of carbohydrate loading was developed when well trained runners were shown to super compensate their glycogen stores without the depletion phase. The modified protocol, consisting simply 3 days of high carbohydrate intake and exercise taper, offered a more practical competition preparation which avoided the fatigue and complexity of the extreme diet and training requirements of the previous depletion phase.

Karlsson and Saltin (1971) evaluated the influence of carbohydrate rich diet and normal diet prior to 30km race in ten athletes. The best performance (shortest work time) was attained in all subjects when they had carbohydrate rich diet. It was also observed that the mean muscle glycogen content in the quadricep muscle was higher after carbohydrate rich diet (35 g/kg wet muscle) than normal diet (17 g/kg wet muscle).

A carbohydrate loading programme was tested by Hodgdon *et al.* (1980) to see whether it increases performance in nine naval warfare personnel. Each participant was given two treatments, a six day carbohydrate loading programme and six day non-loading programme. Each participant served as his own control. Endurance performance was determined on 7^{th} day with the participant running on motorized treadmill. The mean running time was greater by 10.8 min following loading programme vs. the non loading programme. There was significant increase (9%) in running time.

The effect of a high carbohydrate diet on running performance during a 30 km time trial was studied by Williams *et al.* (1991). Eighteen (12 men and 6 women) runners completed a 30 km time trial without modifying their food intake (Trial 1). The subjects were randomly assigned to a control or a carbohydrate group. The carbohydrate group supplemented their normal diets with additional carbohydrate in the form of confectionery products during the seven days before Trial 2. The control group matched the increased energy intake of the carbohydrate group by consuming additional fat and protein. Although there was no overall difference between the performance times for the two groups during Trial 2, the carbohydrate group ran faster during the last 5 km of Trial 2 than during Trial 1 (3.64 m/s vs. 3.44 m/s). The six men in the carbohydrate group ran the 30 km faster after carbohydrate loading (131.0 min vs. 127.4 min) whereas there was no such improvement in times of the men in control group. The results confirmed that dietary carbohydrate loading improves endurance performance during prolonged running and that confectionery can be used as an effective means of supplementing the normal carbohydrate intake in preparation for endurance races.

An investigation to examine the effects of high carbohydrate in comparison with high fat diet, on endurance performance was conducted by Starling *et al.* (1997). Seven endurance trained men completed a 120 min cycling bout. Each subject then ingested an isocaloric high carbohydrate or a high fat diet for the next 12hr. After a 12hr overnight fast, a 1600 KJ self paced cycling bout was completed. After 24hr dietary fasting period muscle glycogen concentration was significantly higher for the high carbohydrate (549 m mol/kg dry weight) compared with the high fat (327 m mol/kg dry weight) trial. While the muscle triglyceride was significantly lower for the high carbohydrate (27.5 m mol/kg dry weight) vs. high fat (44.7 m mol/kg dry weight) trial. Furthermore, self paced cycling time was significantly better for the high carbohydrate (117.1 min) compared with the high fat (139.3 min). The authors concluded that a high carbohydrate diet did not increase muscle triglyceride concentration but did increase muscle glycogen storage and improve cycling performance compared with high fat diet.

Sullo *et al.* (1998) studied the influence of high carbohydrate diet and level of aerobic capacity on running performance during a 25 km treadmill time trial. The twenty four male subjects were divided into four groups based on training and diet composition *viz.*, trained athletes with carbohydrate loading (CHO_1); trained athletes without carbohydrate loading (C_1); untrained athletes with carbohydrate loading (CHO_2) and untrained athletes without carbohydrate loading (C_2). The carbohydrate loading was affected with confectionery. The result showed that the athletes with lower aerobic capacity had better performance time after carbohydrate loading and had a higher glucose and lactate concentrations in the last 5 km. The authors concluded that dietary carbohydrate loading can improve running performance and that confectionery can be used as an effective means of supplementing the normal carbohydrate intake in preparation for endurance competitions.

Kavitha and Yenagi (2006) tested the suitability of dicoccum wheat pasta as carbohydrate loading for long distance runners (n=10). Endurance capacity of five subjects each was tested by running on track and by cycling in the laboratory. The subjects performed three trials separated by one week. Two hundred grams of test foods namely durum and dicoccum wheat pasta was given along with their routine diet for consecutive days before the endurance test. The mean running time to exhaustion in durum (112.2 min) and dicoccum (119.0 min) wheat trials was significantly higher than control (81.4 min). But no significant difference between two test foods was observed. Similar results were recorded for mean cycling time to exhaustion, distance covered in running and cycling. The authors recommend that dicoccum wheat can be an energy food for athletes.

Meti and Saraswati (2006 and 2007) studied the impact of carbohydrate loading on performance of high school football (n=30) and *kabaddi* (n=30) players of Dharwad city. Each group of players were divided into two sub groups of 15 each *viz*., control and experimental. The experimental group received carbohydrate supplementation in form of laddu prepared using maida, grain amaranthus, garden cress seed, groundnut, jaggery and oil. The additional supplementation of carbohydrate in the form of two laddus (72 g carbohydrate and 412 K cal energy) per day for three consecutive days before the match was given. The endurance performance of experimental groups were significantly higher (279 m in football players and 432m in *kabaddi* players) compared to the control group.

Thus the endurance capacity and performance can be effectively improved by carbohydrate loading protocol.

2.5.2 Pre-event meal and endurance capacity

Foods and fluids consumed in the hours prior to competition complete an athlete's nutritional preparation. The pre-event meal adds to muscle glycogen stores if they have not been fully restored since the last exercise session. It also restores liver glycogen for early morning events, ensures the athlete is hydrated and prevents hunger. Food choice also impacts on gastrointestinal comfort and the athlete's psychological outlook. Individual tolerance and competition schedule dictate the ideal timing for the pre-event meal. General guidelines suggest a meal or series of snacks should be consumed 1–4 hours prior to exercise. Liquid meal supplements or carbohydrate containing sports bars can be useful for athletes who suffer from pre-event nerves or have an unpredictable pre-event time table.

Sherman *et al.* (1991) determined the effect of consuming two different amounts of liquid carbohydrate 1hr before exercise on the metabolic responses during exercise and on exercise performance. Subjects consumed either 1.1g (low CHO) or 2.2 g (high CHO) per kg body weight or placebo (P). Subjects cycled for 90 minutes, and underwent performance trial. Blood glucose and insulin responses during exercise were different among the 3 trials. Exercise performance was improved 12.5 per cent when cyclists consumed low carbohydrate compared with P. The performance neither further improved nor impaired when carbohydrate feeding was increased (high CHO).

Chryssanthopoulos (1994) examined the influence of pre-exercise ingestion of a concentrated glucose solution on endurance running capacity. Nine recreational runners (five men and four women) ran to exhaustion on a treadmill, on two occasions. The runners ingested either a solution containing 75 g of glucose in 300 ml of water (G trial), or 300 ml of placebo (P trial) 30 min before each trial. As a consequence, the blood glucose concentrations were 55 per cent higher at the beginning of the G trial compared with those recorded for the P trial. Nevertheless, there were no differences in the running times to exhaustion between the two trials (G trial, 133.79 min vs. P trial, 121.16 min). The results of this study showed that ingesting concentrated glucose (25%) solution 30 min before exercise does not reduce the endurance capacity.

Anderson and co-workers (1994) determined the impact of consumption of oat meal (GI=77), one hour prior to exercise, on endurance capacity in nine male cyclists in comparison with glucose (GI=100) and placebo. Endurance time in oat meal trial (84 min) was significantly longer than the placebo (66 min) trial. The glucose trial was not significantly different from either oat meal or placebo trials.

El-Sayed *et al.* (1997) examined the effect of carbohydrate ingestion on endurance performance during 1hr cycling time trial. Eight male cyclists performed 1hr rides and were fed either carbohydrate (8%) or placebo solution. The beverages were administered 25min before and after the end of the ride. Mean power output was significantly greater during carbohydrate compare to placebo trial (277 and 269 W, respectively). The greater distance covered in the carbohydrate compared with a placebo trial (41.5 and 41.0 km, respectively) was equivalent to 44 second improvement.

Sparks *et al*., 1998 examined the effect of glycemic index of pre-exercise carbohydrate ingestion on exercise metabolism and performance. Eight endurance trained men ingested a high glycemic index (HGI), low glycemic index (LGI), or a placebo (CON) meal, 45 min before exercise and then cycled for 50 min. Subjects subsequently performed 15-min self-paced performance ride, in which total work was recorded. Plasma free fatty acid concentrations were lower following ingestion in HGI and LGI compared with CON and higher in LGI compared with HGI at the start and end of exercise. Carbohydrate oxidation was higher in HGI compared with LGI and CON during exercise. There were no differences in work output during the performance cycle.

Kirwan *et al* (1998) determined whether presweetened breakfast cereal with varying fibre contents and a moderate GI improve endurance. Six recreationally active women consumed 75g carbohydrate in the form of breakfast cereals: sweetened whole grain rolled oats (SRO, 7g dietary fibre) or sweetened whole oat flour (SOF, 3g dietary fibre) and 300ml of water or water alone (control). The meals were provided 45 min before cycle ergometer exercise to exhaustion. Exercise time to exhaustion was 16 per cent longer during SRO than control trial (266.5 and 225.1min, respectively). There was no difference in exercise time for the SOF (250.8 min) and control trials. It was concluded that eating a meal with moderate GI 45min before prolonged moderately intense exercise significantly enhances exercise capacity.

Devi *et al*., (1999) evaluated the impact of pre-game chocolate bar on the performance of 25 athletes from Coimbatore. Their physical work capacity and biochemical parameters before and 3-4 hours after the consumption of pre-game meal were evaluated. After the administration of pre game meal, the blood glucose and lactate levels decreased and hence increased the physical performance.

Smith *et al.* 2002, determined the effect of pre-exercise glucose ingestion on distance swimming performance. Additionally, pre-exercise glucose was provided at two different feeding intervals to investigate the affects of the timing of administration. Ten male triathletes swam 4000 m on three occasions following the consumption of either 10 per cent glucose solution five min prior to exercise (G5), 35 min prior to exercise (G35), or a similar volume of placebo (PL). Despite a significant difference in blood glucose concentration prior to exercise (G35 8.4 vs. G5 5.2 and PL 5.3 mmol/l), no significant differences were observed in total time (G35 70.7, G5 70.1and PL 71.9 min), post-exercise blood glucose, and average heart rate. Glucose feedings did result in improved individual performance times, ranging from 24 seconds to five min in eight of the 10 subjects compared to the placebo.

Male volleyball players (n=16) residing in Hyderabad were selected for the study (Kanabur and Devi, 2005). Subjects were given 250ml of test drinks (mango, honey, lime, carbonated beverage and placebo) with 6 per cent carbohydrate and were asked to run as fast as they could. After 20 min of run, 250ml of the same drink was given and the subjects were asked to complete the remaining distance (total distance of 6.8km). Each drink was tested for a period of one week on alternate days. Mango drink resulted in significant improvement compared with placebo, where as there was no significant improvement in case of other drinks.

Tokmakidis and Karamanolis, (2008) examined the effects of pre-exercise carbohydrate ingestion on exercise metabolism and endurance running capacity. Eleven active subjects performed two exercise trials 15 min after ingesting glucose (1 g / kg body mass) and placebo. Time to exhaustion was 12.8 per cent longer in glucose than in placebo. These results suggest that glucose ingestion 15 min before prolonged exercise provides an additional carbohydrate source to the exercising muscle, thus improving endurance running capacity.

The effect of pre-exercise low and high glycemic index (GI) carbohydrate meals on running performance was examined by Wong *et al.* (2008). Eight endurance trained male runners completed two trials preceded by consumption of meal containing either low (GI=37) or high (GI=77) GI carbohydrate foods (2.4MJ; 65% carbohydrate, 15% protein and 20% fat) that provided 1.5g CHO/kg body weight. After 2hr of ingestion of meal, the subjects completed 21 km performance run on treadmill. All participants achieved a faster performance time after low GI meal (low vs. high GI: 98.7 vs. 101.5min; $p<0.01$). Compared with the high GI trial, carbohydrate oxidation was lower and fat oxidation was higher during exercise in low GI trial. The results indicated that compared with an isocaloric high GI meal, low GI meal 2 hr before a 21km performance run was more effective means of improving performance time.

Rollo and Williams, 2009, investigated the influence of ingesting a carbohydrate -electrolyte solution (CHO-E) on performance during 1hr treadmill run. Eight male endurance trained runners completed three 1hr performance runs separated by one week. On two occasions (P1, P2) runners consumed a placebo solution, 30 min before and at 15-min intervals throughout the 1hr run. On a separate occasion they consumed the same quantity of a CHO-E solution (C). The mean distances covered for P1, P2, and C trials were 13,685 m, 13,715 m, and 14,046 m, respectively. Although there was no difference between the two PLA trials, the distance covered during the C trial was significantly greater than in either PLA trial. Ingestion of a 6.4 per cent CHO-E solution before and during exercise was associated with improved running performance in runners compared with the ingestion of a placebo.

Studies have revealed that consumption of pre-event meal significantly improved the endurance performance. In general, studies have failed to show a universal benefit to performance from consuming low-GI foods prior to exercise.

2.5.3 Nutrition supplementation during event

Endogeneous stores of carbohydrate will eventually become depleted during exerecise. Consuming carbohydrate during exercise maintains blood glucose levels and high rate of carbohydrate oxidation, thus improves endurance capacity. Frequent ingestion of glucose, or preferably a glucose polymer, during the event is a necessity. But the amount and frequency need to be considered as adequate water ingestion is the top priority in endurance events. Concentration of 4-8 per cent carbohydrate with additional electrolytes has been proved to be beneficial. Carbohydrate intake of 0.5-1.0g/kg body weight/ hour is recommended for better performance.

An investigation on effects of a carbohydrate -electrolyte drink on specific soccer tests and performance was carried out by Ostojic and Mazic (2002). The professional male soccer players were allocated to two assigned trials ingesting CHO-E drink or placebo during 90 min on field soccer match. Blood glucose concentration was higher at the end of the match in the CHO-E trial than in the placebo trial. Subjects in the CHO-E trial performed dribble test (12.9 s) and precision test (17.2) better than the placebo trial (13.6 s and 15.1s), suggesting CHO-E consumption throughout a soccer match would prevent deterioration in specific skill performance.

The supplementary effect of CHO-E drink on performance and cardiovascular status of the Indian national level male athletes (n=10) during exercise and recovery were investigated by Khanna and Manna (2005). In phase I no supplementation was given. While in phase II, a CHO-E drink during exercise and recovery were given orally. Significant improvements were noted in total endurance time (94.1 vs. 62.3 min) and heart rate responses during supplementation trial. The cardiovascular responses were significantly better during recovery following supplementation as evident from decreased heart rates.

Phillips *et al.*, 2010 investigated the influence of consuming a CHO-E drink on intermittent, high-intensity endurance performance of adolescent team game players. Fifteen subjects performed two trials. In each trial, they completed 60 min of exercise (part A) of intermittent shuttle test, followed by run to exhaustion (part B) they consumed either CHO-E or placebo during part A. time to exhaustion was increased by 24 per cent during part B when compared with placebo (5.1 vs. 4.1 min). No significant between trials differences were observed for sprint time.

Ghosh *et al* (2010) investigated whether a combination of sago and soy protein ingestion during cycling can improve subsequent endurance capacity compared with sago and with placebo. Eight male recreational cyclists rode cycle ergometer for 60 min at 60per cent VO_2max followed by a time-to-exhaustion ride at 90 per cent VO_2max. Sago feeding provided 60g carbohydrate, and sago-soy combination provided 52.5g carbohydrate and 15 g of protein, both at 20 min intervals during exercise. Sago-soy supplementation (7.53 min) increased endurance by 84 per cent and 37 per cent relative to placebo (4.09 min) and sago (5.49 min), respectively. The study demonstrated that a combination of sago and soy protein can delay fatigue during high intensity cycling.

2.5.4 Protein and endurance capacity

Sports supplements with carbohydrate and protein are suggested to improve exercise duration by increasing the rate of glucose oxidation and muscle glycogen resynthesis during exercise and also during recovery.

Saundrers *et al*. (2004) studied the effects of a carbohydrate-protein (CHO+P) beverage on cycling endurance and muscle damage. Fifteen male cyclists rode a cycle ergo meter to exhaustion, followed 12-15 hour later by a second ride to exhaustion. Subjects consumed 1.8 ml/ kg body weight of randomly assigned carbohydrate or CHO+P beverage every 15 min of exercise and 10 ml / kg body weight immediately after exercise. In the first ride, subjects rode 29 per cent longer when consuming the CHO + P beverage (106.3 min) than the carbohydrate beverage (82.3 min). In the second ride, subjects performed 40 per cent longer when consuming the CHO + P beverage (43.6 min) than the carbohydrate beverage (31.2 min). A carbohydrate beverage with additional protein calories produced significant improvements in time to fatigue and reductions in muscle damage in endurance athletes.

Koopman *et al.* (2004) found that supplementation of carbohydrate and protein during exercise has been found to decrease the endogenous protein oxidation and increase the rate of protein balance. Increased availability of amino acid will also help by limiting the breakdown of muscle protein during prolonged exercise, there by attenuating muscle damage.

Berardi *et al.* (2008) assessed whether a liquid carbohydrate- protein (C+P) supplement (0. 8g/kg carbohydrate + 0.4 g/kg protein) ingested early during recovery from a cycling time trial could enhance a subsequent 60 min effort on the same day vs. an isoenergitic liquid carbohydrate supplement (1.2 g/kg), two hours after standardized breakfast, 15 male cyclists compared a time trial in which they cycled as far as they could in 60 min (AM_{ex}). Then subjects ingested either C+P or carbohydrate at 10, 60 and 120min, followed by a standardized meal at 4 h post exercise. At 6 h post AM_{ex} subjects repeated the time trial (PM_{ex}). There was a significant reduction in performance for both groups in PM_{ex} vs. Am_{ex}. However, performance and power decreases between PM_{ex} and AM_{ex} were significantly greater with carbohydrate (-1.05 km and -16.5 W) vs. C+P (-0.3 km and -3.86 W). The results indicated that C+P ingestion increases recovery and improves subsequent same day, 60min efforts relative to isoenergetic carbohydrate ingestion.

The effects of ingesting cereal and non fat milk (cereal) and a CHO-electrolyte sport drink (drink) immediately following endurance exercise on muscle glycogen synthesis was studied in 12 trained cyclists. After 2hr of cycling, a biopsy from the *vastus lateralis* was obtained (post0), and then subjects consumed either Cereal (77g carbohydrate, 19.5 g protein and 2.7g fat) or Drink (78.5 g carbohydrate). A second biopsy was taken 60 min after supplementation (Post60). Significant Post0 and Post60 changes occurred in glycogen for each treatment, but only cereal significantly affected glycogen synthase. These results by Kammer *et al* (2009) suggest that cereal with non fat milk is as good as commercially available sports drink in initiating post-exercise muscle recovery.

The addition of protein to a carbohydrate supplement can further prolong sub-maxial exercise duration. Hence, it can be inferred by above studies that both carbohydrate and protein play an important role in achieving the peak performance in sports persons.

2.6 Long term supplementation and physical performance of sports persons

It is essential for an athlete to have his or her body working at peak efficiency. Nutrition is an integrated part of an athlete's regimen. Maintaining an energy deficient diet often leads to significant weight loss (including muscle mass), illness, onset of physical and psychological symptoms of overtraining and reductions in performance.

The impact of dietary modification on athletic performance of 30 male athletes of Coimbatore was studied by Chandrasekhar *et al.* (1988). The diet was supplemented with 100 g of a legume such as bengal gram, green gram or cow pea and 80 g of groundnut along with the routine diet every day for three months. The physical performance was assessed by Harvard step test and bicycle ergometer, before and after the supplementation. Results revealed that although there was no significant increase in weight (55.72 to 56.12 kg), skin fold thickness (11.13 to 11.17 mm), heart rate (67.23 to 65.53 beats/min) and blood pressure (113/77 to 111/66 mm Hg); there was a significant improvement in hemoglobin level (13.34 to 13.66 g/dl) of the subjects after supplementation. The cardiovascular efficiency scores registered a significant increase (74.35 to 80.75) indicating positive impact of supplementation. A positive correlation was obtained with hemoglobin level and physical work capacity.

Dragan *et al* (1988) reported the effects of protein supply (Refit milk powder containing 90 per cent protein and 5 per cent mineral salts) and l-carnitine tablets in a group of junior elite cyclists (n=7). The subjects received 1 g protein / kg as supplement of food for six weeks and 2 g/d l-carnitine, 10 days before an important competition. The control subjects (n=7) received the same regimen placebo. Significant and favourable changes were recorded in the treated group for the strength index, lean body mass, fat mass, work performance on ergometer, serum proteins, serum hemoglobin and serum calcium, changes which did not appear in the control group. The treated group obtained higher performances in the international competition which took place at the end of the experiment. The authors recommended a supply of protein up to 3.2 g/kg d, six weeks before competition and 2 g l-carnitine daily, 10 days before competition, for cyclists, in order to improve the biological potential of the body.

Chandrasekhar and Priya (1989) assessed the impact of dietary modification on athletic performance of 30 male athletes of Coimbatore was assessed. The subjects belonged to power event of middle category and were either runners, throwers, jumpers, sprinters and weight lifters. Fifty gram soybean and 120 g groundnuts were given as snack items in the existing diets of the subjects over a period of three months. There was a significant improvement in skin fold thickness (10.43 to 10.70 mm), vital capacity (2700 to 2923 ml), heart rate (72.70 to 71.33 beats/ min) and hemoglobin level (13.00 to 13.68 g/dl) of subjects after the supplementation. Non-significant changes in weight, blood glucose, serum cholesterol and blood pressure were also noted. The cardiac efficiency score increased from 98.01 to 102.35, improvement being non-significant.

The impact of dietary modification on the performance of adolescent boys (n=80) performing middle category power events from YMCA sports school, Madras was reported by Chandrasekhar and Jacob (1992). The dietary modification consisted of addition of 100 g of bengal gram/ green gram/ cowpea in the form of *sundal*; 50 g of roasted groundnuts and reduction of 150 g rice from the diet. The modified diet ensured caloric adequacy and was given over a period of three months. The diet modification significantly improved heart rate (64.68 to 63.68 beats/min), blood pressure (108/79 to 107/78 mm Hg), hemoglobin (11.29 to 11.40 g/dl), cardiovascular efficiency scores (66.04 to 67.45) and endurance capacity (556 to 597 sec.) of the subjects. No significant differences in weight and skin fold thickness of subjects were recorded after supplementation.

The efficacy of Supro isolated soy protein in Olympic athletes was evaluated by Dragan *et al.* (1992). Sixty six Romanian Olympic endurance athletes (30 kayak-canoe, 36 rowing; 45 males and 21 females) were dived into two groups: A group (n=38) receiving 1.5g/kg/day supro soy protein for eight weeks and B group (n=28) receiving no supplement.

Supplementation induced increase in body mass (~3kg), strength index, serum proteins, hemoglobin and total calcium and significant decrease in fatigue after training sessions, especially when comparing to the athletes of the B group. No side effects were noticed and the product was well tolerated by the athletes. Thus authors supported the idea of a beneficial effect of supro soy protein supply on the biological preparation of endurance top athletes.

Ramaswamy and Sampath Kumar (1999) tested the effect of health drinks on the nutritional status and performance of body builders (n=30) of Coimbatore. Two health drinks; based on soybean (Drink 1) and cowpea (Drink 2) were formulated and supplemented to ten subjects each for 60 days. The remaining 10 subjects did not receive any supplement (control). The control group subjects showed a reduction in weight (1.45 kg) while the subjects consuming drink 1 and 2 showed an increase of 1.5 and 1.0 kg respectively. The mean chest arm circumference, shoulder width and mid arm circumference showed an increase after supplementation in both the experimental groups. The serum total proteins of supplemented groups registered a significant increase of 0.16 g (Drink 1) and 0.60 g (Drink 2). The mean blood hemoglobin level of subjects increased, non-significantly in drink 1 (14.45 to 15.06 g/dl) and significantly in drink 2 (13.88 to 14.48 g/dl). The results of bench press test showed significant increase from 72.5 to 82 kg and 83.5 to 96.0 kg for drink 1 and 2 group, respectively. Similar improvements were also recorded for squat test and biceps curl test.

A study by Stroescu *et al.* (2001) evaluated the effect of supplementation of SUPRO brand isolated soy protein on body composition of elite female gymnasts (n=14) of Romanian Olympic team. Subjects undergoing strenuous training for four months were divided into two groups: group A (n=7) with daily supplementation with soy protein at a level of 1 g/kg body weight and group B (n=7) with placebo supplementation. Results showed that the group A had an increase in lean body mass after supplementation with sports beverage protein mix with SUPRO isolated soy protein. It was also reported that supplementation lowered the metabolic-hormonal stress in subjects undergoing strenuous training.

The efficacy of whey and casein supplements on nutritional status and muscle strength in sportsman from Coimbatore was studied by Uthira and Srimati (2005). Supplements using malted cereals, sugar and flavouring with either casein or whey were developed. They were given daily for three months to experimental A (casein based) and B groups (whey based). The muscle strength, vital capacity and endurance level as measured by 50 yard dash, pull up, knee bent up and 600 yard dash tests was significantly better in experimental groups compared to control groups. Further, the effect was pronounced more in subjects receiving whey protein supplements. The study established that supplementation made a positive impact on endurance and proved that whey protein was superior over casein.

Thomas and Chandrasekhar (2005) investigated the impact of iron rich food supplement on performance of sports students. The mild anemic female sports students (n=100) of Kannur, Kerala were selected for the study. Fifty subjects were supplemented for a period of six months with iron rich food formulation. Cardiac efficiency score showed significant improvement from 68.02 to 81.75 after supplementation. Similar improvements in treadmill test (30.58 to 33.34 min.) and vital capacity (2685 to 3030 ml) in the supplemented group was observed.

Sri and Bobby (2005) assessed the supplementary effect of fortified sweet lime squash on the physical endurance of athletes. Athletes from Coimbatore were divided into control (n=10) and experimental (n=10) groups. Vitamin C fortified sweet lime squash, supplying 225 mg vitamin C per day, was supplemented to the experimental group for 60 days. The results of Barach energy index (167 to 160), Crampton blood ptosis (66.0 to 83.0), Harvard step test (70.0 to 88.0) and running time (40.1 to 33.79 sec.) improved significantly following supplementation. Similarly a reduction in heart rate of athletes operating on cycle ergometer was observed upon supplementation. Strength tests in terms of push-ups (15.0 to 18.3) and pull-ups (10.60 to 14.10) also indicated positive impact of supplementation.

Keong *et al.* (2006) evaluated the effects of tocotrienol-rich palm vitamin E supplementation on exercise induced lipid peroxidation and endurance performance. Male recreational athletes(n=18) completed two endurance running trials, until exhaustion, on a motorized treadmill on two separate occasions following 6 week supplementation regimen of either palm vitamin E (E) or placebo (P).

After supplementation serum alpha tocopherol increased by 33 per cent but serum concentrations of tocotrienols were negligible. Although tocotrienol rich palm vitamin E supplementation decreased lipid peroxidation at rest and to some extent, during exercise, as evident from lower malondialdehyde levels, it however did not enhance endurance capacity or prevent exercise induced muscle damage.

The impact of nutrition education and carbohydrate supplementation of performance of high school football and *kabaddi* players was assessed by Meti and Saraswati (2006 and 2007). The subjects were divided into two groups as control (n=15 for football players and n=12 for *kabaddi* players) and experimental group (equal numbers as control group). Experimental groups received nutrition education for 12 contact hours and later they were supplemented with carbohydrate rich snack (carbohydrate 72 g) three days before the final match. Further, the experimental groups received a CHO-E beverage before, during and after the competition. Real matches were organized between control and experimental groups. The findings of nutrition education revealed that overall nutrition knowledge level increased significantly by 35-45 per cent whereas practice was improved only by 13 per cent. The physical performance results revealed significant improvements in selected fitness tests like strength (9 and 12 cm in football and *kabaddi* players, respectively), agility (1.3 sec. in football and 1.5 sec in *kabaddi* players) and endurance (279 and 432 m in football and *kabaddi* players, respectively) at the end of intervention. There were significant improvements in the game performances as evaluated by coaches in experimental groups (8.3 vs 5.0 in football players and 7.6 vs 4.2 in *kabaddi* players).

Smith *et al.* (2007) evaluated whether colostrums (Col) or an isocaloric and isonitrogenous blend of whey and casein in addition to creatine (Cr) effects body composition, muscular strength, endurance and anaerobic performance during resistance training. Forty nine resistance trained subjects supplemented their diet with a protein control (Pro), Pro/Col, Pro/Cr or Col/cr. Supplements provided 60 g/d of casein/whey (Pro) or Col as the protein source. Resistance training increased strength, muscular endurance and anaerobic sprint capacity equally in all groups. Significant effects were found for body mass and fat free mass, where as no changes were noted for fat mass, per cent fat or bone content. Further, compared with Pro, subjects ingesting Pro/Col, Pro/Cr and Col/Cr showed greater gains in body mass. Subjects ingesting Pro/Cr and Col/Cr had greater increase in fat free mass during training in comparison with Pro/Col.

Asha (2008) studied the effect of supplementation of sorghum based sports food on nutritional status and endurance capacity of basketball players (16 each in control and experimental groups) in Dharwad city. Supplementation of 50g sports food for 30 days resulted in a significant improvement in anthropometric measurements, haemoglobin (13.00 to 14.59 g/dl) and endurance capacity (13.33 to 18.29 min) of the experimental group subjects.

The impact of *spirulina* and the commercial antioxidant supplement on cardiopulmonary fitness of athletes from Tirupati was assessed by Kalpana (2009). Ninety male athletes (16-19 years) were recruited as subjects for the study. Among them, 45 subjects in the cycling and running athletic category were assigned to aerobic exercise group (AEG) and 45 hockey players to the mixed exercise group (MEG). They were further classified as control, experimental I and experimental II with 15 subjects in each group. Three g/day of spirulina and 1 capsule/ day of commercially available antioxidant supplement was given to experimental group I and group II, respectively for 60 days. The impact of supplementation on the biochemical profiles of both exercise groups (AEG and MEG) was evident through the increase in the levels of serum tocopherol, ascorbic acid and beta carotene and decrease in the level of malondialdehyde were observed for both supplements. The results of cardio pulmonary exercise test revealed significant improvements in the AEG and MEG after supplementation.

A study on impact of diet modification on the sports performance of female adolescent athletes was conducted in Coimbatore by Sugasri and Premakumari (2010). Thirty four athletes represented the control group who consumed their home diet and the remaining 61 athletes consuming hostel diet represented experimental group. The dietary assessment of experimental group revealed that intake of all nutrients except fat was less than the RDA.

The modified menu consisting of health laddu (50 g - consisted of rice, wheat, Bengal gram and bajra, roasted and ground in equal quantities and made into laddus with jaggery syrup), corn/ sweet potato/ tapioca (50g), soya *sundal*/soya chunks curry (75 g), Rice flakes (35 g) and jaggery (15 g), Amaranth / fenugreek / drumstick leaves curry (100 g) and dates (25 g) was provided to the subjects during different meals in a day for 90 days along with their regular quantity of meals. After intervention, the intake of calories increased from 2284 to 2907 k cal and protein intake increased from 52.4 to 73.2 g. A positive impact on the anthropometric parameters was observed in experimental group after the modification. A positive impact on hemoglobin (11.2 to 12.0 g/dl), cardiac efficiency score (47.7 to 50.5), endurance test on treadmill (13.39 to 14.33 minutes) and bicycle ergometer (18.20 to 18.45 minutes) were also recorded after dietary modification.

Twenty-four recreational athletes were assigned to either the active supplement (GT, n=13) or placebo (PL, n=11) group. The active supplement (GT) was 18g of powder, 40 Kcals, and consisted of a proprietary blend including whey protein, *cordyceps sinensis*, creatine, citrulline, ginseng, and caffeine. The PL was also 18g of powder, 40 Kcals, and consisted of only maltodextrin, natural and artificial flavors and colors. Thirty minutes prior to all testing and training sessions, participants consumed their respective supplements mixed with 8-10 oz of water. Both groups participated in a three-week high intensity intermittent training (HIIT) program three days per week, and testing was conducted before and after the training. Four high-speed runs to exhaustion were conducted at 110, 105, 100, and 90 per cent of VO_2max, and the distances achieved were noted. Critical velocity increased for the GT group (2.9%), while the PL group did not change. Training volume was 11.6 per cent higher for the GT versus PL group ($p=0.041$). Body fat decreased from 19.3 per cent to 16.1 per cent for the GT group and decreased from 18.0 per cent to 16.8 per cent in the PL group ($p=0.178$). LBM increased from 54.2 kg to 55.4 kg ($p=0.035$) for the GT group and decreased from 52.9 kg to 52.4 kg in the PL group ($p=0.694$). The results demonstrated improvements in VO_2max, critical velocity, and LBM when GT is combined with HIIT. Three weeks of HIIT alone also augmented anaerobic running performance, VO_2max and body composition (Smith *et al.* 2010).

An investigation to study the impact of selenium enriched eggs on oxidative stress in sports women was undertaken by Maheshwari *et al.* (2010). Forty two women sports students (21-24 years) trained in various sports events were selected for the study conducted in Coimbatore. The subjects were divided into 3 groups of 14 each *viz*., control, experimental I and experimental II. The participants of experimental I and II groups were given two normal and selenium enriched boiled eggs, respectively for a period of 45 days. The levels of hemoglobin increased significantly in experimental groups I (11.25 to 12.68 g/dl) and II (11.29 to 12.59 g/dl). The levels of hemoglobin and serum protein increased significantly in experimental group I (11.25 to 12.68 g/dl and 7.24 to 7.62 g/dl, respectively) and II (11.29 to 12.59 g/dl and 7.22 to 7.63 g/dl, respectively). Significant improvements in antioxidants levels *viz*., glutathione peroxidase (48.48 to 51.64 U/g Hb), erythrocyte glutathione (31.30 to 34.29 mg/dl) and malondialdehyde (0.12 to 0.10 n moles/dl) were recorded in experimental group II compared to control and experimental group I. The supplementation significantly improved the physical fitness of the subjects compared to control group, the improvement being better in experimental group II than group I.

Consumption of nutrient dense supplements help in maintaining optimum energy intake level in athletes. Thus the literature reveals that the supplementation helps in improving the physical fitness and performance of the athletes to a great extent.

3. MATERIAL AND METHODS

The present investigation was carried out during 2009-2011 to study the physico-chemical and functional properties of little millet genotypes, formulation of little millet based sports food, evaluating its efficacy in sports persons and testing its market viability. The material used and methodology employed in carrying out the study are described in this chapter.

3.1 Physico-chemical and functional properties of little millet genotypes

3.1.1 Selection of little millet genotypes

Local genotype and improved variety *Sukshema* were selected for the study. The local genotype was collected from farmers field in Narendra village, Dharwad district. *Sukshema* genotype was procured from Agricultural Research Station, Hanumanamatti, Haveri district. They were grown during the year 2008-09. Dehulling of the samples was carried out in a commercial mill designed for dehulling of the millets at Haveri, a millet growing area. The dehulled grains were cleaned in one lot and used for the study. All the estimations were carried out in triplicates.

3.1.2 Physical characteristics of little millet genotypes

The various physical characteristics studied were size, shape, colour, thousand grain weight, thousand grain volume, bulk density, hydration capacity, hydration index, swelling capacity, swelling index and grain to flour ratio, using standardized methods. The methods are outlined below.

3.1.2.1 Size

The length, width and thickness of the grains were measured using vernier calipers. The values were expressed as means of 10 randomly selected grains.

3.1.2.2 Shape

The shape of the grain was recorded as spherical if the length: width ratio was close to 1.0 and as oval if the length: width ratio was 1.25 or higher (Khader, 2001).

3.1.2.3 Colour

Chromatic components, L (lightness), a (redness) and b (yellowness) values of sample were measured using spectrophotometer (CM-260d/2500d model of Konica Minolta).

3.1.2.4 Thousand grain weight

One thousand grains from each genotype were randomly selected and weight was recorded in grams using electronic balance.

3.1.2.5 Thousand grain volume

The volume of the thousand grains selected for weight determination was recorded in milliliter by water displacement method.

3.1.2.6 Bulk density

The bulk density was calculated using the formula.

$$\text{Bulk density (g/ml)} = \frac{\text{Weight of 1000 grains}}{\text{Volume of 1000 grains}}$$

3.1.2.7 Hydration capacity

The 1000 grains were soaked in distilled water for 12 hours. The water was drained. The adhering water to the grains was removed by gently pressing with blotting paper. The increase in weight before and after soaking was noted.

Hydration capacity = (g/ 1000 grains) Weight of grain after soaking – weight of grain before soaking

3.1.2.8 Hydration index

$$\text{Hydration index} = \frac{\text{Hydration capacity}}{\text{Weight of 1000 grains}} \times 100$$

3.1.2.9 Swelling capacity

The increase in volume of 1000 grains before and after soaking is called swelling capacity.

Swelling capacity = (ml/1000 grains) Volume of grains after soaking – Volume of grain before soaking

3.1.2.10 Swelling index

$$\text{Swelling index} = \frac{\text{Swelling capacity}}{\text{Volume of 1000 grains}}$$

3.1.3 Chemical composition

The dehulled intact grains were milled into a fine powder in a laboratory model willy mill and were stored under refrigerated condition for further chemical analysis.

3.1.3.1 Proximate principles

3.1.3.1.1 Moisture

Five gram of sample was taken in previously weighed moisture boxes and oven dried at 110°C until constant weight was attained (Anon., 1990).

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

3.1.3.1.2 Protein

The nitrogen content of moisture free samples was estimated by kjel plus method (Anon., 1990). Crude protein of millets was calculated by multiplying total nitrogen by the factor 5.83 (Swaminathan, 1985).

3.1.3.1.3 Fat

Crude fat was extracted in moisture free samples by refluxing with petroleum ether (boiling point: 60-80º C) in Socs plus apparatus.

3.1.3.1.4 Crude fibre

Fat free sample was hydrolysed with acid and alkali and dried in a crucible and weighed. The difference in weight of crucible before and after ashing of the residue was taken as weight of crude fibre (Jacobs, 1979).

3.1.3.1.5 Total mineral matter

Total mineral matter (ash) was determined by igniting the sample in muffle furnace at 600°C for 4-5 hours (Anon., 1990). The difference in the weight was considered as weight of ash.

$$\text{Total mineral matter (\%)} = \frac{\text{Weight of the ash}}{\text{Weight of the sample}} \times 100$$

3.1.3.1.6 Carbohydrates

The carbohydrate content was calculated by deducting the sum of the value of moisture, protein, fat, crude fibre and total mineral matter in 100 (Raghuramalu *et al.*, 1983).

3.1.3.1.7 Calorific value

The calorific value was computed by summing up the values obtained by multiplying the values of carbohydrate, protein and fat with factors 4, 4 and 9, respectively and expressed as Kcal/100 g.

3.1.3.2 Sugars

The reducing, non-reducing and total sugars of the samples were estimated (Somogy, 1955). Reducing sugar was estimated from alcoholic extract by colour change in alkaline solution and quantified based on amount of sugar present. Total sugars were estimated by acid hydrolysis of non-reducing sugar.

3.1.3.3 Starch

Starch content was analysed according to the AOAC procedure (Anon., 1990).

3.1.3.4 Amylose

The amylose content of the isolated starch sample was determined according to the method of Soubhgya and Bhattacharya (1979).

3.1.3.5 Amylopectin

The content of amylopectin was calculated by subtracting the total amylase from 100.

3.1.3.6 Dietary fibre

The soluble, insoluble and total dietary fibre fractions were analysed by enzymatic method (Asp *et al.*, 1983). Moisture and fat free samples were digested with α-amylase, pepsin and pancreatin to remove starch and protein. The filterate was collected and treated with 95 per cent ethanol precipitated, soluble and insoluble fibre was separated by filteration. The residue obtained after filtration was washed with ethanol and acetone, oven dried, weighed and ignited to ash. The soluble, insoluble and total dietary fibre content was calculated by the formula.

$$\text{Soluble/insoluble/total dietary fibre} = \frac{\text{Weight of residue} - \text{Weight of ash}}{\text{Weight of sample}} \times 100$$

3.1.3.7 Minerals

Calcium was precipitated as calcium oxalate. The precipitate was dissolved in hot dilute sulphuric acid and titrated with standard potassium permanganate solution (Anon., 1990).

The trace elements *viz.,* iron, zinc, copper and manganese were estimated using Atomic Absorption Spectrophotometer (model: AAS GBC Avanta).

3.1.3.8 Phytochemicals

The phytochemicals *viz.,* tannins, total phenols and phytates were estimated according to the methods suggested by Schanderl (1970), Bray and Thorpe (1954) and Wheeler and Ferrel (1971). The detailed procedures are given in Appendices I, II and III, respectively.

3.1.4 Functional properties

3.1.4.1 Bulk density of flour

A calibrated centrifuge tube was weighed and the flour samples were filled to 10 ml mark by constant tapping to prevent air space, until there is no further change in volume. The content was weighed and the bulk density of the samples was calculated and expressed as g/ml.

3.1.4.2 Water and oil absorption capacity

One gram sample was mixed with 10 ml of distilled water and also in 10 ml of oil for 30 min. This was allowed to stand at 30°C in a water bath for 30 min and then centrifuged at 4000 rpm for 30 min. The volume of the supernatant was recorded. The water and oil absorption capacity was calculated and the results were expressed as g/g of sample.

3.1.4.3 Swelling power and per cent solubility

The swelling power and per cent solubility was determined according to the method used by Schoch (1964).

500 mg (W_1) of sample was added to a centrifuge tube, weight of centrifuge tube and test sample was noted (W_2). After addition of 20 ml (V_E) distilled water, the centrifuge tube was placed in the water bath at 100°C for 20-30 min till the contents were cooked. Then it was centrifuged at 5000 rpm for 10 min. The supernatant was transferred to a test tube and the inner side of the centrifuge tube was dried well and weighed (W_3). The swelling of flour was calculated as follows.

$$\text{Swelling power (g/g)} = \frac{W_3 - W_2}{W_1} \times 100$$

For per cent solubility, weight of dried moisture dish was noted (W_4) and after pouring 10 ml aliquot (V_A) in a dish, dried at 110°C for 4-5 h. The moisture dish was cooled and weighed (W_5).

$$\text{Solubility (\%)} = \frac{(W_5 - W_4)\, V_E}{V_A} \times \frac{100}{W_1}$$

3.1.4.4 Gelation properties

Gelation properties were studied by employing the method of Sathe *et al.* (1982). Test tubes containing suspensions from 2-14 per cent (w/v) of material in five ml distilled water were heated for one hour in boiling water followed by rapid cooling under running cold water. The tubes were further cooled at 4°C for two hours. The least gelation concentration (LGC) was taken as when the sample in the inverted test tube did not fall down or slip.

3.2 Development of little millet based sports food

3.2.1 Selection of ingredients

Based on the physico-chemical and functional properties, *Sukshema* little millet genotype was selected. Commercially available soybean, sugar powder and skimmed milk powder were procured from local market.

3.2.2 Processing of ingredients

The cleaned grains of little millet and soybean were roasted separately for 16.5 and 12 minutes, respectively until pleasant aroma developed. The roasted grains were pulverized into fine flour in mini mill.

3.2.3 Formulation of sports food mix

Roasted flours of little millet, soybean, sugar powder and skimmed milk powder were mixed in different proportions such that the protein energy ratio of the mix was more than 15, as per the guidelines of ICMR. Totally six mixes were formulated with varying concentration of ingredients (Table 7 and 8). The mixes were passed through 60 mesh sieve.

3.2.4 Preparation of porridge from sports food mix

The formulations were used for the preparation of porridge. Fifty grams of the mix was added to 50 ml of water and stirred to make slurry. This was added to 200 ml of boiling water and heated for two minutes with continuous stirring.

3.2.5 Sensory evaluation of the product

Sensory evaluation of the porridge from sports food mix was carried out using a panel of 10 judges drawn from staff and students of Department of Food Science and Nutrition, University of Agricultural Sciences, Dharwad. The judges were asked to evaluate the samples (Appendix IV) in terms of appearance, consistency, taste, aroma and overall acceptability on a nine point hedonic scale.

3.2.6 Addition of different flavouring agents to the mix

Different flavouring agents *viz.,* cardamom (0.50%), vanilla (0.10%) and cocoa powder (1%) were added to the most acceptable sports food mix. The porridge was evaluated for sensory quality by the panel.

3.2.7 Physical characteristics of sports food

The selected mix was further studied for physical characteristics

3.2.7.1 Colour

The colour was determined as outlined in 3.1.2.3

3.2.7.2 Bulk density

The bulk density was determined as per the procedure given in 3.1.4.1

3.2.7.2 pH

Ten gram of sample was mixed with 100 ml distilled water. The mixture was allowed to stand for 15 min, shaken at five min intervals and centrifuged at 3000 rpm for 15 min. The supernatant was decanted and its pH was determined using a pH meter (Afoakwa *et al*., 2010).

3.2.7.3 Water activity (a_w)

The water activity of the sample was estimated using water activity meter.

3.2.7.4 Dispersibility

Dispersibility was measured by placing 10 g of the sample in a 100 ml stoppered measuring cylinder; distilled water was added to the volume of 100 ml, stirred vigorously and allowed to settle for three hours. The volume of settled particles was subtracted from 100 and difference was reported as per cent dispersibility.

3.2.7.5 Swelling power and per cent solubility

The swelling power and per cent solubility of the product was determined as outlined in 3.1.4.3.

3.2.8 Chemical analysis

The proximate principles, sugars, minerals and dietary fibre content were determined as outlined in 3.1.3.1., 3.1.3.3., 3.1.3.7 and 3.1.3.8 respectively.

The extracted fat from the sample was analysed for fatty acids by chromatographic method using Gas Chromatograph ASXL-GC (Model GC 8610, Chemito), employing the methods of Anon. (1990).

The Trans fatty acid content of the sample was determined by following the chromatographic method (Anon., 1990). It was expressed as per cent of fat.

The amino acid composition of sports food was determined using reverse phase HPLC (Model 23250, ISCO, USA). The tryptophan content was determined by employing the method of Ogunsua, 1988.

3.2.9 Protein quality evaluation of sports food

3.2.9.1 *In vitro* protein digestibility (IVPD)

The *in vitro* protein digestibility was determined by enzymatic method (Moulishwar *et al*., 1993).

3.2.9.2 Amino acid score

The amino acid scores were computed using the FAO/WHO reference pattern (Pellet and Young, 1980).

$$\text{Amino acid score} = \frac{\text{mg of essential amino acid/g N in test protein}}{\text{mg of essential amino acid/g N in reference protein}} \times 100$$

3.2.9.3 Net Protein Value

The net protein value was obtained by multiplying the protein score by the protein content of the product and dividing by hundred (Plahar and Hoyle, 1987).

$$\text{Net Protein Value} = \frac{\text{Protein score (\%)} \times \text{Protein content of the product (\%)}}{100}$$

Where, Protein score = Lowest amino acid score

3.2.10 Shelf life of the sports food

To test the keeping quality, the sample was packed in metalised polyester polyethylene, heat sealed and stored at room temperature for a period of 180 days.

The samples were drawn at the interval of 15 days for evaluation of quality in terms of moisture, peroxide value, water activity, pH and acceptability. The change in colour was analysed at the end of storage period.

3.2.10.1 Effect of storage on moisture

Moisture content of the stored samples was estimated at 15 days interval as outlined in 3.1.3.1.1.

3.2.10.2 Effect of storage on Peroxide value

Peroxide value is a measure of development of rancidity in foods containing fat and expressed in millie equivalents per kilogram of fat (meq/kg). The peroxide value of stored sample was determined at 15 days interval, after extraction of oil using the method of Sadashivam and Manickam (1992) (Appendix V).

3.2.10.3 Sensory evaluation

Acceptability of the sports food was carried out through sensory evaluation by the taste panel consisting of nine members at 15 days interval through out the storage period of six months (Appendix VI).

3.3 Characterisation of sensory profile of sports food

3.3.1 Descriptive sensory characteristics of porridge from sports food

The panel members were assigned to describe the sensory parameters (Hui *et al*., 2006) to document the profile (Appendix VII).

3.3.2 Consumer acceptability of sports food

The porridge was served to 145 sports persons and 11 coaches from Dharwad city who evaluated the acceptability of the product on FACT rating scale (Appendix VIII) as suggested by Cardello and Schutz (2006).

3.4 Efficacy of sports food

The efficacy of sports food was evaluated in three phases, (i) carbohydrate loading (ii) pre-event meal and (iii) long term supplementation. The study design is presented in Fig.1.

3.4.1 Carbohydrate loading and pre-event testing

3.4.1.1 Selection of subjects

A total of 31 men from Dharwad city who were actively involved in sports volunteered to participate in the study. Out of them, 16 men were residing in sports hostel and played for Sports Authority of India (SAI), Dharwad. Another 15 men were free living and played for different sports club. The subjects were training for at least 6 hours/week and playing competitive matches for a minimum period of one year.

3.4.1.2 Orientation and seeking consent

Preliminary orientation for one day was conducted with the help of subject matter specialists. All the subjects were briefed about the study and the experimental protocol. The list of do's and don'ts (Appendix IX) during the experiment was given to the subjects. The written consent for the experiments was taken by the subjects.

3.4.1.3 Data collection

A detailed questionnaire (Appendix X) was structured to collect necessary basic and sports related information of the subjects. The details of various aspects of questionnaire are furnished below.

3.4.1.3.1 General information

General information of subjects such as age, education and occupation were collected by personal interview method.

3.4.1.3.2 Sports related information

The information related to sports such as period of active participation in sports, level of participation, exercise pattern and details of sporting events were collected.

3.4.1.3.3 Dietary habits

The information about food habits, special foods consumed for sports purpose, foods consumed and avoided before, during and after the sporting event and frequency of consumption of different types of foods were collected.

3.4.1.4 Assessment of nutritional status

The nutritional status of subjects was assessed by nutritional anthropometry, diet survey and haemoglobin estimation.

3.4.1.4.1 Nutritional anthropometry

The anthropometric measurements *viz.,* height, weight, mid upper arm, waist and hip circumference were recorded as per the guidelines suggested by Jellife (1966). Skin fold thickness at four sites *viz.,* tricep, bicep, suprailiac and subscapular were measured using Harpenden calipers.

The anthropometric data were further used for computing Body Mass Index (BMI), using the following formula.

$$BMI = \frac{\text{Weight (kg)}}{\text{Height (m}^2\text{)}}$$

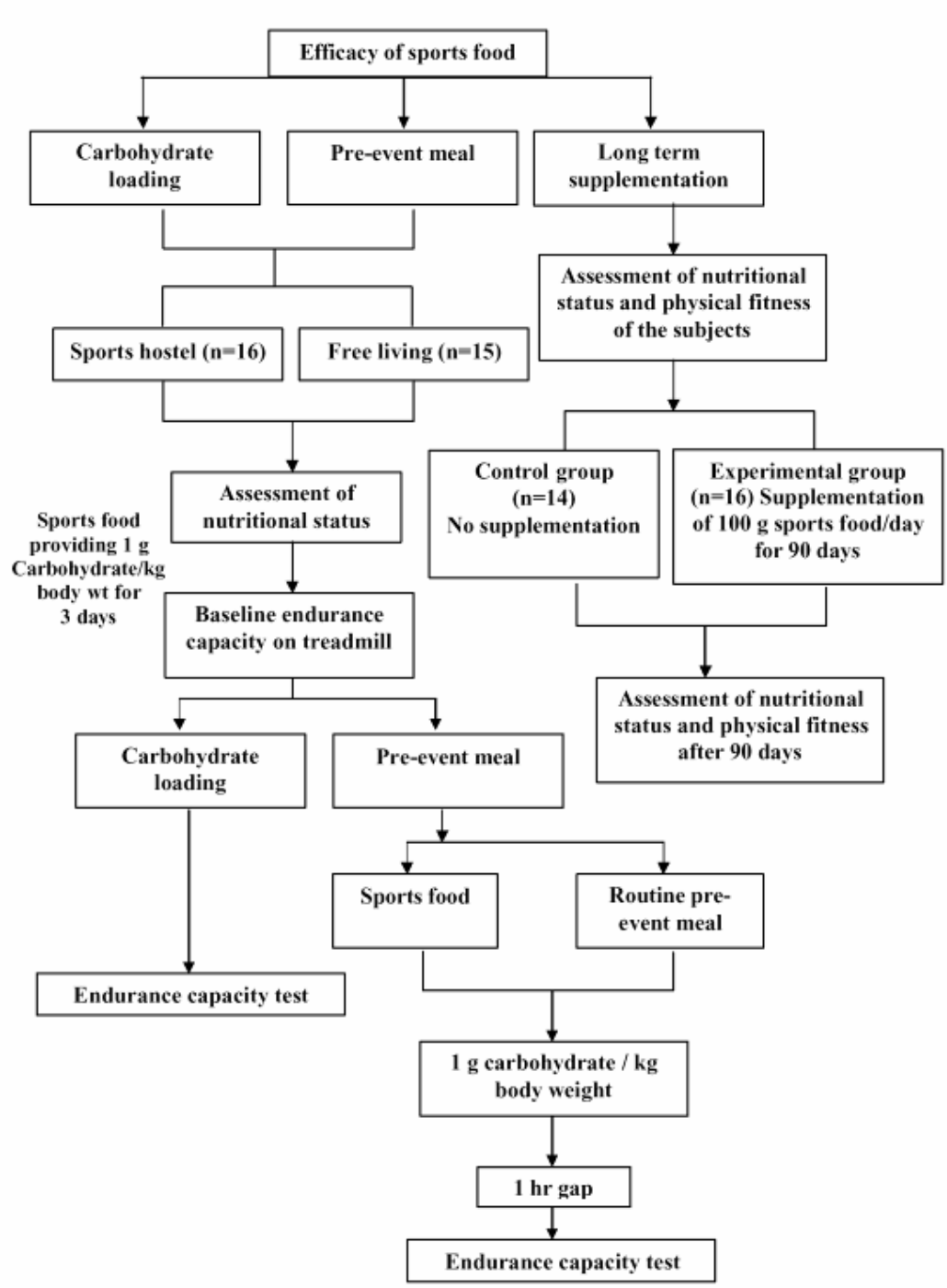


Fig. 1: Schematic representation of study design for efficacy of sports food

Fig 1. Schematic representation of study design for efficacy of sports food

Further individuals were classified into different categories based on the BMI (Anon., 2003).

BMI classes	Presumptive diagnosis
< 18.5	Underweight
18.5 – 22.9	Ideal BMI
23 – 24.9	Over weight
25.0 – 29.9	Obese Grade I
> 30	Obese Grade II

The abdominal obesity was judged by waist to hip ratio (Lean *et al*., 1995). The ratio of more than 0.95 for male was considered as obese.

The body fat per cent was computed using skin fold thickness measurements of the subjects (Mahan and Escott-Stump, 2008).

3.4.1.4.2 Diet survey

Diet survey was carried to know the dietary intake of subjects by 24 hours dietary recall method using standardized vessels and cups.

3.4.1.4.2.1 Food and nutrient adequacy

The raw food equivalents of cooked foods were computed from the standardized cups. The nutrient present in the food were computed from Annapurna VAR-3 a software developed by Mr. Chandrashekhar of Bangalore.

The per cent adequacy of an individual for 11 food groups was computed by utilizing recommended daily allowance for athletes calculated by using the formula given below.

$$\text{Per cent food adequacy} = \frac{\text{Food intake}}{\text{SDA of the foods}} \times 100$$

Per cent adequacy were calculated for each of 11 food groups *viz.,* cereals, pulses, green leafy vegetables, other vegetables, fruits, milk, roots and tubers, sugar, fats and oils, meat and egg.

The average consumption of food items thus calculated from diet survey were used to compute the nutrient intake for calories, protein, fat, carbohydrates, vitamin A, thiamine, riboflavin, niacin, folic acid, vitamin B_{12}, vitamin C, calcium, iron, potassium, magnesium, copper and zinc. Per cent nutrient adequacy was calculated by using the following formula and RDA recommended by Satyanarayan *et al*., 1985 was considered.

$$\text{Per cent nutrient adequacy} = \frac{\text{Nutrient intake}}{\text{RDA of the nutrients}} \times 100$$

3.4.1.4.3 Haemoglobin assessment

The haemoglobin was assessed by cyanmethaemoglobin method (Varley, 1976). The blood (20 µl) was drawn with the help of haemoglobin pipette. It was transferred to labeled Whatman No. 1 filter paper and air dried. In the lab, the portion of the filter paper containing the blood was cut and dipped in 5 ml of Drapkins solution and kept for half an hour. Then contents were mixed by vertex mixer and colorimeter reading were taken at 540 nm and compared with standard curve to get haemoglobin values.

Further the subjects were classified into different groups based on the body fat and haemoglobin level according to Sports Authority of India classifications for sports persons (Goswami, 2005).

3.4.1.5 Energy balance

Energy balance was calculated as the difference between energy intake and energy expenditure. Energy intake of the subjects was obtained by the diet survey.

For energy expenditure, the subjects were asked to keep minute wise record of their activities. The energy spent was estimated by the energy cost of each activity (Sathyanarayana, 1989).

3.4.1.6 Endurance capacity test

A preliminary test on a motorized tread mill (Model - Benson TM 5200) was carried out to familiarize the equipment to the subjects and to set the test speed for the experiment. The test was conducted in the early morning without food. They performed five minutes warm up exercise before performing the endurance capacity test.

A baseline endurance capacity of the subjects was tested by running to exhaustion on a motorized treadmill, set at a constant speed of 10 km/hour. The time to exhaustion, distance covered and calories burnt were recorded.

3.4.1.7 Carbohydrate loading

The subjects were given sports food which provided one gram carbohydrate/kg body weight along with their routine diet for three consecutive days and were asked to taper down their exercise (Sherman *et al*., 1981) during these days. On the fourth day, the subjects performed the endurance capacity test under similar experimental conditions.

3.4.1.8 Pre-event meal

The subjects were asked to perform on two different occasions, separated by at least seven days. Either the sports food or routinely consumed pre-event meal, providing one gram carbohydrate/kg body weight, was fed one hour before the endurance test. *Idli* was selected for routinely consumed pre event meal trial as it was the most preferred one by the subjects. The results were compared with the endurance capacity after an overnight fast. All the trials were conducted in similar experimental conditions.

3.4.3 Long term supplementation study

3.4.3.1 Selection of subjects

The male student athletes from MVAS Shri K.G. Nadiger College of Physical Education, Dharwad were selected for the study. The subjects were regularly and actively taking part in various sports activities.

All of them consumed the hostel diet. Out of 30 subjects, 16 were randomly selected as experimental group for the purpose of long term intervention.

3.4.3.2 Orientation and seeking consent

The subjects were briefed about the study and experimental protocol. The list of dos and don'ts was given to the subjects. The consent of the subjects for the experiment was obtained.

3.4.3.3 Data collection

The data regarding general information, sports related information, dietary habit *etc.* was collected as outlined in 3.3.1.3.

3.4.3.4 Assessment of nutritional status

The nutritional status of the subjects was assessed as mentioned in 3.3.1.4.

3.4.3.5 Assessment of physical fitness

AAHPERD (American Alliance for Health, Physical Education, Recreation and Dance) physical fitness tests were used for the assessment of physical fitness (AAHPERD, 1980). The speed, agility, strength, flexibility, endurance and cardio-respiratory fitness components were determined.

3.4.3.5.1 Speed

Speed was measured using 50 meter dash. The time for travelling 50m distance was noted with the help of stop watch, to the nearest $1/10^{th}$ of a second.

3.4.3.5.2 Agility

The agility was measured using 10 x 6 shuttle run. Two parallel lines were marked 10 m apart and cones were placed. On the signal 'go' the subject sprinted to the opposite line, touched the cone and sprinted back to touch the cone on starting line. He repeated this for three times and was asked to complete quickly. The time taken was recorded.

3.4.2.5.3 Strength

Strength was measured using vertical jump test. The subject stands sidewise to a wall and reaches up with the hand closest to the wall. Keeping the feet flat on the ground, the point of the fingertip is marked and recorded. This is called the standing reach height. The subject then stands away from the wall and leaps vertically as high as possible using both arms and legs to assist in projecting the body upwards. He should touch the wall at the highest point of the jump. The difference between the standing reach height and the jump height is noted.

3.4.2.5.4 Flexibility

Flexibility was measured using forward bend and reach test. Test was conducted on platform which wass marked. Subject stands with toes in line with the edge of the box. From this position he bends forward and while keeping his knees straight. He extends his hands along the scale as down as possible. At a maximum reach he holds the position for about two seconds. The measurement at the tip of middle finger was noted.

3.4.2.5.5 Endurance capacity

Endurance capacity was measured as mentioned in 3.3.1.5.

3.4.2.5.6 Cardio-respiratory fitness

Cardio-respiratory fitness was assessed using the Harvard step test. The subject was asked to step up and down on a platform of 20 inches high. The stepping exercise continued for five minutes unless the subject was forced to stop sooner due to exhaustion. The stepping up and down was done at a rate of 30 steps per minute. The duration of exercise in seconds was recorded. Immediately after completing the exercise the subject rested on a chair. The pulse rate at the radial artery was noted between 1 to 1.5, 2 to 2.5 and 3 to 3.5 minutes after finishing the test. The cardiovascular efficacy score (CES) was calculated using the following formula.

$$CES = \frac{\text{Test duration in seconds}}{\text{2 x sum of pulse rate during recovery}} \times 100$$

3.4.2.6 Supplementation of sports food

The experimental subjects were supplemented with 100 g of sports food per day for a period of 90 days. The subjects consumed the test food along with their routine diet, throughout the intervention period. The control group was given no test food. Before starting the supplementation programme all the subjects were given deworming tablets (Albendazole 400 mg).

3.4.2.7 Parameters observed before and after supplementation

The anthropometric measurements, haemoglobin and physical fitness were recorded in both control and experimental groups before and after supplementation.

3.5 Market viability of sports food

The technology for production of designer sports food was transferred to a food industry. The production process was continuously monitored. The manufacturers' product was tested for acceptability in comparison to laboratory product. The product was sealed in metalized polyester polyethylene covers and packed in cartons with attractive labeling and label containing nutrition information. The cost of production at commercial level was calculated considering fixed and variable costs. The product was launched in the market. The sales were promoted by advertising in daily news papers.

3.6 Statistical analysis

Suitable statistical tools were used for analysis of the data. Data pertaining to physico-chemical and functional properties and nutritional status were analysed using students t test. Completely randomized design was used to test the sensory and storage quality. Where ever the significant result was obtained, the critical difference test was used. The data pertaining to efficacy testing was analysed employing paired t test. The limit of probability fixed for the test of significance was $p<0.05$ and $p<0.01$.

4. RESULTS

The potentiality of minor millets in promoting health is being recognized. Minor millets have been cultivated since time immemorial. Traditionally, millets are considered as poor man's food and were consumed by primitive tribes. Millets are nutritious, healthy and versatile and hence would be a worthy addition to one's diet. The diet of sports man is an important factor for determining the sports performance along with other factors. The results of the present investigation on Evaluation of physico-chemical and functional properties of little millet genotypes, designing of little millet based sports food, acceptability, efficacy and market viability of sports food have been presented in this chapter.

4.1 Physico-chemical and functional properties of little millet genotypes

4.1.1 Physical characteristics of little millet genotypes

The physical characteristics of little millet genotypes are presented in Table 1. The observations revealed variation in size among the genotypes.

The mean length of local genotype was 1.74 mm with a range between 1.63 to 1.85 mm. The length of *Sukshema* genotype ranged from 1.73 to 1.96 mm with a mean value of 1.81 mm. The length of *Sukshema* grain was significantly higher than local genotype. The width of local and *Sukshema* grains were 1.53 and 1.55 mm, respectively. The local genotype had a thickness of 1.06 mm, while the thickness of *Sukshema* genotype was 1.09 mm. However, no significant differences were apperant between the genotypes for width and thickness. Both the genotypes were spherical in shape.

For the colour of grains, the mean L value of local genotype was 84.57 and *Sukshema* was 84.78. The mean a values were 2.20 and 1.98 for local and *Sukshema*, respectively. The mean b value was 11.47 for local and 12.67 for *Sukshema*. The values revealed that the *Sukshema* was lighter, redder (less green), yellower (less blue) and brighter than local genotype.

The mean thousand grain weight was 2.15 g for local and 2.33 g for *Sukshema* genotype. The thousand grain weight of *Sukshema* was significantly greater ($P < 0.05$) than that of local genotype. The mean thousand grain volume of genotypes was 1.60 and 1.65 ml for local and *Sukshema*, respectively. The bulk density of local genotype (1.33 g/ml) was higher than *Sukshema* genotype (1.30 g/ml).

The mean hydration capacity was 0.15 and 0.17 g per 1000 grains for local and *Sukshema* genotypes, respectively. The genotypes exhibited a hydration index of 6.67 in local and 7.66 in *Sukshema*. The difference did not reach statistical significance. Swelling capacity of grains was 0.15 and 0.20 ml per 1000 grains for local and *Sukshema* genotypes. The difference was significant at 5 per cent level. The swelling index of local genotype (9.38) was significantly ($P < 0.01$) lower than *Sukshema* genotype (10.41).

4.1.2 Chemical components of little millet genotypes

4.1.2.1 Proximate composition

The analysis of proximate composition revealed genotypical differences (Table 2). Moisture content was significantly higher in local (11.43%) than *Sukshema* (10.67%). Lower protein content was recorded in local (8.49%) compared with *Sukshema* (8.96) genotype. The difference was significant at 1 per cent level. Significantly higher fat content was recorded in local (4.97%) than in *Sukshema* (4.10%).

The crude fibre contents were 3.10 and 3.05 g per 100 g in local and *Sukshema* genotypes, respectively. The mean ash content was 2.52 and 2.74 g per 100 g in local and *Sukshema* genotypes, respectively. No significant differences in crude fibre and ash contents were noticed among genotypes. The carbohydrate content of local (69.5%) genotype was significantly lower than *Sukshema* genotype (70.47%). The calorific value of local genotype was 357 Kcal and *Sukshema* genotype was 355 Kcal.

Table 1: Physical characteristics of little millet genotypes

Characteristics		Local	*Sukshema*	't' value
Size#	Length (mm)	1.74±0.07	1.81±0.08	2.23*
	Breadth (mm)	1.53±0.03	1.55±0.04	1.55 ^{NS}
	Thickness (mm)	1.06±0.06	1.09±0.04	1.05 ^{NS}
Shape		Spherical	Spherical	
Colour	L (Lightness)	84.57±0.12	84.78±0.10	2.30^{NS}
	a (Redness)	2.20±0.13	1.98±0.08	2.46^{NS}
	b (Yellowness)	11.47±0.47	12.67±0.43	3.27*
1000 grain weight (g)		2.15±0.01	2.32±0.01	2.97*
1000 grain volume (ml)		1.60±0.05	1.65±0.05	1.74^{NS}
Bulk density (g/ml)		1.33±0.02	1.30±0.02	2.89*
Hydration capacity (g/1000 grains)		0.15±0.01	0.17±0.02	2.45 ^{NS}
Hydration index		6.67±0.50	7.66±0.73	1.95 ^{NS}
Swelling capacity (ml/1000grains)		0.15±0.02	0.20±0.03	2.92*
Swelling index		9.38±0.18	10.41±0.11	8.71**

Mean of 10 observations
* - Significant at 5% level
** - Significant at 1% level
NS - Non-significant

Table 2: Proximate composition of little millet genotypes (g/100g)

Nutrients	Local	*Sukshema*	't' value
Moisture	11.43 ± 0.10	10.67 ± 0.11	8.85**
Protein	8.49 ± 0.06	8.96 ± 0.12	6.38**
Fat	4.97 ± 0.13	4.10 ± 0.10	8.91**
Crude fibre	3.05 ± 0.13	3.25 ± 0.11	2.57^{NS}
Ash	2.57 ± 0.05	2.54 ± 0.10	0.54^{NS}
Carbohydrate	69.50 ± 0.45	70.47 ± 0.38	2.84*
Energy (Kcal)	357 ± 3.46	355 ± 2.65	0.79^{NS}

** - Significant at 1% level
NS - Non-significant

Table 3: Minerals content of little millet genotypes (mg/100g)

Minerals	Local	*Sukshema*	't' value
Calcium	15.20 ± 1.05	18.73 ± 1.91	1.19^{NS}
Iron	8.80 ± 0.69	8.58 ± 0.43	0.47^{NS}
Zinc	1.58 ± 0.11	2.03 ± 0.25	2.91*
Copper	0.28 ± 0.02	0.26 ± 0.02	1.04^{NS}
Manganese	0.32 ± 0.02	0.36 ± 0.03	2.09^{NS}

* - Significant at 5% level
NS - Non-significant

4.1.2.2 Minerals content

The mean mineral content of little millet genotype is presented in Table 3.

The calcium content of local genotype (15.20 mg/100g) was lower than Sukshema genotype (18.73 mg/100g). However, no statistically significant difference was recorded between the genotypes. The iron content of local genotype (8.80 mg/100g) was higher than the Sukshema genotype (8.58 mg/100g). The statistical test revealed no significant difference in iron content between the genotypes. The zinc content of Sukshema (2.03 mg/100g) was significantly higher than the local genotype (1.58 mg/100g). The local genotype recorded higher copper (0.28 mg/100g) and lower manganese (0.32 mg/100g) content than Sukshema genotype (0.26 and 0.36 mg/100g, respectively). However, no significant differences in copper and manganese contents were apparent between the genotypes.

4.1.2.3 Sugar, starch and dietary fibre content

The results of sugar, starch and dietary fibre content of little millet genotypes are depicted in Table 4. The mean sugar content of local genotype was lower than *Sukshema* genotype. The reducing, non-reducing and total sugar content of local genotype was 1.23, 2.63 and 3.86 g per 100 g, respectively. The *Sukshema* genotype recorded 1.33, 2.75 and 4.08 g per 100 g of reducing, non-reducing and total sugar content, respectively. No significant difference for the sugar content was observed between the genotypes.

The starch content of local genotype (57.12 g/100 g) was significantly ($P< 0.05$), lower than *Sukshema* genotype (59.19 g/100 g). The local and *Sukshema* genotypes recorded an amylose content of 24.31 and 25.47 g per 100 g, respectively. The amylopectin content was higher in *Sukshema* (33.75 g/100 g) than local (32.81 g/100 g). The statistical test revealed no significant difference between the genotypes for amylose and amylopectin contents.

The mean soluble dietary fibre content of local genotype (3.01 g/100 g) was lower than *Sukshema* genotype (3.25 g/100 g). Higher amount of insoluble dietary fibre was observed in local (5.24 g/100 g) genotype than *Sukshema* (5.15 g/100 g). The mean total dietary fibre content was higher in *Sukshema* (8.60 g/100 g) than local (8.25 g/100 g). The genotypes exhibited no significant difference for dietary fibre contents.

4.1.2.4 Phytochemicals

Table 5 presents the phytochemicals content of little millet genotypes. Tannin content was recorded to be 92.23 and 86.07 mg per 100 g in local and *Sukshema* genotypes, respectively. The difference was not significant statistically.

The total phenols and phytates content were observed to be significantly higher in local genotype (74.20 and 115.13 mg/100 g, respectively) than *Sukshema* genotype (61.87 and 94.36 mg/100 g, respectively).

4.1.3 Functional properties of little millet genotypes

The functional properties of little millet genotypes are presented in Table 6. The water and oil absorption capacities of local genotype (0.82 and 0.64 g/g, respectively) were significantly lower than *Sukshema* genotype (0.88 and 0.66 g/g, respectively). The swelling power of genotypes was observed to be 6.96 and 7.73 g per g in local and *Sukshema* genotypes, respectively. *Sukshema* genotype had significantly higher swelling power than local genotype. The solubility of local genotype was recorded to be 22.20 per cent and that of *Sukshema* genotype was 23.41 per cent. The difference in solubility was statistically not significant. The least gelation concentration of *Sukshema* (9.07%) was significantly lower than local (9.98%) genotype.

4.2 Development and evaluation of little millet based sports food

4.2.1 Formulation of little millet based sports food

The sports food was formulated based on the criteria that the per cent energy from protein was more than 15, as per the ICMR guidelines.

Table 4: Sugars, starch and dietary fibre contents of little millet genotypes (g/100g)

Parameters	Local	*Sukshema*	't' value
Sugars			
Reducing	1.23 ± 0.13	1.36 ± 0.12	1.07^{NS}
Non reducing	2.63 ± 0.37	2.78 ± 0.17	0.64^{NS}
Total	3.86 ± 0.66	4.14 ± 0.24	0.69^{NS}
Starch	57.12 ± 0.70	59.19 ± 0.91	3.11*
Amylose	24.31 ± 1.19	25.47 ± 1.31	1.14^{NS}
Amylopectin	32.81 ± 1.52	33.72 ± 0.63	0.96^{NS}
Dietary fibre			
Soluble dietary fibre	3.21±0.18	3.46±0.47	0.85^{NS}
Insoluble dietary fibre	5.62±0.34	5.35±0.48	0.80^{NS}
Total dietary fibre	8.83±0.83	8.81±0.26	0.05^{NS}

* Significant at 5%
NS – Non-significant

Table 5: Phytochemicals content of little millet genotypes (mg/100g)

Phytochemicals	Local	*Sukshema*	't' value
Tannins	92.23 ± 4.28	86.07 ± 3.72	1.78^{NS}
Total phenols	74.20 ± 3.44	61.87 ± 2.25	5.46**
Phytates	115.13 ± 4.47	94.36 ± 2.70	6.88**

** - Significant at 1% level
NS - Non-significant

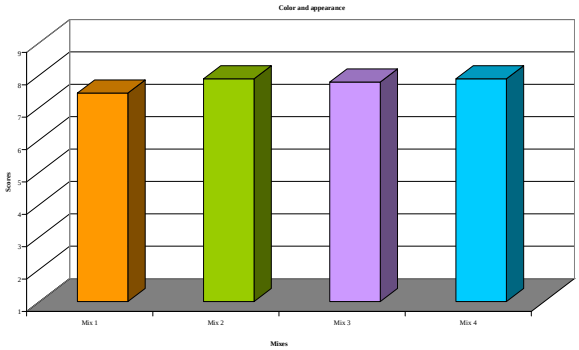
Table 6: Functional properties of flour from little millet genotypes

Properties	Local	*Sukshema*	't' value
Bulk density (g/ml)	0.72 ± 0.01	0.73 ± 0.01	2.74^{NS}
Water absorption capacity (g/g)	0.82 ± 0.01	0.88 ± 0.02	4.88**
Oil absorption capacity (g/g)	0.64 ± 0.008	0.66 ± 0.01	2.89*
Swelling power (g/g)	6.96 ± 0.15	7.73 ± 0.13	6.75**
Solubility (%)	22.24 ± 0.87	23.40 ± 0.69	1.81^{NS}
Least gelation concentration (%)	9.98 ± 0.28	9.07 ± 0.31	3.86*

* - Significant at 5% level
** - Significant at 1% level
NS - Non-significant

Table 7: Composition of sports food mixes (g/100 g) for trial 1

Mixes	Little millet	Soybean	Sugar powder	Skimmed milk powder	Percent energy from protein
Mix 1	30.00	17.50	32.50	20.00	18.50
Mix 2	35.00	13.00	35.00	17.00	15.70
Mix 3	33.00	13.50	37.00	16.50	15.30
Mix 4	30.00	15.00	35.00	20.00	17.60



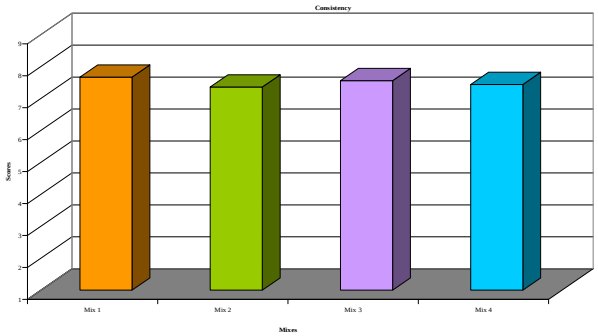
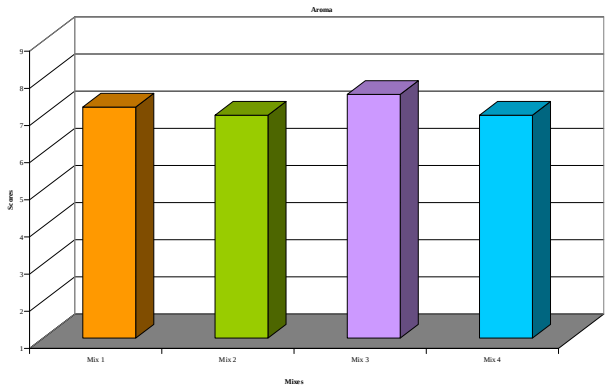
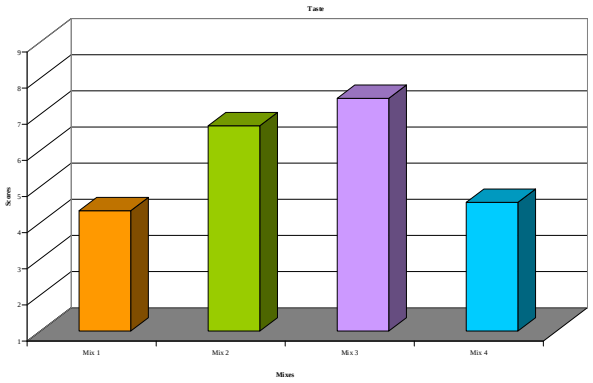


Fig. 2. Mean sensory scores of porridge from sports food mixes for trial 1





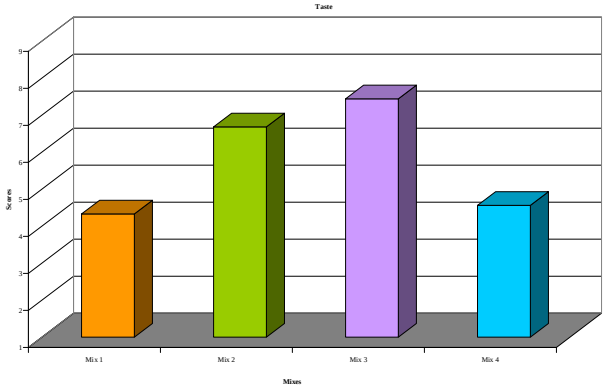


Fig 2. Mean sensory scores of porridge from sports food mixes for trial 1

Table 7 presents the composition of sports food mixes for trial 1. Little millet, soybean, sugar powder and skimmed milk powder were mixed in different proportions. Mix 1 and mix 4 each contained 30 g little millet and 20 g skimmed milk powder.

The soybean and sugar powder content of mix 1 was 17.5 and 32.5 g, respectively. While, mix 4 had 15g soybean and 35g sugar powder. The composition of mix 2 was 35g little millet, 13g soybean, 35g sugar powder and 17g of skimmed milk powder. Mix 3 was constituted of 33g little millet, 13.5 g soybean, 37g sugar powder and 16.5 g skimmed milk powder. The per cent energy from protein ranged from 15.3 (mix 3) to 18.5 (mix 1).

The porridge prepared from the four mixes was subjected to sensory evaluation. The acceptability is illustrated in Appendix XI and Fig 2.

The mean scores of the porridge for colour and appearance ranged from 7.44 to 7.88 with no statistical differences between the mixes. The consistency scores varied between 7.36 (mix 4) and 7.67 (mix 1). However, the variation was statistically non significant.

The aroma scores ranged from 7.00 (mix 4) to 7.56 (mix 3). Statistical test revealed no significant differences. The values indicated that the colour and appearance, consistency and aroma were accepted between like moderately to like very much.

With respect to taste and overall acceptability, there existed a significant difference among the mixes. The taste and overall acceptability scores were highest for mix 3 (7.44 and 7.56, respectively), followed by mix 2 (6.68 and 6.78, respectively). Mix 2 and 3 were statistically on par with respect to taste and overall acceptability. Mix 1 and mix 4 received significantly lower scores for taste (4.33 and 4.56, respectively) and overall acceptability (4.89 and 5.11, respectively). The results indicated that the mix 1 and mix 4 had scores between dislike slightly and neither like nor dislike.

Further, two more mixes (mix 5 and mix 6) were formulated by slightly modifying the composition (Table 8) such that the per cent energy from protein was more than 15. Mix 5 contained 34 g little millet, 13 g soybean, 36 g sugar powder and 17 g skimmed milk powder. While, mix 6 was constituted of 34 g little millet, 12.5 g soybean, 37 g sugar powder and 16.5 g skimmed milk powder. The per cent energy from protein was 15.6 and 15.2 for mix 5 and mix 6, respectively. The sensory evaluation of the porridge was carried out for mix 2, mix 3, mix 5 and mix 6.

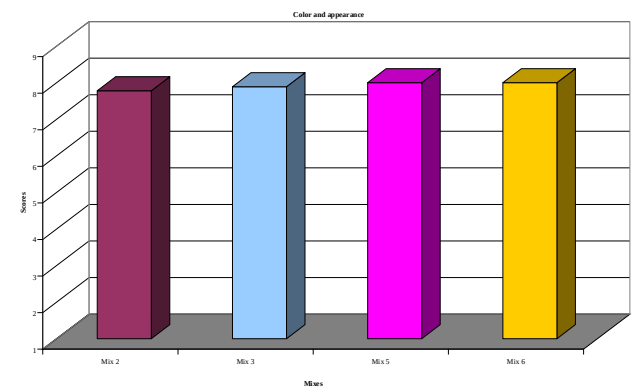
The mean sensory scores of the porridge from sports food mixes for trial 2 are presented in Appendix XII and Fig 3. The mean scores for colour and appearance ranged between 7.78 and 8.00 among the mixes. While, the mean scores for consistency and aroma varied from 7.44 to 7.67 and 7.00 to 7.67, respectively. The statistical analysis showed that there was no significant difference between the mixes for colour and appearance, consistency and aroma.

With respect to taste and overall acceptability, a significant difference was noted between the mixes. Mix 6 recorded highest scores for taste (7.78) and overall acceptability (7.78). This was followed by mix 3 (7.44 and 7.44, respectively) and mix 5 (7.11 and 7.22, respectively).

Statistical test revealed that there was no significant difference in the taste and overall acceptability scores between mix 6, mix 3 and mix 5. Mix 2 recorded lowest scores for taste (6.78) and overall acceptability (6.78). These scores were significantly lower than mix 6, but statistically on par with mix 3 and mix 5.

The data in Table 9 presents the acceptability of porridge from sports food mixes for trial 2. The total score was recorded to be highest in mix 6, with a corresponding acceptability index of 86.44 per cent. Mix 2 had lowest total score (35.78) with a corresponding acceptability index of 79.51 per cent.

Based on the above trials mix 6, which had highest acceptability index was considered for further trials.



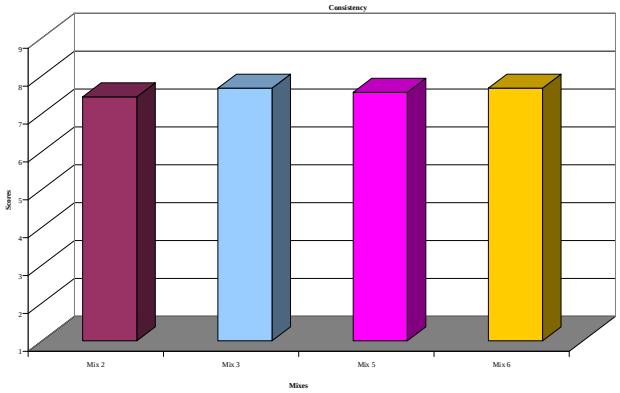
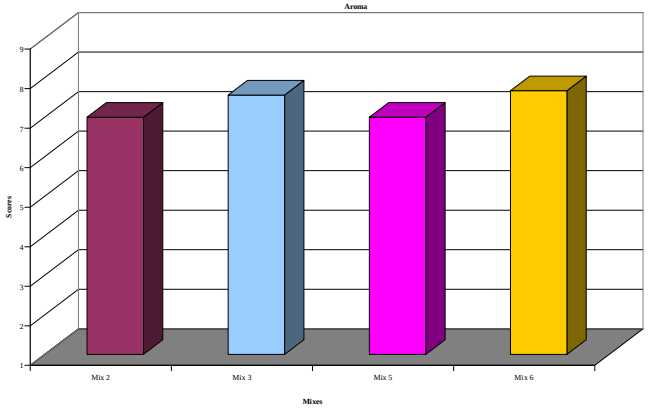
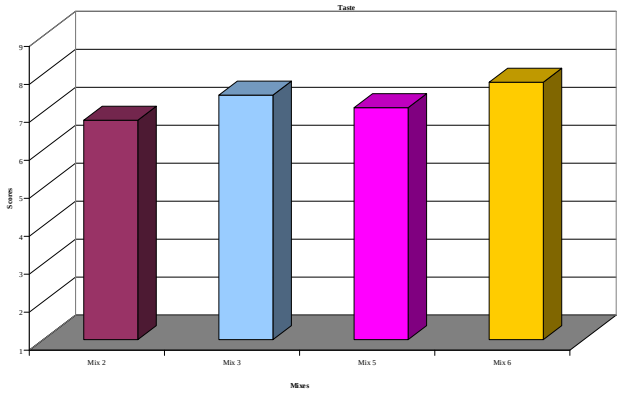


Fig. 3. Mean sensory scores of porridge from sports food mixes for trial 2





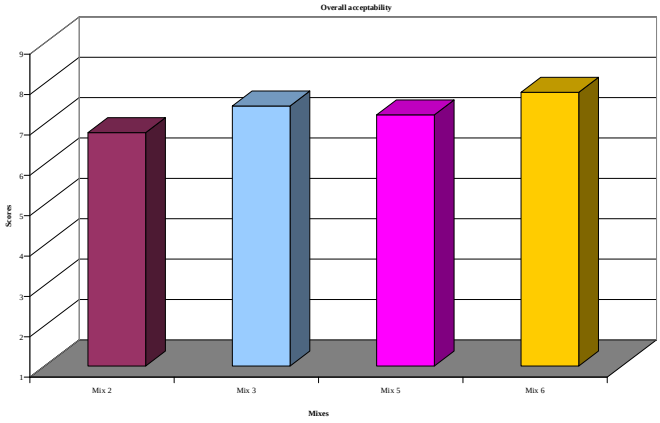


Fig 3. Mean sensory scores of porridge from sports food mixes for trial 2

Table 8: Composition of sports food mixes (g/100 g) for trial 2

Mixes	Little millet (g)	Soybean (g)	Sugar powder (g)	Skimmed milk powder (g)	Percent energy from protein
Mix 2	35.00	13.00	35.00	17.00	15.70
Mix 3	33.00	13.50	37.00	16.50	15.30
Mix 5	34.00	13.00	36.00	17.00	15.60
Mix 6	34.00	12.50	37.00	16.50	15.20

Table 9: Acceptability of porridges from sports food mixes for trial 2

Mixes	Total score (max. 45)	Acceptability index (%)
Mix 2	35.78	79.51
Mix 3	38.00	84.44
Mix 5	36.89	81.98
Mix 6	38.90	86.44

Table 10: Acceptibility of porridge from sports food mix with different flavouring agents

Flavours	Total score (max. 45)	Acceptability index (%)
Cocoa	30.14	66.98
Cardamom	38.26	85.02
Vanilla	37.39	83.09

4.2.3 Addition of flavouring agent to formulated sports food mix

The porridge prepared from mix 6 with different flavouring agents was tested for sensory quality. The sensory profile of porridge from sports food with different flavouring agents is depicted in Appendix XIII and Fig 4.

The mean colour and appearance score ranged from 5.13 in cocoa to 7.50 in vanilla. The consistency scores varied between 7.13 (cocoa) and 7.63 (cardamom and vanilla). The consistency of porridge did not vary significantly among the flavouring agents. The mean aroma scores for cardamom and vanilla were 7.50 and 7.38, which were significantly better than that of cocoa (6.75).

The taste of cocoa powder incorporated porridge was liked the least with a score of 5.63. The cardamom and vanilla flavours recieved taste score values of 7.88 and 7.50, respectively. Similarly, the overall acceptability scores revealed that cardamom (7.75) and vanilla (7.50) had significantly higher values than cocoa (5.50). The porridge with cocoa flavour registered significantly lower scores for all the parameters except consistency. Further, statistical test depicts that there was no significant difference between cardamom and vanilla for all the sensory parameters.

In Table 10, the data pertaining to total sensory scores and acceptability index are presented. Cocoa incorporated porridge registered lowest total score (30.14) with a corresponding acceptability index (66.98%). The acceptability index was highest in cardamom flavoured porridge (85.02%) followed by vanilla flavoured porridge (83.09%). The sports food with cardamom flavor was considered for the further studies. Thus, the final product selected for the further studies was comprised of 34 g of little millet, 12.5 g soybean, 37g sugar powder, 16.5 skimmed milk powder and cardamom powder (Plate 1).

4.2.4 Physical characteristics of sports food

The physical characteristics of sports food were studied and the results are presented in Table 11. For the colour components of the sports food, the L , a and b values were 91.29, 1.29 and 10.80, respectively. The pH and water activity of the sports food was recorded to be 6.63 and 0.51. The bulk density of the sports food was 0.78 g per ml. A dispersability of 84.20 per cent was observed. The sports food had 2.30 g/g swelling power and 51.80 per cent solubility. With respect to texture, the work required to back extrude 90 ml of porridge was 8.10 g force.

4.2.5 Chemical composition of sports food

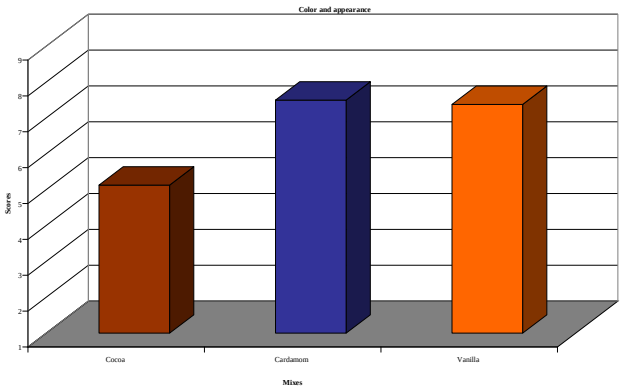
The proximate composition and mineral content of sports food is presented in Table 12. The sports food documented 5.98 per cent of moisture, 14.29 g of protein, 4.05 g of fat and 2.33 per cent of crude fibre. The total minerals and carbohydrates accounted for 2.76 and 70.59 g per 100 g, respectively. The calorific value was 376 Kcal per 100 g.

The sports food was composed of 261.83 mg per 100 g of calcium, 4.69 mg per 100 g of iron and 2.02 mg per 100 g of zinc. The copper and manganese contents were 0.36 and 0.39 mg per 100 g, respectively.

Total sugar content of sports food mix was 47.38 g. The reducing sugar constituted 9.13 g, while non-reducing sugar was 38.25 g. The starch content in the sports food was 18.53 percent. The total dietary fibre content of sports food mix was 4.27 g per 100 g. The soluble dietary fibre content was 1.48 g, while, insoluble fraction was recorded to be 2.79 g (Table 13).

The fatty acid profile of sports food is presented in Fig. 5 and Table 14. The total saturated fatty acid (18.02 g/100 g of total fatty acids) was constituted mainly of 13.89 g of palmatic acid and 3.20 g of stearic acid. Minor amounts of myristic acid (0.42 g), arachadic acid (0.34 g) and behanic acid (0.16 g) were also documented.

Among the monounsaturated fatty acids, the pamotolic acid content was 0.19 g, while oleic acid accounted for 28.88 g per 100 g of total fatty acids. The sports food had high content of total unsaturated fatty acids (81.98%). Among the polyunsaturated fatty acids, the linoleic acid content was 46.90 g per 100 g total fatty acids. The sports food also possessed 6.02 per cent of linolenic acid. The trans fatty acid was not detected in the food.



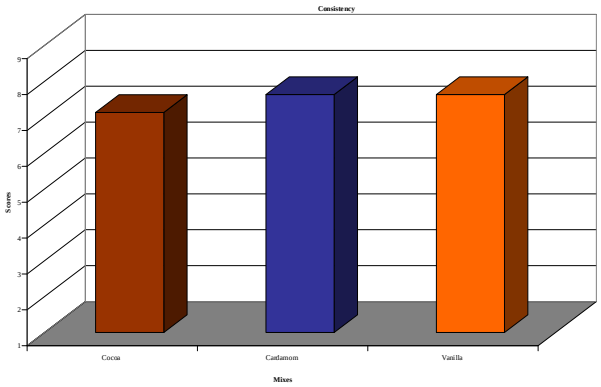
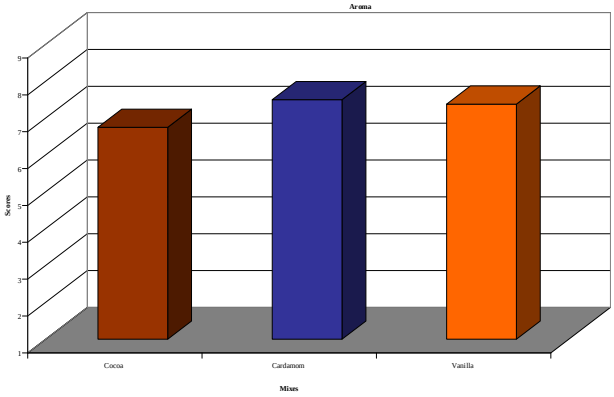
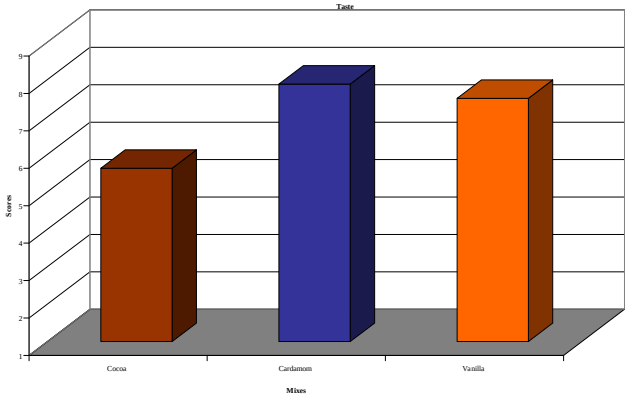


Fig. 4. Mean sensory scores of porridge from sports food with different flavouring agents





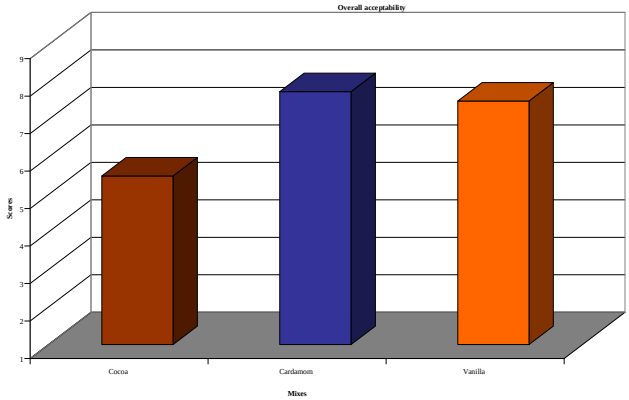


Fig 4. Mean sensory scores of porridge from sports food with different flavouring agents

The amino acid composition of sports food is presented in Table 15. Among essential amino acids, the highest content was recorded for leucine (468 mg/g N), followed by valine (324 mg/g N), phenyl alanine (267 mg/g N) and lysine (258 mg/g N). Among non-essential amino acids glutamic acid (1102 mg/g N) was the most abundant amino acid followed by aspartic acid (438 mg/g N), glycine and serine (271 mg/g N, each). The amino acids present in minor quantities were tryptophan (57 mg/g N), cystine (39 mg/g N) and proline (13 mg/g N).

4.2.6 Protein quality evaluation of sports food

The protein quality of sports food is depicted in Table 16. The *in vitro* digestibility of sports food was 79.15 per cent. With respect to amino acid scores, lysine recorded lowest score of 0.76 followed by isoleucine 0.89. The scores for tryptophan (0.95) and threonine (0.96) were nearer to one. While a score of more than one for phenyl alanine (3.11), metheonine (1.14), leucine (1.06) and valine (1.04). The net protein value of the sports food was 10.85.

4.2.7 Shelf life of sports food

The sports food was packed in metalized polyester polyethylene pouches, heat sealed and stored at ambient conditions (27^0C and 65% RH) for 180 days.

4.2.7.1 Effect of storage on physical characteristics of sports food

Table 17 shows the effect of storage period on physical characteristics of sports food. It is obvious from the table that there was a significant change in the colour of the sports food. The L, a and b values changed from 91.29 to 88.23, 1.29 to 2.29 and 10.80 to 14.87, respectively. The stored sample was darker, redder (less green), yellower (less blue) and brighter than the fresh sample. The total change in colour strength over 180 days of storage was 5.20. Non significant changes in the pH (6.63 to 6.60) and water activity (0.51 to 0.54) of the sports food were also noted at the end of storage period. With respect to texture of porridge, the work required to back extrude 90 ml of porridge increased from 8.10 to 8.40g force. However, the change was statistically not significant.

4.2.7.2 Effect of storage on moisture content of sports food

Changes in moisture content of sports food over a period of storage are shown in Fig. 6 and Appendix XIV. It is obvious that there was a significant increase in moisture values with the days of storage over initial moisture of 5.98 per cent. The highest moisture content of 6.59 per cent was observed at the end of 180 days.

4.2.7.3 Effect of storage on peroxide value of sports food

Effect of storage on peroxide value of sports food is presented in Fig 7. and Appendix XIV.

Initially the peroxide value of sports food was 1.84 meq per kg fat. A steady and significant increase in peroxide value was evident as the storage period progressed. The peroxide value was recorded to be 2.24 meq per kg fat at the end of the 180 days of storage. Never the less peroxide value was well within the BIS specification of 10meq per kg fat.

4.2.7.4 Effect of storage on sensory quality of porridge from sports food

The storage quality of sports food was evaluated for acceptability in the form of porridge on 9 point hedonic scale at the regular intervals of 15 days. The results are depicted in Fig.8 and Appendix XV.

The mean colour and appearance score of the porridge did not differ significantly from 0 to 180 days of storage. However, the scores decreased from 7.27 to 7.18. The colour of the porridge at 165 and 180 days of storage was noticed to be slightly brown compared with colour at 0 day.

The mean consistency scores of porridge decreased from 7.46 to 7.18. But, the change was statistically not significant. However, significant changes in aroma, taste and overall acceptability of porridge was noticed over the storage period. The mean scores for aroma decreased from 7.36 to 6.46.

Plate 1. Development of little millet based sports food

Plate 1. Development of little millet based sports food

Table 11: Physical characteristics of sports food

Parameters	Values
Colour	
L (Lightness)	91.29
a (Redness)	1.29
b (Yellowness)	10.80
pH	6.63
a_w	0.51
Bulk density (g/ml)	0.78
Dispersability (%)	84.20
Swelling power (g/g)	2.30
Solubility (%)	51.8
Texture of porridge (g force)#	8.10

Work required to back extrude specific amount of porridge

Table 12: Proximate composition and mineral content of sports food (per 100 g)

Nutrients	Content
Moisture (g)	5.98
Protein (g)	14.29
Fat (g)	4.05
Crude fibre (g)	2.33
Total minerals (g)	2.76
Carbohydrates (g)	70.59
Energy (Kcal)	376
Calcium (mg)	261.83
Iron (mg)	4.69
Zinc (mg)	2.02
Copper (mg)	0.36
Manganese (mg)	0.39

Table 13: Sugars and dietary fibre contents of sports food (g/100 g)

Components		Content
Sugars		
	Reducing sugar	9.13
	Non reducing sugar	38.25
	Total sugar	47.38
Starch		18.53
Dietary fibre	Soluble dietary fibre	1.48
	Insoluble dietary fibre	2.79
	Total dietary fibre	4.27

Table 14: Fatty acid composition of sports food

Fatty acids	Content (g/100 g of total fatty acids)
Saturated fatty acids	
Myristic acid	0.42
Palmitic acid	13.89
Stearic acid	3.20
Arachidic acid	0.34
Behanic acid	0.16
Total saturated fatty acids	18.02
Mono unsaturated fatty acids	
Palmotolic acid	0.19
Oleic acid	28.88
Total mono unsaturated fatty acids	29.07
Poly unsaturated fatty acids	
Linoleic acid	46.90
Linolenic acid	6.02
Total polyunsaturated fatty acids	52.92
Trans fatty acid	Not detected

Table 15: Amino acid composition of sports food (mg/g N)

Essential Amino acids	Content	Non essential amino acids	Content
Lysine	258	Alanine	223
Tryptophan	57	Aspartic acid	438
Phenyl alanine	267	Glutamic acid	1102
Tyrosine	249	Glysine	271
Methionine	70	Proline	13
Cystine	39	Serine	271
Threonine	241		
Leucine	468		
Isoleucine	223		
Valine	324		
Semi essential amino acids			
Arginine	267		
Histidine	114		

Table 16: Protein quality of sports food

Parameters	Value
1. *In vitro* protein digestibility (%)	79.15
2. **Amino acid score**	
Lysine	0.76
Tryptophan	0.95
Phenyl alanine	3.11
Methionine	1.14
Threonine	0.96
Leucine	1.06
Isoleucine	0.89
Valine	1.04
3. Net Protein Value	10.85

Table 17: Effect of storage on physical properties of sports food

Parameters	Zero day	180 day	't' value
Colour			
L (Lightness)	91.29	88.23	5.16**
a (Redness)	1.29	2.29	3.45**
b (Yellowness)	10.80	14.87	6.38**
ΔE		5.20	
pH	6.63	6.60	1.86 ^{NS}
a_w	0.51	0.54	2.11 ^{NS}
Texture of porridge (g force)#	8.10	8.40	0.92 ^{NS}

Work required to back extrude specific amount of porridge
$\Delta E = \sqrt{\Delta L^2 + \Delta a^2 + \Delta b^2}$
** - Significant at 1%
NS – Non-significant

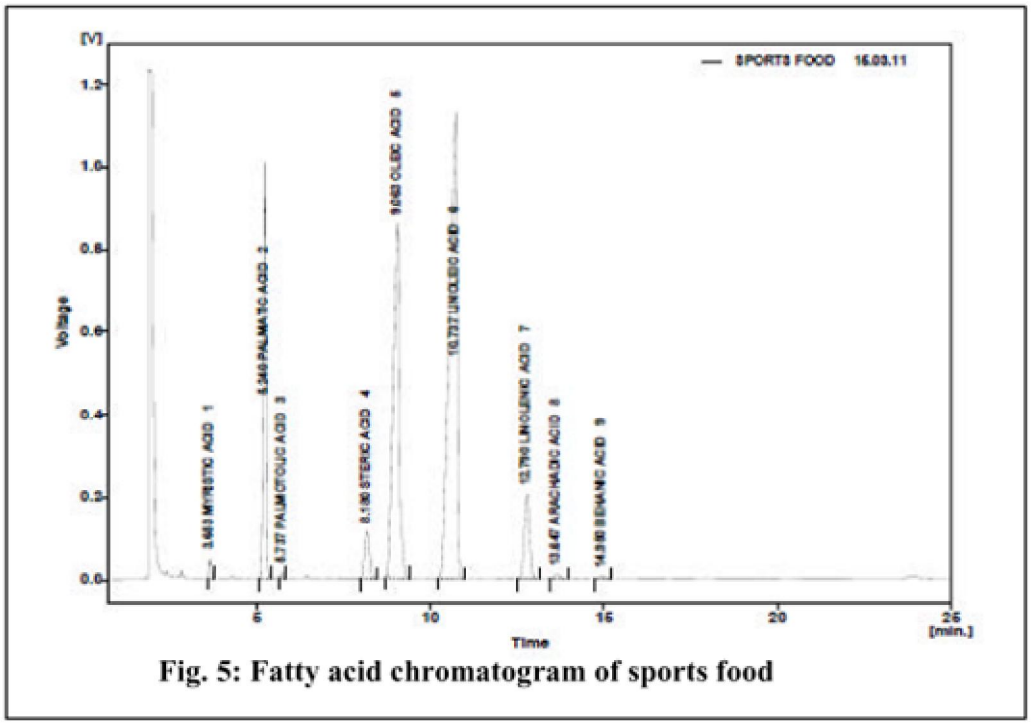


Fig. 5: Fatty acid chromatogram of sports food

Fig 5. Fatty acid chromatogram of sports food

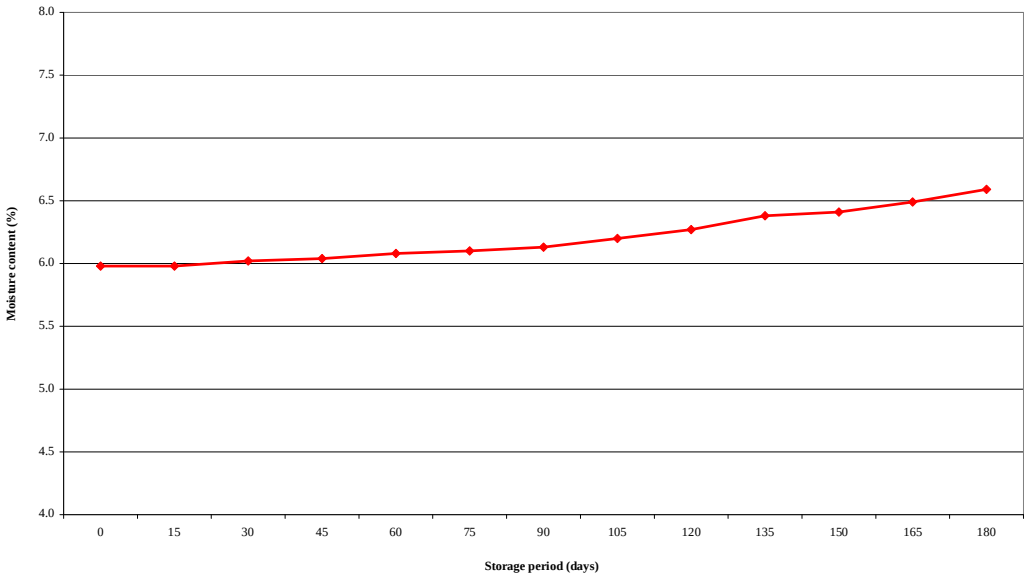


Fig. 6. Effect of storage on moisture content of sports food

Fig 6. Fig. 6. Effect of storage on moisture content of sports food

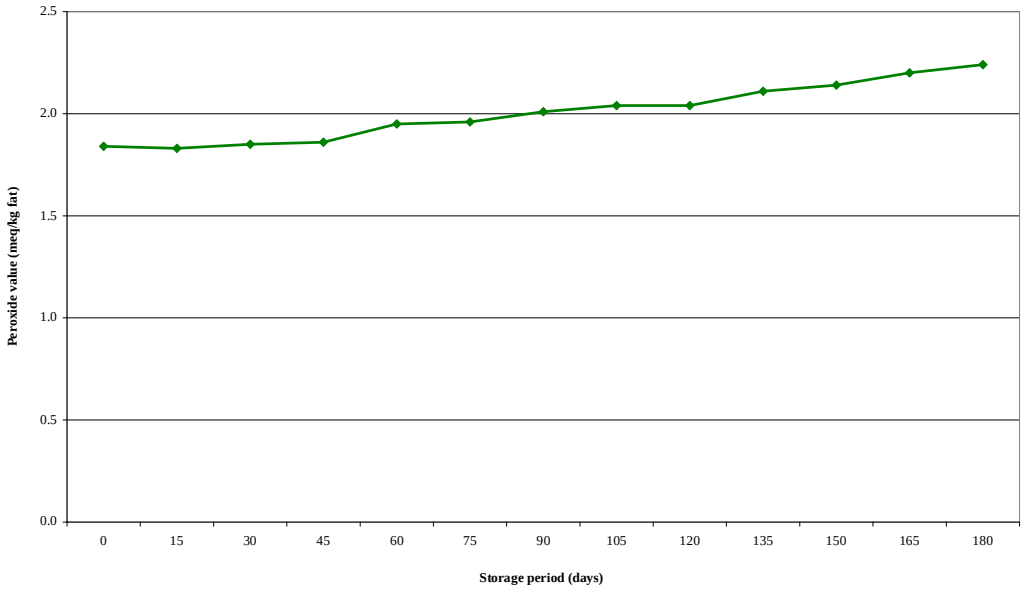
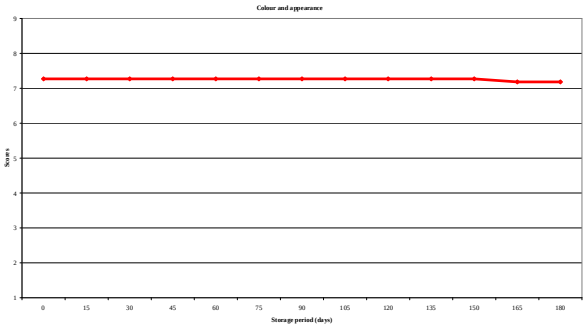


Fig. 7. Effect of storage on peroxide value of sports food

Fig. 7. Effect of storage on peroxide value of sports food



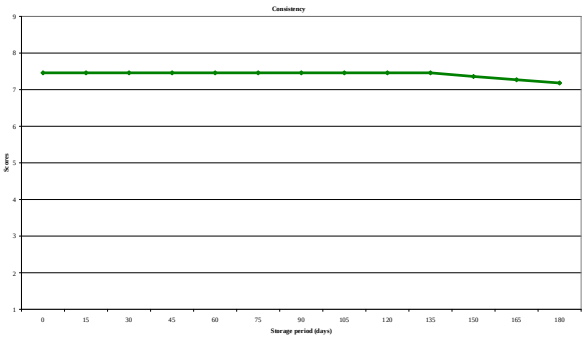
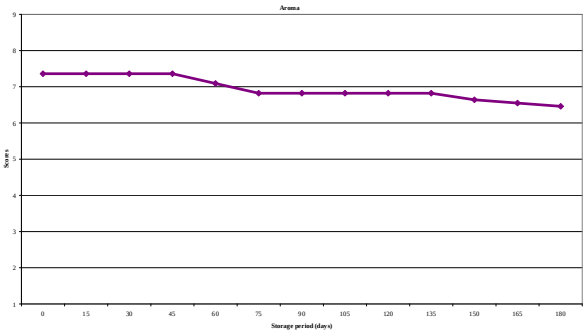
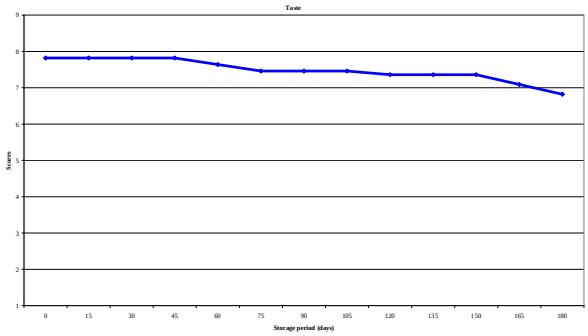


Fig. 8. Effect of storage on sensory scores of porridge prepared from sports food





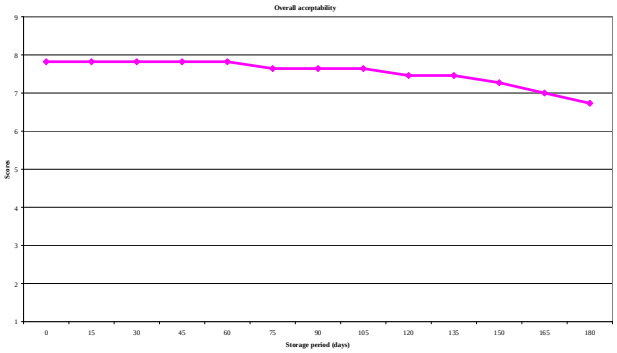


Fig 8. Effect of storage on sensory scores of porridge prepared from sports food

The mean scores for taste of porridge from sports food exhibited declining trend (7.82-6.82) which was found be significantly different at 165 and 180 days compared with zero days of storage. The decrease in overall acceptability score (7.82-6.73) was significantly lower only at 165 and 180 days compared with zero days of storage. However, the porridge was acceptable even at the end of storage period.

4.3 Sensory profile of sports food

4.3.1 Descriptive sensory characteristics of porridge from sports food

Table 18 depicts the descriptive sensory characteristics of porridge from sports food. The colour of the porridge was creamish and had smooth and attractive appearance. The aroma of the porridge was pleasant with cardamom flavour. The mouth feel of the porridge was described to be smooth, swallow able, very easy to consume without any after taste. The taste of the porridge was described to be sweet, mild roasted flavour with highly acceptable taste.

4.3.2 Consumer acceptability of sports food

The sports food was evaluated for consumer acceptability (Plate 2) utilizing food action (FACT) rating scale and the results are presented in Table 19.

The mean score was highest among track and field athletes (8.18) followed by martial arts players (8.11), team game players (8.08), gymnasts (7.83) and weight lifters (7.59). The mean score given by coaches was 7.55. However, no significant difference was observed between the consumer groups.

Among total consumers, majority (46.15%) revealed that they would eat the porridge from sports food at every opportunity. While, one fourth of them reported that they would eat very often. Only 4.49 per cent of them expressed that they would eat only if the product is available. None of the subject mentioned that they disliked the product.

4.4 Efficacy of sports food

The efficacy of the sports food to enhance the performance was tested in sportsman. The effect of sports food on endurance capacity was tested by two different strategies *viz*., carbohydrate loading for three days prior to endurance test and as pre-event meal consumed one hour before the endurance test. The impact of supplementation of sports food for 90 days was tested on anthropometry, haemoglobin and physical fitness in another group of sports persons. The results are presented here.

4.4.1 Efficacy of sports food for carbohydrate loading and pre-event meal

The subjects selected for the study were given orientation about the experiment (Plate 3). The efficacy of sports food in improving the endurance capacity in sports persons was studied by carbohydrate loading and as prevent meal. The results of the study are presented here.

4.4.1.1 General information of the subjects

The information about age, education and food habits of 31 subjects in is presented in Table 20. Majority of the subjects in both sports hostel (68.75%) and free living (60.00%) were aged between 18 to 20 years. Nearly one third of the subjects in both the groups were in the age group of 21 to 23 years. Only 6.67 per cent of free living subjects were between the age of 24 and 26 years. With respect to education, 81.25 of sports hostel and 66.67 per cent of free living subjects were studying Pre University Course. Only 18.75 and 33.33 per cent of sports hostel and free living subjects, respectively were studying graduation. The data on food habits shows that majority (93.75%) of sports hostel subjects belonged to non vegetation food group. Only 6.25 per cent of them were eggerians. In case of free living subjects, 40.00 per cent were eggerians and remaining 60.00 per cent were non vegetarians.

Among the sports hostel subjects, 62.50 per cent were actively participating in sports for 1 to 3 years and 37.50 per cent were taking active participation for 3 to 6 years. In free living subjects, 60 and 40 per cent were actively participating in sports for 1 to 3 years and 3 to 5 years, respectively.

Table 18: Descriptive sensory characteristics of porridge from little millet based sports food

Parameter	Descriptive sensory characteristics
Colour and appearance	Creamish and attractive with smooth and appealing appearance
Aroma	Pleasant with cardamom flavor
Mouth feel	Smooth, swallowable, very easy to consume without any after taste
Taste	Sweet, mild roasted flavor and highly acceptable taste

Plate 2. Consumer acceptability of porridge from sports food mix

Table 19: Consumer acceptability of porridge from sports food

FACT rating Scale	Consumer groups							Total (N=156)
	Score	Coaches (n=11)	Track and field athletes (n=39)	Team game players (n=59)	Gymnasts (n=12)	Weight lifters and boxers (n=17)	Martial arts (n=18)	
Eat every opportunity	9	4 (36.36)*	19 (48.72)	26 (44.06)	5 (41.67)	8 (47.05)	10 (55.56)	72 (46.15)
Eat very often	8	3 (27.27)	12 (30.77)	18 (30.51)	2 (16.67)	2 (11.76)	2 (11.11)	39 (25.00)
Eat frequently	7	1 (9.09)	5 (12.82)	10 (16.95)	3 (25.00)	2 (11.76)	4 (22.22)	25 (16.03)
Eat now and then	6	1 (9.09)	2 (5.19)	4 (6.78)	2 (16.67)	2 (11.76)	2 (11.11)	13 (8.83)
Eat if available	5	2 (18.18)	1 (2.56)	1 (1.69)	-	3 (17.64)	-	7 (4.49)
Mean scores		7.55±1.57	8.18 ±1.02	8.08 ±1.02	7.83±1.19	7.59±1.62	8.11±1.13	7.95±1.26
F value between the groups		1.08 ^{NS}						

FACT – Food Action Rating Scale
* Figures in parentheses indicate per cents
NS- Non significant

With regard to level of participation is sports, there existed a variation among sports hostel and free living subjects. Higher percentage of sports hostel subjects participated in national (6.25) and state level (56.25) competitions compared to free living subjects. Among free living subjects, none participated in national level and 40 per cent took part in state level sports. In district and university competitions, 18.75 per cent each of sports hostel subjects participated, while 20.00 and 13.33 per cent of free living subjects, respectively took part. College level participation was observed only in free living subjects (26.66%).

Majority of the subjects in both the groups exercised for six days in a week. Only 12.50 per cent of sports hostel subjects and 20.00 per cent of free living subjects exercised daily. While, 13.33 per cent of free living subjects exercised for 4 to 5 days per week.

Table 21 presents the time spent for exercise and sleep by the subjects. Majority of the sports hostel subjects exercised for 2 to 3 hours in the morning (87.50%) and evening (81.25%). Lower percentage of sports hostel subjects exercised for more than 3 hours in the morning (12.50%) and evening (18.75%). In free living, majority of the subjects exercised for 2 to 3 hours in the morning (73.37%) and evening (53.36%). Only 13.34 per cent each of subjects exercised for 1 to 2 hours and more than 3 hours in the morning. In the evening session, 26.67 and 20.00 per cent of subjects exercised for 1 to 2 and more than 3 hours, respectively.

During night, majority of the sports hostel subjects slept for 7 to 8 hours (81.25%). This was followed by 8 to 9 hours (12.50) and less than 7 hours (6.25%) of sleep. During day time, 68.75 per cent of the sports hostel subjects slept for 2 to 3 hours and only 31.25 per cent slept for more than 3 hours. In free living subjects, majority of them (66.67%) slept for 8 to 9 hours, followed by more than 9 hours (20.00%) and 7 to 8 hours (13.33%). During day time, 46.69 per cent of the free living subjects did not sleep. While, 20.00, 26.67 and 6.67 per cent of the subjects slept for less than 1 hour, 1 to 2 hours and 2 to 3 hours, respectively.

4.4.1.2 Games played by the subjects

The different games played by the subjects are presented in Table 22. It is observed that basket ball was played by all the sports hostel subjects daily, while 80.00 per cent of free living subjects played basket ball game every day. Only 20.00 per cent of free living subjects played basket ball game thrice in a week. The volley ball games was played by majority of the subjects (87.50% in sports hostel and 40.00% in free living) twice a week. The net ball, hand ball and foot ball games were played by most the subjects twice a week or once in a week. Cricket was played by majority of the free living subjects (46.66%) thrice a week. While cricket was played by majority of the sports hostel subjects once or twice in a week.

4.4.1.3 Special foods consumed by the subjects

Various special foods consumed by the subjects are listed in Table 23.

All the subjects from sports hostel consumed almonds, eggs and milk daily which were provided in hostel. While, free living subjects consumed various foods which they thought would help them to improve health and perform better in sports. Majority (80.00%) of the free living subjects consumed egg regularly. This was followed by consumption of milk (73.33%), resin (66.67%), health drinks (46.67%), soaked bengal gram (40.00%) and dates (26.67%). The consumption of almonds (26.67%) and ghee (20.00%) was recorded in lower percentage of subjects. The subjects expressed that these special foods helped them for better health, formation of blood, gives energy and relieve them from pain.

4.4.1.4 Foods consumed before, during and after the event by the subjects

The various foods consumed before, during and after the event by the subjects are depicted in Table 24.

Among different foods consumed before the event, *idli* was the most preferred by both sports hostel (87.50%) and free living (73.33%) subjects. The sports hostel subjects also consumed fruit juice (50.00%), biscuit (43.75%) and fruits (37.50%) before the event.

During the event subjects consumed glucose. Fifty per cent of sports hostel subjects and 80.00 per cent of free living subjects consumed glucose during the event.

Plate 3. Orientation to the subjects by subject matter specialists and taking consent

Table 20: General information of the subjects

Particulars	Category	Sports hostel (n=16)		Free living (n=15)	
		Frequency	Per cent	Frequency	Per cent
Age (years)	18-20	11	68.75	9	60.00
	21-23	5	31.25	5	33.33
	24-26	-	-	1	6.67
Education	PUC	13	81.25	10	66.67
	Graduation	3	18.75	5	33.33
Food habit	Eggerian	1	6.25	6	40.00
	Non vegetarian	15	93.75	9	60.00
Duration of active participation in sports	1-3 years	10	62.50	9	60.00
	3-6 years	6	37.50	6	40.00
Level of participation	National	1	6.25	-	-
	State	9	56.25	6	40.00
	District	3	18.75	3	20.00
	University	3	18.75	2	13.33
	College			4	26.66
Frequency of exercise	Daily	2	12.50	3	20.00
	6 days/ week	14	87.50	10	66.67
	4-5 days/ week	-	-	2	13.33

Table 21: Time spent for exercise and sleep by the subjects

Time (hours/day)	Sports hostel (n=16)		Free living (n=15)	
	Frequency	Per cent	Frequency	Per cent
Exercise				
Morning				
1-2	-	-	2	13.33
2-3	14	87.50	11	73.33
>3	2	12.5	2	13.33
Evening				
1-2	-	-	4	26.67
2-3	13	81.25	8	53.33
>3	3	18.75	3	20.00
Sleep				
During night				
<7	1	6.25	-	-
7-8	13	81.25	2	13.33
8-9	2	12.50	10	66.67
>9	-	-	3	20.00
During day				
Do not sleep	-	-	7	46.66
<1	-	-	3	20.00
1-2	-	-	4	26.66
2-3	11	68.75	1	6.66
>3	5	31.25	-	-

Table 22: Games played by the subjects

Frequency	Basketball		Volleyball		Netball		Handball		Football		Cricket	
	Sports hostel (n=16)	**Free living (n=15)**	**Sports hostel (n=16)**	**Free living (n=15)**	**Sports hostel (n=16)**	**Free living (n=15)**	**Sports hostel (n=16)**	**Free living (n=15)**	**Sports hostel (n=16)**	**Free living (n=15)**	**Sports hostel (n=16)**	**Free living (n=15)**
Daily	16 (100.00)	12 (80.00)	-	-	-	-	-	-	-	-	-	3 (20.00)
Thrice a week	-	3 (20.00)	2 (12.50)	2 (13.33)	-	5 (33.35)	-	-	-	-	-	7 (46.66)
Twice a week	-	-	14 (87.50)	6 (40.00)	7 (43.75)	3 (20.00)	2 (12.50)	3 (20.00).	3 (18.75)	2 (13.34)	11 (68.75)	3 (20.00)
Once a week	-	-	-	2 (13.33)	-	2 (13.34)	-	4 (26.67)	3 (18.75)	7 (46.66)	4 (25.00)	2 (13.33)

Table 23: Special foods consumed by the subjects

Foods	Sports hostel (n=16)		Free living (n=15)	
	Frequency	Per cent	Frequency	Per cent
Soaked Bengal gram	-	-	6	40.00
Dates	-	-	6	40.00
Almonds	16	100	4	26.67
Cashew	-	-	6	40.00
Resins	-	-	10	66.67
Egg	16	100	12	80.00
Ghee	-	-	3	20.00
Milk	16	100	11	73.33
Health drinks	-	-	7	46.67

Table 24: Foods consumed before, during and after the event by the subjects

Foods	Sports hostel (n=16)		Free living (n=15)	
	Frequency	Per cent	Frequency	Per cent
Before the event				
Idli	14	87.50	11	73.33
Milk	-	-	7	46.67
Biscuit	7	43.75	4	26.67
Fruit	6	37.50	3	20.00
Fruit juice	8	50.00	6	40.00
During the event				
Glucose	8	50.00	12	80.00
After the event				
Glucose	12	75.00	10	66.67
Fruit	3	18.75	6	40.00
Fruit juice	10	62.50	8	53.33
Lassi/milk shake	-	-	8	53.33
Biscuit	8	50.00	6	40.00
Chocolate			7	46.67

Among the various foods consumed after the event, majority of the subjects (75.00% in sports hostel and 66.67% in free living) consumed glucose. This was followed by fruit juice (62.50% in sports hostel and 53.33% in free living). Fifty per cent of sports hostel subjects consumed biscuits after the event. In free living, *lassi* or milk shake, chocolate and fruits were consumed by 53.33, 46.67 and 40.00 per cent of subjects, respectively.

4.4.1.5 Foods avoided before, during and after the event by the subjects

Table 25 depicts the foods avoided before, during and after the event by the subjects. All of the subjects avoided heavy meals before the event. The fried foods, non-vegetarian foods and spicy foods were avoided by 81.25, 37.50 and 87.50 per cent of sports hostel subjects. Similarly, 80.00, 26.67 and 46.67 per cent of free living subjects avoided fried, non vegetarian and spicy foods, respectively.

During the event, 18.75 and 13.33 per cent of sports hostel and free living subjects avoided glucose. Majority of subjects (87.75% in sports hostel and 80.00% in free living) avoided heavy meals immediately after the event. Carbonated beverage was avoided by 75.00 per cent and 73.33 per cent of sports hostel and free living subjects, respectively.

4.4.1.6 Nutritional status of the subjects

The nutritional status of the subjects as assessed by anthropometry, haemoglobin estimation and diet survey are presented here (Plate 4).

4.4.1.6.1 Anthropometry and haemoglobin level of the subjects

The anthropometric measurements and haemoglobin level of the subjects are presented in Table 26. The mean height of the sports hostel subjects (182.31cm) was significantly higher than the free living subjects (177.74 cm). The weight of sports hostel subjects (71.00kg) was higher than the free living subjects (68.97 kg), but no statistically significant difference was observed. The free living subjects had a higher BMI value (21.86 kg/m^2) than the sports hostel subjects (21.40 kg/m^2). But the statistical test revealed that there was no significant difference between the groups. The mean circumferences of chest, mid upper arm, waist and hip were higher for sports hostel subjects (90.72, 28.59, 79.83 and 88.85 cm, respectively) than free living subjects (88.65, 27.75, 78.49 and 87.97 cm, respectively). However no significant differences were noted between the groups. The waist: hip ratio of sports hostel (0.90) and free living (0.89) subjects was statistically on par with each other. The body fat was significantly lower in sports hostel (15.54 %) than the free living (17.99 %) subjects. The mean haemoglobin was recorded to be significantly higher in sports hostel subjects (13.53 g/dl) than free living subjects (12.76 g/dl).

The distribution of the subjects based on BMI, waist:hip ratio, body fat and haemoglobin level is presented in Table 27.

The results showed that all the sports hostel subjects had an ideal BMI, while, 93.33 per cent of free living subjects had ideal BMI. Only 6.67 per cent of free living subjects were over weight (23.00 – 24.90 kg/m^2) according to BMI classification. None of the subjects had BMI less than 18.50 and more than 25.00 kg per m^2. All the subjects from both sports hostel and free living had normal waist:hip ratio. None of them was obese according to waist:hip ratio.

None of the subjects from both the groups had body fat percentage less than 7.00 per cent indicating no one was lean. In sports hostel subjects, 56.25 per cent had desirable body fat. While, only 26.67 per cent of free living subjects had desirable body fat. The percentage of subjects having undesirable body fat was higher in free living subjects (73.33%) than sports hostel subjects (43.75%).

The haemoglobin level of subjects revealed that none of the subject from both the group had undesirable haemoglobin level. The percentage of subjects having borderline haemoglobin content was higher in free living subjects (60.00%) than sports hostel subjects (37.50). While, higher percentage of sports hostel subjects (62.50%) had desirable haemoglobin level than free living subjects (40.00%).

Table 25: Foods avoided before, during and after the event by the subjects

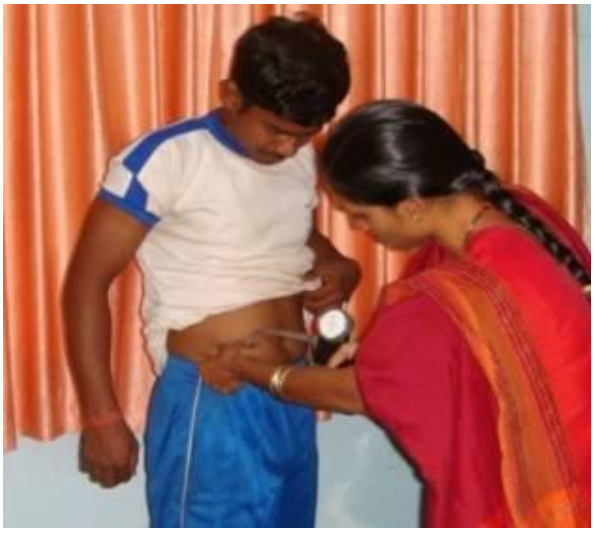
Foods	Sports hostel (n=16)		Free living (n=15)	
	Frequency	Per cent	Frequency	Per cent
Before the event				
Heavy meal	16	100.00	15	100.00
Fried foods	13	81.25	12	80.00
Non vegetarian foods	6	37.50	4	26.67
Spicy foods	14	87.50	7	46.67
During the event				
Glucose	3	18.75	2	13.33
After the event				
Heavy meal	14	87.75	12	80.00
Carbonated beverage	12	75.00	11	73.33

Table 26: Anthropmetric measurements and haemoglobin status of the subjects

Parameters	Sports hostel (n=16)	Free living (n=15)	't' value
Height (cm)	182.31 $\pm$ 4.12	177.74 $\pm$ 5.23	2.70*
Weight (kg)	71.00 $\pm$ 3.21	68.97 $\pm$ 2.82	1.87 ^{NS}
BMI (kg/m^2)	21.40 $\pm$ 1.23	21.86 $\pm$ 1.20	1.07 ^{NS}
Chest circumference (cm)	90.72 $\pm$ 3.16	88.65 $\pm$ 2.82	1.92 ^{NS}
MUAC (cm)	28.59 $\pm$ 1.69	27.75 $\pm$ 1.71	1.37 ^{NS}
Waist circumference (cm)	79.83 $\pm$ 1.42	78.49 $\pm$ 1.87	1.47 ^{NS}
Hip circumference (cm)	88.85 $\pm$ 1.67	87.97 $\pm$ 2.08	1.30 ^{NS}
Waist:hip ratio	0.90 $\pm$ 0.02	0.89 $\pm$ 0.02	0.88 ^{NS}
Body fat (%)	15.54 $\pm$ 2.35	17.99 $\pm$ 1.62	3.37**
Haemoglobin (g/dl)	13.53 $\pm$ 0.73	12.76 $\pm$ 0.59	3.22**

MUAC – Mid upper arm circumference
* - Significant at 5% level
** - Significant at 1% level
NS - Non-significant

Anthropometric measurement



Skin fold thickness measurements

Diet survey

Haemoglobin estimation

Plate 4. Assessment of nutritional status of the subjects

4.4.1.6.2 Food intake and adequacy of the subjects

The results of the food intake revealed differences among sports hostel and free living subjects (Table 28). It is observed from the Table that the mean intake of foods was lower than the suggested dietary allowance for all foods except pulses and fat.

The mean intake of cereals was higher for sports hostel subjects (488.26 g) compared to free living (433.78 g) subjects. The difference was statistically significant. The mean per cent adequacy for cereals was 81.56 and 78.87 in sports hostel and free living subjects, respectively. The mean intake of pulses was higher than the suggested dietary allowance (51.86 g in sports hostel subjects and 42.72 g in free living subjects).

The intake of green leafy vegetables was very low with an adequacy of nearly 7.00 per cent for both the group of subjects. No statistically significant differences were observed between sports hostel (10.30 g) and free living (10.58 g) subjects.

The per cent adequacy for roots and tubers and other vegetables were 41.43 and 74.17 in sports hostel and 35.73 and 51.15 in free living subjects. No statistically significant differences were observed for roots and tubers and other vegetables between the groups. The intake of fruits was significantly ($p<0.01$) higher for sports hostel (163.97 g) subjects with a corresponding adequacy of 109.31 per cent compared with free living (92.86 g) subjects, wherein the adequacy was just 61.91 per cent. With respect to milk intake, the per cent adequacy was significantly ($p<0.01$) higher in sports hostel subjects (94.09) compared with free living subjects (51.90). The adequacy of fat was 140.52 and 130.46 per cent in sports hostel and free living subjects, respectively. Statistical test revealed no significant difference for consumption of fat between the groups. The per cent adequacy for meat was significantly higher in sports hostel subjects (48.06) than free living subjects (16.94). The free living subjects consumed significantly lower (53.54 g) quantity of egg compared with sports hostel subjects (96.38 g). The mean consumption of nuts and oil seeds was higher in sports hostel subjects (36.90 g) than free living subjects (23.86 g).

4.4.1.6.3 Nutrient intake and adequacy of the subjects

Table 29 presents the nutrient intake of the subjects in comparison with RDA. The Table revealed that the per cent adequacy for nutrients was higher in sports hostel subjects than free living subjects. The energy intake of sports hostel subjects (4033 Kcal) was significantly higher than free living subjects (3412 Kcal). With regard to protein, the per cent adequacy was higher for sports hostel subjects (78.86) than free living subjects (57.86%). The fat intake was more than 100 per cent in sports hostel subjects (121.97%) while per cent adequacy was 93.18 in free living subjects. Significantly lower intake for vitamins and minerals was observed in free living subjects than sports hostel subjects. The vitamin A adequacy was 56.87 per cent in sports hostel subjects which was significantly higher than free living subjects (38.87%). The per cent adequacies for thiamine, riboflavin and niacin were 98.57, 86.29 and 69.69, respectively in sports hostel subjects, while 84.57, 68.86 and 51.51 per cent in free living subjects. The folic acid intake was significantly lower in free living subjects (204.60 μg) than sports hostel subjects (248.40 μg). The per cent adequacies for vitamin C, calcium and iron in sports hostel subjects were 72.23, 95.67 and 60.42, which were significantly higher than free living subjects. The intake of zinc was 11.28 and 9.46 mg in sports hostel and free living subjects, respectively.

4.4.1.6.4 Frequency of food consumption in the subjects

The frequency of food consumption in the subjects is presented in Table 30. The cereals and pulses were consumed daily by both sports hostel and free living subjects. The consumption of other vegetables, milk, cooking oil and sugar/jaggery was also recorded daily in both the groups. But, there was a difference in the frequency of consumption of other foods. Leafy vegetables were consumed once in a fortnight by all the sports hostel subjects. Majority of free living subjects (53.33%) consumed leafy vegetables once in a week. The consumption of roots and tubers was weekly twice by all the sports hostel subjects while 60.00 per cent of the free living subjects consumed roots and tubers weekly once. Nuts and oilseeds, meat, egg, fruit and fruit juices were consumed by all the sports hostel subjects daily. While, the free living subjects consumed these foods less frequently compared to sports hostel subjects.

Table 27: Distribution of the subjects based on BMI, waist to hip ratio, body fat and haemoglobin level

Parameters	Classes	Category	Sports hostel (n=16)		Free living (n=15)	
			Frequency	Per cent	Frequency	Per cent
BMI (kg/m^2)	18.5 – 22.9	Ideal BMI	16	100	14	93.33
	23.0 – 24.9	Over weight	-	-	1	6.67
Waist to hip ratio	<0.95	Normal	16	100	15	100
Body fat (%)#	7 – 15	Desirable	9	56.25	4	26.67
	>15	Undesirable	7	43.75	11	73.33
Haemoglobin (g/dl)#	11 – 13	Borderline	6	37.50	9	60.00
	>13	Desirable	10	62.50	6	40.00

Classification for sports persons (Goswami, 2005)

Table 28: Food intake and adequacy of the subjects

Foods (g)	SBD	Sports hostel(n=16)		Free living(n=15)		t value
		Intake	Adequacy (%)	Intake	Adequacy (%)	
Cereals	550	448.26	81.56	433.78	78.87	2.47*
Pulses	40	51.86	129.65	42.72	106.8	2.45*
Green leafy vegetables	150	10.30	6.87	10.58	7.05	0.27^{NS}
Roots and tubers	150	82.85	41.43	71.46	35.73	1.56^{NS}
Other vegetables	200	111.26	74.17	76.73	51.15	1.60^{NS}
Fruits	150	163.97	109.31	92.86	61.91	14.70**
Milk (ml)	750	705.67	94.09	389.28	51.90	15.88**
Fat	50	70.26	140.52	65.23	130.46	1.93^{NS}
Sugars	80	68.56	85.57	51.47	64.34	6.67**
Meat	250	120.15	48.06	42.35	16.94	9.51**
Egg	100	96.38	96.38	53.54	53.54	15.27**
Nuts and Oilseeds	NA	36.90	-	23.86	-	6.84**

NA- Not available
- SBD suggested balanced diet by Satyanarayana *et al*. (1985)
* - Significant at 5% level
** - Significant at 1% level
NS - Non-significant

Table 29: Nutrient intake and adequacy of the subjects

Nutrients	RDA#	Sports hostel (n=16)		Free living (n=15)		t value
		Intake	Adequacy (%)	Intake	Adequacy (%)	
Energy (Kcal)	4320	4033	93.36	3412	78.98	8.37**
Protein (g)	130-150	109	78.86	81	57.86	7.16**
Fat (g)	105-160	161	121.97	123	93.18	8.27**
Carbohydrate (g)	600-700	537	82.62	482	74.15	2.75*
Vitamin A (μg)	1000-2000	853	56.87	583	38.87	15.34**
Thiamine (mg)	3-4	3.45	98.57	2.96	84.57	4.16**
Riboflavin (mg)	3-4	3.02	86.29	2.41	68.86	5.18**
Niacin (mg)	40-50	31.46	69.69	23.18	51.51	7.75**
Folic acid (μg)	400	248.40	62.10	204.60	51.15	4.73**
Vitamin C (mg)	100-200	108.35	72.23	70.58	47.05	9.87**
Calcium (mg)	1000-2000	1435	95.67	874	58.27	14.70**
Iron (mg)	50-75	37.46	60.42	28.23	45.53	4.81**
Zinc (mg)	NA	11.28	-	9.46	-	2.47*

NA- Not available
- Satyanarayana *et al*. (1985)
* - Significant at 5% level
** - Significant at 1% level
NS - Non-significant

The consumption of cheese and butter was more frequent in sports hostel subjects compared to free living subjects. The frequency of consumption of bakery products, fast foods and chocolates was observed to be more in free living subjects than sports hostel subjects.

4.4.1.7 Energy balance of the subjects

Table 31 presents the energy balance of the subjects. The energy intake and expenditure of sports hostel subjects (4033 and 3648 Kcal, respectively) were significantly higher than free living subjects (3365 and 3148 Kcal, respectively). However, both the groups of subjects were in positive energy balance.

4.4.1.8 Effect of carbohydrate loading on endurance capacity of the subjects

The results of efficacy of developed sports food in increasing the endurance capacity of the sports persons (Plate 5) are presented below.

The effect of carbohydrate loading with sports food on endurance capacity of the subjects is presented in Table 32. The Table revealed that there was a significant influence of carbohydrate loading on time to exhaustion, distance covered and calories burnt. In the sports hostel subjects, the time to exhaustion increased from 34.62 to 41.29 minutes after loading. Similarly, the distance covered and calories burnt increased from 5.77 to 6.88 km and 346.20 to 412.90 Kcal, respectively. In free living subjects, the time to exhaustion increased from 20.87 to 26.33 minutes. Significant improvement in distance covered (3.48 – 4.39 km) and calories burnt (208.70 – 263.30 Kcal) were also recorded in free living subjects.

Further, the Table depicts that the effect of carbohydrate loading on endurance capacity increased from 27.97 to 32.32 minutes when both the groups were combined. The increase in distance covered was from 4.66 to 5.39 km, while increase in calories burnt increased from 279.70 to 323.20 Kcal.

The per cent improvement in endurance capacity of the subjects by carbohydrate loading with sports food is presented in Fig. 9. The results indicated that the improvement was more pronounced in free living subjects (18.81%) than the sports hostel subjects (13.70%). The improvement in both the groups combined was 15.55 per cent with a range of 8.99 to 26.51 per cent.

4.4.1.9 Effect of sports food as pre event meal on endurance capacity of subjects

The sports food was provided as pre event meal and endurance capacity of the subjects in comparison with routinely consumed pre event meal was studied. The results are presented in Table 33.

The Table revealed that the mean time to exhaustion of the sports hostel subjects was 40.78 min when routine pre event meal was consumed. The mean time to exhaustion increased to 41.29 min when sports food was consumed before the endurance capacity test. The distance covered and calories burnt were 6.77 km and 407.80 Kcal, respectively when routine pre event meal was consumed. While, the sports hostel subjects covered a distance of 6.88 km and burnt 412.90 kcal.

In free living subjects, the time to exhaustion was 25.62 min when routine pre event meal was consumed. While, the subjects got exhausted in 26.33 min after consuming sports food as pre event meal. The subjects covered a distance of 4.27 and 4.39 km when they consumed routine pre event meal and sports food, respectively. The calories burnt after routine pre event meal and sports food were 256.20 and 263.30 Kcal, respectively.

The mean time to exhaustion of both the groups of subjects combined was 33.44 min for routine pre event meal and 34.05 min for sports as pre event meal. The distance covered and calories burnt by the subjects were 5.57 km and 334.40 Kcal for routine pre event trial, respectively. While, during sports food trial, the subjects covered a distance of 5.68 km and burnt 340.50 Kcal. The statistical test showed that the performance of subjects was significantly better in sports food trial than routine pre event meal.

The per cent improvement in endurance capacity of the subjects with consumption of pre-event meals is depicted in Fig. 10.

Table 30: Frequency of food consumption by the subjects

Foods	Daily		Weekly twice		Weekly once		Fortnightly		Once a month		Occasionally		Never	
	Sports hostel (n=16)	Free living (n=15)	Sports hostel (n=16)	Free living (n=15)	Sports hostel (n=16)	Free living (n=15)	Sports hostel (n=16)	Free living (n=15)	Sports hostel (n=16)	Free living (n=15)	Sports hostel (n=16)	Free living (n=15)	Sports hostel (n=16)	Free living (n=15)
Cereals	16 (100)	15 (100)	-	-	-	-	-	-	-	-	-	-	-	-
Pulses	16 (100)	15 (100)	-	-	-	-	-	-	-	-	-	-	-	-
Leafy vegetables	-	-	-	2 (13.33)	-	8 (53.34)	16 (100)	5 (33.33)	-	-	-	-	-	-
Roots and tubers	-	-	16 (100)	6 (40.00)	-	9 (60.00)	-	-	-	-	-	-	-	-
Other vegetables	16 (100)	15 (100)	-	-	-	-	-	-	-	-	-	-	-	-
Nuts and oil seeds	16 (100)	12 (80)	-	3 (20.00)	-	-	-	-	-	-	-	-	-	-
Fruits	16 (100)	4 (26.67)	-	11 (73.33)	-	-	-	-	-	-	-	-	-	-
Fish and sea foods	-	-	-	-	-	3 (20.00)	-	4 (26.67)	2 (12.50)	3 (20.00)	12 (75.00)	4 (26.67)	2 (12.50)	6 (40.00)
Meat	15 (93.75)	2 (13.33)	-	3 (20.00)	-	4 (26.67)	-	-	-	--	-	-	1 (6.25)	6 (40.00)
Egg	16 (100)	7 (46.67)	-	6 (40.00)	-	2 (13.33)	-	-	-	-	-	-	-	-
Milk/curds	16 (100)	15 (100)	-	-	-	-	-	-	-	-	-	-	-	-
Cheese	-	-	16 (100)	-	-	2 (13.33)	-	4 (26.67)	-	-	-	9 (60.00)	-	-
Butter	-	-	-	-	16 (100)	-	-	-	-	-	-	-		-
Ghee	-	4 (26.67)	-	3 (20.00)	-	3 (20.00)	-	-	-	4 (26.67)	16 (100)	1 (6.67)	-	-
Cooking oil	16 (100)	15 (100)	-	-	-	-	-	-	-	-	-	-	-	-
Sugar/jaggery	16 (100)	15 (100)	-		-	-	-	-	-	-	-	-	-	-
Bakery and fast foods	-	7 (46.67)	2 (12.50)	4 (26.67)	10 (62.5)	3 (20.00)	4 (25.00)	-	-	-	-	-	-	-
Juices	16 (100)	8 (53.34)	-	2 (13.33)	-	5 (33.33)	-	-	-	-	-	-	-	-
Chocolates	-	2 (13.33)	1 (6.25)	6 (40.00)	3 (18.75)	3 (20.00)	6 (37.50)	-	4 (25.00)	4 (26.67)	2 (12.50)	-	-	-

Table 31: Energy balance of the subjects

Particulars	sports hostel (n=16)	free living (n=15)	t value
Energy intake (Kcal)	4033	3365	5.83**
Energy expenditure (Kcal)	3648	3148	4.72**
Energy intake - Energy expenditure (Kcal)	385	217	-
Energy balance	Positive	Positive	-

Table 32: Effect of carbohydrate loading on endurance capacity of the subjects

Subjects	Particulars	Before loading	After loading	t value
Hostel (n=16)	Time to exhaustion (min)	34.62	41.29	8.11**
	Distance covered (km)	5.77	6.88	8.14**
	Calories burnt (Kcal)	346.20	412.90	8.12**
Free living (n=15)	Time to exhaustion (min)	20.87	26.33	16.70**
	Distance covered (km)	3.48	4.39	16.75**
	Calories burnt (Kcal)	208.70	263.30	16.73**
Combined (N=31)	Time to exhaustion (min)	27.97	32.32	13.33**
	Distance covered (km)	4.66	5.39	13.36**
	Calories burnt (Kcal)	279.70	323.20	13.34**

** Significant at 1%

Table 33: Effect of pre-event meal on endurance capacity of the subjects

Subjects	Particulars	Routine pre-event meal	Sports food as pre-event meal	t value
Hostel (n=16)	Time to exhaustion (min)	40.78	41.29	2.35*
	Distance covered (km)	6.77	6.88	2.38*
	Calories burnt (Kcal)	407.80	412.90	2.36*
Free living (n=15)	Time to exhaustion (min)	25.62	26.33	2.54*
	Distance covered (km)	4.27	4.39	2.58*
	Calories burnt (Kcal)	256.20	263.30	2.55*
Combined (N=31)	Time to exhaustion (min)	33.44	34.05	2.73*
	Distance covered (km)	5.57	5.68	2.75*
	Calories burnt (Kcal)	334.40	340.50	2.74*

* Significant at 5%

Loading of sports

Endurance testing on treadmill

Plate 5. Testing efficacy of sports food

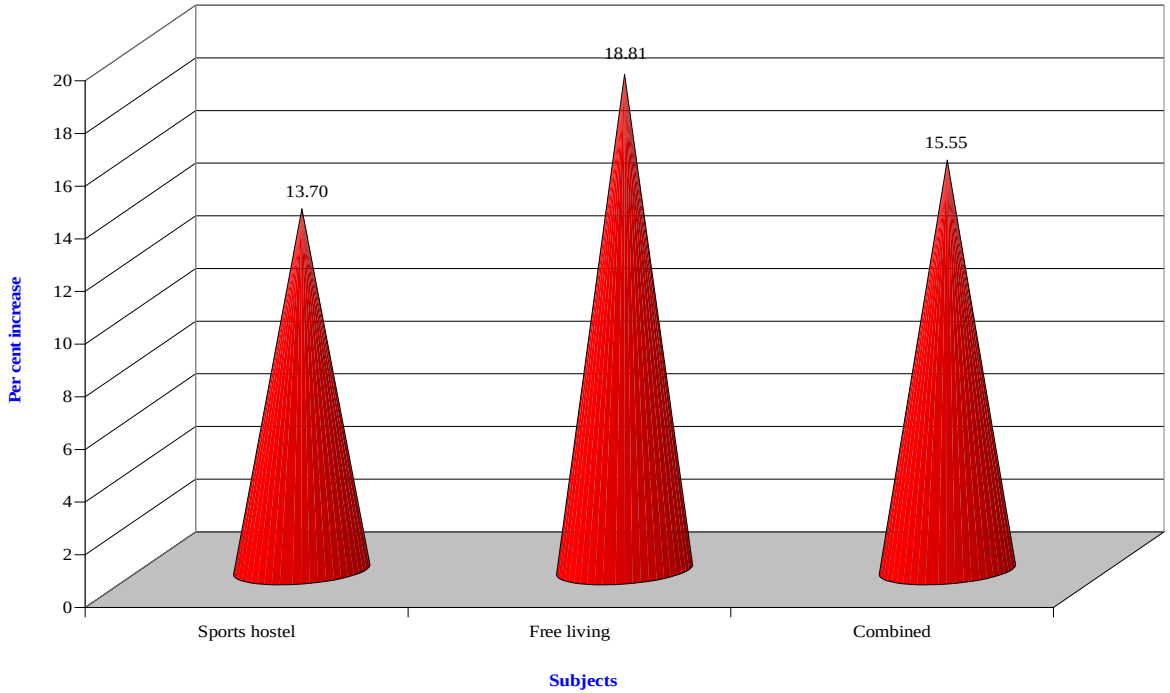


Fig. 9. Increase in endurance capacity of the subjects by carbohydrate loading

Fig. 9. Increase in endurance capacity of the subjects by carbohydrate loading

The overall improvement in endurance capacity was higher with sports food (15.29 to 34.34 with a mean of 21.75%) than routine pre-event meal (19.55%) compared to fasting conditions. When compared between the groups, the improvement in endurance capacity was better in free living subjects (26.13%) than sports hostel subjects (19.28%) with sports food.

The Fig. 11 presents the per cent improvement in endurance capacity with sports food over routine pre-event meal. The improvement in endurance capacity ranged from 0.88 to 5.17 per cent with a mean of 1.83 per cent. The improvement was better in free living subjects (2.81%) compared to sports hostel subjects (1.26%).

4.4.2 Efficacy of sports food in supplementation study

The sports food was supplemented for 90 days and the effect of supplementation (Plate 6) on anthropometry, haemoglobin and physical fitness (Plate 7) of sportsman was studied. The results of this study are presented here.

4.4.2.1 General information of the supplementation study subjects

The general information of the supplementation study subjects is presented in Table 34.

Majority (70.00%) of the subjects were in the age group of 21 to 23 years, while 30.00 per cent were in 24 to 26 years age group. All the subjects had completed graduation and were studying B.P.Ed. course. The data on food habit shows that the 73.33 per cent of the subjects were non vegetarians while remaining 26.67 per cent were eggerians.

Majority (66.67%) of the subjects were actively participating in sports for the last 3 to 6 years. Ten per cent of the subjects took active part in sports for more than six years. Remaining 23.33 per cent of subjects were involved in sports for the last 1 to 3 years.

With regard to level of participation in sports, only 3.33 per cent of subjects participated in state level competition. The district and university level of participations were observed in 40.00 and 30.00 per cent of subjects, respectively. The college level participation was observed in 26.67 per cent of subjects. All the subjects exercised for six days in a week. The spent five hours (2.5hr each in morning and evening) for exercise every day.

Different games played by the subjects are presented in Table 35. Running (53.33%) was the most widely participated event by the subjects. This was followed by cricket (40.00%), volley ball (26.67%), jumping events (23.33%), *kabaddi* (23.33%) and throw ball (20.00%). Very low percentage of subjects took part in basket ball (13.33%) and throwing events (10.00%).

4.4.2.2 Special foods consumed by the supplementation study subjects

The subjects consumed some special foods regularly, which they thought would help to improve health and performance in sports (Table 36).

The consumption of soaked bengalgram regularly was observed in 53.33 per cent of subjects. This was followed by dates (50.00%), egg (50.00%), raisins (46.67%), milk (43.33%) and ghee (13.33%). Almonds, cashew and health drinks were consumed by only 10.00 per cent each of subjects.

4.4.2.3 Foods consumed before, during and after the event by the supplementation study subjects

Table 37 depicts various foods consumed before, during and after the event by the subjects. Highest per cent (60.00%) of subjects consumed *idli* before the event. This was followed by fruit (40.00%), biscuit (26.67%), fruit juice (6.67%) and milk (3.33%). During the event glucose was consumed by 73.33 per cent of subjects.

Among the various foods consumed after the event, majority of the subjects (56.67%) consumed glucose. This was followed by biscuit (50.00%), coconut water (30.00%), chocolate (20.00%) and fruit (16.67%). The consumption of fruit juice and *lassi* were low (10.00% each).

4.4.2.3 Foods avoided before, during and after the event by the supplementation study subjects

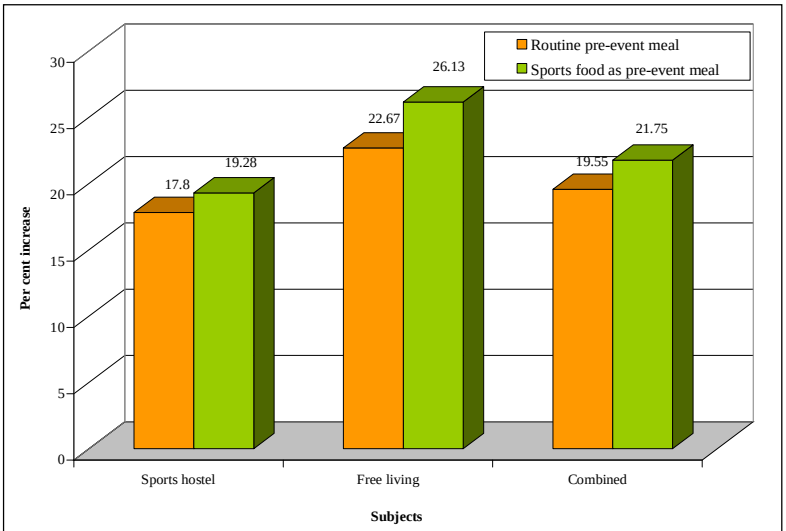


Fig. 10. Increase in endurance capacity of the subjects with consumption of pre-event meals compared to fasting

Fig. 10. Increase in endurance capacity of the subjects with consumption of pre-event meals compared to fasting

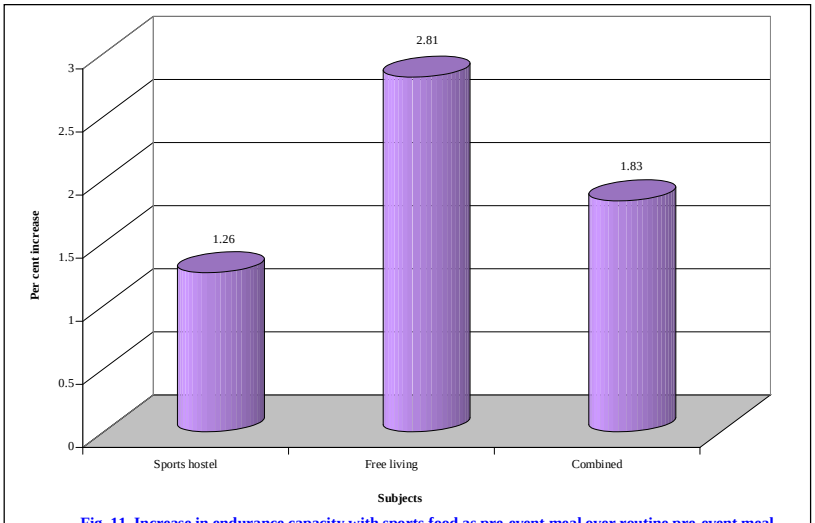


Fig. 11. Increase in endurance capacity with sports food as pre-event meal over routine pre-event meal

Fig. 11. Increase in endurance capacity with sports food as pre-event meal over routine pre-event meal

Control subjects

Experimental subjects

Plate 6. Long term supplementation study

Strength

Flexibility

Speed

Agility

Endurance capacity

Cardiac Efficiency score

Plate 7. Assessment of physical fitness

Table 34: General information of supplementation study subjects

(N=30)

Particulars	Category	Frequency	Per cent
Age (years)	21-23	21	70.00
	24-26	9	30.00
Education	Graduation	30	100.00
Food habit	Eggerian	8	26.67
	Non vegetarian	22	73.33
Duration of active participation in sports	1-3 years	7	23.33
	3-6 years	20	66.67
	>6 years	3	10.00
Level of participation	State	1	3.33
	District	12	40.00
	University	9	30.00
	College	8	26.67
Frequency of exercise	6 days/ week	30	100.00
Time spent for exercise	5 hr/day	30	100.00

Table 35: Games played by supplementation study subjects

(N=30)

Events	Frequency	Per cent
Running	16	53.33
Jumping	7	23.33
Throwing	3	10.00
Basket ball	4	13.33
Throw ball	6	20.00
Volley ball	8	26.67
Cricket	12	40.00
Kabaddi	7	23.33

Table 36: Special foods consumed by supplementation study subjects

(N=30)

Foods	Frequency	Per cent
Soaked Bengal gram	16	53.33
Dates	15	50.00
Almonds	3	10.00
Cashew	3	10.00
Raisins	14	46.67
Egg	15	50.00
Ghee	4	13.33
Milk	13	43.33
Health drinks	3	10.00

Table 37: Foods consumed before, during and after the event by supplementation study subjects

(N=30)

Foods	Frequency	Per cent
Before the event		
Idli	18	60.00
Milk	1	3.33
Biscuit	8	26.67
Fruit	12	40.00
Fruit juice	2	6.67
During the event		
Glucose	22	73.33
Fruit juice	1	3.33
After the event		
Glucose	17	56.67
Fruit	5	16.67
Fruit juice	3	10.00
Lassi/milk shake	3	10.00
Biscuit	15	50.00
Chocolate	6	20.00
Coconut water	9	30.00

Table 38: Foods avoided before, during and after the event by supplementation study subjects

(N=30)

Foods	Frequency	Per cent
Before the event		
Heavy meal	29	96.67
Fried foods	17	56.67
Non vegetarian foods	8	26.67
Spicy foods	14	46.67
During the event		
Glucose	5	16.67
After the event		
Heavy meal	26	86.67
Carbonated beverage	11	36.67

Table 39: Anthropmetric measurements and haemoglobin status of supplementation study subjects

(N=30)

Parameters	Values
Height (cm)	173.53 $\pm$ 8.85
Weight (kg)	65.31 $\pm$ 4.49
BMI (kg/m^2)	21.56 $\pm$ 1.15
Chest circumference (cm)	86.70 $\pm$ 3.50
MUAC (cm)	27.81 $\pm$ 1.86
Waist circumference (cm)	78.92 $\pm$ 2.61
Hip circumference (cm)	87.72 $\pm$ 2.21
Waist:hip ratio	0.90 $\pm$ 0.04
Body fat (%)	19.25 $\pm$ 2.27
Haemoglobin (g/dl)	12.41 $\pm$ 0.71

MUAC – Mid upper arm circumference

The foods avoided before, during and after the event by the subjects are presented in Table 38.

The results revealed that before the event heavy meal is avoided by 96.67 per cent of subjects. The fried and spicy foods are avoided before the event by 56.67 and 46.67 per cent of subjects, respectively. The non vegetarian food is avoided by 26.67 per cent of subjects. During the event 16.67 per cent of subjects avoided glucose. Immediately after the event, heavy meal is avoided by 86.67 per cent of subjects, while the carbonated beverage is avoided by 36.67 per cent of subjects.

4.4.2.4 Nutritional status of supplementation study subjects

4.4.2.4.1 Anthropometry and haemoglobin level of supplementation study subjects

The anthropometric measurements and haemoglobin status of the subjects are depicted in Table 39.

The mean height of the subjects was 173.53 cm with a range of 160 to 190 cm. The weight of the subjects ranged between 58.00 to 73.00 kg with a mean of 65.31 kg. The chest and mid upper arm circumference of the subjects were 86.70 and 27.81 cm. The mean values for waist and hip circumference were 78.92 and 87.72 cm. The body fat of the subjects was recorded to be 19.25 per cent. The subjects had a mean haemoglobin content of 12.41 g per dl.

The distribution of the subjects based on BMI, waist:hip ratio, body fat and haemoglobin level is depicted in Table 40.

The data revealed that all the subjects had ideal BMI and had normal waist:hip ratio. According to body fat content, none of the subject was lean. Only 26.67 per cent of subjects had desirable body fat. Majority of the subjects (73.33%) had undesirable body fat content. The distribution of subjects according to haemoglobin level depicts that none of the subjects had undesirable haemoglobin content. Majority of the subjects (70.00%) had borderline haemoglobin values. While, 30.00 per cent of them had desirable haemoglobin content of more than 13.00 g per dl.

4.4.2.4.2 Food intake and adequacy of supplementation study subjects

The mean intake and adequacy of foods by the subjects is presented in Table 41. The consumption of foods was lower than the suggested dietary allowance except for pulses, which had an adequacy of 139.30 per cent. The food adequacy was more than 70.00 per cent for fat (95.36%), cereals (81.95%) and roots and tubers (73.65%). The food adequacies were less than 50.00 per cent for other vegetables (44.98%), egg (38.12%), sugar (34.33%) and fruits (34.79%). The adequacy for milk (14.02%), meat (9.94%) and green leafy vegetables were very low (6.07%).

4.4.2.4.3 Food intake and adequacy of supplementation study subjects

The mean intake and adequacy of nutrients is presented in Table 42. It is very obvious that the mean intake of nutrients were less than the recommendations for sports persons. The per cent adequacy for energy was 70.02 with a corresponding intake of 3025 Kcal. The adequacies of protein, fat and carbohydrate were 54.17, 68.81 and 73.20 per cent. Among the vitamins, the per cent adequacy was more than 50.00 per cent only for thiamine (65.71%) and folic acid (52.57%). The niacin adequacy was 43.65 per cent. While, the adequacy for vitamin A (28.45%), riboflavin (32.86%) and vitamin C (26.92%) was less than one third the requirement. The intake of calcium (507.64 mg) and iron (22.08 mg) were meeting nearly one third the recommendations. The subjects consumed 9.19 mg of zinc in their diet.

4.4.2.5 Energy balance of the subjects

Table 43 presents the energy balance of the subjects. The mean energy intake of the subjects was 3025 Kcal, while they expended 3381 Kcal of energy. Further, the Table depicts that the subjects were in negative energy balance with a mean deficit of 357 Kcal.

Table 40: Distribution of supplementation study subjects based on BMI, waist to hip ratio, body fat and haemoglobin level

(N=30)

Parameters	Classes	Category	Frequency	Per cent
BMI (kg/m^2)	18.5 – 22.9	Ideal BMI	30	100
Waist to hip ratio	<0.95	Normal	30	100
Body fat (%)#	7 – 15	Desirable	5	16.67
	>15	Undesirable	25	83.33
Haemoglobin (g/dl)#	11 – 13	Borderline	21	70.00
	>13	Desirable	9	30.00

Classification for sports persons (Goswami, 2005)

Table 41: Food intake and adequacy of supplementation study subjects

(N=30)

Foods (g)	SBD#	Intake	Adequacy (%)
Cereals	550	450.75 ± 25.84	81.95
Pulses	40	55.72 ± 4.07	139.3
Green leafy vegetables	150	9.11 ± 0.90	6.07
Roots and tubers	150	110.48 ± 13.56	73.65
Other vegetables	200	89.96 ± 8.59	44.98
Fruits	150	52.18 ± 6.23	34.79
Milk (ml)	750	105.16 ± 48.68	14.02
Fat	50	47.68 ± 27.46	95.36
Sugars	80	27.46 ± 3.88	34.33
Meat	250	24.86 ± 2.76	9.94
Egg	100	38.12 ± 4.16	38.12
Nuts and Oilseeds	NA	11.95 ± 1.23	-

NA- Not available

- SBD suggested balanced diet by Satyanarayana *et al*. (1985)

Table 42: Nutrient intake and adequacy of supplementation study subjects

(N=30)

Nutrients	RDA#	Intake	Adequacy (%)
Energy (Kcal)	4320	3025.00 ± 116.92	70.02
Protein (g)	130-150	75.84 ± 7.59	54.17
Fat (g)	105-160	91.17 ± 7.30	68.81
Carbohydrate (g)	600-700	475.78 ± 17.59	73.20
Vitamin A (μg)	1000-2000	426.78 ± 23.86	28.45
Thiamine (mg)	3-4	2.30 ± 0.17	65.71
Riboflavin (mg)	3-4	1.15 ± 0.13	32.86
Niacin (mg)	40-50	19.64 ± 1.72	43.64
Folic acid (μg)	400	210.29 ± 13.88	52.57
Vitamin C (mg)	100-200	40.38 ± 5.32	26.92
Calcium (mg)	1000-2000	507.64 ± 20.31	33.84
Iron (mg)	50-75	22.08 ± 1.51	35.33
Zinc (mg)	NA	9.19 ± 0.36	-

Satyanarayana *et al*. (1985)

Table 43: Energy balance of supplementation study subjects

(N=30)

Particulars	Values
Energy intake (Kcal)	3025
Energy expenditure (Kcal)	3381
Energy intake - Energy expenditure (Kcal)	-357
Energy balance	Negative

4.4.2.6 Anthropometric measurements and haemoglobin level of the subjects before and after supplementation

The anthropometric measurements and haemoglobin level of the subjects before and after the supplementation are presented in Table 44.

Differences in the anthropometric measurements and haemoglobin content of the subjects in both the groups were observed after the supplementation. The weight of the subjects in control group decreased non-significantly from 65.45 to 65.25 kg, while the experimental group registered a significant increase in weight (65.14 – 65.58 kg) upon supplementation. Significant increase in BMI was also noted in experimental group (21.14 – 21.30 kg/m^2) while non-significant decrease (21.24 – 21.17 kg/m^2) was recorded in control group. With respect to circumferences of chest, mid upper arm, waist and hip, no significant changes were observed in both the groups. The waist:hip ratio of the subjects in both the groups recorded statistically non significant changes. However, there was a significant decrease in body fat (19.32% – 19.07%) and increase in haemoglobin (12.39 – 12.83 g/dl) level was observed in experimental group. No significant changes were noted in control group.

4.4.2.7 Physical fitness components of the subjects before and after supplementation

Table 45 presents the effect of supplementation on physical fitness components of the subjects.

The strength of the subjects increased from 43.79 to 43.83 cm in control group and 43.76 to 46.94 cm in experimental group. The increase in strength was significant only in experimental group. With respect to speed, the time to complete specific distance decreased from 7.14 to 7.08 seconds in control group and from 7.33 to 7.29 seconds in experimental group. The statistical test revealed no significant change. The flexibility of the subjects increased non-significantly from 6.99 to 7.04 cm in control group. While, the experimental subjects showed a significant improvement in flexibility values (6.90 – 6.96 cm). The agility values decreased slightly from 17.43 to 17.38 seconds in control group and 17.58 to 17.53 seconds in experimental group. However, the changes did not reach statistical significance.

The endurance capacity of the experimental subjects increased significantly from 30.60 to 38.82 minutes, while a non-significant increase in endurance capacity of control subjects (30.79 – 31.03 minutes) was noted after the supplementation period. The cardiac efficiency score of the subjects increased from 76.36 to 76.82 in control subjects and 76.30 to 79.88 in experimental subjects. The increase in cardiac efficiency score of experimental subjects upon supplementation with sports food was statistically significant ($p < 0.01$).

4.5 Market viability of sports food

The technology for production of sports food was transferred to a food industry. The details of the marketing of the product are given here under.

4.5.1 Cost of production for sports food

The cost of production for sports food at industrial level is presented in Table 46.

The economics for production of sports food includes fixed and variable cost components. The fixed cost consisted of building and machinery accounting for Rs. 600000. Depreciation on fixed assets was calculated at 10 per cent per annum. The manufacturing capacity of sports food was estimated to be 1 quintal/day. The production cost per quintal of sports food was Rs. 9740 which included the cost of ingredients (Rs. 7100), labour (Rs. 600), electricity (Rs. 100), packaging (Rs. 1000), transport (Rs. 250), miscellaneous expenses (Rs250) and interest on investment (Rs. 240). The marketing cost summed up to Rs. 5260/quintal which consisted of sales tax (Rs. 1364) and commission to distributor and retailer (Rs. 3896). The total cost of production was Rs. 15000 per quintal or Rs. 150/kg. The maximum retail price was fixed at Rs. 180/kg considering 20 per cent profit. The product was sold in a unit pack of 500g, priced at Rs. 90.

Table 44: Anthropometric measurements and haemoglobin level of the subjects before and after supplementation

(N=30)

Parameters	Control (n=14)		t value	Experimental (n=16)		t value
	Before	After		Before	After	
Weight (kg)	65.45 ± 4.72	65.25 ± 4.67	1.92 NS	65.14 ± 4.02	65.58 ± 3.70	2.33*
BMI (kg/m^2)	21.24 ± 1.21	21.17 ± 1.17	1.96 NS	21.14 ± 0.92	21.30 ± 1.07	2.32*
Chest circumference (cm)	86.38 ± 4.44	86.34 ± 4.46	0.43 NS	86.97 ± 2.51	87.02 ± 2.52	1.16 NS
Mid upper arm circumference (cm)	27.53 ± 1.97	27.47 ± 1.92	1.13 NS	28.06 ± 1.79	28.12 ± 1.63	0.46 NS
Waist circumference (cm)	78.47 ± 2.70	78.46 ± 2.70	0.28 NS	79.31 ± 2.54	79.26 ± 2.49	0.47 NS
Hip circumference (cm)	87.11 ± 2.42	86.96 ± 2.53	1.31 NS	88.25 ± 1.94	88.15 ± 2.02	1.66 NS
Waist:Hip ratio	0.90 ± 0.04	0.90 ± 0.04	0.89 NS	0.89 ± 0.03	0.90 ± 0.03	0.49 NS
Body fat (%)	19.17 ± 2.64	19.11 ± 2.48	0.67 NS	19.32 ± 1.98	19.07 ± 1.68	2.24*
Haemoglobin (g/dl)	12.44 ± 0.72	12.68 ± 0.86	1.81 NS	12.39 ± 0.72	12.83 ± 0.49	3.33**

* - Significant at 5% level
** - Significant at 1% level
NS - Non-significant

Table 45: Physical fitness components of the subjects before and after supplementation

(N=30)

Components	Control (n=14)				Experimental (n=16)			
	Before	After	t value	Per cent increase	Before	After	t value	Per cent increase
Strength (cm)	43.79 ± 1.70	43.83 + 2.04	0.39^{NS}	0.09	43.76 ± 2.43	46.94 ± 2.03	6. 29**	7.27
Speed (second)#	7.14 ± 0.71	7.08 ± 0.81	0.46^{NS}	0.84	7.33 ± 0.46	7.29 ± 0.41	0.92^{NS}	0.55
Flexibility (cm)	6.99 ± 1.29	7.04 ± 1.22	1.71^{NS}	0.71	6.90 ± 1.21	6.96 ± 1.15	2.61*	0.86
Agility (second)#	17.43 ± 1.00	17.38 ± 0.98	0.95^{NS}	0.29	17.58 ± 0.93	17.53 ± 0.88	1.20^{NS}	0.28
Endurance (min)	30.79 ± 3.90	31.03 ± 3.72	0.81^{NS}	0.79	30.60 ± 4.24	38.82 ± 4.07	12.36**	26.86
Cardiac Efficiency Score	76.36 ± 3.30	76.82 ± 3.28	1.10^{NS}	0.60	76.30 ± 3.44	79.88 ± 2.38	10.98**	4.69

#Lower the value better the performance
* - Significant at 5% level
** - Significant at 1% level
NS - Non-significant

Table 46: Cost of production for sports food

Particulars	Amount (Rs.)
Fixed costs	
Building (10´x12´)	2,00,000
Equipments	4,00,000
Total	**6,00,000**
Variable costs (per quintal)	
A. Production cost	
Ingredients	7,100
Labour	600
Electricity	100
Packaging	1,000
Transport	250
Miscellaneous	250
Interest on capital investment	240
Total	**9,740**
B. Marketing cost	
Sales tax	1,364
Commission to distributors and retailers	3,896
Total	**5,260**
Total cost of production	**15,000**

Depreciation cost on building @ 10% / annum=Rs. 60,000
Production rate 1 quintal/ day
Maximum Retail Price- Rs. 180/ kg
Maximum Retail Price of unit pack- Rs. 90/ 500g

4.5.2 Acceptability of sports food manufactured by the industry

Once the technology for production of sports food was transferred to the food industry, continuous monitoring was carried out. The manufacturer was asked to follow the exact processing protocol.The food manufactured by the food industry was tested for acceptability in comparison with the food prepared at the laboratory in potential consumers (n=22). Majority of the respondents (45.45%) expressed that there was no difference between the food prepared in laboratory and food manufactured in the industry. While, 31.82 per cent of the respondents liked food manufactured by the industry than that prepared in the laboratory. The remaining 22.73 per cent expressed that they liked food prepared in the laboratory than that manufactured by the industry. The results revealed that the sports food manufactured by the industry was similar to the food prepared in the laboratory (Fig. 12).

4.5.3 Distribution and sales of sports food

Table 47 presents the number of unit packs of sports food distributed to shops and sales at exhibitions.

The sports food packed in commercial packs (Plate 8) was launched into the market at various places in Karnataka. In total it was distributed at 42 outlets. The sales picked up after the promotional advertisements in leading news papers (Plate 9). In Dharwad city 50 unit packs were distributed to five shops. In Hubli the sports food was distributed to eight shops totaling the number of unit packs to 25. Various shops in Bangalore city were distributed with 20 unit packs of sports food. The other cities where sports food was launched were Bagalkot, Belgaum, Hospet, Bellary, Davanagere and Bijapur.

The sales of the sports food was slow immediately after launching in to the market. The sales picked up after the promotional advertisement. There was a huge demand from sports persons and physically active individual. The young sports persons were very keen to purchase the product. The sale of sports food recorded to be highest in Dharwad with the sale of 45 unit packs in one month (Plate 10). There were repeat orders from the consumers. The quantum of sale in other places ranged from 20 to 60 per cent.The sports food was exhibited at various exhibitions in Karnataka. It was sold in Krishimela at Dharwad (20 unit packs), Davanagere (5 unit packs) and Bijapur (8 unit packs). The unit packs sold in *Nudisiri* exhibition at Mudabidire was 12. There was a huge demand for the product in millet *mela* held at Bangalore with sale of 60 unit packs.

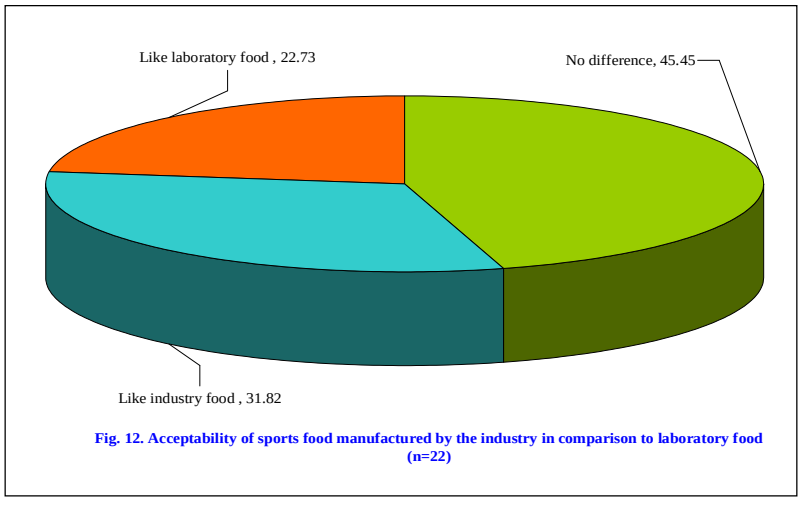
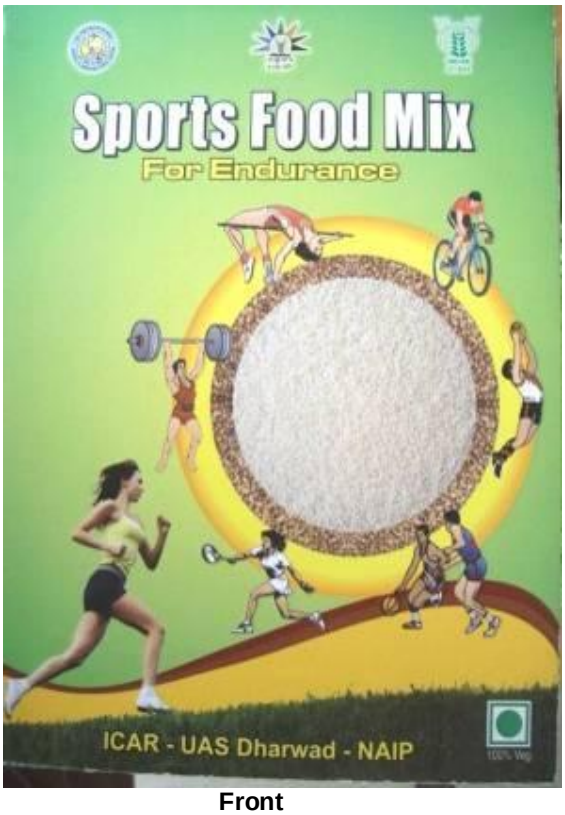


Fig. 12. Acceptability of sports food manufactured by the industry in comparison to laboratory food (n=22)

Fig. 12. Acceptability of sports food manufactured by the industry in comparison to laboratory food (n=22)



Front

Back

Plate 8. Commercial pack for marketing sports food mix

Kannada prabha – Dated: 06-03-2011

Vijaya Karnataka – Dated: 20-03-2011

Plate 9. Advertisements of sports food mix in leading news papers

Table 47: Sports food distribution to shops

Place	No. of unit packs
Dharwad	50
Hubli	25
Bagalkot	10
Belgaum	15
Hospet	10
Bellary	10
Davanagere	20
Bijapur	20
Bangalore	20

Display of sports food mix in shop

Consumer purchasing the sports food

Plate 10. Marketing of sports food

5. DISCUSSION

Little millet (*Panicum miliare*) exhibits good nutritional and therapeutic properties. Millets are being adjudged as miracle grains and potential future crops, besides potentials of cultivation under stress conditions with meager inputs. Utilization of this grain for various value added and therapeutic products can increase the demand for this grain, the production of which is declining. In the present investigation, little millet was explored to develop a nutrient dense sports food for increasing physical endurance of young adults.

In India, the sports performance is not optimum compared with several countries. One of the several reasons is lack of sound sports nutrition principles. Proper nutrition helps athletes to achieve good physique, improve performance, prevent injury and enhance recovery after exercise besides improving the general health. Though the food consumption of sports persons is better than the sedentary group, the proportion of nutrients in the diet is not satisfactory. Hence, need was felt to formulate sports food to improve the performance of sports persons according to ICMR guidelines. Further, the efficacy of the product was also tested and the results are discussed here.

5.1 Development of little millet based sports food

Most of the sports supplements marketed in India and abroad are blends of chemically defined food ingredients such as maltodextrin, sucrose, glucose, hydrolysed proteins, amino acids, caffeine, lipid of vegetables and animal sources, vitamins, minerals and performance enhancing ergogenic aids. Hence, sports food based on natural food materials, having optimum nutrients and other functional properties to boost the sports performance was considered. In this direction, the utilization of little millet, a potential grain for promoting health was selected.

Little millet, being bland in taste, can blend with many ingredients and thus improve the nutrient profile and protein quality in addition to providing convenience by facilitating the possibility of ‘one dish a meal’ or ‘balanced diet in one dish’. However, the protein in little millet is not qualitatively superior owing to the deficiency of lysine.

Selection of a good genotype of millet is of at most importance. Out of two genotypes studied, *Sukshema* genotype had better physical (size, weight, hydration and swelling capacity, hydration and swelling indices) characteristics besides improved nutritional profile. The nutritional evaluation of improved genotypes has been documented by several authors (Kulkarni *et al.,*1992, Mogra *et al.,*1998, Veena *et al*.,2005). *Sukshema* had higher water absorption capacity, swelling power, solubility and least gelation concentration compared to local genotype.

Skimmed milk powder and soybean are rich in protein. Various studies involving milk proteins have solidified the perception of milk protein as a viable protein supplement in the minds of the consumers (Bucci and Ulna, 2000). Many studies on protein supplementation and sports performance have used milk proteins (Dragan *et al*, 1988 and Uthira and Srimati, 2005).

Addition of skimmed milk powder and soybean helped in improving protein quality. Conversely, the skimmed milk powder will not only mask the flavor of soybean, but also improve the amino acid profile. The milk based foods are generally well accepted. The soybean adds to the antioxidants of millets and provides isoflavones which help to wash out free radicals and aids in recovery after physical exertion (Forsythe, 1995).

Soy protein contains a higher per cent of critical cluster amino acids, including glutamine, lysine and Branched Chain Amino Acids (BCAA) than other proteins, such as whey, casein, egg and beef. These are the amino acids preferred for fortification of proteins by the dietary supplement industry, and have benefits for exercising individuals in increasing endurance capacity and recovery after strenuous physical activity (Bucci and Ulna, 2000). The BCAA facilitate anabolic activity and build up muscles. The combination of millet with soybean and skimmed milk powder can complement the amino acid profile. Added sugar imparts taste besides providing energy.

Thermal processing in terms of roasting the grain had added advantage to increase palatability and acceptability and improve shelf life by reducing moisture content.

Addition of cardamom and vanilla flavour enhanced the acceptability of the porridge. Cardamom was considered as a natural flavourant which is commonly used in Indian culinary.

Several foods have been developed for supplementing the diet of the sports persons in India. Vanalli (2003) developed sorghum based sports food. Supplements using malted cereals, sugar and flavouring with either casein or whey protein were developed by Uthira and Srimati (2005). Meti and Saraswati (2006) developed *laddoo* using refined wheat flour, grain amaranthus, garden cress seeds, ground nut, jaggery and fat.

The *laddooes* were supplemented to adolescent football and *kabaddi* players. Sugasri and Premakumari (2010) developed health *laddoo* to supplement the diet of female adolescent athletes. The *laddoo* was formulated from roasted and ground pearl millet, rice, wheat and bengalgram in equal quantities and made into *laddoo* with jaggery syrup.

The physical characteristics of the food influence the sensory qualities and thus the intake. The appearance of the mix was acceptable with creamish white colour. The lower water activity (0.51) of the mix indicates that the mix is not easily susceptible to microbial growth. Dispersability in water indicates the reconstitutability of the mix. The sports food exhibited high dispersability.

The sports food had low moisture, optimum amount of protein, low fat and good amount of carbohydrate. The energy value of sports food satisfied the recommendations of >360 Kcal by Protein Advisory Group (Anon., 1975) and 300 – 400 Kcal according to BIS specification (Anon., 1969). The composition of the developed sports food was comparable to the *laddoo* developed by Meti and Saraswati (2006) which provided 72 g of carbohydrate and 412 Kcal of energy.

The protein quality evaluation of sports food revealed that inspite of efforts to improve the protein quality, lysine was found to be the most limiting amino acid, followed by isoleuicine. The IVPD of the food reflects the utilizable protein present. The sports food exhibited 79.15 per cent IVPD. Hence, there is a further scope for improving the lysine content and protein quality.

Shelf life of any developed product is a crucial factor to be considered for commercial viability, storage and distribution in the market. In the present study, the metalized polyester polyethylene covers were selected as packaging material as they are widely used for packing supplementary foods.

The sports food was highly acceptable for more than 180 days, although there was a slight browning due to Maillard reaction. The moisture content of the sports food was within the BIS specification (<10%) even at the end of 180 days. Peroxide value indicates the extent of rancidity, which in turn influences the quality of the product.

The peroxide value was well within the BIS specification of 10 meq per kg fat at the end of storage period. The sensory evaluation of the porridge from of stored sports food depicted that it was moderately acceptable even at the end of storage study. Although decrease in the scores of sensory parameters were observed with an increase in storage period, the mean values depicted that the product was acceptable at 180 days of storage.

The ultimate purpose of new product development is attained only when it is accepted by the consumer. The product was highly acceptable and 46.15 per cent of the consumers revealed that they would eat the product at every given opportunity. None of the respondents expressed that they disliked the product.

5.2 Efficacy of the sports food

The efficacy of the sports food on physical endurance capacity was tested at three phases in sports persons (i) carbohydrate loading three days before the endurance test, (ii) as prevent meal one hour before the endurance test and (iii) long term supplementation for 90 days.

Carbohydrate loading with sports food improved the endurance capacity by 15.55 per cent under fasting condition. The improvement in endurance capacity has been reported by Karlsson and Saltin (1971), Hodgdon *et al*. (1980), Williams *et al*. (1991) and Kavitha and Yenagi (2006). The muscle glycogen is an important source of fuel for physical endurance. The increase in muscle glycogen of subjects after carbohydrate loading has been documented by Karlson and Saltin (1971) and Starling (1997).

The efficacy of sports food in increasing the endurance capacity varied between the sports hostel subjects and free living subjects. The nutritional status and exercise pattern of sports hostel subjects was better than free living subjects (Table 29 and 21). A significant difference in the food consumption pattern was noted between the subjects (Table 28 and 30). The sports hostel subjects had a budget provision of Rs.125/day/person from the government. They consumed non-vegeterian food, egg, fruits, fruit juice and almonds every day. Sweets and desserts were provided every alternate day to the hostel subjects. While free living subjects consumed routine diet prepared in their home and higher per cent of them consumed non-vegetarian foods occasionally. The sports hostel subjects were taller, heavier, had lower body fat and higher haemoglobin level than free living subjects (Table 26). Apparently the nutrient intake of sports hostel subjects was higher compared to free living subjects (Table 28).

It was also observed that the base line endurance capacity of sports hostel subjects was higher than the free living subjects. Loading of sports food resulted in a greater improvement in free living subjects who consumed a routine diet in their home. Conversely, the magnitude of improvement in endurance capacity of sports hostel subjects was comparatively lower than the free living subjects (Fig. 8).

The foods consumed in the hours prior to competition can greatly influence the sports performance. The efficacy of sports food as a pre-event meal was compared with the routinely consumed pre-event meal. Pre event meals improved the endurance capacity of the subjects significantly. Maintenance of blood glucose and rates of carbohydrate oxidation after consumption of pre-event meal helps to exercise for longer period. Sherman *et al*. (1991) reported that exercise performance was improved by 12.50 per cent when cyclists consumed 1.1g carbohydrate/kg body mass 60 min before cycling compared to placebo. It was also noted that exercise performance was neither further improved nor impaired when carbohydrate intake was increased to 2.2g/kg body mass. The blood glucose and respiratory exchange ratio gradually declined during exercise for placebo, indicating that availability of carbohydrate to support energy production was gradually diminishing. The investigators suggested that pre-exercise feedings increased carbohydrate oxidation above normal amounts, thus, there was a higher work rate during later stages of exercise. This possibility is supported by the observation that when blood glucose is maintained by carbohydrate feeding during exercise, blood glucose is oxidized at high rates late in exercise, even when muscle glycogen concentrations and rate of glycogenolysis are low (Coyle *et al*., 1986 and Coggan *et al*., 1987) and a sparing effect on liver glycogen (Kuipers *et al*., 1986). There may be possible central effect of carbohydrate on exercise performance which could be acting through activation of receptors linked to the brain (Painelli *et al*., 2010). The improvement with sports food as a pre-event meal was 15-34 per cent over fasting conditions (Table 48). Apparently an improvement up to 5 per cent was elicited by sports food over routinely consumed pre-event meal. In sports, an improvement of even one per cent is important as it can make a difference between winning and losing.

When the effects of loading and pre-event meals were compared, it was found that pre event meal improved the endurance capacity to a greater extent (Table 48). Pre-event meal is more advantageous than loading wherein the sportsman has to load for 3 to 4 days. Whereas, consuming the sports food prior to the event can result in better performance. However, the experiment with pre-event meal is a short term study. There are early athletes, young athletes, athletes with poor nutritional status who need nutritional support. Hence, the effect of long term supplementation of the sports food on the nutritional status and physical fitness of the sports persons was also studied.

The sports food supplementation for 90 days greatly improved the anthropometric parameters and haemoglobin level. The weight and BMI of the subjects in supplemented group increased. Chandrasekhar *et al*., (1988) and Sugasri and Premakumari, (2010) have also reported an increase in weight after modification of diet of sports persons.

Table 48: Efficacy of sports food in increasing the endurance capacity of sportsman

Treatments	Time to exhaustion (min)		Per cent improvement
Carbohydrate loading	Before	After	
	27.97 (16.4-42.5)	32.32 (19.2-46.32)	15.55 (8.99-26.51)
Pre-event meal			
Routine meal	33.44 (20.1-48.5)		19.56 (14.12-33.13)
Sports food	34.05 (20.5-49.0)		21.75 (15.29-34.34)
			1.83 (0.88-5.17) sports food over routine pre-event meal
Long-term supplementation			
Group	Before	After	
Control group	30.79 (24.6-38.9)	31.03 (24.8-39.0)	0.79 (0.23-1.21)
Experimental group	30.60 (24.8-38.7)	38.82 (32.4-47.1)	26.86 (20.64-39.92)

Figures in parenthesis indicate range.

The haemoglobin level was also improved as an effect of sports food supplementation which provided good amounts of protein and iron. Similarly, the supplementation of soy protein isolate based health drink was reported to improve the blood iron status in adolescent sports persons (Huisini, 1998).

All the physical fitness components improved after 90 days of supplementation with sports food. The flexibility (0.86%), cardiac efficiency scores (4.69%), strength (7.27%) and endurance capacity (26.86%) of the supplemented group increased significantly compared to control group. An increase in strength indices of sports persons has been reported with supplementation of cereal and casein/whey supplement by Uthira and Srimati, (2005). Flexibility is a health related fitness component (Marrow, 2005). The overall improvement in health status of supplemented group might have improved the flexibility significantly. However, with respect to speed and agility, the improvements did not reach statistical significance. This might be because of the fact that they are skill related fitness components (Marrow, 2005) and supplementation had no significant influence.

The supplementation of nutritious foods to the athletes has been reported to improve endurance capacity by Chandrasekhar *et al*. (1989), Chandrasekhar and Jacob (1992) and Sugasri and Premakumari (2010). Maheshwari *et al.* (2010) reported an improvement in endurance capacity of sports women on supplementation with eggs. In the present investigation, the endurance capacity showed an improvement on supplementation with sports food for 90 days. The cardiac efficiency score was influenced positively upon supplementation with sports food. This might be because of an improvement in nutritional status of the supplemented subjects. The long term supplementations with nutritious foods have been reported to improve cardiac efficiency score in sports persons (Sugasri and Premakumari, 2010 and Maheshwari *et al*., 2010)

The long term supplementation of sports food greatly increased the endurance capacity of the sports persons besides improving the nutritional status and physical fitness components like strength, flexibility and cardiac efficiency score.

Future line of work

1. To study the effect of sports food supplementation on sports recovery.
2. To study the effect of supplementation of sports food on oxidative stress.

6. SUMMARY AND CONCLUSIONS

The present investigation on "Physico-chemical and functional properties of little millet genotypes, development and efficacy of little millet based sports food" was undertaken in the Department of Food Science and Nutrition, Rural Home Science College, University of Agricultural Sciences, Dharwad. A suitable little millet genotype for development of sports food was selected based on the physical, chemical and functional properties.

Sports food mixes were formulated using little millet, soybean, sugar powder and skim milk powder at varying proportions such that the energy from protein was more than 15 per cent, as per the guidelines of ICMR. The little millet and soybean were roasted, powdered and then mixed with sugar powder and skim milk powder. Porridge was prepared from the mixes and evaluated for sensory qualities on a nine point hedonic scale. The most acceptable mix was added with suitable flavouring agent.

The formulated sports food was studied for physical characteristics, chemical composition and nutritional qualities. The keeping quality of sports food in metallized polyester polyethylene laminated pouches was studied for six months at ambient temperature. Fortnightly evaluation was carried out for biochemical and sensory parameters.

The sensory profile of the developed sports food was documented and the acceptability of the sports food by the consumers was also studied using Food Action (FACT) rating scale.

The efficacy of the developed sports food to improve the performance in sports was tested in male sports persons from Dharwad city. The efficacy was tested by three strategies viz., carbohydrate loading three days prior to endurance test, as pre-event meal one hour prior to endurance test and long-term supplementation for 90 days on physical fitness of the subjects.

The impact of loading and pre-event meal on endurance capacity was studied in 31 sports persons, 16 residing in sports hostel and playing for Sports Authority of India and 15 free living sports persons playing for various sports clubs. The impact of long-term intervention on physical fitness including endurance capacity, anthropometric measurements and haemoglobin was studied in students of MVAS, K. G. Nadiger College of Physical Education, who were consuming hostel diet.

The general information, sports related information, dietary habits, foods consumed and avoided before, during and after the event by the subjects was noted. The nutritional status of the subjects was assessed by anthropometry, haemoglobin level and diet survey. In the endurance capacity test, the time to exhaustion, distance covered and calories burnt were recorded. The physical fitness components tested in the long-term supplementation study were strength, speed, agility, flexibility, endurance and cardiac efficiency score.

The salient findings of the study are summarized hereunder.

- The physical characteristics of local and *Sukshema* genotype revealed that *Sukshema* grains were larger in size with higher length (1.83 mm), breadth (1.55 mm), thickness (1.09 mm), 1000-grain weight (2.33 g) and 1000 grain volume (1.65 ml) compared to local genotype.
- The hydration index (7.66 g/g) and swelling index (10.41 g/g) of *Sukshema* genotype was higher than local genotype.
- The *Sukshema* genotype exhibited better nutrient composition with higher protein (8.96 g/100 g), crude fibre (3.25 g/100 g), carbohydrate (70.47 g/100 g) and lower fat (4.10 g/100 g) than local genotype.
- *Sukshema* genotype had higher calcium (18.73 mg/100 g), zinc (2.03 mg/100 g) and manganese (0.36 mg/100 g), while local genotype possessed higher iron (8.80 mg/100 g) and copper (0.28 mg/100 g). However, the difference in mineral content was significant only for zinc among genotypes.
- The tannin (92.23 mg/100 g), phenol (74.20 mg/100 g) and phytate (115.13 mg/100 g) contents of local genotype was higher than *Sukshema* genotype.

- *Sukshema* genotype exhibited better water absorption capacity (0.85 g/g), oil absorption capacity (0.66 g/g), swelling power (7.73 g/g) and solubility (23.40%) compared to local genotype. The *Sukshema* genotype showed gelation at lower concentration (9.07%) than local genotype (9.98%).
- The *Sukshema* genotype with better physical, chemical and functional properties was selected for development of sports food.
- Totally six mixes were formulated using little millet, soybean, sugar powder and skim milk powder at different proportions. The per cent energy from protein ranged from 15.20 to 18.50.
- The mixes with higher per cent of energy from protein were unacceptable as they were not sweet enough in the form of porridge.
- The mix with 34 per cent little millet, 12.5 per cent soybean, 37per cent sugar powder and 16.5 per cent skim milk powder was most accepted with scores between liked moderately and liked very much with a corresponding acceptability index of 86.44 per cent.
- Addition of different flavouring agents revealed that cocoa was not accepted. Cardamom flavour with higher acceptability index was considered for further study.
- The sports food was creamish white in colour with a slight acidic pH (6.63) and low a_w (0.51). The sports food exhibited good dispersability (84.20%), swelling power (2.30 g/g) and solubility (51.80%).
- The sports food had low moisture (5.98%), optimum protein (14.29%), low fat (4.05%) and high carbohydrate (70.59%) content. The sports food possessed 261.83 mg per 100 g of calcium, 4.69 mg per 100 g of iron, 2.02 mg per 100 g of zinc, 0.36 mg per 100 g of copper and 0.39 mg per 100 g of manganese.
- The IVPD of sports food was 79.15 per cent. Lysine was the most limiting amino acid in the sports food. The net protein value of the sports food was 10.85.
- The sports food packed in metalized polyester polyethylene pouches stored at ambient conditions was acceptable beyond 180 days.
- The moisture content and peroxide value of the sports food increased (5.98 – 6.59% and 1.84 – 2.24 meq/kg fat, respectively) with progress in days of storage. However, they were within the permissible limits.
- There was a change in sensory scores of the porridge during storage. The changes in colour and consistency were not significant. The changes in scores for aroma (7.36 – 6.46), taste (7.82 – 6.82) and overall acceptability (7.82 – 6.73) were statistically significant. However, the porridge was acceptable even at the end of storage period with the scores ranging between liked slightly and liked moderately.
- The sensory profile of sports food depicts that the porridge was creamish in colour, had smooth and attractive appearance with pleasant cardamom flavour. The porridge was swallow able, very easy to consume and had no after taste. The porridge was highly acceptable with sweet taste and mild roasted flavour.
- The sports food was highly acceptable among the consumers on a FACT rating scale. Highest (46.15%) per cent of the consumers expressed that they would eat at every opportunity. None of the consumers disliked the product.
- The subjects consumed various special foods viz., soaked bengalgram, dates, almonds, cashew, resins, egg, ghee, milk and health drinks, regularly to help them to perform better in sports.
- The subjects consumed *idli*, milk, fruit juice, biscuits and fruits before the event. The consumption of glucose was common during the event. The foods consumed after the event were glucose, fruit juice, chocolate, fruit and biscuits.

- Subjects avoided heavy meal, fried and spicy foods before the event, while consumption of heavy meal and carbonated beverage was avoided immediately after the event.
- The height and weight of sports hostel subjects (182.31 cm and 71 kg, respectively) was higher than the free living subjects (177.74 cm and 68.97 kg, respectively). The body fat content of sports hostel subjects (15.54%) was higher than the free living subjects (17.99%). While, haemoglobin level was higher in sports hostel subjects (13.53 g/dl) than free living subjects (12.76 g/dl).
- The intake of foods was lower than the suggested dietary allowance for both the groups except for pulses and fat. The consumption of foods was better in sports hostel subjects than free living subjects.
- The mean nutrient intake of both the group of subjects was lower than the RDA except for fat (121.97%) in sports hostel subjects. The sports hostel subjects had better nutrient intake than free living subjects. The sports hostel subjects had more than 80 per cent adequacy for energy, carbohydrates, thiamine, riboflavin, folic acid and calcium. The adequacy of vitamin A (56.87%) and iron (60.42%) were lower in sports hostel subjects. The free living subjects had more than 80 per cent adequacy for fat (93.18%) and thiamine (84.57%). The adequacy for energy, carbohydrate, folic acid, riboflavin and protein were less than 80 per cent. Less than 50 per cent adequacy was recorded for vitamin C (47.05%), iron (45.53%) and vitamin A (38.87%) in free living subjects.
- Loading with sports food significantly (15.55%) improved the endurance capacity of the subjects with respect to time to exhaustion, distance covered and calories burnt. The improvement was better in free living subjects (18.81%) than sports hostel subjects (13.70%).
- Consumption of sports food as pre-event meal improved the endurance capacity of the subjects (15-34%) compared to fasting. The per cent improvement of sports food over routinely consumed pre-event meal was 1-5 per cent. The improvement was better in free living subjects (2.81%) than the sports hostel subjects (1.26%).
- The effect of long term supplementation (90 days) on physical fitness of the sports persons was studied. The mean height, weight and BMI of the subjects were 173.53 cm, 65.31 kg and 21.56 kg per m^2, respectively. The body fat and haemoglobin level were 19.25 per cent and 12.41 g per dl, respectively.
- The food adequacy of long term study subjects was less than the suggested dietary allowance for all the food groups except pulses (139.3%).
- The nutrient adequacy of supplementation study subjects was less than 75 per cent for all the nutrients. The intake of energy (70.00%), protein (54.17%), fat (68.81%) and carbohydrate (73.20%) was lower than the RDA. The adequacy of micronutrients was less than 50 per cent except for thiamine (65.71%) and niacin (52.57%).
- The supplementation of sports food for 90 days significantly improved the weight, BMI and haemoglobin level of supplemented group compared to control group. No significant change in chest, mid upper arm, waist and hip circumferences and waist:hip ratio was observed in both the groups after supplementation. Whereas, the body fat per cent decreased in supplemented group than the control group.
- Improvement in physical fitness components of experimental group was observed upon supplementation with sports food compared to control group. A significant improvement in strength (43.76 to 46.94 cm) by7.27 percent, flexibility (6.90 – 6.96 cm) by 0.86 per cent, endurance capacity (30.60 – 38.82 min) by 26.86 percent and cardiac efficacy score (76.30 – 79.88) by 4.69 per cent were recorded in experimental group. No such improvement was observed in control group.
- The technology for production of sports food was transferred to a food industry. The product was launched in 42 outlets across Karnataka. The sale of the product was enhanced by the promotional advertisements in leading news papers. The sports food was sold at a maximum retail price of at Rs. 90 per 500g after analyzing the economics for cost of production.

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Appendix I: Estimation of tannins

Reagents (i) Folin Denis Reagent 1Nb

Hundred grams of sodium tungstate and 20 g phosphomolybdic acid were dissolved in about 700 ml distilled water and 50 ml of phosphoric acid in a flask. The mixture was boiled under reflux for two hours, the volume made to 1000 ml with distilled water and stored in dark amber colour bottles.

(ii) Sodium carbonate solution

Sodium carbonate (350 g) was dissolved in 800 ml distilled water at 70-80°C and the volume was made to one litre. The solution was made to stand overnight and filtered through glass wool.

(iii) Standard tannic acid

The stock standard solution was prepared by dissolving 100 mg of tannic acid in 100 ml distilled water. Working standard was prepared by diluting 10 ml of stock to 200 ml, so that the concentration of tannic acid was 50 $\mu g\ ml^{-1}$.

Procedure

A known quantity of finely ground sample of little millet was extracted in 100 ml of distilled water by boiling gently for 30 minutes. The extract was centrifuged for 20 minutes and the supernatant was made to a known volume. An aliquot of 2.0 to 4.0 ml was pipetted into 25 ml of volumetric flask and 0.5 ml of RDR and 1.0 ml of sodium carbonate solution were added. The contents were mixed well after addition of each solution and volume was made up and allowed to stand for one hour. The turbidity was eliminated by filtering and the absorbance of colour developed was measured at 710 nm. The concentration of tannin was calculated by referring to the standard curve of tannic acid and expressed as $mg\ g^{-1}$ sample.

Appendix II: Estimation of total phenols

Reagents (i) Folin Ciocalteau Reagent (FCR) 1N

A mixture consisting of 100 g sodium tungstate (NO_2WoO_4 $2H_2O$), 25 g sodium molybdate ($NO_2MoO_42H_2O$), 700 ml distilled water, 50 ml 85 per cent phosphoric acid and 100 ml of concentrated hydrochloric acid were refluxed gently for 10 nours in a 2.0 litre flask. Lithium sulphate 150 g, 50 ml of distilled water and a few drops of bromine water were added and the mixture was boiled for another 15 minutes without the condenser to remove excess bromine. Then the reagent was cooled and filtered. The normality was adjusted with 1N NaOH to a phenolphthalein end point and appropriate quantity of distilled water was added to bring it to 2N. This reagent was stored in amber bottles in dark. The reagent was diluted to 1.0N just before use.

(ii) Alcohol (80 per cent)

(iii) Sodium carbonate solution (20 per cent)

(iv) Standard catechol

One hundred mg of catechol was dissolved in 100 ml water (stock solution). Working standard was prepared by diluting 10 ml of stock standard to 100 ml so that the concentration of catechol was 100 $\mu g\ ml^{-1}$.

Procedure

The finely ground sample (2 g) was extracted with 5-10 ml of 80 per cent alcohol in a pestle and mortar and the homogenate was boiled in water bath for 5-10 minutes, centrifuged and supernatant was collected. The boiling was repeated with 10 ml of 80 per cent alcohol, again centrifuged, supernatant collected in the same flask and volume made up.

A known volume of aliquot was pipetted into a test tube and volume was made upto 3.0 ml with distilled water. Then, 0.5 ml of 1.0 N Folin Ciocalteau Reagent (FCR) was added, mixed well and allowed to stand for five minutes. Then, 2.0 ml of sodium carbonate solution was added and mixed well by shaking. The tube was then placed in boiling water bath for exactly one minute cooled and volume made to 10 ml. The absorbance of the colour developed was measured at 650 nm against a reagent blank. Standard curve was drawn by plotting the absorbance against concentration of catechol. Total free phenol content was expressed as mg g^{-1} sample.

Appendix III: Estimation of phytic acid

Reagents

1. 3 per cent trichloroacetic acid (TCA)
2. 3 per cent sodium sulphate in 3 per cent TCA
3. 1.5 N NaOH
4. 3.2 N HNO_3
5. $FeCl_3$ solution: Dissolve 583 mg $FeCl_3$ in 100 ml at 3 per cent TCA
6. 1.5 M potassium thiocyanate (KCSN) : Dissolve 29.15 g in 200 ml water
7. Standard Fe $(NO_3)_3$ solution

Procedure

Weigh a finely ground (40 mesh) sample estimated to contain 5 to 30 mg phytate P into a 125 ml Erlenmeyer flask. Extract in 50 ml 3 per cent TCA for 30 minutes with mechanical shaking or with occasional swirling by hand for 45 minutes. Centrifuge the suspension and transfer a 10 ml aliquot of the supernatant to a 40 ml conical centrifuge tube. Add 4 ml of $FeCl_3$ solution to the aliquot by blowing rapidly from the pipette. Heat and contents in a boiling water bath for 45 minutes. If the supernatanat is not clear after 30 minutes. Add one or two drops at 3 per cent sodium sulphate in 3 per cent TCA and continue heating. Centrifuge (10-15 mins) and carefully decant the clear supernatanant. Wash the precipitate twice by dispersing well in 20 to 25 mol 3 per cent TCA, heat in boiling water for 5 to 10 minutes and centrifuge. Repeat washing with water. Disperse the precipitate in a few ml of water and add 3 ml of 1.5 N NaOH with mixings. Bring volume of approximately 30 ml with water and heat in boiling water for 30 minutes. Filter hot (quantitatively) through a moderately retentive paper Whatman No. 2. Wash the precipitate with 60-70 ml hot water and discard the filter. Dissolve the precipitate from the paper with 40 ml hot 3.2 N HNO_3 into a 100 ml volumetric flask. Wash the paper with several portions of water, collecting the washings in the same flask. Cool flask and contents to room temperature and dilute to volume with water. Transfer a 5 ml aliquot to another100 ml volumetric flask and dilute to approximately 70 ml. Add 20 ml of 1.5 M KSCN, dilute to volume and read colour immediately (within 1 ml) at 480 nm. Run a regent blank with each set of samples.

Standard

Weigh accurately 433 mg $Fe(NO_3)_3$ and dissolve in 100 ml distilled water in a volumetric flasks. Dilute 2.5 ml at this stock standard and make upto 250 ml in a volumetric flask. Pipette out 2.5, 5, 10, 15 and 20 ml of this working standard into a series at 100 ml volumetric flasks and proceed from step 16.

Calculation

Findout of the µg iron present in the test form the standard curve and calculate phytate P as per the equation.

$$\text{Phytate P (mg/100 g sample)} = \frac{\mu g\ Fe \times 15}{\text{Wt. of sample (g)}} \times \frac{1}{100}$$

Appendix IV: Scorecard for the sensory evaluation of little millet based sports food

Name: Date:

Directions: Please write a numerical score against the given foods for given characters.

Score pattern

Quality	Score
Liked extremely	9
Liked very much	8
Liked moderately	7
Liked slightly	6
Neither liked nor disliked	5
Disliked slightly	4
Disliked moderately	3
Disliked very much	2
Disliked extremely	1

Parameters

Product code	Appearance	Consistency	Flavour	Taste	Overall acceptability

Remarks

Signature of the evaluator

Appendix V: Estimation of peroxide value

Reagents: Solvent mixture of glacial acetic acid and chloroform (2:1)

5% potassium iodide solution

N/500 Sodium Thiosulphate solution

1% starch solution

Procedure:

1. Extract fat by using chloroform and methanol mixture (2:1) by filtration and evaporation
2. Weigh one gram of oil into dry clean boiling tube and add one gram of powdered, KI an d20 ml solvent mixture.
3. Place the tube in boiling water so that the liquid boils within 30 seconds and allow to boil vigorously for not more than 30 seconds.
4. Transfer the contents quickly to a conical flask containing 20 ml of KI solution and collect the washing of the flask.
5. Tritrate against N/500 sodium thiosulphate solution until pale yellow colour disappears.
6. Add 0.5 ml of starch solution, shake vigorously and titrate carefully till the blue colour disappears.
7. Repeat with the blank

$$\text{Peroxide value (mill equivalent / kg of fat)} = \frac{S \times N \times 1000}{\text{Weight of sample (g)}}$$

S = ml of sodium thiosulphare solution (Test-blank)

N = Normality of sodium thiosulphare solution

Appendix VI: Score card for the sensory evaluation of sports food during storage

Name of the judge:

Characteristics/days	0	15	30	45	60	75	90	105	120	135	150	165	180
Appearance and colour													
Liked extremely													
Liked very much													
Liked moderately													
Liked slightly													
Neither liked nor disliked													
Disliked slightly													
Disliked moderately													
Disliked very much													
Disliked extremely													
Consistency													
Liked extremely													
Liked very much													
Liked moderately													
Liked slightly													
Neither liked nor disliked													
Disliked slightly													
Disliked moderately													
Disliked very much													
Disliked extremely													
Aroma													
Liked extremely													
Liked very much													
Liked moderately													
Liked slightly													
Neither liked nor disliked													
Disliked slightly													
Disliked moderately													
Disliked very much													
Disliked extremely													
Taste													
Liked extremely													
Liked very much													
Liked moderately													
Liked slightly													
Neither liked nor disliked													
Disliked slightly													
Disliked moderately													
Disliked very much													
Disliked extremely													
Overall acceptability													
Liked extremely													
Liked very much													
Liked moderately													
Liked slightly													
Neither liked nor disliked													
Disliked slightly													
Disliked moderately													
Disliked very much													
Disliked extremely													

Remarks:

Signature

Appendix VII: Descriptive sensory evaluation of sports food

Name: Date:

Please taste the food and describe the following attributes in your own words.

a. Colour appearance

b. Aroma

c. Mouthfeel

d. Taste

Signature of the judge

Appendix IX: Instructions to the participants of the study

Do's:

- Consume regular diet and fluid during the study period.
- Consume the entire quantity of food given to you, along with your regular diet during loading phase.
- Record the diet during control trial and repeat the same during experimental trial.

Don'ts:

- Fasting and feasting.
- Strenuous work outs or activity during the study.
- Exercise on the day of endurance test.
- Smoking and alcohol consumption.
- Medicines. Please inform if you are taking any medicines.

Appendix X: Questionnaire to elicit the basic information of the subjects

I. General information

Name :

Age :

Education :

Address : Contact No.:

II. Participation in sports

a. Since how long you have been actively participating in sports ? _____ years

b. Which are the major sporting events you participate ?

c. What are the other games you play ?

Sl. No.	Game	No. of times played per week

d. What is your level of participation in sports?

Sport	National	State	District	University	College

e. Did your team get championship any time ? Yes / No

If yes, how many times ?

f. Did you get individual medal/recognition anytime? Yes / No

If yes, how many times ?

g. Give details of exercise pattern

Particulars	Frequency/day	Time spent/day (min)	Since how long (years)

h. Do you practice your game every day? Yes / No

If no, how many times/week?

i. How many hours do you sleep ?

Night _____ hours Day _____ hours

III. Dietary habits

a. Type of diet Vegetarian/Non-vegetarian/Lacto-vegetarian/Eggarian

b. Details of beverage consumption

c. Generally how many meals you take per day ?___

Do you miss any of these meals? Yes / No

If yes, how often you miss__

d. Do you take any supplements? Yes / No

If yes what do you take and how often?

e. Consumption of special foods for sports

Foods	Timing	Quantity	Reasons	Who prescribed

f. Foods taken

Before event	Reasons	During event	Reasons	After event	Reasons

g. Foods avoided

Before event	Reasons	During event	Reasons	After event	Reasons

IV. Frequency of consumption of food

Foods	Daily	Weekly twice	Weekly once	Fortnightly	Once a month	Occasionally	Never
Cereals							
Pulses							
Oil seeds							
Milk/curds							
Cheese							
Egg							
Chicken							
Fish							
Mutton							
Green leafy vegetables							
Other vegetables							
Fruits							
Butter							
Ghee							
Cooking oil							
Sugar/ jaggery							
Bakery products							
Fast foods							
Desserts							
Sweets							
Soft drinks							
Chocolates							
Others, specify							

Appendix XI: Mean sensory scores of porridge from sports food mixes trial 1

Flavor	Color and appearance	Consistency	Aroma	Taste	Over all acceptability
Mix 1	7.44	7.67	7.22	4.33[b]	4.89[b]
Mix 2	7.88	7.36	7.0	6.68[a]	6.78[a]
Mix 3	7.78	7.56	7.56	7.44[a]	7.56[a]
Mix 4	7.88	7.44	7.00	4.56[b]	5.11[b]
F value	0.48[NS]	0.26[NS]	0.91[NS]	50.46**	39.08**
C.D.	-	-	-	0.91	0.82

** - Significant at 1% level

NS – Non-significant

Figures in the same column followed by different letters are significantly different

Appendix XII: Mean sensory scores of porridge from sports food mixes trial 2

Flavor	Color and appearance	Consistency	Aroma	Taste	Over all acceptability
Mix 2	7.78	7.44	7.00	6.78[b]	6.78[b]
Mix 3	7.89	7.67	7.56	7.44[ab]	7.44[ab]
Mix 5	8.00	7.56	7.00	7.11[ab]	7.22[ab]
Mix 6	8.00	7.67	7.67	7.78[a]	7.78[a]
F value	0.10[NS]	0.74[NS]	2.24[NS]	3.29*	3.00*
C.D.	-	-	-	0.68	0.69

** - Significant at 1% level

NS – Non-significant

Figures in the same column followed by different letters are significantly different

Appendix XIII: Mean sensory scores of porridge from sports food with different flavouring agents

Flavor	Color and appearance	Consistency	Aroma	Taste	Over all acceptability
Cocoa	5.13	7.13	6.75[b]	5.63[b]	5.50[b]
Cardamom	7.50	7.63	7.50[a]	7.88[a]	7.75[a]
Vanilla	7.38	7.63	7.38[a]	7.50[a]	7.50[a]
F value	23.53**	1.62 [NS]	3.68*	27.90**	34.07**
C.D.	1.10	-	0.18	0.67	0.84

* - Significant at 5% level

** - Significant at 1% level

Figures in the same column followed by different letters are significantly different

Appendix XIV: Effect of storage on moisture content and peroxide value of sports food

Storage period (days)	Moisture content (%)	Peroxide value (meq/kg fat)
0	5.98	1.84
15	5.98	1.83
30	6.02	1.85
45	6.04	1.86
60	6.08	1.95
75	6.1	1.96
90	6.13	2.01
105	6.2	2.04
120	6.27	2.04
135	6.38	2.11
150	6.41	2.14
165	6.49	2.2
180	6.59	2.24
SEm±	0.007	0.001
F value	158.90**	50.43**
C.D.	0.064	0.073

Appendix XV: Effect of storage on sensory scores of porridge prepared from sports food .

torage period (days)	Colour and appearance	Consistency	Aroma	Taste	Overall acceptability
0	7.27	7.46	7.36	7.82	7.82
15	7.27	7.46	7.36	7.82	7.82
30	7.27	7.46	7.36	7.82	7.82
45	7.27	7.46	7.36	7.82	7.82
60	7.27	7.46	7.09	7.64	7.82
75	7.27	7.46	6.82	7.46	7.64
90	7.27	7.46	6.82	7.46	7.64
105	7.27	7.46	6.82	7.46	7.64
120	7.27	7.46	6.82	7.36	7.46
135	7.27	7.46	6.82	7.36	7.46
150	7.27	7.36	6.64	7.36	7.27
165	7.182	7.27	6.55	7.09	7.00
180	7.182	7.18	6.46	6.82	6.73
SEm$\pm$	0.61	0.66	0.52	0.38	0.37
F value	0.03	0.13	2.30*	2.68*	3.49*
C.D.	NS	NS	0.61	0.68	0.69

PHYSICO-CHEMICAL AND FUNCTIONAL PROPERTIES OF LITTLE MILLET (Panicum miliare), DEVELOPMENT AND EFFICACY OF LITTLE MILLET BASED SPORTS FOOD

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MAJOR ADVISOR

ABSTRACT

Millets are being recognized as potential future crops and little millet (*Panicum miliare*) is one of the minor millet. In the present investigation, the physico-chemical and functional properties of local genotype and *Sukshema*, an improved variety were studied for developing little millet based sports food. The *Sukshema* genotype with better physico-chemical and functional properties was selected for the purpose. Roasted flours of little millet, soybean, sugar powder, skimmed milk powder and cardamom powder were mixed such that the energy from protein in the mix was more than 15, as per the guidelines of ICMR. The porridge from the nutri-dense sports food mix was highly accepted by the consumers and 46.15 per cent of them revealed that they would eat the product at every given opportunity. The sports food had a shelf life of more than 180 days in metallized polyester polyethylene packs at ambient conditions. Carbohydrate loading with sports food improved the endurance capacity of sports persons (n=31) by 15.55 per cent under fasting condition. The improvement in endurance capacity with sports food as pre-event meal over routinely consumed pre-event meal was 1-5 per cent. The sports food supplementation for 90 days significantly improved the anthropometric parameters, haemoglobin status and physical fitness components *viz.,* flexibility (0.86%), cardiac efficiency score (4.69%), strength (7.27%) and endurance capacity (26.86%) of the supplemented group (n=16) compared to control group (n=15). The technology for production of sports food was transferred to a food industry which launched the product into the market with attractive packaging.