

**STANDARDIZATION, EVALUATION AND IMPACT OF FUNCTIONAL
PRODUCTS FROM KODO MILLET (*Paspalum scrobiculatum*) AND
BARNYARD MILLET (*Echinochloa frumentacae*)**

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**DEPARTMENT OF FOOD SCIENCE AND NUTRITION
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MADURAI - 625 104

2013

CERTIFICATE

This is to certify that the thesis entitled “**Standardization, evaluation and impact of functional products from kodo millet (*Paspalum scrobiculatum*) and Barnyard millet (*Echinochloa frumentacea*)**” submitted in partial fulfillment of the requirements for the degree of **DOCTOR OF PHILOSOPHY (FOOD SCIENCE AND NUTRITION)** to the Tamil Nadu Agricultural University, Coimbatore is a record of *bonafide* research work carried out by **Mrs.L.SENTHAMARAI SELVI** under my supervision and guidance and that no part of the thesis has been submitted for the award of any other degree, diploma, fellowship or other similar titles. However, part of the thesis work has been published in peer reviewed scientific journal of national/international repute (copy enclosed).

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EXTERNAL EXAMINER

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*Thesis submitted in part fulfilment of the requirements for the degree of
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Tamil Nadu Agricultural University, Coimbatore.*

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(Mrs.L.SENTAHMARAI SELVI)

ABSTRACT

STANDARDIZATION, EVALUATION AND IMPACT OF FUNCTIONAL PRODUCTS FROM KODO MILLET (*Paspalum scrobiculatum*) AND BARNYARD MILLET (*Echinochloa frumentacea*)

By

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Millets are known for several health benefits and it is mainly attributed to its nutritional composition. A possible strategy of extending the utilization of kodo millet and barnyard millet - a “nutrition packed bundle” is to blend in with the mixture of other ingredients in an acceptable manner, rightly referred to as instant mix. Small millet based food products play the dual role as a tool for achieving food and nutritional security and also addresses life style disorders. Food processing enterprise, especially millet based foods is a promising enterprise to bring about self employment and an income generating activity for rural women. Hence the present study on “Standardization, evaluation and impact of functional products from Kodo millet (*Paspalum scrobiculatum*) and Barnyard millet (*Echinochloa frumentacea*)” was undertaken. The study was conducted in Periyar taluk of Madurai district and 120 rural women were selected as the subjects for the study. The socio economic details with reference to religion, type of family, family size, landholding size, domestic animals, occupation, monthly income, literacy, type of house, source of drinking water, toilet and sanitation facilities, personal habits and health facility available were elucidated from the subjects by way of interview method. To study the millet consumption pattern including food habits and meal pattern, frequency of millet consumption, food expenditure pattern, frequency of millet purchase, the per capita food intake of the selected subjects in comparison with requirement, per capita nutrient intake of the

selected subjects in comparison with RDA, correlation between nutrient intake and anthropometric indicators/indices variables of the selected subjects and biochemical estimations were assessed. Attempts were made to develop ten small millet based instant mixes of popular foods belonging to the categories of traditional foods *viz.*, idli, dosa, adai, pittu, idiyapam, kali, roti, paniyaram, halwa and kesari at various levels of incorporation of kodo millet and barnyard millet and the most acceptable level of incorporation was standardized. The most acceptable level of incorporation of millets in the instant mixes were subjected to shelf life studies. The instant mixes were packed in HDPE, aluminium foil and MPP with and without antioxidant and were kept at ambient conditions for a storage period of 180 days, were studied for changes in the nutritional qualities, microbial and sensory qualities during storage.

The developed ten different instant mixes were taken for consumer acceptability on a large scale. To find out the consumer's acceptability of the developed mixes evaluation of the same was done by selecting 300 judges belonging to the age group 21- 50 years from Peraiyur Taluk, Madurai. A score card of four point hedonic scale for various attributes such as colour, texture, flavour, taste and overall acceptability was utilized. Nutrition education programme specially aimed to improve the knowledge regarding the nutritional significance of the millets, nutrient composition of barnyard millet and kodo millet, health benefits of small millets, product diversification of small millets, general hygiene and sanitation and usage of millet products as a dietary component was conducted. The feasibility of using millet based products in daily dietaries and use of millet based instant mixes was also included as a major theme in the nutrition education programme in the form of hands on training in the method of preparation of instant mixes which was given over a six months period of study.

The results of the socio economic profile of the selected subjects revealed that the majority of the selected subjects belong to the Hindu religion (84 %), 70 per cent of the subjects belonged to nuclear family, household comprised of 4-6 members (53%), 14 per cent of the selected subjects possessed land, 33 per cent of families possessed domestic animals and 47 per cent of them earned an extra income from these sources. The main occupation of the selected subjects were agriculture labour (80 %), monthly income of 53 per cent of the respondents was < Rs.6000. Eighty four per cent were illiterate and among the subjects 34 and 36 per cent lived in brick walled tiled house and concrete house respectively. Electricity facility was not available to only 24 per cent of the respondents. Hundred per cent of the selected subjects depended on public tap of

drinking water facilities and 90 per cent of them used the open area for defecation. Fifty per cent of the respondents does not have any unhealthy personal habits. The monthly expenditure was apportioned for food, clothing, rent, education, health, fuel, transport, remittance, recreation and savings. All the respondents had spent for all the above except recreation.

The mean height was found to be maximum for the age group 20-30 years and accordingly the BMI was also minimum for the age group of 20-30 years. The Waist Hip Ratio was 0.78, 0.80, 0.82 and 0.82 while the Mid Upper Arm Circumference was 20.69, 22.69, 24.60 and 24.24 for the age group of 20-30, 31-40, 41-50 and 51-60 years respectively. The per cent of fat ranged from 11.22 to 14.10 with reference to food habits. All the respondents (100%) were non vegetarian. Seventy two per cent of them had no meal planning and majority of the respondents (66%) had three meals per day with no regular time schedule (34%). The most commonly consumed millet was found to be finger millet (30%) followed by sorghum (28%), kodo millet (17%), barnyard millet (16.7%) and pearl millet (8.3%). Majority of the respondents used millet as a whole grains (61 %), while 39 per cent of the respondents used millet in the form of rice. Porridge was the conventional small millet based product prepared by majority of respondents (43.3%) followed by kali (16.7%), roti (11.6%), health mix (8.4%), dosai (6.6%) and dessert (3.4%). Small millet was not used in the preparation of products like idli, idiyapam and paniyaram. Though instant mixes were available for purchase only

5 per cent of the respondents had the aptitude to purchase and use pittu and roti mix and 4 per cent for kali mix and adai mix.

Majority of the millets were consumed monthly once while kodo millet, finger millet and barnyard millet were consumed monthly twice by 17, 30 and 17 per cent respondents respectively. Sorghum was consumed weekly once by 28 per cent respondents. Little millet, foxtail millet, barnyard millet and proso millet were consumed occasionally by cent per cent of respondents. The food expenditure pattern indicated that the major expenditure was on cereals, pulses, millets and minimum expenditure for fruits, vegetables, green leafy vegetables, milk and milk products. A variation existed in the purchase pattern of the small millet among the subjects. The per capita food intake and nutrients intake of selected subjects in comparison with requirement was found to slightly be lesser than the requirement for all the food groups. There were significant correlation in case of some nutrients with anthropometric indicators.

Regarding standardization of the small millets based instant food mixes the colour, texture, flavour, taste and overall acceptability were highly acceptable for the idli, dosa, adai, pittu, idiyapam, kali, paniyaram, roti, halwa and kesari were prepared from the instant mix that had 100 per cent kodo millet and barnyard millet flour. The nutritional, microbial and sensory quality of the instant food mixes with 100 per cent incorporation of small millets were analysed at regular intervals during storage. The results revealed that the food mixes packed in MPP with antioxidants had retained the nutritional qualities, minimum microbial load and highly acceptable sensory qualities.

The idli mix after 180 days of storage had moisture from 9.95 (T₂P₃WA) to 11.86 (T₀P₁WOA), protein from 9.45 (T₀P₁WOA) to 11.26 (T₁P₃WA), starch from 55.46 (T₁P₁WOA) to 68.70 (T₀P₃WA), fat from 1.02 (T₀P₁WOA) to 2.75(T₂P₃WA) and crude fibre from 1.12 (T₀P₁WOA) to 6.88 (T₂P₃WA) g per 100 g respectively. The dosa mix had moisture ranged from 9.52 (T₂P₃WA) to 10.86 (T₀P₁WOA), protein from 8.43 (T₀P₁WOA) to 10.25 (T₁P₃WA), starch from 55.37 (T₁P₁WOA) to 67.70(T₀P₃WA), fat from 0.48 (T₀P₁WOA) to 1.98 (T₂P₃WA) and crude fibre from 1.02 (T₀P₁WOA) to 5.48 (T₂P₃WA) g per 100 g respectively. The adai mix had moisture ranged from 11.41 (T₂P₃WA) to 12.70 (T₀P₁WOA), protein from 12.39 (T₀P₁WOA) to 15.58 (T₁P₃WA), starch from 27.25 (T₁P₁WOA) to 45.75 (T₀P₃WA), fat from 1.08 (T₀P₁WOA) to 1.97 (T₂P₃WA) and crude fibre from 4.88 (T₀P₁WOA) to 7.75 (T₂P₃WA) g per 100 g respectively. The pittu mix had moisture ranged from 10.55 (T₂P₃WA) to 12.52 (T₀P₁WOA), protein from 4.78 (T₀P₁WOA) to 7.14 (T₁P₃WA), starch from 51.30 (T₁P₁WOA) to 68.64 (T₀P₃WA), fat from 0.69 (T₀P₁WOA) to 1.75(T₂P₃WA) and crude fibre from 0.51 (T₀P₁WOA) to 5.77 (T₂P₃WA) g per 100g respectively. The idiyapam mix had moisture ranged from 10.55 (T₂P₃WA) to 12.52 (T₀P₁WOA), protein from 4.78 (T₀P₁WOA) to 7.14 (T₁P₃WA), starch from 51.30 (T₁P₁WOA) to 68.64 (T₀P₃WA), fat from 0.69 (T₀P₁WOA) to 1.75(T₂P₃WA) and crude fibre from 0.51 (T₀P₁WOA) to 5.77 (T₂P₃WA) g per 100g respectively. The kali mix had moisture ranged from 10.50 (T₂P₃WA) to 11.70 (T₀P₁WOA), protein from 7.03 (T₀P₁WOA) to 9.48 (T₁P₃WA), starch from 52.75 (T₂P₁WOA) to 66.22 (T₀P₃WA), fat from 0.82 (T₀P₁WOA) to 1.75(T₂P₃WA) and crude fibre from 1.76 (T₀P₁WOA) to 6.47 (T₂P₃WA) g per 100 g respectively. The paniyaram mix had moisture ranged from 9.94 (T₂P₃WA) to 11.30 (T₀P₁WOA), protein from 8.03 (T₀P₁WOA) to 10.48 (T₁P₃WA), starch from 48.00 (T₁P₁WOA) to 62.87 (T₀P₃WA), fat from 0.98 (T₀P₁WOA) to 2.87 (T₂P₃WA) and crude fibre from 1.10 (T₀P₁WOA) to 6.30 (T₂P₃WA) g per 100 g respectively. The roti mix had moisture ranged from 9.74 (T₂P₃WA) to 11.57 (T₀P₁WOA), protein from 10.38 (T₀P₁WOA)

to 12.12 (T₁P₃WA), starch from 55.30 (T₁P₁WOA) to 63.70 (T₀P₃WA), fat from 0.55 (T₀P₁WOA) to 2.35 (T₂P₃WA) and crude fibre from 0.78 (T₀P₁WOA) to 6.10 (T₂P₃WA) g per 100 g respectively. The halwa mix had moisture ranged from 9.48 (T₂P₃WA) to 12.00 (T₀P₁WOA), protein from 9.18 (T₂P₁WOA) to 11.44 (T₀P₃WA), starch from 55.00 (T₂P₁WOA) to 68.55 (T₀P₃WA), fat from 1.52 (T₀P₁WOA) to 3.77 (T₂P₃WA) and crude fibre from 1.24 (T₀P₁WOA) to 4.40 (T₂P₃WA) g per 100 g respectively. The kesari mix after 180 days of storage had moisture ranged from 9.22 (T₂P₃WA) to 12.08 (T₀P₁WOA), protein from 7.68 (T₀P₁WOA) to 9.70 (T₁P₃WA), starch from 78.72 (T₁P₁WOA) to 82.94 (T₀P₃WA), fat from 2.56 (T₀P₁WOA) to 3.97 (T₂P₃WA) and crude fibre from 1.42 (T₀P₁WOA) to 5.53(T₂P₃WA) g per 100 g respectively. A significant increase in the mineral crude fibre and dietary fibre was observed between the control, kodo millet and barnyard millet food mixes.

The results of the consumer's acceptability revealed that kali and roti were the highly preferred products followed by pittu, idiyapam, adai, kesari, dosa, idli and halwa. The product tested gave high potential for commercialization and marketability. Nutrition education brought about considerable positive changes in knowledge, attitude and practice among the rural women. Nutrition education had brought about a significant impact on the change in the Knowledge, Attitude and Practice of nutritional significance of small millets, usage of small millet products, improved the millet consumption pattern and processing of small millet products as a tool for self employment and income generation. The millet based instant food mixes not only exerted a therapeutic effect but were also less expensive.

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ABBREVIATIONS USED IN THE STUDY

Cm	Centimeter (s)
G	Gram (s)
Dl	Deciliter
Hrs	Hours (s)
µg	Microgram
Sec	Second (s)
Kg	Kilogram (s)
Mg	Milligram (s)
Meq	Milli equivalent
K.Cal	Kilocalories
%	Percentage
Cfu	Colony forming units
°C	Degree centigrade
Fig	Figure
**	Highly significant
*	Significant
NS	Non significant
KOH	Potassium hydroxide
Hcl	Hydrochloric acid
NaOH	Sodium hydroxide
BHA	Butylated Hydroxyl Anisole
HDPE	High Density Polyethylene bag
MPP	Metalized PolyPropylene
Hb	Haemoglobin
WHR	Waist Hip Ratio
BMI	Body Mass Index
MUAC	Mid Upper Arm Circumference
SW	Sedentary worker
MW	Moderate worker

CHAPTER I

INTRODUCTION

Food is vital for health and well being of an individual. Right to food is the fundamental right with equal footing that of right to life. Our nutritional status, health, physical and mental well being depends on the food we eat and how we eat it. Food has acquired a significant position in human society beyond that of providing nourishment to the body which is reflected in many patterns of human behaviour (Chandrasekara and Shahidi, 2010).

One of the major challenges of nutritionists is to minimise human sufferings due to nutritional stress as Indian population suffer from food and nutritional insecurity. Though, India has achieved self sufficiency in food production and there is “food for all”, the biggest challenge facing the nation is to ensure “food to all” for achieving food and nutrition security. On the other hand, due to significant change in the lifestyle of people, owing to the rapid industrialization, improved socio-economic status, enhanced health facilities and increased life expectancy, economic affluence coupled with sedentary lifestyles and changing food patterns have contributed to several chronic degenerative diseases such as diabetes mellitus, cardiovascular diseases, cancer, etc. Diabetes mellitus is a silent disease and is now recognized as one of the fastest growing threats to public health in almost all countries of the world. Around 150 million people suffer from diabetes in the world, of which above 35 million are Indians, the highest number in any country. Given these two situations of food and nutrition insecurity and life style disorders. In this context, small millets forms an important component to contribute significantly to the regional food and nutritional security and to combat lifestyle disorders as a part of the daily diet in the national food basket. . Small millets thus play an important role as health foods. (Hazra,2011).

Millets are small seeded annual grasses, cultivated as grain crops, primarily on marginal lands of temperate, subtropical and tropical regions. Millets are classified as coarse grains along with the major millets, maize and sorghum. Besides the major millets there are many small millets, which are called minor millets. The small millets comprise of finger millet

or ragi (*Eleusine coracana*), proso millet or panivaragu (*Panicum miliaceum*), foxtail millet or thenai (*Setaria italica*), little millet or samai (*Panicum sumatrense*), barnyard millet or sanwa millet (*Echinochloa colona*) and kodo millet or varagu (*Paspalum scrobiculatum*).

India is the leading producer of small millets namely, finger millet (*ragi*), kodo millet (*varagu*), foxtail millet (*thenai*), barnyard millet (*kuthraivaali*), proso millet (*panivaragu*) and little millet (*samai*) (Majumder *et al.*, 2006). Annual planting area under them is around 2.5 million hectares and at present, small millets account for less than 1% of food grains produced in the world (ICAR, 2010). The cropped area under small millet in India has declined from 46.77 in 1961-66 to 9.05 lakh hectares in 2008-2009. During the same period, the production of small millets has declined from 18.89 to 4.45 lakh tonnes. Production of barnyard millet was 1.65 lakh tonnes contributed from Uttarakhand (0.91), Arunachal Pradesh (0.16), Nagaland (0.14), Madhya Pradesh (0.12), Uttar Pradesh (0.07), Tamil Nadu (0.03) and production of kodo millet was 0.98 lakh tonnes from Madhya Pradesh (0.50), Chhattisgarh (0.17), Tamil Nadu (0.12), Maharashtra (0.08) and Uttar Pradesh (0.07) respectively. (Anon, 2010)

The resilience of Indian agriculture, weathering all the vagaries of the monsoon has resulted in fall in food grain production, in spite of an increase in area under fine cereals which had necessitates a paradigm shift towards increase in production of minor millets, as it has wide adaptability to extremes of soil and climatic conditions.

Kodo millet (*Paspalum scrobiculatum* L.) was domesticated in India almost 3000 years ago. It is found across the old world in humid habitats of tropics and subtropics. It is a minor grain crop in India and an important crop in the Deccan plateau. Barnyard millet (*Echinochloa frumentacea*) is one of the hardiest millets, which is called by several other names *viz.*, Japanese barnyard millet, *kithraivaali, ooda, oadalu, sawan, sanwa, and sanwank*. Barnyard millet is a multipurpose crop which is cultivated for food and fodder. It can be cultivated in all types of soils and sustained adverse climatic conditions. It had an excellent rejuvenating capacity compared to other cereal crops. The fast growing nature of the crop suppressed the weed growth. Thus, it is a promising crop under adverse agro climatic conditions (Roopashree, 2008).

Millets are known for several health benefits and it is mainly attributed to its nutritional composition. Kodo millet and barnyard millet are highly nutritious but have received comparatively little attention in terms of production and utilization. The protein, mineral and fibre content of kodo millet and barnyard millet was higher, while energy content was comparable to that of other cereals and millets. Kodo millet and barnyard millets were also good sources of B vitamins. They were also rich in phytochemicals, including phytic acid (Shashi *et al.*, 2007), which was believed to lower cholesterol, and phytate, was associated with reduced cancer risk. Thus, these two millets are strategic in

terms of their food, nutritional and livelihood security in local agro-ecosystems. (Joshi *et al.*, 2008).

Van der Merwe *et al.* (2001) reported that change in diet from millet based to refined wheat and rice diets contributed to increased prevalence of diabetes and other health ailments. The higher proportion of unavailable carbohydrates and release of sugar from millets and other coarse cereals was slow, thus improving glucose metabolism (Arora and Srivastava, 2002). They also contain a wide variety of antioxidants, which aptly complemented their fibre content in reducing risk of cancer and heart disease (Decker *et al.*, 2002). During the last decade a number of experimental and epidemiological studies had brought into focus the potential chemo preventive substances present in coarse millet grains (Kamp and Jones, 2003). With a surging prevalence of various health ailments attributed to consumption for refined cereals the focus is now on fibre rich millet grains.

Although small millets were superior to other cereals with many nutritional benefits, their utilisation was limited mainly to poor section of population or to cattle and poultry feed, or finds place as fasting food, reason being low palatability, coarseness of grain, lack of time to process the grains and slow the digestibility of protein and carbohydrates. As millets were coarse grains having higher amounts of polyphenols the colour and flavour became unacceptable to new consumer. Further, the non availability of processed millet in ready to use form was another hurdle in its utilization. (Poongodi *et al.*, 2010).

Kodo millet and barnyard millet also needed to be processed to diversify their uses and to improve their nutritive value and consumer acceptability. Study of their suitability for specific end uses would be helpful in diversifying millet for its food and industrial uses. The development of commercial processing centres to obtain processed ready to eat products from kodo and barnyard millet will greatly increase the demand for these crops and improve the diet of the consumers. (Edam *et al.*, 2001). Value added products from kodo and barnyard millet have the potential to add value to business and has a large potential for growth as consumers believe that millets and millet based foods contribute directly to their health.

Most of the foods consumed by people in India are traditionally processed. However their preparation is time consuming and laborious, with the result that convenience foods based on traditional processing has entered the market with huge success. Work on the development of ready premixes from traditional food is on the increase in recent years. Besides the ease in preparation and consumer acceptability, the

functional and attractive packaging, which provides adequate shelf life is of importance in popularizing the product. Instant mixes comprised of a mixture of processed cereals, pulses, condiments, spices or other foods in varying combinations. These are used for the preparation of various dishes, conveniently in a very short span of time. These products have found increasing favour in the recent years for the modern women. The market for instant food is steadily growing, especially among urban consumers with a host of competing brands and flavours. (Shobana *et al.*, 2007). Burgeoning urban spread and nuclear families with double incomes point to a rapid growth potential in the sector. These mixes are available already for a plethora of preparations like the traditional gulab jamun mix, jalebi mix, idli mix, dosa mix etc. More innovative and wide ranging products could be developed keeping in view the tastes and likes of the people and suited to the eating habits of the people. Instant mixes offer great convenience to the homemakers to prepare traditional delicacies. But the development of millet based instant mixes had not received much attention. (Singh and Raghuvanshi, 2012).

A possible strategy of extending the utilization of kodo millet and barnyard millet - a “nutrition packed bundle” is to blend in with the mixture of other ingredients in an acceptable manner, rightly referred to as instant mix. With improvement in product quality and improved shelf life kodo millet and barnyard incorporated traditional foods in the form of instant mixes would find a ready market. Small millet based food products play the dual role as a tool for achieving food and nutritional security and also addresses life style disorders. Improving the income of families is also very important to achieve food security. For this self employment avenues for women can be encouraged. Food processing enterprise, especially millet based foods is a promising enterprise to bring about self employment and an income generating activity for rural women. Hence with a view to improve the health status of women by encouraging the consumption of kodo millet and barnyard millet in the form of value added functional food products and promote self employment among rural women, the present study was undertaken with the following objectives.

- To study the socio economic, health and millet consumption pattern of the selected subjects.
- To standardize functional products viz., instant food mixes from kodo millet and barnyard millet.
- To evaluate the quality of the standardized products during storage.

- To study the consumer acceptability of the developed product.
- To study the impact of the standardized product through nutrition education.
- To work out the cost analysis of the standardized instant mixes.

CHAPTER II

REVIEW OF LITERATURE

In the recent years, there has been an increasing recognition of the importance of millets as the substitutes for major cereal crops. Considering their nutritional value, ease of cultivation, low investment and proportionately high returns, these crops deserve greater attention and investment in research than what has been accorded to them.

At the national and state level, attempts are now being made for popularizing and improving the millet crops.

In this chapter the literature pertaining to the studies related to socio economic and health profile of rural women, millet production and processing, value addition and quality attributes and significance of nutrition education are briefly reviewed under the following headings.

2.1 Overview of socio economic and health profile of women

2.2 Scenario of millet production and processing

2.3 Value added millet products

2.4 Quality attributes of millet products

2.5 Health benefits of millet products

2.6 Significance and impact of nutrition education

2.1 Overview of socio economic and health profile of women

Sreenivasan *et al.*(2001) observed deficient energy intake among the low income group of Tamilnadu and the farm labourers of Agricultural Research Station of Rajasthan. The results revealed that 77 per cent of the farm labour consumed less than 2300 kcal of energy daily.

Murugkar and Pal (2005) conducted a study to examine the food consumption pattern of 1,850 Khasi tribals in Meghalaya as influenced by socio-economic factors. Socio-economic parameters revealed that the majority of tribal followed farming as an occupation (49.96%), had more than five members in their families (72.48%) had higher income (49.83%) and literacy rate (67.34%) than the national average. Rice, meat, roots and tubers, fermented foods; green leafy vegetable and fruits were consumed everyday and farming played a significant role in consumption of cereals and

fruits. The results of the study indicated that an increase in income and level of education did not mean a proportionate improvement in the quality of food consumed.

Nallakuruban (2005) conducted an interview on socioeconomic status of the tribal rural women in the age group of 21-45 years. From the study, 44 per cent of families possessed domestic animal and the main occupation of the selected women were agricultural labourers (89 %) and 4 per cent of them were in government service while rest were housewives.

Divakar and Prema (2009) conducted a study on nutritional status of women workers in cashew industry in Kerala. In this study, the diets of 300 women workers in cashew industry were found to be qualitatively and quantitatively deficit. Calories and proteins were significantly low. Vitamin C deficiency was observed in 45 per cent of the cases and all the women were clinically reported to be anaemic. Eighty per cent of the population had only medium nutritional status.

Padmapriya and Lakshmi (2012) studied prevalence of anaemia among the self help group women. Anthropometric measurements were used to assess their general nutritional status. Clinical assessment was done for all the selected women by a medical practitioner for signs of iron deficiency disease using a schedule formulated and the level of haemoglobin was measured to determine the prevalence of anaemia. It was found out that 42 per cent of women had levels below 10 g /dl and 34 per cent had levels ranging between 10 and 11.9 g/dl. Twenty four per cent of women had normal level. Mild and moderate anaemia found among women which was due to the poor intake of iron rich foods. All the foods consumed by the women were found to be deficit in micronutrients, when compared against the balanced diets suggested by ICMR.

Amaravathi *et al.*(2012) conducted a study on evaluation of nutritional status of the women employed in seafood processing units. Two hundred and forty four seafood women workers randomly selected from four seafood processing unit and surveyed about demographic information, nutrient intake. The mean working hours and work experience was 9.96 and 4.1 years respectively. The mean intake of energy, protein, fat and iron was 1736.8 K.cal, 45.41 g, 22.1 g and 17.61 mg respectively. The dietary survey indicated that all the women had lesser energy consumption and 90 per cent had lesser amount of protein against the RDA. The mean body mass index was 20.63. Regarding the nutritional status 52.9 per cent normal, 29 per cent underweight, 9.4 per cent obese I category, 5.7 per cent and 2.9 per cent in the obese two and morbid obesity respectively.

Women are generally the nutritionally vulnerable segment of our population. The objective of the study was to ascertain the somatic status of women from urban and rural area of Mysore. A total of 756 women aged between 28 -33 years were recruited for the study and their height, weight, waist and hip circumference were recorded. Nutritional status was assessed according to BMI. The average age of women was 30.1 years. Mean weight of women was 52.2 kg with urban women showing higher weight of 54.5 kg and rural women with lesser weight of 49.6 kg, the difference being significant. Mean height of women was 152.4 cm, with no difference between urban and rural women. The mean waist and hip ratio was 0.9 BMI indicated that 21.7 per cent of women were suffering with CED while a considerable number were also overweight (18.4%) and obese (7.9%). The study indicated that most of the women have normal BMI, however, a small number need nutritional care (Shekharnaik and Jamuna, 2012).

Jyotsnadevi and Thulasamma (2012) studied food consumption behaviour of tribal women in Andhra Pradesh. It was observed that among most of the tribal groups, the staple diet was rice or minor millets. Tribal diets were generally grossly deficient in calcium, vitamin A and Vitamin C, riboflavin and animal protein. Nearly half (46%, 50%, 53%) of the respondents from districts, i.e., Khammam, Kurnool and Guntur bought cereal daily. More than one third (38%,40%,46%) of the respondents in three districts bought pulses weekly. Majority (94%, 93% and 80%) of the respondents in the three districts bought vegetables weekly. Cent per cent of respondents from the three districts were consumed cereals and pulses daily. Majority of the respondents (72%) consumed meat and meat products monthly in the three districts.

Geeta *et al.* (2012) conducted a study on nutritional scenario of fast food among women in Bhagalpur Town, Bihar. Fast food consumption was high in women of higher educational qualification, younger age group and higher income level. The consumption of sodium chloride was higher due to consumption of fast food.

Halakatti *et al.* (2010) investigated on utilization pattern of small millet in Haveri District of Karnataka. The study revealed that 63 per cent of the small millet produced were sold in the local market for consumption and other industrial uses, while 21 per cent of the farmers retained their produce for home consumption indicating the usage of traditional grains for their significance. Nine per cent of the farmers used these grains as feed to domestic animals and birds. Straw of the small millets was predominantly used as animal feed (64 %) while other utility purposes including thatching the huts, sale in the market or better exchanges.

Daniel (2008) conducted economic survey on income generating activity in rural areas of South Tamilnadu. The study concluded majority of the household earned least income from agricultural activities which was due to off seasoning of rabi and kharif.

The impact of the training conducted on fruit and vegetable processing indicated that 44 per cent of them earned an income of Rs.20, 000 per month and 54 per cent Rs. 10,000 per month after taking food processing as an income generating entrepreneur (Selvi, 2006).

2.1 Scenario of millet production and processing

In the world, small millets are cultivated on an area of 39.39 million hectare with a production of 30.8 metric ton, while in India they are cultivated on an area of 16.25 million hectare producing about 8.5 metric ton (FAO 2002).

Small millets area in India was around 3.0 million hectare producing around 3.0 million tonnes of food grain. The bulk of small millet production in India was of finger millet (80%) and remaining from kodo millet, little millet, foxtail millet, barnyard millet and proso millet. Small millets in India are grown in Karnataka, Andhra Pradesh, Maharastra, Tamil Nadu, Orissa, Jharkhand, Chhattisgarh, Madhya Pradesh and Uttarkhand (Seetharam and Gowda, 2007).

In Tamilnadu, finger millet was cultivated in an area of 1.18 lakh hectares with a production of 1.76 lakhs metric tonne and productivity of 1909 kg/ha (2003-04). The crop was grown as kharif rainfed crop in June-July, rabi crop during September-October and summer irrigated crop in January – February (Malathi and Nirmalakumari, 2007)

Annual planting area under millet was around 2.5 million hectares and at present, small millets accounted for less than one per cent of food grains produced in the world (ICAR, 2010). The cropped area under small millet in India had declined from 46.77 in 1961-66 to 9.05 lakh hectares in 2008-2009. During the same period, the production of small millets had declined from 18.89 to 4.45 lakh tonnes. Production of barnyard millet was 1.65 lakh tonnes, contributed from Uttarakhand (0.91), Arunachal Pradesh (0.16), Nagaland (0.14), Madhya Pradesh (0.12), Uttar Pradesh (0.07), Tamil Nadu (0.03) and production of kodo millet was 0.98 lakh tonnes from Madhya Pradesh (0.50), Chhattisgarh (0.17), Tamil Nadu (0.12), Maharashtra (0.08) and Uttar Pradesh (0.07) respectively. (Anon, 2010)

Prakash *et al.* (2011) popularization of millets in six districts of Karnataka revealed that, 101.75 acre millet growing land has increased based on demand. On an average 0.03 quintals of grain yield increased during 2011 compared to 2010.

Production of pearl millet, sorghum, little millet, barnyard millet, kodo millet, foxtail millet and proso millet were 88.87, 72.46, 1.42, 1.65, 0.98, 0.58 and 0.26 lakh tonnes contributed from all over India. Millets, and particularly small millets, are in a situation of crisis in India. The period between 1961 and 2009 saw a dramatic decrease in cultivated area under millets (80% for small millets, 46% for finger millet, 59% for sorghum and 23% for pearl millet); a 76% decrease in total production of small millets; a significant decrease in per capita availability of all millets (despite high productivity gains for some varieties); and a steep fall in overall millets consumption (Anon, 2012).

Foxtail millet, pearl millet, little millet and finger millet were the important grains for human consumption. Because of paradigm shift from traditional crops to cash crops the farmers are showing least interest in these millets though the millets are having high nutritional content, dietary fiber, micronutrient and B-vitamins (Rayangoudar and Vaikunthe, 2011).

Traditionally millets were consumed as rice in millet growing areas and as fasting food in several northern states of India. The traditional preparation of millets and culturally accepted fasting foods can be applied in developing therapeutic foods to alleviate hidden hunger and combat life style disorders (Yenagi *et al.*, 2011).

Effect of milling on the nutritional quality of little millet grains was assessed by Goudar *et al.* (2011). The nutrients carbohydrates, fat and total energy did not vary significantly with number of polishing. It was observed that with the increase in number polishing there was a loss in protein, total dietary fiber and total mineral contents.

Vijayakumar and Mohankumar (2011) studied on drying characteristics of pretreated kodo and barnyard millet subjected to sun drying and shade drying. The drying time of both kodo and barnyard millet grains was six hours for sun drying and 15 to 18 hours for shade drying. The overall drying rate of both kodo and barnyard millet on sun drying was significantly higher than shade drying. The weight time relation was non linear for sun drying and linear for shade drying of both millets. The results revealed that shade drying was best method for selected millets though it took a long time than sun drying.

Effect of processing on tannin, phytate and *in vitro* iron in underutilized millets such as dhal (*Pennisetum tyhodeum*) and kangni (*Setaria italica*) were investigated by

Sankhala *et al.* (2004). The impact of processing techniques such as soaking and sprouting on the anti-nutritional factors phytates and tannins and associated improvement in iron bioavailability was studied. Findings of the study revealed that there was a significant reduction in anti nutritional factors in both the millets after soaking and germination. Sprouting the grains also exhibited an observable and positive impact on iron bioavailability. Thus, it was concluded that germination was one of the suitable methods for improving availability of iron.

Srivastava *et al.* (2001a) studied the popping quality of small millets. Popping percentage of finger millet samples ranged from 86 to 95 per cent, while those of foxtail millet ranged from 75 to 96 per cent, barnyard millet ranged from 78 to 84 per cent and proso millet ranged from 52 to 58 per cent. The highest mean popping percentages was observed for finger millet followed by foxtail millet, barnyard millet and proso millet. However, the percentage of fully popped grains was highest for foxtail millet (46 to 75%) and lowest in finger millet (20 to 78 %). Flake size was highest for proso millet (0.033 to 0.035%) and lowest in finger millet (0.006 to 0.0150).

Effect of hydration and pan roasting pre-treatments on the puffing characteristics of ragi (finger millet), variety 'MRI' was studied by Premavalli *et al.*(2005). Water, butter milk, and citric acid solutions were used for hydration. Effect of pan roasting of grains after instant conditioning was studied. The puffed ragi was evaluated for puffing yield, bulk density, water absorption index, water solubility, swelling power, gelatinization, amylase, amylopectin, reducing and total sugars, lipids and fractionated lipids. The results of the study indicated that water and buttermilk hydration influenced puffing yield and bulk density, which played a significant role in reconstitution of instant produces, while the chemical constituents were not significantly affected.

Selvi *et al.*(2010) conducted study to evaluate the popping of selected millet variety of sorghum and bajra. Popped millets were prepared from sorghum and bajra after pearling. Butylated Hydroxyl Toluene (BHT) was used to reduce the development of rancidity in the popped sorghum and bajra. Value added products developed from popped sorghum and bajra were highly acceptable.

Singh *et al.* (2005) reported that foxtail millet (*Setaria italic*), barnyard (*Echinochloa colona*) and finger millet (*Eleusine coracana*) could be processed to flour and incorporated at 10 to 30 percent level to wheat flour for product preparation.

Mohamed *et al.* (2010) studied the effect of refrigeration on improving the storage stability of whole and dehulled millet flour. During storage period, the results

showed that tannin and phytate contents of the whole flour were unchanged by refrigeration. However, cooking of the refrigerated flour significantly decreased tannin and phytate contents. The results obtained demonstrated, that the nutritional as well as sensory quality of millet flour remained unchanged during storage under refrigeration.

2.3 Value added millet products

Barnyard millets and finger millet were incorporated in *khichadi*, *laddu* and *baati* along with legumes and fenugreek seeds (Arora and Srivastava, 2002). *Khichadi* mix was prepared with millet, whole green gram and fenugreek seeds in the ratio of 60:20:20. *Laddu* mix contained millet, roasted soybean, malted fenugreek seeds in the proportion of 65:10:20, along with 5 per cent popped amaranth seeds. Millet based *baati* was prepared with fenugreek seed powder and roasted bengal gram flour both at 20 per cent.

Suitability of barnyard millet in cereal-based common traditional foods was studied by Veena (2003). Five traditional foods rice, *idli*, *dosa*, *roti* and *chakli*, were prepared by different methods of cooking, viz., boiling, pan baking, fermentation, shallow and deep fat frying. The main ingredient of the selected food (except of cooked rice) was substituted with barnyard millet flour in varying levels of 0, 25, 50, 75 and 100 percent. Incorporation of the millet altered the nutrient composition of the foods without affecting organoleptic characters. Substitution of barnyard millet in rice- based foods increased the nutrients per serving in terms of dietary fiber and minerals but reduced calorific value proportionately to the level of substitution.

Sharma and Sayeeda (2005) standardized *idli* prepared from kodo millet. Proportion of standard *idli* were parboiled rice (60g), black gram (30), fenugreek seeds (5g) and water. Proportion of millet *idli* were parboiled rice (30g), black gram (30g), kodo millet (30g), sprouted fenugreek seeds (5g) and water. Proportions of kodo *idli* were kodo millet (60g), black gram (30g), sprouted fenugreek seeds (5g) and water. Nutritive value of kodo *idli* was significantly high when compared to control.

Varnashree *et al.* (2008) evaluated the *idlis* prepared by using ragi and ragi flour along with other ingredients such as parboiled rice and black gram dhal flour in different ratio. Pre soaked whole ragi *idlis* resulted in soft texture and the *idlis* prepared with ragi flour had dark colour compared to whole ragi. Incorporation of whole ragi in the preparation of *idlis* did not affect the acceptability of the product. The study concluded that ragi could be used to replace rice in the preparation of *idli* enhancing the nutritional quality without considerable effect on the quality parameters of *idli*.

An attempt was made to develop chemically leavened; millet legume based instant *idli* mix by Kamareddi *et al.* (2003) with various proportions of little millet rice and black gram with different chemical leavening agents. The proportions of little millet, semolina and black gram flour was 4:1:1 along with sodium bicarbonate (0.2%), citric acid (0.05%) and salt (2.00%) was found to be optimum in terms of cost, bulk density and acceptability of the steamed product. *Idli*, prepared with one part of instant mix soaked in 0.5 parts of curds and 1.5 parts water at room temperature for 30 min followed by steaming for 10 min gave a product of high consumer acceptability.

Vijayakumar *et al.*, (2009) carried out a study to expand the utility of Kodo (*Paspalum srobiculatum*) and barnyard (*Echinochloa colona*) millets by incorporating them in whole wheat flour and defatted soy flour mixture and studied the impact of millet flour blend on different quality characteristics of *chapati*. The incorporation of millet flour blend and soy flour improved the quality of *chapati* in terms of nutrient density and taste. The 30 percent millet flour blend incorporated composite flour based chapatti was highly acceptable.

Roopa *et al.* (2003) developed enriched flour mix from wheat, malted ragi, soya bean and drumstick leaf powder in the ratio of 50:25:15:10 for *chapathi* preparation.

Itagi *et al.* (2011 a) developed dicoccum wheat and millet based designer food such as *Khichadi* and *upma* of low glycemic index recommended for diabetics.

Kulkarni *et al.* (2011) developed value added millet based traditional food products and tested their acceptability. The products developed were proso millet *sweet pongal*, little millet *paddu* and *dosa* with *chakramuni* leaves, little millet *idli* with *methi leaves* and carrot, little millet *upma* with drumstick leaves and with bengal gram leaves, barnyard millet based *upma* with drumstick leaves, foxtails millet *vada* with greens and foxtail millet based *besibelebhath*. The value added millet based traditional products were highly nutritious, cost effective and sustainable strategy to alleviate the hidden hunger and for the management of life style disorders.

Kumari and Srivastava (2000) standardized and evaluated sweet *burfi* from malted finger millet flour and reported that the product from malted finger millet resulted in significant changes in nutrient composition and the sensory evaluation of *burfi* indicated that the product was highly acceptable.

Geetu *et al.* (2003) developed acceptable *ladoos* incorporated with popped pearl millet at 100 and 50 percent levels in a basic recipe containing roasted chickpea and groundnut (both at 25% levels). The nutrient composition of the *ladoo* with 100 percent

millet was reported to be superior to 50 per cent millet *ladoos*. *Ladoos* prepared from 100 percent popped pearl millet had low polyphenol and phytic acid and was high in

in vitro protein and starch digestibility as compared to those *ladoos* prepared from a blend of millet, groundnut and chickpea. The stored *ladoos* were organoleptically acceptable up to three months of storage.

Srivastava *et al.* (2001 b) developed proso millet based multipurpose food with soybean and groundnut, by malting and popping. The mix was used for the development of different foods such as *sweet gruel*, *salty gruel*, *halwa*, *burfi* and *biscuits*. The study concluded that proso millet flour could be effectively used in the preparation of nutritious foods for infants and young children.

Roopa *et al.* (2003) studied to develop a convenience mix for traditional sweet *halwa* using finger millet starch. A formulation containing 20 percent millet starch, 45 to 48 percent sugar and cooked for 30 min resulted in a *halwa* that had highly acceptable sensory scores.

Scientific experiments have been carried out to enhance the nutritional quality of common convenience foods such as *papads*, by substituting conventional grains with nutritious millet. *Papads* was formulated using finger millet (60%), Sago (20%), black gram (20%) along with spices (Begum *et al.*, 2003). Calcium was reported to be exceptionally higher in *papads* with finger millet (156 mg /100g) compared with traditional *papads* (82 mg/100g).

Minor millets like kodo, little barnyard millets and finger millet are the important food crops in the tribal regions of India. Kumar *et al.* (2003) employed the utilization of these millets in traditional foods. Acceptable *chakli*, *kjheechla* and *kichri* were prepared by blending the millet separately with green gram and soybean in different proportions. *Sattu* was developed with puffed chickpea, finger millet, soybean flour and skimmed milk powder in the ratio of 60:25:10:05 had a better nutrient composition over the traditional *Sattu* in terms of protein, calcium and lysine. This could be recommended for growing children, pregnant and lactating mothers to meet the additional needs of calcium and proteins during growth and development.

Sashidevi (2001) studied the processing and evaluation of instant paniyaram mix prepared from millet flour with incorporation at different levels of 25, 50, 75 and 100 per cent. It was organoleptically highly acceptable.

Instant *puliogare* mix and vegetable *palav* mix were formulated using decorticated finger millet and spices to add to variety and convenience to traditional cooking by Sahoo *et al.*(2003). Dehydrated vegetables such as carrot, beans, onion, and tomato were used to formulate instant vegetable *palav* mix. The products contained higher amount of macro and micronutrients.

Machewad *et al.*(2006) developed instant mix a combination of sorghum flour and soy bean flour, sorghum flour and puffed chick pea flour and reported that 25 per cent of inclusion of both the pulse flour to be highly acceptable and a significant increase in the protein content of the flour was also observed.

Surekha *et al.* (2007) developed and evaluated barnyard millet based multi purpose mix. Barnyard millet constituted the main ingredient and other ingredients such as black gram dhal, carrot and spices were added and the developed mix was highly acceptable.

Karuppasamy *et al.* (2010) developed millet based convenience mix laddu, uthiriputtu, kuzhaputtu and roti mix and it was organoleptically highly acceptable.

Anju and Sarita (2010) developed two types of multipurpose composite flour mix namely foxtail millet flour (45%) and refined wheat flour (55%) and barnyard millet flour (45%) and refined wheat flour (51%). The mix had a shelf life of 180 days at ambient conditions.

Composite flour mix was developed by Deshpande and Poshadri (2011) using foxtail millet (60%), amaranthus (5%), rice (5%), bengal gram (20%) and cowpea (10%) which was reported to produce quality extrudates with acceptable sensory properties.

Karuppasamy *et al.*(2012) developed kodo and little millet based boli mix. The mix was prepared from kodo millet flour, little millet flour, refined wheat flour, cowpea and horse gram flour at different proportion. The mix had a shelf life of 90 days at ambient conditions.

Rekhasinha *et al.* (2012) standardized a nutritious ready mix prepared from finger millet, quality maize protein, Bengal gram and soybean in the proportion of 40:25:25:10. It was organoleptically highly acceptable and had higher protein content.

Nithya (2004) developed health drink namely 'Nutrimix' for athletes. The nutrimix consisted of malted flours of bajra (10g), ragi (10g), soybean (10g), potato flour (5g) curry leaves powder (5g), sesame seeds powder (5g), milk powder (24g), cardamom

powder (3g) and powdered sugar (24g). The health drink was prepared by mixing 25g of nutrimix in 250ml of water and boiled for three minutes.

Roopa *et al.* (2011) developed a nutrient dense sports food from little millet for increasing physical endurance of young adults. Little millet based sports food mix was formulated according to ICMR guidelines. The mix had varying proportions of little millet, soybean, sugar powder and skimmed milk powder and it was highly acceptable.

Lakshmi and Veena (2004) conducted a study on value added extruded products using tapioca, cereals (wheat and ragi), pulses (green gram and soy flour) at different ratios and developed the products. Results indicated that the ragi and soya incorporated extruded product were nutritionally superior and had good consumer acceptability.

Finger millet pasta products were developed by Devaraju *et al.* (2003). Composite finger millet flour/refined finger millet flour (50%), refined wheat flour (40%), refined soy/whey protein concentrate (10%) and hot water (75°C) were standardized for pasta making.

Shanthi *et al.* (2005) standardized the formulas as whole wheat flour (20 to 30%) and soya flour (10 to 20%) for making nutritionally balanced pasta products. The results revealed that sensory scores of ragi flour up to 30 percent and soya flour up to 10 percent was highly acceptable.

Kulkarni *et al.* (2012) made attempts to develop nutrient rich noodles by the addition of optimized proportions of wheat and malted ragi flour with other ingredients. Combinations of wheat and malted ragi flour (90:10, 80:20, 70:30, 60:40 and 50:50) and other ingredients like vegetable oil, corn flour, wheat gluten, GMS and guar gum were optimized by varying proportion to result a better quality noodles. Results revealed that among all the formulations tried, noodle sample prepared from 70:30 flour combination had same sensory score as that of control and higher value of protein, fibre and minerals (i.e. calcium, iron and phosphorus) than the control sample.

Akoth *et al.* (2012) developed instant breakfast cereals from optimized flours of pearl millet, red and white sorghum. The developed breakfast cereals had better nutrient attributes in comparison to their control products. The developed breakfast cereals from optimized flours of sorghum and millet were generally acceptable to the consumer with their nutritive value being as high as that of similar products in the market.

Development, consumer acceptability and quality evaluation of millet choco flakes have been studied by Kotagi (2011 b). The consumer acceptance of millet choco

flakes were evaluated by desire to eat the flakes frequently among the 216 consumers of different age groups studied and reported to be highly desirable and acceptable.

Flax seed (*Linum usitatissimum*) incorporated little millet flakes were developed to enrich omega -3 fatty acid (Kotagi *et al.*, 2011a). The study indicated potential value of fortified little millet flakes as a novel food with nutraceutical properties.

Kshirsagar *et al.* (2004) studied the effect of improvers and sorghum malt (0.5 and 1.0%) on the preparation of wheat bread. Bread was prepared using maida and whole-wheat flour (100g), sorghum malt (0.5%), improvers (50 ppm potassium bromate + 150 PPM ascorbic acid), shortening (3g), yeast (3g), salt (1.5g), sugar (5g) and required amount of water. Sensory characteristics of addition of sorghum malt at 0.5 per cent level along with improvers improved the crust colour, texture and taste. The whole-wheat flour bread with improvers and sorghum malt at 0.5 per cent levels also showed superior crust colour. But addition of 1.0 per cent sorghum malt with improvers decreased the sensory attributes when compared to control.

Dingra and Jood (2006) developed fibre rich bread with whole-wheat flour incorporated with barley at 5, 10, 15 and 20 per cent levels. Breads prepared were found to be organoleptically (colour, flavour, texture, appearance and taste) acceptable up to 15 per cent level of incorporation. Good quality bread could be developed by supplementation of barley up to 15 per cent level without any adverse effect on baking and organoleptic characteristics.

Joshi *et al.* (2003) conducted an experiment to diversify the use of foxtail millet in cake preparation. Flour blends of wheat and foxtail millet in the ratio of 100:0, 95:5, 90:10, 85:15, 80:20 and 75:25 were used. The 75:25 blends was found to be highly acceptable although it decreased the cake volume, but did not affect symmetry and uniformity indices.

Sponge cakes were prepared using flours from blanched pearl millet (*Pennisetum glaucan*), refined wheat flour and green gram (*Phaseolus aureus*) flour in the ratio of 40:50:10 (type I) and 60:30:10 (type II) and control which contained 100 percent refined wheat flour (Sehgal and Kwatra, 2006). Both types of cakes were highly accepted upon sensory evaluation. The results showed that blanched pearl millet flour in combination with refined wheat flour and green gram flour could be successfully incorporated for the development of nutritious sponge cake.

Cakes were prepared by using various blends of wheat flour and malted ragi flour (80:20, 60:40, 50:50, 40:60 and 30:70) with other ingredients as per the standardized recipe. A blend of 50:50 of wheat flour and malted ragi flour resulted in good quality cakes (Desai *et al.*, 2009)

Syed *et al.*(2011) standardized the preparation of low calorie cake with pearl millet maltodextrin. The aim was to replace fat in cake by incorporation of pearl millet maltodextrin prepared by acid hydrolysis of pearl millet starch at the rate of 20, 30 and 40 per cent. It was recommended to adopt maltodextrin as fat replacer in cake formulation upto the extent of 30 per cent with results on the basis of organoleptic evaluation compared to experimental control.

Singh *et al.* (2006) developed four types of non-khatai using 50 per cent blanched pearl millet flour and 50 per cent soyabean flour (Type-I), 100 per cent blanched pearl millet flour (Type-II), 50 per cent malted pearl millet flour with 50 per cent soyabean flour (Type-III) and 100 per cent malted pearl millet flour (Type-IV) with addition of ghee (90g), milk powder (7.5g), sugar (115g) and curd (1tsp). All the products were highly acceptable and nan-khatai prepared from malted pearl millet flour reduced the antinutrient content and improved the digestibility of the products.

Effect of bajra flour on quality of biscuits fortified with defatted soy flour was studied by Mridula and Gupta (2008). Biscuits prepared from flour blends containing varying proportions of bajra flour (0, 10, 20, 30, 40, and 50%) and fortified with 5 percent defatted soy flour were prepared and evaluated for physical, textural, colour, nutritional and sensory properties. The study showed that bajra flour up to 30 percent could be utilized for making acceptable quality biscuits. The highest mean sensory scores was observed for biscuits prepared from flour blends containing 10 percent bajra flour, 85 percent wheat flour and 5 percent DSF.

Biscuits were produced from composite flour comprising of three varying proportions of blends of flour from tiger nuts, sorghum and groundnuts. Sensory evaluation of biscuits from these flours revealed no significant difference among the products (Aliyu and Sani, 2009).

Ballolli *et al.* (2001b) developed nutraceuticals enriched barnyard millet cookies by incorporating nuts and dry fruits such as cashew grits and dates flakes, five percent each in the standard barnyard millet cookie recipe. The barnyard millet cookies were highly acceptable with light and crisp texture, pleasant aroma and excellent taste.

2.4 Quality attributes of millet products

Balasubramanian and Viswanathan, (2010) studied influence of moisture content on physical properties of minor millet. Physical properties including 100 kernel weight, bulk density, true density, porosity, angle of repose, coefficient of static friction, coefficient of internal friction and grain hardness were determined for foxtail millet, little millet, kodo millet, common millet, barnyard millet and finger millet in the moisture content range of 11.1 to 25 per cent db. Thousand kernel weights increased from 2.3 to 6.1 g and angle of repose increased from 25.0 to 38.2°. Bulk density decreased from 868.1 to 477.1 kg/m³ and true density from 1988.7 to 884.4 kg/m³ for all minor millets when observed in the moisture range 63.7 to 32.5 per cent. Coefficient of static friction of minor millets against mild steel surface increased from 0.253 to 0.728 and coefficient of internal friction was in the range of 1.217 and 1.964. Grain hardness decreased from 30.7 to 12.4 for all minor millets when moisture content was increased from 11.01 to 25 per cent db.

Shirsat *et al.* (2009) studied the effect of pre milling treatment on colour analysis of kodo millet. The pre milling treatment *viz.*, soaking for 1-5 hours at 60, 70, 80°C, steaming for 30 minutes prior to milling and roasting for 15 minutes prior to milling were given to the samples. The yellow index (YI) of untreated kodo grains was 47.61 while the whiteness index was – 144.74. The two treatments soaking and steaming, the white index decreased the yellow index slightly increased or remained unchanged. The results showed that soaking imparted the yellowish colour to the grains, which in turn resulted in dullness. Roasting improve the brightness of white index and yellow index. The roasting of grains also improve the colour of puffed kernels has minimum value of yellow index and highest value of white index for puffed products.

Shinde *et al.*(2011) evaluated eight genotypes including released and pre-released for physico chemical quality. The colour of the grain was found to be dull white to white and creamy white. The grains were round in shape. Hectoliter weight ranged from 73.85 to 79.81 kg/hl. The protein content ranged from 9.36 to 10.47 percent, soluble proteins 1.67 to 1.75 percent, total soluble sugars from 1.29 to 1.92 percent, starch ranged from 66.84 to 69.12 percent and phenolics 0.51 to 1.45 percent.

Several functional properties of flour of newly developed four hybrids and three varieties of pearl millet grown under similar agronomic conditions were examined by

Malik and Singh (2001). The study concluded that there was no significant difference in the water and oil absorption values among the hybrids than in varieties; Mean flour solubility values were significantly higher in hybrids than in varieties. Significant differences in the nitrogen solubility index were also observed. The higher concentration of the flour was required to form a gel in case of varieties as compared with hybrids.

Selvi *et al.* (2010) reported the moisture, acidity, pH and protein content of popped sorghum and bajra were 4.58 and 5.08 per cent, 0.012 and 0.10g, 5.71 and 8.28 and 10.10 g per 100g for sorghum and bajra respectively. A decreasing trend in acidity, total sugar, fat and antinutritional factors like tannin and phytic acid was noted while an increasing trend was observed in moisture, pH, reducing sugar, free fatty acid, peroxide value.

Singh *et al.* (2005) indicated the chemical characteristics of composite flour (wheat flour, millet flour) such as protein, fat, ash and carbohydrates. The proximate compositions of wheat flour incorporated with finger millet flour (90:10) were 11.37, 1.11, 0.80 and 86.72 per cent of protein, fat, ash and carbohydrate respectively.

Singh and Singh (2005) studied the physical characteristics of millet flour (foxtail and barnyard millet) such as bulk density, true density and porosity. Milled flour of foxtail millet exhibited highest bulk density (0.80g/cc). Milled flour of barnyard millet had the highest true density. Milled whole finger millet flour exhibited the highest (52.50%) values of porosity.

Shahsi *et al.* (2009) made an attempt to investigate the functional properties, proximate composition and fiber content in different finger millet genotypes. The different genotypes of Indo African finger millets selected were ML-197, MI-553, ML-31, ML-426, ML-322 and ML-365 with two check varieties GPU-28 and Indaf-5. Seeds of each finger millet genotype were milled to get fine flour. The protein and fiber content ranged from 7.50 to 11.70 g and 3.2 to 4.7 percent respectively.

Geetu *et al.* (2003) reported that the protein, calcium, phosphorus, iron and manganese contents were higher (7.34g, 65.5 mg, 168.26 mg, 4.89 mg and 0.49 mg/100 g, respectively), in the pearl millet laddoo at 50 per cent incorporation with chickpea, groundnut flour.

Supplementary foods based on popped wheat, ragi, bajra and sorghum blended with legumes (soy and Bengal gram) were developed by Baskaran *et al.* (2000). Hundred gram of these foods provided 370 kilocalories and 11g protein. Moisture,

protein, total carbohydrate, lipids, ash, dietary fiber and energy met one –third of the Recommended Dietary Allowances of these nutrients per day for preschool children.

Surekha *et al.* (2007) developed and evaluated barnyard millet based health mix. The moisture and fat content of the health mix were low (4.63% and 4% respectively), protein fairly high (12%) and higher levels of dietary fibre (37%) with moderate total carbohydrate content (50%).

Yenagi (2007) developed millet based diabetic mix from foxtail millet. The mix had protein 12.91 g, fat 3.47 g, crude fibre 1.42, carbohydrate 74.04 g, total dietary fibre 23.40 g and energy 379 K cal per 100 g of the mix. The diabetic mix had low glycemic response to the patients suffering from diabetics.

Anju and Sarita (2010) developed two types of composite flour mix namely foxtail millet flour (45%) and refined wheat flour (55%) and barnyard millet flour (45%) and refined wheat flour (51%) and the resultant flours had crude protein 9.92 ± 11.08 g, crude fat 4.7 and 4.46 g and crude fibre 8.07 and 8.13 g/100g.

Jothilakshmi (2012) developed inulin incorporated multigrain mix from kodo millet, wheat flour, bengal gram and horse gram at different proportion. The mixes contained moisture (7.47 %), protein (13.65%), fat (3.84%), crude fiber (3.5 %) and mineral like calcium (85 mg), phosphorus (294 mg) and iron (4.04 mg).

Barnyard millets and finger millet were incorporated in *khichadi*, *laddu* and *baati* along with legumes and fenugreek seeds. Carbohydrate content in finger millet based *khichadi*, *laddu* and *baati* mix provided 56.47, 81.71 and 79.32 per cent of total energy, whereas, in barnyard millet products provided lower level *viz.*, 51.59, 79.40 and 67.76 per cent of total energy respectively (Arora and Srivastava, 2002).

Veena (2003) reported that substitution of barnyard millet in rice- based traditional foods increased the nutrients per serving in terms of dietary fiber and minerals but reduced calorific value proportionately to the level of substitution.

Sharma and Sayeeda (2005) standardized *idli* prepared from kodo millet and gave the proximate compositions of *idli* as protein (11.35-58.3g), fat (0.95-9.11g), fibre (0.69-5.97g), calcium (59.6-105.4mg) and phosphorus (219.8-246.2mg), respectively.

The millet based *khichadi* was found to contain 330 Kcal energy, 64.91 g carbohydrates, 17.34 g protein, 3.87 g fat and 3.03 g minerals per 100 g. It had high fiber (7.57 g) content and resulted in slow release of glucose in the body (Itagi *et al.*, 2011a).

Foxtail millet (*Setaria Italica*) based *Khakhara* (18 g) provided protein 2.35 g, carbohydrate 13.7 g, fiber 3.49 g and 66 Kcal energy with very low fat (0.25 g) (Itagi *et al.*, 2011b).

Bindhu and Sumathi (2010) studied the effect of processing on *in vitro* starch and protein digestibility of white and brown ragi. The variety of white *ragi* (Surva) and brown ragi grain (Ratnagiri) were selected and four products namely *malt*, *weaning mix*, *roti* and *sangati* were prepared and subjected to sensory evaluation. Overall acceptability and proximate composition were found to be significantly higher for white grain ragi than brown ragi.

Shanthi *et al.* (2000) reported that instant idli mix had high protein 11.37 g, starch 58.65 g, fat 1.67 g, fibre 2.32 g, calcium 29.37 mg and iron 2.34 mg per 100 g respectively.

Srivastava *et al.* (2001 b) developed proso millet based multipurpose food with soybean and groundnut, by malting and popping. The mix contained protein (15.15%), fat (5.2%) and energy (332 K cal/ 100g).

Hemalatha (2004) standardized small millet based instant murukku mix prepared from incorporation of kodo millet at 10, 20 and 30 per cent with rice flour and the resultants had the moisture, total sugar, reducing sugar protein, fat, fiber, tannin content were 8.50, 2.25, 0.89, 8.61, 1.06, 2.15 and 2.10 g per 100 g respectively.

Instant *puliogare* mix formulated by Sahoo *et al.* (2003). Dehydrated vegetable such as carrot, beans, onion, and tomato were used to formulate instant vegetable *palav* mix. *Puliogare* provided 7 g protein 5 g fat, 4 g crude fiber, 224 kcal energy, 280 mg calcium and 7.4 mg iron per 100 g of the product and the vegetable *palav* mix provided 10 g protein, 5.3 mg calcium and 9.6 mg iron per 100 g of the product.

Karuppasamy *et al.*(2012) developed kodo and little millet based boli mix and reported that a slight change was noted in the moisture, protein, reducing sugar, total sugar and crude fibre content of the kodo millet and little millet based boil mix during storage.

The protein content of the finger millet based RTE snack food ranged from 12.19 to 18.72 g, fat 2.28 to 3.72 g, and calcium 246 to 408 mg per 100g. The energy content of raw blends was in the range of 361.90 to 377.188 Kcal/100g as given by Thakor *et al.*(2011).

The chemical composition of the millet based health drink for athletes contained 15g protein, 9.4g fat, 5.2g total sugar, 2.7g reducing sugar, 384mg calcium, 4.6mg iron and 3.46mg phosphorus per 100g, respectively (Nithya, 2004).

Roopa *et al.* (2011) developed a nutrient dense sports food from little millet and reported that the sports food had low moisture, optimum amount of protein, low fat and good amount of carbohydrate. The sports food exhibited 79.15 percent *in vitro* protein digestibility.

The mean protein, energy, calcium and iron in finger millet based pasta ranged from 14-18 g, 365-372 kcal, 102-148 mg and 3-5 mg per 100g respectively as given by Devaraju *et al.*, (2003).

Flax seed (*Linum usitatissimum*) incorporated little millet flakes were developed to enrich omega -3 fatty acid (Kotagi, 2011a). The value added flakes recorded increased linolenic acid (116 mg/100 g) content compared to control flakes (2.00 mg/100 g). The developed flakes were also a good source of protein (8.43 %), dietary fiber (22.70%), calcium (28.01 mg %) and energy (295 kcal /100 g.) The acceptability index was 71.37 with mean total score of 32.21 on nine point hedonic scale. The study indicated potential value of fortified little millet flakes as a novel food with nutraceutical properties.

Ballolli *et al.* (2011b) developed nutraceuticals enriched barnyard millet cookies and reported that cookies provided 5.46 g of protein, 23.83 g of fat, 9.79 g of dietary fiber and 461 K cal per 100 g.

Nan-khatai developed from blanched pearl millet flour had high calcium, phosphorus, iron and manganese content as compared to that of malted flour (Singh *et al.*,2006).

Biscuits were produced from composite flour comprising of three varying proportions of blends of flour from tiger nuts, sorghum and groundnuts. Sensory evaluation of biscuits from these flours revealed no significant difference among the products (Aliyu and Sani, 2009)

Dingra and Jood (2006) showed that nutritional composition of barley incorporated bread to contain higher content of fat (5.49-5.58%), sugar (21.08-21.84%), protein digestibility (74.14-74.32%), total lysine (2.52-2.80%) and total dietary fibre (9.05-9.80%) compared to control bread.

Studies of Desai *et al.* (2009) indicated that cake sample enriched with malted ragi flour were rich in mineral content like calcium, iron, phosphorus and crude fiber as compared to the control sample. Sensory scores of cake sample prepared with 50 per cent wheat flour and 50 percent malted ragi flour was same as the control. The cake

prepared with 70 per cent malted ragi flour had highest mineral and fiber content, but the sensory score was low due to loss in sponginess and increased intensity of brown colour.

2.5 Health benefits of millet products

Millets are appreciated for their content of dietary fiber, trace elements and antioxidant components. Scientific studies have proved that millet products have high satiety value, low digestibility, low glycemic value and have been considered as therapeutic foods in management of many metabolic disorders.

Kavita *et al.* (2001) studied the effect of different methods of cooking on total dietary fiber content of foods and glycemic response in NIIDDM patients. They reported that dry heat cooking methods like baking, roasting and pan roasting, use of minimum amount of water for cooking and selection of whole wheat products helped in maximum retention of total dietary fiber and ensured better glycemic control in diabetic subjects.

Health benefits of low glycemic index foods, such as pulses, in diabetic patients and healthy individual were reviewed by Rizkalla *et al.* (2002). They stated that intake of low glycemic index diet reduced fasting and postprandial glucose, triacylglycerol and non esterified fatty acid concentrations and the study also observed that the diet with low glycemic index value improved the prevention of coronary heart diets, increased HDL cholesterol and decreased total cholesterol.

Archana *et al.* (2003) reported that dhokla mix prepared from bleached and unbleached pearl millet with 10, 20, and 30 percent germinated fenugreek seeds exerted a beneficial glycemic index of 37.99 in diabetic subjects.

Itagi (2003) supplemented 80 g per day of composite mixes prepared from foxtail millet and little millet along with wheat and black gram dhal and hypoglycemic spices like fenugreek seeds to diabetics and non diabetics for a period of four weeks. The fasting blood glucose in diabetics and non –diabetics were reduced by 17 and 19 percent, respectively and HDL-cholesterol increased by 2 and 6 percent. There was also considerable reduction in triglycerides and improvement in lipid profile. Millets contained higher proportion of unavailable carbohydrate and release of sugar from millet was slow. Millets contained water soluble beta glucan that was useful in improving glucose metabolism (Anderson *et al.*, 2003). Therefore, millets are suitable for diabetic diet. The grain also contained a high proportion of carbohydrates and dietary fiber which helped in prevention of constipation, lowering cholesterol and slow release of glucose

to the blood stream during digestion. Important vitamins namely thiamine, riboflavin and niacin were present in high quantities. It was reported that cardiovascular diseases, duodenal ulcers and hyperglycemia occur rarely in regular millet eaters (Menon, 2004).

Shukla and Srivastava, (2011) developed finger millet incorporated noodles for diabetic patients. The glycemic index (GI) of 30% finger millet incorporated noodles was observed significantly lower (45.13) than control noodles (62.59). It was found that finger millet flour incorporated noodles to be nutritious and showed hypoglycemic effect.

Gitanjali *et al.* (2004) concluded that cooked rice, dhal, sprouted green gram, malted ragi flour, wheat and *jowar roti* to be good sources of phenolics which along with fiber would reduce chronic disease. It was observed that the consumption of these whole grain products would increase the average daily antioxidant intake.

Results of Surekha (2004) revealed that the barnyard millet based health mix would be an ideal food for the obese and diabetics as it showed a significant reduction in blood glucose level (7%) improved lipid profile and reduction of body weight (mean/kg) during a 28 days feeding experiment to obese diabetics.

Vijayalakshmi and Jamuna (2005) studied the effect of processing on invitro digestibility of tender and regular finger millet based products and blood glucose responses in diabetics. The developed products were tender ragi sundal (steamed and seasoned), mature ragi porridge (ragi and pulse sprouted and powdered) and tender ragi porridge (tender ragi and carrot dehydrated and powdered). These products were supplemented to ten Non Insulin Dependent Diabetes Mellitus (NIDDM) patients. The subjects were in the age group of 40-60 years with body weight ranging from 62 to 74 kgs. The fasting blood glucose and postprandial blood glucose were also recorded for all the four test products at 60,120,180 and 240 minutes after feeding the patients on each consecutive day. The quantity of the products fed to the subjects was one serving, which gives 50g of carbohydrates. Accordingly 75g of sundal, 75g of ragi puttu, 125g of mature ragi porridge and 125g of tender ragi porridge were fed to the patients. The tender ragi sundal food administered subjects had low glycemic index (71), low digestibility percentage (56), low glucose and hydrolysable starch (55.7) when compared to other products. The overall acceptability was highest for tender ragi sundal (4.7) and lower for ragi puttu (3.8), respectively.

Readymade foxtail millet mix for diabetics was developed by Itagi *et al.* (2012). The diabetic mix was prepared with 80% foxtail millet along with 10 % both wheat semolina and black gram dhal and selected spices. The Glycemic Index 54.39 was

noted for foxtail millet mix. The feeding study of four weeks was conducted on nine type 2 diabetics and non diabetics as control group. The difference in the plasma glucose of experimental diabetic and non diabetics with control group was significant ($p < 0.01$) and after intervention the fasting blood glucose reduced upto 16-19 % in experimental subjects. The lipid profile of experimental subjects was improved after consumption of millet mix.

Vijayalakshmi and Radha (2006) studied the effect of little millet supplementation on hyperlipidaemia. One hundred cardiovascular patients were selected from two private Hospitals out of whom 69 were men and 31 were women in the age group of 36-75 years. Little millet containing 22 g of fibre was distributed to the patient in the form of individual packets to be consumed by the subjects in the form of porridge or as a substitute for rice. These supplements were given for a period of 60 days. Lipid profile was estimated before and after supplementation in control and experimental groups. There was a definite reduction in the total cholesterol to the extent of 7.7mg/dl which was significant at one per cent level. In experimental group, LDL, VLDL cholesterol was reduced and HDL cholesterol was increased with little millet supplementation of 60 days than control group.

The hypolipidemic and hypoglycemic effect on multigrain mixes with and without inulin were evaluated by conducting experiments on wistar albino rats for the period of 28 days feeding trail. The weight of the various groups of rats ranged from 189.86 ± 4.51 to 211.66 ± 5.72 g. After 28 days of study there was a statistically significant

increase in the body weight of the rat in control and treatment groups. The average weight gain in treated group ranged from 19 g to 36g after 28 days of study period (Jothilakshmi, 2012).

2.6 Significance and impact of nutrition education

The impact on vitamin A deficiency (VAD), wasting malnutrition, and excessive childhood mortality of two alternative approaches - nutrition education and mega-dose capsule distribution (6-12-month-olds: 100 000 IU; 1-5-year-olds: 200 000 IU) - in communities in Nepal were compared. Approximately 40000 children from 75 locations in seven districts in two ecological settings (lowland and hills) took part in the study and were randomly allocated to intervention cohorts or a control group. At 24 months after the implementation of the project the reduction of risk for xerophthalmia was greater among children whose mothers were able to identify vitamin-A-rich foods (relative risk (RR) = 0.25; 95% confidence interval (CI) = 0.10-0.62) than among the

children who received mega-dose capsules (RR = 0.59; 95% CI = 0.41-0.84). The risk of mortality at 2 years was reduced for both the nutrition education (RR = 0.64; 95% CI = 0.48-0.86) and capsule distribution (RR = 0.57; 95% CI = 0.42-0.77) cohorts (Pant *et al.*, 1996).

Caulfield *et al.* (1999) evaluated the maternal infant feeding knowledge, attitude and practices of the four nutrition education programs and reported that there was an improvement in dietary intakes of maternal and in growth of infants. This range of improvement growth was predicted to reduce prevalence of malnutrition (< -2 SD) at 12 months of age by 1-19 per cent, and could reduce deaths due to malnutrition by 2-13 per cent, depending on the underlying prevalence of malnutrition in the community.

Hyunsook *et al.* (2001) reported that information on nutrition education was taught to children by lecture method, small group discussion and role playing. But the most preferred methods of teaching nutrition education by the children were small group discussion (44.30 per cent) and role playing method (22.90 per cent).

Kapur *et al.* (2003) conducted a study on effectiveness of nutrition education with supplementation among children in the age group of 9-36 months. Group-I received

nutrition education, group-II received supplementation, group-III received nutrition education with supplementation and group-IV served as control. The results revealed that nutrition education had a positive effect on children by improving the nutritional status.

Caballero *et al.* (2003) conducted a study for a period of three years to examine the effects of school based interventions through nutrition education among 1704 school children belonging to the 3rd and 4th grade. The results revealed that there was a significant effect on dietary intake, knowledge attitude and behaviour as a result of nutrition education.

Monden (2004) examined the relationship between food intake, frequency, awareness, knowledge and attitude on health practices of students who have been taught health education through book as part of their curriculum in school. It was found that the children acquired knowledge on health education and their attitude towards health has been effectively achieved. The findings indicated that the health education

can be included as a part in curriculum to teach about the importance of right eating habits.

Lakshmi and Priya (2004) conducted a study to create awareness on nutrition among preschool children by using educational methods like lectures, demonstrations, songs, exhibitions, dramas and use of audio visual aids. The results of the study revealed that 56 per cent of the children had better nutritional knowledge after the nutrition education programme.

Powers *et al.* (2005) investigated a study on the effects of a nutrition education program on dietary behavior and nutrition knowledge among elementary school children. The results showed that pre and post assessment of children had greater improvement in the overall dietary behaviors such as consumption of dairy products, fruits, and vegetables and improvement in nutrition knowledge than children in the control group. Results suggested that nutrition education programs that taught positive dietary messages, potentially improved dietary behavior and increased nutrition knowledge in children.

Choudhary *et al.* (2008) conducted a study on impact of visual media on knowledge, attitude and practice of school children regarding nutrition education. A package of media including posters, charts, leaflets and booklet were prepared on each message and exposed to school children. The results indicated that pre and post explained scores had significant gain in knowledge and change in attitude of the children. The study concluded that education with media was interesting and easy to understand and encouraging in terms of knowledge gain and attitudinal change.

Lakshman *et al.* (2010) conducted a study on effectiveness and acceptability of a novel educational intervention to increase nutrition knowledge among primary school children. The results revealed that mean total nutrition knowledge score increased during intervention (29.2) and in control schools (27.6). Total nutrition knowledge score was higher in intervention than in control schools (mean difference = 1.1, 95 per cent CI: 0.05 to 2.16, $p = 0.042$).

Niemeier *et al.* (2010) conducted a study on educating children about healthy foods. The results revealed that nutrition knowledge scores (range of 0 to 7) increased from 3.5 (± 1.8) to 5.9 (± 1.9) ($p < 0.001$, $n = 19$) among preschool children. Analysis concluded that the children learned more about fruits and vegetables through this experience. The nutrition education program demonstrated the importance of combination of nutrition education, repeated exposure to fruit and vegetables and an

environment that supported fruit and vegetable consumption was an effective strategy to increase preschooler's knowledge about fruit and vegetables.

Nazni and Sureshkumar (2011) conducted a study on formulation of high nutrient density low cost weaning foods followed by demonstration as part of nutrition education programme. The results showed that all the experimental food formulations were acceptable and the nutrition education brought about an increase in knowledge about the weaning foods.

Silveira *et al.* (2011) conducted a study on the effectiveness of school based nutrition education about changing food habits. The results showed that the effectiveness of the study brought about changes the children food habits and an increase in fruits and vegetable consumption.

Kostanjevec *et al.* (2011) conducted a study on effectiveness of nutrition knowledge in different ways and indirectly the development of healthy eating habits in children and teenagers. The nutrition knowledge was assessed by a knowledge test at the

beginning and the end of the study. The results showed that the nutrition knowledge of students significantly improved and they understood the role of particular nutrients in human nutrition.

Jeyabharathi (2012) conducted a study on nutrition education on the knowledge level of selected school children in the age group of 8-10 years (control) and 9-10 years (experiment). The results showed that the intervention group had significant knowledge gain after the exposure to the educational programme.

Minijoesph and Prema (2012) conducted a study on knowledge, attitude and practice of state players of Tamilnadu with respect to sport nutrition. The nutrition education was conducted for a period of six months after exposure to nutrition education their attitude and practice had significantly changed and good healthy and hygienic practice was adopted.

CHAPTER III

MATERIALS AND METHODS

This chapter deals with the materials used and methods adopted during the course of the study “**Standardization, evaluation and impact of functional products from kodo millet (*Paspalum scrobiculatum*) and Barnyard millet (*Echinochloa frumentacea*)**”. The investigation was carried out in the Department of Food Science and Nutrition, Home Science College and Research Institute, Madurai during the year 2010-2013.

3.1 STUDY OF THE SOCIO ECONOMIC AND HEALTH PROFILE

3.1.1 Selection of area

Madurai district was selected for conducting the survey. Madurai district comprised of seven taluks namely Madurai North, Thirumangalam, Vadipatti, Usilampatti, Madurai South, Melur and Peraiyur. Of them Peraiyur taluk was selected as the study area.

3.1.2 Selection of village

Peraiyur taluk holds about 75 revenue villages and among them Mangalrevu was selected for the study.

3.1.3 Selection of subject

One hundred and twenty rural women of Mangalrevu between the age group of 18 to 57 years were selected as the subjects. The socio economic and health profile of the selected subjects were assessed after obtaining ethical clearance. (Appendix-I)

3.1.4 Conduct of survey

For the present investigation, a survey was conducted to elucidate information on socio economic status, food frequency pattern, millet consumption pattern. Well structured questionnaire that served as the interview schedule was prepared for collecting the information. The interview schedule utilized is given in Appendix II. Anthropometric measurements, dietary pattern and nutrient intake of the selected subjects were also taken as detailed below (Plate 1).

3.1.4.1 Socio economic status

For the questionnaire on general background and socio economic status of the selected subjects included background information regarding age, educational status, occupation, monthly income, religion, nature of family and type of house.

3.1.4.2 Anthropometric measurements (Plate 1)

All the anthropometric measurements were taken following the standard techniques (WHO, 2004). Height and weight were measured to the nearest 0.1 cm and 0.5 kg, respectively, using an anthropometric rod, and standard weight scale, respectively. Minimum waist (WC) and maximum hip (HC) circumferences and Mid Upper Arm Circumference (MUAC) were measured to the nearest 0.1 cm using a tape measure. Three skin fold namely, triceps (TSF), sub scapular (SSF) and supra-iliac (SISF), were measured to the nearest 0.2 mm using a Harpenden skin fold calliper. The Body Mass Index (BMI) and Waist Hip Circumference (WHR) were computed using the following standard equations.

3.1.4.2.1 Body Mass Index (BMI)

BMI was calculated by using the formula given by Garrow (1987) to classify the individual as normal, obese and under weight.

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

After the cessation of linear growth around the age of 21 years, weight for height indicates muscle fat mass in the selected subjects. Therefore BMI provided a reasonable indication of the nutritional status. The BMI had good correlation with fatness. It may also be used as indicator of health risk. The following had been suggested by WHO (2004).

Presumptive diagnosis	BMI Class
Under weight	<18.5
Normal range	18.5 – 22.9
Over weight	23.0 – 24.9
Obese I	25.0 – 29.9
Obese II	≥ 30

3.1.4.2.2 Waist Hip Ratio

The ratio of waist to hip is an indicator of central obesity. The abdominal obesity was assessed by waist to hip ratio (Lean *et al.*, 1995).

Gender	WHR Class	Presumptive diagnosis
Male	>0.95	Obese
	<0.95	Normal
Female	>0.80	Obese
	<0.80	Normal

3.1.4.2.3 Skin fold thickness

A Harpenden skin fold caliper was used to measure skin fold thickness. By using skin fold callipers, measurements were taken at three sites. Three sites skin fold measurements are the most commonly used approached to assess the body composition (WHO,2004).

Triceps: The triceps skin fold site is on the posterior aspects of the right arm, over the biceps muscle mid way between the lateral projection of the acromion process at scapula and inferior margin of the olecranon process of the ulna. Double fold of skin and subcutaneous adipose tissue grasped with the thumb and index finger of the left hand. Spot was marked and the calliper tip was placed on the site, where the sides of the skin fold were approximately parallel and 1 cm distal to where the skin fold was grasped. Measurement was obtained after placing calliper tips on the skin.

Suprailiac: This skin fold was measured just above the iliac crest at the mid axillary line. The subjects stood erectly with the feet together and arms hanging at the sides although the right arm was abducted and flexed slightly to improve to the site. The skin fold was grasped about 1 cm posterior to the mid axillary line.

Abdomen: The subjects stand erect, abdominal muscles relaxed and breathing quietly. A horizontal skin fold of 3 cm to the right of the abdomen and 1 cm below the umbilicus was selected and measured.

Per cent body fat

The per cent body fat was computed using skin fold measurement *viz.*, triceps, abdomen, superailiac and thigh by referring to the equation and results were interpreted using following Table.

Equation for per cent body fat

$$\text{Males: } 0.29288(X_2) - 0.00050(X_2)^2 + 0.15845(X_8) - 5.076377$$

$$\text{Females: } 0.29699(X_2) - 0.00043(X_2)^2 + 0.0.2963(X_8) - 1.4072$$

(X₂): Abdomen + superailiac+ triceps

X₈ – age in years

Classification of body fat ranges for the select subjects over 18 years of age

Classification	Male	Female
Unhealthy range (Too low)	≤ 5%	≤ 8%
Acceptable range (lower end)	6-15 %	9-23 %
Acceptable range (upper end)	16-24%	24-31%
Unhealthy range (too high)	≥ 25%	≥ 32%

WHO (2004)

3.1.4.2.4 Biochemical estimation of blood

Doing related biochemical tests is appropriate for screening obesity. In any intervention biochemical changes can be expected to occur prior to clinical changes and also caution the risk factors associated with the development of obesity. Blood was drawn from each respondent before the intervention for estimating the following parameters (Plate 1).

1. Blood sugar
2. Haemoglobin

Blood glucose

Venous blood was collected from the subjects after overnight fasting and assessed the serum glucose by oxidase method. The normal range of fasting blood glucose in adults is 80 -120 mg/dl (Anon, 1997).

Haemoglobin

Venous blood was collected and haemoglobin level was estimated by cyanomet haemoglobin method. The normal range of haemoglobin in adult is 13 to 17 g/dl for men and 12 to 15 g/ dl for women (Bamji *et al.*, 2009).

3.2 STUDY ON MILLET CONSUMPTION PATTERN

3.2.1 Dietary pattern

Information about type of diet and frequency of meals were collected and the detailed questionnaire is given in Appendix III.

Three days recall method: Food consumption pattern was assessed by three consecutive day recall method (Bamji *et al.*, 2009). Data was collected for the last three

days preceding the interview. A set of standardized vessels were used to obtain estimates of the amount of raw food consumed by the selected subjects.

Food frequency pattern: Food frequency pattern are designed to obtain information about usual food consumption patterns. They provide estimates on intake over a specified time period, ranging from a week to one month. A food frequency pattern was designed for collecting the information on location and age specific foods based on the form described by ICMR (2010 b).

3.2.2 Nutrient intake and adequacy

The individual intake was calculated based on the three day recall dietary survey data. The cooked food was converted into raw ingredients. The nutritive value was computed based on the food composition table (Gopalan *et al.*, 2004). The per cent adequacies of nutrients were computed in comparison to that of RDA suggested by ICMR (Raghuram *et al.*, 1997).

3.3 STANDARDIZATION OF MILLET BASED INSTANT MIXES

MATERIALS

3.3.1 Raw Ingredients

Locally cultivated, available and traditionally utilized small millets of Peraiyur taluk *viz.*, barnyard and kodo millet were procured from the village merchant.

3.3.2 Miscellaneous items

Whole green gram, bengal gram dhal, black gram dhal, red gram dhal, horse gram, asafoetida, fenugreek, red chilli powder, jaggery, sugar, oil, salt, onion, green chillies and coconut were purchased from local departmental stores.

3.3.3 Packaging materials

Three different packing materials such as High Density Polyethylene (HDPE- P₁), Aluminium foil (P₂) and Metallised polypropylene (MPP- P₃) were used for packaging and it was purchased from the Arul Poly bags stores at Madurai (Plate 2).

3.3.4 Chemicals used for laboratory analysis

The chemicals and reagents used for the study were either of laboratory reagent (LR), analytical reagent (AR), or guaranteed reagent (GR) grades.

3.3.5 Equipments used in the study

The list of equipments used in the present investigation is given in Table 1

Table 1. Equipments used in the study

Sl. No.	Equipments	Purpose
1.	Avery balance (2 kg capacity)	To weigh raw ingredients in bulk.
2.	Electronic balance (Shimadzu BL-120-H)	To weigh samples in decimals for nutrient estimation and also to weigh chemicals.
3.	Muffle furnace (Gambak make, UK)	To estimate the ash content of the sample with thermostatic control between 100°C and 1000°C.
4.	Hot air oven (Narang Scientific Company, India)	To estimate the moisture content of the sample.
5.	Kel plus (Pelican Equipments, Chennai)	To estimate the protein content of the sample.
6.	Sox plus (Pelican Equipments, Chennai)	To estimate the fat content of the sample.
7.	Fibra plus (Pelican Equipments, Chennai)	To estimate the crude fibre content of the sample.
8.	Centrifuge (Universal model II)	Centrifuge was used for analytical work.
9.	Laminar air flow chamber	To determine microbial quality of the product.
10.	Cabinet drier (Kilburn make)	To dry the processed product for further analysis.
11.	Spectrophotometer (Turner 430 model, USA)	Spectrophotometer was used to estimate chemical constituents of the barnyard and kodo millets.
12.	Satake dehusker (Type THU 35 A)	Satake dehusker (Type THU 35 A) was used to dehusk barnyard millet and kodo millet.
13.	Mixie (Preethi)	To powder the sugar and dried samples.
14.	Electric hand sealer (Preethi)	To pack the instant mixes.
15.	Liquid Petroleum Gas (LPG)	Used as the heating source.

3.3.6 Utensils

Stainless steel, vessels, frying pan, ladles, trays and spoons were used in the study.

METHODS

3.3.7 Kodo millet and barnyard millet based instant food mixes

Ten traditional south Indian breakfast foods *viz.*, idli, dosa, adai, pittu, idiyapam, kali, roti, panyaram, halwa and kesari were selected. Instant mixes of these traditional products with the incorporation of millets (Kodo millet and barnyard millet) were standardized. Parboiled rice, which was a major ingredient in all these traditional products for idli, dosa, adai, pittu, idiyapam, kali, panyaram, roti and wheat semolina for halwa and kesari were replaced with millets at various levels (25, 50, 75 & 100) for the development of instant mixes. The proportion of rest of the ingredients in the instant mixes was maintained as the same as that of the traditional method of preparation.

Standardization of instant kodo millet idli mix and barnyard millet idli mix

The proportion of ingredients required for the preparation of instant kodo millet idli mix and barnyard millet idli mix is given in Table 2.

Table 2. Proportion of ingredients used for instant kodo millet idli mix and barnyard millet idli mix

Ingredients (g)	Control	Kodo millet idli mix				Barnyard millet idli mix			
		Level of incorporation				Level of incorporation			
		25%	50%	75%	100%	25%	50%	75%	100%
Kodo millet rice	-	25	50	75	100	-	-	-	-
Barnyard millet rice	-	-	-	-	-	25	50	75	100
Parboiled rice	100	75	50	25	-	75	50	25	-
Black gram dhal	30	30	30	30	30	30	30	30	30
Salt	2	2	2	2	2	2	2	2	2

- Kodo millet rice, parboiled rice and black gram dhal were separately ground to powder.
- It was then mixed together as per the given proportion of ingredients.
- Salt was finally added to the mix.
- For the development of barnyard millet idli mix, the method adopted for kodo millet idli mix was followed, except for the replacement of the millet.

- The idli mix that did not contain either kodo millet or barnyard millet served as control.

Preparation of idli

Hundred gram of the mix was taken, to which 200 ml of curd and 50 ml of water was added and the batter was prepared. It was then allowed to ferment for 30 minutes at room temperature. The fermented batter was poured into idli mould and steamed for 20 minutes. The product was organoleptically evaluated by a panel of 15 semi trained judges for various quality attributes namely colour, taste, texture, flavour and overall acceptability using 9 point hedonic scale. The score card used for sensory evaluation is given in Appendix IV.

Standardization of instant kodo millet dosa mix and barnyard millet dosa mix

The proportion of ingredients required for the preparation of instant kodo millet dosa mix and barnyard millet dosa mix is given in Table 3.

Table 3. Proportion of ingredients used for instant kodo millet dosa mix and barnyard millet dosa mix

Ingredients (g)	Control	Kodo millet dosa mix				Barnyard millet dosa mix			
		Level of incorporation				Level of incorporation			
		25%	50%	75%	100%	25%	50%	75%	100%
Kodo millet rice	-	25	50	75	100	-	-	-	-
Barnyardmillet rice	-	-	-	-	-	25	50	75	100
Parboiled rice	100	75	50	25	-	75	50	25	-
Black gram dhal	25	25	25	25	25	25	25	25	25
Fenugreek	5	5	5	5	5	5	5	5	5
Salt	2	2	2	2	2	2	2	2	2

- Kodo millet rice, parboiled rice and black gram dhal were separately ground to powder.
- It was then mixed together as per the given proportion of ingredients.
- Fenugreek powder and salt was finally added to the mix.
- For the development of barnyard millet dosa mix, the method adopted for kodo millet dosa mix was followed, except for the replacement of the millet.

- The dosa mix that did not contain either kodo millet or barnyard millet served as control.

Preparation of dosa

Hundred gram of the mix was taken, to which 200 ml of curd and 50 ml of water was added and the batter was prepared. It was allowed to ferment for 30 minutes at room temperature. The tawa was heated and batter was spread, smeared with oil (1 ml) and cooked till the colour turned to golden brown and the prepared product was organoleptically evaluated.

Standardization of instant kodo millet adai mix and barnyard millet adai mix

The proportion of ingredients required for the preparation of instant kodo millet adai mix and barnyard millet adai mix is given in Table 4.

Table 4. Proportion of ingredients used for instant kodo millet adai mix and barnyard millet adai mix

Ingredients (g)	Control	Kodo millet adai mix				Barnyard millet adai mix			
		Level of incorporation				Level of incorporation			
		25%	50%	75%	100%	25%	50%	75%	100%
Kodo millet rice	-	25	50	75	100	-	-	-	-
Barnyard millet rice	-	-	-	-	-	25	50	75	100
Parboiled rice	100	75	50	25	-	75	50	25	-
Blackgram dhal	10	10	10	10	10	10	10	10	10
Whole green gram	10	10	10	10	10	10	10	10	10
Bengalgram dhal	15	15	15	15	15	15	15	15	15
Horse gram	10	10	10	10	10	10	10	10	10
Redgram dhal	10	10	10	10	10	10	10	10	10
Asafoetida	1	1	1	1	1	1	1	1	1
Chilli powder	4	4	4	4	4	4	4	4	4
Salt	2	2	2	2	2	2	2	2	2

- Kodo millet rice, parboiled rice, black gram dhal, whole green gram, Bengal gram dhal, horse gram and red gram dhal were separately ground to powder.
- It was then mixed together as per the given proportion of ingredients.
- Asafoetida, chilli powder and salt were finally added to the mix.
- For the development of barnyard millet adai mix, the method adopted for kodo millet adai mix was followed, except for the replacement of the millet.

- The adai mix that did not contain either kodo millet or barnyard millet served as control.

Preparation of adai

For preparing adai, 100 g of mix was mixed well in 200 ml of water and made to a batter. The tawa was heated and batter was spread, smeared with oil and cooked till the colour turned to golden brown and the prepared product was organoleptically evaluated.

Standardization of instant kodo millet pittu mix and barnyard millet pittu mix

The proportion of ingredients required for the preparation of instant kodo millet pittu mix and barnyard millet pittu mix is given in Table 5.

Table 5. Proportion of ingredients used for instant kodo millet pittu mix and barnyard millet pittu mix

Ingredients (g)	Control	Kodo millet pittu mix				Barnyard millet pittu mix			
		Level of incorporation				Level of incorporation			
		25%	50%	75 %	100%	25%	50%	75 %	100%
Kodo millet rice	-	25	50	75	100	-	-	-	-
Barnyard millet rice	-	-	-	-	-	25	50	75	100
Parboiled rice	100	75	50	25	-	75	50	25	-
Salt	2	2	2	2	2	2	2	2	2

- Kodo millet rice and parboiled rice were separately ground to powder.
- It was then mixed together as per the given proportion of ingredients.
- Salt was finally added to the mix.
- For the development of barnyard millet pittu mix, the method adopted for kodo millet pittu mix was followed, except for the replacement of the millet.
- The pittu mix that did not contain either kodo millet or barnyard millet served as control.

Preparation of pittu

Hundred gram of the mix was taken and to it 30 ml of water was added and mixed well. This mix was put in pittu mould and steamed for 10 minutes. The prepared product was served along with sugar (20 g) and coconut scrappings (5 g) for sensory evaluation.

Standardization of instant kodo millet idiyapam mix and barnyard millet idiyapam mix

The proportion of ingredients required for the preparation of instant kodo millet idiyapam mix and barnyard millet idiyappam mix is given in Table 6.

Table 6. Proportion of ingredients used for instant kodo millet idiyapam and barnyard millet idiyapam mix

Ingredients (g)	Control	Kodo millet pittu mix				Barnyard millet pittu mix			
		Level of incorporation				Level of incorporation			
		25%	50%	75 %	100%	25%	50%	75 %	100%
Kodo millet rice	-	25	50	75	100	-	-	-	-
Barnyard millet rice	-	-	-	-	-	25	50	75	100
Parboiled rice	100	75	50	25	-	75	50	25	-
Salt	2	2	2	2	2	2	2	2	2

- Kodo millet rice and parboiled rice were separately ground to powder.
- It was then mixed together as per the given proportion of ingredients.
- Salt was finally added to the mix.
- For the development of barnyard millet idiyapam mix, the method adopted for kodo millet idiyapam mix was followed, except for the replacement of the millet.
- The idiyapam mix that did not contain either kodo millet or barnyard millet served as control.

Preparation of idiyapam

Hundred gram of the mix was taken and to it 75 ml of hot water was added and a soft pliable dough was prepared. The dough was passed through a hand extruder and the idiyappam was extruded. Then it was steamed for 10 minutes. The steamed idiyappam was served with sugar (20 g) and coconut scrappings (5 g) for sensory evaluation.

Standardization of instant kodo millet kali mix and barnyard millet kali mix

The proportion of ingredients required for the preparation of instant kodo millet kali mix and barnyard millet kali mix is given in Table 7.

Table 7. Proportion of ingredients used for instant kodo millet kali mix and barnyard millet kali mix

Ingredients (g)	Control	Kodo millet kali mix				Barnyard millet kali mix			
		Level of incorporation				Level of incorporation			
		25%	50%	75 %	100%	25%	50%	75 %	100%
Kodo millet rice	-	25	50	75	100	-	-	-	-
Barnyard millet rice	-	-	-	-	-	25	50	75	100
Parboiled rice	100	75	50	25	-	75	50	25	-
Fenugreek	10	10	10	10	10	10	10	10	10
Salt	2	2	2	2	2	2	2	2	2

- Kodo millet rice, parboiled rice and fenugreek were separately ground to powder.
- It was then mixed together as per the given proportion of ingredients.
- Fenugreek powder and salt was finally added to the mix.
- For the development of barnyard millet kali mix, the method adopted for kodo millet kali mix was followed, except for the replacement of the millet.
- The kali mix that did not contain either kodo millet or barnyard millet served as control.

Preparation of kali

For preparing kali, 100 g of mix was mixed well in 300 ml of water and made to a thin batter. The batter was then heated in a medium flame until it was cooked and became thick. The cooked kali was moulded to a round shape and served with palm sugar and the prepared kali was organoleptically evaluated.

Standardization of instant kodo millet paniyaram mix and barnyard millet paniyaram mix

The proportion of ingredients required for the preparation of instant kodo millet paniyaram mix and barnyard millet paniyaram mix is given in Table 8.

Table 8. Proportion of ingredients used for instant kodo millet paniyaram mix and barnyard millet paniyaram mix

Ingredients (g)	Control	Kodo millet paniyaram mix				Barnyard millet paniyaram mix			
		Level of incorporation				Level of incorporation			
		25%	50%	75 %	100%	25%	50%	75 %	100%
Kodo millet rice	-	25	50	75	100	-	-	-	-
Barnyard millet rice	-	-	-	-	-	25	50	70	100
Parboiled rice	100	75	50	30	-	75	50	30	-
Black gram dhal	25	25	25	25	25	25	25	25	25
Fenugreek	5	5	5	5	5	5	5	5	5
Salt	2	2	2	2	2	2	2	2	2

- Kodo millet rice, parboiled rice, black gram dhal and fenugreek were separately ground to powder.
- It was then mixed together as per the given proportion of ingredients.
- Fenugreek powder and salt was finally added in the mix.
- For the development of barnyard millet paniyaram mix, the method adopted for kodo millet kali mix was followed, except for the replacement of the millet.
- The paniyaram mix that did not contain either kodo millet or barnyard millet served as control.

Preparation of paniyaram

For preparing paniyaram, 100 g of mix was mixed with 100 ml of water and 150 ml of jaggery syrup. The batter was mixed and allowed to ferment for one hour at room temperature. Heated a paniyaram mould frying pan with oil. Then poured a laddleful of batter and deep fried till it turned to golden brown colour and the prepared paniyaram was organoleptically evaluated.

Standardization of instant kodo millet roti mix and barnyard millet roti mix

The proportion of ingredients required for the preparation of instant kodo millet roti mix and barnyard millet roti mix is given in Table 9.

Table 9. Proportion of ingredients used for instant kodo millet roti mix and barnyard millet roti mix

Ingredients (g)	Control	Kodo millet roti mix				Barnyard millet roti mix			
		Level of incorporation				Level of incorporation			
		25%	50%	75%	100%	25%	50%	75%	100%
Kodo millet rice	-	25	50	75	100	-	-	-	-
Barnyard millet rice	-	-	-	-	-	25	50	75	100
Parboiled rice	100	75	20	25	-	75	20	25	-
Green gram dhal	20	20	20	20	20	20	20	20	20
Salt	2	2	2	2	2	2	2	2	2

- Kodo millet rice, parboiled rice and green gram dhal were roasted separately ground to powder.
- It was then mixed together as per the given proportion of ingredients.
- Salt was finally added to the mix.
- For the development of barnyard millet roti mix, the method adopted for kodo millet roti mix was followed, except for the replacement of the millet.
- The roti mix that did not contain either kodo millet or barnyard millet served as control.

Preparation of roti

To 100 g of roti mix, chopped chilly (2 g), onion (10 g) and water (60 ml) was added, mixed and made into a dough. This dough was then flattened and shallow fat fried and the prepared roti was organoleptically evaluated.

Standardization of instant kodo millet halwa mix and barnyard millet halwa mix

The proportion of ingredients required for the preparation of instant kodo millet halwa mix and barnyard millet halwa are given in Table 10.

Table 10. Proportion of ingredients used for instant kodo millet halwa mix and barnyard millet halwa mix

Ingredients (g)	Control	Kodo millet halwa mix				Barnyard millet halwa mix			
		Level of incorporation				Level of incorporation			
		25%	50%	75%	100%	25%	50%	75%	100%
Kodo millet rice	-	25	50	75	100	-	-	-	-
Barnyard millet rice	-	-	-	-	-	25	50	75	100
Wheat	100	75	50	25	-	75	50	25	-
Lemon yellow colour	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

- Kodo millet rice and wheat were separately ground to fine powder.
- It was then mixed together as per the given proportion of ingredients.
- Lemon yellow colour was finally added to the mix.
- For the development of barnyard millet halwa mix, the method adopted for kodo millet halwa mix was followed, except for the replacement of the millet.
- The halwa mix that did not contain either kodo millet or barnyard millet served as control.

Preparation of halwa

To 100 g of halwa mix, 300 ml of water was added and made to a batter. This batter was heated in a thick bottom vessel in a medium flame for 20 minutes. Then powder sugar (45 g), ghee (30 g) was added and continued cooking, till the ghee separated out and the solid mass left the sides of the pan. Finally roasted cashewnuts were added and the prepared halwa was organoleptically evaluated.

Standardization of instant kodo millet kesari mix and barnyard millet kesari mix

The proportion of ingredients required for the preparation of instant kodo millet kesari mix and barnyard millet is given in Table 11.

Table 11. Proportion of ingredients used for instant kodo millet kesari mix and barnyard millet kesari mix

Ingredients (g)	Control	Kodo millet halwa mix				Barnyard millet halwa mix			
		Level of incorporation				Level of incorporation			
		25%	50%	75%	100%	25%	50%	75%	100%
Kodo millet rice	-	25	50	75	100	-	-	-	-
Barnyard millet rice	-	-	-	-	-	25	50	75	100
Wheat semolina	100	75	50	25	-	75	50	25	-

- Kodo millet rice and wheat semolina were roasted separately and kodo millet rice and barnyard millet rice were separately broken to rava.
- It was then mixed together as per the given proportion of ingredients.
- Lemon yellow colour was finally added to the mix.
- For the development of barnyard millet kesari mix, the method adopted for kodo millet kesari mix was followed, except for the replacement of the millet.
- The kesari mix that did not contain either kodo millet or barnyard millet served as control.

Preparation of kesari

For preparing kesari, 300 ml of water was boiled in a thick bottom vessel in a medium flame for 10 minutes. Then 100 g of mix was added to the boiling water and cooked for 20 minutes. After 20 minutes, sugar (40 g), ghee (10 g) was added and continued cooking, till the ghee separated out and the solid mass left the sides of the pan. Finally roasted cashewnuts were added and the prepared kesari was organoleptically evaluated.

3.4 SHELF LIFE STUDIES OF THE SMALL MILLETS BASED INSTANT FOOD MIXES

Based on the sensory evaluation of the products standardized from the instant food mixes at various levels of incorporation the most accepted level of incorporation in the instant food mix was subjected to shelf life studies. The instant food mixes were packed with and without addition of the antioxidant (Butylated Hydroxy Anisole-0.1%) in three different packaging materials *viz.*, High Density Polyethylene (HDPE-P₁), aluminium foil (P₂) and Metallised polypropylene (MPP-P₃). The packs were then

heat sealed and stored at ambient condition for shelf life studies for a period of 180 days (Plates 3,4,5,6).

3.4.1 Quality evaluation of the small millets based instant food mixes

3.4.1.1 Chemical constituents

The following table gives the chemical constituents that were analysed in the developed kodo millet and barnyard millet instant food mixes during storage for the period of 180 days.

Chemical constituents analysed

S.No	Chemical constituents	Frequency of analysis	Method adopted	Reference
1	Moisture	Once in 30 days	Hot air oven Method	AOAC (1995)
2.	Starch	Once in 30 days	Anthrone Method	AOAC (1995)
3.	Protein	Once in 30 days	Kjeldahl Method	AOAC (1995)
4.	Free fatty acid	Once in 30days	Titration Method	AOAC (1995)
5.	Fat	0 day and 180 days	Soxhlet Method	Cohen (1917)
6.	Crude fibre	0 day and 180 days	Acid and alkali titration	Maynard, (1970)
7.	Dietary fibre	0 day and 180 days	Digestion method	AOAC (1995)
8.	Tannin	0 day and 180 days	Colorimeter	Schandert (1970)
9.	Ash	0 day and 180 days	Muffle furnace	AOAC (1995)
10.	Calcium	0 day and 180 days	Titration Method	Clark & Collip (1925)
11.	Phosphorus	0 day and 180 days	Titration Method	(Fiske and Subbarow, 1925).
12.	Iron	0 day and 180 days	U.V. Spectrophotometer	Wong (1928)

The detailed procedure of analysis is given in Appendix VI.

3.4.1.2 Microbiological examination

The microbial load of the stored samples were enumerated once in 30 days by the method described by Istavankiss (1984). Ten gram of the sample was taken in 90ml sterile water blank and thoroughly mixed in a rotary shaker for 10 minutes. From the solution, a series of 10^{-4} dilution were obtained using serial dilution techniques and was used for the estimation of total plate count. From the 10^{-4} dilution, 1.0ml of the sample was poured into a petri plate and rotated clockwise and anticlockwise for the uniform spreading of the sample. Nutrient agar medium was then added and allowed to solidify. After solidification the plates were incubated at room temperature ($28\pm 2^{\circ}\text{C}$) for 24 to 28 hours and the colonies were counted.

3.4.1.3 Sensory quality

The quality parameters like color, flavor, texture, taste and overall acceptability of the stored samples were organoleptically evaluated using 9-point hedonic scale by a panel of 15 semi trained judges.

3.5 CONSUMER ACCEPTABILITY OF THE STANDARDIZED INSTANT FOOD MIXES

The traditionally consumed small millet products of the selected village, that were converted in the form of instant food mixes were popularized in the study area, in Periyur block and evaluated the consumer acceptability.

3.5.1 Conduct of consumer acceptability of the instant food mixes

The developed instant food mixes were popularized in the study area by exhibiting the products in the village merchant shop that was located in the prime area of the village, catering to the purchase needs of the entire village. Hundred gram of the instant food mixes packed in Metallised Polypropylene bag were exhibited and given for free sales. Free samples of the instant mixes were given to the selected subjects and also to the other customers of the shop (300 members). The pack also contained the information on method of preparation of the products. The consumers were asked to prepare the product from the instant food mixes following the instructions given in the pack. A score card was given along with pack and the feedback about the product was collected from consumers (Appendix-VII). The feedback about the instant food mixes viz., idli, dosa, adai, pittu, idiyapam, kali, panyaram, roti, halwa and kesari were obtained (Plate 7).

3.6 IMPACT STUDY OF THE DEVELOPED PRODUCTS NUTRITION EDUCATION

Attempts were also made to emphasize the nutritional significance and health benefits of the developed small millet products among the selected subjects through nutrition education. Hands on training on preparation of the instant mixes was given to the selected subjects.

3.6.1 Conduct of nutrition education

Nutrition education was given to the selected 120 rural women. The education was given during the leisure time. The women were asked to assemble together in common hall in the village and conducted the educational programme. It was given in an easily understandable way. The nutrition educational aids used were posters, pamphlets, live specimens and lecture. The education class emphasised nutritional significance of millets, nutrient composition of barnyard millet and kodo millet, health benefits of small millets, product diversification of small millets and general hygiene and sanitation and usage of millet products as a dietary component. Hands on training was given to the selected subjects on the method of preparation of the developed instant kodo millet mixes and barnyard millet mixes through method demonstration. Packaging, labelling requirements of the instant mixes was also given as a part of the training programme. Training was given to the selected subjects in six batches (20 members per batch). Nutrition education was conducted once in month for a period of six months (Plate 8).

3.6.1.1 Measurement of knowledge gain (KAP)

The pre and post knowledge, attitude and practices (KAP) test was conducted to evaluate the outcome of the nutrition education programme. The study was to measure the existing knowledge of the selected rural women on nutritional significance and use of small millets. Knowledge gain was assessed by the difference in knowledge level of the selected rural women before and after exposure to nutrition education. Attitude towards small millet food products and its health benefits and practice of using small millet food products in their daily diet was assessed. This was interpreted by the correct or incorrect answer given by rural women with scores of one and zero respectively (Appendix –VIII,IX, X,XI, XII).

3.7 COST ANALYSIS

The cost involved in the processing of small millets based instant food mixes was computed by taking into account the fixed and variable cost involved during the course of processing. The cost of the product was analyzed systematically.

3.8 STATISTICAL ANALYSIS

The data obtained by the various experiments were subjected to statistical analysis to find out the impact of different treatments, packaging materials used and storage periods. Factorial Completely Randomised Design (FCRD) was applied for the analysis of the study as described by Rangaswamy (1995).

CHAPTER IV

RESULTS AND DISCUSSION

The results of the study entitled “**Standardization, evaluation and impact of functional products from Kodo millet (*Paspalum scrobiculatum*) and Barnyard millet (*Echinochloa frumentacea*)**” are presented and discussed in this chapter under the following headings.

- 4.1 Socio economic and health profile of the selected subjects.
- 4.2 Millet consumption pattern of the selected subjects.
- 4.3 Standardization of instant food mixes
- 4.4 Quality attributes of the standardized instant food mixes during storage.
- 4.4 Consumer acceptability of the standardized instant food mixes.
- 4.5 Impact of the standardized instant food mixes through nutrition education.
- 4.6 Cost analysis of the standardized products

4.1 SOCIO ECONOMIC AND HEALTH PROFILE OF THE SELECTED SUBJECTS

4.1.1 Socio economic status of the selected subjects

The socio economic conditions are considered as the most important factors influencing the food and nutrition security of the people. Poor socio economic conditions are the root causes for most of the nutritional problems observed in our country. The socio economic details with reference to religion, type of family, family size, landholding size, domestic animals, occupation, monthly income, literacy, type of house, source of drinking water, toilet and sanitation facilities, personal habits and health facility available were elucidated from the subjects by way of interview method and the results are presented in Table 12.

From the table, it could be seen that majority of the selected subjects belong to the Hindu religion (84 %) and only six per cent were Muslim. A study of NNMB (2006) in the rural area of nine states including Tamilnadu had indicated the predominance of Hindu community in different stage with lowest percentage (61.8 %) in Kerala and highest in Andhra Pradesh (97.3%).

Regarding type of family, 70 per cent of the subjects belonged to nuclear family, the rest lived in the joint family. Reports of NNMB (2006) indicated nuclear family system among (67.6 %) of families with an average family size of 4.5 in rural

areas of Kerala. In the present investigation similar type of result was obtained with the nuclear family being the majority.

Family size is a major factor that influenced the nutrition security of the family members, thus food security of the families, in the present study on the household size the majority of the household comprised of 4-6 members (53%) followed by 1-3 members (27%). Families comprising of more than six members were minimum. Latheef (2011) stated that due to urbanization and changes in social values joint family system is disintegrating in different communities of Tamilnadu. Unlike others small family norm has become very popular even among the low income group due to better medical and educational facilities and constant exposure of the public to small family norm through different media. A similar condition was observed in the present study also.

Land holding of the families are considered as an important determinant indicating resources of household. In this study it was noted that only 14 per cent of the selected subjects possessed land and, of them nine per cent held one acre and 5 per cent had less than one acre. On contrary, studies of Anusha (2012) indicating that among the farm labours household of Kuttanad in Kerala 36 per cent possessed land.

Though only 33 per cent of families possessed domestic animal *viz.*, milch animal, cattle and poultry. Among them 47 per cent of them earned an extra income from these sources which are in line with the reports of Anusha (2012) who had indicated that, with the possession of domestic animals 58 per cent of the families had an extra earning.

The occupation status of family members is an important factor influencing the food purchasing pattern and thus, health and nutritional status of the family. The main occupation of the selected subjects were agriculture labour (80 %) and 13 per cent of them were in government service while rest were housewives. Jose (1998), also indicated occupation as daily wage labours among the male and female members in the unorganised sectors.

Access to food depends on access to income and regular employment. Monthly income is a major factor influencing economic status and in turn household food insecurity. In this study, only 14 per cent of the respondents had monthly income of more than Rs.10, 000 followed by 33 per cent of them being in the group of Rs.6000-10,000 of monthly income. This indicated that majority of the respondents had monthly income of less than Rs. 6000. Studies of Deepa (2009) and Anusha (2012) also indicated a monthly income of Rs.6000 among the different labour categories which is in line with the present investigation.

Literacy is an important demographic characteristic which is an indicator of advancement of people. Corresponding to their occupation, the education level of the subjects showed that 84 per cent were illiterate and only 3 per cent had completed higher secondary school education.

The type of house is considered as an index of the economic status of households. From the table it could be seen that, neither their occupation, monthly income and education level had influenced the type of house, they live in as it is which is evident from the Table 12. Among the subjects 34 and 36 per cent live in brick walled tiled house and concrete house respectively. Very few of them live in concrete double storied houses. This might be due to the Tamilnadu government scheme of Arasu Veedu Vazhangum Thittam that had facilitated the subjects to live in concrete houses despite of their low income. The present investigation is in line with the studies of Latheef (2011) who states that most of the labour household resided in houses of tiles or concrete roof, cement as flooring materials. Electricity facilities was not available to only 24 per cent of the respondents who lived in shed thatched and mud wall thatched type of house (76%) while the rest of them had electricity facilities.

It is right of every person to have proper housing sanitation, environmental hygiene and safe drinking water. In the present study, 100 per cent of the selected subjects depended on public tap for drinking water facilities. This might be due to fact that common drinking water facility was made available to the entire village by the village panchayat to ensure safe drinking water. NNMB (2006) report revealed that in rural areas of Kerala open well for drinking water facility were available for 81.9 per cent of the families, which is contrary to the situation prevailed in rural areas of Tamilnadu.

Toilet and sanitation facilities were available to only 10 percent of the selected subjects and 90 per cent of them used the open area for defecation. Almost all the homes and surrounding were found to be unclean in the present study. On the contrary, in rural areas of Kerala NNMB (2006) indicated that sanitary latrine facilities was available in 88.3 per cent of the households.

The healthcare system in Tamilnadu is good and each and every person of the selected village was getting full benefit from the prevailing system. Contrary to the opinion that the needy do not get the best medical care due to financial constraints and ever increasing medical expenses, the respondents of the study fully utilised the government hospital nearer to the village in a distance of 5 kilometres. The main reason

for this was the availability of required facilities and proper functioning of the government hospital.

Anusha (2012) observed unhealthy habits mainly alcoholism among the male members of the rural families and indicated that this is one of the major contributing factors for the socio economic backwardness of the household. But in the present investigation, as the respondents were rural women 50 per cent of them did not have any unhealthy personal habits while 33 per cent they chewed betel leaf and 17 per cent them chewed tobacco.

4.1.2 Monthly expenditure pattern

Details pertaining to the monthly expenditure pattern of the selected subjects are furnished in Table 13.

The monthly expenditure was apportioned for food, clothing, rent, education, health, fuel, transport, remittance, recreation and savings. All the respondents had spent for all the above except recreation. Fifty three per cent of the subjects had spent 41-50 per cent for food, 33 per cent had spent 31-35 per cent for food while only 14 per cent had spent 21-25 per cent for food, which was due to the difference in the monthly income. The low income group had spent only 5-10 per cent for clothing while the high income group spent 26-30 per cent for clothing. On the contrary, the low income group had to spend more for rent and less than five per cent for education, health, transport, remittance and recreation. The expenditure for fuel and saving were found to be nil among the low income group. The expenditure on education, health, transport, remittance, recreation and savings were comparatively more in the middle and higher income group which had a monthly income in the range of Rs.6001-10000 and more than Rs.10001 respectively.

4.1.3 Morbidity and mortality pattern

Though mortality rate in Tamilnadu is low the population continue to suffer from high morbidity rates like dengue fever, H1N, and chykion guniya but in the present study only 33 per cent of them had suffered from illness during the last one year with cases of fever, cough, cough and cold and only a minimum had suffered from leg pain. Ninety five per cent of them had not suffered from epidemic and only five per cent of them were the victims of chick pox. Details about deworming treatment taken during the last one year indicated that 65 per cent had taken deworming measures and rest of 35 per cent avoided the treatment (Table 14).

4.1.4 Subjects – Institutional linkage (Table 15)

It was found that women gave equal importance to ration shop, anganwadi, school, health centre and hospital but they had more access and benefits from ration shops when compared to other organisation.

4.1.5 Nutritional status of the selected subjects

4.1.5.1 Anthropometric measurement

The nutritional status of the selected subjects was assessed by measuring the weight, height, Body Mass Index (BMI), Waist Hip Ratio (WHR), Mid Upper Arm Circumference (MUAC) and per cent of fat. The results pertaining to the mean of the anthropometric measurements are given in Table 16.

The mean weight ranged from 57.3 kg (20-30 yrs) to 60.00 kg (51-60 yrs). The mean height was found to be maximum for the age group 20-30 years and minimum for 51-60 years. Accordingly the BMI was also minimum for the age group of 20-30 years. The Waist Hip Ratio was 0.78, 0.80, 0.82 and 0.82 while the Mid Upper Arm Circumference was 20.69, 22.69, 24.60 and 24.24 for the age group of 20-30, 31-40, 41-50 and 51-60 years respectively. The anthropometric measurements were not statistically significant due to age. The per cent of fat ranged from 11.22 to 14.10 and it was highly significant. From the results, a decrease in height was apparent among the elderly. This is consistent with what was reported by Robertson (2005) that is, loss of height becomes more progressively severe as the age progressed.

4.1.5.2 Anthropometric indices of the selected subjects

The anthropometric indices of the selected subjects were computed by taking into account the Body Mass Index, Waist Hip Ratio and Per cent of fat and the data was classified to obtain the nutritional status as given by ICMR 2010 and presented in Table 17.

Among the selected subjects, 62.5 per cent of them were found to be normal (BMI- 18.5 – 25%) while 27.5 per cent of them were lean and underweight (BMI <18.5%) and only 10 per cent were obese (BMI >25%). The Waist Hip Ratio of the 10 per cent of the subjects were > 0.85 indicating obesity while the rest of the 90 per cent were in the normal categories of < 0.85. Consequently the per cent of fat of this 90 per cent were in the acceptable range of 9-23 while remaining 10 per cent was in the unhealthy range of ≥ 32 which is too high. This might be due to the fact that these 10 per cent of women belonged to 51-60 years of age, and were housewives. They were not engaged neither in any heavy agricultural operations nor other works. Obesity was more predominant among women which could be due to hormonal changes when

reaching menopause as observed by Dhipali and Rajeswari (2012) and Athulya (2012) which is in line with present investigation.

4.1.5.3 Biochemical estimation

Biochemical estimation of blood for haemoglobin and random blood sugar was conducted among the 120 selected respondents who were willing to give blood samples after obtaining ethical clearance. The results are presented in Table 18. It was noted from the table that 53 per cent of the subjects were in the mild anaemia category with the haemoglobin level in the range of 10.1 to 11.9 while 47 per cent of them had normal haemoglobin level, which was more or less equal to 12.00. Similarly on examining the random blood glucose level, majority of the respondents (53%) had 82-120mg of glucose/ 100g of blood glucose level and only 47 per cent had more than 120 indicating that they were prone to diabetic.

Nutritional anaemia has been reported as a major micronutrient deficiency with the prevalence rate of 75.2 per cent in India (NIN, 2007). Anusha (2012) also indicated the blood haemoglobin level below 12 g /dl among women indicating anaemia among more than 85 per cent of the women in Kerala, which was close to the values observed in the present study.

4.2 MILLET CONSUMPTION PATTERN OF THE SELECTED SUBJECTS

An in depth study was conducted to assess the millet consumption pattern and actual food and nutrient intake of the rural women by three day recall method and the results are given and discussed below.

4.2.1 Food habits and meal pattern

The details about the food habit and meal pattern of the selected subjects are furnished in Table 19. All the respondents (100%) were non vegetarians. Seventy two per cent of them had no meal planning while the rest planned the meals in advance. Majority of the respondents (66%) had three meals per day with no regular time schedule (34%).

4.2.2 Millet consumption pattern

Table 20 provides the millet consumption details which included the most common millet consumed, preferred method of cooking, use of processed millet products, conventional millet based products preparation, preparation of millet savouries, preparation of millet sweet meat, consumption of millet based convenience foods, aptitude to purchase instant mixes, storage of millet grains and by products.

The most commonly consumed millet was found to be finger millet (30%) followed by sorghum (28%), kodo millet (17%), barnyard millet (16.7%) and pearl millet (8.3%). Boiling was the most preferred method of cooking (53%) while shallow fat frying/deep fat frying were least preferred methods (14%). Majority of the respondents used millet as a whole grains (61 %), while 39 per cent of the respondents used millet in the form of rice. The 80 per cent of the respondents used millet flour, while 5 per cent of them take in germinated form and 10 per cent used malted millet flour. None of them had used either popped or flaked millets. Porridge was the conventional millet based products prepared by majority of respondents (43.3%) followed by kali (16.7%), roti (11.6%), health mix (8.4%), dosa (6.6%) and dessert (3.4%). Millet was not used in the preparation of products like idli, idiyapam and paniyaram as the respondents did not have knowledge on preparation of these products. Savouries such as murukku, omapodi, karasev and pakoda were prepared with incorporation of any of the millets, the majority being sorghum; however kodo millet was also used in the preparation of these products. Majority of the respondents (77.5%) prepared the Indian sweet like sweet appam exclusively from millet rice, while 10 per cent of them used millet rice for kesari preparation and 12.5 per cent for payasam preparation. None of them had used millet for halwa preparation. As far as the consumption of millet based convenience food was concerned only 14 per cent of the respondents had consumed the sorghum biscuits as it was available in the village shops. Though instant mixes were available for purchase only 5 per cent of the respondents had the aptitude to purchase and use pittu and roti mix and 4 per cent for kali mix and adai mix. The whole grain millets were stored in gunny bags by majority of the respondents (73.4%) while the rest used earthen pots for the storage of these grains. Millet flour and malted millet flour were stored either in plastic container or polypropylene bag.

4.2.3 Frequency of millet consumption

Table 21 gives the frequency of millet consumption as daily, weekly thrice, twice, once and monthly twice or once and occasionally. From the table, it could be seen that majority of the millets were consumed monthly once while kodo millet, finger millet and barnyard millet were consumed monthly twice by 17, 30 and 17 per cent respondents respectively. Sorghum was consumed weekly once by 28 per cent respondents. Little millet, foxtail millet, barnyard millet and proso millet were consumed occasionally by cent per cent of respondents.

4.2.4 Food expenditure pattern of the selected subjects

Regarding the expenditure pattern for food, it was found from Table 22 that majority of the respondents spent on purchase of cereals, millets, pulses, greens, roots and tubers, fat and oils, spice and condiments, sugar and jaggery and flesh foods with a variation in the percentage of the amount spent on these items.

Thirty three per cent of the respondents spent 41-50 per cent money for the purchase of cereals followed by 31-35 per cent and 26-30 per cent of the income for cereal purchase by 33 and 14 per cent of the respondents respectively. Majority of the respondents had spent 41-50 per cent of the income for the purchase of millets. The percentage of monthly income spent on the purchase of pulses ranged from 16-25 per cent while that of green leafy vegetables ranged from 5-15 per cent. Cent per cent of the respondents spent only less than five per cent for the purchase of roots and tubers and sugar and jaggery while 53 per cent of the respondents did not spend for the purchase of other vegetable, fruits and milk products rest of them had spent at least less than or more than five per cent for the purchase of these items. It is evident from the table that there exists definite difference in the percentage of amount spent for the purchase of various food products depending on the monthly income. These results were also supported by the studies of Shobha and Sheela (2004) who also noted a difference in the food expenditure pattern among the rural women depending on the monthly income.

4.2.5 Frequency of millet purchase

The frequency of millet purchase is shown in Table 23 and it was found from the table that sorghum was purchased monthly by 72 per cent of respondents and the rest buy weekly. The kodo millet was purchased monthly by 83 per cent and once in fortnight by 17 per cent and finger millet was purchased by 70 per cent of the respondents monthly and by 30 per cent of the respondents once in fortnight, barnyard millet was purchased once in six months by 83 per cent respondents and once in a month by 17 per cent. The millets that were annually purchased by cent per cent of the respondents included little millet, foxtail millet and pearl millet while proso millet was purchased only occasionally.

4.2.6 Per capita food intake of selected subjects in comparison with requirement

The per capita food intake of the selected women who were classified as sedentary worker and moderate worker based on their occupation was assessed and the intake was compared with the quantity suggested by ICMR (2010 a) for a balanced

diet and the results are tabulated in Table 24. The cereal intake by the sedentary workers was more or less equal with the requirement with values being 270 and 330 g, while a slight deficit in the intake of millets was noted and it was statistically significant. The pulses intake by sedentary worker and moderate workers were deficit with values being 30 and 45 g and the deficiency was more prone in the rainy and winter season, however data was statistically non significant. The consumption of root and tubers was also less than the requirement and the value of the moderate worker group was much more than sedentary worker group, being statistically significant. Similarly the intake of green leafy vegetables and other vegetables were lower with the sedentary workers (100 g) and comparatively more by the moderate workers (100 g). But both the groups showed deficiency in the intake of green leafy vegetables and other vegetables when compared with the requirement. The intake of fruits by the moderate workers ranged from 17.26 to 20.74 g while that of the sedentary workers ranged from 66.22 to 70.75 g. The requirement for milk and milk products per day as given by ICMR is 300 g but the intake was poor among the sedentary workers and ranged from 120 to 150 g per day. The intake of fats and oils, sugar and jaggery were near to the daily requirement in both the groups. A statistically significant difference in the per capita intake of other vegetables, fruits, milk and milk products, flesh foods, fat and oils, sugar & jaggery between seasons was observed except green leafy vegetable that was non significant. Seralathan *et al.*(1993) has indicated deficit of all food groups in the diet of the women as observed in the present investigation.

4.2.7 Per capita nutrient intake of the selected subjects in comparison with RDA

The per capita nutrient intake of the selected subjects during the three day recall method were computed from the quantity of food consumed and was compared with RDA suggested by ICMR (2010 a) and the results obtained are given in Table 25 and 26.

It is evident from the tables that 100 per cent of the respondents met out 75 per cent of RDA for calories and 47 per cent of respondents met 50-75 per cent of RDA for protein, while 40 per cent of the respondents met 50-75 per cent of RDA for calcium from their food intake. Only 14 per cent of respondents met 75 per cent of RDA for calcium. Studies of Lawrence (2003) and Yenagi *et al.* (2007) indicated that the deficit in the intake of micronutrient like calcium, iron, carotene, thiamine, niacin, riboflavin and Vitamin C among the rural women met only 50 per cent of the RDA for these nutrients. Similar results were also noted in the present study with 100 per cent subjects

meeting 25 to 50 per cent RDA values for iron, carotene, thiamine, niacin, riboflavin and Vitamin C.

4.2.8 Correlation between nutrient intake and anthropometric indicators/ indices variables of the selected subjects

Correlation was found for variables pertaining to nutrient intake and anthropometric indicators and the results are given in Table 27. Present study revealed that there were significant associations in case of some nutrients with anthropometric indicators. Weight was positively correlated for all the nutrients except calcium, vitamin C, thiamine, riboflavin and niacin. Whereas height was not positively correlated, Significant positive correlation was observed in energy, fat, crude fibre, iron, carotene and Vitamin C for Body Mass Index (BMI). All the nutrients were positively correlated with Mid Upper Arm Circumference (MUAC) and energy, protein, fat, crude fibre and vitamin C being statistically significant. Waist Hip Ratio (WHR) was positively correlated with protein and fat whereas all the nutrients exhibited a positive correlation with per cent body fat in which the energy, fat, crude fibre, minerals and B vitamins being statistically significant.

Table 27. Correlation between nutrient intake and anthropometric indicators/ indices variables of the selected subjects (N-120)

Nutrients	'r' values					
	Weight	Height	BMI	MUAC	WHR	Per cent body fat
Energy	0.36**	0.001 NS	0.359**	0.287 **	-0.277 **	0.397**
Protein	0.189*	0.167 NS	0.158 NS	0.296 **	0.294 **	0.026 NS
Fat	0.267*	-0.040 NS	0.277 **	0.206 *	0.176 **	0.253 *
Crude fibre	0.302*	-0.030 NS	0.0298*	0.240 *	-0.226 **	0.350 **
Calcium	0.058 NS	0.079 NS	0.071 NS	0.111 NS	-0.112 NS	0.365 **
Iron	0.230*	0.002 NS	0.231**	0.160NS	-0.94*	0.320**
Carotene	0.211*	-0.069 NS	0.200 *	0.206 *	-0.230**	0.275 **
Vitamin C	0.168 NS	0.043 NS	0.176 *	0.254**	-0.134 NS	0.332 **
Thiamine	0.129 NS	0.005 NS	0.129 NS	0.110 NS	--0.213*	0.121 *
Riboflavin	0.189 NS	0.005 NS	0.015 NS	0.014 NS	-0.361NS	0.122 *
Niacin	0.001 NS	-0.13 NS	0.084 NS	0.01 NS	-0.075NS	0.016 *

** Correlation is significance at the 0.01 % (2 tailed)

* Correlation is significance at the 0.05 % (2 tailed)

4.3 SENSORY EVALUATION OF THE SMALL MILLETS BASED INSTANT FOOD MIXES

Small millets viz., kodo millet and barnyard millet become essential food crops due to their potential to increase food production and utilization in both the developing and developed regions of the world. These two millets have diversified uses and high food value and are rightly categorized as nutritious cereals which could be an effective and cheap commodity in combating malnutrition on one hand and at the same

time provide a balanced diet rich in dietary fibre, vitamins and minerals on the other hand. But the consumption of these millets rich in micronutrients has declined for want of standardized processing techniques to compete with fine cereals. Hence the development of value added products such as instant mixes from kodo millet and barnyard millet could find ready acceptability in the market with the tag of 'health foods'.

Therefore attempts were made to standardized ten small millet based instant mixes of popular foods belonging to the categories of traditional foods viz., idli, dosa, adai, pittu, idiyapam, kali, roti, paniyaram, halwa and kesari at various levels of incorporation of kodo millet and barnyard millet and the most acceptable level of incorporation was standardized and the results are discussed in each section.

Table 28 gives the mean scores of sensory evaluation of the products prepared from millet based instant mixes at various levels of incorporation. Based on the sensory scores, the most acceptable level of incorporation of kodo millet and barnyard millet in the different mixes were standardized.

Idli mix

Colour is one of the important cues used by the consumers to assess the quality of a food product and also it is an individual response to the visual signals generated by the light on a product. The prepared idli had a white colour with cream tinch which was due to the utilization of millets, yet the colour was highly acceptable even at 100 per cent incorporation level with the score of 8.2 (T₁) and 8.0 (T₂). Texture constitutes a physical property of food stuffs apprehended by the eyes, the skin and muscle senses that are located in the mouth. The texture of the idli prepared from kodo millet and barnyard millet was soft, fluffy with more air space up to 75 per cent incorporation level. Still in 100 per cent incorporation level, there was a slight reduction in the air space of the idli but the texture was soft. The values for texture at 100 per cent incorporation level were 8.4 and 8.2 for T₁ and T₂ respectively. The results indicated that sensory attributes were highly acceptable for the idlis prepared from the instant mix that using 100 per cent kodo millet and barnyard millet flour.

Dosa mix

The characteristic colour of dosa, the golden brown colour was maintained in the samples prepared from the instant dosa mix that contained 100 per cent kodo millet and barnyard millet flour. The scores for colour of dosa was 9.0, 8.2 and 8.1 for T₀, T₁ and T₂. Though, the colour of small millet dosa was on par with the control, the score

for texture were slightly reduced than that of control. The texture of the small millet dosa was not very crisp and a very slight rubbery texture persisted, yet the score fell within the highly acceptable to acceptable range with the values 8.3 (T₁) and 8.1 (T₂). Flavour is the sensory impression of the food and taste is the sensation produced when a substance in the mouth reacts chemically with receptors of taste buds and it is the major attribute which determines the acceptability of the food materials. The dosa had an unique fermented millet flavour, taste and overall acceptability to be highly acceptable with the respective score of 8.4, 8.5, 8.5 for T₁ and 8.3, 8.4, 8.4 for T₂ at all levels of incorporation. The results indicated that except for a slight difference in the texture, the rest of the sensory attributes were highly acceptable for the dosa prepared from the instant mix that had 100 per cent kodo millet and barnyard millet flour respectively.

Adai mix

The scores for colour of adai revealed that incorporation of small millet did not affect the characteristic lemon yellow colour of the adai instead the colour had been enhanced with the presence of golden brown tinch. The scores were 9.0, 8.4 and 8.4 for T₀, T₁ and T₂ respectively even at 100 per cent incorporation level of both the small millets. Adai prepared from control (T₀) had a soft pliable texture, with the outer sides being crisp with a score of 8.8 for texture. These characteristics were maintained in the kodo millet and barnyard millet adai up to 50 per cent level of incorporation. Beyond 50 per cent level of incorporation the texture of the adai was slightly rubbery, yet pliable and crisp on the outer sides and the scores were 8.3 (T₁) and 8.2 (T₂) at 100 per cent incorporation level. The flavour, taste and overall acceptability were highly acceptable with a score of 9.0, 9.0, and 8.9 for T₀, 8.5, 8.7, 8.6 for T₁ and 8.5, 8.5, 8.6 for T₂ respectively at 100 per cent incorporation level. The results indicated that based on the sensory attributes were highly acceptable for the adai prepared from the instant mix that had 100 per cent kodo millet and barnyard millet flour.

Pittu mix

Pittu prepared from the control mix had an extremely white colour, but the one prepared from millet based mixes was just white with a cream tinch. This had led to a slight reduction in the scores for colour for T₁ and T₂ as 8.7 and 8.5 at 75 and 100 per cent incorporation level. The texture of pittu of T₀, T₁ and T₂ was highly acceptable and it had crumbly texture which was the unique feature of pittu. Accordingly the flavour, taste and overall acceptability of the pittu were also highly acceptable in T₀, T₁ and T₂ up to 100 per cent incorporation level with the scores of 8.9, 9.0, 9.0 (T₀), 8.7, 8.8, 8.6

(T₁) and 8.6, 8.6, 8.6 (T₂) respectively. The results indicated that except for a slight difference in the colour, the rest of the attributes were highly acceptable for the pittu prepared from the instant mix that had 100 per cent kodo millet and barnyard millet flour.

Idiyapam mix

The colour of the idiyapam prepared from the control mix was extremely white but the kodo millet and barnyard millet mixes resulted in idiyapam that was just white with creamy tinch. The scores for colour of T₀ and 100 per cent of T₁ and T₂ were 9.0, 8.4 and 8.3 respectively. Similar to colour, the control idiyapam had a continuous thin string hopped and soft and pliable texture, while the idiyapam prepared from kodo millet and barnyard millet mixes at 75 and 100 per cent incorporation level had slight discontinuous thin string hopped and soft and pliable texture, yet it was highly acceptable. The scores for texture of T₁ and T₂ were 8.3 and 8.2 at 100 per cent incorporation level. Incorporation of millet had not influenced the flavour, taste and overall acceptability of the idiyapam and was highly acceptable. The results indicated though there was a slight difference in the colour and texture, all the sensory attributes were highly acceptable for the idiyapam prepared from the instant mix with 100 per cent kodo millet and barnyard millet flour.

Kali mix

Kali is a traditional South Indian food usually prepared from rice flour with fenugreek which when replaced with 100 per cent kodo millet or barnyard millet flour resulted in a product that was highly acceptable in terms colour, texture, flavour, taste and overall acceptability was highly acceptable. Each attributes even at 100 per cent incorporation level of kodo millet and barnyard millet, the scores for T₀ were 9.0 for colour, flavour, taste and overall acceptability and 8.9 for texture and that of T₁ were 8.6, 8.5, 9.0, 8.8, 8.7 and that of T₂ were 8.5, 8.4, 8.9, 8.7, 8.6 for colour, texture, flavour, taste and overall acceptability respectively.

Paniyaram mix

The colour of the paniyaram prepared from control mix, kodo millet and barnyard millet incorporated mix at 100 per cent level was highly acceptable with a cream colour and golden brown tinch with the scores of 9.0 for T₀, 8.3 for T₁ and 8.2 for T₂ respectively. The featured texture of paniyaram, the spherical uniform surface, fluffy nature with more air space was found in the samples of T₀, and T₁ and T₂ up to 50 per cent incorporation level of the millet. At 75 per cent and 100 per cent incorporation level of small millets, the surface

was uniform but a very slight reduction in the fluffiness and air space was observed, yet the product was highly acceptable. The scores for texture for 100 per cent of T₁ and T₂ at 100 per cent were 8.2 and 8.1 respectively. The flavour, taste and overall acceptability of paniyaram prepared from the instant mixes with 100 per cent kodo millet and barnyard millet flour were highly acceptable. The results indicated that though there was a slight difference in the texture, all the sensory attributes were highly acceptable for the paniyaram prepared from the instant mix that had 100 per cent kodo millet and barnyard millet flour.

Roti mix

Roti an ethnic South Indian food usually prepared from rice and ragi flour when replaced with 100 per cent kodo millet or barnyard millet flour was highly acceptable in terms of colour, texture, flavour, taste and overall acceptability up to 100 per cent. The score for colour, texture, flavour, taste and overall acceptability of T₀ was 9.0, 8.8, 9.0, 9.0, 8.9, T₁ at 100 per cent level was 8.7, 8.5, 8.8, 8.7, 8.6 and T₂ at 100 per cent level was 8.2, 8.1, 8.6, 8.6, and 8.5 respectively.

Halwa mix

Halwa the famous Indian sweet, when prepared from small millet based instant mix yielded a product, which had an acceptable colour and flavour. The colour of the halwa prepared from the control mix was honey brown with a very glossy appearance with a highly acceptable score of 9.0 but the colour of the halwa prepared from 75 and 100 per cent incorporation of barnyard millet and kodo millet was dull brown with a slight glossy appearance that led to the reduction in the scores as 8.2 and 8.1 for T₁ and T₂ at 100 per cent incorporation level respectively. The control halwa had the characteristic, soft extremely pliable and slippery texture but the halwa prepared from small millets at 100 per cent incorporation level was just soft and non slippery. Hence the scores were only moderately acceptable. Though, there was a difference in the colour and texture of the halwa, the flavour, taste and overall acceptability were on par with the control being highly acceptable with the score of 8.8, 8.9, 9.0 (T₀), 8.4, 8.5, 8.5 (T₁) and 8.3, 8.4, 8.4 (T₂) at 100 per cent incorporation level respectively. The results indicated that though there was a slight difference in the colour and texture, all the sensory attributes were highly acceptable for the halwa prepared from the instant mix with 100 per cent kodo millet and barnyard millet flour.

Kesari mix

The colour of the kesari was orange red irrespective of the control and small millet incorporated product which was due to the addition of the food grade orange red

colour powder. The scores for colour of T₀, T₁ and T₂ was 9.0 irrespective of the level of incorporation small millets. The kesari prepared from control mix had a grainy appearance, soft pliable, non sticky texture with the score of 8.9 At 100 per cent level of incorporation of barnyard millet and kodo millet, the kesari was soft and pliable but the grainy appearance was slightly reduced and a slight stickiness was observed. The scores for texture of T₁ and T₂ at 100 per cent incorporation level were 8.1 and 8.0 respectively. The flavour, taste and overall acceptability of the kesari prepared from 100 per cent kodo millet and barnyard millet mix was highly acceptable and on par with control. The results indicated that except for a slight difference in the texture, the rest of the attributes were highly acceptable for the kesari prepared from the small millet instant mix at 100 per cent incorporation level. The above results indicated that 100 per cent incorporation of barnyard millet and kodo millet was highly suitable for standardization of instant food mixes.

4.4 QUALITY ATTRIBUTES OF STANDARDIZED INSTANT FOOD MIXES DURING STORAGE

The standardized small millets based instant food mixes were subjected to shelf life studies. The instant food mixes were packed in HDPE, aluminium foil and MPP with and without antioxidant and were kept at ambient conditions for a storage period of 180 days. The products were studied for changes in nutritional qualities, microbial load and sensory qualities during storage. The results obtained are presented and discussed below.

4.4.1 Idli mix

4.4.1.1 Chemical constituents

Moisture

The changes noted in the moisture content of the control, kodo and barnyard millet incorporated instant idli mixes stored under ambient condition are given in Table 29. The initial moisture content of T₀, T₁ and T₂ were observed to be 11.00, 10.10 and 9.60 g per cent which might be due to incorporation of millets. A gradual increase in moisture content was observed in all the samples packed in different materials throughout the storage period. Among the packaging materials, the mixes stored in P₁WOA absorbed more moisture followed by P₁WA, P₂WA, P₂WOA, P₃WA and P₃WOA for T₀, T₁ and T₂. The moisture permeable nature of the packaging materials and the presence of antioxidant have contributed to the difference in the moisture pick up. The final moisture content ranged from 11.60 (T₀P₃WA) to 11.86

(T₀P₁WOA) in T₀, 10.77 (T₁P₃WA) to 10.87(T₁P₁WOA) in T₁ and 9.95 (T₂P₃WA) to 10.08 (T₂P₁WOA) in T₂ g per 100 g. The statistical analysis of the data revealed a highly significant difference between the treatment, packaging materials and period of storage.

Premavalli *et al.* (2003) also reported a decrease in moisture content with increase in incorporation of finger millet flour in convenience mixes. Significant increase in moisture was reported on storage of composite mix based on millets (80%) during a storage period of six months in polyethylene bags by Itagi *et al.* (2003). These findings concur with those of the present research findings.

Protein

The changes in the protein content of the kodo and barnyard millet instant idli mix during storage are presented in Table 30. The incorporation of small millets had significantly increased the protein content as it is evident from the initial values of T₁, T₂ and T₀ as 11.37,10.65 and 9.62 g per 100g respectively. A gradual reduction in the protein content was observed for all the samples during storage. The reduction in the protein content was lesser in the samples packed in P₃WA when compared to P₃WOA, P₂WOA, P₂WA, P₁WOA and P₁WA for T₀, T₁ and T₂. The protein content after 180 days of storage ranged from 9.45 (T₀P₁WOA) to 9.50 (T₀P₃WA) for T₀, 11.20 (T₁P₁WOA) to 11.26 (T₁P₃WA) for T₁ and 10.45 (T₂P₁WOA) to 10.53 (T₂P₃WA) g per 100g for T₂. The statistical analysis revealed a significant difference between treatments, packaging materials and the days of storage.

Shanthi *et al.* (2000) reported that instant idli mix had an initial protein content of 11.37g per 100 g and was gradually lost upon storage and the loss was reported to be 1.4g per 100g, whereas in the present study the loss of protein was found to be comparatively lesser (0.17g per 100g).

Starch

The changes in starch content during storage of the kodo and barnyard millet instant idli mix are given in Table 31. The starch content of the control was maximum (69.00 g per 100g) and the values decreased for the small millet instant mixes as 55.80 (T₁) and 57.00 (T₂). A gradual reduction in the starch content was observed in all samples during storage irrespective of treatment and packaging material. The changes were more predominant in T₀ P₁WOA samples and the least changes was observed in T₂P₃WA samples. Overall reduction in starch content was significant in T₀ than T₁ and T₂ which might be due to the incorporation of small millets and the characteristics of

millet

starch.

The final starch content of the idli mix ranged from 68.50 (T₀P₁WOA) to 68.70 (T₂P₃WA) for T₀, 55.37(T₁P₁WOA) to 55.46 (T₁P₃WA) for T₁ and 56.60 (T₂P₁WOA) to 56.74 (T₂P₃WA) g per 100g for T₂.

A similar trend was observed by Shanthi *et al.* (2000) who reported a reduction in the starch content of instant idli mix which might be due to the conversion of starch into sugar in the stored samples.

Fat

Table 32 gives the changes in the fat content of the kodo and barnyard millet instant idli mix during storage. The fat content of the control idli mix was minimum and a significant increase in fat was observed with increase in incorporation of kodo millet and barnyard millet flour. The initial fat content of T₀, T₁ and T₂ was 1.08, 1.50 and 2.80 g/ 100g irrespective of the packaging material. After 180 days of storage, the final fat content ranged between 1.02 (T₀P₁WOA) to 1.06(T₀P₃WA) for T₀, 1.35(T₁P₁WOA) to 1.47 (T₁P₃WOA) for T₁ and 2.66 (T₂P₁WOA) to 2.75 (T₂P₃WOA) g /100g for T₂ respectively. This shows that, there was a reduction in the fat after 180 days of storage and the reduction was minimum in the samples of P3WA irrespective of the treatment. A statistically significant difference was noted for fat between the treatment, packaging and storage period.

A similar trend of reduction in the fat content depending upon the packaging materials was also observed by Shanthi *et al.* (2000).

Free fatty acid and peroxide value

There was an increase in the free fatty acid and peroxide value of the kodo and barnyard millet instant idli mix during storage irrespective of the packaging material and treatment as it is evident in Table 32. Incorporation of small millets had significantly reduced the free fatty acid and peroxide value of the instant mixes. As the storage period progressed there was a slight increase in free fatty acid and peroxide value and was more notable in control samples than treated samples. The initial free fatty acid of T₀, T₁ and T₂ were 2.20, 1.00 and 1.20 mgKOH/g and peroxide value were 1.00, 0.50 and 0.30meq/kg for T₀, T₁ and T₂ respectively irrespective of the packaging material. After 180 days of storage, the final free fatty acid and peroxide values ranged between 2.50 (T₀P₃WA) to 2.78 (T₀P₁WOA) and 1.42 (T₀P₃WA) to 1.51(T₀P₁WOA)

for T₀, 1.30 (T₁P₃WA) to 1.42 (T₁P₁WOA) and 0.80(T₁P₃WA) to 1.00(T₁P₁WOA) for T₁, 1.37(T₂P₃WA) to 1.50 (T₂P₁WOA) and 0.55(T₂P₃WA) to 0.70 (T₂P₁WOA) for T₂ respectively. The statistical analysis of the data also revealed a significant difference among treatment, packaging materials and the storage period.

An increase in the free fatty acid and peroxide value during storage of finger millet based convenience mixes was reported by Premavalli *et al.*(2003) and the rate of increase was found to be more predominant in samples having higher proportion of rice compared to finger millet. Similar observations were recorded in the present study also.

Crude fibre and tannin

The crude fibre and tannin content of the kodo and barnyard millet instant idli mix during storage was analysed and the results are given in Table 33. From the table, it could be inferred that a significant increase in the fibre content was noticed in the small millet based instant mixes than control. The initial crude fibre content for T₀, T₁ and T₂ were 1.20, 4.20 and 6.90 while the tannin content for T₀, T₁ and T₂ were 2.14, 3.40 and 4.10 g/100g respectively in all the packaging materials. Upon storage there was a slight loss in the crude fibre and tannin contents in the samples packed in P₁, P₂ and P₃ with and without antioxidants but was statistically non significant.

Meenatchisundram (2005) stated that the fibre and tannin content of the bajra based convenience mix showed a non significant change during storage. Similar observations were also recorded in the present study.

Ash and mineral contents

Significant increase in ash content was also observed with increase in level of incorporation of kodo millet and barnyard millet flour in the instant idli mix. The initial ash content of T₀, T₁ and T₂ were observed to be 1.80, 2.20 and 2.10 g/100g in all the packaging material which might be due to incorporation of millets. The final ash content ranged from 1.77 (T₀P₁WOA) to 2.10 (T₂P₃WA) g per 100g. A slight decrease in ash content on storage was observed in all the samples which was non significant as revealed by the statistical analysis of the data.

The data pertaining to the changes in calcium, phosphorus and iron content of the small millet instant idli mix is presented in Fig1. Significant increase in calcium, phosphorus and iron content was observed with the incorporation of kodo millet and barnyard millet flour. The control samples recorded 50.20mg calcium, 121.70mg phosphorus and 1.50mg of iron per 100g of the sample. The kodo millet incorporated idli mix recorded higher values for calcium (57.18mg/100g), phosphorus (210.10mg/100g) and iron (4.17mg/100g). The comparative values for barnyard millet

millet incorporated idli mix were 52.20mg calcium, 330.60mg phosphorus and 6.34mg of iron per 100g of the sample during the initial period of storage. A slight reduction in calcium, phosphorus and iron content was observed during storage. However on statistical analysis of the data a non significant difference was observed between packaging materials and storage period.

Shanthi (2000) reported that during storage there was a non significant reduction in the calcium and iron content of instant idli mixes. The present investigation is in line with the above study.

4.4.1.2 Microbial load

The changes in microbial load of the kodo and barnyard millet instant idli mix during storage are presented in Table 34. An increasing trend was observed in terms of the total plate count between the treatments and between packaging materials in both the kodo millet and barnyard millet incorporated products. The initial values for total plate count were nil. The total plate count showed slight elevation on storage and ranged between 2.4 (T₀P₃WA) to 3.4 (T₀P₁WOA) x 10⁴ for T₀, 1.5 (T₁P₃WA) to 2.5(T₁P₁WOA) x 10⁴ for T₁ and 0.7(T₂P₃WA) to 1.2(T₂P₁WOA) x 10⁴ cfu/g for T₂ respectively at the end of the storage period of 180 days. The low permeable nature of P₃ and the presence of antioxidants had hindered the growth of microbes in these samples in all the treatment including the control samples.

Shanthi (2000) reported that the bacterial load of instant idli mix was found to be 3.50x10⁴ cfu/g and the samples stored in 400 gauge High Density Polyethylene (HDPE) bags had minimum microbial population.

4.4.1.3 Sensory quality

The mean organoleptic scores for colour and appearance, flavour, texture, taste and overall quality during the initial storage period and the changes observed after 180 days of storage were tabulated and presented in Table 35.

The colour of the control idli mix was extremely white and that of millet based instant mixes were white with creamy tinch. The scores for colour T₀, T₁ and T₂ were highly acceptable with the value of 9.0, 8.9 and 8.8 irrespective of the packaging materials. After 180 days of storage, the score value for colour of the control samples decreased and ranged between 8.6 (T₀P₁WOA) to 8.8 (T₀P₃WA), while that of T₁ and T₂ remained the same. This might be due to the changes as extremely white colour to dull white colour in the control samples. The flavour of the samples were highly acceptable with the score of 8.9 throughout the storage period in all the treatments with

a slight reduction observed only in the samples of T₀P₁WOA with the value of 8.5. However, no off flavour was observed in the samples.

The texture of the instant idli mix was slightly grainy, non sticky without caking in T₀, T₁ and T₂ with highly acceptable score values of 8.9, 8.7 and 8.6 during the initial storage period. As the storage days passed by a reduction in the scores for texture was noted only in the control samples irrespective of the packaging materials and presence of antioxidants. The final value of T₀P₁WOA was 8.4, T₀P₁WA was 8.5, T₀P₂WOA was 8.4, T₀P₂WA was 8.5, T₀P₃WOA was 8.5 and T₀P₃WA was 8.6 respectively. Though, there existed a difference in the scores for colour, flavour and texture between treatments and packaging materials, it did not influence the taste and overall acceptability of the mixes which was highly acceptable throughout the storage period irrespective of the treatments and packaging materials.

Similar results was observed by Shanthi (2000) and Kamaraddi *et al.* (2003) who had also reported that the nature of packaging material and storage had brought about changes in the sensory scores for colour, flavour, texture and the overall acceptability of the idli mix was found to be highly acceptable even after a storage period of three months.

4.4.2 Dosa mix

4.4.2.1 Chemical constituents

Moisture

Table 36 gives the changes in the moisture content of the kodo and barnyard millet instant dosa mix during storage. The initial moisture content was 10.00, 9.60 and 9.00 for T₀, T₁ and T₂ g per 100g respectively. The final moisture content after 180 days of storage ranged from 10.60 T₀P₃WA to 10.86 T₀P₁WOA for T₀, 9.80 T₁P₃WA to 9.90 T₁P₁WOA for T₁ and 9.60 T₂P₃WA to 9.87 T₂P₁WOA g per 100g for T₂ respectively. There was an influence of the packaging material and the presence of antioxidant in the moisture pick up of the samples indicated by the samples packed in the P₃ with antioxidant that had the minimum moisture pick up irrespective of the treatments and control. A statistically significant difference was noted for moisture pick up among treatments, packaging materials and storage period.

These results were in tune with the studies of Parvathi (2010) who had reported the moisture content of sorghum dosa mix as 7.39g per 100g.

Protein and starch

Table 37 and 38 gives the protein and starch content of the kodo and barnyard millet instant dosa mix during storage. The initial protein content was 8.65, 10.37 and 9.32 for T₀, T₁ and T₂ while that of the starch content of T₀, T₁ and T₂ were 68.00, 55.80 and 56.00g per 100g respectively in all the packaging. Incorporation of small millet flour had reduced starch content and increased the protein content of the samples. The final protein content ranged from 8.43 (T₀P₁WOA) to 8.50 (T₀P₃WA) for T₀, from 10.18 (T₁P₁WOA) to 10.25 (T₁P₃WA) for T₁ and 9.11(T₂P₁WOA) to 9.18(T₂P₃WA) for T₂ while the final starch content ranged from 67.50(T₀P₁WOA) to 67.70 (T₀P₃WA) for T₀, from 55.37(T₁P₁WOA) to 55.46 (T₁P₃WA) for T₁ and from 55.60 (T₂P₁WOA) to 55.74 (T₂P₃WA) for T₂ g per 100g respectively. The packaging material and the presence of antioxidant had influenced the rate of decrease in protein and starch of the samples during storage and the samples in P₃ with antioxidant showed the minimum changes irrespective of the treatment. The statistical analysis of the data revealed that there excited a significant difference between treatments, packaging materials and period of storage.

Sorghum based dosa mix had a starch content of 50.80 g per 100g as given by Parvathi (2010) which was similar to the present study.

Fat, free fatty acid and peroxide value

Table 39 gives the fat, free fatty acid and peroxide value of the kodo and barnyard millet instant dosa mix during storage. The initial fat content of T₀, T₁ and T₂ were 1.00, 1.30 and 2.00g per 100g respectively and after 180 days of storage, there was a slight reduction in the fat content which ranged from 0.48 (T₀P₁WOA) to 0.62 (T₀P₃WA) for T₀, from 1.15(T₁P₁WOA) to 1.22 (T₁P₃WA) for T₁ and 1.90(T₂P₁WOA) to 1.98(T₀P₃WA)g per 100g for T₂ respectively. The free fatty acid content of T₀, T₁ and T₂ were 1.10, 2.00 and 2.20 mg KOH per g respectively and after 180 days of storage, there was a slight increase in the free fatty acid content and ranging between 1.40(T₀P₃WA) and 1.68 (T₀P₁WOA) in T₀, 2.20(T₁P₃WA) and 2.32 (T₁P₁WOA) in T₁ and 2.37(T₂P₃WA) and 2.50 (T₂P₁WOA) in T₂ mgKOH per g respectively. As there was an increase in free fatty acid, a concurrent increase in the peroxide value was also noted and the initial peroxide value was 1.10, 0.60 and 0.40 for T₀, T₁ and T₂ and after 180 days of storage ranged from 1.42(T₀P₃WA) to 1.51(T₀P₁WOA) for T₀, from 0.80(T₁P₃WA) to 1.00(T₁P₁WOA) for T₁ and from 0.55(T₂P₃WA) to 0.70(T₂P₁WOA) meq/kg for T₂ respectively. The packaging material and presence of antioxidant had influenced the changes in the fat, free fatty acid and peroxide value of the samples and changes being very minimum in the samples P₃WA irrespective of the treatments.

Statistical analysis of the data also revealed that a significant difference existed between treatments, packaging materials and period of storage.

Malathi (2012) developed sorghum dosa mix and reported a fat content of 2.10 and noted a slight change in the fat content during storage which is in line with the present investigation.

Crude fibre and tannin

Table 40 gives the changes in the crude fibre and tannin content of the kodo and barnyard millet instant mixes during storage. The initial crude fibre content of T₀, T₁ and T₂ were 1.10, 4.20 and 5.50g per 100g in all the packaging and after 180 days of storage, the final crude fibre content was slightly reduced and ranged between 1.02 (T₀P₁WOA) and 1.08(T₀P₃WA) for T₀, 4.12 (T₁P₁WOA) and 4.20 (T₁P₃WA) for T₁ and 5.41(T₂P₁WOA) and 5.48 (T₂P₃WA) for T₂ g per 100g respectively. The initial tannin content of T₀, T₁ and T₂ were 2.14, 3.60 and 4.50 g per 100g in all the packaging and after 180 days of storage, a reduction was observed in the tannin content of all the samples irrespective of the treatment and packaging material. The final tannin content ranged between 2.04(T₀P₁WOA) and 2.12 (T₀P₃WA) in T₀, 3.36 (T₁P₁WOA) and 3.45(T₁P₃WA) in T₁ and 3.41(T₂P₁WOA) and 3.48 (T₂P₃WA) in T₂ g per 100g respectively. Though, there was a slight decrease in the crude fibre and tannin content during storage as influenced by the packaging material and the presence of antioxidant, it was statistically non significant.

Malathi (2012) reported that the crude fibre content of sorghum based instant dosa mix as 1.0 g per 100 g which was lower than that of the present investigation may be due to difference in the millet incorporated. However, the author has indicated that the crude fibre content of the sorghum based dosa mix was higher than the control samples that contained rice and black gram dhal, which was in accordance with the present study.

Ash and Mineral contents

The changes in the ash, calcium, phosphorus and iron content of kodo and barnyard millet dosa mix during storage are presented in Fig 2. The initial ash content of T₀, T₁ and T₂ were 2.10, 2.20 and 2.80 for all the packaging material and after 180 days, a non significant decrease was observed in the ash content in all the samples and the final values ranged from 2.04 (T₀P₁WOA) to 2.80 (T₂P₃WA) g per 100g respectively. The initial calcium content of T₀, T₁ and T₂ were 51.20, 58.18 and 52.40 while phosphorus was 121.00, 217.60 and 328.10 mg per 100g for T₀, T₁ and T₂

respectively. Similar to that of ash a non significant decrease in the calcium and phosphorus content was observed and the final values ranged between 51.05 (T₀P₁WOA) and 58.17 (T₁P₃WA) for calcium and 120.92 (T₀P₁WOA) and 328.04 (T₂P₃WA) mg per 100g for phosphorus. The initial iron content was 1.40, 4.07 and 5.24 for T₀, T₁ and T₂ in all the packaging and after 180 days of storage, the final iron content of T₀ ranged between 1.32 (T₀P₁WOA) and 1.40 (T₀P₃WA), T₁ between 3.96(T₁P₁WOA) and 4.07(T₁P₃WA) and that of T₂ between 5.17 (T₂P₁WOA) and 5.23(T₂P₃WA) mg per 100g respectively. Statistical analysis of the data showed a significant difference only between the treatment and not for packaging and storage for ash and mineral contents.

Bhavani (2000) reported that during storage calcium and iron content of instant mixes reduced. Malathi (2012) reported a calcium content 75.30mg and iron content of 4.00mg of sorghum based instant dosa mix. The present investigation is in line with the above studies.

4.4.2.2 Microbial load

Table 41 gives the total plate count of the kodo and barnyard millet instant dosa mix during storage. Initially, there was no total plate count irrespective of the treatment and packaging material. But as the storage period progressed, a slight increase in the total plate count was observed. The rise in the microbial load was more in the control (T₀) samples than the small millet based samples (T₁&T₂). The final total plate count after 180 days of storage was minimum in the samples of P₃WA when compared to P₁ and P₂ with and without antioxidant. This showed that the presence of antioxidant and the nature of the packaging material exerted an influence on the increase in the microbial load. The final total plate count of T₀ ranged between 2.4 (T₀P₃WA) and 3.4 (T₀P₁WOA), T₁ ranged between 2.2(T₁P₃WA) and 2.5(T₁P₁WOA) and T₂ ranged between 0.7(T₂P₃WA) and 1.2(T₂P₁WOA) x10⁴ cfu/g respectively.

The bacterial load of sorghum based instant dosa mix was found to be 4.00x10⁴cfu/g and the samples stored in 400 gauge Low Density Polyethylene (LDPE) bags had minimum microbial population (Malathi, 2012).

4.4.2.3 Sensory quality

Table 42 gives the changes in the sensory qualities namely the colour, flavour, texture, taste and overall acceptability of the control and small millet mixes during storage. Initially, the colour, flavour, texture, taste of the control (T₀) and small millet based instant mixes (T₁ &T₂) were highly acceptable. As the storage day progressed the score for colour of

the control samples decreased while that of small millet samples remained unchanged. This might be due to extreme white colour of the control mixes and creamy white colour of the small millet based mixes during the initial day of storage that had become creamy in the control sample while the small millet based samples remained unchanged during the storage period. The final score for colour ranged between 8.4 (T₀P₁WOA) and 8.6 (T₂P₃WA). The flavour of the control and small millet based mixes were highly acceptable during initial storage period with scores of 8.8 and after 180 days of storage, the flavour of the control mixes alone had decreased which might be due to the increase in the free fatty acid and peroxide value of the control samples that varied between the packaging material. The final score for flavour of the mixes ranged between 8.4 (T₀P₁WOA) and 8.7 (T₂P₃WA).

As that of flavour, the scores for texture of the small millet samples remained unchanged even after 180 days of storage and the initial and final values of the scores ranged from 8.3 (T₀P₁WOA) and 8.6 (T₂P₃WA). The taste of the small millet samples (T₁ & T₂) was highly acceptable on par with control (T₀) with the score of 8.9 irrespective of the packaging materials. A slight decrease in the scores of taste was noted in the control samples and the values ranged from 8.5 (T₀P₁WOA) to 8.7 (T₀P₃WA) for T₀ while that of T₁ and T₂ ranged from 8.2 (T₁P₁WOA) to 8.7 (T₁P₃WA) and 8.6 (T₂P₁WOA) to 8.8 (T₂P₃WA) respectively. The initial overall acceptability of T₀, T₁ and T₂ were 9.0, 8.7 and 8.6 in all the packaging and after 180 days of storage, the values ranged between 8.4 (T₀P₁WOA) and 8.7 (T₀P₃WA) for T₀, between 8.3 (T₁P₁WOA) and 8.6 (T₁P₃WA) for T₁ and between 8.2 (T₂P₁WOA) and 8.5 (T₂P₃WA) for T₂ respectively.

Bhavani (2000) showed that multipurpose instant mixes packed in polypropylene bag did not show any change in their sensory attributes for three months. Malathi (2012) reported that the colour and appearance, texture, taste, and flavour of the sorghum based instant dosa mix packed in different packaging materials were found to be highly acceptable throughout the storage period of 180 days which is in accordance with the present investigation.

4.4.3 Adai mix

4.4.3.1 Chemical constituents

Moisture

The data pertaining to the changes in the moisture content of the control and small millet instant adai mix packed in different packaging material with and without antioxidant and stored at room temperature is presented in Table 43.

A significant increase was observed in the moisture content in all the samples during storage. The moisture pick up was more in P₁ when compared to P₂ and

P₃. Among the treatments, the moisture pick up was more in T₀ followed by T₂ and T₁. Similarly, between the presence and absence of antioxidant, the samples packed without antioxidant had more moisture than the samples packed with antioxidant. The initial moisture content of T₀, T₁ and T₂ was 12.10, 11.35 and 11.00g per 100g irrespective of the packaging material and after 180 days of storage, the final moisture content ranged from 11.41 (T₂P₃WA) to 12.70 (T₀P₁WOA) g per 100g of the sample. These significant changes in moisture content might be due to the incorporation of small millets and the nature of the packaging material and presence of antioxidant.

Parvathi (2010) recorded a moisture content of 11.35g per 100g in multigrain adai mix which is similar to the moisture content of the adai mix in the present study.

Protein

The data pertaining to the changes in the protein content of the kodo and barnyard millet instant mix and control adai mix during storage is furnished in Table 44. The incorporation of small millet increased in the protein content when compared to control. As the storage period progressed, there was a reduction in the protein content in all the samples, the reduction being more prominent in P₁ than P₂ and P₃. Similarly, the loss in protein was more in the samples packed with antioxidant. Among the treatment, the loss of protein was more in T₀ followed by T₂ and T₁. The initial protein content of T₀, T₁ and T₂ was 12.56, 15.70 and 14.00g per 100g irrespective of packaging materials which reduced with the values ranging from 12.39 (T₀P₁WOA) to 12.44 (T₀P₃WA) for T₀, from 15.52 (T₁P₁WOA) to 15.58 (T₁P₃WA) for T₁ and from 13.82 (T₂P₁WOA) to 13.90 (T₂P₁WA) for T₂ g per 100g respectively. A significant difference was observed between the treatment, packaging material and storage days.

Bhavani (2000) had also reported a significant loss of protein in instant adai mix during storage. Malathi (2012) reported 8.33g protein in sorghum based instant adai mix.

Starch

The data pertaining to the changes in the starch content of the kodo and barnyard millet instant adai mix and control adai mix during storage is furnished in Table 45. The incorporation of small millet had significantly reduced the starch content of the adai mix as it is evident from the initial values of 48.10 (T₀), 27.68 (T₁) and 31.46 (T₂) g per 100 g in all the packaging material. A decreasing trend was observed in the starch content of all the samples during storage. The control samples indicated the maximum reduction in the starch content while the treated samples (T₁ and T₂) showed the minimum reduction which might be due to the difference in the

characteristics of the starch between the small millet. Among the packaging material and the presence of antioxidant samples of P₃WA had recorded the minimum change in the starch after 180 days of storage irrespective of the treatment. The final starch content ranged from 45.68 (T₀P₁WOA) to 45.75 (T₀P₃WA) for T₀, from 27.25(T₁P₁WOA) to 27.38 (T₁P₃WA) for T₁ and 31.04(T₂P₁WOA) to 31.18 (T₂P₃WA) for T₂ g per 100g respectively. The statistical analysis of the data revealed a highly significant difference among the treatment, packaging material and storage days.

These results are in tune with the study of Bhavani (2000) who had also reported a significant reduction in the starch content of the instant adai mix packed in polypropylene bag during storage at room temperature. Malathi (2012) reported the initial and final carbohydrate content of sorghum based instant adai mix to be 64.25 and 64.15 g per 100 g respectively.

Fat, free fatty acid and peroxide value

The data pertaining to the changes in the fat, free fatty acid and peroxide value of the kodo and barnyard millet instant adai mix and control adai mix during storage is presented in Table 46. The initial fat content of T₁ and T₂ was found to be more than T₀ which might be due to the incorporation of small millets. A decreasing trend was noticed in the fat content after 180 days of storage. The reduction in fat was more in the samples of P₁ WOA followed by P₁ WA, P₂ WOA, P₂WA, P₃ WOA and P₃ WA in T₀, T₁ and T₂ respectively. This showed that the permeable nature and the presence of antioxidant have led to the minimum reduction of the fat in the samples of P₃WA. The initial fat content of T₀, T₁ and T₂ irrespective of the packaging materials were 1.20, 1.70 and 2.00 g per 100 g respectively. The final fat content after 180days of storage ranged from 1.08 (T₀P₁WOA) to 1.97 (T₂P₃WA) g per 100g.

The initial free fatty acid and peroxide value of T₀, T₁ and T₂ were found to be 1.20 2.40 and 3.30 mg KOH per 100g and 0.90 and 0.60 & 0.50meq /kg respectively irrespective of the packaging materials. As the storage day progressed, there was a slight increase in the free fatty acid with corresponding increase in the peroxide value of all the samples and the increase was minimum in the samples of T₂P₃WA and T₀ P₁WOA. The final free fatty acid ranged between 1.78 (T₀P₁WOA) to 3.43 (T₂P₃WA) mg KOH/ 100g and peroxide value ranged between 0.62 (T₂P₃WA) to 1.25 (T₀P₁WOA) meq/kg respectively. In the present investigation the samples of P₁WOA that had the higher moisture pick up also indicated the higher increase in free fatty acid during storage. The statistical analysis of the data revealed a highly significant

difference for the changes noted in the fat, free fatty acid and peroxide value between treatment, packaging material and storage days.

Bhavani (2000) also observed a similar reduction in the fat content of the instant adai mix during storage. Hui Li *et al.* (2003) stated that an increase in free fatty acid during storage might be due to the depolymerisation of lipids to free fatty acid. Malathi (2012) gave the fat content of sorghum based instant mix as 3.45g per 100g.

Crude fibre

The data pertaining to the changes in the crude fibre content of the kodo and barnyard millet instant adai mix is given in Table 47. The crude fibre content of T₁ and T₂ were more when compared to T₀. After 180 days of storage, there was a slight reduction in the crude fibre content and the variation in the reduction existed between the packaging material and the presence of antioxidant. Though a visible reduction was observed, it was statistically non significant. The initial crude fibre content of T₀, T₁ and T₂ in all the samples were 4.98, 6.20 and 7.78g per 100g respectively. The final crude fibre content ranged between 4.88 (T₀P₁WOA) and 7.75 (T₂P₃WA) g per 100g of the sample.

Pattan *et al.* (2001) reported a decrease in fibre content from 1.19 to 1.14 and 1.09 per cent on storage of millet based instant mixes in polythene pouches and aluminium box respectively. Hemalatha (2004) observed a non significant decrease in the millet based instant mixes during storage which is in line with the present investigation.

Tannin

The data pertaining to the changes in the tannin content is represented in Table 47. The tannin content of T₁ and T₂ were more than T₀ owing to the presence of small millets which continued to remain the same throughout the storage period. As the storage days passed by there was a notable reduction in the tannin content and was more prominent in the samples P₁WOA in all the treatments, because of the higher permeable nature of the packaging material and absence of antioxidant. But the statistical analysis of the data indicated a non significant difference between the packaging material and storage and a significant difference between treatments. The initial tannin content of T₀, T₁ and T₂ were 5.40, 5.70 and 6.25 g per 100g in all the packaging material respectively. The final tannin content ranged between 5.28 (T₀P₁WOA) and 6.25 (T₂P₃WA) g per 100g respectively.

Hemalatha (2004) also observed an increase in the phytate and tannin content in the small millet based instant mixes when compared to rice based mixes. The author also reported a non significant reduction in the phytate and tannin content during storage which was observed in the present investigation as well.

Ash and mineral contents

The data pertaining to the changes in the ash and mineral content of the kodo and barnyard millet instant adai mix during storage is given in Fig 3. A notable difference in the ash content existed between T₀, T₁ and T₂ during initial storage period, which might be due to the presence of small millets. As the storage days progressed, there was reduction in the ash content depending upon the permeable of the packaging material and the presence of antioxidants. Accordingly, the samples packed in P₃ WOA had the minimum change. The statistical analysis of the data revealed that significant difference existed only between the treatment and not between packaging material and storage period and their interaction. The initial ash content of T₀, T₁ and T₂ were 2.40, 2.50 and 2.60g per 100g irrespective of the packaging materials. The final ash content ranged between 2.38 (T₀P₁WOA) and 2.60 (T₂P₃WA) g per 100g.

The initial calcium content of T₀, T₁ and T₂ were 51.00, 71.30 and 60.20 while that of phosphorus was 100.18, 244.70 and 336.28mg per 100g respectively in all the packaging. The iron content of these samples were noted to be 2.26 (T₀), 5.88 (T₁) and 7.30 (T₂) mg per 100g in all the packaging material respectively. Barnyard millet mix (T₂) had minimum calcium content and the maximum phosphorus content. As far as, the iron content of the samples were considered maximum iron content was found in T₂ followed by T₁ and T₀. On the whole, the differences in the mineral content were due to nature of the small millet incorporated in the respective mixes. During storage, there was a slight loss in the mineral content with notable difference among the packaging material and the presence of antioxidants but statistically non significant. The final calcium content ranged from 50.87 (T₀P₁WOA) to 71.28 (T₁P₃WA), phosphorus content ranged from 100.08 (T₀P₁WOA) to 336.25 (T₂P₃WA) and iron content ranged from 2.18 (T₀P₁WOA) to 7.27 (T₂P₃WA) mg per 100g respectively.

Selvi (2003) reported that the calcium, phosphorus and iron content of pearl millet flour incorporated products were found to be higher than the products prepared from rice flour alone. The present investigation is in line with the above study.

4.4.3.2 Microbial load

The data pertaining to the changes in the microbial load of the kodo and barnyard millet instant adai mix during storage is furnished in Table 48. Initially the total plate count in all the samples was found to be nil and as the storage day progressed, there was an increase in the microbial load. The samples that were packed in P₃ along with the antioxidant showed the minimum microbial load when compared to the samples of the P₁ and P₂ with and without antioxidant in all the treatments. This showed that the less permeable nature of the packaging material and the presence of antioxidant has checked the growth of microorganism in these samples. The final total plate count of T₀ ranged from 2.7 (T₀P₃WA) to 3.1 (T₀P₁WOA), T₁ ranged from 2.0(T₁P₃WA) to 2.5 (T₁P₁WOA) and T₂ ranged from 1.2 (T₂P₃WA) to 2.2 (T₂P₁WOA) x 10⁴cfu/g respectively.

Pragati and Singh (2003) observed minimum count of fungi in maize flour based convenience mixes, while Hemalatha (2004) reported that no significant trend was observed for changes in the bacteria, fungi and yeast during storage in millet based instant mixes.

4.4.3.3 Sensory quality

The data pertaining to the changes in the sensory qualities of the kodo and barnyard millet instant adai mix during storage is presented in Table 49. No distinct variation was observed between the control and small millet incorporated instant mix for colour, flavour, texture, taste and overall acceptability and were highly acceptable in all the samples during initial period of storage. A slight decrease in the organoleptic scores was observed for the control samples than the treated samples during storage. The colour of the control samples became slightly dull, the texture being non grainy with slight caking and an acceptable flavour and taste was observed after 180 days of storage. On the contrary, in the T₁ and T₂ samples had no dullness of the colour, the texture of the mixes were grainy and non sticky without caking and highly acceptable taste, flavour and overall acceptability was observed. Among the packaging material, the samples packed in P₃WA had retained the highly acceptable sensory properties in T₁ and T₂ including the control. The final score for colour ranged between 8.5 (T₀P₁WOA) and 8.7 (T₂P₃WA), flavour ranged between 8.3 (T₀P₁WOA) and 8.5 (T₂P₃WA), texture ranged between 8.2 (T₀P₁WOA) and 8.4 (T₂P₃WA), taste ranged between 8.4 (T₀P₁WOA) and 8.7 (T₂P₃WA) and overall acceptability ranged between 8.4 (T₀P₁WOA) and 8.6 (T₂P₃WA) respectively.

Itagi *et al.*(2003) observed no apparent changes in the sensory qualities of traditional products developed from composite mix based on foxtail millet (80%) wheat

(10%) and black gram dhal (10%). Hemalatha (2004) indicated that the change in the sensory qualities of the millet based instant mixes was highly influenced by the nature of the packaging material and storage condition.

4.4.4 Pittu mix

4.4.4.1 Chemical constituents

Moisture

The changes noted in the moisture content of the control and small millet incorporated instant mixes stored under ambient condition are given in Table 50. The moisture content of instant mixes is usually used as an indicator of food quality. The initial moisture content of T₀, T₁ and T₂ were observed to be 11.80, 10.70 and 10.00g per100g in all the packaging, which might be due to incorporation of small millets. A gradual increase in moisture content was observed in all the samples packed in different materials throughout the storage period. Among the packaging materials, the mixes stored in P₁WOA absorbed more moisture followed by P₁WA, P₂WA, P₂WOA, P₃WA and P₃WOA. The moisture permeable nature of the packaging materials and the presence of antioxidant have contributed to the difference in the moisture pick up. The final moisture content ranged from 12.27 (T₀P₃WA) to 12.52 (T₀P₁WOA) in T₀, 10.97 (T₁P₃WA) to 11.10 (T₁P₁WOA) in T₁ and 10.55 (T₂P₃WA) to 10.67 (T₂P₁WOA) in T₂ g per 100g. The statistical analysis of the data revealed a highly significant difference between the treatments, packaging materials and period of storage.

Subbulakshmi (2006) observed significant increase in moisture content with increase in the level of incorporation of oats flour in pittu mix (10.80%) compared to the control (9.90 %). A slight increase in moisture was observed during (120 days) storage periods. These findings concur with those of the present research findings.

Protein

The changes in the protein content of the kodo and barnyard millet instant pittu mix during storage are presented in Table 51. The incorporation of small millets had significantly increased the protein content as it is evident from the initial values of T₁, T₂ and T₀ as, 7.30, 6.25 and 5.00g per 100g in all the packaging material. A gradual reduction in the protein content was observed for all the samples during storage.

The reduction in the protein content was lesser in the samples packed in P₃WA when compared to P₃WOA, P₂WOA, P₂WA, P₁WOA and P₁WA for T₀, T₁ and T₂. The protein content after 180 days of storage ranged from 4.78 (T₀P₁WOA) to 4.84 (T₀P₃WA) for T₀, 7.04 (T₁P₁WOA) to 7.14 (T₁P₃WA) for T₁ and 6.05 (T₂P₁WOA) to 6.14 (T₂P₃WA) g per 100g for T₂. The statistical analysis revealed a significant difference between treatments, packaging materials and days of storage.

Parvathi (2010) had also reported a significant loss of protein in instant pittu mix during storage. Subbulakshmi (2006) reported a protein content of oats flour incorporated pittu mix to ranged from 3.80 to 3.98g per 100g.

Starch

The changes in starch content during storage of the kodo and barnyard millet instant pittu mix are in Table 52. The starch content of the control was maximum (69.00g) and the values decreased for the small millet based instant mixes as 51.80 (T₁) and 56.10 (T₂) in all the packaging. A gradual reduction in the starch content was observed in all samples during storage, irrespective of treatment and packaging material. The changes were more predominant in T₀P₁WOA samples and least changes was observed in T₂P₃WA samples. Overall reduction in starch was significant in T₀ than T₁ and T₂ which might be due to the incorporation of small millets and the characteristics of millet starch. The final starch content of the pittu mix ranged from 68.50 (T₀P₁WOA) to 68.64 (T₀P₃WA) for T₀, 51.30 (T₁P₁WOA) to 51.47(T₁P₃WA) for T₁ and 55.50 (T₂P₁WOA) to 55.70 (T₂P₃WA) g per 100g for T₂. The reduction in starch during storage might be due to the hydrolysis of starch.

Finger millet based instant *baati* mix had a starch content of 79.32g as given by Arora and Srivastava *et al.* (2002). Subbulakshmi (2006) who had also reported a significant reduction in the starch content of the oat incorporated pittu mix packed in polypropylene bag during storage at room temperature.

Fat

Table 53 gives the changes in the fat content of the kodo and barnyard millet instant pittu mix during storage. The fat content of the control pittu mix was minimum and a significant increase was observed with increase in incorporation of kodo millet and barnyard millet flour. The initial fat content of T₀, T₁ and T₂ was 0.80, 1.00 and 1.80g per 100g in all the packaging. After 180 days of storage, the final fat content ranged between 0.69 (T₀P₁WOA) to 0.75 (T₀P₃WA) for T₀, 0.85 (T₁P₁WOA) to 0.96 (T₁P₃WA) for T₁ and 1.67 (T₂P₁WOA) to 1.75 (T₂P₃WA) g per 100g for T₂. This shows that, there was a reduction in fat after 180 days of storage and the reduction was minimum in the samples of P₃WA irrespective of the treatment. A statistically significant difference was noted for fat between the treatment, packaging and storage period of their interactions.

Itagi *et al.* (2011a) developed millet based designer *upma* mix and reported a fat content of 3.87g and noted a slight change in the fat content during storage which is in line with the present investigation.

Free fatty acid and peroxide value

There was an increase in the free fatty acid and peroxide value of the kodo and barnyard millet instant pittu mix during storage irrespective of the packaging material and treatment as it was presented in Table 53. Incorporation of small millet showed significant reduction in the free fatty acid and peroxide values of the instant mixes. As the storage days progressed there was a slight increase in free fatty acid and peroxide value and was more notable in control samples than treated samples. The initial free fatty acid of T₀, T₁ and T₂ were 2.10, 2.50 and 2.85mg KOH/g and peroxide value were 1.10, 0.55 and 0.40meq/kg for T₀, T₁ and T₂ respectively. After 180 days of storage, the final free fatty acid and peroxide value ranged from 2.37 (T₀ P₃WA) to 2.60 (T₀ P₁WOA) and 1.14 (T₀ P₃WA) to 1.19 (T₀ P₁WOA) for T₀, 2.75 (T₁ P₃WA) to 2.87 (T₁ P₁WOA) and 0.65 (T₂ P₃WA) to 0.75 (T₁ P₁WOA) for T₁, 3.02 (T₂ P₃WA) to 3.10 (T₂ P₁WOA) and 0.55 (T₂ P₃WA) to 0.62 (T₂ P₁WOA) for T₂ respectively. In the present investigation, the samples of P₁WOA that had higher moisture pick up also indicated the higher increase in free fatty acid during storage. The statistical analysis of the data also revealed a significant difference among treatment, packaging material and days of storage.

Mestres *et al.*(2003) stated that free fatty acid and peroxide values were not related to the initial lipid content of the product but should be linked with lipolytic activity induced by product ingredients such as moisture content.

Crude fibre and tannin

The crude fibre and tannin of the kodo and barnyard millet instant pittu mix during storage was analysed and the results are given in Table 54. From the table, it could be inferred that a significant increase in the fibre content had occurred for the small millet instant mixes than control. The initial values of the crude fibre for T₀, T₁ and T₂ were 0.60, 3.10 and 5.80 while the tannin content for T₀, T₁ and T₂ were 1.56, 4.80 and 5.00 g per 100 g respectively in all packaging. Upon storage there was a slight loss in the crude fibre and tannin contents packed in P₁, P₂ and P₃ with and without antioxidants in all the treatments but was statistically non significant.

Kulkarni *et al.* (2011) observed significant increase in crude fibre content with increase in the level of incorporation of barnyard millet flour (6.48%) compared to the control (0.59 %) in the instant mixes developed, which is in line with the present investigation.

Ash and mineral contents

Significant increase in ash content was also observed with the incorporation of kodo millet and barnyard millet flour. The initial ash content of T₀, T₁ and T₂ were observed to be 1.50, 2.20 and 3.10g per 100g in all the packaging, which might be due to incorporation of small millets. The final ash content ranged from 1.16 (T₀P₁WOA) to 3.10 (T₂P₃WA) g per 100g. A slight decrease in ash content on storage was observed which was non significant. Statistical analysis of the data revealed non significant difference between packaging materials and days of storage and significant between the treatments.

The data pertaining to the changes in calcium, phosphorus and iron content of instant pittu mix is presented in Fig 4. Significant increase in calcium, phosphorus and iron content was observed with the incorporation of kodo millet and barnyard millet flour. The control sample, initially recorded 9.60mg calcium, 138.10mg phosphorus and 0.90mg of iron per 100g of the sample in all the packaging. The kodo millet flour pittu mix recorded higher values than control for calcium (30.00mg /100g), phosphorus (176.00mg / 100g) and iron (4.20mg /100g) and the comparative values for barnyard millet flour pittu mix were 26.00mg calcium, 278.10mg phosphorus and 6.80mg of iron per 100g of sample in all the packaging material during the initial storage period. A slight reduction in calcium, phosphorus and iron was observed during storage. However, it was statistically non significant between packaging materials, days of storage and significant only between the treatments.

Kulkarni *et al.* (2011) stated that calcium (39.97mg) and iron (17.95mg) content of the barnyard millet based *upma* mix were higher than foxtail millet *upma* mix. The present study clearly indicated that mineral content of the millet based instant mix was significantly higher compared to the control.

4.4.4.2 Microbial load

The changes in microbial load of the kodo and barnyard millet instant pittu mix during storage are presented in Table 55. An increasing trend was observed in terms of the total plate count between the treatments and between packaging materials in both the kodo millet and barnyard millet incorporated products. The initial values for total plate count were nil. The total plate count showed slight elevation on storage and ranged from 1.5 (T₀P₃WA) to 2.5(T₀P₁WOA) x 10⁴ for T₀, 1.8 (T₁P₃WA) to 2.7 (T₁P₁WOA) x 10⁴ for T₁ and 1.8 (T₂P₃WA) to 2.2 (T₂P₁WOA) x 10⁴ cfu/g for T₂ respectively at the end of the storage period of 180 days. The low permeable nature of

P₃ and the presence of antioxidants had hindered the increase of microbes in these samples, in all the treatment including the control samples.

Meenatchisundram (2005) reported that the total plate count increased from an initial value of 1.7×10^6 to 2.0×10^6 cfu/g in bajra based instant mix after a storage period of 180 days which is in line with the present investigation.

4.4.4.3 Sensory quality

The mean organoleptic scores for colour, flavour, texture, taste and overall quality of the kodo and barnyard millet instant pittu during the initial storage period and the changes observed after 180 days of storage were tabulated and presented in Table 56.

The colour of the control pittu mix was extremely white and that of small millet based samples were white with a creamy tinch. The scores for colour T₀, T₁ and T₂ were highly acceptable with the respective value of 9.0, 8.8 and 8.7 irrespective of the packaging materials. After 180 days of storage, the score value for colour of the control samples decreased and ranged between 8.3 (T₀P₁WOA) and 8.7 (T₀P₃WA), while that of T₁ and T₂ remained the same. This might be due to the change of the extremely white colour to dull white colour in the control samples. The flavour of the control and treated samples were highly acceptable with the score of 8.9 throughout the storage period with a slight reduction observed only in the samples of T₀P₁WOA with the value of 8.3. However, no off flavour was observed in these samples also. The texture of the pittu mix was slightly grainy, non sticky without caking in T₀, T₁ and T₂ in all the packaging with highly acceptable score values of 8.9, 8.8 and 8.7 during the initial storage period. As the storage days passed by the reduction in the scores for texture was noted only in the control samples irrespective of the packaging materials and presence of antioxidants. The final value of T₀P₁WOA was 8.4, T₀P₁WA was 8.5, T₀P₂WOA was 8.4, T₀P₂WA was 8.5, T₀P₃WOA was 8.6 and T₀P₃WA was 8.7 respectively. Though, there existed a difference in the score for colour, flavour and texture between treatment and packaging material, it did not influence the taste and overall acceptability of the mixes and was highly acceptable, which remained the same throughout the storage period irrespective of the treatments and packaging materials.

Parvathi (2010) reported that the colour and appearance, texture, taste, and flavour of the sorghum based instant pittu mix packed in different packaging materials were found to be highly acceptable throughout the storage period of 180 days which is in accordance with the present investigation.

4.4.5 Idiyapam mix

4.4.5.1 Chemical Constituents

Moisture

Table 57 gives the changes in the moisture content of the kodo and barnyard millet instant idiyapam mix during storage. The initial moisture content was 11.80, 10.70 and 10.00 for T₀, T₁ and T₂ g per 100g respective irrespective of the packaging. The final moisture content after 180 days of storage ranged from 12.27 (T₀P₃WA) to 12.52 (T₀P₁WOA) for T₀, 10.97 (T₁P₃WA) to 11.10 (T₁P₁WOA) for T₁ and 10.55 (T₂P₃WA) to 10.67 (T₂P₁WOA) g per 100g for T₂ respectively. There was an influence of the packaging material and the presence of antioxidant in the moisture pick up as indicated by the samples packed in the P₃ with antioxidant that had the minimum moisture pick up irrespective of the treatments. A statistically significant difference was noted for moisture pick up among treatments, packaging materials and storage period.

Significant increase in moisture (4.08 to 4.25 %) was reported on storage of sorghum based idyappam mix during a storage period of six months in polyethylene bags by Malathi (2012). These findings concur with those of the present research findings.

Protein and starch

Table 58 and 59 gives the protein and starch content of the kodo and barnyard millet instant idiyapam mix during storage. The protein content was 5.00, 7.30 and 6.25g per 100g for T₀, T₁ and T₂ while that of the starch content of T₀, T₁ and T₂ were 69.00, 51.80 and 56.10g per 100g respective irrespective of the packaging material. Incorporation of millet flour had reduced starch content and increased the protein content. The final protein content ranged from 4.78 (T₀P₁WOA) to 4.84 (T₀P₃WA) for T₀, from 7.04 (T₁P₁WOA) to 7.14 (T₁P₃WA) for T₁ and 6.05 (T₂P₁WOA) to 6.14(T₂P₃WA) for T₂ while the final starch content ranged from 65.50 (T₀P₁WOA) to 68.64 (T₀P₃WA) for T₀, from 51.30 (T₁P₁WOA) to 51.47 (T₁P₃WA) for T₁ and from 56.50 (T₂P₁WOA) to 56.70 (T₂P₃WA) for T₂ g per 100g respectively. The packaging material and the presence of antioxidant had influenced the rate of decrease in protein and starch of the samples during storage and the samples in P₃ with antioxidant showed the minimum changes irrespective of the treatment. Statistical analysis of the data revealed that a significant difference between treatments, packaging materials and period of storage and its interaction.

Suriya (2002) a reduction in protein content in millet and tuber blended noodles during storage. Suhendro *et al.* (2000) reported that protein content of sorghum noodles ranged from 7.3 to 8.9g per 100g. Malathi (2012) reported that sorghum based instant idiyappam mix had an initial protein content of 10.42 per cent and was gradually lost upon storage and the loss was reported to be 0.12 per cent, whereas in the present study the loss of protein was found to be comparatively lesser (0.10 %). Higher protein content was recorded in the present study for the kodo millet and barnyard millet flour incorporated instant idiyappam mix.

Fat, free fatty acid and peroxide value

Table 60 gives the fat, free fatty acid and peroxide value of the kodo and barnyard millet instant idiyappam mix during storage. The initial fat content of T₀, T₁ and T₂ were 0.80, 1.00 and 1.80g per 100g respectively and after 180 days of storage, there was a slight reduction in the fat content which ranging from 0.69 (T₀P₁WOA) to 0.75 (T₀P₃WA) for T₀, from 0.85 (T₁P₁WOA) to 0.96 (T₁P₃WA) for T₁ and 1.67 (T₂P₁WOA) to 1.75 (T₂P₃WA) g per 100 g for T₂ respectively. The initial free fatty acid content of T₀, T₁ and T₂ were 2.10, 2.50 and 2.85mg KOH per g respectively and after 180 days of storage, there was a slight increase in the free fatty acid content ranging between 2.37(T₀P₃WA) and 2.60 (T₀P₁WOA) for T₀, 2.75 (T₁P₃WA) and 2.87 (T₁P₁WOA) for T₁ and 3.02 (T₂P₃WA) and 3.10 (T₂P₁WOA) for T₂ mgKOH per g respectively. As there was an increase in free fatty acid, a concurrent increase in the peroxide value was also noted and the initial peroxide value was 1.10, 0.55 and 0.40meq/ kg for T₀, T₁ and T₂ irrespective of the package and after 180 days of storage, it ranged from 1.14 (T₀P₃WA) to 1.17 (T₀P₁WOA) for T₀, from 0.65 (T₁P₃WA) to 0.75 (T₁P₁WOA) for T₁ and from 0.55 (T₂P₃WA) to 0.65(T₂P₁WOA) meq/kg for T₂ respectively. The packaging material and the presence of antioxidant had influenced the changes in the fat, free fatty acid and peroxide value of the samples and changes being very minimum in the samples P₃WA irrespective of the treatments. The statistical analysis of the data revealed a significant difference between treatments, packaging materials, period of storage and their interactions.

A similar trend was observed by Hemalatha (2004) who reported a reduction in the fat content and an increase in free fatty acid and peroxide value during storage of little millet based instant mix.

Crude fibre and tannin

Table 61 gives the changes in the crude fibre and tannin content of the kodo and barnyard millet instant idiyappam mixes during storage. The initial crude fibre

content of T₀, T₁ and T₂ were 0.60, 3.10 and 5.80g per 100g irrespective of the packaging and after 180 days of storage, the final crude fibre content had slightly reduced ranging between 0.51 (T₀P₁WOA) and 0.57(T₀P₃WA) for T₀, 3.00 (T₁P₁WOA) and 3.10 (T₁P₃WA) for T₁ and 5.66 (T₂P₁WOA) and 5.77(T₂P₃WA) for T₂ g per 100g respectively. The initial tannin content of T₀, T₁ and T₂ were 1.56, 4.80 and 5.00g per 100g and after 180 days of storage, a reduction was observed in the tannin content of all the samples irrespective of the treatment and packaging material. The final tannin content had slightly reduced and ranged between 1.38 (T₀P₁WOA) and 1.50 (T₀P₃WA) for T₀, 4.52 (T₁P₁WOA) and 4.74 (T₁P₃WA) for T₁ and 4.87(T₂P₁WOA) and 4.95(T₂P₃WOA) for T₂ g per 100g respectively. Though, there was a slight decrease in the crude fibre and tannin content during storage as influence by the packaging material and the presence of antioxidant, it was statistically non significant. However, the difference between the treatment for crude fibre and tannin were statistically significant.

Ash and Minerals

The changes in the ash, calcium, phosphorus and iron content of the kodo and barnyard millet idiyapam mix during storage are given in Fig 5. The initial ash content of T₀, T₁ and T₂ were 1.20, 2.20 and 3.10g per 100g and after 180 days, a non significant decrease was observed in the ash content of all the samples and the final values ranged from 1.16 (T₀P₁WOA) to 3.10 (T₂P₃WA) g per 100g respectively. The initial calcium content of T₀, T₁ and T₂ irrespective of packaging were 9.60, 30.00 and 26.00 while phosphorus was 138.10, 176.00 and 278.10mg per 100g for T₀, T₁ and T₂ respectively. Similar to that of ash a non significant decrease in the calcium and phosphorus content was observed during storage and the final values ranged between 9.46 (T₀P₁WOA) and 30.00 (T₁P₃WA) for calcium and 137.96 (T₀P₁WOA) and 278.08 (T₂P₃WA) mg per 100g for phosphorus respectively. The initial iron content was 0.90, 4.20 and 6.80 for T₀, T₁ and T₂ and after 180 days of storage, the final iron content of T₀ ranged between 0.82 (T₀P₁WOA) and 0.88 (T₀P₃WA), of T₁ between 4.10 (T₁P₁WOA) and 4.20 (T₁P₃WA) and that of T₂ between 6.72 (T₂P₁WOA) and 6.78 (T₂P₃WA) mg per 100g respectively.

Vani and Manimegalai (2002) also reported no changes in calcium, phosphorus and iron content during storage of composite flour noodles.

4.4.5.2 Microbial load

Table 62 gives the total plate count of the kodo and barnyard millet instant idiyapam mix during storage. Initially, there was no total plate count irrespective of the

treatment and packaging material. But as the storage days progressed, a slight increase in the total plate count was observed. The rise in the microbial load was more in the control (T_0) samples than the small millet based samples (T_1 & T_2). The final total plate count after 180 days of storage was minimum in the samples of P_3 WA when compared to P_1 and P_2 with and without antioxidant. This showed that the presence of antioxidant and the nature of the packaging material exerted an influence on the increase in the microbial load. The final total plate count of T_0 ranged between 1.5 (T_0P_3 WA) and 2.5 (T_0P_1 WOA), T_1 ranged between 1.8 (T_1P_3 WA) and 2.7 (T_1P_1 WOA) and T_2 ranged between 1.8 (T_2P_3 WA) and 2.2 (T_2P_1 WOA) $\times 10^4$ cfu/g respectively.

Sehgal *et al.* (2002) reported that yeast and fungi were not detected initially in extruded products and also when stored for two months. Similar observations were made in the present study also.

4.4.5.3 Sensory quality

Table 63 gives the changes in the sensory qualities namely the colour, flavour, texture, taste and overall acceptability of the control and small millet based instant mixes during storage. Initially, the colour, flavour, texture, taste of the control (T_0) and small millet based instant mixes (T_1 & T_2) were highly acceptable. As the storage day progressed, the score for colour of the control samples decreased while that of the small millet based samples remained unchanged. This might be due to the extreme white colour of the control mixes and creamy white colour of the small millet based mixes during the initial day of storage, which had become creamy in the control sample, while that of small millet based samples remained unchanged during the storage period. The final score for colour ranged between 8.5 (T_0P_1 WOA) and 8.7 (T_2P_3 WA). The flavour of the control and small millet based mixes were highly acceptable during initial storage period with scores of 8.8 and after 180 days of storage, the flavour of the control mixes alone had decreased which might be due to increase in the free fatty acid and peroxide value of the control samples. The final score for flavour of the mixes ranged between 8.3 (T_0P_1 WOA) and 8.5 (T_2P_3 WA). As that of flavour the score for texture of the millet based samples remained unchanged even after 180 days of storage and the initial and final values of the scores ranged from 8.2 (T_0P_1 WOA) and 8.4 (T_2P_3 WA). The taste of the millet based samples (T_1 & T_2) was highly acceptable on par with control (T_0) with the score of 8.9 irrespective of the packaging materials. A slight decrease in the scores of taste was noted in the control samples and the values ranged from 8.4 (T_0P_1 WOA) to 8.7 (T_0P_3 WA) for T_0 while that of T_1 and T_2 ranged from 8.4 (T_1P_1 WOA) to 8.7 (T_1P_3 WA) and 8.3 (T_2P_1 WOA) to 8.7 (T_2P_3 WA) respectively. The

initial overall acceptability of T₀, T₁ and T₂ were 8.8, 8.6 and 8.6 and after 180 days of storage, the values ranged between 8.4 and 8.7 (T₀), between 8.2 and 8.5 (T₁) and between 8.1 and 8.6 (T₂) respectively.

Agrawal *et al.* (2002) reported that increasing the level of foxtail millet from 10 to 40 per cent in noodle blends, improved the scores of various sensory attributes namely colour, appearance, flavour texture and overall acceptability. Similar results were obtained in the present study also.

4.4.6 Kali mix

4.4.6.1 Chemical constituents

Moisture

The data pertaining to the changes in the moisture content of the control and small millet based instant kali mix packed in different packaging with and without antioxidant and stored at room temperature is presented in Table 64.

A significant increase was observed in the moisture content in all the samples during storage. The moisture pick up was more in P₁ when compared to P₂ and P₃. Among the treatments, the moisture pick up was more in T₀ followed by T₂ and T₁. Similarly, between the presence and absence of antioxidant the samples packed without antioxidant had more moisture than samples packed with antioxidant. The initial moisture content of T₀, T₁ and T₂ was 11.10, 10.50 and 10.20g per 100g irrespective of the packaging material and after 180 days of storage, the final moisture content ranged from 10.50 (T₂P₃WA) to 11.70 (T₀P₁WOA) g per 100g. The significant changes in moisture content might be due to the incorporation of small millets and the nature of the packaging material and presence of antioxidant.

Parvathi (2010) recorded a moisture content of 10.80g in millet kali mix which is similar to the moisture content of the kali mix in the present study.

Protein

The data pertaining to the changes in the protein content of the kodo and barnyard millet instant kali mix and control kali mix during storage is furnished in Table 65. The incorporation of small millet increased in protein content when compared to control. As the storage period progressed, there was a reduction in the protein content in all the samples, the reduction being more prominent in P₁ than P₂ and P₃. Similarly, the loss in protein was more in the samples packed with antioxidant. Among the treatment, the loss of protein was more in T₀ followed by T₂ and T₁. The

initial protein content of T₀, T₁ and T₂ was 7.30, 9.60 and 8.20g per 100g irrespective of packaging materials which reduced with the values ranging from 7.03 (T₀P₁WOA) to 7.18 (T₀P₃WA) for T₀, from 9.37 (T₁P₁WOA) to 9.48 (T₁P₃WA) for T₁ and from 7.96 (T₂P₁WOA) to 8.08 (T₂P₃WA) for T₂ g per 100g respectively. A significant difference was observed between the treatment, packaging material and storage days upon statistical analysis of the data.

Parvathi (2010) reported 8.33g protein in millet based instant kali mix and also found it to decrease during storage which is in tune with the present investigation.

Starch

The data pertaining to the changes in the starch content of the kodo and barnyard millet instant mix and control kali mix during storage is furnished in Table 66. The incorporation of small millet had significantly reduced the starch content of the kali mix as it is evident from the initial values of 66.50 (T₀), 55.30 (T₁) and 53.20 (T₂) g per 100g. A decreasing trend was observed in the starch content of all the samples during storage. The control samples indicated the maximum reduction in the starch content while the T₁ sample showed the minimum reduction which might be due to the difference in the characteristics of the starch between the small millets. Among the packaging material and the presence of antioxidant, samples of P₃ WA had recorded the minimum change in the starch after 180 days of storage irrespective of the treatment. The final starch content ranged from 66.08 (T₀P₁WOA) to 66.22 (T₀P₃WA) for T₀, from 54.84 (T₁P₁WOA) to 55.00 (T₁P₃WA) for T₁ and 52.75 (T₂P₁WOA) to 52.90 (T₂P₃WA) for T₂ g per 100g respectively. The statistical analysis of the data revealed a highly significant difference among the treatment, packaging material and storage days.

Onuorah and Akinjede (2004) reported that the starch content of millet based convenience food mix was 67.20 per cent. Parvathi (2010) reported the initial and final carbohydrate content of millet based instant kali mix to be 68.71 and 68.53g per 100g respectively and observed a slight reduction during storage that varied with the packaging material. These results are in tune with the study of present investigation.

Fat, free fatty acid and peroxide value

The data pertaining to the changes in the fat, free fatty acid and peroxide value of the kodo and barnyard millet instant kali mix and control kali mix during storage is presented in Table 67. The initial fat content of T₁ and T₂ was found to be more than T₀ which might be due to the incorporation of millets. A decreasing trend was noticed in the fat content after 180 days of storage. The reduction in fat was more in the samples of P₁ WOA followed by P₁ WA, P₂ WOA, P₂WA, P₃ WOA and P₃ WA in T₀, T₁ and T₂.

This showed that the less permeable nature and the presence of antioxidant have led to the minimum reduction of the fat in the samples. The initial fat content of T₀, T₁ and T₂ irrespective of the packaging materials were 0.90, 1.30 and 1.80g per 100g respectively. The final fat content after 180days of storage ranged from 0.87 (T₀P₁WOA) to 1.75 (T₂P₃WA) g per 100g.

The initial free fatty acid and peroxide value of T₀, T₁ and T₂ were found to be 1.12 & 2.00 and 2.90mgKOH per 100g and 0.70 and 0.50 & 0.40meq/kg respectively in all the packaging materials. As the storage day progressed, there was a slight increase in the free fatty acid with corresponding increase in the peroxide value of all the samples and the increase was minimum in the samples of T₂P₃WA and T₀ P₁WOA. The final free fatty acid ranged between 1.52 (T₀P₁WOA) to 3.19 (T₂P₃WA) mg KOH/100g and peroxide value ranged between 0.52 (T₂P₃WA) to 0.92 (T₀P₁WOA) meq/kg respectively. In the present investigation the samples of P₁WOA that had the higher moisture pick up also indicated the higher increase in free fatty acid during storage. The statistical analysis of the data revealed a highly significant difference for the changes noted in the fat, free fatty acid and peroxide value between treatment, packaging material and storage days.

Onuorah and Akinjede (2004) observed that the fat and free fatty acid content of millet based convenience food mix had increased from 4.20 to 4.96 and 1.26 to 2.14 per cent respectively during storage of 150 days.

Crude fibre

The data pertaining to the changes in the crude fibre content of the kodo and barnyard millet instant kali mix is given in Table 68. The crude fibre content of T₁ and T₂ were more when compared to T₀. After 180 days of storage, there was a slight reduction in the crude fibre content and a variation in the reduction existed between the packaging material and the presence of antioxidant. Though a visible reduction was

observed, it was statistically non significant. The initial fibre content of T₀, T₁ and T₂ in all the samples irrespective of the packaging material were 1.80, 4.80 and 6.50g per 100g respectively. The final crude fibre content ranged between 1.80 (T₀P₁WOA) and 6.47 (T₂P₃WA) g per 100g.

Onuorah and Akinjede (2004) stated that the fibre content of the millet based convenience mix showed a non significant change during storage. Similar observations were also recorded in the present study.

Tannin

The data pertaining to the changes in the tannin content are represented in Table 68. The tannin content of T₁ and T₂ were more than T₀ owing to the presence of small millets which continued to remain the same throughout the storage period. As the storage days passed by there was a notable reduction in the tannin content and was more prominent in the samples P₁WOA in all the treatments, due to the higher permeable nature of the packaging material and absence of antioxidant. But the statistical analysis of the data indicated a non significant difference between the packaging material and storage and a significant difference between treatments. The initial tannin content of T₀, T₁ and T₂ were 1.00, 1.90 and 2.00g per 100g in all the packaging material respectively. The final tannin content ranged between 0.80 (T₀P₁WOA) and 1.97 (T₂P₃WA)g per 100g

Hemalatha (2004) also observed an increase in the phytate and tannin content in the small millet based instant mixes when compared to rice based mixes. The author has also reported a non significant reduction in the phytate and tannin content during storage which was also observed in the present investigation.

Ash and mineral contents

The data pertaining to the changes in the ash and mineral contents of the millet based instant kali mix during storage is given in Fig 6. A notable difference in the ash content existed between T₀, T₁ and T₂ during initial storage period which might be due to the presence of small millets. As the storage days progressed, there was reduction in the ash content depending upon the permeability of the packaging material and the presence of antioxidants. Accordingly, the samples packed in P₃ WOA had the minimum change. The statistical analysis of the data revealed that significant difference occurred only between the treatments and not between packaging material and storage period and their interaction. The initial ash content of T₀, T₁ and T₂ were 1.80, 2.00 and

2.10g per 100g irrespective of the packaging materials. The final ash content ranged between 1.72 (T₀P₁WOA) and 2.10 (T₂P₃WA).

The initial calcium content of T₀, T₁ and T₂ were 39.00, 54.90 and 52.50 while that of phosphorus was 167.00, 188.90 and 287.30mg per 100g respectively in all the packaging. The iron content of these samples were noted to be 2.30 (T₀), 3.10 (T₁) and 5.20 (T₂) mg per 100g in all the packaging material respectively. Control kali mix (T₀) had minimum calcium content followed by barnyard millet mix and kodo millet kali mix. As far as, the iron content of the samples were considered, maximum iron content was found in T₂ followed by T₁ and T₀. On the whole, the differences in the mineral content were due to nature of the small millet incorporated in the respective mixes. During storage, there was a slight loss in the mineral content with notable difference among the packaging material and the presence of antioxidants, but statistically non significant. The final calcium content ranged from 38.90 (T₀P₁WOA) to 54.87 (T₁P₃WA), phosphorus ranged from 166.92 (T₀P₁WOA) to 287.27 (T₁P₃WA) and iron content ranged from 2.23 (T₀P₁WOA) to 5.19 (T₂P₃WA) mg per 100g respectively.

Onuorah and Akinjede (2004) reported that during storage calcium and iron content of instant mixes reduced. Parvathi (2010) reported a calcium content 66.30mg and iron content of 2.30mg of millet based instant kali mix. The present investigation is in line with the above studies.

4.4.6.2 Microbial load

The data pertaining to the changes in the microbial load of the kodo and barnyard millet instant kali mix during storage is furnished in Table 69. Initially the total plate count in all the samples was found to be nil and as the storage day progressed, there was an increase in the microbial load. The samples that were packed in P₃ along with the antioxidant showed the minimum microbial load when compared to the samples of the P₁ and P₂ with and without antioxidant. This indicated that the less permeable nature of packaging material and presence of antioxidant has checked the growth of microorganism in these samples. The final total plate count of T₀ ranged from 2.5 (T₀P₃WA) to 3.2 (T₀P₁WOA), T₁ ranged from 1.3 (T₁P₃WA) to 2.0 (T₁P₁WOA) and T₂ ranged from 1.7 (T₂P₃WA) to 2.7 (T₂P₁WOA) x 10⁴cfu/g respectively.

Shanthi (2000) reported that the total aerobic bacterial load of millet convenience mix was found to be 2.90x10² cfu/g and the samples stored in aluminium bag had minimum microbial load population.

4.4.6.3 Sensory quality

The data pertaining to the changes in the sensory qualities of the kodo and barnyard millet instant kali mix during storage is presented in Table 70. No distinct variation was observed between the control and small millet incorporated instant mix for colour, flavour, texture, taste and overall acceptability and were highly acceptable in all the samples during initial period of storage. A slight decrease in the organoleptic scores was observed for the control samples than the treated samples. The colour of the control samples became slightly dull, the texture being non grainy with slight caking and on acceptable flavour and taste after 180 days of storage. On the contrary, T₁ and T₂ samples had no dullness of the colour, the texture of the mixes were grainy and non sticky without caking and the taste, flavour and overall acceptability were highly acceptable. Among the packaging material, the samples packed in P₃WA had retained the highly acceptable sensory properties in T₁ and T₂ including the control. The final score for colour ranged between 8.3 (T₀P₁WOA) and 8.6 (T₂P₃WA), flavour ranged between 8.3 (T₀P₁WOA) and 8.7 (T₂P₃WA), texture ranged between 8.5 (T₀P₁WOA) and 8.6 (T₂P₃WA), taste ranged between 8.3 (T₀P₁WOA) and 8.8 (T₂P₃WA) and overall acceptability ranged between 8.5 (T₀P₁WOA) and 8.7 (T₂P₃WA) respectively.

Similar results was observed by Parvathi (2010) reported that the nature of packaging material and storage had brought about changes in the sensory scores for colour, flavour, texture and the overall acceptability of the instant kali mix was found to be highly acceptable even after a storage period of six months.

4.4.7 Paniyaram mix

4.4.7.1 Chemical constituents

Moisture

Table 71 gives the changes in the moisture content of the kodo and barnyard millet instant paniyaram mix during storage. The initial moisture content was 10.80, 9.80 and 9.60 for T₀, T₁ and T₂ g per 100g respectively. The final moisture content after 180 days of storage ranged from 11.10 (T₀P₃WA) to 11.30 (T₀P₁WOA) for T₀, 10.04 (T₁P₃WA) to 10.18 (T₁P₁WOA) for T₁ and 9.94 (T₂P₃WA) to 10.02 (T₂P₁WOA) g per 100g for T₂ respectively. There was an influence of the packaging material and the presence of antioxidant in the moisture pick up, as the samples packed in the P₃ with antioxidant had the minimum moisture pick up irrespective of the treatments. A statistically significant difference was noted for moisture pick up among treatment, packaging materials and storage period.

Sashidevi (2001) recorded a moisture content of 9.60g per 100g in instant paniyaram mix which is similar to the moisture content of the instant paniyaram mix in the present study.

Protein and starch

Table 72 and 73 gives the protein and starch content of the kodo and barnyard millet instant paniyaram mix during storage. The initial protein content was 8.30, 10.60 and 9.20 for T₀, T₁ and T₂ while that of the starch content of T₀, T₁ and T₂ were 63.20, 48.50 and 54.40 g per 100g respectively in all the packaging. Incorporation of small millet flour had reduced starch content and increased the protein content. The final protein content ranged from 8.03 (T₀P₁WOA) to 8.18(T₀P₃WA) for T₀, from 10.37 (T₁P₁WOA) to 10.48 (T₁P₃WA) for T₁ and 8.96 (T₂ P₁WOA) to 9.08 (T₂P₃WA) for T₂ while that of the final starch content was ranged from 62.78 to 62.87 (T₀), from 48.00 to 48.18 (T₁) and from 53.87 to 54.03 (T₂) g per 100g respectively. The packaging material and the presence of antioxidant had influenced the decrease in protein and starch of the samples during storage and the samples of P₃ with antioxidant showed the minimum changes irrespective of the treatment. Statistical analysis of the data revealed a significant difference between treatment, packaging materials and period of storage and their interaction.

Sashidevi (2001) also reported a slight decrease in starch and protein content of instant paniyaram mix after 180 days of storage at room temperature, the per cent loss of starch exhibited slightly higher values for samples stored in 200 gauge polyethylene pouches. Similar trend was observed in the present study.

Fat, free fatty acid and peroxide value

Table 74 gives the fat, free fatty acid and peroxide value of the kodo and barnyard millet instant paniyaram mix during storage. The initial fat content of T₀, T₁ and T₂ were 1.10, 1.20 and 2.90g per 100g respectively and after 180 days of storage, there was a slight reduction in the fat content and ranged from 0.98 (T₀P₁WOA) to 1.06 (T₀P₃WA) for T₀, from 1.05 (T₁P₁WOA) to 1.15 (T₁P₃WA) for T₁ and 2.78 (T₂P₁WOA) to 2.87 (T₂P₃WA) g per 100g for T₂ respectively. The free fatty acid content of T₀, T₁ and T₂ in all the packaging were 2.00, 2.90 and 3.10mg KOH per g respectively and after 180 days of storage, there was a slight increase in the free fatty acid content and ranged between 2.37 (T₀P₃WA) and 2.57 (T₀P₁WOA) for T₀, 3.15 (T₁P₃WA) and 3.30 (T₁P₁WOA) for T₁ and 3.45 (T₂P₃WA) and 3.57 (T₂P₁WOA) for T₂ mg KOH per g respectively. As there was an increase in free fatty acid, a concurrent increase in the peroxide value was also noted and the initial peroxide value was 1.00,

0.90 and 0.80 for T₀, T₁ and T₂ irrespective of the packaging and after 180 days of storage it ranged from 1.27 (T₀P₃WA) to 1.40 (T₀P₁WOA) for T₀, from 1.10 (T₁P₃WA) to 1.18 (T₁P₁WOA) for T₁ and from 0.98 (T₂P₃WA) to 1.08 (T₂P₁WOA) meq/kg for T₂ respectively. The nature of packaging material and presence of antioxidant had influenced the changes in the fat, free fatty acid and peroxide value of the samples and changes being very minimum in the samples P₃WA irrespective of the treatments. Statistical analysis of the data revealed a significant difference between treatment, packaging materials and period of storage.

Sashidevi (2001) also observed a similar reduction in fat content of the instant paniyaram mix during storage. Hemalatha (2004) stated that an increase in free fatty acid during storage might be due to the depolymerisation of lipids to free fatty acid.

Crude fibre and tannin

Table 75 gives the changes in the crude fibre and tannin content of the kodo and barnyard mille instant mixes during storage. The initial crude fibre content of T₀, T₁ and T₂ were 1.20, 4.30 and 6.33g per 100g irrespective of the packaging and after 180 days of storage, the final crude fibre content was slightly reduced and ranged between 1.10 (T₀P₁WOA) and 1.18 (T₀P₃WA) for T₀, 4.15 (T₁P₁WOA) and 4.27(T₁P₃WA) for T₁ and 4.20 (T₂P₁WOA) and 4.30 (T₂P₃WA) for T₂ g per 100g respectively. The initial tannin content of T₀, T₁ and T₂ were 2.25, 3.10 and 3.80g per 100g and after 180 days of storage, a significant reduction was observed in the tannin content of all the samples irrespective of the treatment and packaging material. The final tannin content was slight reduced and ranged between 2.00 (T₀P₁WOA) and 2.23 (T₀P₃WA) for T₀, 2.90(T₁P₁WOA) and 3.07 (T₁P₃WA) for T₁ and 3.70 (T₂P₁WOA) and 3.78 (T₂P₃WA) for T₂ g per 100g respectively. Though, there was a slight decrease in the crude fibre and tannin content during storage as influenced by the packaging material and the presence of antioxidant, it was statistically non significant.

Sashidevi (2001) was observed that a decrease in fibre content during storage of instant paniyaram mixes in polyethylene pouches. Hemalatha (2004) observed a non significant decrease in the millet based instant mixes during storage which is in line with the present investigation.

Ash and Mineral contents

Fig. 7 gives the changes in the ash, calcium, phosphorus and iron content of millet based instant paniyaram mix during storage. The initial ash content T₀, T₁ and T₂ were 1.20, 2.20 and 3.10 and after 180 days, a non significant decrease was observed

in the ash content in all the samples and the final values ranged from 1.16 (T₀P₁WOA) to 3.10 (T₂P₃WA) g per 100g respectively. The initial calcium content of T₀, T₁ and T₂ were 50.00, 58.90 and 51.78 while phosphorus was 120.30, 214.00 and 329.10mg per 100g for T₀, T₁ and T₂ respectively. Similar to that of ash a non significant decrease in the calcium and phosphorus content was observed and the final value ranged between 49.82 (T₀P₁WOA) and 58.87 (T₁P₃WA) for calcium and 120.12 (T₀P₁WOA) and 329.10 (T₂P₃WA) mg per 100 g for phosphorus. The initial iron content was 1.89, 4.98 and 6.75 for T₀, T₁ and T₂ and after 180 days of storage, the final iron content of T₀ ranged between 1.75 (T₀P₁WOA) and 1.89 (T₀P₃WA), of T₁ between 4.88 (T₁P₁WOA) and 4.96 (T₁P₃WA) and of T₂ between 6.68 (T₂P₁WOA) and 6.73 (T₂P₃WA)mg per 100g respectively.

The ash content of proso millet based convenience mix was reported to range between 1.45 and 2.50 per cent (Srivastava *et al.*, 2001 b) and these values were more or less similar to the present study. Sashidevi (2001) reported non significant reduction in calcium and iron content between packaging materials and days of storage (180 days) of instant paniyaram mix. The iron content of proso millet based convenience mix was found to range between 4.10 and 4.20mg/100g (Srivastava *et al.*, 2001 b). The calcium, phosphorus and iron content of pearl millet flour was reported to be 50.0, 35.0 and 5.8mg/100g respectively compared to 10.0, 28.0 and 2.80mg/100g recorded in rice flour which indicated that blending of millet flour with rice flour would increase mineral content (Selvi, 2003)

4.4.7.2 Microbial load

Table 76 gives the total plate count of the kodo and barnyard millet instant paniyaram mix during storage. Initially, there was no total plate count irrespective of the treatment and packaging material. But as the storage days progressed, a slight increase in the total plate count was observed. The rise in the microbial load was more in the control (T₀) samples than the millet based samples (T₁&T₂). The final total plate count after 180 days of storage was minimum in the samples of P₃WA when compared to P₁ and P₂ with and without antioxidant. This showed that the presence of antioxidant and the nature of the packaging material exerted an influence on the increase in the microbial load. The final total plate count T₀ ranged between 2.5 (T₀P₃WA) and 3.2 (T₀P₁WOA), T₁ ranged between 1.7 (T₁P₃WA) and 2.2 (T₁P₁WOA) and T₂ ranged between 1.5 (T₂P₃WA) and 2.5 (T₂P₁WOA) x10⁴ cfu/g respectively.

Sashidevi (2001) observed minimum count of bacteria, fungi and yeast in instant paniyaram mix, while Inyang and Idoko (2006) reported that no significant

trend was observed for changes in the total plate count during storage in millet based ogi mix.

4.4.7.3 Sensory quality

Table 77 gives the changes in the sensory quality namely the colour and appearance, flavour, texture, taste and overall acceptability of the control and small millet based instant mixes during storage. Initially, the colour, flavour, texture, taste of the control (T₀) and millet based instant mixes (T₁ & T₂) were highly acceptable. As the storage days progressed, the score for colour of the control samples decreased while the millet based samples remained unchanged. This might be due to the extreme white colour of the control mixes and creamy white colour of the millet based mixes during the initial days of storage, that had become creamy in the control sample while the millet based samples remained unchanged. The final score ranged between 8.6 (T₀P₁WOA) and 8.6 (T₂P₃WA). The flavour of the control and millet based mixes were highly acceptable during initial storage period with score of 9.0 and after 180 days of storage, the flavour of the control mixes alone had decreased which might be due to the comparative increase in the free fatty acid and peroxide value of the control samples. The final score for flavour of the mixes ranged between 8.4 (T₀P₁WOA) and 8.7 (T₂P₃WA). As that of flavour the score for texture of the small millet based samples remained unchanged even after 180 days of storage and the final values of the scores ranged from 8.6 (T₀P₁WOA) and 8.6 (T₂P₃WA). The taste of the small millet based mixes (T₁ & T₂) was highly acceptable on par with control (T₀) with the score of 8.9 irrespective of the packaging materials. A slight decrease in the scores of taste was noted in the control samples and the values ranged from 8.4 (T₀P₁WOA) to 8.7 (T₀P₃WA) for T₀ while that of T₁ and T₂ ranged from 8.3 (T₁P₁WOA) to 8.7 (T₁P₃WA) and 8.3 (T₂P₁WOA) to 8.6 (T₂P₃WA) respectively. The initial overall acceptability of T₀, T₁ and T₂ were 8.9, 8.8 and 8.8 and after 180 days of storage, the values ranged between 8.4 (T₀P₁WOA) and 8.8 (T₀P₃WA) for T₀, between 8.3 (T₁P₁WOA) and 8.7 (T₁P₃WA) for T₁ and between 8.3 (T₂P₁WOA) and 8.6 (T₂P₃WA) for T₂ respectively.

Sashidevi (2001) indicated that the change in the sensory qualities of the instant panyaram mix was highly influenced by the nature of the packaging material and storage condition.

4.4.8. Roti mix

4.4.8.1 Chemical Constituents

Moisture

The changes noted in the moisture content of the control, kodo millet and barnyard millet incorporated instant roti mixes stored under ambient condition are given in Table 78. The moisture content of instant mixes is usually used as an indicator of food quality. The initial moisture content of T₀, T₁ and T₂ were observed to be 11.00, 10.70 and 9.35g per 100g which might be due to incorporation of small millets. A gradual increase in moisture content was observed in all the samples packed in different materials throughout the storage period. Among the packaging materials, the mixes stored in P₁WOA absorbed more moisture followed by P₁WA, P₂WA, P₂WOA, P₃WA and P₃WOA. The moisture permeable nature of the packaging materials and the presence of antioxidant had contributed to the difference in the moisture pick up. The final moisture content ranged from 11.38 (T₀P₃WA) to 11.57 (T₀P₁WOA) in T₀, 10.96 (T₁P₃WA) to 11.15 (T₁P₁WOA) in T₁ and 9.74 (T₂P₃WA) to 9.83 (T₂P₁WOA) in T₂ g per 100g respectively. The statistical analysis of the data revealed highly significant difference between the treatment, packaging materials and the storage period.

Malathi (2012) reported a moisture content of 7.23 per cent in roti mix which is in line with the present study.

Protein

The changes in the protein content of the kodo and barnyard millet instant roti mix during storage are presented in Table 79. The incorporation of small millets had significantly increased the protein content as it is evident from the initial values of T₁, T₂ and T₀ as 12.25, 11.20 and 10.58g per 100g. A gradual reduction in the protein content was observed in all the samples during storage. The reduction in the protein content was lesser in the samples packed in P₃WA when compared to P₃WOA, P₂WOA, P₂WA, P₁WOA and P₁WA for T₀, T₁ and T₂. The protein content after 180 days of storage ranged from 10.38 (T₀P₁WOA) to 10.43 (T₀P₃WA) for T₀, 11.98 (T₁P₁WOA) to 12.12 (T₁P₃WA) for T₁ and 10.98 (T₂P₁WOA) to 11.07 (T₂P₃WA) g per 100g for T₂. The statistical analysis revealed a significant difference between treatments, packaging materials and the days of storage.

Similar results were also reported by Srivastava *et al.* (2002) reported a protein content of 8.82 and 9.97 per cent in barnyard millet and finger millet instant mixes respectively compared to the control (6.84 %).

Starch

The changes in starch content during storage of the kodo and barnyard millet instant roti mix are in Table 80. The starch content of the control was maximum (64.00g) and the values decreased for the small millet based instant mixes as 55.80 (T₁) and 56.10 (T₂) g per 100g. A gradual reduction in the starch content was observed in all samples during storage irrespective of treatment and packaging material. The changes were more predominant in T₀ P₁WOA samples and the least changes was observed in T₂P₃WA samples. Overall reduction in starch content during storage was significant in T₀ than T₁ and T₂ which might be due to the incorporation of millets and the characteristics of millet starch. The final starch content of the roti mix ranged from 63.55 (T₀P₁WOA) to 63.70 (T₀P₃WA) for T₀, 55.30 (T₁P₁WOA) to 55.40 (T₁P₃WA) for T₁ and 55.60 (T₂P₁WOA) to 55.72 (T₂P₃WA) g per cent for T₂. The reduction in starch during storage might be due to the hydrolysis of starch. Sorghum based roti mix had a starch content of 55.80g as given by Malathi (2012) which is similar to the present study.

Fat

Table 81 gives the changes in the fat content of the kodo and barnyard millet instant roti mix during storage. The fat content of the control roti mix was minimum and a significant increase in fat was observed with increase in incorporation of kodo millet and barnyard millet flour. A slight decline in fat content was observed in all the samples during storage. The initial fat content of T₀, T₁ and T₂ irrespective of the packaging material was 0.65, 1.00 and 2.40g per 100g. After 180 days of storage, the final fat content ranged between 0.55 (T₀P₁WOA) to 0.62 (T₀P₃WA) for T₀, 0.87(T₁P₁WOA) to 0.97 (T₁P₃WA) for T₁ and 2.21 (T₂P₁WOA) to 2.35 (T₂P₃WA) g per 100g for T₂. This showed that, there was a reduction in the fat after 180 days of storage and the reduction was minimum in the samples of P₃WA, irrespective of the treatment. A statistical significant difference was noted for fat between the treatment, packaging and storage period.

Malathi (2012) reported a fat content of sorghum based roti mix had 2.17 per cent. Similar trend was observed in the present investigation also.

Free fatty acid and peroxide value

There was an increase in the free fatty acid and peroxide value of the kodo and barnyard millet instant roti mix during storage irrespective of the packaging

material and treatment as it is presented in Table 81. Incorporation of small millets had significantly reduced the free fatty acid and peroxide value of the instant mixes. As the storage period progressed there was a slight increase in free fatty acid and peroxide value and was more notable in control samples than treated samples. The initial free fatty acid of T₀, T₁ and T₂ were 1.60, 2.15 and 2.85mg KOH/g and peroxide values were 1.20, 1.00 and 0.80meq/kg for T₀, T₁ and T₂ respectively for all the packaging material. After 180 days of storage, the final free fatty acid and peroxide value ranged between 1.86 (T₀P₃WA) to 2.12 (T₀P₁WOA) and 1.35 (T₀P₃WA) to 1.42 (T₀P₁WOA) for T₀, 2.33 (T₁P₃WA) to 2.49 (T₁P₁WOA) and 1.10 (T₁P₃WA) to 1.18 (T₁P₁WOA) for T₁, 3.15 (T₂P₃WA) to 3.25 (T₂P₁WOA) and 0.92 (T₂P₃WA) to 1.00 (T₂P₁WOA) for T₂ respectively. The statistical analysis of the data also revealed a significant difference among treatment, packaging materials and the storage period.

Arokiamary (2006) observed that the free fatty acid content of greens and millet based convenience food mix had increased from 0.231 to 0.274 per cent during 180 days of storage at room temperature. A gradual increase in free fatty acid content was noticed in the different packaging materials throughout the storage period in the present study also.

Crude fibre and tannin

The crude fibre and tannin of the kodo and barnyard millet instant roti mix during storage was analysed and the results are given in Table 82. From the table, it could be inferred that a significant increase in the fibre content was noticed in the small millet based instant mixes than control. The initial crude fibre content for T₀, T₁ and T₂ were 0.88, 5.55 and 6.12 while the tannin content for T₀, T₁ and T₂ were 4.25, 5.60 and 5.90g per 100g respectively irrespective of packaging. Upon storage there was a slight loss in the crude fibre and tannin contents packed in P₁, P₂ and P₃ with and without antioxidants but was statistically non significant.

These results were in tune with the studies of Selvi *et al.*(2010) who had reported that the crude fibre and tannin content of popped sorghum and bajra based convenience foods ranged from 5.71 to 5.73 and 4.10 to 4.02g per 100g.

Ash and Minerals

Significant increase in ash content was also observed with increase in level of incorporation of kodo millet and barnyard millet flour. The initial ash content of T₀, T₁ and T₂ were observed to be 2.00, 2.30 and 2.50g per 100g irrespective of the packaging which might be due to incorporation of millets. The final ash content ranged from 1.90

(T₀P₁WOA) to 2.50 (T₂P₃WA) g per 100g. A slight decrease in ash content on storage was observed which was non significant.

The data pertaining to the changes in calcium, phosphorus and iron content of the kodo and barnyard millet instant roti mix is presented in Fig 8. Significant increase in calcium, phosphorus and iron content was observed with increase in the incorporation of kodo millet and barnyard millet flour. The control sample recorded 20.30mg calcium, 142.10mg phosphorus and 1.72mg /100g of iron during the initial storage period irrespective of the packaging material. Initially, the kodo millet flour roti mix recorded higher values for calcium (34.50mg/100g), phosphorus (180.20mg/100g) and iron (4.24mg/100g). The comparative values for barnyard millet flour roti mix were 25.20mg calcium, 288.50mg phosphorus and 6.90mg/100g iron during the initial storage period. A slight reduction in calcium, phosphorus and iron content was observed during storage. However, on statistical analysis of the data a non significant difference was observed between packaging materials and days of storage.

Hemalatha (2004) reported that increase in ash content over control (0.71%) was observed with increase in the level of incorporation (10 and 20%) of little millet flour (0.88 and 1.05% respectively) and kodo millet flour (0.95 and 1.26% respectively). Malathi (2012) reported that the calcium and iron content of sorghum based roti mix were found to be higher than the mix prepared from rice flour alone. The present investigation is in line with the above study.

4.4.8.2 Microbial load

The changes in microbial load of the kodo and barnyard millet instant roti mix during storage are presented in Table 83. An increasing trend was observed in terms of the total plate count between the treatments and between packaging materials in both the kodo millet and barnyard millet incorporated mixes. The initial values for total plate count were nil. The total plate count showed slight elevation on storage and at the end of the storage period, it ranged between 2.1 (T₀P₃WA) to 3.2 (T₀P₁WOA) x 10⁴ for T₀, 1.5 (T₁P₃WA) to 2.5(T₁P₁WOA) x 10⁴ for T₁ and 1.8 (T₂P₃WA) to 2.5 (T₂P₁WOA) x 10⁴ cfu/g for T₂ respectively. The low permeable nature of P₃ and the presence of antioxidants had hindered the increase of microbes in these samples in all the treatment including the control samples.

The bacterial load of sorghum based instant roti mix was found to be 4.00x10⁴ cfu/g and the samples stored in 400 gauge Low Density Polyethylene (LDPE) bags had the minimum microbial population (Malathi, 2012).

4.4.8.3 Sensory quality

The mean organoleptic scores for colour, flavour, texture, taste and overall quality during the initial storage period and the changes observed after 180 days of storage were tabulated and present in Table 84.

The colour of the control roti mix was extremely white and that of small millet based samples were white with a creamy tinch. Initially, the scores for colour T₀, T₁ and T₂ were highly acceptable with the value of 9.0, 8.8 and 8.8 irrespective of the packaging materials. After 180 days of storage, the score value for colour of the control samples decreased and ranged between 8.5 (T₀P₁WOA) to 8.8 (T₀P₃WA), while that of T₁ and T₂ remained the same. This might be due to the changes of colour in the control extremely white colour to dull white colour. The flavour of the samples were highly acceptable with the score of 8.9 throughout the storage period with a slight reduction observed only in the treatments of T₀P₁WOA with the value of 8.2. However, no off flavour was observed in the samples. The texture of the roti mix was slightly grainy, non sticky without caking in T₀, T₁ and T₂ with highly acceptable score values of 8.8, 8.7 and 8.7 during the initial storage period. As the storage days passed by a reduction in the scores for texture was noted only in the control samples irrespective of the packaging materials and presence of antioxidants. The final value of T₀P₁WOA was 8.4, T₀P₁WA was 8.5, T₀P₂WOA was 8.4, T₀P₂WA was 8.5, T₀P₃WOA was 8.5 and T₀P₃WA was 8.6 respectively. Though, there existed a difference in the scores for colour, flavour and texture between treatments and packaging materials, it did not influence the taste and overall acceptability of the mixes which was highly acceptable throughout the storage period irrespective of the treatments and packaging materials.

Malathi (2012) reported that the colour, texture, taste, and flavour of the sorghum based instant roti mix packed in different packaging materials were found to highly acceptable throughout the storage period of 180 days which is in accordance with the present investigation.

4.4.9 Halwa mix

4.4.9.1 Chemical Constituents

Moisture

The data pertaining to the changes in the moisture content of the control and small millet based instant halwa mix packed in different packaging with and without antioxidant and stored at room temperature is presented in Table 85. A significant increase was observed in the moisture content in all the samples during storage. The

moisture pick up was more in P₁ when compared to P₂ and P₃. Among the treatments, the moisture pick up was more in T₀ followed by T₂ and T₁. Similarly, between the presence and absence of antioxidant the samples packed without antioxidant had more moisture than samples packed with antioxidant. The initial moisture content of T₀, T₁ and T₂ was 11.50, 10.00 and 9.10g per 100g irrespective of the packaging material and after 180 days of storage, the final moisture content ranged from 9.37 (T₂P₃WA) to 12.00 (T₀P₁WOA) g per 100g. The significant changes in moisture content might be due to the incorporation of small millets and the nature of the packaging material and presence of antioxidant.

Malathi (2012) recorded a moisture content of 4.37g in sorghum halwa mix which was lower from the present investigation that might be due to difference in the millet incorporated.

Protein

The data pertaining to the changes in the protein content of the kodo and barnyard millet instant mix and control halwa mix during storage is furnished in Table 86.

The incorporation of small millets increased the protein content when compared to control. As the storage period progressed, there was a reduction in the protein content in all the samples. The reduction being more prominent in P₁ than P₂ and P₃. Similarly, the loss in protein was more in the samples packed without antioxidant. Among the treatment, the loss of protein was more in T₀ followed by T₂ and T₁. The initial protein content of T₀, T₁ and T₂ was 11.55, 10.20 and 9.40g per 100g irrespective of packaging materials which reduced with the values ranging from 11.33 (T₀P₁WOA) to 11.44 (T₀P₃WA) for T₀, from 9.98 (T₂P₁WOA) to 10.08 (T₂P₃WA) for T₁ and from 9.18 (T₀P₁WOA) to 9.25 (T₀P₃WA) for T₂ g per 100g respectively. A significant difference was observed between the treatment, packaging material and storage days.

Malathi (2012) reported a protein content of 5.20g protein in sorghum based instant halwa mix and noted a reduction in protein during storage.

Starch

The data pertaining to the changes in the starch content of the kodo and barnyard millet instant mix and control halwa mix during storage is furnished in Table 87. The incorporation of small millet had significantly reduced the starch content of the halwa mix as it is evident from the initial values of 68.90 (T₀), 57.60 (T₁) and 55.50 (T₂) g per 100g irrespective of the packaging material. A decreasing trend was observed in the starch content

of all the samples during storage. The control samples indicated the maximum reduction in the starch content, while the T₁ sample showed the minimum reduction which might be due to the difference in the characteristics of the starch between the small millets. Among the packaging material and the presence of antioxidant, samples of P₃ WA had recorded the minimum change in the starch after 180 days of storage irrespective of the treatment. The final starch content ranged from 68.43(T₀P₁WOA) to 68.55 (T₀P₃WA) for T₀, from 57.12 (T₁P₁WOA) to 57.23 (T₁P₃WA) for T₁ and 55.00 (T₂P₁WOA) to 55.12 (T₂P₁WA) for T₂ g per 100g respectively. The statistical analysis of the data revealed a highly significant difference among the treatment, packaging material and storage days.

Malathi (2012) reported the initial and final carbohydrate content of sorghum based instant mix to be 68.71 and 68.53g per 100g respectively and observed a slight reduction during storage that varied with the packaging material. These results are in tune with the study of present investigation.

Fat, free fatty acid and peroxide value

The data pertaining to the changes in the fat, free fatty acid and peroxide value of the kodo and barnyard millet instant halwa mix and control halwa mix during storage is presented in Table 88. The initial fat content of T₁ and T₂ was found to be more than T₀ which might be due to the incorporation of small millets. A decreasing trend was noticed in the fat content after 180 days of storage. The reduction in fat was more in the samples of P₁ WOA followed by P₁ WA, P₂ WOA, P₂WA, P₃ WOA and P₃ WA in T₀, T₁ and T₂. This showed that the less permeable nature and the presence of antioxidant have led to the minimum reduction of the fat in the samples. The initial fat content of T₀, T₁ and T₂ irrespective of the packaging materials were 0.90, 1.30 and 1.80g per 100g respectively. The final fat content after 180days of storage ranged from 1.52 (T₀P₁WOA) to 3.77 (T₂P₃WA) g per 100g.

The initial free fatty acid and peroxide value of T₀, T₁ and T₂ were found to be 2.90 & 3.30 and 3.10mg KOH per 100g and 1.80 and 1.20 & 1.00meq/kg respectively in all the packaging materials. As the storage day progressed, there was a slight increase in the free fatty acid with corresponding increases in the peroxide value of all the samples and the increase was minimum in the samples of T₂P₃WA and maximum in T₀ P₁WOA. The final free fatty acid ranged between 3.31 (T₂P₃WA) to 3.42 (T₀P₁WOA) mg KOH/ 100 g and peroxide value ranged between 1.04 (T₂P₃WA) to 2.00 (T₀P₁WOA) meq/kg respectively. In the present investigation the samples of P₁WOA that had the higher moisture pick up also indicated the higher increase in free fatty acid during storage. The statistical analysis of the

data revealed a highly significant difference for the changes noted in the fat, free fatty acid and peroxide value between treatment, packaging material and storage days.

Malathi (2012) observed a minimal decrease in the fat content (1.48 %) in sorghum halwa mix packed in both 200 gauge low density polyethylene bag and 400 gauge low density polyethylene bags during the storage period of 180 days.

Crude fibre

The data pertaining to the changes in the crude fibre content of the kodo and barnyard millet instant halwa mix is given in Table 89. The crude fibre content of T₁ and T₂ were more when compared to T₀. After 180 days of storage, there was a slight reduction in the crude fibre content and variation in the reduction existed between the packaging material and the presence of antioxidant. Though a visible reduction was observed, it was statistically non significant. The initial fibre content of T₀, T₁ and T₂ in all the samples were 1.30, 3.15 and 4.43g per 100g respectively. The final crude fibre content ranged between 1.24 (T₀P₁WOA) and 4.40 (T₂P₃WA) g per 100g.

Malathi (2012) stated that the incorporation of sorghum considerably increased the fibre content of sorghum halwa mix. Similar results were found in the present study where the fibre content had increased for the millet samples.

Tannin

The data pertaining to the changes in the tannin content are represented in Table 89. The tannin content of T₁ and T₂ were more than T₀ owing to the presence of small millets which continued to remain the same throughout the storage period. As the storage days passed by, there was a notable reduction in the tannin content and was more prominent in the samples P₁WOA in all the treatments, due to the higher permeable nature of the packaging material and absence of antioxidant. But the statistical analysis of the data indicated a non significant difference between the packaging material, storage and a significant difference between treatments. The initial tannin content of T₀, T₁ and T₂ were 4.10, 5.20 and 4.45g per 100g in all the packaging material respectively. The final tannin content ranged between 4.00 (T₀P₁WOA) and 4.42 (T₂P₃WA) g per 100g .

Hemalatha (2004) also observed an increase in the phytate and tannin content in the small millet based instant mixes when compared to rice based mixes. The author also reported a non significant reduction in the phytate and tannin content occurred during storage which was observed in the present investigation as well.

Ash and mineral contents

The data pertaining to the changes in the ash and mineral content of the kodo and barnyard millet instant halwa mix during storage is given in Fig 9. A notable difference in the ash content existed between T₀, T₁ and T₂ during initial storage period which might be due to the presence of small millets. As the storage days progressed, there was reduction in the ash content depending upon the permeability of the packaging material and the presence of antioxidants. Accordingly, the samples packed in P₃ WOA had the minimum change. The statistical analysis of the data revealed a significant difference only between the treatment and not between packaging material, storage period and their interaction. The initial ash content of T₀, T₁ and T₂ were 2.50, 2.80 and 3.40g per 100g irrespective of the packaging materials. The final ash content ranged between 2.40 (T₀P₁WOA) and 3.40 (T₂P₃WA).

The initial calcium content of T₀, T₁ and T₂ were 46.80, 32.60 and 24.80 while that of phosphorus was 348.00, 120.90 and 270.30mg per 100g respectively. The iron content of these samples were noted to be 4.45 (T₀), 5.88 (T₁) and 6.45 (T₂)mg per 100g in all the packaging material respectively. Kodo and barnyard millet mixes had the minimum calcium and phosphorus while control mix had more calcium and phosphorus. As far as, the iron content of these samples were considered maximum iron content was found in T₂ followed by T₁ and T₀. On the whole, the differences in the mineral content were due to nature of the wheat flour incorporated in the respective mixes. During storage, there was a slight loss in the mineral content with notable difference among the packaging material and the presence of antioxidants, but statistically non significant. The final calcium content ranged from 24.76 (T₂P₁WOA) to 46.78 (T₀P₃WA), phosphorus ranged from 120.85 (T₁P₁WOA) to 347.97 (T₀P₃WA) and iron content ranged from 4.35 (T₀P₁WOA) to 6.45 (T₂P₃WA) mg per 100g respectively.

Malathi (2012) reported that during storage calcium and iron content of sorghum instant halwa mix reduced. The present investigation is in line with the above study.

4.4.9.2 Microbial load

The data pertaining to the changes in the microbial load of the kodo and barnyard millet instant halwa mix during storage is furnished in Table 90. Initially the total plate count in all the samples was found to be nil and as the storage day progressed, there was an increase in the microbial load. The samples that were packed in P₃ along with the antioxidant showed the minimum microbial load when compared

to the samples of the P₁ and P₂ with and without antioxidant. This showed that the less permeable nature of packaging and presence of antioxidant had checked the growth of microorganism in these samples. The final total plate count of T₀ ranged from 2.7 (T₀P₃WA) to 3.1 (T₀P₁WOA), T₁ ranged from 1.5 (T₁P₃WA) to 2.2 (T₁P₁WOA) and T₂ ranged from 1.7 (T₂P₃WA) to 2.7 (T₂P₁WOA) x 10⁴ cfu/ g respectively.

Malathi (2012) observed that the total microbial load in sorghum instant halwa mix was within the permissible level before and after storage. In the present study also an increase in the microbial load was noted but was within the permissible limits.

4.4.9.3 Sensory quality

The data pertaining to the changes in the sensory qualities of the millet based instant halwa mix during storage is presented in Table 91. No distinct variation was observed between the control and small millet incorporated instant mix for colour and appearance, flavour, texture, taste and overall acceptability and were highly acceptable in all the samples during initial period of storage. A slight decrease in the organoleptic scores was observed for the control samples than the treated samples. The colour of the control samples became slightly dull the texture being non grainy with slight caking, and on acceptable flavour and taste being acceptable after 180 days of storage. On the contrary, T₁ and T₂ samples had no dullness of the colour, the texture of the mixes were grainy and non sticky without caking and highly acceptable taste, flavour and overall acceptability being highly acceptable. Among the packaging material, the samples packed in P₃WA had retained the highly acceptable sensory properties in T₁ and T₂ including the control. The final score for colour ranged between 8.4 (T₀P₁WOA) and 8.5 (T₂P₃WA), flavour ranged between 8.3 (T₀P₁WOA) and 8.6 (T₂P₃WA), texture ranged between 8.5 (T₀P₁WOA) and 8.5 (T₂P₃WA), taste ranged between 8.6 (T₀P₁WOA) and 8.7 (T₂P₃WA) and overall acceptability ranged between 8.5 (T₀P₁WOA) and 8.6 (T₂P₃WA) respectively.

4.4.10 Kesari mix

4.4.10.1 Chemical Constituents

Moisture

The changes noted in the moisture content of the control and small millet incorporated instant kesari mix stored under ambient condition are given in Table 92. The initial moisture content of T₀, T₁ and T₂ were observed to be 11.60, 9.80 and 8.90 g per 100g irrespective of the packaging material which might be due to incorporation of millets. A gradual increase in moisture content was observed in all the samples packed in different materials throughout the storage period. Among the

packaging materials, the mixes stored in P₁WOA absorbed more moisture followed by P₁WA, P₂WA, P₂WOA, P₃WA and P₃WOA. The moisture permeable nature of the packaging materials and the presence of antioxidant had contributed to the difference in the moisture pick up. The final moisture content ranged from 11.91 (T₀P₃WA) to 12.08 (T₀P₁WOA) in T₀, 10.25 (T₁P₃WA) to 10.40 (T₁P₁WOA) in T₁ and 9.22 (T₂P₃WA) to 9.47 (T₂P₁WOA) in T₂ g per 100g. The statistical analysis of the data revealed a highly significant difference between the treatment, packaging materials, period of storage and their interaction.

Geetu *et al.* (2003) reported a decrease in moisture content was observed in pearl millet *ladoo* mix and these findings concur with those of the present research findings.

Protein

The changes in the protein content of the kodo and barnyard millet instant kesari mix during storage are presented in Table 93. The incorporation of small millets had significantly increased the protein content as it is evident from the initial values of T₁, T₂ and T₀ as 9.80, 8.28 and 7.85g per 100g irrespective of the packaging. A gradual reduction in the protein content was observed for all the samples during storage. The reduction in the protein content was lesser in the samples packed in P₃WA when compared to P₃WOA, P₂WOA, P₂WA, P₁WOA and P₁WA for T₀, T₁ and T₂. The protein content after 180 days of storage ranged from 7.68 (T₀P₁WOA) to 7.73 (T₀P₃WA) for T₀, 9.60 (T₁P₁WOA) to 9.70 (T₁P₃WA) for T₁ and 8.04 (T₂P₁WOA) to 8.18 (T₂P₃WA) g per 100g for T₂. The statistical analysis revealed a significant difference between treatments, packaging materials and the days of storage.

Thathola and Srivastava (2002) reported that the protein content of millet based convenience food mix was 18.37. Malathi (2012) observed that the protein content of sorghum based kesari mix decreased after a storage period of six months. Similar trend was observed in this present study also.

Starch

The changes in starch content during storage of the kodo and barnyard millet instant kesari mix are in Table 94. The starch content of the control was maximum (83.20 g) and the values decreased for the millet based instant mixes as 79.20 (T₁) and 79.30 (T₂)g per 100g. A gradual reduction in the starch content was observed in all samples during storage irrespective of treatment and packaging material. The changes were more predominant in T₀ P₁WOA samples and the least changes was observed in

T₂P₃WA samples. Overall reduction in starch content during storage was significant in T₀ than T₁ and T₂ which might be due to the incorporation of small millets and the characteristics of millet starch. The final starch content of the kesari mix ranged from 82.72(T₀P₁WOA) to 82.80 (T₀P₃WA) for T₀, 78.72 (T₁P₁WOA) to 78.94 (T₁P₃WA) for T₁ and 78.82 (T₂P₁WOA) to 78.90 (T₂P₁WA) g per 100g for T₂. The reduction in starch during storage might be due to the hydrolysis of starch.

Hemalatha (2004) observed a reduction in the starch content of the millet based instant adhirasam dough during storage period of 270 days. Similar picture was noted in the present study too.

Fat

Table 95 gives the changes in the fat content of the kodo and barnyard millet instant kesari mix during storage. The fat content of the control kesari mix was minimum and a significant increase was observed with increase in incorporation of kodo millet and barnyard millet flour. The initial fat content of T₀, T₁ and T₂ was 2.70, 3.20 and 4.00g per 100g irrespective of the packaging material. After 180 days of storage, the final fat content ranged between 2.56 (T₀P₁WOA) to 2.66 (T₀P₃WA) for T₀, 3.08 (T₁P₁WOA) to 3.17 (T₁P₃WA) for T₁ and 3.90 (T₂P₁WOA) to 3.97 (T₂P₃WA) g per 100g for T₂. This showed that, there was a reduction in the fat after 180 days of storage and the reduction was minimum in the samples of P₃WA, irrespective of the treatment. A statistically significant difference was noted for fat between the treatment, packaging and storage.

Similar to the present study Srivastava *et al.*, (2001 b) also reported that the fat content of burfi prepared from a mix containing proso millet and soy bean was 5.2g per 100g and decreased as the storage period progressed.

Free fatty acid and peroxide value

There was an increase in the free fatty acid and peroxide value of the kodo and barnyard millet instant kesari mix during storage irrespective of the packaging material and treatment as it is presented in Table 95. Incorporation of small millets had significantly reduced the free fatty acid and peroxide value of the instant mixes. As the storage period progressed there was a slight increase in free fatty acid and peroxide value and was more notable in control samples than treated samples. The initial free fatty acid of T₀, T₁ and T₂ were 2.00, 2.70 and 3.00 mg KOH/g and peroxide value were 0.50, 0.75 and 0.60meq/kg for T₀, T₁ and T₂ respectively in all the packaging. After 180 days of storage, the final free fatty acid and peroxide values

ranged between 2.38 (T₀P₃WA) to 2.50 (T₀P₁WOA) and 2.95(T₀P₃WA) to 3.10 (T₀P₁WOA) for T₀, 3.30 (T₁P₃WA) to 3.38 (T₁P₁WOA) and 0.62 (T₁P₃WA) to 0.72 (T₁P₁WOA) for T₁, 0.83 (T₂P₃WA) to 0.88 (T₂P₁WOA) and 0.68 (T₂P₃WA) to 0.78 (T₂P₁WOA) for T₂ respectively. The statistical analysis of the data also revealed a significant difference among treatment, packaging materials and the storage period.

Crude fibre and tannin

The crude fibre and tannin of the kodo millet and barnyard millet instant kesari mix during storage was analysed and the results are given in Table 96. From the table, it could be inferred that a significant increase in the fibre content was noticed in the millet based instant mixes than control. The initial values of the crude fibre content for T₀, T₁ and T₂ were 1.50, 4.17 and 5.53 while the tannin content for T₀, T₁ and T₂ were 3.50, 4.70 and 3.80g per 100g respectively irrespective of the packaging material. Upon storage there was a slight loss in the crude fibre and tannin contents packed in P₁, P₂ and P₃ with and without antioxidants, but was statistically non significant.

Chitra (2000) observed that the tannin content of the banana and millet based food mixes ranged from 0.68 to 0.77 per cent. Malathi (2012) reported that crude fibre content of sorghum based kesari mix ranged from 1.42 to 1.57g per 100g and was maintained throughout the storage period of six months. The present investigation is in line with the above study.

Ash and minerals

Significant increase in ash, calcium, phosphorus and iron content of the kodo and barnyard millet instant kesari mix is presented in Fig 10. The initial ash content of T₀, T₁ and T₂ were observed to be 1.80, 2.00 and 2.10g per 100g in all the packaging materials. The final ash content ranged from 1.74 (T₀P₁WOA) to 2.10 (T₂P₃WA) g per 100g. The control sample recorded 15.40mg calcium, 99.80mg phosphorus and 1.50mg /100g of iron. The kodo millet flour kesari mix recorded higher values for calcium (25.40mg /100g), phosphorus (122.95mg /100g) and iron (5.00mg /100g). The comparative values for barnyard millet flour kesari mix were 21.25 mg calcium, 270.55 mg phosphorus and 6.00mg / 100g iron during the initial storage period irrespective of the packaging material. A slight reduction in ash, calcium, phosphorus and iron content was observed during storage. However, it was statically non significant difference between packaging materials and storage period.

Hemalatha (2004) reported that increase in ash content over control (0.71%) was observed with increase in the level of incorporation (10 and 20%) of little millet

flour (0.88 and 1.05% respectively) and kodo millet flour (0.95 and 1.26% respectively). Malathi (2012) reported that the calcium (29.54 mg/100g) and iron (5.31 mg/100g) content of sorghum incorporated kesari mix to be higher than the products prepared from rice flour alone. The present investigation is in line with the above study.

4.4.10.2 Microbial load

The changes in microbial load of the kodo and barnyard millet instant kesari mix during storage are presented in Table 97. An increasing trend was observed in terms of the total plate count between the treatments and between packaging materials in both the kodo millet and barnyard millet incorporated mixes. The initial values for total plate count were nil. The total plate count showed slight elevation on storage and ranged between 3.2 (T_0P_3WA) to 2.5 (T_0P_1WOA) $\times 10^4$ for T_0 , 1.7 (T_1P_3WA) to 2.7 (T_1P_1WOA) $\times 10^4$ for T_1 and 1.7 (T_2P_3WA) to 2.7 (T_2P_1WOA) $\times 10^4$ cfu/g for T_2 respectively at the end of the storage period. The low permeable nature of P_3 and the presence of antioxidants had hindered the increase of microbes in these samples in all the treatments including the control samples.

4.4.10.3 Sensory quality

The mean organoleptic scores for colour and appearance, flavour, texture, taste and overall quality of the kodo and barnyard millet instant kesari mix during the initial storage period and the changes observed after 180 days of storage were tabulated and presented in Table 98. The colour of the control kesari mix were extremely white and that of millet based samples were white with creamy tinch. The scores for colour T_0 , T_1 and T_2 were highly acceptable with the value of 9.0, 8.9 and 8.9 irrespective of the packaging materials. After 180 days of storage, the score value for colour of the control samples decreased. The final scores for colour ranged between 8.5 (T_0P_1WOA) to 8.7 (T_0P_3WA), while that of T_1 and T_2 remained the same. This might be due to the changes of extreme white colour to dull white colour in the control samples. The flavour of the samples were highly acceptable with the score of 8.8 throughout the storage period in all treatments with a slight reduction observed only in the samples of T_0P_1WOA with the value of 8.4. However, no off flavour was observed in the samples. The texture of the kesari mix was slightly grainy, non sticky without caking in T_0 , T_1 and T_2 with highly acceptable score values of 8.8, 8.7 and 8.7 during the initial storage period. As the storage days passed by a reduction in the scores for texture was noted only in the control samples, irrespective of the packaging materials and presence of antioxidants. The final value for texture of T_0P_1WOA was 8.4, T_0P_1WA was 8.5, T_0P_2WOA was 8.5, T_0P_2WA was 8.6, T_0P_3WOA was 8.6 and T_0P_3WA was 8.7

respectively. Though, there existed a difference in the score for colour, flavour and texture between treatment and packaging material, it had not influenced the taste and overall acceptability of the mixes which was highly acceptable throughout the storage period irrespective of the treatments and packaging materials.

Narayan (1999) reported that the organoleptic characteristics like appearance, colour, flavor, taste and over all acceptability were high (8.5-9.0) for all the products (Chapathi, laddu, payasam, samosa and paratha) developed from composite mix based on greens and malted millet grains both before and after storage.

4.4.11. TOTAL DIETARY FIBRE CONTENT OF THE SMALL MILLET BASED INSTANT FOOD MIXES

The total dietary fibre of the developed small millet based instant food mixes is given in Table 99. The storage study of the instant food mixes revealed that the mixes that were packed in MPP with antioxidant (P₃WA) had retained the nutritional and sensory properties with minimum microbial load throughout the storage period of 80 days. Hence, the total dietary fibre of the control, kodo millet and barnyard millet instant idli, dosa, adai, pittu, idiyapam, kali, paniyaram, roti, halwa and kesari were analysed before testing for consumers acceptability. The Table 99 indicated that the total dietary fibre content of the kodo millet and barnyard millet food mixes were comparatively higher than control. Between the kodo millet and barnyard millet food mixes, the total dietary fibre content of the kodo millet food mixes were higher among the mixes developed. The total dietary fibre content of adai mix was the highest 21.50 (T₁) and 19.60 (T₂) g respectively, while the least was recorded in idli mix of both kodo millet and barnyard millet and the values being 13.10 (T₁) and 11.20 (T₂) g respectively.

Jothilakshmi (2012) had reported that the total dietary fibre of multigrain mixes that contained wheat flour, kodo millet and horse gram flour recorded the highest total dietary fibre content when compared to the control flour.

Table 99 . Total dietary fibre content (g/100g) of the small millet based instant food mixes

Instant food mixes	Total dietary fibre (g)		
	Control mix (T ₀)	Kodo millet mix (T ₁)	Barnyard millet mix (T ₂)
Idli mix	5.40	13.10	11.20
Dosa mix	6.80	19.60	17.70
Adai mix	10.20	21.50	19.60
Pittu mix	5.00	14.70	13.60
Idiyapam mix	5.00	14.70	13.60
Kali mix	6.80	18.70	17.40
Paniyaram mix	6.80	19.30	17.60
Roti mix	5.00	16.70	14.90
Halwa mix	12.90	14.70	13.60
Kesari mix	1.00	14.60	13.50

4.5 CONSUMER ACCEPTABILITY OF THE DEVELOPED INSTANT MIXES

The present scenario with the rise of income, increase in number of working women change in eating habits of the people, prevalence of life style disorder had led to a great demand of millet based instant foods. It was decided to give hands on training to the selected subjects on processing of millet based instant mixes. A new product will gain popularity and marketing demand, if only liked by the consumers. Therefore, before the training programme, the developed instant mixes were tested for consumer's acceptability on a large scale. The developed ten different instants mixes *viz.*, idli mix, dosa mix, adai mix, pittu mix, idiyapam mix, kali mix, roti mix, paniyaram mix, halwa mix and kesari mix with 100 per cent incorporation kodo millet/ barnyard millet, which were found to possess highly acceptable nutritional and sensory qualities throughout the storage study period were taken for consumer acceptability on a large scale. To find out the consumer's acceptability of the developed mixes evaluation of the same was done by selecting 300 judges belonging to the age group 21- 50 years from Peraiyur Taluk, Madurai. The freshly prepared instant mixes were used for conducting the study. Hundred gram of each mix were freely distributed to the consumers. The pack also had the instruction on the method of preparation of the products. The consumer's were asked to prepared the products and evaluate between 10.30 am to 11.30 pm in their residence. For

the evaluation, a score card of four point hedonic scale for various attributes such as colour, texture, flavour, taste and overall acceptability was utilized and this was given to the consumer's along with the pack. The score card used for evaluation is given Appendix VII. The evaluation report of the instant kodo millet mix and barnyard millet mix was collected from the consumers and results are furnished in Table 100 and 101.

Kodo millet mixes

The colour of the idli was adjudged to be very good by 46 per cent of the consumers, good by 30 per cent and fair and poor by 14 and 10 per cent respectively. The consumers indicated that the prepared idli had a white colour with a cream tinch which was very much liked by only less than 46 per cent of the consumers. The mean score for colour was 3.90. The texture of idli was said to be very good by 44 per cent, good by 28 per cent, fair 20 per cent and poor 8 per cent of the consumers. The mean score for texture was 3.88. The consumers also pointed out that texture of idli was soft but not very fluffy; hence only 44 per cent of the consumers liked the product very much. Sixty per cent of the consumer had accepted the flavour, taste and overall acceptability to be very good, while 20 per cent had accepted to be good, fair 10 per cent and 10 per cent to be fair. The mean score for flavour taste and overall acceptability was 3.91, 3.89 and 3.90 respectively.

The colour of dosa prepared from the instant mix was expressed as very good by 52 per cent of the consumers, 24 per cent of the consumers expressed to be good, 16 per cent expressed as fair while 8 per cent indicated it to be poor. All the consumers stated that the colour of the dosa was golden brown. The mean score for colour was 3.90. The comments for the texture as given by these consumers was a slight rubbery nature but still it was liked and stated to be very good only by 43 per cent of the consumers, while the rest 28, 17 and 12 per cent had indicated it to be good, fair and poor respectively. The mean score for texture of dosa was 3.89. The flavour, taste and overall acceptability were stated to be very good, good and fair respectively for each attribute by 60, 20, 10 and 10 per cent of consumers. The mean scores were 3.92 (flavour), 3.90 (taste) and 3.91 (overall acceptability).

The lemon yellow colour of the adai as express by the consumers was rated to be very good by 75 per cent, good by 15 per cent and fair by 10 per cent of the consumers. A slightly rubbery, yet pliable and crisp on the outer sides of adai as indicated by the consumers was liked to be very good by only 60 per cent of them, while 20 per cent of them liked it to be good and 20 per cent of them liked it to be fair. The mean score for texture was 3.91. About 75 per cent of the consumers rated the flavour, taste and overall

acceptability of the product to be very good, while 15 per cent rated it as good and the rest of the five per cent rated it to be fair.

The colour of the pittu was liked by majority of the consumers and 92 per cent of them scored it to be very good and 8 per cent of them to be good. The presence of creamy tinch in the white colour of the pittu had led to the increase in the acceptability. Similarly, the crumby texture of the pittu was scored to be very good by 92 per cent of the consumers and good by 8 per cent of the consumers. Ninety eight per cent of the consumers scored for flavour and taste to be very good, while only 2 per cent of them indicated it to be good. Cent per cent of the consumers had indicated the overall acceptability of the product to be very good. The mean score for flavour, taste and overall acceptability was 3.95, 3.95 and 3.96 respectively.

Ninety one per cent of the consumers had indicted the colour of the idiyapam to be very good, while nine per cent said it to be good. Similarly the texture of the idiyapam was said to be very good by 91 per cent of them and good by 9 per cent of them. The soft pliable and string hopped texture of the product might have been responsible for the higher levels of scores. The flavour, taste and overall acceptability was said to be very good by 98 per cent and good by 2 per cent respectively. The mean score for flavour, taste and overall acceptability was 3.94, 3.94 and 3.94 respectively.

Cent per cent of the consumers liked the colour, texture, flavour, taste and overall acceptability of kali owing to it characteristic feature of mustard yellow colour, soft, pliable texture excellent millet flavour and taste. The mean score for colour, texture, flavour, taste and overall acceptability was 3.98, 3.97, 3.98, 3.98 and 3.99 respectively.

Ninety eight per cent of the consumers rated the colour and texture of the roti to be very good, while two per cent alone had rated it to be good. Cent per cent of the consumer's rated flavour, taste and overall acceptability of the product to be very good. The mean score for 3.96, 3.96 and 3.96 respectively.

Ninety per cent of the consumers expressed the colour of the panyaram which was cream with golden brown tinch to be very good, while ten per cent of them indicated it to be good. The uniform surface spherical shape and the fluffed texture of the panyaram was rated to be very good by ninety per cent of the consumer's, while ten of them indicated it to be good. Ninety seven per cent of consumers had rated the flavour,

taste and overall acceptability to be very good and three per cent of them had indicated it to be good. The mean score of colour, texture, flavour, taste and overall acceptability of the panyaram was 3.93, 3.92, 3.93, 3.93 and 3.93 respectively.

The colour of the halwa was said to be very good, only by 36 per cent of the consumers and 30 per cent of the consumer's said it to be good. Twenty four per cent of them said it to be fair and 10 per cent of them said it as poor. This might be due to fact of the halwa not being honey brown and extremely glossy. Similar to colour, the texture of the halwa was stated to be very good by 34 per cent of them, good by 38 per cent of them, fair by 20 per cent of them and poor by 8 per cent of them which might be due to the absence of the characteristics extremely slippery texture of the product. The flavour, taste and overall acceptability was rated to be very good (50%), good (20%), fair (15%) and poor (10%) respectively for each attribute. The mean scores for colour, texture, flavour, taste and overall acceptability of the halwa was 3.90, 3.87, 3.88, 3.89 and 3.89 respectively.

Seventy five, fifteen and five per cent of the consumer's rated the colour of kesari to be very good, good, fair and poor. Seventy, fifteen and fifteen per cent rated the texture to be very good, good and fair respectively. Similarly 70 per cent of the consumer's had rated the flavour, taste and overall acceptability to be very good, 20 per cent of them had given it to be good, while 10 per cent of them had indicated it to be fair. The mean score for colour, texture, flavour, taste and overall acceptability was 3.92, 3.91, 3.92, 3.92 and 3.92 respectively.

Barnyard millet mixes

The colour of the idli was adjudged to be very good by 44 per cent of the consumers, good by 28 per cent and fair and poor by 20 and 8 per cent respectively. The consumers indicated that the prepared idli had a white colour with a cream tinch which was very much liked by only less than 44 per cent of the consumers. The mean score for colour was 3.88. The texture of idli was said to be very good by 42 per cent, good by 25 per cent, fair 18 per cent and poor 15 per cent of the consumers. The mean score for texture was 3.87. The consumer pointed out that texture of idli was soft but not very fluffy; hence only 42 per cent of the consumers liked the product very much. Fifty eight per cent of the consumer had accepted the flavour, taste and overall acceptability to be very good, while 18 per cent had accepted to be good, fair 12 per cent and 12 per cent to be poor. The mean score for flavour taste and overall acceptability was 3.90, 3.88 and 3.89 respectively.

The colour of dosa prepared from the instant mix was expressed as very good by 50 per cent of the consumers, 22 per cent of the consumers expressed to be good, 17 per cent expressed as fair while 12 per cent indicated it to be poor. All the consumers stated that the colour of the dosa was golden brown. The mean score for colour was 3.89. The comments for the texture as given by these consumers was a slight rubbery nature

but still it was liked and stated to be very good only by 40 per cent of the consumers, while the rest 26, 20 and 14 per cent had indicated it to be good, fair and poor respectively. The mean score for dosa was 3.88. The flavour, taste and overall acceptability were stated to be very good, good and fair respectively for each attribute by 58, 18, 12 and 12 per cent of consumers. The mean scores were 3.91 (flavour), 3.89 (taste) and 3.91 (overall acceptability).

The lemon yellow colour of the adai as express by the consumers was rated to be very good by 70 per cent, good by 15 per cent and fair by 15 per cent of the consumers. A slightly rubbery, yet pliable and crisp on the outer sides of adai as indicated by the consumers was liked to be very good by only 55 per cent of them, while 25 per cent of them liked it to be good and 20 per cent of them liked it to be fair. The mean score for texture was 3.90. About 70 per cent of the consumers rated the flavour, taste and overall acceptability of the product to be very good, while 15 per cent rated it as good and the rest of 15 per cent rated it to be fair.

The colour of the pittu was liked by majority of the consumers and 90 per cent of them scored it to be very good and 10 per cent of them to be good. The presence of creamy tinch in the white colour of the pittu had led to the increase in the acceptability level. Similarly, the crumby texture of the pittu was scored to be very good by 90 per cent of the consumers and good by 10 per cent of the consumers. Ninety per cent of the consumers scored for flavour and taste to be very good, while only ten per cent of them indicated it to be good. Cent per cent of the consumers had indicated the overall acceptability of the product to be very good. The mean score for flavour, taste and overall acceptability was 3.94, 3.94 and 3.95 respectively.

Eighty eight per cent of the consumers had indicted the colour of the idiyapam to be very good, while twelve per cent said it to be good. Similarly the texture of the idiyapam was said to be very good by 88 per cent of them and good by 12 per cent of them. The soft pliable and string hopped texture of the product might have been responsible for the higher levels of scores. The flavour, taste and overall acceptability was said to be very good by 88 per cent and good by 12 per cent respectively. The mean score for flavour, taste and overall acceptability was 3.93, 3.93 and 3.93 respectively.

Cent per cent of the consumer's liked the colour, texture, flavour, taste and overall acceptability of kali owing to it characteristic features of mustard yellow colour, soft, pliable texture excellent millet flavour and taste. The mean score for colour, texture, flavour, taste and overall acceptability was 3.97, 3.96, 3.97, 3.97 and 3.98 respectively.

Ninety five per cent of the consumers rated the colour and texture of the roti to be very good, while five per cent alone had rated it to be good. Cent per cent of the consumer's rated flavour, taste and overall acceptability of the product to be very good. The mean score for 3.95, 3.95 and 3.95 respectively.

Eighty eight per cent of the consumers expressed the colour of the paniyaram which was cream with golden brown tinch to be very good, while twelve per cent of them indicated it to be good. The uniform surface spherical shape and the fluffed texture of the paniyaram was rated to be very good by eighty eight per cent of the consumers, while twelve of them indicated it to be good. Ninety five per cent of consumers had rated the flavour, taste and overall acceptability to be very good and five per cent of them had indicated it to be good. The mean score of colour, texture, flavour, taste and overall acceptability of the paniyaram was 3.92, 3.91, 3.92, 3.92 and 3.92 respectively.

The colour of the halwa was said to be very good, only by 34 per cent of the consumers and 28 per cent of the consumer's said it to be good. Twenty six per cent of them said it to be fair and 12 per cent of them said it as poor. This might be due to fact of the halwa not being honey brown and extremely glossy. Similar to colour, the texture of the halwa was stated to be very good by 36 per cent of them, good by 34 per cent of them, fair by 22 per cent of them and poor by 8 per cent of them which might be due to the absence of the characteristics extremely slippery texture of the product. The flavour, taste and overall acceptability was rated to be very good (45%), good (25%), fair (15%) and poor (10%) respectively for each attribute. The mean scores for colour, texture, flavour, taste and overall acceptability of the halwa was 3.87, 3.86, 3.87, 3.88 and 3.88 respectively.

Seventy, twenty and ten per cent of the consumer's rated the colour of kesari to be very good, good, fair and poor. Sixty five, twenty and fifteen per cent rated the texture to be very good, good and fair respectively. Similarly 65 per cent of the consumer's had rated the flavour, taste and overall acceptability to be very good, 20 per cent of them had given it to be good, while 15 per cent of them had indicated it to be fair. The mean score for colour, texture, flavour, taste and overall acceptability was 3.91, 3.90, 3.91, 3.91 and 3.91 respectively.

The results of the consumer's acceptability revealed that kali and roti were the highly preferred products followed by pittu, idiyapam, adai, kesari, dosa, idli and halwa. The product tested gave high potential for commercialization and marketability. The consumer preference for kodo millet and barnyard millet based instant mixes had increased manifold as that of commercial mixes available in the market. The consumer's have also stated that they will surely purchase the kodo millet and barnyard millet based instant mixes, if available in the market like any other snacks and

processed food products. The change in the habit of consumer's the new products will definitely create more demand for the millet based instant mixes. Hence, hands on training on preparation of these millet based instant mixes were given to the selected subjects.

4.6 IMPACT OF THE DEVELOPED MIXES THROUGH NUTRITION EDUCATION

Nutrition education programme specially aimed to improve the knowledge regarding the nutritional significance of the millets, nutrient composition of barnyard millet and kodo millet, health benefits of small millets, product diversification of small millets, general hygiene and sanitation and usage of millet products as a dietary component was conducted. The feasibility of using millet based products in daily dietaries and use of millet based instant mixes was also included as a major theme in the nutrition education programme in the form of hands in training in the method of preparation of instant mixes which was given over a six months period of study. This brought about considerable positive changes in knowledge, attitude and practice among the rural women and the information related to this aspect is presented below

4.6.1 Changes in nutrition knowledge

The knowledge of the rural women regarding the nutritional significance of the millets, nutrient composition of barnyard millet and kodo millet, health benefits of small millets, product diversification of small millets, general hygiene and sanitation and usage of millet products as a dietary component were initially and finally tested using specially designed proforma and the scores assigned are presented in Table 102.

Table 102. Nutritional knowledge scores of rural women before and after nutrition education (N-120)

Category of scores	Before nutrition education No.(%)	After nutrition education No.(%)
0-25	64 (53)	2(2)
26-50	40 (33)	4(3)
51-75	13 (10)	27 (23)
76-100	3 (4)	87 (72)

Before nutrition education, 53 per cent of the rural women obtained a very low score of 0-25 followed by 33 per cent of the rural women having a score of 26-50, only 10 per

cent and 7 per cent of the women had scores of 51-75 and 76 -100 respectively. After nutrition education 72 per cent of the women scored maximum scores 76-100, 23 per cent of the women had knowledge scores ranging from 51-75. Around three and two per cent of the women had obtained scores from 26-50 and 0-25 respectively. These results indicated that nutrition education had brought about considerable change in the nutrition knowledge of the rural women.

4.6.2 Changes in attitude of the women

As nutrition education had imparted considerable nutritional knowledge to the women, they were able to retain their knowledge and this resulted in change in the attitudes of the rural women regarding millet consumption and its nutritional significance after their participation in the nutrition education programme. The results of the change in attitude of the rural women before and after nutrition education is given in Table 103.

Before participating in the nutrition classes, only 16 and 11 of them accepted that health is directly related to food and adequate diet improves health. But after nutrition education, all of them realised the state of health is related to food and illness is due to ill balance diet. Initially, only three of them had the attitude that mixed diet provides all the nutrients but after participating in nutrition education, all women understood that only a mixed diet provides all the nutrition. Though millets were abundantly available in their locality only 15 and 10 of them had known that it is good for health and contained vitamins and minerals while none of them knew that it contained fibre. Similarly, only 16 of them were aware that kodo millet and barnyard millet can be used in daily diet. None of them had neither a positive attitude nor of the view that kodo millet and barnyard millet are rich in calcium and phosphorus, iron and fibre and these are essential for blood and bone health and also to prevent constipation. The impact of nutrition education indicated that all 120 of them had developed a positive attitude towards the nutritional significance of kodo millet and barnyard millet. Before participating in the nutrition education, three of them were aware the diabetes was due to high carbohydrate diet and increased consumption of rice caused diabetes. Twenty of them stated that blood sugar level increases if direct sugar is consumed. None of them were aware that barnyard millet and kodo millet were hypoglycemic, hypocholesterolemic and antioxidants rich foods to prevent diabetes, heart disease and cancer. Nutrition education had brought about a remarkable change in the attitude of the participants regarding the relation between millets and life style disorders as it is evident from the table that all 120 of them agreed that diabetes was due to high carbohydrate diet,

barnyard and kodo millet are low glycemic foods and prevents diabetes, hypertension and cancer because of its hypocholesterolemic and antioxidant rich nature.

Regarding general hygiene and sanitation, 48 of them were aware of the habit the hands should be properly washed before handling food and only 16 of them had known the six steps of hand washing and importance of hand washing after using the washroom. After nutrition education, 120 of them indicated that hands should be properly washed following the six steps of hand washing before handling food and after using the washroom. Only 25 of them had known potable drinking water should be used and

should be stored clean containers, but nutrition education had changed the scenario where all 120 of them developed the positive attitude of using potable drinking water in clean containers.

All 120 of them accepted to have regular bath, proper nail and hair care which was entirely contrary, before nutrition education as only 73 of them had accepted for regular bath and 32 of them for nail and hair care. Open defecation was a common practice and only 10 of them had indicated that it should not be followed. Similarly they were also not aware of the concept of soak pit in every house and safe disposal of kitchen waste. After nutrition education, all of them (120) accepted the need of soak pit and safe kitchen disposal. Necessities for the presence of proper drainage was realised by only 12 of them and none of them had the attitude to maintain personal hygiene to avoid communicable diseases. After nutrition education, 120 of them accepted for the presence of proper drainage and need for maintaining of personal hygiene.

4.6.3 Attitude of the rural women towards millet product diversification, usage of millet products for self employment

The following table gives the changes in the attitude of the selected rural women towards millet product diversification and usage of millet products for self employment.

The change in the attitude of the rural women towards millet product diversification and usage of millet products is given Table104. From the table, it could be seen that, only sixteen of them had told all millet can be used as foods, eleven of them expressed that it could be a part of the daily menu and only fifteen of them had the view that millets are tasty and comparatively cheap. After nutrition education, all the subjects accepted that all millets can be used as a food in their daily diet and are tasty and cheap. None of the respondents had the attitude towards the usage of millets in idli, dosa, idiyapam and

adai and after nutrition education; they accepted that millets can be used in these foods also. Fifty two subjects had the attitude of using millets for kali and porridge. After nutrition education 100 per cent of the subjects decided to use millets in the preparation of kali and porridge in their daily diet. Very few of the respondents (10) accepted that millets can be used for preparation of sweets and twelve of them used them as malted foods even before nutrition education. And after nutrition education, all 120 of them accepted the use of millets in sweets and malted millet foods. None of them had the view of using millets as puffed and flaked products like rice flakes but intervention of nutrition education had brought about a change in their attitude indicating that the millets can be used as flakes and popped products. Similar only five of them had view that millet flour can be used like wheat flour and after nutrition education sessions all the rural women were aware of the possibility of using millets flour like wheat flour. Three of the rural women had initial thought that instant idli, dosa, adai and kali mix cannot be prepared with the inclusion of millets. And after nutrition education, all of them realised that these instant mixes can be prepared from millets also. While two of them only had thought that variety of the products can be easily prepared from instant mixes. After nutrition education, all of them developed this positive attitude. Five of them alone accepted that it is easy to prepare the same product using instant mixes than by traditional method. But after nutrition education all of them were very happy to accept that it is easy to prepared tasty small millets based idli, dosa, adai, pittu, idiyapam, kali, roti, panyaram, halwa and kesari from the instant mixes than by conventional method. Twenty of them were in the attitude that getting training on preparation of millet based instant mixes would pave for self employment, it is a promising enterprise for women during non crop season and income generation for women which lead to women empowerment. But after nutrition education, all 120 subjects them developed a positive attitude with the points stated above.

Changes in the millet consumption practices of the rural women

Changes observed in the practice of the rural women before and after their participation in nutrition education session is given in Table 105.

Before nutrition education only twelve of them had been using millet in their daily diet and for breakfast food. But after nutrition education, all of them started using millet in their daily diet and as a breakfast food. Earlier to nutrition education, only two of them had used millet flour like wheat and after education, all of them had initiated to use millet flour for the preparation of chappathi, roti, puri and their like as that of wheat flour. Twenty two of them had the habit of using millet kali and porridge daily, but

after nutrition education, all of them cultivated the habit of using kali and porridge daily. Before nutrition education, none of them had the practice of using instant mixes but after nutrition education, all of them practiced using only instant mixes for the preparation of millet based food. As seen from the table where only five of them had the practice of using malted millet product and after nutrition education, all of them started using it. On contrary to the data were none of them had the practice of using flaked and popped millet products, the data after nutrition education indicated that all of them had put into the practice of using it. Similarly, initially when no one had the practice of processing of millet based instant mixes as the tool of self employment and income generating activity. After nutrition education, eighty eight of them had become self employment by processing millet based instant mixes and fifty three of them had started generating income from it. These observation on knowledge, attitude and practice are indicative of the possibility of commercializing millet based instant mixes among populated groups. These results are similar to the observations of Malathi (1996) who reported improvement in knowledge, attitude and practice (KAP) of mothers given nutrition education during supplementation studies with extruded soy foods.

COST ANALYSIS (Table 106-115)

The cost of production of small millets based instant food mixes was calculated by taking into account the fixed and the variable cost involved in the course of processing as detailed in Appendix. It was found that the unit cost of production of instant idli mix for T₀, T₁ and T₂ were Rs. 7.33, Rs. 6.83 and Rs.6.33 per 100 g respectively. The cost of production of 100 g of dosa mix was found to be Rs.7.13, Rs. 6.63 and Rs. 6.13. T₀, T₁ and T₂ of 100 g of adai mix was worked out to be Rs. 8.78, Rs. 8.23 and Rs. 7.78 while that of pittu mix was Rs. 5.38, Rs. 4.88 and Rs. 4.38 respectively. The cost of production of 100 g of the control idiyapam mix was Rs. 5.38, kodo millet mix was Rs. 4.88 and barnyard millet mix was Rs. 4.38. The unit cost of production of instant kali mix for T₀, T₁ and T₂ were Rs. 5.63, Rs. , Rs. 5.13 and Rs.4.63 per 100 g respectively. The cost of production of 100 g of panyaram mix was found to be Rs.7.13, Rs. 6.63 and Rs. 6.13. T₀, T₁ and T₂ of 100 g of roti mix was worked out to be Rs. 6.58, Rs. 6.08 and Rs. 5.58 while that of halwa mix was Rs. 5.86, Rs. 4.86 and Rs. 4.36 respectively. The cost of production of 100 g of the control kesari mix was Rs. 5.36, kodo millet mix was Rs. 4.86 and barnyard millet mix was Rs. 4.36.

From these results, it could be inferred that the cost of control mixes were costlier when compared to the millet based mix. This might be due to the higher procurement cost of

the rice and pulses flour and the cost of small millet flour was comparatively cheap when procured from the farmers directly. A reduction in the cost of the production about 30 per cent was also observed in the millet based instant food mixes when compared to the commercially available food mixes in the market. This showed that the millet based instant food mixes not only exerted a therapeutic effect but also less expensive.

CHAPTER V

SUMMARY AND CONCLUSION

The summary of the results obtained on the experiments carried out during the study on “**Standardization, evaluation and impact of functional products from Kodo millet (*Paspalum scrobiculatum*) and Barnyard millet (*Echinochloa frumentacea*)**” are given in this chapter. The results are summarized from valid conclusion drawn from the results of the study have been enumerated.

5.1 SOCIO ECONOMIC AND HEALTH PROFILE OF THE SELECTED SUBJECTS

The socio economic details with reference to religion, type of family, family size, landholding size, domestic animals, occupation, monthly income, literacy, type of house, source of drinking water, toilet and sanitation facilities, personal habits and health facility available were elucidated from the subjects by way of interview method. The majority of the selected subjects belong to the Hindu religion (84 %) and only six per cent were Muslims. Regarding the type of family, 70 per cent of the subjects belonged to nuclear family; the rest lived in joint family. The household size the majority of the household comprised of 4-6 members (53%) followed by 1-3 members (27%). Families comprising of more than six members were minimum. Only 14 per cent of the selected subjects possessed land and, of them nine per cent held one acre and 5 per cent had less than one acre. Though only 33 per cent of families possessed domestic animal *viz.*, milch animal, cattle and poultry and among them 47 per cent of them earned an extra income from these sources. The main occupation of the selected subjects were agriculture labour (80 %) and 13 per cent of them were in government service while the rest were housewives. Only 14 per cent of the respondents had monthly income of more than Rs.10, 000 followed by 33 per cent of them being in the group of Rs.6000-10,000 of monthly income. Eighty four per cent were illiterate and only 3 per cent had completed higher secondary school education. Among the subjects 34 and 36 per cent live in brick walled tiled house and concrete house respectively. Electricity facilities was not available to only 24 per cent of the respondents who lived in shed thatched and mud wall thatched type of house (76%) while the rest of them had electricity facilities. Hundred per cent of the selected subjects depended on public tap for drinking water facilities. Toilet and sanitation facilities were available to only 10 percent of the selected subjects and 90 per cent of them used the open area for defecation. The respondents of the study fully utilised the government hospital near to the village in a distance of 5 kilometres. Fifty per cent of the respondents did not have any unhealthy

personal habits while 33 per cent they chewed betel leaf and 17 per cent them chewed tobacco.

The monthly expenditure was apportioned for food, clothing, rent, education, health, fuel, transport, remittance, recreation and savings. All the respondents had spent for all the above except recreation. In the present study only 33 per cent of them had suffered from illness during the last one year with cases of fever, cough, cough and cold and only a minimum had suffered from leg pain. Ninety five per cent of them had not suffered from epidemic and only five per cent of them were the victims of chick pox. Details about deworming treatment taken during the last one year indicated that 65 per cent had taken deworming measures and rest of them avoided the treatment. It was found that women gave equal importance to ration shop, anganwadi, school, health centre and hospital but they had more access and benefits from ration shops when compared to other organisation.

5.1.1 Nutritional status of the selected subjects

The mean weight of the subjects ranged from 57.3 kg (20-30 yrs) to 60.00 kg (51-60 yrs). The mean height was found to be maximum for the age group 20-30 years and minimum for 51-60 years. Accordingly the BMI was also minimum for the age group of 20-30 years. The Waist Hip Ratio was 0.78, 0.80, 0.82 and 0.82 while the Mid Upper Arm Circumference was 20.69, 22.69, 24.60 and 24.24 for the age group of 20-30, 31-40, 41-50 and 51-60 years respectively. The per cent of fat ranged from 11.22 to 14.10. Among the selected subjects, 62.5 per cent of them were found to be normal (BMI- 18.5 – 25%) while 27.5 per cent of them were lean and underweight (BMI <18.5%) and only 10 per cent were obese (BMI >25%). The Waist Hip Ratio of this 10 per cent of the subjects were > 0.85 indicating obesity while the rest of the 90 per cent were in the normal categories of < 0.85. Consequently the per cent of fat of this 90 per cent were in the acceptable range of 9-23 while the rest of the 10 per cent was in the unhealthy range of ≥ 32 which is too high.

5.2 MILLET CONSUMPTION PATTERN OF THE SELECTED SUBJECTS

5.2.1 Food habit and meal pattern

All the respondents (100%) were non vegetarians. Seventy two per cent of them had no meal planning while the rest planned the meals in advance. Majority of the respondents (66%) had three meals per day with no regular time schedule (34%).

5.2.2 Millet consumption

The most commonly consumed millet was found to be finger millet (30%) followed by sorghum (28%), kodo millet (17%), barnyard millet (16.7%) and pearl millet (8.3%). Boiling was the most preferred method of cooking (53%) while shallow fat frying/deep fat frying were least preferred methods (14%). Majority of the respondents used millet as a whole grains (61 %), while 39 per cent of the respondents used millet in the form of rice. The 80 per cent of the respondents used millet flour, while 5 per cent of them take in germinated form and 10 per cent used malted millet flour. None of them had used either popped or flaked millets. Porridge was the conventional small millet based products prepared by majority of respondents (43.3%) followed by kali (16.7%), roti (11.6%), health mix (8.4%), dosai (6.6%) and dessert (3.4%). Small millet was not used in the preparation of products like idli, idiyapam and paniyaram. Savouries such as murukku, omapodi, karasev and pakoda were prepared with incorporation of any of the millets, the majority being sorghum, however kodo millet was also used in the preparation of these products. Majority of the respondents (77.5%) prepared the Indian sweet like sweet appam exclusively from millet rice, while 10 per cent of them used millet rice for kesari preparation and 12.5 per cent for payasam preparation. Only 14 per cent of the respondents had consumed the sorghum biscuits as it was available in the village shops. Though instant mixes were available for purchase only 5 per cent of the respondents had the aptitude to purchase and use pittu and roti mix and 4 per cent for kali mix and adai mix. The whole grain millets were stored in gunny bags by majority of the respondents (73.4%) while the rest used earthen pots for the storage of these grains. Millet flour and malted millet flour were stored either in plastic container or polypropylene bag.

5.2.3 Frequency of millet consumption

Majority of the millets were consumed monthly once while kodo millet, finger millet and barnyard millet were consumed monthly twice by 17, 30 and 17 per cent respondents respectively. Sorghum was consumed weekly once by 28 per cent respondents. Little millet, foxtail millet, barnyard millet and proso millet were consumed occasionally by cent per cent of respondents.

5.2.4 Food expenditure pattern of the selected subjects

Thirty three per cent of the respondents spent 41-50 per cent for the purchase of cereals followed by 31-35 per cent and 26-30 per cent of the income for cereal purchase by 33 and 14 per cent of the respondents respectively. Majority of the respondents had spent 41-50 per cent of the income for the purchase of millets. The percentage of monthly income spent on the purchase of pulses ranged from 16-25 per cent while that of green leafy vegetables ranged from 5-15 per cent. Cent per cent of the respondents spent only less than five per cent for the purchase of roots, tubers, sugar and jaggery while

53 per cent of the respondents did not spend for the purchase of other vegetables, fruits and milk products rest of them had spent at least less than or more than five per cent for the purchase of these items.

5.2.5 Frequency of millet purchase

Sorghum was purchased monthly by 72 per cent of respondents and the rest buy weekly. The kodo millet was purchased monthly by 83 per cent and once in fortnight by 17 per cent and finger millet was purchased by 70 per cent of the respondents monthly and by 30 per cent of the respondents once in fortnight, barnyard millet was purchased once in six months by 83 per cent respondents and once in a month by 17 per cent. The millets that were annually purchased by cent per cent of the respondents included little millet, foxtail millet and pearl millet while proso millet was purchased only occasionally.

5.2.6 Per capita food intake of selected subjects

The cereal intake by the sedentary workers was more or less equal with the requirement, while a slight deficit in the intake of millets was noted. The pulses intake by sedentary worker and moderate workers were deficit and the deficiency was more prone in the rainy and winter season. The consumption of root and tubers were also less than the requirement with values being 270 g and 330 g. The intake of green leafy

vegetables and other vegetables were lower with the sedentary workers and comparatively more by the moderate workers. The intake of fruits by the moderate workers ranged from 17.26 to 20.74 g while that of the sedentary workers ranged from 66.22 to 70.75 g. The requirement for milk and milk products per day as given by ICMR is 300 g but the intake was poor among the sedentary workers and ranged from 120 to 150 g per day. The intake of fats and oils, and sugar and jaggery were near to the daily requirement in both the groups.

4.2.7 Per capita nutrient intake of the selected subjects in comparison with RDA

Hundred per cent of the respondents met out 75 per cent of RDA for calories and 47 per cent of respondents had got 50-75 per cent of RDA for protein, while 37 per cent of the respondents had got 50-75 per cent of RDA for calcium from their food intake. Only 14 per cent of respondents had obtained 75 per cent of RDA was met from the daily diet for protein, fat, fibre, carotene, calcium, iron, thiamine, niacin, riboflavin and vitamin C. There were significant associations in case of some nutrients with anthropometric indicators. Weight was positively correlated for all the nutrients, whereas height was not positively correlated, Significant positive correlation was observed in energy, fat, crude fibre, iron, carotene and Vitamin C for Body Mass Index (BMI). All the nutrients were positively correlated with Mid Upper Arm Circumference (MUAC) and energy, protein, fat, crude fibre and vitamin C being statistically significant. Waist Hip Ratio (WHR) was positively correlated with protein and fat whereas all the nutrients exhibited a positive correlation with per cent body fat in which the energy, fat, crude fibre, minerals and B vitamins being statistically significant.

5.2.8 Biochemical estimation

Fifty three per cent of the selected subjects were in the mild anaemia category with the haemoglobin level in the range of 10.1 to 11.9 while 47 per cent of them had normal haemoglobin level, which was more or less equal to 12.00. Similarly on examining the random blood glucose level, 53 per cent of the respondents had 82-120 mg of glucose/ 100 g of blood glucose level and only 47 per cent had more than 120 indicating that they were prone to diabetic.

5.3 STANDARDIZATION OF KODO MILLET AND BARNYARD MILLET BASED INSTANT FOOD MIXES

Attempts were made to developed ten small millet based instant mixes of popular foods belonging to the categories of traditional foods (idli, dosa, adai, pittu, idiyapam, kali,

roti, paniyaram, halwa and kesari) with various levels of incorporation of kodo millet and barnyard millet and the most acceptable level of incorporation was standardized.

The colour, texture, flavour, taste and overall acceptability were highly acceptable for the idli, dosa, adai, pittu, idiyapam, kali, paniyaram, roti, halwa and kesari were prepared from the instant mix that had 100 per cent kodo millet and barnyard millet flour. Hence, 100 per cent incorporation of kodo millet and barnyard millet was standardized for the preparation of small millets based instant food mixes.

5.4 QUALITY ATTRIBUTES OF STANDARDIZED INSTANT FOOD MIXES DURING STORAGE

The standardized small millets based instant food mixes were subjected to shelf life studies. The instant food mixes were packed in HDPE, aluminium foil and MPP with and without antioxidant and were kept at ambient conditions for a storage period of 180 days. The products were studied for their nutritional qualities, microbial load and sensory qualities during storage.

5.4.1 Idli mix

5.4.1.1 Chemical constituents

The initial moisture content of T₀, T₁ and T₂ were observed to be 11.00, 10.10 and 9.60 g per cent which might be due to incorporation of millets. The final moisture content ranged from 11.60 (T₀P₃WA) to 11.86 (T₀P₁WOA) in T₀, 10.77 (T₁P₃WA) to 10.87(T₁P₁WOA) in T₁ and 9.95 (T₂P₃WA) to 10.08 (T₂P₁WOA) in T₂ g per 100 g. The incorporation of small millets had significantly increased the protein content as it is evident from the initial values of T₁, T₂ and T₀ as 11.37,10.65 and 9.62 g per 100g respectively. The protein content after 180 days of storage ranged from 9.45 (T₀P₁WOA) to 9.50 (T₀P₃WA) for T₀, 11.20 (T₁P₁WOA) to 11.26 (T₁P₃WA) for T₁ and 10.45 (T₂P₁WOA) to 10.53 (T₂P₃WA) g per 100g for T₂. The starch content of the control was maximum (69.00g per 100) and the values decreased for the small millet based instant mixes as 55.80 (T₁) and 57.00 (T₂). The final starch content of the idli mix ranged from 68.50 (T₀P₁WOA) to 68.70 (T₂P₃WA) for T₀, 55.37(T₁P₁WOA) to 55.46 (T₁P₃WA) for T₁ and 56.60 (T₂P₁WOA) to 56.74 (T₂P₃WA) g per 100g for T₂. The initial fat content of T₀, T₁ and T₂ was 1.08, 1.50 and 2.80g/ 100g irrespective of the packaging material. After 180 days of storage, the final fat content ranged between 1.02 (T₀P₁WOA) to 1.06(T₀P₃WA) for T₀, 1.35(T₁P₁WOA) to 1.47 (T₁P₃WOA) for T₁ and 2.66 (T₂P₁WOA) to 2.75 (T₂P₃WOA) g /100g for T₂ respectively. A slight increase in the free fatty acid and peroxide value was observed upon storage that varied with the

packaging material. The initial values of the crude fibre for T₀, T₁ and T₂ were 1.20, 4.20 and 6.90 while the tannin content for T₀, T₁ and T₂ were 2.14, 3.40 and 4.10g / 100 g respectively in all the packaging materials. The initial ash content of T₀, T₁ and T₂ were observed to be 1.80, 2.20 and 2.10g/100g in all the packaging material which might be due to incorporation of millets. The kodo millet incorporated idli mix recorded higher values for calcium (57.18 mg /100g), phosphorus (210.10mg / 100g) and iron (4.17mg /100g). The comparative values for barnyard millet millet incorporated idli mix were 52.20 mg calcium, 330.60 mg phosphorus and 6.34mg of iron per 100g of the sample during the initial period of storage. A slight reduction in calcium, phosphorus and iron was observed during storage.

5.4.1.2 Microbial load

The initial values for total plate count were nil. The total plate count showed slight elevation in storage and ranged between 2.4 (T₀P₃WA) to 3.4 (T₀P₁WOA) x 10⁴ for T₀, 1.5 (T₁P₃WA) to 2.5(T₁P₁WOA) x 10⁴ for T₁ and 0.7(T₂P₃WA) to 1.2(T₂P₁WOA) x 10⁴ cfu/g for T₂ respectively at the end of the storage period of 180 days.

5.4.1.3 Sensory quality

No distinct variation was observed between the control and small millet incorporated instant mix for the colour, flavour, texture, taste and overall acceptability and were highly acceptable in all the samples during initial period of storage. The final score for colour ranged between 8.6 (T₀P₁WOA) and 8.8 (T₂P₃WA), flavour ranged between 8.5 (T₀P₁WOA) and 8.8 (T₂P₃WA), texture ranged between 8.4 (T₀P₁WOA) and 8.5 (T₂P₃WA), taste ranged between 8.4 (T₀P₁WOA) and 8.5 (T₂P₃WA) and overall acceptability ranged between 8.5 (T₀P₁WOA) and 8.6 (T₂P₃WA) respectively.

5.4.2 Dosa mix

5.4.2.1 Chemical constituents

The initial moisture content was 10.00, 9.60 and 9.00 for T₀, T₁ and T₂ g per 100g respectively. The final moisture content after 180 days of storage ranged from 10.60 T₀P₃WA to 10.86 T₀P₁WOA for T₀, 9.80 T₁P₃WA to 9.90 T₁P₁WOA for T₁ and 9.60 T₂P₃WA to 9.87 T₂P₁WOA g per 100g for T₂ respectively. The initial protein content was 8.65, 10.37 and 9.32 for T₀, T₁ and T₂ while that of the starch content of T₀, T₁ and T₂ were 68.00, 55.80 and 56.00g per 100g respectively in all the packaging. The final protein content ranged from 8.43 (T₀P₁WOA) to 8.50 (T₀P₃WA) for T₀, from 10.18 (T₁P₁WOA) to 10.25 (T₁P₃WA) for T₁ and 9.11(T₂P₁WOA) to 9.18(T₂P₃WA) for

T₂ while the final starch content ranged from 67.50(T₀P₁WOA) to 67.70 (T₀P₃WA) for T₀, from 55.37(T₁P₁WOA) to 55.46 (T₁P₃WA) for T₁ and from 55.60 (T₂P₁WOA) to 55.74 (T₂P₃WA) for T₂ g per 100g respectively. The initial fat content of T₀, T₁ and T₂ were 1.00, 1.30 and 2.00g per 100g respectively and after 180 days of storage, there was a slight reduction in the fat content and ranged from 0.48 (T₀P₁WOA) to 0.62 (T₀P₃WA) for T₀, from 1.15(T₁P₁WOA) to 1.22 (T₁P₃WA) for T₁ and 1.90(T₂P₁WOA) to 1.98(T₀P₃WA) g per 100g for T₂ respectively. A slight increase in the free fatty acid and peroxide value was observed upon storage that varied with the packaging material. The initial crude fibre content of T₀, T₁ and T₂ were 1.10, 4.20 and 5.50 g per 100 g in all the packaging and after 180 days of storage, the final crude fibre content was slight reduced and ranged between 1.02 (T₀P₁WOA) and 1.08(T₀P₃WA) for T₀, 4.12 (T₁P₁WOA) and 4.20 (T₁P₃WA) for T₁ and 5.41(T₂P₁WOA) and 5.48 (T₂P₃WA) for T₂ g per 100g respectively. The initial tannin content of T₀, T₁ and T₂ were 2.14, 3.60 and 4.50g per 100g in all the packaging and after 180 days of storage, a reduction was observed in the tannin content of all the samples irrespective of the treatment and packaging material. The initial ash content T₀, T₁ and T₂ were 2.10, 2.20 and 2.80 for all the packaging material and after 180 days. The initial calcium content of T₀, T₁ and T₂ were 51.20, 58.18 and 52.40 while phosphorus was 121.00, 217.60 and 328.10mg per 100g for T₀, T₁ and T₂ respectively

5.4.2.2 Microbial load

Initially, there was no total plate count irrespective of the treatment and packaging material. The final total plate count T_0 ranged between 2.4 (T_0P_3WA) and 3.4 (T_0P_1WOA), T_1 ranged between 2.2(T_1P_3WA) and 2.5(T_1P_1WOA) and T_2 ranged between 0.7(T_2P_3WA) and 1.2(T_2P_1WOA) $\times 10^4$ cfu/g respectively.

5.4.2.3 Sensory quality

No distinct variation was observed between the control and small millet incorporated instant mix for the colour, flavour, texture, taste and overall acceptability and were highly acceptable in all the samples during initial period of storage. The final score for colour ranged between 8.4 (T_0P_1WOA) and 8.6 (T_2P_3WA), flavour ranged between 8.4 (T_0P_1WOA) and 8.7 (T_2P_3WA), texture ranged between 8.3 (T_0P_1WOA) and 8.6 (T_2P_3WA), taste ranged between 8.5 (T_0P_1WOA) and 8.8 (T_2P_3WA) and overall acceptability ranged between 8.4 (T_0P_1WOA) and 8.5 (T_2P_3WA) respectively.

5.4.3 Adai mix

5.4.3.1 Chemical constituents

The initial moisture content of T_0 , T_1 and T_2 was 12.10, 11.35 and 11.00g per 100g irrespective of the packaging material and after 180 days of storage, the final moisture content ranged from 11.41 (T_2P_3WA) to 12.70 (T_0P_1WOA) g per 100 g of the sample. The initial protein content of T_0 , T_1 and T_2 was 12.56, 15.70 and 14.00g per 100g irrespective of packaging materials which had reduced and ranged from 12.39 (T_0P_1WOA) to 12.44 (T_0P_3WA) for T_0 , from 15.52 (T_1P_1WOA) to 15.58 (T_1P_3WA) for T_1 and from 13.82 (T_2P_1WOA) to 13.90 (T_2P_1WA) for T_2 g per 100g respectively. The incorporation of millet had significantly reduced the starch content of the adai mix as it is evident from the initial values of 48.10 (T_0), 27.68 (T_1) and 31.46 (T_2) g per 100g in all the packaging material. The final starch content ranged from 45.68 (T_0P_1WOA) to 45.75 (T_0P_3WA) for T_0 , from 27.25(T_1P_1WOA) to 27.38 (T_1P_3WA) for T_1 and 31.04(T_2P_1WOA) to 31.18 (T_2P_3WA) for T_2 g per 100g respectively. The initial fat content of T_0 , T_1 and T_2 irrespective of the packaging materials were 1.20, 1.70 and 2.00g per 100g respectively. The final fat content after 180days of storage ranged from 1.08 (T_0P_1WOA) to 1.97 (T_2P_3WA) g per 100 g. A slight increase in the free fatty acid and peroxide value was observed upon storage that varied with the packaging material. The initial crude fibre content of T_0 , T_1 and T_2 in all the samples were 4.98, 6.20 and 7.78g per 100g respectively. The final crude fibre content ranged between 4.88

(T₀P₁WOA) and 7.75 (T₂P₃WA) g per 100 g of the sample. The initial tannin content of T₀, T₁ and T₂ were 5.40, 5.70 and 6.25g per 100g in all the packaging material respectively. The final tannin content ranged between 5.28 (T₀P₁WOA) and 6.25 (T₂P₃WA) g per 100g respectively. The initial ash content of T₀, T₁ and T₂ were 2.40, 2.50 and 2.60g per 100g irrespective of the packaging materials. The initial calcium content of T₀, T₁ and T₂ were 51.00, 71.30 and 60.20 while that of phosphorus was 100.18, 244.70 and 336.28 mg per 100g respectively in all the packaging. The initial iron content of these samples were noted to be 2.26 (T₀), 5.88 (T₁) and 7.30 (T₂) mg per 100g in all the packaging material respectively which showed a non significant reduction upon storage.

5.4.3.2 Microbial load

Initially the total plate count in all the samples was found to be nil and as the storage day progressed, there was an increase in the microbial load. The final total plate count of T₀ ranged from 2.7 (T₀P₃WA) to 3.1 (T₀P₁WOA), T₁ ranged from 2.0(T₁P₃WA) to 2.5 (T₁P₁WOA) and T₂ ranged from 1.2 (T₂P₃WA) to 2.2 (T₂P₁WOA) x 10⁴ cfu/g respectively.

5.4.3.3 Sensory quality

No distinct variation was observed between the control and small millet incorporated instant mix for the colour, flavour, texture, taste and overall acceptability and were highly acceptable in all the samples during initial period of storage. The final score for colour ranged between 8.5 (T₀P₁WOA) and 8.7 (T₂P₃WA), flavour ranged between 8.3 (T₀P₁WOA) and 8.5 (T₂P₃WA), texture ranged between 8.2 (T₀P₁WOA) and 8.4 (T₂P₃WA), taste ranged between 8.4 (T₀P₁WOA) and 8.7 (T₂P₃WA) and overall acceptability ranged between 8.4 (T₀P₁WOA) and 8.6 (T₂P₃WA) respectively.

5.4.4 Pittu mix

5.4.4.1 Chemical constituents

The initial moisture content of T₀, T₁ and T₂ were observed to be 11.80, 10.70 and 10.00g per100g in all the packaging, which might be due to incorporation of millets.

The final moisture content ranged from 12.27 (T₀P₃WA) to 12.52 (T₀P₁WOA) in T₀, 10.97 (T₁P₃WA) to 11.10 (T₁P₁WOA) in T₁ and 10.55 (T₂P₃WA) to 10.67 (T₂P₁WOA) in T₂ g per 100g. The incorporation of small millets had significantly increased the protein content as it is evident from the initial values of T₁, T₂ and T₀ as, 7.30, 6.25 and 5.00 g per 100 g respectively. The protein content after 180 days of storage ranged from 4.78 (T₀P₁WOA) to 4.84 (T₀P₃WA) for T₀, 7.04 (T₁P₁WOA) to 7.14 (T₁P₃WA)

for T₁ and 6.05 (T₂P₁WOA) to 6.14 (T₂P₃WA) g per 100g for T₂. The starch content of the control was maximum (69.00%) and the values decreased for the small millet based instant mixes as 51.80 (T₁) and 56.10 (T₂) g per 100 g. The final starch content of the pittu mix ranged from 68.50 (T₀P₁WOA) to 68.64 (T₀P₃WA) for T₀, 51.30 (T₁P₁WOA) to 51.47(T₁P₃WA) for T₁ and 55.50 (T₂P₁WOA) to 55.70 (T₂P₃WA) g per 100g for T₂. The initial fat content of T₀, T₁ and T₂ was 0.80, 1.00 and 1.80 g per 100 g in all the packaging. After 180 days of storage, the final fat content ranged between 0.69 (T₀P₁WOA) to 0.75 (T₀P₃WA) for T₀, 0.85 (T₁P₁WOA) to 0.96 (T₁P₃WA) for T₁ and 1.67 (T₂P₁WOA) to 1.75 (T₂P₃WA) g per 100g for T₂ respectively. A slight increase in the free fatty acid and peroxide value was observed upon storage that varied with the packaging material. The initial values of the crude fibre for T₀, T₁ and T₂ were 0.60, 3.10 and 5.80 while the tannin content for T₀, T₁ and T₂ were 1.56, 4.80 and 5.00g per 100g respectively in all packaging. The initial ash content of T₀, T₁ and T₂ were observed to be 1.50, 2.20 and 3.10g per 100g in all the packaging, which might be due to incorporation of millets. The kodo millet flour pittu mix recorded higher values than control for calcium (30.00mg/100g), phosphorus (176.00 mg/100g) and iron (4.20mg/100g) and the comparative values for barnyard millet flour pittu mix were 26.00mg calcium, 278.10mg phosphorus and 6.80 mg of iron per 100g of sample in all the packaging material during the initial storage period. A slight reduction in calcium, phosphorus and iron was observed during storage.

5.4.4.2 Microbial load

The initial values for total plate count were nil. The total plate count showed slight elevation in storage and ranged between 1.5 (T₀P₃WA) to 2.5(T₀P₁WOA) x 10⁴ for T₀, 1.8 (T₁P₃WA) to 2.7 (T₁P₁WOA) x 10⁴ for T₁ and 1.8 (T₂P₃WA) to 2.2 (T₂P₁WOA) x 10⁴ cfu /g for T₂ respectively at the end of the storage period of 180 days.

5.4.4.3 Sensory quality

No distinct variation was observed between the control and millet incorporated instant mix for the colour, flavour, texture, taste and overall acceptability and were highly acceptable in all the samples during initial period of storage. The final score for colour ranged between 8.3 (T₀P₁WOA) and 8.7 (T₂P₃WA), flavour ranged between 8.3 (T₀P₁WOA) and 8.6 (T₂P₃WA), texture ranged between 8.4 (T₀P₁WOA) and 8.6 (T₂P₃WA), taste ranged between 8.5 (T₀P₁WOA) and 8.7 (T₂P₃WA) and overall acceptability ranged between 8.5 (T₀P₁WOA) and 8.6 (T₂P₃WA) respectively.

5.4.5 Idiyapam mix

5.4.5.1 Chemical Constituents

The initial moisture content was 11.80, 10.70 and 10.00 for T₀, T₁ and T₂ g per 100g respectively irrespective of the packaging. The final moisture content after 180 days of storage ranged from 12.27 (T₀P₃WA) to 12.52 (T₀P₁WOA) for T₀, 10.97 (T₁P₃WA) to 11.10 (T₁P₁WOA) for T₁ and 10.55 (T₂P₃WA) to 10.67 (T₂P₁WOA) g per 100 g for T₂ respectively. The protein content was 5.00, 7.30 and 6.25g per 100g for T₀, T₁ and T₂ while that of the starch content of T₀, T₁ and T₂ were 69.00, 51.80 and 56.10g per 100g respectively irrespective of the packaging material. The final protein content ranged from 4.78 (T₀P₁WOA) to 4.84 (T₀P₃WA) for T₀, from 7.04 (T₁P₁WOA) to 7.14 (T₁P₃WA) for T₁ and 6.05 (T₂P₁WOA) to 6.14(T₂P₃WA) for T₂ while the final starch content ranged from 65.50 (T₀P₁WOA) to 68.64 (T₀P₃WA) for T₀, from 51.30 (T₁P₁WOA) to 51.47 (T₁P₃WA) for T₁ and from 56.50 (T₂P₁WOA) to 56.70 (T₂P₃WA) for T₂ g per 100g respectively. The initial fat content of T₀, T₁ and T₂ were 0.80, 1.00 and 1.80g per 100g respectively and after 180 days of storage, there was a slight reduction in the fat content and ranged from 0.69 (T₀P₁WOA) to 0.75 (T₀P₃WA) for T₀, from 0.85 (T₁P₁WOA) to 0.96 (T₁P₃WA) for T₁ and 1.67 (T₂P₁WOA) to 1.75 (T₂P₃WA) g per 100g for T₂ respectively. A slight increase in the free fatty acid and peroxide value was observed upon storage that varied with the packaging material. The initial crude fibre content of T₀, T₁ and T₂ were 0.60, 3.10 and 5.80g per 100g irrespective of the packaging and after 180 days of storage, the final crude fibre content had slight reduced and ranged between 0.51 (T₀P₁WOA) and 0.57(T₀P₃WA) for T₀, 3.00 (T₁P₁WOA) and 3.10 (T₁P₃WA) for T₁ and 5.66 (T₂P₁WOA) and 5.77(T₂P₃WA) for T₂ g per 100g respectively. The initial tannin content of T₀, T₁ and T₂ were 1.56, 4.80 and 5.00g per 100g and after 180 days of storage, a reduction was observed in the tannin content of all the samples irrespective of the treatment and packaging material. The initial ash content T₀, T₁ and T₂ were 1.20, 2.20 and 3.10g per 100g and after 180 days. The initial calcium content of T₀, T₁ and T₂ irrespective of packaging were 9.60, 30.00 and 26.00 while phosphorus was 138.10, 176.00 and 278.10mg per 100g for T₀, T₁ and T₂ respectively. The final value ranged between 9.46 (T₀P₁WOA) and 30.00 (T₁P₃WA) for calcium and 137.96 (T₀P₁WOA) and 278.08 (T₂P₃WA)mg per 100g for phosphorus respectively. The final iron content of T₀ ranged between 0.82 (T₀P₁WOA) 6.78 (T₂P₃WA) mg per 100g respectively which showed a non significant reduction upon storage.

5.4.5.2 Microbial load

Initially, there was no total plate count irrespective of the treatment and packaging material. The final total plate count T_0 ranged between 1.5 (T_0P_3WA) and 2.5 (T_0P_1WOA), T_1 ranged between 1.8 (T_1P_3WA) and 2.7 (T_1P_1WOA) and T_2 ranged between 1.8 (T_2P_3WA) and 2.2 (T_2P_1WOA) $\times 10^4$ cfu/g respectively.

5.4.5.3 Sensory quality

No distinct variation was observed between the control and millet incorporated instant mix for the colour, flavour, texture, taste and overall acceptability and were highly acceptable in all the samples during initial period of storage. The final score for colour ranged between 8.5 (T_0P_1WOA) and 8.7 (T_2P_3WA), flavour ranged between 8.3 (T_0P_1WOA) and 8.5 (T_2P_3WA), texture ranged between 8.2 (T_0P_1WOA) and 8.4 (T_2P_3WA), taste ranged between 8.4 (T_0P_1WOA) and 8.7 (T_2P_3WA) and overall acceptability ranged between 8.4 (T_0P_1WOA) and 8.6 (T_2P_3WA) respectively.

5.4.6 Kali mix

5.4.6.1 Chemical constituents

The initial moisture content of T_0 , T_1 and T_2 was 11.10, 10.50 and 10.20 g per 100g irrespective of the packaging material and after 180 days of storage, the final moisture content ranged from 10.50 (T_2P_3WA) to 11.70 (T_0P_1WOA) g per 100 g of the sample. The initial protein content of T_0 , T_1 and T_2 was 7.30, 11.60 and 9.20g per 100g irrespective of packaging materials which had reduced and ranged from 7.03 (T_0P_1WOA) to 7.18 (T_0P_3WA) for T_0 , from 9.37 (T_1P_1WOA) to 9.48 (T_1P_3WA) for T_1 and from 7.96 (T_2P_1WOA) to 8.08 (T_2P_3WA) for T_2 g per 100g respectively. The incorporation of small millet had significantly reduced the starch content of the kali mix as it is evident from the initial values of 66.50 (T_0), 55.30 (T_1) and 53.20 (T_2) g per 100g in all the packaging material. The final starch content ranged from 66.08 (T_0P_1WOA) to 66.22 (T_0P_3WA) for T_0 , from 54.84 (T_1P_1WOA) to 55.00 (T_1P_3WA) for T_1 and 52.75 (T_2P_1WOA) to 52.90 (T_2P_3WA) for T_2 g per 100g respectively. The initial fat content of T_0 , T_1 and T_2 irrespective of the packaging materials were 0.90, 1.30 and 1.80g per 100g respectively. The final fat content after 180days of storage ranged from 0.87 (T_0P_1WOA) to 1.75 (T_2P_3WA) g per 100g. A slight increase in the free fatty acid and peroxide value was observed upon storage that varied with the packaging material. The initial fibre content of T_0 , T_1 and T_2 in all the samples irrespective of the packaging material were 1.80, 4.80 and 6.50g per 100g respectively. The final crude fibre content ranged between 1.80 (T_0P_1WOA) and 6.47 (T_2P_3WA) g per 100 g of the

samples. The initial tannin content of T₀, T₁ and T₂ were 1.00, 1.90 and 2.00 g per 100g in all the packaging material respectively. The final tannin content ranged between 0.80 (T₀P₁WOA) and 1.97 (T₂P₃WA) g per 100g respectively. The initial ash content of T₀, T₁ and T₂ were 1.80, 2.00 and 2.10 g per 100 g irrespective of the packaging materials. The initial calcium content of T₀, T₁ and T₂ were 39.00, 54.90 and 52.50 while that of phosphorus was 167.00, 188.90 and 287.30mg per 100g respectively in all the packaging. The iron content of these samples were noted to be 2.30 (T₀), 3.10 (T₁) and 5.20 (T₂) mg per 100g in all the packaging material respectively which showed a non significant reduction upon storage.

5.4.6.2 Microbial load

Initially the total plate count in all the samples was found to be nil and as the storage day progressed, there was an increase in the microbial load. The final total plate count of T₀ ranged from 2.5 (T₀P₃WA) to 3.2 (T₀P₁WOA), T₁ ranged from 1.3 (T₁P₃WA) to 2.0 (T₁P₁WOA) and T₂ ranged from 1.7 (T₂P₃WA) to 2.7 (T₂P₁WOA) x 10⁴ cfu/ g respectively.

5.4.6.3 Sensory quality

No distinct variation was observed between the control and small millet incorporated instant mix for the colour, flavour, texture, taste and overall acceptability and were highly acceptable in all the samples during initial period of storage. The final score for colour ranged between 8.3 (T₀P₁WOA) and 8.6 (T₂P₃WA), flavour ranged between 8.3 (T₀P₁WOA) and 8.7 (T₂P₃WA), texture ranged between 8.5 (T₀P₁WOA) and 8.6 (T₂P₃WA), taste ranged between 8.3 (T₀P₁WOA) and 8.8 (T₂P₃WA) and overall acceptability ranged between 8.5 (T₀P₁WOA) and 8.7 (T₂P₃WA) respectively.

5.4.7 Paniyaram mix

5.4.7.1 Chemical constituents

The initial moisture content was 10.80, 9.80 and 9.60 for T₀, T₁ and T₂ g per 100g respectively. The final moisture content after 180 days of storage ranged from 11.10 (T₀P₃WA) to 11.30 (T₀P₁WOA) for T₀, 10.04 (T₁P₃WA) to 10.18 (T₁P₁WOA) for T₁ and 9.94 (T₂P₃WA) to 10.02 (T₂P₁WOA) g per 100g for T₂ respectively. The initial protein content was 8.30, 10.60 and 9.20 for T₀, T₁ and T₂ while that of the starch content of T₀, T₁ and T₂ were 63.20, 48.50 and 54.40 g per 100g respectively in all the packaging.

The final protein content ranged from 8.03 (T₀P₁WOA) to 8.18(T₀P₃WA) for T₀, from 10.37 (T₁P₁WOA) to 10.48 (T₁P₃WA) for T₁ and 8.96 (T₂ P₁WOA) to 9.08 (T₂P₃WA)

for T₂ while that of the final starch content was ranged from 62.78 to 62.87 (T₀), from 48.00 to 48.18 (T₁) and from 53.87 to 54.03 (T₂) g per 100g respectively. The initial fat content of T₀, T₁ and T₂ were 1.10, 1.20 and 2.90g per 100g respectively and after 180 days of storage, there was a slight reduction in the fat content and ranged from 0.98 (T₀P₁WOA) to 1.06 (T₀P₃WA) for T₀, from 1.05 (T₁P₁WOA) to 1.15 (T₁P₃WA) for T₁ and 2.78 (T₂P₁WOA) to 2.87 (T₂P₃WA) g per 100g for T₂ respectively. A slight increase in the free fatty acid and peroxide value was observed upon storage that varied with the packaging material. The initial crude fibre content of T₀, T₁ and T₂ were 1.20, 4.30 and 6.33g per 100g irrespective of the packaging and after 180 days of storage, the final crude fibre content was slightly reduced and ranged between 1.10 (T₀P₁WOA) and 1.18 (T₀P₃WA) for T₀, 4.15 (T₁P₁WOA) and 4.27(T₁P₃WA) for T₁ and 4.20 (T₂P₁WOA) and 4.30 (T₂P₃WA) for T₂ g per 100g respectively. The initial tannin content of T₀, T₁ and T₂ were 2.25, 3.10 and 3.80g per 100g and after 180 days of storage, a significant reduction was observed in the tannin content of all the samples irrespective of the treatment and packaging material. The initial ash content T₀, T₁ and T₂ were 1.20, 2.20 and 3.10 and after 180 days. The final values ranged from 1.16 (T₀P₁WOA) to 3.10 (T₂P₃WA) g per 100g respectively. The initial calcium content of T₀, T₁ and T₂ were 50.00, 58.90 and 51.78 while phosphorus was 120.30, 214.00 and 329.10mg per 100g for T₀, T₁ and T₂ respectively. The initial iron content was 1.89, 4.98 and 6.75 for T₀, T₁ and T₂ mg per 100g respectively which showed a non significant reduction upon storage.

5.4.7.2 Microbial load

Initially, there was no total plate count irrespective of the treatment and packaging material. The final total plate count T₀ ranged between 2.5 (T₀P₃WA) and 3.2 (T₀P₁WOA), T₁ ranged between 1.7 (T₁P₃WA) and 2.2 (T₁P₁WOA) and T₂ ranged between 1.5 (T₂P₃WA) and 2.5 (T₂P₁WOA) x10⁴ cfu/g respectively.

5.4.7.3 Sensory quality

No distinct variation was observed between the control and small millet incorporated instant mix for the colour, flavour, texture, taste and overall acceptability and were highly acceptable in all the samples during initial period of storage. The final score for colour ranged between 8.6 (T₀P₁WOA) and 8.6 (T₂P₃WA), flavour ranged between 8.4 (T₀P₁WOA) and 8.7 (T₂P₃WA), texture ranged between 8.6 (T₀P₁WOA) and 8.6 (T₂P₃WA), taste ranged between 8.4 (T₀P₁WOA) and 8.6 (T₂P₃WA) and overall acceptability ranged between 8.6 (T₀P₁WOA) and 8.6 (T₂P₃WA) respectively.

5.4.8. Roti mix

5.4.8.1 Chemical Constituents

The initial moisture content of T₀, T₁ and T₂ were observed to be 11.00, 10.70 and 9.35g per 100g which might be due to incorporation of small millets. The final moisture content ranged from 11.38 (T₀P₃WA) to 11.57 (T₀P₁WOA) in T₀, 10.96 (T₁P₃WA) to 11.15 (T₁P₁WOA) in T₁ and 9.74 (T₂P₃WA) to 9.83 (T₂P₁WOA) in T₂ g per 100g respectively. The incorporation of small millets had significantly increased the protein content as it is evident from the initial values of T₁, T₂ and T₀ as 12.25, 11.20 and 10.58g per 100g. The protein content after 180 days of storage ranged from 10.38 (T₀P₁WOA) to 10.43 (T₀P₃WA) for T₀, 11.98 (T₁P₁WOA) to 12.12 (T₁P₃WA) for T₁ and 10.98 (T₂P₁WOA) to 11.07 (T₂P₃WA) g per 100g for T₂. The starch content of the control was maximum (64.00 g) and the values decreased for the small millet based instant mixes as 55.80 (T₁) and 56.10 (T₂) g per 100g. The final starch content of the roti mix ranged from 63.55 (T₀P₁WOA) to 63.70 (T₀P₃WA) for T₀, 55.30 (T₁P₁WOA) to 55.40 (T₁P₃WA) for T₁ and 55.60 (T₂P₁WOA) to 55.72 (T₂P₃WA) g per 100g for T₂. The initial fat content of T₀, T₁ and T₂ irrespective of the packaging material was 0.65, 1.00 and 2.40g per 100g. After 180 days of storage, the final fat content ranged between 0.55 (T₀P₁WOA) to 0.62 (T₀P₃WA) for T₀, 0.87(T₁P₁WOA) to 0.97 (T₁P₃WA) for T₁ and 2.21 (T₂P₁WOA) to 2.35 (T₂P₃WA)g per 100g for T₂ respectively. A slight increase in the free fatty acid and peroxide value was observed upon storage that varied with the packaging material. The initial values of the crude fibre for T₀, T₁ and T₂ were 0.88, 5.55 and 6.12 while the tannin content for T₀, T₁ and T₂ were 4.25, 5.60 and 5.90 g per cent respectively irrespective of packaging. The initial ash content of T₀, T₁ and T₂ were observed to be 2.00, 2.30 and 2.50g per 100g irrespective of the packaging which might be due to incorporation of millets. Initially, the kodo millet flour roti mix recorded higher values for calcium (34.50mg /100g), phosphorus (180.20mg/100g) and iron (4.24mg/100g). The comparative values for barnyard millet flour roti mix were 25.20mg calcium, 288.50mg phosphorus and 6.90mg/100g iron during the initial storage period. A slight reduction in calcium, phosphorus and iron was observed during storage.

5.4.8.2 Microbial load

. The initial values for total plate count were nil. The total plate count showed slight elevation on storage and at the end of the storage period, it ranged between 2.1

(T₀P₃WA) to 3.2 (T₀P₁WOA) x 10⁴ for T₀, 1.5 (T₁P₃WA) to 2.5(T₁P₁WOA) x 10⁴ for T₁ and 1.8 (T₂P₃WA) to 2.5 (T₂P₁WOA) x 10⁴ cfu/g for T₂ respectively.

5.4.8.3 Sensory quality

No distinct variation was observed between the control and small millet incorporated instant mix for the colour, flavour, texture, taste and overall acceptability and were highly acceptable in all the samples during initial period of storage. The final score for colour ranged between 8.5 (T₀P₁WOA) and 8.6 (T₂P₃WA), flavour ranged between 8.2 (T₀P₁WOA) and 8.7 (T₂P₃WA), texture ranged between 8.4 (T₀P₁WOA) and 8.7 (T₂P₃WA), taste ranged between 8.4 (T₀P₁WOA) and 8.7 (T₂P₃WA) and overall acceptability ranged between 8.4 (T₀P₁WOA) and 8.7 (T₂P₃WA) respectively.

5.4.9 Halwa mix

5.4.9.1 Chemical Constituents

The initial moisture content of T₀, T₁ and T₂ was 11.50, 10.00 and 9.10g per 100g irrespective of the packaging material and after 180 days of storage, the final moisture content ranged from 9.37 (T₂P₃WA) to 12.00 (T₀P₁WOA) g per 100g. The initial protein content of T₀, T₁ and T₂ was 11.55, 10.20 and 9.40g per 100g irrespective of packaging materials which had reduced and ranged from 11.33 (T₀P₁WOA) to 11.44 (T₀P₃WA) for T₀, from 9.98 (T₂P₁WOA) to 10.08 (T₂P₃WA) for T₁ and from 9.18 (T₀P₁WOA) to 9.25 (T₀P₃WA) for T₂ g per 100g respectively. The incorporation of millet had significantly reduced the starch content of the halwa mix as it is evident from the initial values of 68.90 (T₀), 57.60 (T₁) and 55.50 (T₂) g per 100g irrespective of the packaging material. The final starch content ranged from 68.43(T₀P₁WOA) to 68.55 (T₀P₃WA) for T₀, from 57.12 (T₁P₁WOA) to 57.23 (T₁P₃WA) for T₁ and 55.00 (T₂P₁WOA) to 55.12 (T₂P₁WA) for T₂ g per 100g respectively. The initial fat content of T₀, T₁ and T₂ irrespective of the packaging materials were 0.90, 1.30 and 1.80g per 100g respectively. The final fat content after 180days of storage ranged from 1.52 (T₀P₁WOA) to 3.77 (T₂P₃WA) g per 100g. A slight increase in the free fatty acid and peroxide value was observed upon storage that varied with the packaging material. The initial fibre content of T₀, T₁ and T₂ in all the samples were 1.30,3.15 and 4.43 g per 100g respectively. The final crude fibre content ranged between 1.24 (T₀P₁WOA) and 4.40 (T₂P₃WA) g per 100g. The initial tannin content of T₀, T₁ and T₂ were 4.10, 5.20 and 4.45g per 100g in all the packaging material respectively. The final tannin content ranged between 4.00 (T₀P₁WOA) and 4.42 (T₂P₃WA)g per 100g respectively. The

initial ash content of T₀, T₁ and T₂ were 2.50, 2.80 and 3.40g per 100g irrespective of the packaging materials. The initial calcium content of T₀, T₁ and T₂ were 46.80, 32.60 and 24.80 while that of phosphorus was 348.00, 120.90 and 270.30 mg per 100g respectively. The iron content of these samples were noted to be 4.45 (T₀), 5.88 (T₁) and 6.45 (T₂)mg per 100g in all the packaging material respectively which showed a non significant reduction upon storage.

5.4.9.2 Microbial load

Initially the total plate count in all the samples was found to be nil and as the storage day progressed, there was an increase in the microbial load. The final total plate count of T₀ ranged from 2.7 (T₀P₃WA) to 3.1 (T₀P₁WOA), T₁ ranged from 1.5 (T₁P₃WA) to 2.2 (T₁P₁WOA) and T₂ ranged from 1.7 (T₂P₃WA) to 2.7 (T₂P₁WOA) x 10⁴ cfu/ g respectively.

5.4.9.3 Sensory quality

No distinct variation was observed between the control and small millet incorporated instant mix for the colour and appearance, flavour, texture, taste and overall acceptability and were highly acceptable in all the samples during initial period of storage. The final score for colour ranged between 8.4 (T₀P₁WOA) and 8.5 (T₂P₃WA), flavour ranged between 8.3 (T₀P₁WOA) and 8.6 (T₂P₃WA), texture ranged between 8.5 (T₀P₁WOA) and 8.5 (T₂P₃WA), taste ranged between 8.6 (T₀P₁WOA) and 8.7 (T₂P₃WA) and overall acceptability ranged between 8.5 (T₀P₁WOA) and 8.6 (T₂P₃WA) respectively.

5.4.10 Kesari mix

5.4.10.1 Chemical Constituents

The initial moisture content of T₀, T₁ and T₂ were observed to be 11.60, 9.80 and 8.90 g per 100g irrespective of the packaging material which might be due to incorporation of millets. The final moisture content ranged from 11.91 (T₀P₃WA) to 12.08 (T₀P₁WOA) in T₀, 10.25 (T₁P₃WA) to 10.40 (T₁P₁WOA) in T₁ and 9.22 (T₂P₃WA) to 9.47 (T₂P₁WOA) in T₂ g per 100g. The incorporation of small millets had significantly increased the protein content as it is evident from the initial values of T₁, T₂ and T₀ as 9.80, 8.28 and 7.85g per 100g irrespective of the packaging. The protein content after 180 days of storage ranged from 7.68 (T₀P₁WOA) to 7.73 (T₀P₃WA) for T₀, 9.60 (T₁P₁WOA) to 9.70 (T₁P₃WA) for T₁ and 8.04 (T₂P₁WOA) to 8.18 (T₂P₃WA)g per 100g for T₂. The starch content of the control was maximum (83.20 g) and the values decreased for the millet based instant mixes as 79.20 (T₁) and 79.30 (T₂)g per

100g. The final starch content of the kesari mix ranged from 82.72(T₀P₁WOA) to 82.80 (T₀P₃WA) for T₀, 78.72 (T₁P₁WOA) to 78.94 (T₁P₃WA) for T₁ and 78.82 (T₂P₁WOA) to 78.90 (T₂P₁WA) g per 100 g for T₂. The reduction in starch during storage might be due to the hydrolysis of starch. The initial fat content of T₀, T₁ and T₂ was 2.70, 3.20 and 4.00g per 100g irrespective of the packaging material. After 180 days of storage, the final fat content ranged between 2.56 (T₀P₁WOA) to 2.66 (T₀P₃WA) for T₀, 3.08 (T₁P₁WOA) to 3.17 (T₁P₃WA) for T₁ and 3.90 (T₂P₁WOA) to 3.97 (T₂P₃WA)g per 100g for T₂ respectively. A slight increase in the free fatty acid and peroxide value was observed upon storage that varied with the packaging material. The initial values of the crude fibre for T₀, T₁ and T₂ were 1.50, 4.17 and 5.53 while the tannin content for T₀, T₁ and T₂ were 3.50, 4.70 and 3.80g per 100g respectively irrespective of the packaging material. Significant increase in ash content was also observed with increase in level of incorporation of kodo millet and barnyard millet flour. The initial ash content of T₀, T₁ and T₂ were observed to be 1.80, 2.00 and 2.10g per 100g which might be due to incorporation of millets. The kodo millet flour kesari mix recorded higher values for calcium (25.40 mg /100g), phosphorus (122.95mg / 100g) and iron (5.00mg /100g). The comparative values for barnyard millet flour kesari mix were 21.25mg calcium, 270.55mg phosphorus and 6.00mg/100 g iron during the initial storage period irrespective of the packaging material. A slight reduction in calcium, phosphorus and iron was observed during storage.

5.4.10.2 Microbial load

The initial values for total plate count were nil. The total plate count showed slight elevation on storage and ranged between 3.2 (T₀P₃WA) to 2.5 (T₀P₁WOA) x 10⁴ for T₀, 1.7 (T₁P₃WA) to 2.7 (T₁P₁WOA) x 10⁴ for T₁ and 1.7 (T₂P₃WA) to 2.7 (T₂P₁WOA) x 10⁴ cfu/g for T₂ respectively at the end of the storage period.

5.4.10.3 Sensory quality

No distinct variation was observed between the control and millet incorporated instant mix for the colour and appearance, flavour, texture, taste and overall acceptability and were highly acceptable in all the samples during initial period of storage. The final score for colour ranged between 8.5 (T₀P₁WOA) and 8.7 (T₂P₃WA), flavour ranged between 8.4 (T₀P₁WOA) and 8.4 (T₂P₃WA), texture ranged between 8.4 (T₀P₁WOA) and 8.5 (T₂P₃WA), taste ranged between 8.6 (T₀P₁WOA) and 8.7 (T₂P₃WA) and overall acceptability ranged between 8.4 (T₀P₁WOA) and 8.6 (T₂P₃WA) respectively.

5.4.11. Total dietary fibre content of the small millet based instant food mixes

The total dietary fibre content of the kodo millet and barnyard millet food mixes were comparatively higher than control. Between the kodo millet and barnyard millet food mixes, the total dietary fibre content of the kodo millet food mixes were higher among the mixes developed. The total dietary fibre content of adai mix was the highest 21.50 (T₁) and 19.60 (T₂) g respectively, while the least was recorded in idli mix of both kodo millet and barnyard millet and the values being 13.10 (T₁) and 11.20 (T₂) g respectively.

5.5 CONSUMER ACCEPTABILITY OF THE DEVELOPED INSTANT MIXES

The developed ten different instant mixes *viz.*, idli mix, dosa mix, adai mix, pittu mix, idiyapam mix, kali mix, roti mix, paniyaram mix, halwa mix and kesari mix with 100 per cent incorporation kodo millet/ barnyard millet, which were found to possess highly acceptable nutritional and sensory qualities throughout the storage study period were taken for consumer acceptability on a large scale. To find out the consumer's acceptability of the developed mixes evaluation of the same was done by selecting 300 judges belonging to the age group 21- 50 years from Peraiyur Taluk, Madurai. A score card of four point hedonic scale for various attributes such as colour, texture, flavour, taste and overall acceptability was utilized.

Kodo millet mixes

The colour of the idli was adjudged to be very good by 46 per cent of the consumers, good by 30 per cent and fair and poor by 14 and 10 per cent respectively. The texture of idli was said to be very good by 44 per cent, good by 28 per cent, fair 20 per cent and poor 8 per cent of the consumers. The texture of idli was soft but not very fluffy; hence only 44 per cent of the consumers liked the product very much. Sixty per cent of the consumer had accepted the flavour, taste and overall acceptability to be very good, while 20 per cent had accepted to be good, fair 10 per cent and 10 per cent to be fair.

The colour of dosa prepared from the instant mix was expressed as very good by 52 per cent of the consumers, 24 per cent of the consumers expressed to be good, 16 per cent expressed as fair while 8 per cent indicated it to be poor. The texture stated to be very good only by 43 per cent of the consumers, while the rest 28, 17 and 12 per cent had indicated it to be good, fair and poor respectively. The flavour, taste and overall acceptability were stated to be very good, good and fair respectively for each attribute by 60, 20, 10 and 10 per cent of consumers. The lemon yellow colour of the adai as expressed by the consumers was rated to be very good by 75 per cent, good by 15 per cent and fair by 10 per cent of the consumers. The texture was liked to be very good

by only 60 per cent of them, while 20 per cent of them liked it to be good and 20 per cent of them liked it to be fair. About 75 per cent of the consumers rated the flavour, taste and overall acceptability of the product to be very good, while 15 per cent rated it as good and the rest of the five per cent rated it to be fair. The colour of the pittu was liked by majority of the consumers and 92 per cent of them scored it to be very good and 8 per cent of them to be good. The crumby texture of the pittu was scored to be very good by 92 per cent of the consumers and good by 8 per cent of the consumers. Ninety eight of the consumers scored for flavour and taste to be very good, while only 2 per cent of them indicated it to be good. Cent per cent of the consumers had indicated the overall acceptability of the product to be very good. Ninety one per cent of the consumers had indicted the colour of the idiyapam to be very good, while nine per cent said it to be good. Similarly the texture of the idiyapam was said to be very good by 91 per cent of them and good by 9 per cent of them. The flavour, taste and overall acceptability was said to be very good by 98 per cent and good by 2 per cent respectively. Cent per cent of the consumers liked the colour, texture, flavour, taste and overall acceptability of kali. Ninety eight per cent of the consumers rated the colour and texture of the roti to be very good, while two per cent alone had rated it to be good. Cent per cent of the consumer's rated flavour, taste and overall acceptability of the product to be very good. Ninety per cent of the consumers expressed the colour of the panyaram which was cream with golden brown tinch to be very good, while ten per cent of them indicated it to be good. The texture was rated to be very good by ninety per cent of the consumer's, while ten of them indicated it to be good. Ninety seven per cent of consumers had rated the flavour, taste and overall acceptability to be very good and three per cent of them had indicated it to be good. The colour of the halwa was said to be very good, only by 36 per cent of the consumers and 30 per cent of the consumer's said it to be good. Twenty four per cent of them said it to be fair and 10 per cent of them said it as poor. The texture of the halwa was stated to be very good by 34 per cent of them, good by 38 per cent of them, fair by 20 per cent of them and poor by 8 per cent of them which might be due to the absence of the characteristics extremely slippery texture of the product. The flavour, taste and overall acceptability was rated to be very good (50%), good (20%), fair (15%) and poor (10%) respectively for each attribute. Seventy five, fifteen and five per cent of the consumer's rated the colour of kesari to be very good, good, fair and poor. Seventy, fifteen and fifteen per cent rated the texture to be very good, good and fair respectively. Similarly 70 per cent of the consumer's had rated the flavour, taste and overall

acceptability to be very good, 20 per cent of them had given it to be good, while 10 per cent of them had indicated it to be fair.

Barnyard millet mixes

The colour of the idli was adjudged to be very good by 44 per cent of the consumers, good by 28 per cent and fair and poor by 20 and 8 per cent respectively. The texture of idli was said to be very good by 42 per cent, good by 25 per cent, fair 18 per cent and poor 15 per cent of the consumers. Fifty eight per cent of the consumer had accepted the flavour, taste and overall acceptability to be very good, while 18 per cent had accepted to be good, fair 12 per cent and 12 per cent to be poor. The colour of dosa prepared from the instant mix was expressed as very good by 50 per cent of the consumers, 22 per cent of the consumers expressed to be good, 17 per cent expressed as fair while 12 per cent indicated it to be poor. The texture was stated to be very good only by 40 per cent of the consumers, while the rest 26, 20 and 14 per cent had indicated it to be good, fair and poor respectively. The flavour, taste and overall acceptability were stated to be very good, good and fair respectively for each attribute by 58, 18, 12 and 12 per cent of consumers. The mean scores were 3.91 (flavour), 3.89 (taste) and 3.91 (overall acceptability). The lemon yellow colour of the adai as express by the consumers was rated to be very good by 70 per cent, good by 15 per cent and fair by 15 per cent of the consumers. The texture was liked to be very good by only 55 per cent of them, while 25 per cent of them liked it to be good and 20 per cent of them liked it to be fair. About 70 per cent of the consumers rated the flavour, taste and overall acceptability of the product to be very good, while 15 per cent rated it as good and the rest of 15 per cent rated it to be fair.

The colour of the pittu was liked by majority of the consumers and 90 per cent of them scored it to be very good and 10 per cent of them to be good. The crumbly texture of the pittu was scored to be very good by 90 per cent of the consumers and good by 10 per cent of the consumers. Ninety of the consumers scored for flavour and taste to be very good, while only ten per cent of them indicated it to be good. Cent per cent of the consumers had indicated the overall acceptability of the product to be very good. Eighty eight per cent of the consumers had indicted the colour of the idiyapam to be very good, while twelve per cent said it to be good. Similarly the texture of the idiyapam was said to be very good by 88 per cent of them and good by 12 per cent of them. The flavour, taste and overall acceptability was said to be very good by 88 per cent and good by 12 per cent respectively. Cent per cent of the consumer's liked the

colour, texture, flavour, taste and overall acceptability of kali. Ninety five per cent of the consumers rated the colour and texture of the roti to be very good, while five per cent alone had rated it to be good. Cent per cent of the consumer's rated flavour, taste and overall acceptability of the product to be very good. Eighty eight per cent of the consumers expressed the colour of the paniyaram which was cream with golden brown tinch to be very good, while twelve per cent of them indicated it to be good. The texture of the paniyaram was rated to be very good by eighty eight per cent of the consumers, while twelve of them indicated it to be good. Ninety five per cent of consumers had rated the flavour, taste and overall acceptability to be very good and five per cent of them had indicated it to be good. The colour of the halwa was said to be very good, only by 34 per cent of the consumers and 28 per cent of the consumer's said it to be good. Twenty six per cent of them said it to be fair and 12 per cent of them said it as poor. The texture of the halwa was stated to be very good by 36 per cent of them, good by 34 per cent of them, fair by 22 per cent of them and poor by 8 per cent of them which might be due to the absence of the characteristics extremely slippery texture of the product. The flavour, taste and overall acceptability was rated to be very good (45%), good (25%), fair (15%) and poor (10%) respectively for each attribute. Seventy, twenty and ten per cent of the consumer's rated the colour of kesari to be very good, good, fair and poor. Sixty five, twenty and fifteen per cent rated the texture to be very good, good and fair respectively. Similarly 65 per cent of the consumer's had rated the flavour, taste and overall acceptability to be very good, 20 per cent of them had given it to be good, while 15 per cent of them had indicated it to be fair. The results of the consumer's acceptability revealed that kali and roti were the highly preferred products followed by pittu, idiyapam, adai, kesari, dosa, idli and halwa. The product tested gave high potential for commercialization and marketability.

5.6 IMPACT OF THE DEVELOPED MIXES THROUGH NUTRITION EDUCATION

Nutrition education programme specially aimed to improve the knowledge regarding the nutritional significance of the millets, nutrient composition of barnyard millet and kodo millet, health benefits of small millets, product diversification of small millets, general hygiene and sanitation and usage of millet products as a dietary component was conducted. The feasibility of using millet based products in daily dietaries and use of millet based instant mixes was also included as a major theme in the nutrition education programme in the form of hands on training in the method of preparation of instant mixes which was given over a six months period of study.

This brought about considerable positive changes in knowledge, attitude and practice among the rural women and the information related to this aspect is presented below

5.6.1 Changes in nutrition knowledge

Before nutrition education, 53 per cent of the rural women obtained a very low score of 0-25 followed by 33 per cent of the rural women having a score of 26-50, only 10 per cent and 7 per cent of the women had scores of 51-75 and 76 -100 respectively. After nutrition education 72 per cent of the women scored maximum scores 76-100, 23 per cent of the women had knowledge scores ranging from 51-75. Around three and two per cent of the women had obtained scores from 26-50 and 0-25 respectively.

5.6.2 Changes in attitude of the women

After nutrition education, all of them realised the state of health is related to food and illness is due to ill balance diet. Initially, only three of them had the attitude that mixed diet provides all the nutrients but after participating in nutrition education, all women understood that only a mixed diet provides all the nutrition. The impact of nutrition education indicated that all 120 of them had developed a positive attitude towards the nutritional significance of kodo millet and barnyard millet. Nutrition education had brought about a remarkable change in the attitude of the participants regarding the relation between millets and life style disorders. After nutrition education, 120 of them indicated that hands should be properly washed following the six steps of hand washing before handling food and after using the washroom. Nutrition education had changed the scenario where all 120 of them developed the positive attitude of using potable drinking water in clean containers. All 120 of them accepted to have regular bath, proper nail and hair care. After nutrition education, all of them (120) accepted the need of soak pit and safe kitchen disposal. After nutrition education, 120 of them accepted for the presence of proper drainage and need for maintaining of personal hygiene.

5.6.3 Attitude of the rural women towards millet product diversification, usage of millet products and self employment

After nutrition education, the subjects accepted that all millet can be used as a food in their daily diet and are tasty and cheap and all of them accepted that millets can be used in preparation of idli, dosa and the like. After nutrition education, all 120 of them accepted the use of millets in sweets and malted millets in foods. Nutrition education had brought about a change in their attitude indicating that the millets can be used millet flakes and popped products. After nutrition education sessions all the rural

women were aware of the possibility of using millet flour like wheat flour and also the preparation of small millet based instant food mixes. But after nutrition education all of them were very happy to accept that it is easy to prepare tasty small millets based idli, dosa, adai, pittu, idiyapam, kali, roti, paniyaram, halwa and kesari from the instant mixes than by conventional method. After nutrition education, all 120 of them developed a positive attitude towards small millet based instant food mixes as a tool for self employment and income generation.

5.6.4 Changes in the practices of the rural women

After nutrition education, all of them started using millet in their daily diet and as a breakfast food, initiated to use millet flour for the preparation of chappathi, roti, puri and their like as that of wheat flour. After nutrition education, all of them cultivated the habit of using kali and porridge daily, and all of them practiced using only instant mixes for the preparation of millet based food. After nutrition education indicated that all of them had put into the practice of using flaked and popped millet products. After nutrition education, eighty eight of them had become self employment by processing millet based instant mixes and fifty three of them had started generating income from it. These observation on knowledge, attitude and practice are indicative of the possibility of commercializing millet based instant mixes among population groups.

5.7 COST ANALYSIS

It was found that the unit cost of production of instant idli mix for T₀, T₁ and T₂ were Rs. 7.33, Rs. 6.83 and Rs.6.33 per 100 g respectively. The cost of production of 100 g of dosa mix was found to be Rs.7.13, Rs. 6.63 and Rs. 6.13. T₀, T₁ and T₂ of 100 g of adai mix was worked out to be Rs. 8.78, Rs. 8.23 and Rs. 7.78 while that of pittu mix was Rs. 5.38, Rs. 4.88 and Rs. 4.38 respectively. The cost of production of 100 g of the control idiyapam mix was Rs. 5.38, kodo millet mix was Rs. 4.88 and barnyard millet mix was Rs. 4.38. The unit cost of production of instant kali mix for T₀, T₁ and T₂ were Rs. 5.63, Rs. , Rs. 5.13 and Rs.4.63 per 100 g respectively. The cost of production of 100 g of paniyaram mix was found to be Rs.7.13, Rs. 6.63 and Rs. 6.13. T₀, T₁ and T₂ of 100 g of roti mix was worked out to be Rs. 6.58, Rs. 6.08 and Rs. 5.58 while that of halwa mix was Rs. 5.86, Rs. 4.86 and Rs. 4.36 respectively. The cost of production of 100 g of the control kesari mix was Rs. 5.36, kodo millet mix was Rs. 4.86 and barnyard millet mix was Rs. 4.36. This showed that the millet based instant food mixes not only exerted a therapeutic effect but also less expensive.

The valid conclusion drawn from the present investigations are highlighted

- A mixed socio economic profile existed among the selected subjects. The health profile of the majority of the respondents were normal.
- The expenditure pattern on food of the selected subjects exhibited a mixed pattern irrespective of the socio economic status.
- Though the selected area was millet growing area, the consumption pattern of millet among the selected subjects were poor.
- Hundred per cent incorporation of kodo millet and barnyard millet was highly suitable for standardization of small millet based instant food mixes such as idli, dosa, adai, pittu, idiyapam, kali, paniyaram, roti, halwa and kesari.
- Incorporation of millet had significantly increased the protein, ash, minerals, crude fibre and dietary fibre content while a decrease in starch was observed in all the developed instant food mix.
- The instant mixes had a shelf life of 180 days when packed in MPP along with antioxidant with highly acceptable quality attributes.
- Consumer acceptability revealed that most preferred instant mix was kali, pittu, roti, paniyaram, idiyapam, adai, kesari, dosa, idli and halwa.
- Nutrition education had brought about a significant impact in the change on the Knowledge, Attitude and Practice of nutritional significance of small millets, usage of small millet products, improved the millet consumption pattern and processing of small millet products as a tool for self employment and income generation.
- The millet based instant food mixes not only exerted a therapeutic effect but was also less expensive.

Further research on standardizing small millet based instant food mixes to suit regional preferences, pre cooked instantize, agglomerate foods, and ready to eat foods from small millet with wider application to serve as a convenience and breakfast food is recommended which when developed and popularized such foods with their multi dimensional applications will no doubt be a boon for sustainable human resource development in future.

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11.1.2013

INSTITUTIONAL ETHICS CLEARANCE CERTIFICATE

The First Institutional Ethics Committee of TNAU reviewed the Project Proposal on "*Revalorizing small millets: Enhancing the food and nutritional security of women and children in rainfed regions of South Asia using underutilized species*" submitted by Dr. D. Malathi, Professor (FSN) and Principal Investigator of the project funded by CIDA - IDRC - CIFSRF, Canada.

The Committee has awarded the Ethics Clearance for the project and permitted her to carry out the following works:

1. To study the bioavailability of the small millet based products (Cookies, bread and porridge) using albino rats / human subjects.
2. Evaluation of the antidiabetic effect of small millets using albino rats / human subjects
3. To study the health and knowledge impact of selected functional foods involving Survey on nutritional and socio economic status, anthropometric, clinical, dietary survey and Biochemical estimation.
4. Nutrition education survey on Knowledge Attitude Practice (KAP) before and after the nutrition education


Member Secretary
(Institutional Ethics Committee)

APPENDIX II

Interview schedule to elicit information on socio economic and health profile of the rural women

1. Name of the respondent :
2. Address :
3. Type of family : Joint/nuclear
4. Family size : 1-3 Members
4-6 Members
>6 Members
5. Religion : Hindu/Christian/Muslim

6. Education and occupational status of the rural women

S.No	Age	Educational qualification	Occupation	Monthly income

7. Do you have own land? : Yes/No
If yes, total acres of land :
8. Do you have any Domestic animals? : Yes/No
If yes, specify :
9. Type of House : Own/ Rent
 - a. Shed thatched
 - b. Mud walled and thatched
 - c. Brick wall and tiled
 - d. Concrete house
 - e. Concrete and double storied
- a. Does the household utilised electricity? : Yes/No
- b. Do you have proper toilet facilities? : Yes/No
If yes, specify : Own/public/open area
- c. Source of drinking water : Own well/public tap/public well/pond
10. Personal habits
 - a. Do you or any member of the family : Chewing tobacco/chewing betel leaf/snuffy/nil
have the habit of
11. Do you have any health facilities in : Yes/No
your locality?
If yes, specify : PHC/Private Hospital/Government Hospital

12. Monthly expenditure pattern of the selected subjects

Expenditure	Amount spent/month	Percentage of total income
Food		
Clothing		
Rent		
Education		
Health		
Fuel		
Transport		
Remittance		
Recreation		
Savings		

13. Details on morbidity and mortality

- a. Have you or any member : Yes/No
suffered from any illness during
the last one year?
Specify the illness : Fever/cough/cold/diarrhoea/dysentery/other
conditions
- b. Epidemic prevalent in the : Measles/chicken box/Typhoid/whooping
locality in the past one year cough/Mumps
- c. Do you or any member used : Yes/No
any deworming treatment
during the past one year?

14. Anthropometric measurements

Name of the respondent	Age	Weight (Kg)	Height (cm)	BMI	MUAC	WHR	Per cent body fat

15 Biochemical assessment

Haemoglobin (g/dl) :

Random Blood glucose (mg/dl) :

16. Details about food habit and meal pattern

- a. Are you : Vegetarian/ non vegetarian
- b. Do you plan your meals in : Yes/No
advance
- c. No. of meals per day : Two/Three/Four
- c. Do you keep the time schedule : Yes/No
for taking meals

APPENDIX - III

Millet consumption pattern of the rural women

I. Details about millet consumption

- 1 Most consumed millets : Sorghum/ Kodo millet / Finger millet/ Little millet /Foxtail millet /Pearl millet /Barnyard millet/ Proso millet
- 2 Preferred method of cooking : Boiling/ Steaming/ Roasting/ Shallow fat frying/ deep fat frying
- 3 Form of use of millets : Whole grain/Millet rice
4. Millets by products : Millet flour/ Popped millet/ Flaked millet/ Germinated millet/ Malted millet flour
- 4 Conventional millet based products preparation : Idli/ Dosai/ Pittu /Idiyapam /Kali/Porridge /Paniyaram/ Roti/ Dessert /Adai/ Health mix
- 5 Preparation of millet savouries : Murukku/Omapodi/ karasev/Pakoda
- 6 Preparation of millet sweet meat : Halwa /Kesari/Payasam/Sweet appam
- 7 Consumption of millet based convenience foods. : Bun/Bread/Biscuits/Noodles
- 8 Aptitude to purchase instant mixes : Idli/dosa mix/Adai mix/Pittu mix/Idiyapam mix/Kali mix
Roti mix/Paniyaram mix/Halwa mix/Kesari mix
- 9 Storage of millet grains : Earthen pot/Gunny bag
- 10 Storage of millet by products : Plastic containers/Glass containers/ Stainless steel containers/ Polypropylene bags

II. Frequency of millets consumption

Food items	Daily	W3	W2	W1	M2	M1	Occasionally
Sorghum							
Kodo millet							
Food items	Daily	W3	W2	W1	M2	M1	Occasionally
Finger millet							
Little millet							
Foxtail millet							
Pearl millet							
Barnyard millet							
Proso millet							

III. Frequency of millets purchase

Food items	Daily	Weekly	Once in fortnight	Monthly	Once in six months	Annually	Occasionally
Sorghum							
Kodo millet							
Finger millet							
Little millet							
Foxtail millet							
Pearl millet							
Barnyard millet							
Proso millet							

IV. Three days dietary recall for 24 hours.

Meal time	Menu	Amount per serving	Day I	Day II	Day III
Early Morning					
Break Fast					
Lunch					
Tea time					
Dinner					

APPENDIX - IV

Score card for organoleptic evaluation of the standardized products

Characteristics	Scores			T₀	T₁	T₂
Colour	9 8 7	6 5 4	3 2 1			
	Highly acceptable	Not acceptable				
Texture	9 8 7	6 5 4	3 2 1			
	Highly acceptable	Not acceptable				
Flavour	9 8 7	6 5 4	3 2 1			
	Highly acceptable	Not acceptable				
Taste	9 8 7	6 5 4	3 2 1			
	Highly acceptable	Not acceptable				
Overall acceptability	9 8 7	6 5 4	3 2 1			
	Highly acceptable	Not acceptable				

APPENDIX –VI
PROCEDURE OF CHEMICAL ANALYSIS

Moisture

The moisture content of the sample was estimated by hot air oven method as per the procedure given by AOAC (2000). The sample was dried at 110°C and the drying was continued till a constant reading was obtained. The moisture content was expressed as percentage.

Protein

Protein was analysed by micro Kjeldhal method. One gram of the sample was weighed and transferred to a digestion flask. Three grams of catalyst mixture 5:1 ratio (sodium sulphate and copper sulphate) and ten ml of concentrated sulphuric acid were added to the digestion flask. The sample was digested till the solution became colourless. The digest was then cooled and transferred to the distillation flask. Then the sodium hydroxide (40 %) and boric acid (4 %) was placed in separate beakers. The digested sample was treated with the boric acid sodium hydroxide. After collected the solution was titrated against standard (0.1 N hydro chloric acid) acid till the appearance of red colour as the end point. The same procedure was repeated for a reagent blank. The nitrogen content of the sample can be obtained by this method. The nitrogen value was multiplied by a factor, 6.25 to give the crude protein content of the sample (Ranganna, 1995).

Starch

The starch content was analysed by a method described by Sadasivam and Manickam (2008). A sample of 100 mg was homogenized in hot 80% (80 ml ethanol + 20 ml water) ethanol to remove sugar, centrifuged and retained residue. The residue was washed repeatedly with hot 80% ethanol till the washings did not give colour with anthrone reagent. The residue was dried over a water bath. Five ml of water and 6.5 ml of 52% perchloric acid were added to the residue. The sample was extracted at 0°C for 20 min, centrifuged and saved the supernatant. The extraction was repeated using fresh perchloric acid. The sample was centrifuged and the supernatant was collected and made upto 100 ml. Samples of 0.1 or 0.2 ml was pipetted out from the supernatant and made upto a volume of 1 ml with distilled water. Standards were prepared by taking 0.2, 0.4, 0.6, 0.8 and 1 ml of the working standard and made up the volume to 1 ml in each tube with water. Four ml of anthrone reagent were added to each tube then heated for eight minutes in a boiling water bath. It was then cooled rapidly and read at the intensity of green to dark green

colour at 630 nm. The amount of starch present in the sample tube was calculated from the graph.

Fat

The fat content of the samples was estimated using the method given by AOAC (1995). Two gram of sample was taken in a thimble. Then the thimble was kept inside the known quantity of petroleum ether (60-80° C) in the soxhlet flask put on the mantle, connected with the apparatus and operated for 2 hours at 100-180⁰C for complete extraction of fat. Finally the recovered oil along with the flask was weighed and the amount of fat present in the sample was expressed in terms of gram.

Free fatty acid

The free fatty acids of fat extracted from the sample were determined as per the method described in AOAC (1995). A weighed quantity of the sample (fat extracted from the sample) was dissolved in 50 ml of neutral 95 per cent alcohol by heating to boiling. The solution was titrated against 0.1 N KOH. The free fatty acid was expressed as mg KOH/g of fat.

Peroxide value

The peroxide value of fat extracted from the sample was determined as per the method described in AOAC (1995). Oil obtained from the sample was taken in a clean dry boiling tube and 1.0 g of powdered potassium iodide and 20 ml of solvent mixture was added to it. The tube was heated for 30 seconds to boil and then transferred into a conical flask containing 20 ml of 5.0 per cent potassium iodide solution. The tube was then washed twice with 25 ml of water and titrated against N/50 sodium thiosulphate solution until the disappearance of yellow colour. Then 0.5 ml of starch was added to it and titrated against N/50 sodium thio sulphate solution till the colour disappears. A blank was also set at the same time and peroxide value was expressed as meq/kg of fat.

Crude fibre

The crude fibre content was determined by the method described by Maynard (1970). The dried sample was taken in a beaker and 200 ml of 1.25 per cent sulphuric acid was added and boiled for 30 min. The content was filtered through muslin cloth and washed with distilled water until washing were no longer acidic. The residue was transferred into the same beaker and boiled with 1.25 per cent, NAOH for 30 min and filtered through muslin cloth, washed with 50 ml distilled water and 25 ml of alcohol. The residue was transferred into a preweighed silica crucible, dried for 2-4

hrs at 130⁰C, cooled and weighed. It was ignited and ashed for 30 min at 600⁰C, cooled and weighed. The loss in weight on ignition was expressed in percentage.

Dietary fibre

The soluble, insoluble and total dietary fibre content was determined by the method described by Johansson *et al.*, (1983). To the fat extracted sample (~ 1g), 15.0 ml of phosphate buffer (0.1M, pH 6.0) was added. Termamyl (0.1ml) was added while keeping it in water bath for 30 min with occasional stirring. The contents were cooled, 20 ml water added and pH adjusted to 1.5 with HCl (4N). Pepsin (100 mg) was added and incubated in a shaking water bath at 37⁰C for 1 h. The contents were again cooled, 20 ml water added and pH adjusted to 6.8 with sodium hydroxide (4M). It was then incubated by the addition of pancreatin (100 mg) for 1 h at 40⁰C. Finally, the contents were cooled and pH adjusted to 4.5 with HCl (4N) and filtered through a dried and weighed crucible containing 0.5 g of celite. (Drying and weighing of crucible with celite was done by adding 0.5 g of celite into the crucible and washing it with 20 ml of 95% ethanol and 20 ml of acetone. It was then dried in oven at 105⁰C for 30 min and weighed).

The residue (insoluble fiber) retained on the crucible was washed with 20 ml of 95% ethanol and 20 ml of acetone. The crucibles were dried at 105⁰C overnight and weight taken.

To the filtrate (soluble fiber); 4 volumes of 95% ethanol was added and kept at room temperature for 1 h for precipitation. The precipitation was filtered through dried and weighed crucible containing celite as before and washed with 20 ml of 95% ethanol & 20 ml acetone. Crucibles were dried at 105⁰C overnight and weighed.

Blank was processed as above without sample. The crucibles were incinerated at 500⁰C in a muffle furnace for 6-8 h.

Insoluble or soluble dietary fiber was calculated using the formula

$$\text{Weight after drying} = \frac{\text{Weight after incineration} - \text{blank}}{\text{Weight of the sample (g)}} \times 100$$

Tannin

The tannin content in the sample was determined as per the method described by Sadasivam and Manickam (1996). The powdered sample of 0.5g was transferred to a 250ml conical flask. To it 75ml water was added and heated gently for 30 min, then centrifuged at 2,000 rpm for 20 min and supernatant was collected in 100ml volumetric

flask and the volume was made up. One ml of the sample extract was transferred to 100ml volumetric flask containing 75ml water to it 5ml of folin-denis reagent and 10ml of sodium carbonate solution were added and made up to 100ml with water. The absorbance was read at 700nm after 30 min. A blank was prepared with water. Standard solution was prepared by diluting 5ml of stock solution to 100ml with distilled water. The standard graph was prepared by using 10-100µg tannic acid. The tannin content of the sample was calculated as tannic acid equivalents from the standard graph.

Ash

Ash content of sample was determined as per the method described by AOAC (1995). Five gram of sample was accurately weighed in crucible, placed on a wire gauge and heated first over low flame till material completely charred. The material was then ashed at 500 – 600°C in muffle furnace for 4 hours until white ash was obtained. Crucible was cooled in the desiccators and the ash content was calculated and expressed as gram.

Preparation of ash solution for the estimation of calcium, phosphorus and iron

Five gram of sample was ashed, acid digested and filtered through whatman No.41 filter paper. The filtrate was made upto 100 ml using distilled water and the ash solution was used for the estimation of calcium, phosphorus and iron.

Calcium

Two ml of the prepared ash solution and calcium standard were taken in duplicates. One ml of ammonium oxalate was added to each test tube. The solution was allowed to stand for 30 minutes with shaking at intervals and centrifuged. The supernatant was discarded and 2 ml of 1 N sulphuric acid was added and kept in the boiling water bath for 8 min and then the hot solution was titrated against 0.021 N potassium permanganate. The difference between the two titration indicated the volume of potassium permanganate required to titrate the oxalic acid formed from calcium oxalate. The result was expressed as mg of calcium per 100 g of sample (Clark and Collip, 1925).

Phosphorus

Two ml of ash solution was taken in duplicates. One ml of ammonium molybdate was added and the volume was made up to 9.6 ml with double distilled water. To this, about 0.4 ml of Amino Naphthal Solphonic Acid (ANSA) was added and mixed well and allowed to stand for 30 minutes and read at 660 nm. One to five ml of standard phosphorus solution was taken in 5 test tubes and a blank was prepared simultaneously, to all the test tubes, ammonium molybdate, distilled water and ANSA

were added and the reading was taken as in the case of sample. The percentage of phosphorus was calculated using the standard phosphorus graph (Fiske and Subbarow, 1925).

Iron

Two ml of ash solution was taken in a test tube to which one ml of saturated potassium sulphate and one ml of 30 per cent sulphuric acid were added and made upto 8.5 ml with double distilled water. About 1.5 ml of 3 N potassium thiocyanate was added to the test tube for colour development. The intensity of colour was read at 530 nm in a colorimeter. The mg percent of iron was calculated by the values in the iron standard graph (Wong, 1928).

APPENDIX- VII

Score card for consumer acceptability of the kodo millet and barnyard millet instant food mixes

Criteria	Scores	Kodo millet instant food mixes	Barnyard millet instant food mixes
Colour			
Very good	4		
Good	3		
Fair	2		
Poor	1		
Texture			
Very good	4		
Good	3		
Fair	2		
Poor	1		
Flavour			
Very good	4		
Good	3		
Fair	2		
Poor	1		
Taste			
Very good	4		
Good	3		
Fair	2		
Poor	1		
Overall acceptability			
Very good	4		
Good	3		
Fair	2		
Poor	1		

APPENDIX- VIII

PROFOMA FOR NUTRITIONAL KNOWLEDGE OF THE RURAL WOMEN

1. Which foods or food items should be eaten daily
 - a) Rice, Vegetables/green leafy vegetables b) Dhal, milk, fruits and fleshy foods
 - b) Do not know
2. Why should we eat food daily
 - a) To give us energy b) Growth c) Maintenance d) Do not know
3. Name the food that gives us energy
 - a) Starchy foods b) Protein foods c) Starch and fat d) Do not know
4. Mention the method of cooking cereals
 - a) Boiling b) Frying c) Steaming d) Do not know
5. Mention the method used for cooking pulses
 - a) Boiling b) Frying c) Steaming d) Do not know
6. What is the best method for cooking vegetables?
 - a) Boiling b) Frying c) Steaming d) Do not know
7. Suggest the best method for cooking green leafy vegetables?
 - a) Boiling b) Frying c) Steaming d) Do not know
8. Do you wash vegetables before cutting?
 - a) Yes b) No
9. What size do you cut the vegetables?
 - a) Small pieces b) Big pieces c) Minced
10. Do you include salads in your daily diet?
 - a) Yes b) No c) Do not know
11. Do you germinate pulses/ millets?
 - a) Yes b) No c) Do not know
12. How do you include the germinated pulses/ millets in your daily diet?
 - a) Salad b) Any other c) Do not know
13. Millets are rich source of
 - a) Starch b) Fibre c) Minerals d) Do not know
14. Mention names of two fibre rich cereal grains _____
15. Have you heard of millets that grow in your area
 - a) Yes b) No

16. What Millets do you consume?

- a) Ragi b) Bajra c) Samai d) Thenai
e) Sorghum f) Barnyard millet g) Kodo millet h) any other

17. What is the common method used for cooking small millets?

- a) Boiling b) Roasting c) Frying d) Steaming e) Do not know

18. How often do you prepare millet based foods?

- a) Daily b) Alternate days c) Once in a week d) Once in 15 days
e) Once in a month g) Not at all

19. In what form do you include millets in your regular diet?

- a) Snacks foods b) Breakfast food c) Dinner
d) Lunch e) Do not know

20. Do you have any special occasions for using the millet based foods?

- a) Yes b) No c) Do not Know

21. Do you think that millets are good for our health?

- a) Yes b) No

22. Calcium and phosphorus required for bone health

- a) Yes b) No

23. Kodo millet rich

- a) Calcium and phosphorus b) Fibre c) Do not know

24. Iron deficiency causes

- a) Anaemia b) Protein energy malnutrition c) Do not know

25. Constipation occur due to lack of

- a) Fibre b) Starch c) Do not know

26. Kodo millet and barnyard millet are rich in fibre and prevents constipation

- a) Yes b) No

27. Barnyard millet and kodo millet prevents diabetes

- a) Yes b) No

29. Hands should be wash properly before handling food

- a) Yes b) No

30. Six steps of hand washing should followed

- a) Yes b) No

31. Hands should be washed after using the wash room

- a) Yes b) No

32. Use portable drinking water
a) Yes b) No
33. Stored the drinking water in clean containers
a) Yes b) No
34. Have a regular bath and tooth care
a) Yes b) No
35. Take care of the nails and hair properly
a) Yes b) No
36. Open defecation should not practiced
a) Yes b) No
37. Soak pit should be present in every house
a) Yes b) No
38. Safe disposal of kitchen waste is necessary
a) Yes b) No
39. Proper drainage should be present in every house
a) Yes b) No
40. Maintain personal hygiene to avoid communicable disease.
a) Yes b) No

APPENDIX – IX

Proforma for assessing attitude regarding small millet utilization among the rural women

Attitude	Yes	No	Don't know
Health is directly related to food Adequate diet improves health Mixed diet provide all the nutrient Millet is good for health Millet has vitamins and minerals Millet contains fibre Kodo millet and barnyard millet can be used in daily diet Calcium and phosphorus required for bone health Kodo millet rich in calcium and phosphorus Iron required for blood health Iron deficiency causes anaemia Barnyard millet is rich in iron Constipation occur due to lack of fibre Kodo millet and barnyard millet are rich in fibre and prevents constipation Diabetic due to high carbohydrate diet Increased consumption of rice causes diabetes Carbohydrate content of barnyard millet and kodo millet is low Sugar is high glycemic index foods Barnyard millet and kodo millet are low glycemic foods Barnyard millet and kodo millet prevents diabetes Hypertension is influenced by the cholesterol content Increase in cholesterol is also due to consumption of refined foods. Barnyard and kodo millet have hypocholesterlemic effect. Consumption of barnyard millet and kodo millet reduce the hypertension Foods rich in antioxidants prevent cancer Kodo millet and barnyard millet are rich in antioxidants and prevent cancer Hands should wash properly before handing food Six steps of hand washing should followed Hands should be washed after using the wash room Use portable drinking water Stored the drinking water in clean containers Have a regular bath and tooth care Take care of the nails and hair properly Open defecation should not practiced Soak pit should be present in every house Safe disposal of kitchen waste is necessary Proper drainage should be present in every house Maintain personal hygiene to avoid communicable disease.			

APPENDIX - X

Proforma for assessing attitude of the rural women towards millet diversification

Attitude	Yes	No	Neutral
All small millets can be used as food			
Millet should be a part of daily menu			
Millet are tasty and cheap			
Millet can be used in preparation of regular breakfast foods (Idli, dosa, idiyappam, pittu, adai)			
Millet can be used for the preparation of kali and porridge in daily diet			
Millet can be used for the preparation of sweet meat			
Millet can be malted and use			
Millet can be puffed and used as a snack food			
Millet flaked can also be used like rice flakes			
Millet flour can be used like wheat flour			
Instant idli, dosa, adai and kali mix can be prepared from millets			
Varieties of product can be prepared instant mixes			
Products can be easily prepared from instant mixes			
Instant millet products are tasty and cheap			
Training on instant mixes paves way for self employment			
Processing of millet based instant mixes can be income generating activity			
Instant millet mix enterprise is a promising enterprise for women during non crop season.			
Income generation leads to women empowerment			

APPENDIX- XI

Proforma for assessing changes in practices of the rural women

Practices	Yes	No	Neutral
Using millets in daily diet			
Using millets in breakfast foods			
Using millets flour like wheat flour			
Using millets kali and porridge daily			
Using millets based instant mixes for idiyapam, pittu, roti, kali, paniyaram, idli, doda preparation			
Using millet based instant mixes for sweets preparation			
Using malted millet products			
Using flaked and popped millet products			
Keeping the environment clean			
Maintaining personal hygiene			
Processing of millet based instant mixes as self employment activity			
Income generation thought millet based instant mixes			

APPENDIX- XII

NUTRITION EDUCATION AIDS