PRODUCT DEVELOPMENT AND SENSORY EVALUATION OF FOXTAIL MILLET INCORPORATED RECIPES

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Foods and Nutrition

(Dietetics)

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A Dissertation Submitted in Partial Fulfillment of the Requirement
for the Degree of Masters of Science
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BY

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CERTIFICATE

This is to certify that the research work presented in this thesis has been carried out independently by Ms. Nidhi Thite under the guidance of Dr. Swati Dhruv in pursuit of Master's degree in Foods and Nutrition (Dietetics) and this is her original work.

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LIST OF ABBREVIATIONS

ATP	Adenosine Triphosphate
BHT	Butylated Hydroxy Toluen
BP	Blood Pressure
CURES	Chennai Urban Rural Epidemiology Study
CVD	Cardio Vascular Disease
DBP	Diastolic Blood Pressure
FAO	Food and Agriculture Organization
GI	Glycemic Index
Hb	Hemoglobin
HbA1c	Glycated Hemoglobin
HDL	High Density Lipoprotein
HepG2	Human Liver Cancer Cell
IGT	Impaired Glucose Tolerance
LDL	Low Density Lipoprotein
MUFA	Mono Unsaturated Fatty Acid
NCD	Non Communicable Disease
NNMB	National Nutrition Monitoring Bureau
NSSO	National Sample Survey Office
PEM	Protein Energy Malnutrition
PUFA	Poly Unsaturated Fatty Acid
SAFA	Saturated Fatty Acid
TC	Total Cholesterol
TG	Triglyceride
Type 2 DM	Type II Diabetes Mellitus
VLDL	Very Low Density Lipoprotein
WHO	World Health Organization

ABSTRACT

ABSTRACT

Millets are the ancient crops of the mankind and are important for rain fed agriculture. They are the major energy source and staple foods for people living in the dry and arid regions of the world. Millets had been the lifeline of dry regions of Asia and Africa for food and fodder. Their importance and cultivation reduced due to large scale cultivation of rice and wheat because of urbanization and industrialization. With diabetes, hypertension and cardiovascular disease becoming more prevalent, as gifts of newly acquired life-styles and food habits, millets have returned as a viable option to live healthy life and can reduce the incidence of these lifestyle diseases. Millets have many nutritional, nutraceutical and health promoting properties especially the high fibre content, as a prebiotic feeding micro-flora in our inner ecosystem, the nature of starch has major role in reducing the risk of diabetes. Millet consumption decreases triglycerides and C-reactive protein, thereby preventing cardiovascular disease. All millet varieties show high antioxidant activity and are gluten free and non-allergenic. In this regard, Foxtail millet (*Setaria Italica*) possess all the nutritional properties that benefits in prevention and management of obesity, non communicable diseases, gastric disorders and certain type of cancer. Hence, foxtail millet incorporated recipes needed to be developed to increase its awareness and propagation in maintaining a healthy lifestyle.

The present study was planned with the broad objective of developing the foxtail millet incorporated recipes and the specific objectives were: 1) To standardize the foxtail millet incorporated recipes. 2) To carry out sensory evaluation of the foxtail millet incorporated recipes. 3) To develop a booklet from the acceptable foxtail millet incorporated recipes subjected to sensory evaluation.

In phase I, Foxtail millet was procured from the market. Further, 15 foxtail millet incorporated recipes were developed and standardized. The recipes developed by incorporating foxtail millet partially or fully in place of wheat / rice used traditionally in the standard recipes. The recipes developed were Veg Khichdi, Dhokla, Masala Bhakri, Muthia, Thalipith, Curd Rice, Chakli, Handvo, Methi Thepla, Sev, Idli, Dosa, Uttapam, Idada and Hari Bhari Tikki using the different cooking methods. These recipes were

found to be more nutritious than the traditionally made recipes in terms protein, fibre, iron, calcium and also has a lower caloric and carbohydrate content.

In phase II, the acceptability of these recipes was assessed by the composite and hedonic rating tests. The 30 semi-trained panelist members were asked to register their responses in the Google form that was developed to rate each attributes of the recipes. The foxtail millet incorporated recipes were found to be acceptable with respect to all the attributes. From the overall acceptability of the fifteen products, Chakli, Idli and Sev were highly acceptable followed by Idada, Uttapam, Veg Khichdi, Thalipith, Hari Bhari Tikki, Dosa, Curd rice, Methi Thepla, Muthia, Handvo, Dhokla and Masala Bhakri. Whereas the hedonic score was found to be high for Chakli, Idada, Sev, Idli and Uttapam. For attributes like texture, taste, after taste and mouthfeel; scores were lower for Masala bhakri, Dhokla and Curd rice as compared to other recipes. A significant difference was found between the attributes of the recipes and when assessed further it was found that some recipes had a significant difference with the other recipes for their colour and appearance, taste, texture, after taste, mouthfeel, aroma and overall acceptability. This significant difference observed among different attributes could be attributed to different cooking methods as well as the variation in the level of substitution of foxtail millet in these recipes.

In addition to the sensory evaluation, we also tried to elicit information by carrying out a Post Sensory Evaluation survey on the same semi trained panelists who took part in the sensory evaluation. Results showed that 44.1% of the panel members had heard about foxtail millet before taking part in the study but none of them had ever consumed. Despite of being aware of the benefits of millets, only 5.8% of them had consumed it on a daily basis, 5.8% thrice and twice a week, 2.9% once a fortnight and 23.5% once a week. 88.2% of the panel members were willing to incorporate foxtail millet in different recipes in their daily diet with a greater liking to incorporate the same in Veg Khichdi, Curd rice, Muthia, Dhokla and Methi thepla.

In phase III, the booklet of the foxtail millet incorporated recipes was been developed with an aim to propagate the consumption of foxtail millet amongst the population.

Thus, the foxtail millet incorporated recipes were found to be highly acceptable and can be partially or fully substituted with wheat / rice. If complete substitution for wheat is achieved, then being gluten free it will help in the management of celiac diseases as well as the beneficial nutritional properties of foxtail millet would also aid in the prevention and management of Non Communicable Diseases. Also, the dissemination of the foxtail millet incorporated recipes booklet would help in increasing the foxtail millet consumption amongst the population so as to improve the nutritional quality of their diet.

INTRODUCTION

INTRODUCTION

Millets are considered as one of the oldest foods or cultivated crops known to humans. They are said to be the minor cereals of grass family Poaceae. They are the most important crops widely grown around the world for animal fodder and human food. They are mostly cultivated in Eastern hemisphere, regions in primitive agriculture and high density population. They are labeled as food for poor due to their ability of growing in poorly watered or fertilized soils.

Millets are a group of cereals which are profusely seeding, adapted to cultivation over a range of tropical and subtropical climates. These crops require lower inputs, are climate resilient, hardy and dry land crops also called as "Nutri-cereals" that significantly contribute for food and nutritional security. These crops are generally rain fed and grown in areas with lower rainfall and thereby resume greater importance for sustainable agriculture and food security.

Millets were the first crops domesticated by mankind in Asia and Africa which later on spread worldwide as critical food sources to the evolving civilizations. They complete their lifecycle in 2-4 months adapting to short cropping windows with wider adaption, shifting cultivation and withstanding nature's unforeseen vagaries. All the millets are generally kharif crops that complete their cycle in monsoon period. However, most of them also give satisfactory to excellent yields in warmer climate as well. Millets are specially drought tolerant and also can perform well in areas with rainfall of 450mm or more.

Millets are grown by traditionally used techniques and the land used for growing millets is totally pest free. Millets like foxtail millet are totally pest free and act as an anti-pest agent in storing the pulses like green gram. Millets do not need any type of fumigants. They have relatively a lower position in India among the feed crops in agriculture, but are very important from the food security point at regional and farm level (Stanley Joseph, *et al.,* 2013).

Millets are basically of three types: Major millets, Minor millets and pseudo millets. Major millets have a greater seed size than that of the minor ones. Pseudo millets are so called as they are not a part of the family Poaceae as that of the other millets but are nutritionally similar to that of the true grains. Major millets are Sorghum (*Sorghum vulgare*), Pearl millet (*Pennisetum thyphoideum*) and Finger millet (*Eleusine coracana*). The seed size of finger millet is smaller than that of the other two millets but due to its higher availability and consumption it falls under the category of major millets. Minor millets are Proso millet (*Panicum miliaceum*), Foxtail millet (*Setaria italica*), Kodo millet (*Paspalum scrobiculatum*), Little millet (*Panicum sumatrense*) and Barnyard millet (Echinochloa crusgalli). Pseudo millets are Amaranth (*Amaranthus cruentus*), Buckwheat and Quinoa (*Chenopodium quinoa*).

According to FAO 2018, India is the leading producing country in the world followed by Niger and China. The highest production share of millets by region was observed in Africa in 2019 i.e. 48.5% followed by Asia with 47.5%, Europe 2.8% and Oceania 0.1%.

The production of the nutri-cereals in India in the year 2018-19 was reported as 42.95 million tonnes being highest in Rajasthan followed by Karnataka and Madhya Pradesh. The average estimate of millets from 2013-14 to 2017-18 shows that the area is around 24.81 million hectares, production 43.08 million tonnes and yield comes out around 1736 Kg/Hectare (FAO STAT 2018).

Rajasthan leads the millet production followed by Maharashtra and Gujarat (Adekunle et al., 2018). With respect to the other minor millets, the highest production is of finger millet followed by foxtail millet, proso millet, barnyard millet, little millet and kodo millet. The highest cultivable area of millets is found to be greater in Madhya Pradesh followed by Chhattisgarh, Uttarakhand, Maharashtra, Gujarat and Tamil Nadu.

Sorghum is one of the major cereal in terms of world production and acerage. It is grown extensively in Maharashtra and Karnataka. Pearl millet is grown in Rajasthan, Gujarat and Haryana. Finger millet is cultivated mostly in Southern India. Greater than 60% of the finger millet is produced in Karnataka which is the 34% of the global production.

Foxtail millet and proso millet are grown in Northern India mostly on drylands. The average production of foxtail millet is around 780 kg ha-1 and can be doubled under proper agronomic management (Monisha et al., 2019; Ramyasri et al., 2018; Mubeena et al., 2019). Little millet and kodo millet are found in parts of Madhya Pradesh, Tamil Nadu and Chhattisgarh. Barnyard millet is mainly found in Uttarakhand, Madhya Pradesh, Maharashtra and Tamil Nadu.

NNMB has reported the millet consumption highest in Gujarat (pearl millet, maize), Karnataka (finger millet), Maharashtra (sorghum), but least in Kerala, Orissa, West Bengal and Tamil Nadu where rice is their staple food. A study on dietary profile of urban Indians from the Chennai Urban Rural Epidemiology Study (CURES) reported by NNMB revealed that only 2% of the total calories (6.7g/day) contributed to millets.

The total millet production and domestic consumption both has increased over time from 1960s to 2018 (Das et al. 2019). Assam with 18.8kg/hsh/m and Bihar with 18.69kg/hsh/m were found to be the two states consuming highest millets specifically small millets in rural and all over India by NSSO. The consumption of finger millet was highest in Bihar with 12.02kg/hsh/m followed by Karnataka, Maharashtra and Gujarat.

There are some limiting factors that contribute to the lower consumption of millets like small size, uniqueness in grain morphology and the lack of commercially available decorticating techniques. Thereby they lack in their processing technologies confining them to their consumption as traditional foods only and thereby no variety can be developed from it (Shobana and Malleshi, 2007). But now with the increasing awareness; dehusked, milled grains, flours and various other ways of millets are now available from which variety of products can be developed and thereby promoted in the daily diets.

As per the Global Nutrition Report 2016, 44% of the world population experience serious levels of malnutrition. The reason behind it is an imbalanced nutrient diet in most of such diseases. According to UN FAO, around 795 million people were reported undernourished, more than 1.9 billion adults with age 18 and above were overweight and 13% were obese. India is said to be the home of world's largest undernourished population. About 15.2% of the total population of India, are undernourished. India was ranked 100th among 119 countries by Global Hunger Index Report 2017, stating that it is

poorer than Nepal, Sri Lanka and Bangladesh (Grebmar et al., 2017). 4,69,000 deaths were reported due to Protein Energy Malnutrition (PEM) with 84,000 deaths from the deficiency of other vital nutrients such as iron, iodine and Vitamin A (Lozano et al., 2012). Millets are the staple food in many parts of the world and secure sixth position in world agricultural production of cereal grains. They are a rich source of the vital nutrients and thereby, promise an additional advantage of combating the micronutrient deficiencies in the third world countries (Kumar et al., 2018).

Millets are a good source of valuable nutrients such as carbohydrate, proteins, dietary fibre, minerals and vitamins. The protein content of millets is similar to that of the cereals but carbohydrates are present in lower amounts. The average carbohydrate content of millets varies from 56.88 ton 72.97g per 100g. The least carbohydrate content is noted in barnyard millet. Millets are also a rich source of dietary fibre also called as crude fibre. The higher content of fibre makes them low glycemic, low lipemic foods and hence a good choice for diabetic and CVD patients. Fibres also have fractions of phytochemicals such as polyphenols, phytosterols, lignins and phytocyanins. They helps in protecting against age related degenerative diseases as they function as antioxidants, detoxifying agents and immune modulators (Rao et al. 2011).

Except finger millet, the protein content of all the other millets is comparable to each other with an average value of 10 to 11%. But the protein present in it is rich in amino acids such as methionine, valine and lysine. Millets are also rich in prolamine and glutelin fractions followed by albumin+globulin fractions. Proso millet has the highest mean value for protein followed by foxtail millet, being exceptional as they are a very good source of protein (Himanshu et al. 2018).

The lipid content of the millets is ranges from 1.43 to 6g per 100g in comparison to wheat and rice. Among them, the least lipid content is reported in finger millet while the highest in pearl millet. Monounsaturated fatty acids (MUFAs) and polyunsaturated fatty acids (PUFAs) are significantly higher in millets than the wheat and rice (Hasan, Garg, et al 2019).

Millets are a rich source of beta carotene, Vitamin E and B complex Vitamins except B12. Highest thiamine (0.6mg/100g) content is found in foxtail millet whereas highest

riboflavin is found in barnyard millet (4.2mg/100g) followed by foxtail millet (1.65mg/100g). Vitamin B helps in the breakdown of carbohydrates and fats more efficiently. It also helps in reducing the homocysteine levels in blood to prevent cholesterol from bonding and forming deposits. Niacin helps in preventing cholesterol from getting into the blood stream and raises high density lipoprotein (HDL) in blood. This protects the blood vessels from atherosclerosis and hemorrhage (O.S.K. Reddy, 2017).

The mineral content present in millets ranges from 1.7 to 4.3g per 100g which is several times higher than that of wheat and rice. Calcium content of finger millet is about eight times than that of rice and wheat. It is one of the richest source of calcium (348mg/100g) which helps in the prevention of osteoporosis. The iron content of little millet and barnyard millet was very high 9–12%, whereas kodo millet and common millet were rich in copper content. The total mineral matter or ash content was higher in common, little, foxtail, kodo, and barnyard millets than most commonly consumed cereal grains including sorghum. They are also a rich source of phosphorus and magnesium. Phosphorus helps in energy production, essential component of ATP, part of nervous system and cell membrane. Magnesium helps in blood vessels relaxation and maintains blood pressure, improving blood flow thereby, protects the cardiovascular system. It also helps in increasing insulin sensitivity and lowers the triglyceride levels.

Phenols present in the millets are found to be antioxidant, anti-mutagenic, antiviral and have platelet aggregation inhibiting activity. The total antioxidant capacity is found higher in little, foxtail, proso and finger millet due to their high total carotenoids and tocopherol content.

Thus, it shows that the consumption of millets helps in prevention and management of various Non-Communicable diseases, obesity, gastric disorders, certain types of cancer, etc as shown in the table.

MILLETS AS FUNCTIONAL FOODS

Millets are a major food component specifically among the non affluent segments in their respective societies. There are various traditional foods and beverages such as roti, bread

TABLE 1.1: BENEFITS OF MILLETS

Consumption of Millets helps in:
• Prevention of Constipation • Lowers Blood Cholesterol • Lowers the Incidence of CVD • Prevention and Management of Hyperglycemia (DM) • Prevention and Management of Obesity • Increases the time span of gastric emptying • Detoxifies Body • Increase Energy Levels • Lowers the Risk of Cancer • Improves Muscular & Neural Systems • Protection against Degenerative Diseases: ➢ Metabolic Syndrome ➢ Parkinson's Disease

(fermented or unfermented), snacks, fast foods, baby foods, wine, nutrition powder etc that are made from it (Chandrasekara & Shahidi 2012).

Millets act as a functional food as well as nutraceuticals that have promising health benefits and epidemiological studies have shown that its consumption helps in reducing the risk of heart disease, diabetes, lowers the risk of esophageal cancer and protects against several degenerative diseases (Manach *et al.,*2005; Scalbert *et al.*, 2005; Chandrasekara and Shahidi, 2012).

Being highly consumed, there are many studies done on major millets, their uses, advantages and product development. Hence, the major focus is now upcoming on the minor millets due to their beneficial nutrition profile and health benefits.
Small amounts of the minor millets and pseudo-cereals in the daily diet of people can ensure "no malnutrition." These neglected crops have huge potential for food and nutritional security through sustainable agriculture in marginal areas (Rahman et al 2020).

While comparing the nutrient profile between the minor millets, foxtail millet was found to be a good source of fiber, protein, carbohydrate, antioxidants, phytochemicals, B vitamins, amino acids and other minerals. These nutrients have found to be beneficial in the prevention and management of various Non-Communicable diseases.

Foxtail millet, botanically known as *Setaria Italica,* belongs to the Setaria genus of grass family Poaceae and sub-family Panicoideae. It is one of the oldest cultivated crops in the world. It is cultivated in 26 countries and ranks second in world millet production. With regard to yielding ability, it ranks fourth among normal production practices with no use of fertilizers or pesticides that makes it easier to classify it as an organic food (Patangare et al. 2019).

Foxtail millet is commonly called as 'Italian millet' around the world whereas, regionally it is known as 'Kang' in Gujarati, 'Kangni' in Hindi, 'Rala' in Marathi, 'Tenai' in Tamil and 'Korra' in Telugu. The colour of the grains mainly ranges from dark yellow, yellowish brown to the lightest of yellow shades.

NUTRITIONAL PROPERTIES OF FOXTAIL MILLET:

- The grain contains 60.9% carbohydrates and 12.3% protein.
- It is a good source of crude fibre which helps in digestion process and helps to induce the bowel movement, producing a laxative effect that is beneficial for the healthy digestive system.
- The beta-glucans present in fibre, helps to enhance the blood glucose and cholesterol metabolism that prevents diabetes and cardiovascular diseases (Itagi et al. 2012; Muthamilarasan and Prasad 2015).
- Phytochemical tests revealed that it contains phenolics that are the major antioxidants has the ability to reduce agents, singlet oxygen quenchers and metal chelators. (Chandrasekara et al. 2010)
- Phytates in foxtail millet protects against oxidative stress.
- It contains appreciable amounts of vitamins, minerals and essential amino acids.(Sharma 2017)

RATIONALE

Foxtail millet, a minor millet is found to be a rich source of protein, dietary fiber, phosphorus, B vitamins, minerals and antioxidants; benefits in the prevention and management of gastric disorders, obesity and non-communicable diseases. However, this facet has not studied extensively. The millet is highly underutilized and under researched as very few product development and clinical studies were carried out in earlier years thereby no recent data on the same is much available. Thereby, the foxtail millet was selected to explore its food properties in developing the foxtail millet incorporated recipes in which various traditional Indian recipes were developed and subjected them to sensory evaluation to study each and every attribute of the product and its overall acceptability so that the general population along with the patients with obesity, NCD's,

gastric problems and certain types of cancer may try to include these recipes in their daily diet.

The present study was planned with the objective of developing the foxtail millet incorporated recipes.

The specific objectives of the study were:

- To standardize the foxtail millet incorporated recipes.
- To carry out sensory evaluation of the foxtail millet incorporated recipes.
- To develop a booklet from the acceptable foxtail millet incorporated recipes subjected to sensory evaluation.

REVIEW OF LITERATURE

REVIEW OF LITERARTURE

MILLETS

Millets are the small seeded grains and minor cereals considered as the oldest food or cultivated crops known to humans. They belong to the grass family Poaceae. Millets are widely grown around the world for animal fodder and human food. They form a functional and agronomic group but not a taxonomic one. Millets are consumed by greater than one third of the world's population and ranks as 6^{th} cereal crop in terms of world's agricultural production.

Millets were the first domesticated crops by the mankind in Asia and Africa that later on spread globally as the critical food source to the civilizations that are been evolved. They had been the lifeline of these dry regions for food and fodder. Millet grain is the basic foodstuff for farm households in the poorest countries of the world and among the poorest people. Also they are invariably used as a staple food in certain regions of the world. Along with this, in many countries they are also used as a feed for birds, bird seed, for brewing, industrial material, etc.

Millets mature quickly and require relatively few inputs as compared to the other major cereals. They are adapted to a wide range of ecological conditions that can be grown on skeletal soils that are less than 15cm in depth. They do not require rich soils for their growth and survival which make them attractive for marginal farming environments. They are generally the rain-fed crops that can be grown in low rainfall areas and thus resume greater importance for sustainable agriculture and food security. Moreover, they can also give benefits in ecological, nutritional and socio-economic areas. Millets are found to be highly nutritious, non-glutinous and non acid forming foods. Hence, they are soothing and easily digestible. They are also rich in lecithin and are excellent for strengthening the nervous system (Michael R & Shanmugam, 2013). Besides being farmer-friendly, due to their unique nutritional properties of millets, they are being called as "Nutri-cereals".

FIGURE 2.1: TYPES OF MILLETS

Source: IIMR 2018

FIGURE 2.2: TYPES OF MILLETS BASED ON THEIR SEED SIZE

Major Millets	Minor Millets	Pseudo Millets
•Sorghum •Pearl millet •Finger millet	•Proso millet •Foxtail millet •Kodo millet •Little millet •Barnyard millet	•Amaranth •Buckwheat •Quinoa

Source: IIMR 2018

TABLE 2.1: VERNACULAR NAMES OF MILLETS

English	Sorghum	Pearl Millet	Finger Millet	Little Millet	Kodo Millet	Foxtail Millet	Barnyard Millet	Proso Millet
Hindi	Jowar	Bajra	Mandua	Kutki	Kodon	Kangni, Kakum	Sanwa	Barre
Sanskrit	-	-	Nandimukhi	-	Kodara	Kanguni	Shyama	China
Kannada	Jola	Sajjai	Ragi	Same	Harka	Navane	Oodalu	Baragu
Tamil	Cholam	Kamboo	Kelvaragu	Samai	Varagu	Tenai	Kuthira-vaali	Paniva-ragu
Telugu	Jonna	Sajjalu	Ragulu	Samalu	Arikelu, Arika	Korra, Korralu	Udalu	Varigu-lu
Malayalam	Cholam	Kamboo	Moothari	Chama	Varagu	Thina	-	Paniva-ragu
Marathi	Jowari	Bajri	Nachni	Sava	Kodra	Kang, Rala	Shamul	Vari
Gujarati	Juar	Bajri	Nagli, Bavto	Gajro, Kuri	Kodra	Kang	Sama	Cheno
Bengali	Juar	Bajra	Mandua	Sama	Kodo	Kaon	Shamula	Cheena
Punjabi	-	Bajra	Mandhuka, Mandhal	Swank	Kodra	Kangni	Swank	Cheena

Source: IIMR 2018.

Millets complete their life cycle of 2-4 months with wider adaption, shifting cultivation and withstanding nature's unforeseen vagaries. They are essentially *Kharif* crops that complete their cycle in monsoon, though most of them give excellent yields in warm climate as well. They are drought tolerant and may sustain in 450mm or more rainfall receiving areas. They are referred to as famine crops as they assure yields in the famine situations as well. They are also called as orphan crops as they are the last choice for cultivation due to lower demand in the market and profits are also lower than that of the other crops. However, these neglected crops are important in all virtues in means of livelihood, fodder, food and nutritional security in the various parts of the world which also diversifies our food basket.

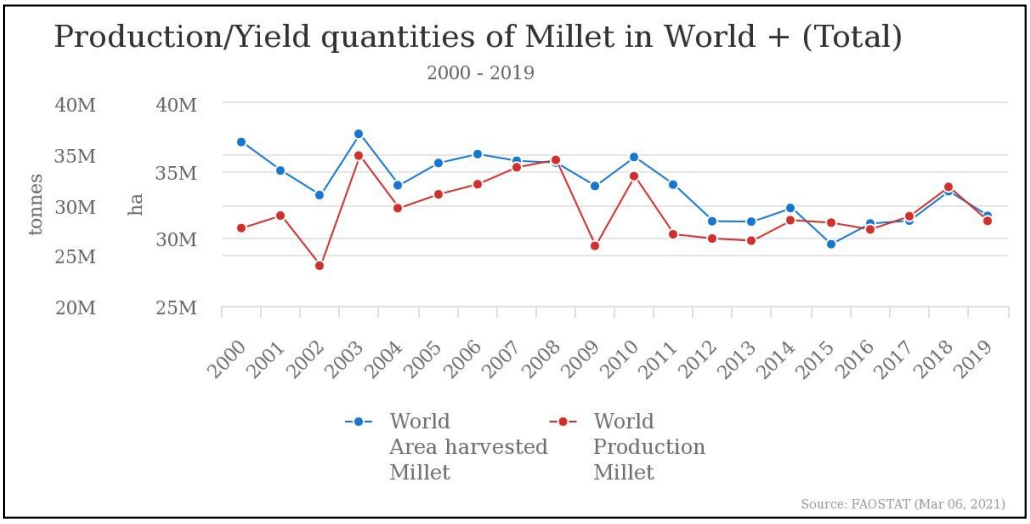
TYPES OF MILLETS

Millets are classified into two types based on their seed size: Major millets and Minor millets (Figure 2.2). Major millets have a greater seed size than that of the minor ones. One more classification added recently is the Pseudo millets. They are so called as they are not a part of the family Poaceae as that of the other millets but are nutritionally similar to that of the true grains. Major millets are Sorghum (*Sorghum vulgare*), Pearl millet (*Pennisetum thyphoideum*) and Finger millet (*Eleusine coracana*). The seed size of finger millet is smaller than that of the other two millets but due to its higher availability and consumption it falls under the category of major millets. Minor millets are Proso millet (*Panicum miliaceum*), Foxtail millet (*Setaria italica*), Kodo millet (*Paspalum scrobiculatum*), Little millet (*Panicum sumatrense*) and Barnyard millet (Echinochloa crusgalli). Pseudo millets are Amaranth (*Amaranthus cruentus*), Buckwheat and Quinoa (*Chenopodium quinoa*).

PRODUCTION OF MILLETS

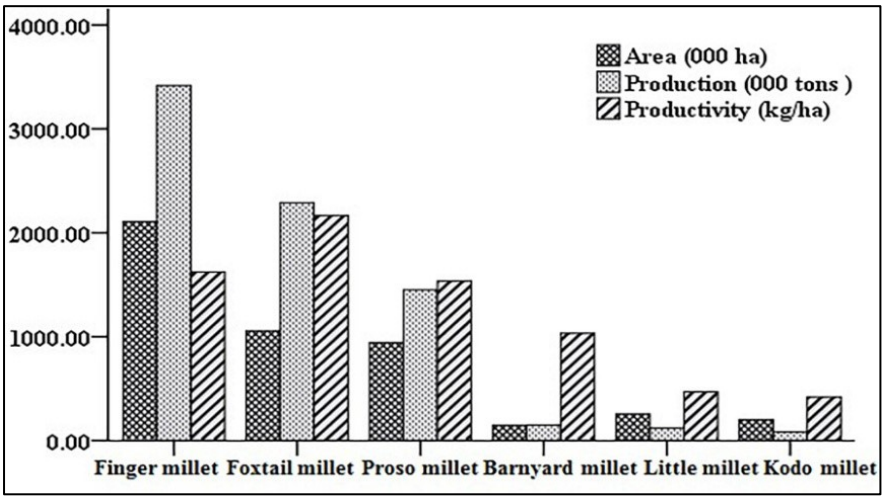
According to FAO statistics 2016, world millet production was 32 million tonnes and has been declining since the sharp increases seen in the early 2000s. Africa accounts for more than 55 percent of global production, followed by Asia with 41 percent and Europe represents 3 percent while America accounting for only 1 percent of the world market. Among all the other millets, pearl millet is found most commonly in India and Africa.

2.3: WORLD MILLET PRODUCTION 2000-2019



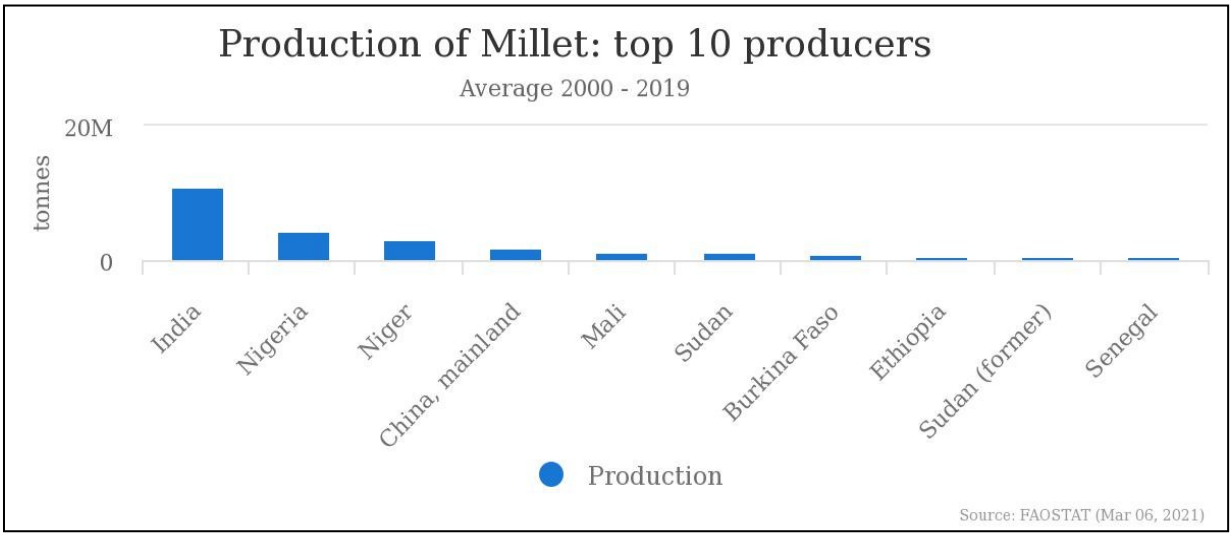
Source: FAOSTAT 2021

FIGURE 2.4: PRODUCTION, PRODUCTIVITY AND AREA-WISE CULTIVATION OF SMALL MILLETS



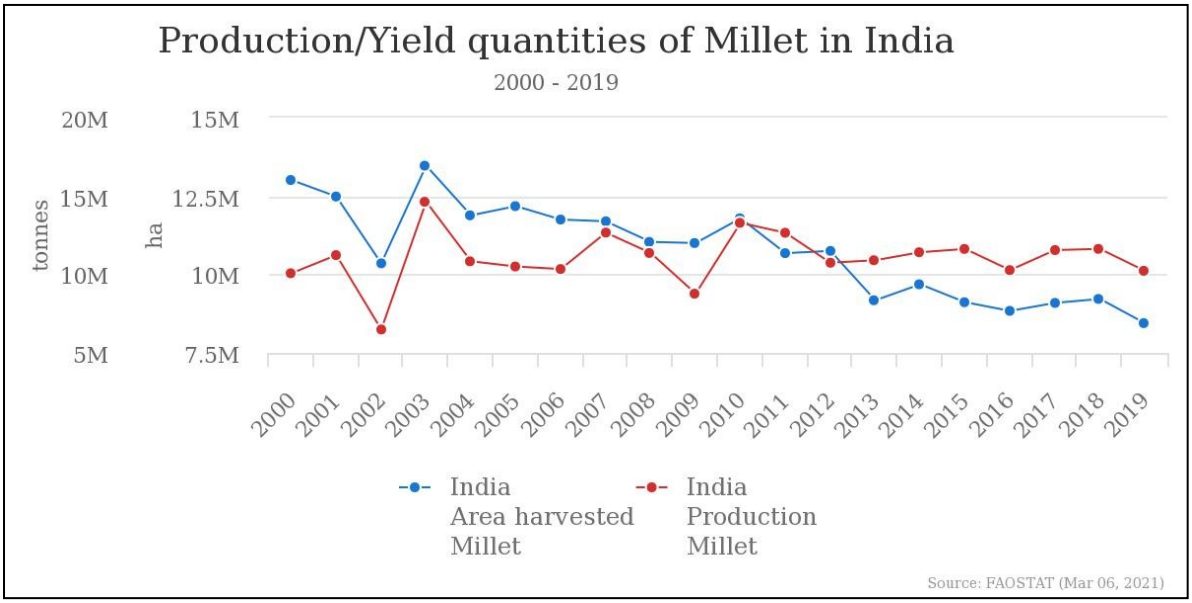
Source: IIMR 2018

FIGURE 2.5: TOP MILLET PRODUCING COUNTRIES IN THE WORLD



Source: FAOSTAT 2021

FIGURE 2.6: MILLET PRODUCTION AND AREA HARVESTED IN INDIA



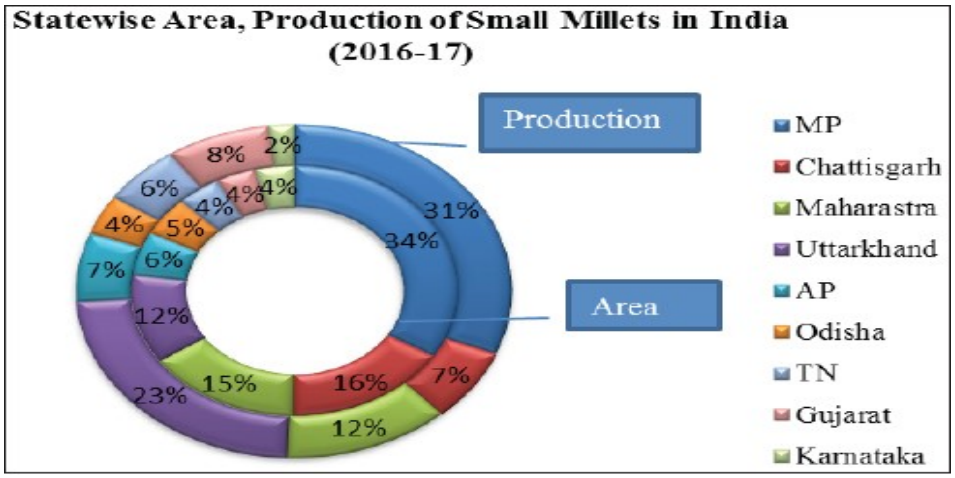
Source: FAOSTAT 2021

FIGURE 2.7: MAJOR PRODUCING STATES OF SMALL MILLETS IN INDIA (2016-2017)

State	Area ('000 ha)	Share (%)	Production ('000 Tn)	Share (%)
Madhya Pradesh	184.00	29.72	113.02	25.57
Chattisgarh	89.20	14.41	25.40	5.75
Maharastra	83.70	13.52	44.73	10.12
Uttarkhand	63.00	10.18	85.00	19.23
AP	31.00	5.01	24.00	5.43
Odisha	27.41	4.43	13.84	3.13
Tamil Nadu	23.55	3.80	21.22	4.80
Gujarat	22.00	3.55	28.00	6.34
Karnataka	21.00	3.39	7.00	1.58
Rajasthan	14.67	2.37	10.19	2.31
Nagaland	10.03	1.62	11.13	2.52
Total	**619.11**	**100.00**	**441.94**	**100.00**

Source: INDIASTAT 2019

FIGURE 2.8: SELECTED STATE WISE PERCENTAGE AREA AND PRODUCTION OF SMALL MILLETS IN INDIA (2016-2017)



Source: INDIASTAT 2019

FAO in 2018 stated that India is the world's leading producing country followed by Niger and China. And in India, Rajasthan is the leading millet producing state followed by Maharashtra and Gujarat (Adekunle et al., 2018). With respect to the minor millets, the production is highest of finger millet followed by foxtail millet, proso millet, barnyard millet, little millet and kodo millet. Whereas, the highest area of millets is found to be greater in Madhya Pradesh followed by Chhattisgarh, Uttarakhand, Maharashtra, Gujarat and Tamil Nadu.

Sorghum is the world's fifth major cereal in terms of production and acerage. It is extensively grown in north-western, western and central India and southern peninsula, with maximum acerage in Maharashtra and Karnataka. Pearl millet is extensively grown in Rajasthan, Gujarat and Haryana. Finger millet is mostly cultivated in Southern India and East and Central Africa. More than 60% of the finger millet is produced in Karnataka in India that is about 34% of global production.

Foxtail millet and proso millet are mainly grown in Northern India, China and Russia. Foxtail millet is a low input demanding and ecologically sound crop which can be automatically chosen for agricultural sustainability in dry lands. The average productivity of foxtail millet in India is around 780 kg ha-1 (Monisha *et al*., 2019). But under proper agronomic management, the crop can produce about double of its yield in unit area as evidenced in experimental results (Ramyasri *et al*., 2018; Mubeena *et al*., 2019). Little millet and kodo millet are grown in parts of Madhya Pradesh, Tamil Nadu and Chhattisgarh. Barnyard millet is grown both for animal fodder and human consumption mainly in Uttarakhand, Madhya Pradesh, Maharashtra and Tamil Nadu in India and also in China, Japan and Korea.

Nutri cereals production in India in the year 2018-19 was reported as 42.95 million tonnes being highest in Rajasthan followed by Karnataka and Madhya Pradesh. The average estimate of millets from 2013-14 to 2017-18 shows that the area is around 24.81 million hectares, production 43.08 million tonnes and yield comes out around 1736 Kg/Hectare.

Over the years, there has been a sharp decline in the area in India but a remarkable increase in the production and yield is noted. Despite the potential benefits, however in India, overall production of millets has increased over the past few decades, but the area dedicated to minor millets has fallen remarkably. The factors attributing to this decline are agronomic, economic and social. Other than this, some major constraints are millet grown in poor conditions, seeds are often broadcast, cultivated under unmanured and unfertilized conditions and little research on crop improvement and agro-techniques were neglected till recently.

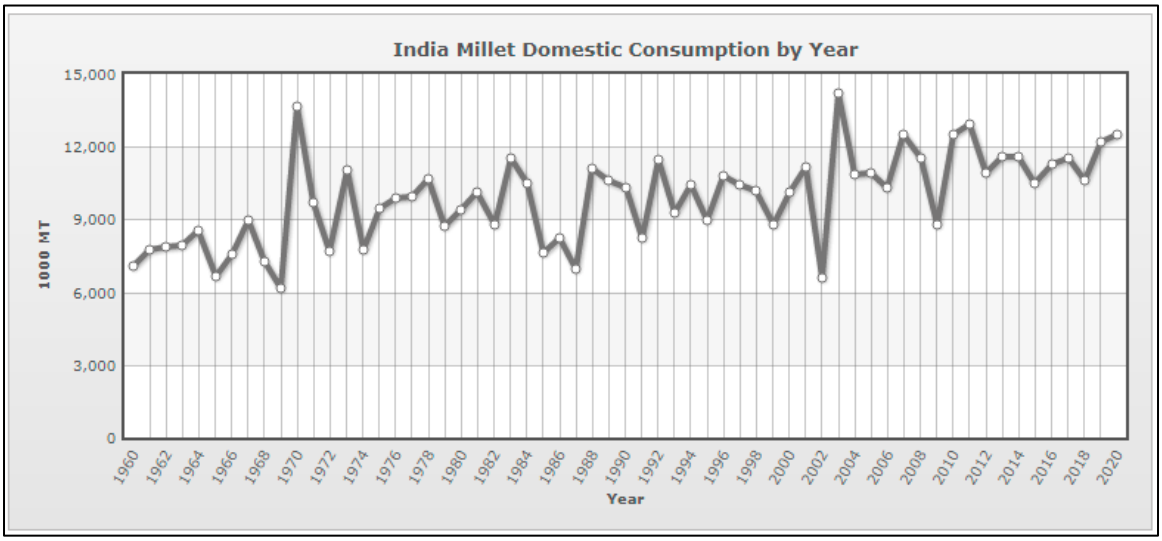
CONSUMPTION PATTERN OF MILLETS

Millet is grown as a substinence crop in most parts of the world for local consumption. It was consumed as a staple cereal and brewed from pre-historic times in Asia, Africa and Europe. Sorghum and other millets are the staple food of central and western regions of Maharashtra and the northern region of Karnataka and Andhra Pradesh. Some traditional recipes are Jowar(Sorghum) roti or bhakri in Maharashtra, Karnataka, Madhya Pradesh, Uttar Pradesh and Rajasthan; bajra roti in Punjab, Haryana, Uttar Pradesh and Rajasthan; and ragi mudde in Karnataka, Tamil Nadu and Andhra Pradesh. Dehusked grains of small millets is cooked like rice and eaten or made into porridge.

National Nutrition Monitoring Bureau has reported that the consumption of millets was higher Gujarat (pearl millet, maize), Karnataka (finger millet), Maharashtra (sorghum) but negligible in the states of Kerala, Orissa, West Bengal and Tamil Nadu where rice is the most consumed cereal. Cereals are being consumed as main staple by Indians that constitute 70-80% of the total energy intake. A study on dietary profile of urban Indians by NNMB (from the Chennai Urban Rural Epidemiology Study (CURES)) revealed that only 2% of the total calories (6.7 g/d) were contributed by the millets.

In India, the area under cultivation has decreased for pearl millet but production and productivity has however increased whereas for finger millet, both area and production has decreased but productivity has increased. The total millet production and domestic consumption both has increased over time from 1960s to 2018. (Das et al. 2019)

FIGURE 2.9: INDIA'S DOMESTIC CONSUMPTION OF MILLETS (1960-2020)



Source: US Dept of Agriculture 2020

Anubukkani et al. (2017) reported that the minor millets are rich in nutrients and minerals and resistant to draught and stress in rain fed farming. Minor millets structural break was observed in the year 1998 and between 2000 and 2002. By using the NSSO unit level data, Assam (18.8 kg/hsh/m) and Bihar (18.69kg/hsh/m) were the states consuming highest levels of small millets in rural and all over India. Whereas for finger millet, consumption in Bihar was highest i.e. 12.02kg/hsh/m followed by Karnataka, Maharashtra and Gujarat.

A study done by Devi C.A. in 2018 on the high income group of Telangana state assessing the consumption pattern of millets states that there was a consumption of 63.6% ragi, 58.3% Sorghum, 76.1% bajra, 73.7% maize, 73.7% foxtail millet, 41.7% little millet and 51.7% kodo millet respectively among them. From these, the most frequently consumed millet was sorghum followed by ragi and bajra.

Some of the limiting factors that contribute to lower consumption of millets are small size, uniqueness in grain morphology and the lack of commercially available decorticating techniques. These unavailability of processing technologies confine them to their consumption as traditional foods only (Shobana and Malleshi, 2007).

NUTRITIONAL INFORMATION OF MILLETS

Millets are a good source of protein, micronutrients and phytochemicals that are nutritionally comparable to the major cereals. The anti-oxidant content and activity of the millets are affected by processing methods like soaking, malting and decortications (Saleh et al., 2013).

Millets are amazing in their nutrition content (Subramanian et al. 2010; Trivedi et al. 2015). Each of the millets is three to five times nutritionally superior to the widely promoted rice and wheat in terms of proteins, minerals and vitamins. They provide the nutritious grain and fodder in a short period of time. The longer storability of millets under ordinary conditions has made them "famine reserves". The government has renamed jowar, bajra, ragi and other millets as “Nutri Cereals”, dispensing with the nomenclature “coarse cereals (Bhat et al. 2018).

TABLE 2.2: NUTRITIONAL PROFILE OF MILLETS

Millets	Energy (kcal)	CHO (g)	Protein (g)	Fat (g)	Total Dietary Fiber (g)	Insoluble Dietary Fiber (g)	Soluble Dietary Fiber (g)	Minerals (g)	COST Rs./kg
Pearl Millet	361	67.5	11.6	5.4	11.5	9.1	2.3	2.3	25-30
Sorghum	349	72.6	10.4	1.7	10.2	8.5	1.7	1.6	40-60
Finger Millet	336	72	7.2	1.9	11.2	9.5	1.7	2.7	45-75
Proso Millet	364	70.4	12.5	1.1	7.72	5.4	2.3	1.9	115-180
Foxtail Millet	331	60.9	12.3	4.3	8	4.3	3.7	3.3	55-75
Little Millet	341	67	7.7	4.7	7.7	5.5	2.2	1.3	65-150
Kodo Millet	309	66	8.9	2.5	6.3	4.2	2.1	1.7	60-120
Barnyard Millet	397	65.5	6.2	2.2	9.8	-	-	4.4	130-180
Quinoa	330	53.6	13.1	5.5	14.6	-	-	3.8	180-560

Source: MDRF & IFCT, NIN, ICMR 2017, Sharma 2017, Indian Food Composition Tables, NIN – 2017 and Nutritive value of Indian foods, NIN – 2007.

Some of the important nutrients present in millets are resistant starch, oligosaccharides, lipids, antioxidants such as phenolic acids, avenanthramides, flavonoids, lignans and phytosterols that are responsible for many health benefits (Miller, 2001; Edge et al., 2005).

These nutrients from the millets are studied based on their macro and micro quantities. The macronutrients are carbohydrate, protein and fat whereas, the micronutrients include the various vitamins and minerals.

Macronutrients

The average carbohydrate content of millets varies from 56.88 ton 72.97g per 100g. The least carbohydrate content is noted in barnyard millet. Except finger millet, the protein content of millets is comparable to each other with an average of 10 to 11%. But the protein present in it is rich in amino acids such as methionine, valine and lysine. The mean protein value is highest of proso millet. It is comparable to that of wheat but the essential amino acid content is much higher in the proso millet. The lipid content of the millets ranges from 1.43 to 6g per 100g that is comparable to wheat and rice. Among them, the least lipid content is reported in finger millet while the highest in pearl millet. Monounsaturated fatty acids (MUFAs) and polyunsaturated fatty acids (PUFAs) are significantly higher in millets than the wheat and rice (Hasan, Garg, et al 2019). Millets are also a rich source of dietary fibre also called as crude fibre. The higher content of fibre makes them low glycemic foods and hence a good choice for diabetic patients.

Micronutrients

The mineral content present in millets ranges from 1.7 to 4.3g per 100g which is several times higher than that of wheat and rice. Calcium content of finger millet is found to be eight times greater than that of rice and wheat. It is one of the richest source of calcium (348mg/100g) which helps in the prevention of osteoporosis. Barnyard millet and pearl millet are the rich sources of iron, where barnyard millet accounts for 17.47mg of iron per 100g of millet that is just 10g less than the total daily requirement. Foxtail millet

contains high amount of zinc (4.1mg/100g) and is also a good source of iron (2.7mg/100g).

Millets are also a good source of beta carotene and B vitamins such as niacin, riboflavin and folic acid. Highest thiamine (0.60mg/100g) content is found in foxtail millet whereas highest riboflavin is found in barnyard millet (4.2mg/100g) followed by foxtail millet (1.65mg/100g).

Vitamin B helps in the breakdown of carbohydrates and fats more efficiently. It also helps in reducing the homocysteine levels in blood to prevent cholesterol from bonding and forming deposits. Niacin helps in preventing cholesterol from getting into the blood stream and raises high density lipoprotein (HDL) in the blood. This protects the blood vessels from atherosclerosis and hemorrhage. (O.S.K. Reddy, 2017)

Phenolic Compounds

Phenolic compounds are generally classified as phenolic acids, flavonoids and tannins. Phenolic acids are further divided into hydroxybenzoic acids, hydroxycinnamic acids, hydroxyphenylacetic acids and hydroxyphenylpropanoic acids. A study by Chandrashekhar & Shahidi in 2011 reported that the soluble fraction found in finger millet had the highest amount of hydroxybenzoic acid derivatives (62.2µg/g) and flavonoids (1896µg/g) and the highest amount of hydroxycinnamic acid and their derivate in soluble form was found in little millet (173 µg/g) and foxtail millet (171 µg/g) respectively. Phenols present in the millets possess antioxidant, anti-mutagenic, antiviral effects and platelet aggregation inhibiting activity. Total antioxidant capacity is found higher in little, foxtail, proso and finger millet due to their high total carotenoids and tocopherol content.

The phytochemicals present in Sorghum act as blood thinners, anti-obesity agents and prevents rheumatoid arthritis (Mathanghi, 2012).

As from the literature it seems that millets have a variety of nutrients that have been used for different therapeutic effects. Some of the beneficial effect of millets in different disorders is given below.

Millets and Obesity

Obesity is associated with various non-communicable diseases such as diabetes and cardiovascular diseases. Some studies have shown that high fibre diet reduces the prevalence of obesity, improves the bowel function and slows the digestion process, thereby reducing the risk of chronic diseases. Millets help in giving satiety and weight management reducing obesity. They also contains tryptophan which lowers appetite and helps in managing weight. The high fibre content of millets help in reducing the problems such as constipation, bloating, flatulence and stomach cramping (O.S.K. Reddy, 2017).

Millets and Diabetes

The incidences of diabetes has been reported as lower in the millet consuming population. The phenolics help in inhibiting alpha-glucosidase and pancreatic amylase that reduces postprandial hyperglycemia by partially inhibiting the enzymatic hydrolysis of complex carbohydrates. It also helps in wound healing process with the help of antioxidants. Inhibitors like aldose reductase prevents the accumulation of sorbitol and reduce the risk of diabetes induced cataract diseases. Thereby, millets help in the prevention and management of Type II Diabetes due to the significant levels of magnesium present in them. Magnesium is an important mineral that helps in increasing the efficiency of insulin and glucose receptors, thereby producing many carbohydrate digesting enzymes, which manages insulin action (O.S.K.Reddy, 2017).

In India, for diabetic patients a study has found out that wheat based and millet based formulations yield lower glycemic index as compared to rice based formulations (Shobana et al., 2007)

A systematic review was done by Almaski et. al. in 2019 on millet intake and risk factors of type 2 diabetes. A literature search was done using various databases. From the 15 articles, 19 were selected on the basis of the inclusion criteria that included millet and healthy, pre-diabetics, diabetics and fasting blood glucose levels, post prandial blood glucose levels, glycemic response and insulin response. Although the glycemic and insulin responses vary depending in the type of millet consumed, overall it showed a

beneficial effect on fasting and post-prandial blood glucose levels along with the plasma insulin response in healthy individuals and with type-2 diabetes. It was concluded that millets do have the potential to play a protective role in the management of type-2 diabetes.

Millets and CVD

Millets are found to be a good source of magnesium which is known for reducing the risk of heart attack, stroke and atherosclerosis. They are rich in potassium that acts as a vasodilator which also helps in reducing blood pressure and helps in optimizing cardiovascular system. They are also rich in phytochemicals which contain phytic acid that helps in reducing cholesterol and triglyceride levels, thereby preventing cardiovascular disease (Lee et al., 2010).

Lignans present in millets are the prebiotic fibre which gets fermented by bacteria in the intestinal gut and can be converted into animal lignans that have shown some protective effect against certain chronic diseases. They produce enterolactone upon fermentation, which is known to protect against heart disease and some forms of breast cancer (O.S.K. Reddy, 2017).

A study by Singh et al., in 2020 revealed that a designer food was associated with a significant decline in fasting and postprandial blood glucose levels, total cholesterol and triglycerides along with oxidative stress and pro-inflammatory cytokines that are the important coronary risk factors observed in diabetic subjects. An increase in haemoglobin, calcium and magnesium levels was also noted indicating the designer food in preventing undernutrition, anemia and osteoporosis. The designer food included 60% millets, 20% soybean, 10% brown rice, 8% peanuts and 1-2% flaxseeds which was given to them in the form of paratha, pakora, bread or stuffed bread.

The flavonoids present in pearl millet such as tricin, acacetin, 3,4 Di-OMe luteolin, and 4-OMe tricin indicates chemopreventive efficacy. They may have inversely proportional properties to mortality from coronary heart disease and incidence of heart attacks. (Nambiar & Sareen, 2012)

Millets and Cancer

Millets are rich in phenolic acid, phytates and tannins which are the antinutrients that help in reducing the risk factor for colon and breast cancer. The phenolics are said to be effective in preventing the initiation and progression of cancer in vitro. (Chandrashekhar A, et al., 2011)

Millets and Celiac Disease

Celiac disease is an immune mediated enteropathic disease which gets triggered by the ingestion of gluten in susceptible individuals (Catassi and Fasano, 2008). A gluten free diet therefore helps in managing such subjects. Replacing the cereals like wheat, rye, barley with rice and millets may help them adhere to gluten free diet (Thompson, 2009). Hence, millets being gluten free are considerable potential foods that can meet the growing demand of gluten free foods and make them suitable for the individuals suffering from celiac disease and gluten sensitivity.

Millets and Antioxidants

Antioxidants helps in preventing tissue damage, ageing and stimulate the wound healing process. Ferulic acid present in millets is one such strong antioxidant that helps in free radical scavenging and possess anti-inflammatory activity.

Millets and Anti-microbial activity

Millet fractions and extracts have been found to have antimicrobial activity. The seed protein extracts from pearl millet, sorghum, foxtail millet, barnyard millet and samai millet when evaluated in vitro, they were able to inhibit the growth of *Rhizoctonia solani, Macrophomina phaseolina* and *Fusarium oxysporum.*

Millets as Prebiotics and Probiotics

Probiotics are the living microorganisms that aid the existing floras or repopulate the bacterial colon levels that are reduced by antibiotics, chemotherapy or due to any disease. Fermented millet based products helps in treating diarrhea in young children acts as a natural probiotic treatment. One such product is millet *koko*, an African fermented porridge and drink also called as lactic-acid fermented porridge.

Prebiotics are the non-digestible ingredients of food that benefits in stimulating the growth and activity of bacteria in the colon. Millet shows the prebiotic activity, which helps in increasing the population of good bacteria that promotes digestion. Malting helps in inducing important beneficial biochemical changes in the millet grain.

Millets as Functional Foods

Millets act as a functional food as well as nutraceuticals that have potential health benefits and epidemiological studies have showed that millet consumption helps in reducing the risk of heart disease, diabetes, improves digestive system and protects against several degenerative diseases such as metabolic syndrome and Parkinson's disease (Manach *et al.,*2005; Scalbert *et al.*, 2005; Chandrasekara and Shahidi, 2012).

Millets are traditionally used in various fermented and non fermented recipes such as flat breads, thin and thick porridges, steamed and boiled products, snacks, weaning foods, alcoholic and non alcoholic beverages. They are dehulled and then cooked like rice and their flour can easily be substituted with rice or wheat flour in different food preparations. Traditional cereal processing as well as contemporary methods can be applied to the millets for the preparation of ready to eat snacks. Various researches on food product development of different millets are being done, most of them focuses on the major millets due to their higher consumption since years.

A study by Schober et al. states that products like cookies, pasta, cakes, parboiled rice been successfully produced from sorghum and other millets. These wheat free sorghum breads are suitable for the celiac patients and may possibly replace the wheat breads in developing countries that may result in the reduction of expensive wheat imports. Sorghum is brewed commercially to produce large and stout beers (John et al. 2006).

Anu in 2006 reported that sponge cakes were prepared from blanched pearl millet, refined wheat flour and green gram flour in the ratio of 40:50:10(type I) and 60:30:10(type II) with a control group of only refined wheat flour. The moisture, protein, fat, calcium and crude fibre of type II cake was higher as compared to the control.

Finger millet products are fed as nutritional supplement to pregnant and lactating mothers, babies and the sick. The main fraction protein (Eleusinian) present in the millet has high biological value that is deficient in most of the cereals. Hence, used to prevent malnutrition. Malted millet is highly nutritious and also helps in easy digestion; hence recommended for elderly and infants. Because of its various nutritional properties, it has medicinal value and thereby can be used in the management and/or prevention of measles, anemia and diabetes (Chrispus, 2008 & Taylor, 2012).

A study concluded that when the millet idli batter was made from different blends of decorticated little millet and black gram, the most acceptable being well fermented for 14 hours was with 4:1 proportion (Deshpande et al. 2015).

MINOR MILLETS FOR NUTRITIONAL SECURITY

Minor millets are rich in some or most of the nutrients compared to the most widely consumed major millets, rice and wheat. There are many studies being done on the major millets; their uses, advantages and various products developed. Hence, now the major focus has shifted towards the minor millets due to their high nutrition profile that ensures nutritional security through regular consumption and health benefits. Small amounts of the minor millets and pseudo cereals in the daily diet of people can ensure “no malnutrition”. These neglected crops have huge potential for food and nutritional security through sustainable agriculture in marginal areas (Rahman et al., 2020).

Decline in the cultivation of small millets resulted in their reduced availability to needy population and also the traditional consumers that shifted towards the fine cereals due to Government policies. By strengthening the small millet cultivation through various approaches, it will help in combating the hidden hunger and malnutrition and also economically benefit the farmers and stake holders involved in small millet cultivation

amidst the ongoing pandemic (Muthamilarasan & Prasad, 2021). Improvement in productivity and enhancing demand will not increase the cultivation in future but also may rise the consumption. Developing their health foods and commercialization must receive focused attention to promote the consumption of small millets among the urban elite which may lead to the reduction in life-style related disorders.

There has been many departmental studies being conducted on different millets such as clinical trials, intervention studies and knowledge-attitude practices as shown in the table. With respect to the proso millet, currently a clinical study is going on.

While the single crops such as wheat and rice can succeed in producing the nutritional security for India, minor millets may produce multiple securities in terms of food, nutrition, health, fodder, ecology, economy and livelihood. One such millet is the foxtail millet that when compared to the other minor millets is found to be a good source of fiber, protein, carbohydrate, antioxidants, phytochemicals, B vitamins, amino acids and other minerals. These nutrients have found to be beneficial in the prevention and management of various Non-Communicable diseases and certain type of cancers.

Foxtail Millet

Introduction

Foxtail millet (*Setaria Italica*), originated from China, is one of the oldest cultivated crops. It is the sixth highest yielding grain in terms of worldwide production of millets. It has an important place in the world agriculture providing approximately six million tonnes of food, mainly on poor or marginal soil areas in Southern Europe and in temperate, sub-tropical and tropical Asia. It is thought to be indigenous to South Asia and is an important cereal crop of Nepal (Austin 2006; Cheng and Dong 2010; Mal et al., 2010).

TABLE 2.3 DEPARTMENTAL STUDIES ON MILLETS

Author	Results
Iyer and Dhruv et al., 2012	The study on Kodo millet supplementation on Type 2 DM subjects for 28 days, revealed that 53.3% subjects showed improvement in FBS and HbA1c. Also, the prevalence of Microalbuminuria reduced to 21.4% from 35.7% and no toxic effects on biomarkers of liver and kidney were seen.
Iyer and Dhruv et al, 2012	A non-randomized clinical trial was done to study the impact of kodari supplementation on lipemic status of 30 T2DM subjects for 28 days showed a significant increase in Apo A levels (10.1%), significant decrease in Apo B/A ratio (14.2) and LDL (5.5%). The initially higher levels of TC, TG, LDL & VLDL turned to normal stating the millet as an hypolipidemic agent.
Mehta and Shah, 2010	On intervention of the Ragi laddoo with Shankhpushpi, the results showed an improvement in Hb and Calcium levels, significant change in LDL, TC/HDL ratio and HDL levels. Also, in elderly it showed slight reduction in the joint pain, lethargy, improved appetite, mental performance and retention power.
Nambiar and Sareen, 2010	Production of pearl millet was highest in Rajasthan, followed by Maharashtra and Gujarat. Whereas in Gujarat it is found mainly in Saurashtra and Northern plains. The study showed an increase in the iron bioavailability of pearl millet when the different household processing treatments such as soaking, milling and roasting were used in pearl millet based foods. Also, they were found to be feasible and cost effective that can be adopted at household levels by people at large.

Nambiar et al., 2011 & 2015	The study showed that Pearl millet have many potential health benefits due to its nutraceutical properties. One of which is that it contains the polyphenols which have a protective role against the chronic degenerative diseases.
Gandhi and Parmar, 2017	The study showed that the knowledge regarding the importance of millets and consumption was poor in the areas like urban, rural and tribal in Panchmahal district of Gujarat. They only knew about bajri and kodari. Only 15% urban, 31% rural and 27% tribal people knew about the health benefits of millets. Hence, promotion of production and consumption of millets should be encouraged.
Nambiar and Patwardhan, 2013	The study conducted in Pune reveals that 85% males and 88% females consumed millets in the form of traditional Maharashtrian recipes but <16% consumed on daily basis as wheat and rice were their staple foods. 7 traditional recipes were made from the millets from which vada was the most acceptable and bhakri and khichdi being the least. Whereas, the GI & GL of cheela was the lowest and bhakri being the highest. Emic views on the millets stated them as the food for diabetics and hyperlipidemic subjects. Hence, more traditional millet based foods need to be promoted among youth in order to prevent the rise of NCDs.

It is one of the easily cultivable crop belonging to the Setaria genus of Poaceae family and subfamily Panicoideae. It is cultivated in 26 countries and ranks second in worldmillet production. With regard to yielding ability, it ranks fourth among normal production practices with no use of fertilizers or pesticides that makes it easier to classify it as an organic food (Patangare et al. 2019).

Foxtail millet is commonly known as Italian millet or German millet and also as Hungarian or Siberian millet. In India, it is commonly called as 'kakun'. Whereas in different regions it is known as 'Kangni' in Hindi, 'Kang' in Gujarati, 'Rala' in Marathi, 'Navane' in Kannada, 'Tenai' in Tamil' 'Korra' in Telugu, 'Thina' in Malayalam, 'Kaon' in Bengali and 'Kangni' in Punjabi.

Foxtail millet is an annual crop. It has stems with little branches and a well developed root system. The leaf blade is wide, dense, with bright midrib colour. Inflorescence has one main stalk with small branches that bears spikes and bristles. It bears two flowers per spikelet from which the upper one is bisexual. The fruit is of caryopsis and has grains of different colours. The seeds are enclosed in thin, papery hulls bearing small, convex seeds which is either oval or elliptical in shape (Sapkota et al. 2016).

According to Doust, it has a short generation time of 5–8 weeks from planting to flowering, 8–15 weeks from planting to seed maturity, and can produce hundreds of seeds per inflorescence. It is morphologically similar to the other millets in terms of having layers of husk and bran. Husk forms 13.5%(w/w) and the bran and germ only constitute to 1.5-2%(w/w) of the grain (Dharmaraj et al. 2016).

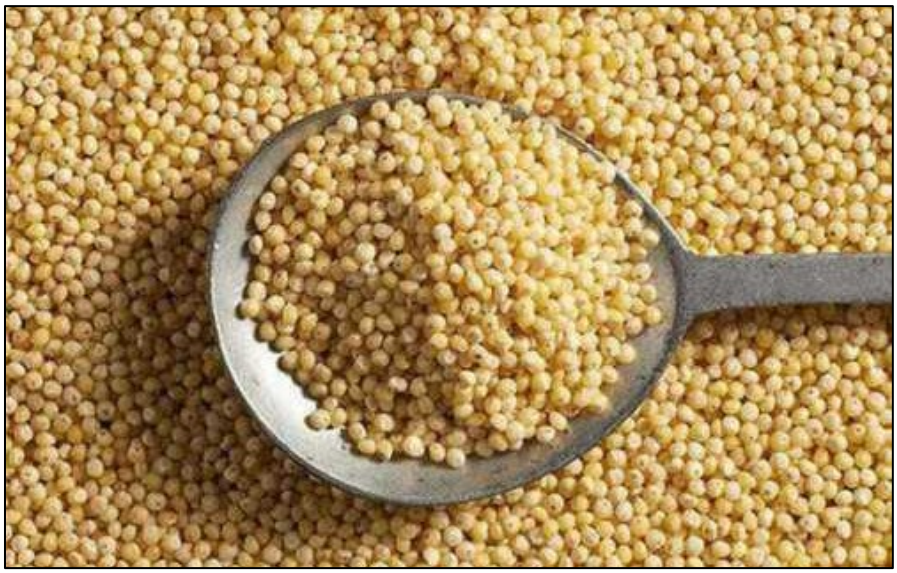
The colour of the grains mainly ranges from dark yellow, yellowish brown to the lightest of yellow shades. The yellow grain of the foxtail millet is used specifically as a poultry feed ingredient to replace corn (Tirajoh et al. 2014).

Foxtail millet is generally grown as a rain-fed crop. It can also grown under saline conditions. Mainly it is cultivated in China, Africa, India, Russia, USA and some parts of Europe (Pawar et al. 2006; Amadou et al. 2013; Pradip et al. 2015). Also like other millets, it is an exceptionally drought resistant crop that suits regions with erratic

FIGURE 2.10(A): FOXTAIL MILLET PLANT

Source: IIMR 2018

FIGURE 2.10 (B): FOXTAIL MILLET GRAIN



Source: IIMR 2018

rainfalls. It can also be cultivated into glass houses with densities upto 100 plants per square metre also making it suitable for further research purposes (Doust et al. 2009).

Foxtail millet has an erect leafy system that grows about 60-75 cm in height and bends when it gets matured due to heavy weight of earhead (Figure 2.10A). Over an area of 0.87 lakh ha with total production of about 0.66 lakh tonnes and with productivity of 762kg/ha it is cultivated in India during 2015-2016.It can be grown I tropics as well as temperate and under low as well as moderate rainfall. The best season in Tamil Nadu, Karnataka and Andhra Pradesh is around August-September, July-August and first fortnight of July respectively. It also happens to be seen in Maharashtra around second and third week of July and in Uttar Pradesh and Bihar in the middle of June.

Foxtail millet is a non-glutinous and non-acid forming grain that is soothing and easy to digest. It is also considered to be one of the least allergenic and a warming grain (Prashant et al. 2005; Xue et al. 2008).

Nutrient Composition of Foxtail Millet

Foxtail millet contains a pertinent amount of nutrients especially starch, protein, fibre, vitamins and minerals as shown in the table. The nutritional value of foxtail millet is highly appreciating as 100g of the grain contains 323-350kcal energy, 8 g fibre, 12.3g protein, 60.9g carbohydrates, 4.3g fat, 31mg calcium, 2.8mg iron, 290mg phosphorus, 3.3g vitamins and 3.3g minerals (Vanithasri *et al*., 2012).

Fibre

Due to its coarse nature, it contains about 79% digestible part and remaining is the undigestible part which is relatively high in fibre and has some amount of anti-nutritional components. It is a good source of crude fibre which helps in digestion process and helps to induce the bowel movement, producing a laxative effect that is beneficial for the healthy digestive system.

Besides this, the beta-glucans (42.6%) present in fibre, helps to enhance the blood glucose and cholesterol metabolism that prevents diabetes and cardiovascular diseases (Itagi et al. 2012; Muthamilarasan and Prasad 2015).

TABLE 2.4: NUTRIENT COMPOSITION OF FOXTAIL MILLET

Component	Amount/100g
Energy (kcal)	331
Protein (g)	12.3
Fat (g)	4.3
Minerals (g)	3.3
Fibre (g)	8.0
Carbohydrates (g)	60.9
Calcium (mg)	31
Phosphorus (mg)	290
Iron (mg)	2.8

Source: Indian Food Composition Tables, NIN – 2017 and Nutritive value of Indian foods, NIN – 2007

TABLE 2.5: AMINO ACID COMPOSITION OF FOXTAIL MILLET PER 100G

Amino Acids	Amount (mg)/100g
Arginine	220
Histidine	130
Lysine	140
Tryptophan	60
Phenyl Alanine	420
Methionine	180
Cystine	100
Threonine	190
Leucine	1040
Isoleucine	480
Valine	430

Source: Indian Food Composition Tables, NIN – 2017 and Nutritive value of Indian foods, NIN – 2007

TABLE 2.6: VITAMIN CONTENT OF FOXTAIL MILLET

Vitamins	Amount (mg)/100g
Thiamin	0.59
Niacin	3.2
Riboflavin	0.11
Vitamin A (carotene)	32
Folic Acid	15
Vitamin B5	0.82
Vitamin E	31

Source: Indian Food Composition Tables, NIN – 2017 and Nutritive value of Indian foods, NIN – 2007

TABLE 2.7: MINERAL CONTENT OF FOXTAIL MILLET

Minerals	Amount (mg)/100g
Magnesium	81
Sodium	4.6
Potassium	250
Copper	1.4
Manganese	0.6
Molybdenum	0.070
Zinc	2.4
Chromium	0.030
Sulphur	171
Chloride	37

Source: Indian Food Composition Tables, NIN – 2017 and Nutritive value of Indian foods, NIN – 2007

TABLE 2.8: FATTY ACID CONTENTS OF FOXTAIL MILLET

Fatty Acid	Amount (mg)/100g
Palmitic	6.4
Stearic	6.3
Oleic	13.0
Linoleic	66.5

Source: Indian Food Composition Tables, NIN – 2017 and Nutritive value of Indian foods, NIN – 2007

TABLE 2.9: STARCH CONTENTS OF FOXTAIL MILLET

Starch Content	Amount (%)/100g
Amylose	17.5
Amylopectin	82.5

Source: Indian Food Composition Tables, NIN – 2017 and Nutritive value of Indian foods, NIN – 2007

Starch

Starch is one of the principal carbohydrate constituent making up approximately 61%. It is composed of amylase and amylopectin in the 25:75 weight ratio. Even though the heat processing techniques improves starch digestibility, a fraction is believed to be resistant to the mammalian digestive enzymes. This fraction is called as resistant starch which exerts a significant positive effect on human health, particularly in glucose metabolism, mental performance, management of chronic diet related diseases and weight control. Thus, the functional property of effective fecal bulking, hypoglycemic and hypolipidemic agent of foxtail millet resistant starch were investigated in rats by Krishna Kumari and Thayumanavan.

A study by Bangoura et al. reveals that cooking of foxtail millet decreased the resistant starch content and increased the amylase content aiming to a high degree of syneresis and gel consistency to the starch. Also, the swelling power and solubility of the starch increased with increase in temperature which may be due to the retrogradation of starch molecules. This starch is of great interest among the entrepreneurs owing to its flexibility to make gels of the foxtail millet flour and divalent cations such as CaCl2 and FeSO4 (Nagaprabha and Bhattacharya, 2016).

Protein

Researches have shown that the foxtail millet protein components and amino acid composition is better than the other millets, hence, it is a good and relatively cheaper source of protein for value addition into food products. The major storage proteins present are alcohol-soluble prolamines. Lookhart and Bean found that the highest protein fraction found was albumin, followed by gliadin, globulin, glutein and other proteins forming an average of 11.54g per 100g of the millet grain.

In addition to the different protein fractions, the size and composition of amino acids also plays an important role in the protein functionality determination. On the amino acid analysis of foxtail millet protein, Kamara et al. and Mohamed et al. found that it is rich in glutamic acid, leucine, alanine, aspartic acid and lysine. These essential amino acids were

complied with the FAO/WHO/UNU requirements and also comparable to that of the soy protein concentrate.

The results of another study, the amino acid profile of enzymatically digested foxtail millet protein concentrate revealed that it produced a heat stable alpha amylase digestion that had relatively higher amounts of amino acids than the other millets. They also reported protein digestibility, biological value and protein utilization concepts. By comparing the foxtail millet and non-foxtail millet diets in rats, it showed that the foxtail millet protein concentrate was a superior dietary supplement to that of the other millets.

Phytochemicals

Apart from proteins, antioxidants also constitute the major functional component present in foxtail millet. They are known to scavenge the free radicals present in our bodies. One of the main antioxidants found in the foxtail millet are phenolics. They chemically act by donating the hydrogen ions via hydroxyl groups on benzene rings to the free radicals that are electron deficient and form a resonating stabilized and less reactive phenoxyl radical. Phenolic compounds from foxtail and other millets are known for their abilities of reducing agents, singlet oxygen quenchers and metal chelators. (Chdandrasekara, 2010)

A study by Chandrasekara et al. on phenolic antioxidant of millets showed that both soluble and insoluble –bound phenolic extracts significantly contribute to the antioxidant efficacy of the millets. The bound fraction have a higher antioxidant activity in terms of trolox equivalents, reducing power, ferrous ion chelation and and ferulic and p-coumaric acid content. Ferulic and p-coumaric acids were found to be the major hydroxycinnamic acids with effective radical and ROS inhibition activities. When looked into the various processing techniques of foxtail millet and the antioxidant activity, they found that the maximum antioxidant property was found to be in the hull followed by the whole grain, dehulled grain and cooked grain.

The hydroxyl radicals in the phenolics induce DNA scission inhibition, and at a concentration of 0.5 mg ml–1, the phenolic extract can suppress the antiproliferation of HT-29 human colon adenocarcinoma cells by 30–40% between 72 and 96 hours.

In another study by Zhang and Liu, it was found that phenolic acid composition of foxtail millet was comprised of chlorogenic acid, syringic acid, and caffeic acid along with the ferulic and p-coumaric acid, that showed dose-dependent antiproliferative activity on the growth of the MDA human breast cancer cells and human HepG2 liver cancer cells.

The protein hydrolysates of the foxtail millet were found to have an antioxidant activity close to the alpha tocopherol but lower than butylated hydroxyl toluene (BHT) (Mohamed et al. 2012). Even the carotenoids present in them exert the antioxidant effects (Shen et al. 2015).

Zhu et al. when extracted the polysaccharides from the foxtail millet by using an optimum combination of alkali concentration, liquid-solid ratio, extraction time and temperature, found that they also had a considerable antioxidant activity. Apart from these, the insoluble fibres present in foxtail millet constitute a dominant part of the fibre that contains a good proportion of hemicellulose A and B, followed by cellulose, lignin and pectin. These fibres have significant free radical scavenging activities, reducing power and ferrous ion chelating capacity (Bangoura et al, 2011 & 2013).

Amadou et al. in their study indicated that ethanol and water extracts of foxtail millet bran had potent antioxidant activities, including reducing power, scavenging activities of DPPH, ABTS and superoxide radicals.

Fatty Acid

The foxtail millet bran oil contains a large proportion of mono-unsaturated fatty acid with cholesterol lowering ability, but deficient in poly-unsaturated fatty acid that contains essential fatty acids (Liang et al. 2010).

Another study by Amadou et al. found that around 87% MUFA, 4% PUFA and 9% SAFA is present in the foxtail millet bran oil. Hence, it could be an emerging source of nutritional food compared to the known olive oil in the market which is also rich in MUFA.

There has been found very few studies of foxtail millet intervention but those found has shown promising effect on blood glucose and lipemic response of the subjects. Apart from this, there are few studies done on the chemical, physical, thermal and food processing techniques of foxtail millet. Germination, fermentation and extrusion helps in enhancing the nutritional composition of various products developed and also helps in enhancing the taste and texture of the cooked foxtail millet.

Studies on Foxtail Millet

There has been ample diversity of foxtail millet available in various parts of the world; India, China, France, Japan, Kenya and Mexico gene banks that can be exploited for various nutritional traits including proteins, as the protein content is higher than that of the other millets (Rao et al. 2011).

Consumption of foxtail millet helps in improving the glycemic control, inhibits hyperinsulinemia and decreases plasma lipid concentrations in persons with type-2 diabetes (Jali *et al.* 2012).

Foxtail millet is an extremely suitable food for type 2 diabetes subjects due to its lower glycemic index(GI) as its starch digestibility is much lower than that of wheat and rice (Rodriguez et al. 2020).

It is considered as one of the best minor millet crops for anemic and diabetic people, thus enforcing nutritional security besides food security (Bandyopadhyay et al. 2017).
The processed protein from the millet has been reported as a potential source of food additive (Mohamed et al. 2009).

A study by Anju & Sarita in 2010, states that the use of millet flour, especially foxtail millet in biscuit making would greatly enhance the utilisation of this crop in the developing countries for the therapeutic purpose; in these regions, the crop has not been optimally utilised. The nutritional quality of refined wheat flour biscuits can be improved by supplementing foxtail millet and barnyard millet. Foxtail millet is preferred to barnyard millet as the later has a higher glycemic index.

A randomized, cross-over study, on 300 patients with type 2 diabetes mellitus was carried out for which they were made to follow a foxtail millet based diabetic diet (80g) each for 90 days. The diet was a combination of foxtail millet, split black gram and spice mix in specific ratio that had a glycemic index of 49.64%, 16g fibre, 248kcal energy, 11.4g protein, 71mg calcium, 60microgram carotene and 3mg iron. The results showed a decrease in HbA1c by 19.14%, fasting blood glucose levels by 13.5% and Homocysteine concentrations by 0.85% and increased the insulin by 1.9% in their blood. Reduction in plasma lipid parameters were also significant as the total cholesterol concentration decreased by 13.25%, triglyceride concentration by 13.51% and VLDL cholesterol concentration by 4.5%. An increase in HDL cholesterol level was also seen by 17.69%. Hence, the study showed that a high intake of millet based dietary fibre helped in improving the glycemic response, decreased hyperinsulinemia and lowered the plasma lipid concentrations in patients with type 2 diabetes (Jali et al., 2012).

An open-label, self-controlled clinical trial for 12 weeks on free living subjects with IGT was conducted, to whom foxtail millet (50g/day in raw weight) was supplemented and its effect on glycemic metabolism, lipid metabolism, inflammation status and body composition was investigated. The results showed that the mean fasting blood glucose levels decreased to 5.3 $\pm$ 0.7 from 5.7 $\pm$ 0.9 and postprandial blood glucose levels decreased from 10.2 $\pm$ 2.6 to 9.4 $\pm$ 2.3. The average of diastolic blood pressure (DBP) was significantly decreased from 84.9 $\pm$ 8.5 mmHg to 81.6 $\pm$ 7.8 mmHg ($p = 0.003$). It also showed a significant increase in serum leptin levels, decrease in body weight, body fat and the degree of obesity (Ren et al. 2018).

A study by Akhoundan et al. on patients with IGT carried out a 12 week foxtail millet intervention resulted in an increase serum leptin, decrease insulin resistance and a minimal reduction in the inflammatory marker. Apart from this, a slight increase in the foxtail millet consumption also aided the subjects with type 2 diabetes mellitus, since the symptoms for both are same.

In a study by Shobana et al. in 2009, it was noticed that millets and millet-based products had lower glycemic and insulinemic response compared to the other cereals. For

example, when biscuits were made from foxtail millet flour, they had the lowest GI of 50.8 compared to 68 for the biscuits that were made from barnyard millet flour and refined wheat flour (Annor et al. 2017). A significant reduction ($p < 0.001$) was observed in the postprandial blood glucose level of patients who consumed a millet-based dosa when compared to those who consumed a rice-based dosa. Millet-based products might play a protective role in the management of hyperglycaemia; moreover, millets without gluten make them suitable for people with celiac disease (Narayanan et al. 2016).

Various epidemiological studies have shown that an expanded consumption of foxtail millet in the daily diet lowers the risk of developing chronic diseases such as cholesterol metabolism and type 2 diabetes mellitus. Foxtail millet showed a dose-dependent decrease on fasting blood glucose of diabetic rats up to a dose of 300 mg kg–1 body weight; beyond this dosage, the fasting blood glucose level stayed more or less constant at 41%(Sireesha et al. 2011). These health benefits of foxtail millet are mainly attributed to the antioxidants, range of vitamins, minerals, phytochemicals, and other bioactive components, which also make it a promising functional food (Zhang et al. 2015).

Dietary fibers are responsible for many favorable physiological effects like laxation, blood cholesterol and blood glucose reduction. The dietary fibers present in foxtail millet have been found to have similar physicochemical properties to that of soy insoluble fibers, that may help to aid in the gastrointestinal functions and decrease the postprandial hike in serum glucose concentrations with a modest effect on the serum cholesterol concentrations (Bangoura et al. 2013; Anderson et al. 2009).
The similar study also showed that foxtail millet–derived insoluble dietary fibers can delay the diffusion of glucose and may promote the absorption in the gastrointestinal tract. These insoluble fibers could also inhibit α-amylase activity and delay the digestibility of carbohydrates and deter the release of glucose. This is known to improve the insulin sensitivity and lower the risk of diabetes mellitus (Ju-Sung et al. 2011).

Along with the dietary fibers, various other components of foxtail millet also have a beneficial effect on the plasma levels of lipid, glucose, insulin, and adinopectin associated with risk factors like dyslipidemia, elevated low-density lipoprotein (LDL)

cholesterol level, decreased high-density lipoprotein (HDL) cholesterol level, and hyperglycemia. For example, the protein component of foxtail millet is reported to have a positive effect on type 2 diabetes and cardiovascular diseases (Choi et al. 2005); the antioxidants from foxtail millet are reported to inhibit LDL peroxidation, triglyceride levels, and c-reactive protein levels (Chandrasekara et al. 2012).

An aqueous extract of foxtail millet has also been shown to decrease the atherogenic index and increase protection against atherogenicity, that may help the millet in responding against diabetic complications and disturbed lipid metabolism in diabetics (Sireesha et al. 2011).

Many other studies have also reported that the milled fraction containing greater portion of hulls can be used as a potential source of antioxidants due to the significant presence of phenolics (Shahidi et al. 2013; Seo et al. 2011; Shejawale et al. 2015).
A study on the effect of milling on volatile components of foxtail millet concluded that the milled fractions like brown millet, milled millet, and millet bran comprised total 34 volatile compounds like aldehydes, benzene derivatives, alcohols, ketones, hydrocarbons, acids, esters, heterocycles, and sulfur-containing compounds. It was also found that the overall aroma of millet bran was due to the presence of more heterocycles (Liu et al. 2012).

Studies also suggest that the waste fraction removed during milling serves as a potential source of natural antioxidants as well as anti-nutrients, as the major polyphenols and phytates that are usually concentrated in the pericarp, seed coat, and aleurone layer of the grain. So, milling of foxtail millet can cause the consumers to compromise with its superior antioxidant potential. Thus, more research should be carried out to identify methods that can help to utilize all possible components of foxtail millet grain.

There are various traditional simple as well as advanced food processing techniques that help in improving the bioavailability of micronutrients i.e. iron, zinc and B vitamins and renders them in the form that is easy to assimilate in the body along with a significant decrease in the anti nutrients such as phytates and polyphenols (Pawar and Machewad 2006; Saleh et al. 2013).

Even though these traditional methods of processing are very commonly used, there is very limited exploitation of foxtail millet in the context of processed food. The use of advanced processing methods like extrusion has been studied and is still under study by many researchers. Extrusion cooking is normally used to produce fiber-rich foods and usually results in minimum nutritional losses as compared to the other thermal processing methods (Kharat et al. 2015).

Moreover, Wang et al. has also shown a positive effect on the flavor stability during long-term storage of foxtail millet. They suggested that the extrusion could successfully inhibit the formation of unpleasant odors and extended the shelf life of the products.

Fermentation is one of the convenient, easy, and economical method to enhance the nutritional value as well as sensory and functional properties of foxtail millet (Amadou et al. 2014). The variety of microbial strains have been used for the fermentation of foxtail millet flour, such as Lactobacillus paracasei Fn032 (Amadou et al. 2013); Lactobacillus acidophilus, Lactobacillus rhamnosus, Bifidobacterium bifidus, and Bifidobacterium longum (Farooq et al. 2013); Saccharomyces boulardii and Lactobacillus acidophilus (Pampangouda et al. 2014).

A study by Amadou et al. reveals that solid state fermentation using L. paracasei Fn032 and protease enhanced the physicochemical and nutritional properties of the foxtail millet meal, that exhibited the significance of antioxidant and antimicrobial activity due to the formation of bioactive peptides as a by-product of fermentation. Increased albumin/globulin ratio and total protein extractability suggested that fermentation also resulted in better protein quality (Antony et al. 1996). The bioactive peptides produced by L. paracasei Fn032 also showed the proper radical scavenging activity and antibacterial activity against E. coli ATCC 8099, with complete resistance toward trypsin proteolysis (Amadou et al. 2013).

In addition to this, microbial processing by probiotic yeast and lactic acid bacteria also resulted in nutritional improvement of foxtail millet flour. Addition of a single strain of L. acidophilus increased the mineral content (calcium, magnesium, phosphorus, iron, and zinc) and reduced anti-nutritional factor (phytic acid content) (Pampangouda et al. 2014).

Fermentation of foxtail millet using various microbial strains have shown an increased physicochemical and nutritional properties along with the antioxidant and antimicrobial activitities. It has also been shown that this method can be successfully used to prepare alternative food supplements and food preservatives due to the presence of various antioxidative-antimicrobial peptides.

One of the most common effects of germination on millets is the increased yield of hydroxyl radical-inhibiting water-soluble protein (Bai et al. 2009).

Sharma et al. stated that germination of foxtail millet enhanced its composition by increasing the availability of higher amount of bioactive compounds such as total phenolics, antioxidants, total flavonoids, dietary fiber, proteins, minerals, and decreasing the anti-nutritional factors. Laxmi et al. reported that steeping of foxtail millet for 12 hours followed by germination for 48 hours increased its nutritional properties significantly.

Pawar and Pawar reported that steeping of grains in water for 16 hours and germinating for 48 hours resulted in maximum malt yield.

Choudhury et al. optimized the germination process for yellow and purple varieties of foxtail millet, suggesting that a soaking period of 20 hours and germination period of 72 hours at temperatures of 25 °C– 30 °C produced foxtail millet with negligibly reduced protein content, significantly lower fat and carbohydrate content, and increased starch and protein digestibility.

During germination, the action of lipolytic enzymes utilized the fat in the grains for producing energy required for seed growth. This fat utilization rendered the grains more palatable and without any possible action of lipase, that can cause the meal to be unacceptable and bitter due to the formation of free fatty acids. Similarly, the action of amylase broke down the starch granules and formed simpler and more absorbable sugars. Similar results were also reported by Coulibaly and Jie and Sharma et al. with respect to the effect on increase in total phenolic content, antioxidant activity, total flavonoid content, dietary fiber, protein, and minerals. Moreover, the anti-nutritional factor was found to be minimum in the germinated samples. Hence, the study concluded that

germination could prove to be very useful in the development of foxtail millet-based products.

Although foxtail millet being commonly used as a bird/animal feed in the higher societies, its potential remains unexploited. Whole grains processing techniques like drying, roasting, germination, and fermentation can produce products that can be nutritionally preferable to decorticated grains.

With the growing challenge of producing health-promoting food products, the food industries are now focusing on less exploited ingredients. Foxtail millet has pertinent levels of all the nutritional components required. In addition, this gluten-free flour can also be used to partially substitute wheat flour in food products (Devisetti et al. 2014). It is a cereal suitable to address food and nutrition security due to its yielding potential in drought and poor-resource environments, and also due to its ability to produce food products with significant health-benefitting properties. It is evident that a number of researchers have demonstrated the favorable nutritional, physical, rheological, and chemical properties for foods produced using foxtail millet.

The literature published till now, gives a thorough understanding of the properties and potential uses of foxtail millet, but further research and development particularly on processing techniques of foxtail millet that are more efficient and sustainable, clear links between processing conditions and the product quality, and the health impact of the products is necessary in order to exploit its full potential (Sharma & Niranjan, 2017).

Thus, foxtail millet can be potentially used to prepare various low-glycemic index foods that can lead to a prudent improvement in the long-term control of diabetes and hyperlipidemia. It can also be used in the daily diets of the people in order to sustain healthy diets. For any intervention studies with foxtail millet, it is necessary to robustly establish its effects on hyperglycemia and hyperlipidemia.

METHODS AND MATERIALS

METHODS AND MATERIALS

Millets are considered as oldest foods or cultivated crops known to humans. They belong to the grass family Poaceae. Millets are widely grown around the world for animal fodder and human food. In western countries, millets are grown primarily as birdseed, hay or as an emergency cash crop. Millets are consumed by people from the low economic strata and as forage crop in the developing countries (Baker, 2003). They are nutritionally comparable or even superior to the staple cereals such as rice and wheat (Gopalan, Ramashastri & Balasubramanium, 2004). Millets are a rich source of vitamins, minerals, sulphur containing amino acids and phytochemicals, and hence they are termed as nutri-cereals. They have higher proportions of non starchy polysaccharides and dietary fibre which helps in releasing the sugars slowly and thus have a low glycemic index. Due to the polyphenols and other bioactive compounds present in millets, it also helps in lowering cholesterol and thereby reducing the risk of heart disease and high blood pressure. They have been designated as 'nutritious millets' (Bala Ravi, 2004). Despite the above facts, the nutraceutical property of some millets has not been much exploited for treating various degenerative diseases. One such millet is the Foxtail millet also known as 'Italian millet' in common is found to be a good source of protein, essential amino acids, fibre, phytochemicals, B vitamins and minerals. These nutrients have found to be beneficial in the prevention and management of various Non-Communicable diseases. It is a non-glutinous and non-acid forming grain that is soothing and easy to digest. It is also considered to be one of the least allergenic and a warming grain (Prashant et al. 2005; Xue et al. 2008). Hence, being highly nutritious and underutilized, the present study was planned to increase the awareness, consumption and thereby production of Foxtail millet so as to enhance the nutritional status of the normal as well as malnourished. The broad objective of the study was to develop foxtail millet incorporated recipes. The study was approved by the Institutional Ethics Committee for Human Research (IECHR), Faculty of Family and Community Sciences, Baroda and the allotted ethical approval Number is IECHR/FCSc/2020/47 (Appendix I).

The specific objectives were as follows:

1. To standardize the foxtail millet incorporated recipes.
2. To carry out sensory evaluation of the foxtail millet incorporated recipes.
3. To develop a booklet from the acceptable foxtail millet incorporated recipes subjected to sensory evaluation.

The study was carried out in following 3 phases:

PHASE I – Standardization and development of foxtail millet incorporated recipes.

PHASE II – Sensory evaluation of the foxtail millet incorporated recipes.

PHASE III – Development of a foxtail millet incorporated recipe booklet.

The details of different phases of the study, study design and tools and techniques used are discussed below.

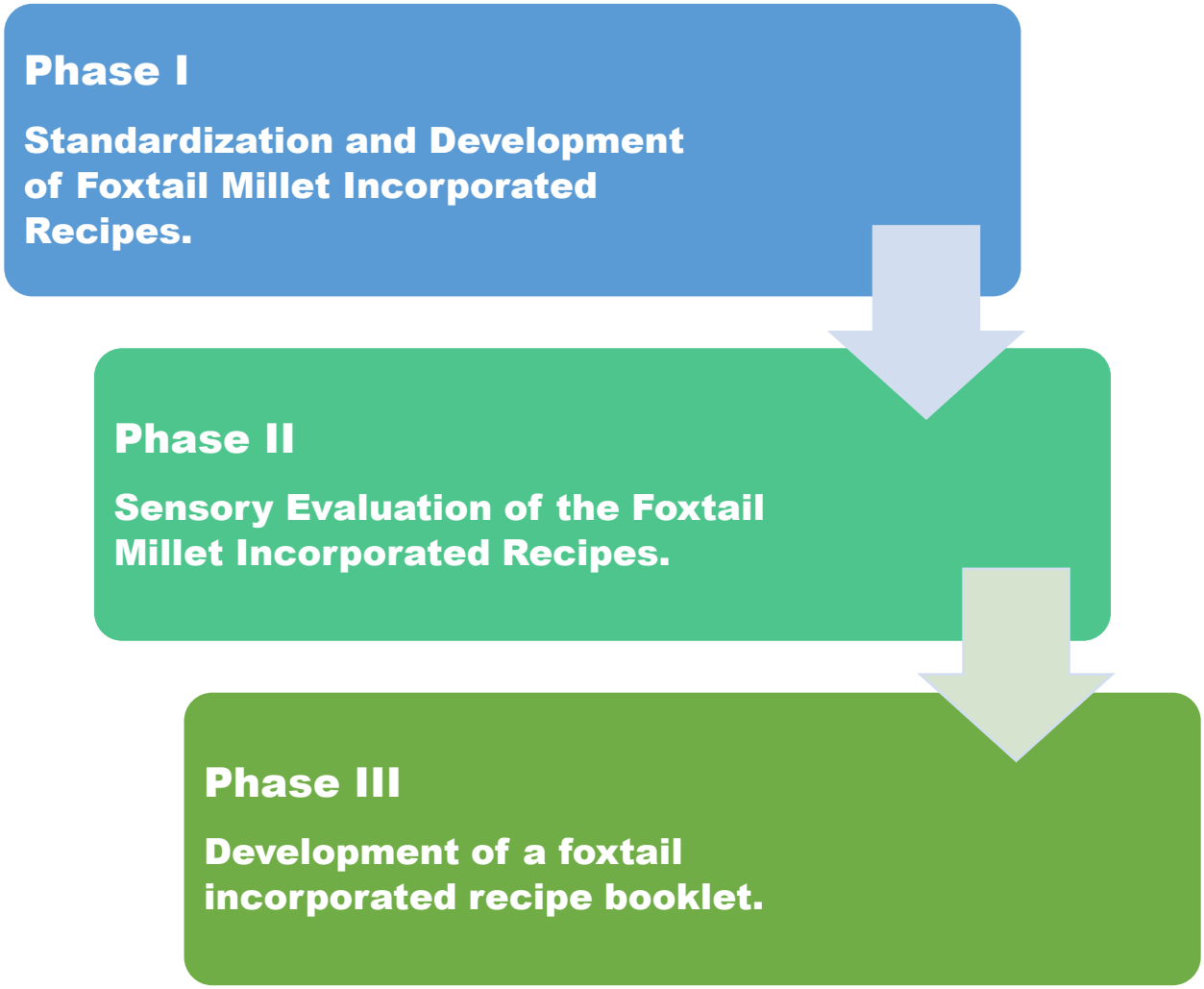
PHASE I - STANDARDIZATION AND DEVELOPMENT OF FOXTAIL MILLET INCORPORATED RECIPES.

Foxtail millet, botanically known as *Setaria Italica*, belonging to the family of Poaceae and subfamily Panicoideae, is an annual grass with a vertical leafy system that reach the height of 120 to 200cm. The matured seed head gets dense, hairy panicle 5-30cm long, the seed color vary from yellow to yellowish brown and it is around 2mm in diameter encased in a thin, papery hull that can be removed by threshing.

Foxtail millet is also known as Italian millet and regionally known as ‘Kang’ in Gujarati,‘Korra’ in Telugu, ‘Kangni’ in Hindi and Punjabi, ‘Rala’ in Marathi, ‘Thina’ in Malyalam and ‘Thinai’ in Tamil.

The nutrient profile of foxtail millet is found to be better than the other minor millets. However, despite having a rich nutrient profile there are very few scientific studies conducted on it. Hence the present study was planned to propagate the consumption of foxtail millet in the diets of the general population and because of its functional property it can also be used in the prevention and management of obesity, non-communicable diseases, gastric disorders and certain types of cancer.

FIGURE 3.1: EXPERIMENTAL PLAN OF THE STUDY



PROCUREMENT OF FOXTAIL MILLET

The foxtail millet was found to be available in the local market and on the online websites as well. For the study, it was procured from the local store of a city market. There were two types of foxtail millet available in the market: dehusked foxtail millet and husked foxtail millet. The husked one had two varieties: 'Moti Kang' and 'Nani Kang'. As such it is difficult to cook and process the husked millet, flour can be made from it and the dehusked one can be used as the whole grain to prepare the other recipes.

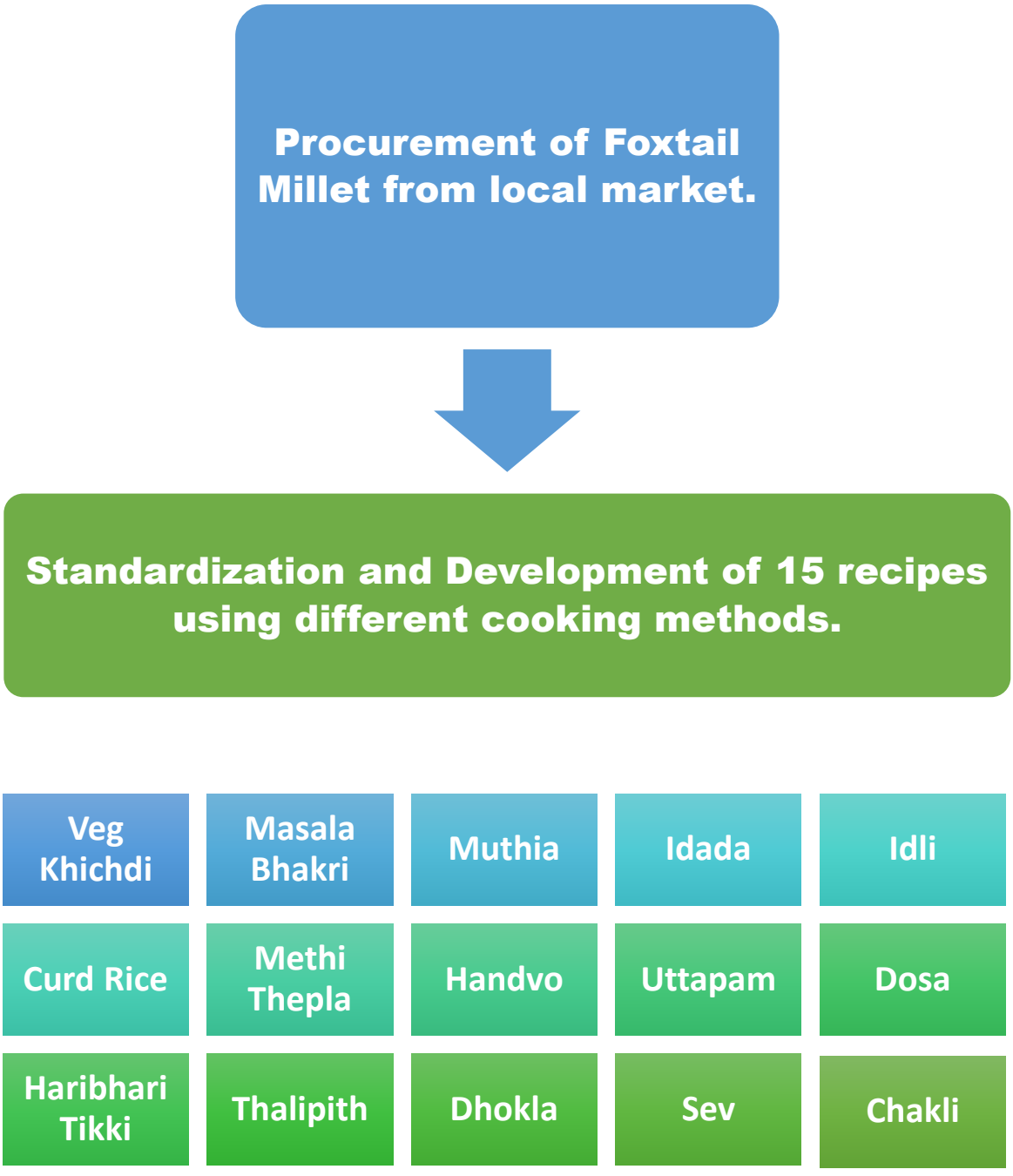
STANDARDIZATION AND DEVELOPMENT OF THE RECIPES

Foxtail millet is like a cereal thereby can be used in place of any other cereal grain or millet. It can be cooked like rice, boiled, roasted or ground into flour. Foxtail millet is a good source of protein, B vitamins, amino acids and other minerals. It contains polysaccharides as fiber which may not only help in reducing blood sugar levels but may also have cardiovascular protective effect. It also contains phenolics that are the major antioxidants and phytates. The millet was readily available in the local market. The overall cost range was around 55-75rupees per kg. The seeds were used after cleaning, washing and soaking for about 10-15 minutes. The 15 recipes developed incorporating foxtail millet were Veg Khichdi, Dhokla, Masala Bhakri, Muthia, Thalipith, Curd Rice, Chakli, Handvo, Methi Thepla, Sev, Idli, Dosa, Uttapam, Idada and Hari Bhari Tikki as shown in the Figure 3.2. The details of these products are given in Appendix VI.

PHASE II – SENSORY EVALUATION OF THE FOXTAIL MILLET INCORPORATED RECIPES.

Sensory evaluation of the developed and standardized products namely; Veg Khichdi, Dhokla, Masala Bhakri, Muthia, Thalipith, Curd Rice, Chakli, Handvo, Methi Thepla, Sev, Idli, Dosa, Uttapam, Idada and Hari Bhari Tikki was carried out with a panel of 30 semi-trained panelists from the Faculty who gave their consent to participate in the study for the sensory evaluation (Appendix II). It was carried out to study whether the developed recipes are acceptable when foxtail millet was partially or fully substituted with rice and/or wheat in the traditional Indian recipes and to look after the various sensory attributes if any.

FIGURE 3.2: EXPERIMENTAL PLAN FOR PHASE I



A baseline data on the general information, medical or medication history was taken using a Google Form on the basis of which the panelists were selected. The 30 semi-trained panelist members were asked to rate each attributes of the developed recipes using a Google form. It consisted of two parts: Composite rating scale and overall liking of recipes using the Hedonic rating test. Due to the ongoing pandemic, all the precautionary measures were taken while carrying out the sensory evaluation. Therefore, Google form was given to the panelists to minimize the contact so as to taste and rate the developed recipes.

Composite Rating Scale: The 10 point scoring test was conducted so that the specific characteristics of the product could be rated separately. It helps to point out which specific attribute is not acceptable or is at fault.

All the developed recipes were evaluated for the following attributes:

- Color & Appearance
- Aroma
- Texture
- Taste
- After taste
- Mouth feel
- Overall acceptability

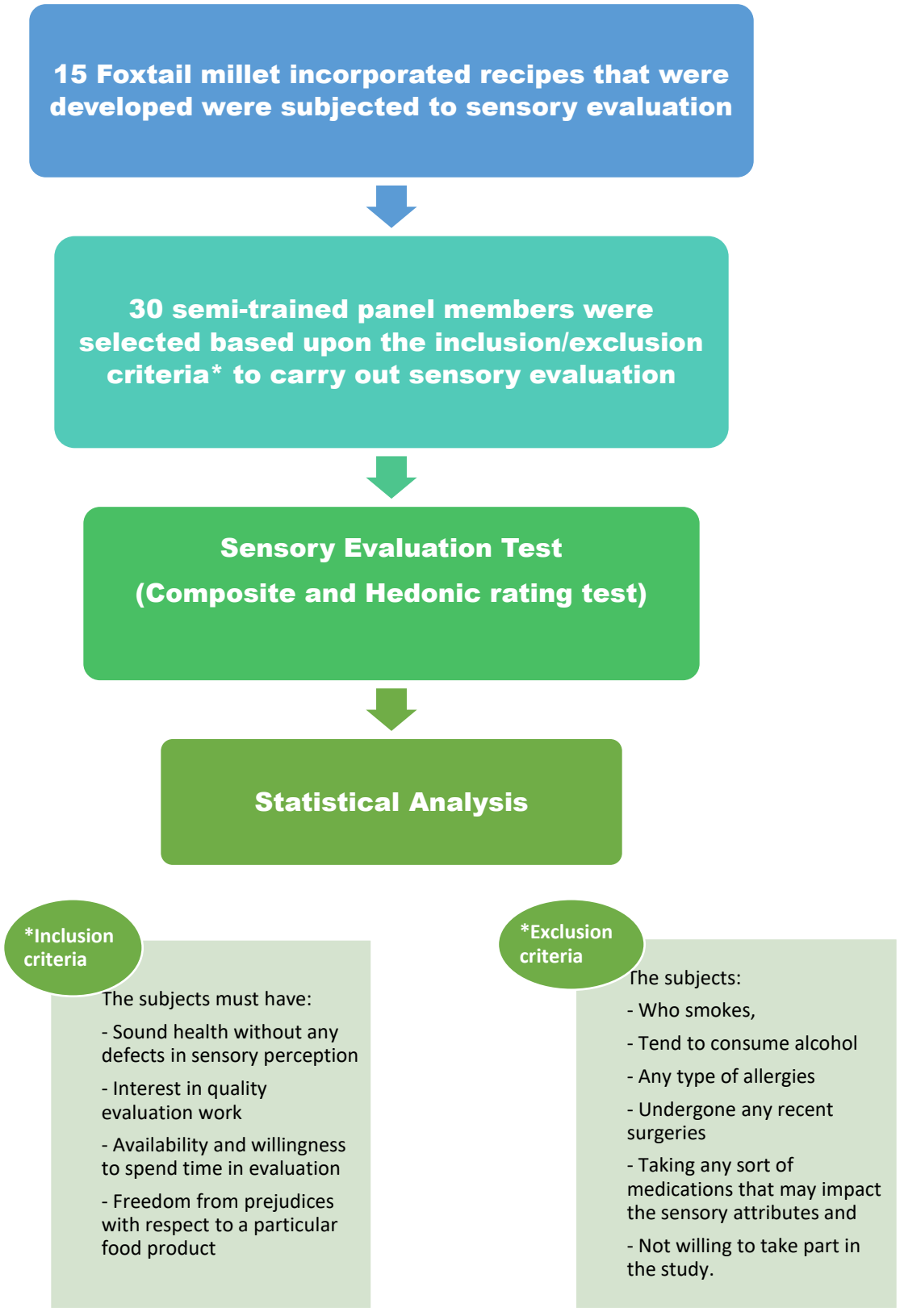
Hedonic Rating Test: This test has a 7 point rating scale ranging from 'like very much' to 'dislike very much' with 'neither like nor dislike' as the middle score that helped in identifying the most or least liked product from the various recipes.

The specific attributes studied for each of the products is mentioned in Appendix IV. The flow chart for sensory evaluation is given in Figure.

Inclusion criteria for sensory evaluation panelists:

- The subjects must have
- sound health without any defects in sensory perception
- interest in quality evaluation work

FIGURE 3.3: EXPERIMENTAL PLAN FOR PHASE II



- availability and willingness to spend time in evaluation
- freedom from prejudices with respect to a particular food product

Exclusion criteria for sensory evaluation panelists:

- The subjects who smokes,
- tend to consume alcohol
- any type of allergies
- undergone any recent surgeries
- taking any sort of medications that may impact the sensory attributes and
- not willing to take part in the study are to be excluded.

Other than the sensory evaluation, we also tried to elicit information with respect to the awareness and consumption of millets by carrying out a post sensory evaluation survey with the help of a Google Form (Appendix V). The panelists were asked to register their responses in the same form to rate each attributes of the developed recipes. The tools and techniques used for data collection are shown in Table 3.1.

PHASE III - DEVELOPMENT OF FOXTAIL MILLET INCORPORATED RECIPE BOOKLET.

The recipe booklet of the foxtail millet incorporated recipes which was subjected to the sensory evaluation has been developed (Appendix VI). The booklet contains introduction of millets, information on foxtail millet, advantages of foxtail millet, ingredients of recipes, methodology and its nutrient composition.

DATA ANALYSIS

All the data from the questionnaires was entered into a Microsoft Excel Spreadsheet. It was further sorted according to the various recipes, attributes and different score cards. All the data was subjected to statistical analysis using:

- Mean
- Standard Deviation
- Percentages
- ANOVA
- Unpaired t test

TABLE 3.1: TOOLS AND TECHNIQUES

PARAMETERS	METHODS/TOOLS
General Information of Semi-Trained Panelists	Pretested Questionnaire (Google Form)
Sensory Attributes	Composite Rating Scale (Google Form)
Sensory Attributes	Hedonic Rating Test (Google Form)
Post Sensory Evaluation Survey	Pretested Questionnaire (Google Form)

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

"Millets are one of the oldest foods known to humans and possibly the first cereal grain to be used for domestic purposes" (O.S.K. Reddy, 2017). Millet grain is the basic foodstuff for farm households in the world's poorest countries and among the poorest people. Today, millet ranks as the sixth most important grain in the world. In the present era of food scarcity there exists a need to diversify the use of these millets by developing various millet recipes. Millets are highly nutritious, healthy and versatile grain that would increase the nutritional value of the foods thereby leading to a healthy diet.

Millets are a rich source of vitamins, minerals, sulphur containing amino acids and phytochemicals, and hence are termed as nutri-cereals. They have higher proportions of non starchy polysaccharides and dietary fibre that helps in releasing sugars slowly and thus have a low glycemic index. Due to the polyphenols and other bioactive compounds present in millets, it also helps in lowering cholesterol and thereby reducing the risk of CVD, CHD and high blood pressure (Bala Ravi, 2004). Despite these nutritional facts, the nutraceutical property of some millets has not been much exploited for the treatment of various degenerative diseases. One such millet is the Foxtail millet also known as 'Italian millet' in common. It is found to be a good source of protein, essential amino acids, fibre, phytochemicals, B vitamins and minerals. These nutrients are beneficial in the prevention and management of various Non-Communicable diseases. It is a non-glutinous and non-acid forming grain that is soothing and easy to digest. It is also considered to be one of the least allergenic and a warming grain (Prashant et al. 2005; Xue et al. 2008). However, this facet has not studied extensively and not much literature is available on it. Thereby, the present study was planned with the objective of developing the foxtail millet incorporated recipes to increase the awareness, consumption and thereby production of foxtail millet so as to enhance the nutritional status of the normal as well as malnourished.

The study was carried out in the following three phases:

PHASE I – Standardization and development of foxtail millet incorporated recipes.

PHASE II – Sensory evaluation of the foxtail millet incorporated recipes.

PHASE III – Development of a foxtail millet incorporated recipe booklet.

PHASE I - STANDARDIZATION AND DEVELOPMENT OF FOXTAIL MILLET INCORPORATED RECIPES

Foxtail millet, locally known as Kang is an annual crop. It is 60-75cm tall in height and the colour of the grains mainly ranges from dark yellow, yellowish brown to the lightest of yellow shades. The scientific name is *Setaria Italica* and it belongs to grass family Poaceae and sub-family Panicoideae. Foxtail millet is a non-glutinous and non-acid forming grain that is soothing and easy to digest. It is also considered to be the one of least allergenic and a warming grain (Prashant et al. 2005; Xue et al. 2008). Traditionally it was used in making of porridges and gruels for kids and pregnant and lactating women. Foxtail millet is now trying to receive increased attention in various parts of the world where it can enter the daily diet in various forms, including porridge, ready-to-eat snacks, and beverages. In addition, this gluten-free flour can also be used to partially substitute wheat and rice flour in food products (Devisetti et al. 2014). Due to scanty data on food processing techniques and food product development of foxtail millet, the present study was planned to increase the awareness, consumption and thereby production of foxtail millet in general population as well as with disease patients due to its ability in prevention and management of various NCD's, obesity, gastric problems and certain types of cancer as it is a rich source of protein, fibre and various antioxidants.

In this phase, Foxtail millet was first purchased from the local shop and online website, cooked and compared the differences if any. Further, 15 foxtail millet incorporated recipes were developed and standardized. The recipes developed were Veg Khichdi (steamed food), Dhokla (fermented food), Masala Bhakri (roasted product), Muthia (steamed food), Thalipith (roasted product), Curd Rice (steamed food), Chakli (extruded product), Handvo (fermented food), Methi Thepla (roasted product), Sev (extruded product), Idli, Dosa, Uttapam, Idada (fermented foods) and Hari Bhari Tikki (shallow-fried food) using the different cooking methods (Figure 4.1). These recipes were found to be more nutritious than the ones which are traditionally being consumed in terms of protein, iron, fibre, calcium and their caloric value was also found on a lower side (Table 4.1).

FIGURE 4.1: FOXTAIL MILLET INCORPORATED RECIPES

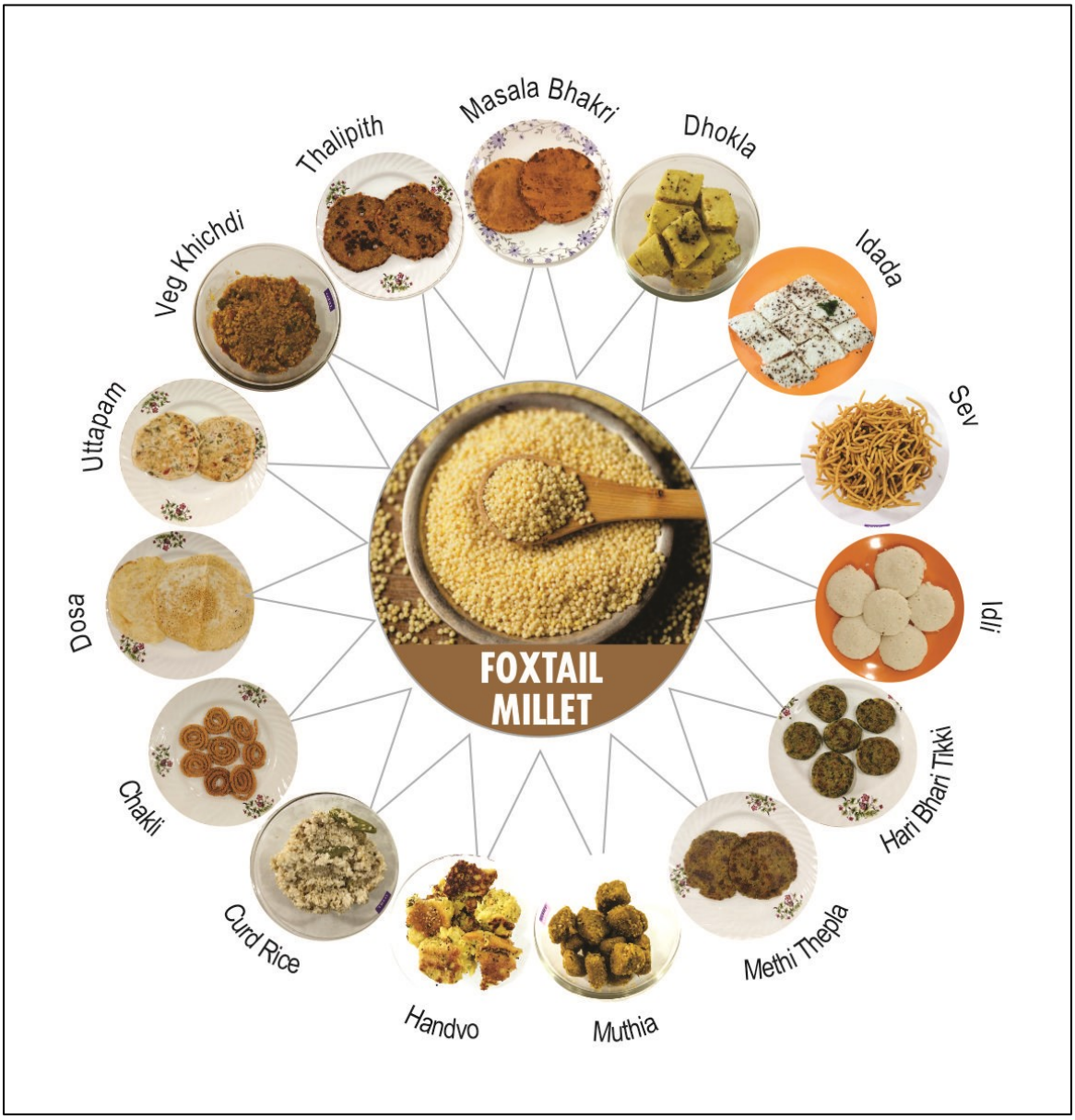


TABLE 4.1: COMPARISON BETWEEN TRADITIONAL AND FOXTAIL MILLET INCORPORATED RECIPES.

CHAKLI – per chakli

NUTRIENTS	FOXTAIL MILLET INCORPORATED	TRADITIONAL (WHEAT/RICE)
Energy (kcal)	34	42
Protein (g)	0.7	0.3
Fibre (g)	0.4	0.1
Iron (mg)	0.24	0.2
Calcium (mg)	10.3	1.6

SEV – 1 cup

NUTRIENTS	FOXTAIL MILLET INCORPORATED	TRADITIONAL (WHEAT/RICE)
Energy (kcal)	243	352
Protein (g)	7.9	5.1
Fibre (g)	5.3	3.9
Iron (mg)	2.3	1.2
Calcium (mg)	17.5	10.1

CURD RICE – 1 cup

NUTRIENTS	FOXTAIL MILLET INCORPORATED	TRADITIONAL (WHEAT/RICE)
Energy (kcal)	225	376
Protein (g)	7.3	4.4
Fibre (g)	3.2	1.8
Iron (mg)	1.7	0.6
Calcium (mg)	131.2	112

DHOKLA – 1 cup

NUTRIENTS	FOXTAIL MILLET INCORPORATED	TRADITIONAL (WHEAT/RICE)
Energy (kcal)	208	546
Protein (g)	7.9	5.6
Fibre (g)	4.7	3.8
Iron (mg)	2.3	3.5
Calcium (mg)	72.7	67.2

Veg Khichdi – 1 cup

NUTRIENTS	FOXTAIL MILLET INCORPORATED	TRADITIONAL (WHEAT/RICE)
Energy (kcal)	230	360
Protein (g)	8.2	7.1
Fibre (g)	6.2	8.2
Iron (mg)	2.5	1.6
Calcium (mg)	45.3	53.4

Contd.

MASALA BHAKRI – per bhakri

NUTRIENTS	FOXTAIL MILLET INCORPORATED	TRADITIONAL (WHEAT/RICE)
Energy (kcal)	110	145
Protein (g)	2.3	1.4
Fibre (g)	1.7	1.4
Iron (mg)	0.8	0.6
Calcium (mg)	6	8.4

THALIPITH – per thalipith

NUTRIENTS	FOXTAIL MILLET INCORPORATED	TRADITIONAL (WHEAT/RICE)
Energy (kcal)	115	141
Protein (g)	3.9	2
Fibre (g)	3.3	1
Iron (mg)	1.4	1.3
Calcium (mg)	13.5	14

METHI THEPLA – per thepla

NUTRIENTS	FOXTAIL MILLET INCORPORATED	TRADITIONAL (WHEAT/RICE)
Energy (kcal)	103	108
Protein (g)	2.5	1.5
Fibre (g)	2.2	1.5
Iron (mg)	1.1	0.6
Calcium (mg)	27.8	11.1

MUTHIA – 1 cup

NUTRIENTS	FOXTAIL MILLET INCORPORATED	TRADITIONAL (WHEAT/RICE)
Energy (kcal)	227	222
Protein (g)	7.6	4.8
Fibre (g)	4.9	4.1
Iron (mg)	2.7	1.5
Calcium (mg)	73.4	36.3

HANDVO – 1 cup

NUTRIENTS	FOXTAIL MILLET INCORPORATED	TRADITIONAL (WHEAT/RICE)
Energy (kcal)	272	352
Protein (g)	9.8	6.6
Fibre (g)	5.9	4.6
Iron (mg)	3.3	2.2
Calcium (mg)	119.9	102.1

Contd.

DOSA – 1 serving

NUTRIENTS	FOXTAIL MILLET INCORPORATED	TRADITIONAL (WHEAT/RICE)
Energy (kcal)	98	266
Protein (g)	4.3	3.8
Fibre (g)	1.5	2.2
Iron (mg)	0.9	1
Calcium (mg)	14	21.8

IDLI - per idli

NUTRIENTS	FOXTAIL MILLET INCORPORATED	TRADITIONAL (WHEAT/RICE)
Energy (kcal)	39	33
Protein (g)	4.2	1
Fibre (g)	1.5	0.3
Iron (mg)	0.9	0.2
Calcium (mg)	12.2	4

IDADA – 1 CUP

NUTRIENTS	FOXTAIL MILLET INCORPORATED	TRADITIONAL (WHEAT/RICE)
Energy (kcal)	159	210
Protein (g)	5.7	6
Fibre (g)	2	3.7
Iron (mg)	1.5	1
Calcium (mg)	98.5	34.2

UTTAPAM – per uttapam

NUTRIENTS	FOXTAIL MILLET INCORPORATED	TRADITIONAL (WHEAT/RICE)
Energy (kcal)	90	92
Protein (g)	4.5	4.9
Fibre (g)	1.9	1.5
Iron (mg)	1.2	0.7
Calcium (mg)	18.2	32.8

HARI BHARI TIKKI – per tikki

NUTRIENTS	FOXTAIL MILLET INCORPORATED	TRADITIONAL (WHEAT/RICE)
Energy (kcal)	30	68
Protein (g)	0.9	1.1
Fibre (g)	0.8	1.2
Iron (mg)	0.4	0.6
Calcium (mg)	11.6	12.1

PHASE II – SENSORY EVALUATION OF THE DEVELOPED RECIPES

Sensory evaluation of all the 15 recipes developed was done using a Composite and Hedonic Rating test. The 30 semi-trained panelist members were asked to rate each attributes of the developed recipes using a Google form. It consisted of two parts: Composite and Hedonic rating tests. The rating for Composite scale was based on a 10 point scoring for all the attributes such as color and appearance, aroma, taste, after taste, mouth feel and overall acceptability of the product where as for the hedonic rating test the overall liking of the product was assessed on a 7 point rating ranging from dislike very much to like very much with neither like nor dislike as the mid-score. Due to the ongoing pandemic, all the precautionary measures were taken while carrying out the sensory evaluation. Therefore, Google form was given to the panelists to minimize the contact so as to taste and rate the developed recipes.

Table 4.2 & 4.3 depicts the mean scores of the sensory attributes of the panelists for the composite scoring test. The results of this reveal that all the fifteen recipes developed were well accepted by the panelists. For each of the attribute studied viz. colour and appearance, aroma, texture, taste, after taste, mouthfeel and overall acceptability which were scored on a 10 point scale revealed that for all the attributes majority of them scored more than 9, which is an indication that the recipes developed by incorporating foxtail millet were highly acceptable by the subjects.

When the statistical test of ANOVA was applied, it was observed that a significant difference was found with respect to all the attributes (significance at $p<0.001$) (Table 4.2). This was then subjected to further analysis of 't' test, whereby the results indicated that a significant difference was observed in the colour and appearance of Masala bhakri v/s Chakli and Idada, Curd rice v/s Chakli, Dosa, Idada, Idli, Sev and Uttapam at $p<0.001$. In aroma, it was found that the significant difference was seen in Idli v/s Dhokla and Masala bhakri; in texture the difference was seen in Masala bhakri v/s Chakli, Idada, Idli, Methi thepla, Sev, Thalipith and Uttapam; in taste it was found between Masala bhakri v/s Chakli, Idada and Idli and Dhokla v/s Idada; in after taste it was found between

TABLE 4.2: ATTRIBUTES OF THE COMPOSITE RATING SCORE FOR THE FOXTAIL MILLET INCORPORATED RECIPES (MEAN±SD)

Recipe	Color & Appearance	Aroma	Texture	Taste	After Taste	Mouth feel
Chakli	9.6 ± 0.72	9.5 ± 0.77	9.4 ± 0.82	9.4 ± 0.81	9.3 ± 0.78	9.5 ± 0.77
Curd Rice	8.6 ± 1.03	8.9 ± 0.96	8.6 ± 1.21	8.9 ± 1.22	8.6 ± 1.24	8.9 ± 1.17
Dhokla	8.9 ± 1.38	8.6 ± 1.35	8.3 ± 1.82	8.3 ± 1.80	8.0 ± 1.81	8.4 ± 1.75
Dosa	9.4 ± 0.62	9.2 ± 0.72	8.9 ± 1.14	9.1 ± 0.89	8.9 ± 0.95	9.1 ± 0.86
HariBhari Tikki	9.2 ± 0.77	8.9 ± 0.96	8.8 ± 1.14	8.8 ± 1.06	8.8 ± 1.04	8.8 ± 1.06
Handvo	9.1 ± 1.04	9.1 ± 0.96	8.7 ± 1.20	8.9 ± 1.05	8.7 ± 1.26	8.7 ± 1.23
Idada	9.5 ± 0.67	9.4 ± 0.80	9.3 ± 1.04	9.5 ± 0.76	9.2 ± 0.91	9.3 ± 0.82
Idli	9.5 ± 0.67	9.5 ± 0.67	9.3 ± 0.69	9.4 ± 0.67	9.3 ± 0.73	9.4 ± 0.71
Masala Bhakri	8.8 ± 1.04	8.6 ± 1.35	7.9 ± 1.44	8.4 ± 1.38	8.1 ± 1.48	8.1 ± 1.47
Methi Thepla	9.3 ± 0.92	9.0 ± 1.06	9.1 ± 0.95	8.9 ± 0.98	8.9 ± 0.89	8.9 ± 1.17
Muthia	9.2 ± 0.98	9.0 ± 1	8.9 ± 1.09	8.8 ± 1.03	8.5 ± 1.45	8.5 ± 1.26
Sev	9.4 ± 0.77	9.3 ± 0.71	9.4 ± 0.85	9.3 ± 0.87	9.3 ± 0.84	9.5 ± 0.73
Thalipith	9.3 ± 0.89	9.2 ± 0.87	9.3 ± 0.92	9.2 ± 0.97	8.9 ± 1.15	8.8 ± 1.19
Uttapam	9.3 ± 0.55	9.4 ± 0.67	9.3 ± 0.65	9.3 ± 0.74	9.1 ± 0.76	9.3 ± 0.59
Veg Khichdi	9.2 ± 0.86	8.9 ± 0.95	8.9 ± 1.19	9.2 ± 0.97	9.1 ± 1.23	9.0 ± 1.11
p Value	0.00004***	0.0002***	0.0000003***	0.0001***	0.00001***	0.0000004***
F Value	3.33	2.97	4.33	3.24	3.53	4.24

*** Significantly different at $p<0.001$

TABLE 4.3: OVERALL ACCEPTABILITY OF THE FOXTAIL MILLET INCORPORATED RECIPES (MEAN ± SD)

Recipes	Overall Acceptability
Chakli (Ch)	9.5 ± 0.63
Curd Rice (Cr)	9.0 ± 1.13
Dhokla (Dh)	8.5 ± 1.83
Dosa (Do)	9.1 ± 0.73
Hari Bhari Tikki (Hbt)	9.1 ± 0.94
Handvo (Ha)	8.8 ± 1.03
Idada (Ida)	9.4 ± 0.99
Idli(Id)	9.5 ± 0.57
Masala Bhakri (Mb)	8.3 ± 1.39
Methi Thepla (Mt)	9.0 ± 0.95
Muthia (Mu)	8.9 ± 1.10
Sev (S)	9.5 ± 0.68
Thalipith (T)	9.1 ± 0.9
Uttapam (U)	9.3 ± 0.54
Veg Khichdi (Vk)	9.2 ± 1.02
p Value	0.00001***
F Value	3.68

*** Significantly different at $p<0.001$

Dhokla v/s Chakli, Idada, Idli and Sev and Masala bhakri v/s Chakli, Idada, Idli and Sev; in mouthfeel it was found between Masala bhakri v/s Chakli, Idada, Idli and Uttapam and Muthia v/s Chakli and Sev at $p<0.001$. In overall acceptability, significant difference was found in Masala bhakri v/s Chakli, Idada, Idli, Sev and Uttapam at $p<0.001$.

These pairs were highly significant in their respective attributes, whereas some of others also showed a significant difference at $p<0.05$ and $p<0.01$. The majority of the recipes showed a great significant difference with Masala bhakri. This could be due to the lower scores given to it as compared to other recipes. The recipe pairs which were found to be highly significant for almost all the attributes were Masala bhakri v/s Chakli, Dosa, Idada, Idli, Sev and Uttapam and Dhokla v/s Chakli, Idada, Idli, Sev and Uttapam. This difference is because of the rating as Masala bhakri and Dhokla were among the least scored as compared to the other recipes. The recipes were developed using different cooking methods and the level of substitution also varied depending upon the type of recipe. Hence, this difference was noticed in the statistical tests.

The hedonic scores of the standardized recipes ranged between 5.9-6.8 for the foxtail millet incorporated recipes. It was found that Chakli, Idada and Sev ranked first among all the recipes followed by Idli and Uttapam ranking second, Veg Khichdi third, Green tikki, Thalipith fourth and Curd rice, Dosa and Methi Thepla fifth as seen in the Figure 4.4. The same is depicted in the radar graph (Figure 4.2) where it is clearly visible that the most preferred products are Chakli, Idada, Sev followed by Idli, Uttapam and Veg Khichdi. Despite the preference for certain recipes the hedonic rating did not show huge difference, indicates that all the recipes were highly acceptable to the panelists.

When the hedonic scores were subjected to the statistical test ANOVA a significant difference was found within the recipes (significance at $p<0.001$). This was then subjected to 't' test whereby the results indicated that a significant difference was observed in the hedonic scores of Masala bhakri v/s Chakli, Idada, Idli, Sev and Uttapam, Dhokla v/s Chakli, Idada and Sev and Muthia v/s Chakli, Idada and Sev at $p<0.001$. These pairs were highly significant in their hedonic scores due to the greater hedonic

Table 4.4: p VALUE OF THE 't' TEST FOR THE ATTRIBUTES OF THE FOXTAIL MILLET INCORPORATED RECIPES

	Colour and Appearance	Aroma	Texture	Taste	After Taste	Mouth feel	Overall Acceptability
Ch-Cr	0.000***	0.01**	0.01**	0.2	0.1	0.06	0.08
Ch-Dh	0.01**	0.002**	0.004**	0.003**	0.001***	0.002**	0.01**
Ch-Do	0.2	0.2	0.1	0.2	0.1	0.1	0.03*
Ch-Hbt	0.03*	0.03*	0.02*	0.04*	0.07	0.01	0.1
Ch-Ha	0.02*	0.2	0.03*	0.07	0.1	0.008**	0.03*
Ch-Ida	0.5	0.8	1.0	0.6	1.0	0.4	0.7
Ch-Id	0.3	0.8	0.4	1.0	1.0	0.4	0.8
Ch-Mb	0.000***	0.003**	0.000***	0.001***	0.000***	0.000***	0.000***
Ch-Mt	0.1	0.1	0.2	0.07	0.1	0.05*	0.04*
Ch-Mu	0.04*	0.03*	0.05*	0.03*	0.03*	0.001***	0.02*
Ch-S	0.3	0.3	0.7	0.6	0.7	0.8	0.7
Ch-T	0.08	0.06	0.3	0.2	0.1	0.003**	0.03
Ch-U	0.07	0.5	0.4	0.5	0.4	0.3	0.4
Ch-Vk	0.02*	0.01**	0.03*	0.2	0.4	0.05*	0.2
Cr-Dh	0.4	0.3	0.2	0.03*	0.03*	0.08	0.1
Cr-Do	0.001***	0.1	0.6	0.9	0.9	0.7	1.0
Cr-Hbt	0.01**	0.6	0.7	0.5	0.9	0.6	0.8
Cr-Ha	0.04*	0.1	0.8	0.6	0.9	0.4	0.8
Cr-Ida	0.000***	0.01**	0.01**	0.08	0.1	0.2	0.06
Cr-Id	0.000***	0.004**	0.04*	0.1	0.1	0.2	0.1
Cr-Mb	0.5	0.4	0.02*	0.03*	0.03*	0.01**	0.02*
Cr-Mt	0.01**	0.2	0.2	0.7	0.8	0.9	0.9
Cr-Mu	0.04*	0.6	0.6	0.4	0.4	0.1	0.5
Cr-S	0.001***	0.04*	0.02*	0.4	0.06	0.07	0.04*
Cr-T	0.01**	0.3	0.08	1.0	0.9	0.2	0.9
Cr-U	0.001***	0.02*	0.03*	0.4	0.3	0.2	0.2
Cr-Vk	0.04*	0.7	0.7	0.8	0.5	0.9	0.6
Dh-Do	0.04*	0.02*	0.1	0.02*	0.02*	0.03*	0.1
Dh-Hbt	0.2	0.1	0.1	0.04	0.04*	0.1	0.1
Dh-Ha	0.3	0.03*	0.2	0.08	0.05*	0.3	0.2
Dh-Ida	0.02*	0.002**	0.003**	0.001***	0.001***	0.008**	0.008**
Dh-Id	0.04*	0.001***	0.01**	0.003**	0.001***	0.007**	0.01**
Dh-Mb	0.7	0.9	0.3	0.8	0.8	0.5	0.5
Dh-Mt	0.1	0.05*	0.03*	0.08	0.02*	0.1	0.2
Dh-Mu	0.3	0.1	0.1	0.1	0.1	0.6	0.3
Dh-S	0.05*	0.008**	0.007**	0.008**	0.001***	0.002**	0.007**
Dh-T	0.1	0.07	0.02*	0.04*	0.03*	0.3	0.1
Dh-U	0.09	0.004**	0.01**	0.01**	0.004**	0.01**	0.03*
Dh-Vk	0.3	0.2	0.1	0.03*	0.02*	0.1	0.08
Do-Hbt	0.2	0.2	0.8	0.4	0.7	0.3	0.7
Do-Ha	0.1	1.0	0.7	0.5	0.8	0.1	0.7
Do-Ida	0.5	0.2	0.04*	0.08	0.1	0.3	0.02*
Do-Id	0.8	0.1	0.1	0.2	0.1	0.3	0.03*
Do-Mb	0.004**	0.03*	0.004**	0.02*	0.02*	0.002**	0.01**

* Significantly different at $p<0.05$

** Significantly different at $p<0.01$

*** Significantly different at $p<0.001$ Contd.

	Colour and Appearance	Aroma	Texture	Taste	After Taste	Mouth feel	Overall Acceptability
Do-Mt	0.5	0.7	0.4	0.5	0.8	0.6	0.8
Do-Mu	0.2	0.3	1.0	0.2	0.3	0.03*	0.5
Do-S	1.0	0.6	0.1	0.4	0.06	0.1	0.01**
Do-U	0.5	0.3	0.1	0.5	0.3	0.3	0.1
Do-Vk	0.1	0.7	0.8	1.0	0.6	0.6	0.5
Hbt-Ha	0.7	0.3	0.9	0.8	1.0	0.6	0.5
Hbt-Ida	0.08	0.03*	0.02*	0.01**	0.08	0.07	0.07
Hbt-Id	0.1	0.01**	0.08	0.03*	0.07	0.06	0.1
Hbt-Mb	0.07	0.1	0.006**	0.1	0.04*	0.02*	0.006**
Hbt-Mt	0.6	0.4	0.3	0.8	0.6	0.7	0.6
Hbt-Mu	0.8	1.0	0.8	0.7	0.4	0.2	0.3
Hbt-S	0.2	0.1	0.05*	0.1	0.05*	0.02*	0.06
Hbt-T	0.7	0.6	0.1	0.5	0.8	0.4	0.6
Hbt-U	0.4	0.06	0.06	0.1	0.2	0.07	0.3
Hbt-Vk	0.7	0.7	1.0	0.4	0.5	0.7	0.7
Ha-Ida	0.06	0.2	0.02*	0.03*	0.1	0.04*	0.02*
Ha-Id	0.1	0.1	0.09	0.06	0.1	0.03*	0.03*
Ha-Mb	0.1	0.04*	0.01**	0.07	0.05*	0.06	0.02*
Ha-Mt	0.45	0.7	0.3	1.0	0.7	0.4	0.8
Ha-Mu	0.8	0.3	0.7	0.7	0.5	0.4	0.7
Ha-S	0.1	0.6	0.05*	0.1	0.07	0.01**	0.02*
Ha-T	0.5	0.5	0.1	0.6	0.8	0.8	0.8
Ha-U	0.3	0.4	0.06	0.2	0.3	0.04*	0.1
Ha-Vk	1.0	0.2	0.9	0.5	0.5	0.4	0.4
Ida-Id	0.7	0.7	0.3	0.5	1.0	1.0	0.5
Ida-Mb	0.001***	0.003**	0.000***	0.000***	0.001***	0.000***	0.000***
Ida-Mt	0.2	0.1	0.1	0.02*	0.1	0.1	0.03*
Ida-Mu	0.1	0.04*	0.04*	0.01**	0.03*	0.01**	0.01**
Ida-S	0.5	0.4	0.7	0.3	0.7	0.5	1.0
Ida-T	0.2	0.07	0.3	0.08	0.1	0.02*	0.02*
Ida-U	0.2	0.7	0.4	0.2	0.4	0.8	0.2
Ida-Vk	0.05*	0.02*	0.03*	0.1	0.3	0.1	0.1
Id-Mb	0.003**	0.001***	0.000***	0.001***	0.000***	0.000***	0.000***
Id-Mt	0.4	0.09	0.5	0.05*	0.1	0.1	0.06
Id-Mu	0.1	0.02*	0.1	0.02*	0.03*	0.004**	0.02*
Id-S	0.8	0.2	0.6	0.6	0.7	0.4	0.5
Id-T	0.3	0.04*	0.8	0.1	0.1	0.02*	0.04*
Id-U	0.4	0.4	0.8	0.4	0.3	0.8	0.4
Id-Vk	0.1	0.007**	0.1	0.2	0.3	0.1	0.2
Mb-Mt	0.04*	0.07	0.000***	0.07	0.01**	0.01**	0.02*
Mb-Mu	0.1	0.2	0.004**	0.1	0.2	0.2	0.06
Mb-S	0.007**	0.01**	0.000***	0.004**	0.000***	0.000***	0.000***
Mb-T	0.05*	0.1	0.000***	0.03*	0.03*	0.09	0.01**
Mb-U	0.01**	0.01**	0.000***	0.004**	0.002**	0.000***	0.000***
Mb-Vk	0.1	0.2	0.01**	0.02*	0.01**	0.01**	0.004**
Mt-Mu	0.6	0.5	0.4	0.7	0.2	0.1	0.6
Mt-S	0.5	0.4	0.3	0.1	0.08	0.06	0.02*
Mt-T	0.8	0.7	0.6	0.6	0.9	0.3	1.0

* Significantly different at $p<0.05$

** Significantly different at $p<0.01$

*** Significantly different at $p<0.001$

Contd.

	Colour and Appearance	Aroma	Texture	Taste	After Taste	Mouth feel	Overall Acceptability
Mt-U	0.8	0.2	0.4	0.1	0.4	0.2	0.1
Mt-Vk	0.4	0.3	0.3	0.5	0.7	1.0	0.5
Mu-S	0.2	0.1	0.09	0.08	0.02*	0.001***	0.01**
Mu-T	0.6	0.6	0.2	0.3	0.3	0.6	0.6
Mu-U	0.4	0.07	0.1	0.09	0.1	0.004**	0.06
Mu-Vk	0.8	0.7	0.8	0.3	0.2	0.1	0.2
S-T	0.4	0.2	0.5	0.4	0.1	0.004**	0.02*
S-U	0.5	0.7	0.7	0.8	0.2	0.3	0.2
S-Vk	0.1	0.06	0.06	0.4	0.2	0.06	0.1
T-U	0.7	0.1	0.7	0.4	0.4	0.02*	0.1
T-Vk	0.6	0.4	0.1	0.8	0.6	0.3	0.5
U-Vk	0.2	0.03*	0.09	0.5	0.8	0.2	0.5

* Significantly different at $p<0.05$

** Significantly different at $p<0.01$

*** Significantly different at $p<0.001$

FIGURE 4.2: MEAN SCORES OF HEDONIC TEST OF THE RECIPES

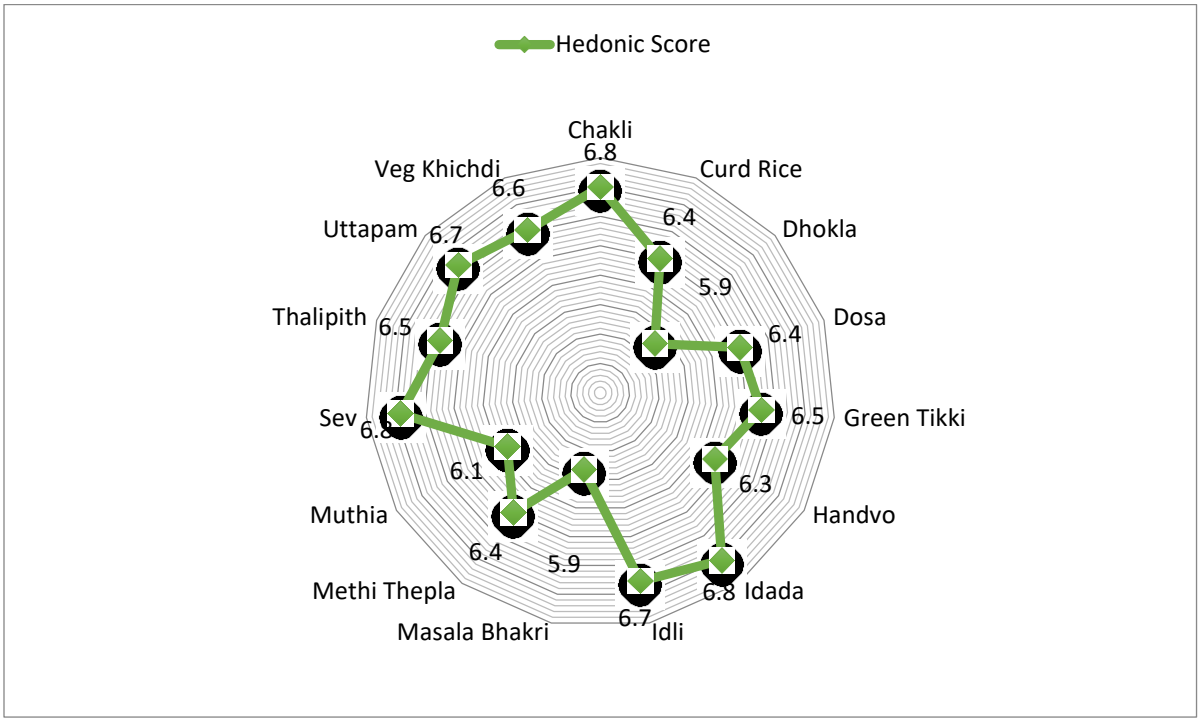


FIGURE 4.3: RELATIVE RANKING OF THE RECIPES ON THE MEAN SCORES OF HEDONIC TEST

Hedonic Scores	Recipes	Rank
6.8	Chakli, Idada, Sev	1
6.7	Idli, Uttapam	2
6.6	Veg. Khichdi	3
6.5	Green Tikki, Thalipith	4
6.4	Curd rice, Dosa, Methi Thepla	5

TABLE 4.5: ANOVA VALUE FROM THE HEDONIC SCORE OF THE FOXTAIL MILLET INCORPORATED RECIPES

Sensory Attribute	p value	F value
Hedonic Score	0.0000001***	4.63
Note: *** depicts significant difference at p<0.001.		

Table 4.6: p VALUE OF THE 't' TEST FOR THE HEDONIC SCORE OF THE FOXTAIL MILLET INCORPORATED RECIPES

Recipe pairs	Hedonic Score	Recipe pairs	Hedonic Score
Ch-Cr	0.08	**Cr-T**	1.0
Ch-Dh	0.001***	**Cr-U**	0.2
Ch-Do	0.05*	**Cr-Vk**	0.7
Ch-Hbt	0.06	**Dh-Do**	0.06
Ch-Ha	0.02*	**Dh-Hbt**	0.03*
Ch-Ida	0.5	**Dh-Ha**	0.1
Ch-Id	0.5	**Dh-Ida**	0.000***
Ch-Mb	0.000***	**Dh-Id**	0.002**
Ch-Mt	0.05*	**Dh-Mb**	0.9
Ch-Mu	0.001***	**Dh-Mt**	0.06
Ch-S	1.0	**Dh-Mu**	0.4
Ch-T	0.09	**Dh-S**	0.001***
Ch-U	0.5	**Dh-T**	0.02*
Ch-Vk	0.3	**Dh-U**	0.003**
Cr-Dh	0.02*	**Dh-Vk**	0.01**
Cr-Do	0.6	**Do-Hbt**	0.7
Cr-Hbt	0.8	**Do-Ha**	0.7
Cr-Ha	0.4	**Do-Ida**	0.02*
Cr-Ida	0.03*	**Do-Id**	0.1
Cr-Id	0.2	**Do-Mb**	0.03*
Cr-Mb	0.004**	**Do-Mt**	1.0

* Significantly different at p<0.05

** Significantly different at p<0.01

*** Significantly different at p<0.001

Contd.

Recipe pairs	Hedonic Score	Recipe pairs	Hedonic Score
Cr-Mt	0.6	**Do-Mu**	0.1
Cr-Mu	0.05*	**Do-S**	0.05*
Cr-S	0.08	**Do-T**	0.5
Do-Khichdi	0.4	**Do-U**	0.1
Hbt-Ha	0.5	**Ida-Vk**	0.1
Hbt-Ida	0.02*	**Id-Mb**	0.000***
Hbt-Id	0.1	**Id-Mt**	0.1
Hbt-Mb	0.008**	**Id-Mu**	0.004**
Hbt-Mt	0.7	**Id-S**	0.6
Hbt-Mu	0.08	**Id-T**	0.2
Hbt-S	0.06	**Id-U**	1.0
Hbt-T	0.8	**Id-Vk**	0.5
Hbt-U	0.1	**Mb-Mt**	0.03*
Hbt-Vk	0.5	**Mb-Mu**	0.4
Ha-Ida	0.01**	**Mb-S**	0.000***
Ha-Id	0.06	**Mb-T**	0.005**
Ha-Mb	0.06	**Mb-U**	0.000***
Ha-Mt	0.7	**Ida-Id**	0.2
Ha-Mu	0.3	**Ida-Mb**	0.000***
Ha-S	0.02*	**Ida-Mt**	0.02*
Ha-T	0.3	**Ida-Mu**	0.001***
Ha-U	0.07	**Ida-S**	0.5
Ha-Vk	0.2	**Ida-T**	0.04*
Mb-Vk	0.003**	**Ida-U**	0.3
Mt-Mu	0.2	**Mu-S**	0.001***
Mt-S	0.05*	**Mu-T**	0.06
Mt-T	0.5	**Mu-U**	0.006**
Mt-U	0.1	**Mu-Vk**	0.03*
Mt-Vk	0.4	**S-T**	0.1
S-Vk	0.3	**S-U**	0.6
T-U	0.3	**T-Vk**	0.7
U-Vk	0.5		

* Significantly different at $p<0.05$

** Significantly different at $p<0.01$

*** Significantly different at $p<0.001$

rating for Idada, Sev and Chakli compared to Dhokla, Masala bhakri and Muthia with the least rating. Apart from these, some recipe pairs were also found to be significant at $p<0.05$ and $p<0.01$. Hedonic score reveals the extent of like or dislike the subjects possess towards a product, hence the significant difference noted here can be due to the variations in individuals' liking for a specific recipe or their thoughts or beliefs for a certain recipe.

As seen from the literature the benefits of millets and the need to propagate more consumption of foxtail millet we had also conducted a Post Sensory Evaluation survey on the same semi trained panelists that took part in the sensory evaluation to illicit information on their regular consumption of millets, benefits of millets and their willingness to incorporate foxtail millet in their daily diets. The results of this survey are as discussed below:

The information pertaining to the millets known by the panelists (Table 4.7) revealed that 94.12% knew about Pearl millet (Bajra) followed by Sorghum (91.18%), Ragi (88.24%), Quinoa (85.29%) and Amaranth (85.29%). Very few panelists knew about the minor millets such as Foxtail millet (67.65%), Kodo millet (64.71%), Barnyard millet (47.06%), Proso millet (38.24%) and Little millet (14.71%).

Figure 4.4 shows that 65% of the panelists were aware regarding benefit of millets whereas 25% were not aware about it. When we tried to elicit information about the specific benefit of millets (Table 4.8), it was found that 32.35% said that millets are a good source of fibre followed by 29.41% who felt that it was a rich source of minerals as well as it helped to lower the blood glucose levels / good for diabetes. 23.53% reported millets to be a good source of vitamins, 14.71% said that it helps in digestion and 11.76% said that it helps in preventing NCD's.

With respect to the consumption of millets (Table 4.9), Pearl millet was the millet that was maximally consumed i.e. 61.76% by the panelists followed by Sorghum (47.06%), Amaranth (35.29%), Finger millet (29.41%), Barnyard millet (14.71%), Kodo millet (11.76%), Quinoa (8.82%) and Buckwheat (2.94%). Whereas, nobody had consumed ever consumed Foxtail millet, Proso millet and Little millet.

Table 4.10 shows the information about the frequency of consumption of millets where 23.53% consumed millets on a weekly basis, followed by once in fifteen days (17.65%), monthly (14.71%), seasonally (11.76%) and occasionally (11.76). Only 5.88% consumed on a daily basis and 5.88% thrice a week.

Table 4.11 shows that 44.12% of the subjects have heard about foxtail millet before taking part in the study whereas 55.88% had not heard about foxtail millet. When asked them about their willingness to incorporate foxtail millet in their daily diets (Table 4.12), 88.24% were willing to incorporate whereas 11.76% declined.

When looked at the willingness of panelists to make the recipes incorporating foxtail millet; 44.12% of them wanted to try Veg Khichdi followed by Curd rice (26.47%), Muthia (20.59%), Dhokla (17.65%) and Methi Thepla (17.65%).

TABLE 4.7: AWARENESS ABOUT MILLETS AMONG THE PANELISTS

MILLETS	Awareness [n(%)]
Pearl millet (Bajra)	32(94.12)
Sorghum (Jowar)	31(91.18)
Finger millet (Ragi)	30(88.24)
Quinoa	29(85.29)
Amaranth (Rajgira)	29(85.29)
Foxtail millet (Kang)	23(67.65)
Kodo millet (Kodri)	22(64.71)
Buckwheat (Kuttu)	17(50)
Barnyard millet (Sama)	16(47.06)
Proso millet (Cheno)	13(38.24)
Little millet (Gajro)	5(14.71)

TABLE 4.8: PERCEPTION OF MILLET BENEFITS AMONG THE PANELISTS

BENEFITS	n(%)
Source of fibre	11(32.35)
Low GI/blood sugar regulation/Good for Diabetes	10(29.41)
Source of minerals	10(29.41)
Source of vitamins	8(23.53)
Helps in digestion	5(14.71)
Good for health and body	4(11.76)
Help prevent NCDs	4(11.76)
Source of protein	3(8.82)
Source of antioxidants	3(8.82)
Gives satiety	2(5.88)
Source of energy	2(5.88)
Constipation	1(2.94)
Helps in weight loss	1(2.94)
Good for heart	1(2.94)
Gluten free	1(2.94)
Improves Hb level	1(2.94)
Controls BP	1(2.94)

TABLE 4.9: CONSUMPTION PATTERN OF MILLETS AMONG THE PANELISTS

MILLETS	Awareness [n(%)]
Pearl millet (Bajra)	21(61.76)
Sorghum (Jowar)	16(47.06)
Amaranth (Rajgira)	12(35.29)
Finger millet (Ragi)	10(29.41)
Barnyard millet (Sama)	5(14.71)
Kodo millet (Kodri)	4(11.76)
Quinoa	3(8.82)
Buckwheat (Kuttu)	1(2.94)
Foxtail millet (Kang)	0(0)
Proso millet (Cheno)	0(0)
Little millet (Gajro)	0(0)

TABLE 4.10: FREQUENCY OF MILLET CONSUMPTION AMONG THE PANELISTS

	n(%)
Once a week	8(23.53)
Once in 15 days	6(17.65)
Monthly	5(14.71)
Seasonally	4(11.76)
Occasionally	4(11.76)
Daily	2(5.88)
Twice a week	2(5.88)
Thrice a week	2(5.88)
Once a fortnight	1(2.94)
Never	0(0)

FIGURE 4.4: AWARENESS OF MILLET BENEFITS AMONG THE PANELISTS

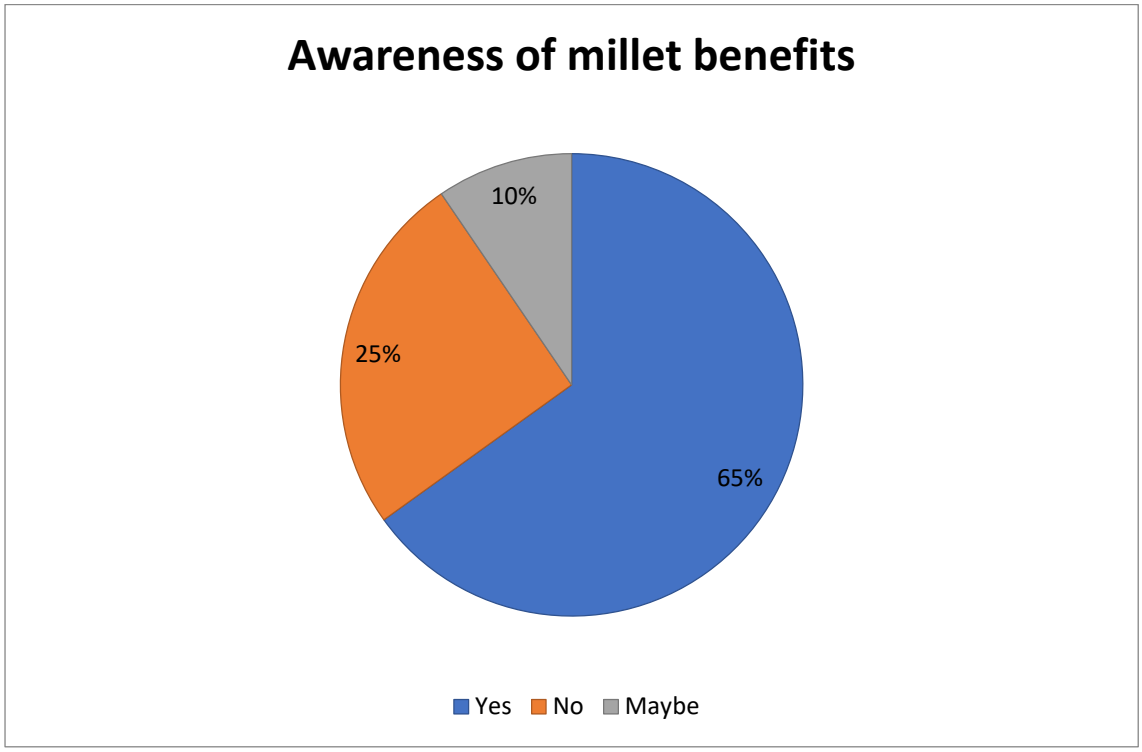


TABLE 4.11: AWARENESS ABOUT FOXTAIL MILLET BEFORE PARTICIPATING IN THE STUDY

	n(%)
No	19(55.88)
Yes	15(44.12)

TABLE 4.12: WILLINGNESS OF PANELISTS TO INCORPORATE FOXTAIL MILLET IN THEIR DAILY DIET

	n(%)
Yes	30(88.24)
No	4(11.76)

TABLE 4.13: WILLINGNESS OF THE PANELISTS TO PREPARE DIFFERENT RECIPES INCORPORATING FOXTAIL MILLET

Recipes	n(%)
Veg Khichdi	15(44.12)
Curd rice	9(26.47)
Muthia	7(20.59)
Dhokla	6(17.65)
Methi thepla	6(17.65)
Chakli	4(11.76)
Handvo	4(11.76)
Idli	4(11.76)
Uttapam	4(11.76)
Idada	4(11.76)
Green tikki	4(11.76)
Sev	3(8.82)
Masala Bhakri	2(5.88)
Thalipith	2(5.88)
Dosa	2(5.88)

DISCUSSION

The incorporation of foxtail millet in daily diet will provide newer horizons for prevention and management of various NCD's. This novel grain is rich in protein, fibre, B vitamins and minerals. The focus was thus to come up with newer, innovative, easily available, comparatively less expensive than the commercially available products that can be exploited to have beneficial effects in dietary management. Millets are one of these amazing foods. Foxtail millet has a lower GI compared to wheat and rice, thereby a good option to partially or fully substitute it with the traditional recipes easily prepared at home scale level. The literature available showed that traditionally these grains were used to prepare porridge and gruels as energy dense foods for small children, pregnant and lactating mothers. Foxtail millet is also said to be effective against gastric problems, GI dysfunction, esophageal cancer and improves bowel movement. So the objective of the study was to develop recipes incorporating foxtail millet and to carry out the sensory evaluation of the developed recipes. The recipes that were developed were either partially or fully substituted with foxtail millet. By doing so, we wanted to see how effectively foxtail millet can be partially or fully substituted for wheat and/or rice in traditional Indian recipes and how much is the acceptability and liking of these recipes among the population.

Results from the sensory evaluation of fifteen recipes revealed that the foxtail millet incorporated recipes were highly acceptable and does not alter any of the sensory attributes. These results are in line with the results of Fatima and Rao (2019) on the Development, Organoleptic Evaluation and Acceptability of Products Developed by Incorporating Foxtail Millet. The products developed were laddu, kheer, peanut chutney and panjeri. Another studies by Sudha et al. (2019) and Narmada et al. (2020) where foxtail millet was used as a partial substitution with whole wheat and other millet flours respectively, also showed that the recipes were highly acceptable in terms of all the sensory attributes especially in their taste, flavor and texture. The products made were biscuits and cookies which were also high in fibre and protein.

IMPLICATIONS AND USAGE

With the limited data available on the nutrient and non nutrient properties and uses of foxtail millet; at household level, these seeds that are easily available can be used in various other recipes. The grains can be grounded in to flour or cooked as rice. Apart from these fifteen recipes, foxtail millet can also be used in making of Roti/Rotla, Dhebra, Cheela, Khakhra, Appam, Pulao, Biryani, etc. It can also be used to make sweets such as Payasam, Laapsi and Sheera.

Thus, from the sensory data it can be concluded that Foxtail millet can be efficiently used in several household recipes with good acceptability along with the willingness of the members to incorporate into their daily diets.

SALIENT OBSERVATIONS FROM THE STUDY

1. Foxtail millet can be effectively incorporated into traditional Indian recipes.
2. Foxtail millet can be partially / fully substituted for rice and/or wheat in traditional recipes without altering the sensory attributes of the recipes.
3. It can be a good substitute for high glycemic foods in diabetic and CVD subjects.
4. Advocacy measures need to be devised to propogate the use of foxtail millet incorporated recipes not only in the management of NCD patients but also for optimizing the health in general population.

PHASE III – DEVELOPMENT OF A FOXTAIL MILLET INCORPORATED RECIPES BOOKLET.

The booklet of the foxtail millet incorporated recipes subjected to the sensory evaluation was developed for propagating the use of foxtail millet in the daily diet of the population (Appendix).

The booklet contains the following information:

- Introduction of Millets
- Information on Foxtail millet
- Advantages of the Foxtail millet
- Ingredients of the recipes
- Methodology of the recipes
- Nutrient Composition of the recipes.

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

Millets are the grains considered as the oldest foods or cultivated crops known to humans. They are the minor cereals of grass family Poaceae. Millets are considered as the world's most important food crop and mostly cultivated in the Eastern hemisphere, regions in primitive agriculture and high-density population. It is labeled as the food for poor due to its ability to grow in poorly watered or fertilized soils. It is referred to as a cereal and plant both that bears the edible grains. Millets are traditionally the staple foods of the dry land regions of the world. The production of the nutri-cereals in India in the year 2018-19 was reported as 42.95 million tonnes being highest in Rajasthan followed by Karnataka and Madhya Pradesh. The average estimate of millets from 2013-14 to 2017-18 shows that the area is around 24.81 million hectares, production 43.08 million tonnes and yield comes out around 1736 Kg/Hectare (FAO STAT 2018). They are highly nutritious and found to be rich source of protein, essential fatty acids, fibre, B vitamins, minerals such as iron, calcium, zinc, potassium and magnesium. These nutrients benefits in reducing blood glucose levels, blood pressure regulation, thyroid, cardiovascular and celiac diseases. Despite having health benefits, the consumption of millet as food has declined significantly over the past three decades (Swaminathan 2017). The reasons behind this are lack of awareness of the nutritional merits, inconveniences in food preparation, lack of processing techniques and also the government policy of disincentives towards millets and favoring of supply of fine cereals at subsidized prices. In this context, it is important to explore ways for creating awareness on the nutritional merits of millets. Hence, the importance of nutrition as a foundation for healthy development is underestimated. People are now becoming more conscious about their healthy living practices in order to overcome the metabolic disorders and life style diseases. Therefore, there is a need to develop the therapeutic foods in order to explore the utility of millets. Among the different millets, one is the foxtail millet with high nutritional properties and ability to prevent and manage various non communicable diseases.

The review of literature suggests a need to explore the utility of foxtail millet in food product development and its use as a functional food as a partial or complete substitute to

wheat and rice among normal and healthy population as well as for diabetic individuals. Foxtail millet is found to be a rich source of protein, dietary fiber, phosphorus, B vitamins, minerals and antioxidants; benefits in the prevention and management of gastric disorders, obesity, non-communicable diseases and certain type of cancer.

Keeping this background in mind the present study was planned with the broad objective of developing the foxtail millet incorporated recipes. The specific objectives were as follows:

1. To standardize the foxtail millet incorporated recipes.
2. To carry out sensory evaluation of the foxtail millet incorporated recipes.
3. To develop a booklet from the acceptable foxtail millet incorporated recipes subjected to sensory evaluation.

Thus keeping the above objectives in mind, the present study was planned in 3 phases.

PHASE I – Standardization and Development of Foxtail Millet Incorporated Recipes.

PHASE II – Sensory Evaluation of the Foxtail Millet Incorporated Recipes.

PHASE III – Development of a foxtail incorporated recipe booklet.

PHASE I – STANDARDIZATION AND DEVELOPMENT OF FOXTAIL MILLET INCORPORATED RECIPES.

Due to scanty data on food processing techniques and food product development of foxtail millet, the present study was planned to increase the awareness, consumption and thereby production of foxtail millet in general population as well as with disease patients due to its ability in prevention and management of various NCD's, obesity, gastric problems and certain types of cancer as it is a rich source of protein, fibre and various antioxidants.

In this phase, Foxtail millet was procured from the market. Further, 15 foxtail millet incorporated recipes were developed and standardized. The recipes were developed by incorporating foxtail millet partially or fully substituted in place of wheat / rice used traditionally in the standard recipes. The recipes developed were Veg Khichdi (steamed food), Dhokla (fermented food), Masala Bhakri (roasted product), Muthia (steamed food), Thalipith (roasted product), Curd Rice (steamed food), Chakli (extruded product),

Handvo (fermented food), Methi Thepla (roasted product), Sev (extruded product), Idli, Dosa, Uttapam, Idada (fermented foods) and Hari Bhari Tikki (shallow-fried food) using the different cooking methods. These recipes were found to be more nutritious in terms of protein, fibre, iron, calcium and also the caloric and carbohydrate content was found on a lower side as compared to the traditional recipes made from wheat and/or rice.

PHASE II – SENSORY EVALUATION OF THE FOXTAIL MILLET INCORPORATED RECIPES.

Sensory evaluation of all the 15 recipes was carried out using a Composite and Hedonic Rating test. The 30 semi-trained panelist members were asked to register their responses in the Google form that was developed to rate each attributes of the recipes. The form consisted of two parts: Composite and Hedonic rating tests. The rating for Composite scale was based on a 10 point scoring for each of the attributes such as color and appearance, aroma, taste, after taste, mouth feel and overall acceptability of the product where as for the hedonic rating test, the overall liking of the product was assessed on a 7 point rating ranging from dislike very much to like very much with neither like nor dislike as the mid-score.

Other than the sensory evaluation we also tried to elicit information with respect to the awareness and consumption of millets by carrying out a Post Sensory Evaluation Survey on the same semi trained panelists who took part in the sensory evaluation.

The results of this phase are highlighted below:

1. The foxtail millet incorporated recipes were found to be acceptable in terms of all the attributes.
2. From the overall acceptability of the fifteen products, Chakli, Idli and Sev were highly acceptable followed by Idada, Uttapam, Veg Khichdi, Thalipith, Hari Bhari Tikki, Dosa, Curd rice, Methi Thepla, Muthia, Handvo, Dhokla and Masala Bhakri.
3. For attributes like texture, taste, after taste and mouthfeel; scores were lower for Masala bhakri, Dhokla and Curd rice as compared to other recipes.

4. All the recipes on the hedonic scale were scored between 5.9 to 6.8 indicating that the recipes were highly acceptable and the most accepted ones were Chakli, Idada and Sev.
5. A significant difference was found between the attributes of the recipes and when assessed further it was found that some recipes had a significant difference with the other recipes for their colour and appearance, taste, texture, after taste, mouthfeel, aroma and overall acceptability. This significant difference observed among different attributes could be attributed to different cooking methods as well as the variation in the level of substitution of foxtail millet in these recipes.
6. The post sensory evaluation survey indicated that 44.1% of the panel members had heard about foxtail millet before taking part in the study but none had ever consumed foxtail millet.
7. Despite being aware of the benefits of millets, only 5.8% of them had consumed it on a daily basis, 5.8% thrice and twice a week, 2.9% once a fortnight and 23.5% once a week.
8. 88.2% of the panel members were willing to incorporate foxtail millet in different recipes in their daily diet with a greater liking to incorporate the same in Veg Khichdi, Curd rice, Muthia, Dhokla and Methi thepla.
9. Foxtail millet has the potential of being a functional substitute for rice and wheat due to its unique nutrient profile.

PHASE III – DEVELOPMENT OF A FOXTAIL INCORPORATED RECIPE BOOKLET.

The booklet of the foxtail millet incorporated recipes which were subjected to the sensory evaluation has been developed. The main purpose for the development of the same is to propagate the consumption of foxtail millet amongst the population.

The booklet contains the following aspects:

- Introduction of Millets
- Information on Foxtail millet
- Advantages of the Foxtail millet

- Ingredients of the recipes
- Methodology of the recipes
- Nutrient Composition of the recipes.

Thus, the acceptability of foxtail millet incorporated recipes will help in promoting the millet to increase its consumption so that it will enhance the nutritional status of the healthy as well as malnourished individuals. It may help in prevention and management of obesity, non communicable diseases, gastric disorders and certain type of cancer. The recipe booklet will help the general and diseased population in gaining the knowledge about millets; more specifically foxtail millet, its benefits, uses, recipes made and the nutritional composition of the recipes with the adequate serving size.

RECOMMENDATIONS

1. Protein rich foxtail millet incorporated recipes developed using different cooking methods were highly acceptable to the panelists. Hence, a need is felt to develop more recipes which would help in providing more preferences to the individuals for incorporating the same as per their own taste and cuisines.
2. The effect of different food processing techniques like malting, puffing, parching, flaking etc. can be explored for foxtail millet so as to help in the development of products with these techniques and also scaling up at industrial level.
3. Foxtail millet does not need any pesticides, huge amount water and thereby can be grown with the other crops by the farmers. Hence, the agricultural sector can propagate the cultivation of the same so as to increase the production of this nutritious foxtail millet. It will also help in bringing down the cost and thereby it will help in increasing the consumption of foxtail millet.
4. There is a paucity of data with respect to clinical trials to study the efficacy of foxtail millet in the management of Non Communicable Diseases. Hence, there is a need to conduct studies pertaining to the same.
5. A need is also felt to incorporate foxtail millet with other indigenous millets possessing functional properties in order to study the cumulative effect of these millets in the management of Non Communicable Diseases.

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APPENDICES

APPENDIX I

ETHICAL CERTIFICATE

Institutional Ethics
Committee for Human
Research
(IECHR)

FACULTY OF FAMILY AND COMMUNITY SCIENCES
THE MAHARAJA SAYAJIRAO UNIVERSITY OF BARODA

Ethical Compliance Certificate 2020 – 2021

This is to certify that **Ms. Thite Nidhi Tushar**'s study titled, "**Product Development and Sensory Evaluation of Foxtail Millet Incorporated Recipes**" has been approved by the Institutional Ethics Committee for Human Research (IECHR), Faculty of Family and Community Science, The Maharaja Sayajirao University of Baroda. The study has been allotted the ethical approval number **IECHR/FCSc/2020/47.**

Prof Mini Sheth
Member Secretary
IECHR

Prof Shagufa Kapadia
Chairperson
IECHR

APPENDIX II

CONSENT FORM FOR SENSORY EVALUATION

STUDY TITLE: Product Development and Sensory Evaluation of Foxtail Millet Incorporated Recipes

INVESTIGATORS

Dr. Swati Dhruv
Assistant Professor
Department of Foods and Nutrition
Faculty of Family and Community Science
The Maharaja Sayajirao University of Baroda.
Mobile no.: 9898078988

Ms. Nidhi Thite
Department of Foods and Nutrition
Faculty of Family and Community Sciences
The Maharaja Sayajirao University of Baroda
Mobile no.: 9714568366

PURPOSE OF THE STUDY

Millets are amazing in their nutrition content. They are nutritionally comparable to major cereals and serve as good source of protein, micronutrients and phytochemicals. The important nutrients present in millets include resistant starch, oligosaccharides, lipids, antioxidants such as phenolic acids, avenanthramides, flavonoids, lignans and phytosterols which are believed to be responsible for many health benefits.

Foxtail millet being considered as a minor millet is a rich source of protein, dietary fiber, phosphorus, B vitamins, minerals and antioxidants; benefits in the prevention and management of gastric disorders, obesity, non-communicable diseases and certain types of cancer.

Despite having a rich nutrient profile, the consumption of foxtail millet is on the lower side; hence, the purpose of the study to develop the foxtail millet incorporated recipes and subject them to sensory evaluation.

BENEFITS AND RISKS

As the prevalence of dual burden of malnutrition is increasing, the consumption of foxtail millet will help in increasing the energy and protein levels for the under nourised along with the appreciable amounts of B vitamins. It will also help in the prevention and management of obesity and other NCDs due to its hypoglycemic property and various antioxidants present in it.

PROTOCOL OF THE STUDY

If you decide to join this study, you will be required to taste foxtail millet incorporated recipes and carry out the sensory evaluation using the hedonic rating scale and composite rating scale. 10-15 recipes will be developed from the foxtail millet, sensory evaluation of which will be carried out on different days.

COSTS

The study only requires your time and cooperation. All the costs incurred will be borne by the researcher and there is no financial compensation for your participation in this research.

CONFIDENTIALITY

In the study, your identity will be kept confidential. The results of the study, including laboratory or any other data, may be published for scientific purposes but will not reveal your name or include any identifiable references to you.

RIGHT TO WITHDRAW

Your decision to join this study is voluntary. You may quit at any time, for any reason, without notice. We hope you will take part for the entire study period because we need all the information to draw correct conclusions.

VOLUNTARY CONSENT

Your co-operation is important to the success of this study. Unless many volunteers like you agree to join; this study will not be possible.

INVESTIGATORS STATEMENT

I have explained the research program, the purpose of the study and the possible benefits and risks to the participant. The participant was given an opportunity to discuss these procedures and ask any additional questions.

_____

Nidhi Thite

9714568366

PARTICIPANT'S STATEMENT

I certify that I have read, or had read out to me, and that I have understood the description of the study. By signing this form, I am attesting that I have read and understood the information given above.

I give my consent to be included as a subject in the study being carried out by Ms. Nidhi Thite under the guidance of Dr. Swati Dhruv of the Maharaja Sayajirao University of Baroda to determine the acceptability of Foxtail millet (*Setaria Italica*) incorporated recipes.

I understand that the study requires the participant to taste foxtail millet incorporated recipes. I have had a chance to ask questions about the study. I understand that I may ask further questions at any time. I have been explained to my satisfaction the purpose of this study and I am also aware of my right to opt out of the study any time.

_____

Participants name and signature Date:

APPENDIX III Questionnaire

General information of the semi-trained panelists required for the sensory evaluation.

* Required

1. Name *

_____

2. Age

_____

3. Sex

Mark only one oval.

- ◯ Female
- ◯ Male
- ◯ Other: _____

4. Occupation *

Mark only one oval.

- ◯ Teacher
- ◯ MSc Student
- ◯ PhD Student
- ◯ Other: _____

5. Mobile Number *

_____

6. 1. Interested in the qualitative work of sensory evaluation for the foxtail millet incorporated recipes: *

Mark only one oval.

- ◯ Yes
- ◯ No

7. 2. Willing to spend the time in sensory evaluation of the developed recipes: *

Mark only one oval.

- ◯ Yes
- ◯ No

8. Medical History: *

Mark only one oval.

- ◯ Yes
- ◯ No

9. If yes:

Mark only one oval.

- ◯ Diabetes
- ◯ Hypertension
- ◯ CHD
- ◯ Other: _____

10. Medications if any:

_____

11. History of cold/cough in past three days: *

Mark only one oval.

- Yes
- No
- Maybe

12. Allergies if any: *

Mark only one oval.

- Yes
- No

13. If yes, please specify:

_____

14. Undergone any type of surgeries in past one year: *

Mark only one oval.

- Yes
- No

15. Habit of: *

Mark only one oval.

- Smoking
- Alcohol
- Tobacco
- None

Thank You!

APPENDIX IV Sensory Evaluation Score Card

Dear panel members, I, Nidhi Thite, conducting this sensory evaluation of foxtail millet incorporated recipes as part of my MSc dissertation 2020-2021 under the guidance of Dr Swati Dhruv. I request you all to kindly fill up the form with the required details. Thank you.

* Required

1. Name of the panelist *

2. Mobile Number

3. Age

4. Name of the product *

5. Taste and rate the sample for its Color and Appearance: *

Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Very Poor	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very Good

6. Taste and rate the sample for its Aroma: *

Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Very Poor	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very Good

7. Taste and rate the sample for its Texture: *

Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Very Poor	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very Good

8. Taste and rate the sample for its Taste: *

Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Very Poor	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very Good

9. Taste and rate the sample for its After Taste: *

Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Very Poor	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very Good

10. Taste and rate the sample for its Mouthfeel: *

Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Very Poor	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very Good

11. Taste and rate the sample for its Overall Acceptability: *

Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Very Poor	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	Very Good

12. Overall, how much do you liked this product ? *

Mark only one oval.

- ◯ Like very much
- ◯ Like moderately
- ◯ Like slightly
- ◯ Neither like nor dislike
- ◯ Dislike slightly
- ◯ Dislike moderately
- ◯ Dislike very much

13. Comments/suggestions:

APPENDIX V Post Sensory Evaluation Questionnaire

Thank you for being the panel members in the sensory evaluation of foxtail millet incorporated recipes as part of my MSc Dissertation. Please fill the form given below.

* Required

1. Name *

_____

2. Mobile Number *

_____

3. Which of the following millets you know/have heard of ? *

Check all that apply.

- [ ] Sorghum-Jowar
- [ ] Pearl millet-Bajra
- [ ] Finger millet-Ragi
- [ ] Foxtail millet-Kang
- [ ] Barnyard millet-Sama
- [ ] Proso millet-Cheno
- [ ] Kodo millet-Kodri
- [ ] Little millet-Gajro
- [ ] Quinoa
- [ ] Amaranth-Rajgira
- [ ] Buckwheat-Kuttu

4. Which of the above mentioned millets has been consumed in your house ? Please name them. *

5. How often you tend to consume millets ? *

Mark only one oval.

- Daily
- Once a fortnight
- Once a week
- Twice a week
- Thrice a week
- Once in 15 days
- Monthly
- Seasonally
- Occassionaly
- Never

6. Are you aware about the benefits of millets ? *

Mark only one oval.

- Yes
- No
- Maybe

7. If yes, state the benefits you know..

8. Have you ever heard about Foxtail millet (Kang) before taking part in this sensory evaluation? *

Mark only one oval.

- Yes
- No

9. Will you be willing to incorporate the foxtail millet in your daily diet? *

Mark only one oval.

- Yes
- No

10. If yes, which recipe would you be willing to make incorporating the foxtail millet?

APPENDIX VI

RECIPE BOOKLET – FOXTAIL MILLET INCORPORATED RECIPES

FOXTAIL MILLET INCORPORATED RECIPES

THE MAHARAJA SAYAJIRAO UNIVERSITY OF BARODA

सत्यं शिवं सुन्दरम्

Estd. 1946

Dr. Swati Dhruv

Ms. Nidhi Thite

Department of Foods and Nutrition

Faculty of Family and Community Sciences

The Maharaja Sayajirao University of Baroda.

Vadodara, Gujarat, India.

For any queries related to Foxtail Millet,

Contact:
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FOXTAIL MILLET INCORPORATED RECIPES

Estd. 1946

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Vadodara, Gujarat, India.

Preface

Foxtail millet is nutritious millet which has been highly underutilized and used as an animal feed or bird feed. It has proven to be an excellent functional food and a good substitute to wheat and rice in the traditional Indian recipes. Therefore, this is an attempt to increase the awareness amongst people regarding various traditional recipes that can be made using this "Nutri-Cereal" and to propagate the use and thereby consumption of these Foxtail millet incorporated recipes for optimizing health.

Dr. Swati Dhruv
Assistant Professor,
Department of Foods and Nutrition,
Faculty of Family and Community Sciences,
The Maharaja Sayajirao University of Baroda, Vadodara.

INDEX

MILLETS

Millets are considered as one of the oldest foods or cultivated crops known to humans. They are said to be the minor cereals of grass family Poaceae. These crops require lower inputs, are climate resilient, hardy and dry land crops also called as "Nutri-cereals" that significantly contribute for food and nutritional security.

There are basically three types of millet: Major millets (Jowar, Bajra and Ragi), Minor millets (Foxtail millet, Little millet, Proso millet, Barnyard millet and Kodo millet) and pseudo millets (Amaranth, Quinoa and Buckwheat).

Millets are a good source of valuable nutrients such as carbohydrate, proteins, dietary fibre, minerals and vitamins. Phenols present in the millets reported to have antioxidant, anti-mutagenic, antiviral effects and platelet aggregation inhibiting activity.

Millets act as a functional food that have potential health benefits. Epidemiological studies have shown that consumption of millets reduces the risk of heart disease, protects from diabetes, improves digestive system, lowers the risk of esophageal cancer, detoxifies the body, increases immunity in respiratory health, increases energy levels and improves muscular and neural systems and are protective against several degenerative diseases such as metabolic syndrome and Parkinson's disease (Manach et al.,2005; Scalbert et al., 2005; Chandrasekara and Shahidi, 2012). Being highly consumed, there are many studies done on major millets, their uses, advantages and product development. Hence, the major focus is now upcoming on the minor millets due to their beneficial nutrition profile and health benefits. One such millet is the foxtail millet.

Source: IIMR 2018

WHAT IS FOXTAIL MILLET?

Foxtail millet is commonly called as 'Italian millet' or 'German millet' around the world whereas, regionally it is known as 'Kang' in Gujarati, 'Kangni' in Hindi, 'Rala' in Marathi, 'Tenai' in Tamil and 'Korra' in Telugu. The colour of the grains mainly ranges from dark yellow, yellowish brown to the lightest of yellow shades.

Consumption of foxtail millet helps in improving the glycemic control as its starch digestibility is much lower than that of wheat and rice, inhibits hyperinsulinemia and decreases plasma lipid concentrations in persons with type-2 diabetes (Jali et al. 2012 and Rodriguez et al. 2020).

Foxtail millet is a non-glutinous and non-acid forming grain that is soothing and easy to digest. It is also considered to be the one of least allergenic and a warming grain (Prashant et al. 2005; Xue et al. 2008).

Nutritive value of Foxtail millet per 100gram	
Energy (kcal)	331
Protein (g)	12.3
Fat (g)	4.3
Minerals (g)	3.3
Fibre (g)	8
Carbohydrates (g)	60.9
Calcium (mg)	31
Phosphorus (mg)	290
Iron (mg)	2.8

Source: IFCT, NIN & Foxtail millet: Properties, processing, health benefits, and uses
Nitya Sharmaa,b and Keshavan Niranjan

Nutritional Properties of Foxtail Millet:

· It is a good source of crude fibre which helps in digestion process and helps to induce the bowel movement, producing a laxative effect that is beneficial for the healthy digestive system.

· The beta-glucans present in fibre, helps to enhance the blood glucose and cholesterol metabolism that prevents diabetes and cardiovascular diseases (Itagi et al. 2012; Muthamilarasan and Prasad 2015).

· Phytochemical tests revealed that it contains phenolics that are the major antioxidants has the ability to reduce agents, singlet oxygen quenchers and metal chelators (Chandrasekara et al. 2010).

· Phytates in foxtail millet protects against oxidative stress.

· The foxtail millet bran oil contains a large proportion of mono-unsaturated fatty acid with the ability to lower cholesterol levels (Liang et al. 2010).

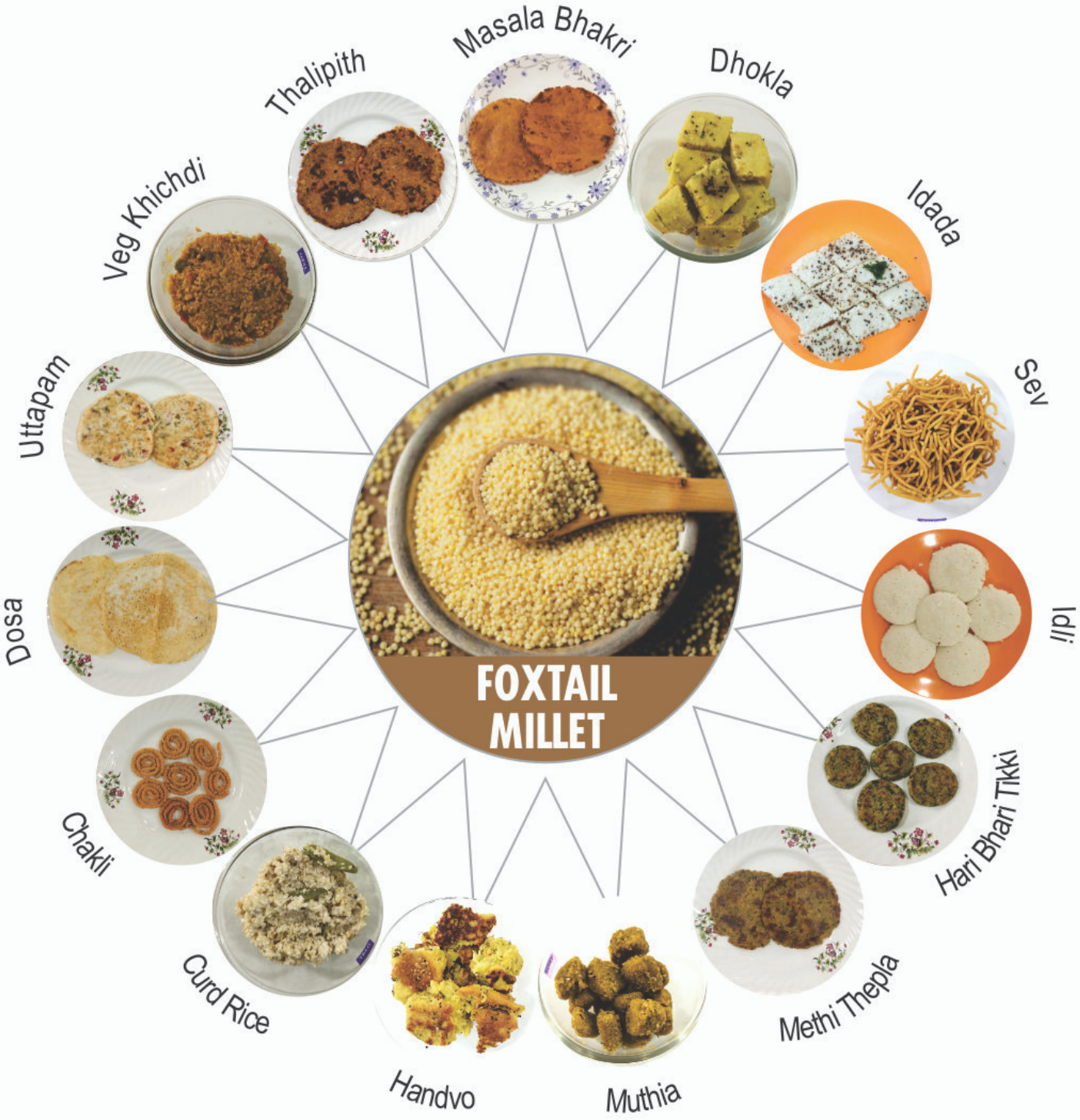
· It contains appreciable amounts of vitamins, minerals and essential amino acids (Sharma 2017).

Hence, foxtail millet being considered as a minor millet is a rich source of protein, dietary fiber, phosphorus, B vitamins, minerals and antioxidants; benefits in the prevention and management of gastric disorders, obesity and non-communicable diseases.

Despite having a rich nutrient profile, the consumption and awareness of foxtail millet is less amongst the population and there are very few scientific studies conducted on it. Thereby, the idea of developing this booklet came into picture.

Source: Foxtail millet: Properties, processing, health benefits, and uses
Nitya Sharmaa,b and Keshavan Niranjan

Foxtail Millet Incorporated Recipes



VEG KHICHDI

Ingredients:

Foxtail millet(25g), Green gram dal(15g), Capsicum(20g), Onion(20g), Tomato(20g), Carrot(15g), Peas(10g), Coriander leaves(10g), Oil(1.5tsp).

Other Ingredients:

Haldi(1/2tsp), Chilli ginger-garlic paste(1tsp), Salt(1/2tsp), Hing(1/2tsp), Mustard seeds(1/2tsp), Cumin seeds(1tsp), Garam masala(1tsp), Cumin-coriander powder(1tsp), Red chilli powder(1tsp) and Water(1/2cup).

Cooked weight = 245g

Cooked volume = 1.5 cups

Method:

·Heat oil in a cooker.

·Add mustard seeds, cumin seeds and asafoetida to it.

·Add the chilli ginger-garlic paste and all the vegetables and sauté on a medium flame for 5 minutes.

·Add haldi, garam masala, cumin-coriander powder, chilli powder and salt to it. Mix well.

·Add soaked foxtail and green gram dal to the veggies and mix well.

·Add water, mix well and let it come to a boil.

·Close the lid and let it cook up to 3 whistles on a medium flame.

·Serve hot with curd or kadhi.

Ingredients	Amount (g/ml)	Energy (kcal)	CHO* (g)	Protein (g)	Fat (g)	Crude fibre (g)	Calcium (mg)	Iron (mg)
Foxtail millet whole	25	82	15	3	1	2	7.5	0.9
Green gram dal	15	48	7.8	3.5	0.2	1.4	6.4	0.6
Capsicum	20	3	0.3	0.2	-	0.4	2.9	0.1
Onion	20	10	1.8	0.3	-	0.5	4.2	0.1
Tomato	20	4	0.6	0.1	-	0.3	1.7	-
Carrot	15	5	0.8	0.1	-	0.6	5.2	0.1
Peas	10	8	1.1	0.7	-	0.6	2.8	0.2
Coriander leaves	10	3	0.2	0.3	--	0.4	14.6	0.5
Oil	7.5	67	-	-	7.5	-	-	-
TOTAL		**230**	**27.6**	**8.2**	**8.7**	**6.2**	**45.3**	**2.5**

Note: All amounts depicted in the table are edible portions of the ingredients.

MASALA BHAKHRI

Ingredients:

Foxtail millet flour(30g), Whole wheat flour(10g), Oil(2tsp).

Other Ingredients:

Salt(1/2tsp), Cumin seeds(1tsp), Carom seeds(1tsp), Turmeric powder(1/2tsp), Red chilli powder(2tsp) and Water(1/3rd cup).

Cooked weight = 30g (for 2 Bhakri)
Diameter = 10cm

Method:

·Take both the flours in a vessel.
·Add salt, cumin and carom seeds to it.
·Add turmeric and red chilli powder.
·Add oil, water and mix well to form a soft dough.
·Divide the dough into 2 equal portions and roll.
·Place the rolled bhakri on heated tawa and cook on a medium flame till it turns slight brown on both the sides.
·Serve hot or cold with your favourite beverage at snacks.

Ingredients	Amount (g/ml)	Energy (kcal)	CHO* (g)	Protein (g)	Fat (g)	Crude fibre (g)	Calcium (mg)	Iron (mg)
Foxtail millet flour	30	105	19.2	3.8	1.3	2.5	9.6	1.2
Whole wheat flour	8	25	5.1	0.8	0.1	0.9	2.4	0.3
Oil	10	90	-	-	10	-	-	-
TOTAL		**220**	**24.3**	**4.6**	**11.4**	**3.4**	**12**	**1.5**

Note: All amounts depicted in the table are edible portions of the ingredients.

THALIPITH

Ingredients:

Foxtail millet flour(25g), Jowar flour(15g), Bengal gram flour(10g), Onion(25g), Coriander leaves(10g), Oil(1tsp).

Other Ingredients:

Salt(1/2tsp), Turmeric powder(1/2tsp), Cumin seeds(1tsp), Chilli and ginger-garlic paste(2tsp), Carom seeds(1tsp) and Water(1/3rd cup).

Cooked weight = 112g
(for 2 medium sized Thalipith)
Diameter = 12 cm

Method:

·Take all the three flours in a vessel.
·Add onion and mix gently in the flour. Add salt, turmeric powder, cumin and carom seeds to it.
·Add coriander leaves and chilli ginger-garlic paste to it and mix all the ingredients well. It may leave some water due to onion and coriander leaves. Thereby, add water slowly as required and form a soft sticky dough.
·Take a plastic wrap and put on a platform.
·Take a small part of dough, spread it on the sheet and make some holes onto it with the help of a finger so it can get cooked properly.
·Add some oil on a tawa, put the thalipith on it and cover for few minutes.
·Cook it on a medium flame till it turns golden brown on both the sides.
·Serve hot with curd or green chutney.

Ingredients	Amount (g/ml)	Energy (kcal)	CHO* (g)	Protein (g)	Fat (g)	Crude fibre (g)	Calcium (mg)	Iron (mg)
Foxtail millet flour	25	82	15	3	1	2	7.5	0.9
Jowar flour	15	50	10	1.5	0.2	1.5	4.1	0.6
Bengal gram flour	10	39	5.5	2.5	0.6	1.8	5.5	0.7
Onion	25	12	2.3	0.4	-	0.6	5.2	0.1
Oil	5	45	-	-	5	-	-	-
Coriander leaves	10	3	0.2	0.3	--	0.4	14.6	0.5
TOTAL		**231**	**33**	**7.7**	**6.8**	**6.3**	**36.9**	**2.8**

Note: All amounts depicted in the table are edible portions of the ingredients.

METHI THEPLA

Ingredients:

Foxtail millet flour(25g), Bajra flour(30g), Fenugreek leaves(15g), Sugar(5g), Oil(10g), Coriander leaves(10g), Curd(10g).

Other Ingredients:

Salt(1/2tsp), Turmeric powder (1/2tsp), Carom seeds(1tsp), Chilli ginger-garlic paste(2tsp) and Water(1/2cup).

Cooked weight = 84g
(3 medium sized Thepla)
Diameter = 10cm

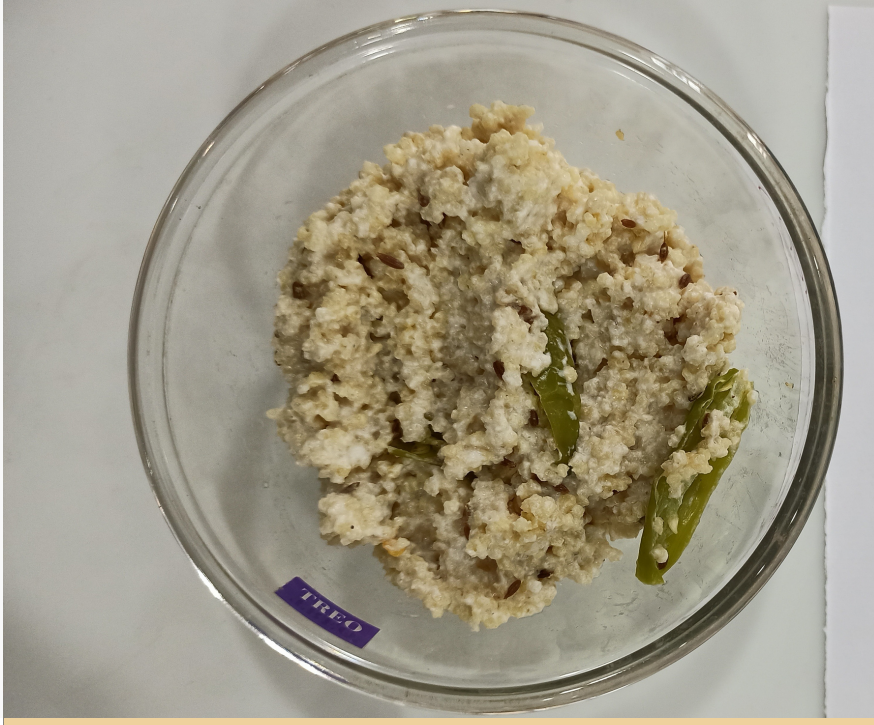
Method:

·Take both the flours in a broad vessel.
·Add fenugreek and coriander leaves to it.
·Mix and rub gently with fingers.
·Add salt, carom seeds, turmeric powder and chilli ginger-garlic paste to it.
·Mix all the ingredients together and add water slowly to form a soft yet firm dough.
·Divide into 3 equal sized balls of the dough and roll on a platform.
·Heat oil on a tawa and place the thepla on it.
·Roast from both the sides on a medium flame till it turns golden brown.
·Serve hot with curd or green chutney.

Ingredients	Amount (g/ml)	Energy (kcal)	CHO* (g)	Protein (g)	Fat (g)	Crude fibre (g)	Calcium (mg)	Iron (mg)
Foxtail millet flour	25	82	15	3	1	2	7.5	0.9
Bajra flour	30	104	18.5	3.2	1.6	3.4	4.1	1
Fenugreek leaves	15	5	0.3	0.5	0.1	0.7	41.1	0.9
Sugar	5	20	5	-	-	-	-	-
Oil	10	90	-	-	10	-	-	-
Coriander leaves	10	3	0.2	0.3	--	0.4	14.6	0.5
Curd	10	6	0.2	0.2	0.4	-	14.9	-
TOTAL		**310**	**39.2**	**7.2**	**13.1**	**6.5**	**82.2**	**3.3**

Note: All amounts depicted in the table are edible portions of the ingredients.

CURD RICE



Ingredients:
Foxtail millet whole(40g), Curd(80g), Ghee(5g).

Other Ingredients:
Cumin seeds(2tsp), Green chillies (2nos.), Red chilli(1), Salt(1/2tsp), Hing(1/2tsp) and Water(1/2cup).

Cooked weight = 225g
Cooked volume = 1 cup

Method:
·Wash and soak the whole foxtail millet for 15 minutes.
·Cook in a pressure cooker upto 3 whistles.
·Take out the rice and spread it in a broad vessel and add salt to it.
·Heat ghee in a small pan.
·Add cumin seeds and asafetida to it.
·Slit the green chillies and cut the red chilli into half and add it to the pan.
·Pour this hot mixture in the rice, add curd and mix it well.
·Serve hot or cold as per your choice.

Ingredients	Amount (g/ml)	Energy (kcal)	CHO* (g)	Protein (g)	Fat (g)	Crude fibre (g)	Calcium (mg)	Iron (mg)
Foxtail millet whole	40	132	24	4.8	1.7	3.2	12	1.5
Curd	80	48	2.4	2.5	3.2	-	119.2	0.2
Ghee	5	45	-	-	5	-	-	-
TOTAL		**225**	**26.4**	**7.3**	**9.9**	**3.2**	**131.2**	**1.7**

Note: All amounts depicted in the table are edible portions of the ingredients.

SEV

Ingredients:

Foxtail millet flour(25g), Rice flour(10g), Bengal gram flour(20g), Oil(7.5g).

Other Ingredients:

Carom seeds(1tsp), Hing(1/2tsp), Salt(1/4th tsp) and Water(1/4th cup).

Cooked weight = 65g

Cooked volume = 1 cup

Method:

·Sieve and mix all the flours in a deep vessel.

·Add salt, carom seeds and oil to it.

·Slowly add water and mix it gently to form a soft yet firm dough.

·Heat the oil in a kadai for frying on a medium flame.

·Take a small part of dough, put it into the extruder and directly extrude the thin shaped spiral sev into the hot oil.

·Turn once it gets abit firm and takeout when turns slight brown. Do not over fry it.

Ingredients	Amount (g/ml)	Energy (kcal)	CHO* (g)	Protein (g)	Fat (g)	Crude fibre (g)	Calcium (mg)	Iron (mg)
Foxtail millet flour	25	83	15	3	1	2	7.5	1
Rice flour	10	26	5.6	0.7	0.1	0.3	0.8	0.1
Bengal gram flour	20	66	9.2	4.2	1	3	9.2	1.2
Oil	7.5	68	-	-	7.5	-	-	-
TOTAL		**243**	**29.8**	**7.9**	**9.6**	**5.3**	**17.5**	**2.3**

Note: All amounts depicted in the table are edible portions of the ingredients.

CHAKLI

Ingredients:

Foxtail millet flour(25g), Rice flour(5g), Bengal gram flour(5g), Sesame seeds(5g), Ghee(2.5g), Oil(11g).

Other ingredients:

Salt(1/4th tsp), Red chilli powder(2tsp), Hing(1/2tsp), Carrom seeds(1/2tsp), Cumin seeds(1tsp) and Water(1/4th cup).

Cooked weight = 60g
(8 Chakli)

Method:

·Sieve and mix all the flours in a deep vessel.
·Add salt and other spices to it.
·Add ghee as shortening.
·Add water slowly while mixing it altogether.
·Make a soft yet firm dough that can easily pass through the extruder.
·Heat oil in a kadai on a medium flame.
·Make spiral shaped chaklis with the help of the extruder and fry in the oil until it turns golden brown.

Ingredients	Amount (g/ml)	Energy (kcal)	CHO* (g)	Protein (g)	Fat (g)	Crude fibre (g)	Calcium (mg)	Iron (mg)
Foxtail millet flour	25	83	15	3	1	2	7.5	1
Rice flour	5	26	5.5	0.7	0.1	0.3	0.8	0.1
Bengal gram flour	5	16	2.3	1	0.2	0.7	2.3	0.3
Sesame seeds	5	28	1.3	0.9	2.1	0.2	72.5	0.5
Ghee	2.5	22	-	-	2.5	-	-	-
Oil	11	101	-	-	11	-	-	-
TOTAL		**276**	**24.1**	**5.6**	**16.9**	**3.2**	**83.1**	**1.9**

Note: All amounts depicted in the table are edible portions of the ingredients.

MUTHIYA

Ingredients:

Foxtail millet flour(25g), Bengal gram dal(5g), Red gram dal(5g), Black gram dal(5g), Bottlegourd(25g), Coriander leaves(5g), Oil(6g), Sugar(2.5g), Sesame seeds(2.5g), Mustard seeds(2.5g).

Other ingredients:

Chilli ginger-garlic paste(1tsp), Salt(1/2tsp), Carom seeds(1tsp), Turmeric powder(1/2tsp), Water(1/4th cup) and few curry leaves.

Cooked weight = 90g
Cooked volume = 1cup

Method:

·Wash and soak all dals for 15 minutes. Dry them completely by roasting on a pan and grind them into a coarse flour.

·Add foxtail millet flour to it and mix well.

·Add grated bottlegourd, chilli ginger-garlic paste, coriander leaves, salt, turmeric powder and carom seeds to it. Mix well and add water to it and form a sticky dough.

·Tap some water on the dough (so it does not get dry after steaming) and then put on the steaming plate. Steam it for 20 minutes and check if done with the help of a knife or fork. Let it cool for few minutes and the cut into small pieces.

·Take oil, add sesame and mustard seeds and curry leaves in a kadhai and then add the cut pieces to it. Mix well. Serve hot.

Ingredients	Amount (g/ml)	Energy (kcal)	CHO* (g)	Protein (g)	Fat (g)	Crude fibre (g)	Calcium (mg)	Iron (mg)
Foxtail millet flour	25	83	15	3	1.1	2	7.5	1
Bengal gram dal	5	24	3.5	1.6	0.4	1.1	3.5	0.5
Red gram dal	5	16	2.7	1.2	0	0.5	3.6	0.2
Black gram dal	5	8	1.5	0.6	0.4	0.3	1.4	0.1
Bottlegourd	25	3	0.4	0.2	-	0.5	3.8	0.1
Coriander leaves	5	1	0.1	0.1	--	0.2	7.3	0.2
Oil	6	56	-	-	6.3	-	-	-
Sugar	2.5	10	2.5	-	-	-	-	-
Sesame seeds	2.5	14	0.6	0.5	1	0	36.3	0.2
Mustard seeds	2.5	12	0.4	0.4	1	0.3	10	0.4
TOTAL		**227**	**26.7**	**7.6**	**10.2**	**4.9**	**73.4**	**2.7**

Note: All amounts depicted in the table are edible portions of the ingredients.

HANDVO

Ingredients:

Foxtail millet whole(25g), Red gram dal(10g), Bengal gram dal(5g), Black gram dal(5g), Green gram dal(5g), Bottlegourd(25g), Coriander leaves(5g), Oil(5g), Sugar(2.5g), Curd(2.5g), Sesame(5g) & Mustard seed(2.5g).

Other Ingredients:

Chilli ginger-garlic paste(1tsp), Carom seeds(1/2tsp), Salt(1/2tsp), Turmeric powder(1/2tsp) and water as req.

Cooked weight = 250 g

Cooked volume = 1 cup

Method:

·Wash and soak all dals and foxtail in water for about 3-5 hours and then grind into a smooth batter.

·Add curd to it and keep aside in warm environment for fermentation. After the fermentation; add grated bottlegourd and chopped coriander leaves, salt, sugar, turmeric powder, carom seeds and chilli ginger-garlic paste. Mix everything well.

·Heat oil in a nonstick pan, add sesame and mustard seeds to it. Add the batter into the pan and cover it with the lid. Let it cook for about 15 minutes on a medium flame or till it turns golden brown and turn on the other side. Let it cook on the other side for about 7 minutes or till it turns golden brown.

·Check with a toothpick or knife if cooked well from the center. Cut into pieces and serve hot.

Ingredients	Amount (g/ml)	Energy (kcal)	CHO* (g)	Protein (g)	Fat (g)	Crude fibre (g)	Calcium (mg)	Iron (mg)
Foxtail millet whole	25	83	15	3	1	2	7.5	1
Red gram dal	10	33	5.5	1.2	0.1	0.9	7.1	0.4
Bengal gram dal	5	16	2.3	1	0.3	0.8	2.3	0.3
Black gram dal	5	15	2.5	1.1	0.8	0.3	2.7	0.2
Green gram dal	5	24	3.6	1.7	0.1	0.7	3.2	0.3
Bottlegourd	25	2	0.4	0.1	-	0.5	3.8	0.1
Coriander leaves	5	2	0.1	0.2	--	0.2	7.3	0.3
Oil	5	45	-	-	5	-	-	-
Sugar	2.5	10	2.5	-	-	-	-	-
Curd	2.5	1	0.1	0.1	0.1	-	3.5	-
Sesame seeds	5	28	1.2	0.9	2.1	0.1	72.5	0.4
Mustard seeds	2.5	13	0.4	0.5	1	0.4	10	0.3
TOTAL		**272**	**33.6**	**9.8**	**10.5**	**5.9**	**119.9**	**3.3**

Note: All amounts depicted in the table are edible portions of the ingredients.

DHOKLA

Ingredients:

Foxtail millet whole(60g), Bengal gram dal(5g), Black gram dal(5g), Green gram dal(5g), Coriander leaves(5g), Oil(5g), Sugar(2.5g), Curd(2.5g), Sesame(2.5g) & Mustard seed(2.5g).

Other Ingredients:

Chilli ginger-garlic paste(1tsp), Salt(1/4th tsp), Turmeric powder(1/2tsp), Soda(1/2tsp) and water as required.

Cooked weight = 85g

Cooked volume = 1 cup

Method:

·Wash and soak all dals and foxtail in water for about 3-5 hours and then grind into a smooth batter.

Add curd to it and keep aside in warm environment for fermentation. After fermentation, add chilli ginger-garlic paste, salt, sugar, chopped coriander leaves, turmeric powder and soda. Mix well.

·Grease a plate with oil and add the batter to it. Keep the plate in the steamer and then close with the lid and cook for about 10-15 minutes on a medium flame. Check with the toothpick or knife after 15 minutes if cooked or not.

Take the plate out and let it cool. Cut into pieces. Take oil in a pan, add sesame and mustard seeds to it. Drizzle the oil on the pieces and

Ingredients	Amount (g/ml)	Energy (kcal)	CHO* (g)	Protein (g)	Fat (g)	Crude fibre (g)	Calcium (mg)	Iron (mg)
Foxtail millet whole	20	60	12	2.5	0.7	1.6	6.1	0.9
Bengal gram dal	5	16	2.3	1	0.3	0.7	2.3	0.2
Black gram dal	5	32	5	2.2	1.6	0.6	5.4	0.2
Green gram dal	5	16	2.6	1.2	0	0.5	2.1	0.1
Coriander leaves	5	2	0.1	0.1	--	0.4	7.3	0.3
Oil	5	45	-	-	5	-	-	-
Sugar	2.5	10	2.5	-	-	-	-	-
Curd	2.5	1	0	0	0.1	-	3.5	-
Sesame seeds	2.5	14	0.6	0.4	1	0	36	0.2
Mustard seeds	2.5	12	0.4	0.5	1.1	0.4	10	0.4
TOTAL		**208**	**25.5**	**7.9**	**9.8**	**4.2**	**72.7**	**2.3**

Note: All amounts depicted in the table are edible portions of the ingredients.

IDLI

Ingredients:

Foxtail millet whole(15g), Black gram dal(30g), Curd(2.5g) and Oil(2.5g).

Other Ingredients:

Salt(1/4th tsp) and water as required.

Cooked weight = 60g

(For 4 Idlis)

Diameter = 7 cm

Method:

·Wash and soak foxtail millet and black gram dal for 3-5 hours and then grind into a smooth paste.

·Add curd and keep aside in warm environment for fermentation. After fermentation, add salt and mix well.

·Grease the idli moulds with oil, pour the batter into it and keep in the steamer. Let it steam for about 10-15 minutes on a medium flame. Take out the mould and let it rest for few minutes. Scoop the idlis with spoon or knife as per your comfort.

·Serve with hot sambhar or coconut chutney.

Ingredients	Amount (g/ml)	Energy (kcal)	CHO* (g)	Protein (g)	Fat (g)	Crude fibre (g)	Calcium (mg)	Iron (mg)
Foxtail millet whole	15	49	9	1.8	0.6	1.2	4.5	0.6
Black gram dal	30	86	15	6.6	4.8	1.8	16.2	1.2
Curd	2.5	1	0.1	0.1	0.1	-	3.8	-
Oil	2.5	22	-	-	2.5	-	-	-
TOTAL		**158**	**48.1**	**16.9**	**13.6**	**6**	**48.9**	**3.5**

Note: All amounts depicted in the table are edible portions of the ingredients.

DOSA

Ingredients:

Foxtail millet whole(10g), Black gram dal(15g), Curd(2.5g), Oil(2.5g).

Other Ingredients:

Salt(1/4th tsp) and water as required.

Cooked = 2 thin medium sized Dosa

Diameter = 15cm

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Method:

·Wash and soak foxtail millet and black gram dal for about 3-5 hours and then grind into a smooth paste.

·Add curd and keep aside in warm environment for fermentation.

·After fermentation, add salt and water (if required for the consistency). Mix well.

·Heat oil on a nonstick tawa.

·Pour the dosa batter onto it and spread evenly. Cook on a medium flame till it turns slight yellow to golden or crisps.

·Serve hot with sambhar or coconut chutney.

Ingredients	Amount (g/ml)	Energy (kcal)	CHO* (g)	Protein (g)	Fat (g)	Crude fibre (g)	Calcium (mg)	Iron (mg)
Foxtail millet whole	10	25	4.5	0.9	0.3	0.6	2.3	0.3
Black gram dal	15	48	7.5	3.3	2.4	0.9	8.1	0.6
Curd	2.5	2	0.1	0.1	0.1	-	3.6	-
Oil	2.5	23	-	-	2.5	-	-	-
TOTAL		**98**	**12.1**	**4.3**	**5.3**	**1.5**	**14**	**0.9**

Note: All amounts depicted in the table are edible portions of the ingredients.

UTTAPAM

Ingredients:

Foxtail millet whole(15g), Black gram dal(30g), Curd(2.5g), Oil(2.5g), Coriander leaves(5g), Onion(10g), Tomato(15g), Capsicum(10g).

Other Ingredients:

Salt(1/4th tsp), Black pepper powder(1/2tsp), Green chilli(1), and water as required.

Cooked = 2 medium sized Uttapam
Diameter = 12cm

Method:

·Wash and soak foxtail millet and black gram dal for 3-5 hours and then grind into a smooth batter.
·Add curd and keep aside in warm environment for fermentation.
·After fermentation, add salt and water (if required for the consistency). Mix well.
·Chop and add all the veggies, finely chopped green chilli and coriander leaves.
·Add black pepper powder to it and mix well.
·Heat oil on a nonstick tawa and pour the batter onto it and spread evenly.
·Flip and let it cook on a medium flame till it turns golden on both the sides.
·Serve hot with sambhar, coconut chutney or tomato ketchup.

Ingredients	Amount (g/ml)	Energy (kcal)	CHO* (g)	Protein (g)	Fat (g)	Crude fibre (g)	Calcium (mg)	Iron (mg)
Foxtail millet whole	15	49	9	1.8	0.6	1.2	4.5	0.6
Black gram dal	30	96	15	6.6	4.8	1.8	16.2	1.2
Curd	2.5	1	0.1	0.1	0.1	-	3.8	-
Oil	2.5	22	-	-	2.5	-	-	-
Coriander leaves	5	2	0.1	0.1	--	0.2	7.3	0.3
Onion	10	5	0.9	0.2	-	0.3	2.1	0.1
Tomato	15	3	0.5	0.1	-	0.2	1.4	-
Capsicum	10	1	0.1	0.1	-	0.2	1.1	0.1
TOTAL		**179**	**25.7**	**9**	**8**	**3.9**	**36.4**	**2.3**

Note: All amounts depicted in the table are edible portions of the ingredients.

IDADA

Ingredients:

Foxtail millet whole(10g), Black gram dal(15g), Curd(2.5g), Oil(2.5g), Sesame(5g) & Mustard seed(2.5g).

Other ingredients:

Salt(1/2tsp), Black pepper powder(1tsp), 4-5 curry leaves and water as required.

Cooked weight = 65g

Cooked volume = 1 cup

Method:

·Wash and soak foxtail millet and black gram dal for 3-5 hours and then grind into a smooth batter. Add curd and keep aside in warm environment for fermentation. After fermentation, add salt and water (if required for the consistency). Mix well.

·Grease a plate with oil and pour the batter into it. Sprinkle some black pepper powder on it and keep the plate in steamer. Steam it for about 10-15 minutes and check later with toothpick or knife if done. Take the plate out and rest it for few minutes.

·Take oil in a pan, add sesame, mustard seeds and curry leaves to it. Cut them into pieces and spread the oil mixture onto it.

·Serve hot with green chutney.

Ingredients	Amount (g/ml)	Energy (kcal)	CHO* (g)	Protein (g)	Fat (g)	Crude fibre (g)	Calcium (mg)	Iron (mg)
Foxtail millet whole	10	24	4.5	0.9	0.3	0.6	2.2	0.25
Black gram dal	15	48	7.5	3.3	2.4	0.9	8.1	0.6
Curd	2.5	1	0.1	0.1	0.1	-	3.7	-
Oil	5	45	-	-	5	-	-	-
Sesame seeds	5	28	1.7	0.9	2.1	0.1	74.5	0.4
Mustard seeds	2.5	13	0.4	0.5	1	0.4	10	0.3
TOTAL		**159**	**14.2**	**5.7**	**10.9**	**2**	**98.5**	**1.55**

Note: All amounts depicted in the table are edible portions of the ingredients.

HARI BHARI TIKKI

Ingredients:

Foxtail millet whole(20g), Spinach(20g), Peas(20g), Potato(40g), Cornflour(5g), Coriander leaves(10g), Oil(5g).

Other Ingredients:

Chilli ginger-garlic paste(2tsp), Black pepper powder(1/4th tsp), Chaat masala(1/2tsp), Salt(1/3rd tsp), few drops of lemon juice.

6 tikkis:
Diameter = 6cm with medium thickness

Method:

·Boil and mash the potatoes.
·Cook whole foxtail millet in pressure cooker upto 3 whistles on a medium flame and mash similar to that of potatoes.
·Blanch peas and spinach and mash them as well.
·Mix all the above ingredients in a vessel, add coriander leaves and chilli ginger-garlic paste to it.
·Add chaat masala, pepper, salt, lemon juice, cornflour and mix well.
·Divide the mixture into 6 equal portions and make medium sized round tikkis.
·Heat oil in a pan and put the tikkis into it.
·Cook it on a medium flate till it turns brown on both the sides.
·Serve hot with green chutney or tomato ketchup.

Ingredients	Amount (g/ml)	Energy (kcal)	CHO* (g)	Protein (g)	Fat (g)	Crude fibre (g)	Calcium (mg)	Iron (mg)
Foxtail millet whole	20	65	12	2.4	0.8	1.6	6	0.8
Spinach	20	5	0.4	0.4	0.1	0.5	16.4	0.6
Peas	20	16	2.2	1.4	-	1.2	5.6	0.4
Potato	40	24	5.1	0.5	-	0.7	3.4	0.2
Cornflour	5	17	3.2	0.4	0.2	0.6	0.4	0.1
Coriander leaves	10	3	0.2	0.3	--	0.4	14.6	0.5
Oil	5	45	-	-	5	-	-	-
TOTAL		**175**	**23.1**	**5.4**	**6.1**	**5**	**46.4**	**2.6**

Note: All amounts depicted in the table are edible portions of the ingredients.

Abbreviations & Measures

- tsp - teaspoon
- tbsp - tablespoon
- nos. - numbers
- g - gram
- mg - milligram
- cm - centimetre
- kcal - kilocalories
- ml - millilitre
- CHO - carbohydrates
- 1 cup - Standard cup

- 1 tsp - 5g
- 1 tbsp - 15g
- 1 std cup - 200mL

Estd. 1946

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