Utilisation of foxtail millet in value-added products

Dissertation-1 Report

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CERTIFICATE

This is to certify that Shahid Sidheeque (registration No.11718839) has personally completed M.Sc, dissertation entitled, "Utilisation of foxtail millet in value-added products" under my guidance and supervision. To the best of my knowledge, the present work is the result of her original investigation and study. No part of the dissertation has ever been submitted for any other purpose at any university.

The project report is appropriate for the submission and the partial fulfillment of the condition for the evaluation leading to the award of Master of food technology.

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Declaration

I hereby declare that the framework presented in the Thesis entitled “Utilisation of foxtail millet in value added products” is my own and original. The work will be carried out by me at the school of Agriculture, Lovely Professional University, Phagwara, Punjab, India, for the award of the degree of Master of Science in Food Technology.

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I certified that the above statement made by the student is correct to the best of my knowledge and belief.

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Utilisation of foxtail millet in value-added products

Introduction

Millet is a general term used for a different group of cereal crops that characteristically produce small seeds and consist of a number of annual food and fodder grasses such as foxtail millet (*Setaria italic*), pearl millet (*Pennisetum glaucum*), finger millet (*Eleusine coracana*), proso millet (*Panicum miliaceum*), etc. It is one of the easily grown cereal grains which belonging to the *Setaria* genus, of Poaceae family and subfamily panicoideae. Foxtail millet is a self pollinating crop with chromosome number 2n=18. Foxtail millet is a C4 annual monocot with slim, leafy stem and erect. Foxtail millet can grow in sandy loamy soils and grows 2-5 feet tall. It has a thick root system. The leaves are lack hairiness and arc broad, while culms are slim and vertical (Doust *et al., 2009).* Foxtail millet is ancient cultivated millet crops and need warm weather and small amount of water for rapid maturation during the hot and dry months of the year. Foxtail millet has been the most main cereal since earliest times in China. It became a most leading crop 4100 years ago. This cereal is also called as Italian millet, German millet, Siberian millet, and foxtail bristlegrass. In India , this millet is grown mostly in the hot drought - pron arid and semiarid zones - and used commonly for food purposes particularly by people of economically weaker sections. And also, in China the millet bran is utilised as animal feed. Foxtail millet is used mostly as animal food mainly in North America and Europe. Now a day the acceptance of this millet is getting high as human diet, mainly the people seeking for gluten-free alternatives and healthier foods. This millet is also used for the production of many food items like steamed meal, porridge, bread and beverages (Choi *et al.,* 1982). After planting it is harvested in 75-90 days after planting and in semiarid tropics it plays economically important role. It also grows under saline condition (Nitya Sharma and Keshavan Niranjan, 2017).

Foxtail millet is rich in protein and iron along with calcium and zinc, It contain seven of the eight essential amino acids, which cannot be produced in our body and the biological value of the digestible protein is higher than rice and wheat (Zhang, 2007). Foxtail millet consists of seed protein (14-16%), crude fat (5-8%) and it has comparatively high minerals than finger millet (Ravindran, 1991). This consists 2.5 times Edible fiber than found in rice and it is good for intestine and stomach health (Liang, 2010). It contains 9.4% crude oil in its barn

which is rich in linoleic (66.5%) and oleic acid (13.0%). This millet contains health benefit component which are unique among the other cereals, starch was found to be 65.59-74.12 g/100g, crude protein content were 11.85-20.58 g/100g, and amino acid content was 0.25-4.31 g/100g (Nitya Sharma and Keshavan Niranjan). It also contains Vitamin B1-0.26 mg vitamin E-0.78 mg, Vitamin B2-0.09 mg, Vitamin B6-0.23 mg, Niacin-2.21 mg, Folate-37.7 micrograms, Potassium-364 mg, Pantothenic acid-2.39 mg, Calcium-18.2 mg, Sodium-1.3 mg, Zinc-0.59 mg, Magnesium-143 mg, Iron-6.24 mg, Phosphorus-364 mg and Copper-0.59 mg in foxtail millet.

Foxtail millet has a high content of bioactive compound that hold many health profits. Though research on foxtail millet has mostly reported on the medicine of diabetes by increasing cholesterol-metabolism. Foxtail millet has many medical and nutritious functions. Such as buckwheat and quinoa, foxtail millet is not an acid making and gluten free, so it is smooth and digests easily. So that it is considered as least allergenic and digestible.

Gluten

Foxtail millet is gluten-free millet. A gluten-free diet is naturally good for the health, and then it helps digestion, rises energy levels and benefits in correcting the cholesterol levels in the body. Non Glutinous grains automatically remove harmful food that is high in glucose fat, and fatty acids. Moreover, you can also avoid treated food, which we all know is sternly prohibited for a health. Foxtail millets nutrition gives you your vital amount of vitamins and minerals. Moreover, foxtail millets being gluten-free mean that you can construct up a tough prevention against cardiovascular diseases, and heart-related complications, cancers. In conclusion, this sole benefit of foxtail millets aids you in eliminating microorganisms such as viruses and germs.

Traditional uses

In china foxtail millet is used as a emollient and harsh in diarrhea, Pinellia choleric affections and and millet soup, a simple mix of Pinella rhizoma and Setaria italica, used for the treatment of insomnia and diuretic, to make stronger virility, treat stomachache, enhance

vigor, treat bone fractures and rheumatism. It is also used for sexual vigor and potency by crushing the seed and mixed with ghee and made like a cake. Mixture of bark decoction of Acacia modesta and oil of Setaria were used as a contraceptive tonic. This was also used to cure diabetes. Treated grains are used in Chhattisgarh as a medicine for many diseases, This millet also helps to treat food shortage and the seeds support to strengthen virility. For fever and cholera white foxtail grains are beneficial. Old-fashioned dishes like chapatti, payasam, porridge were made by foxtail millet. Modern turn of millets comes in the form of kabab, salads, burfi, biscuits, baked stuffs and almost whatever that can be prepared from it. It is obtainable in hulled form i.e., millet grains are present in a tough indigestible hull which are eliminate before human intake. Hulling retains the nutrient significance intact.

Problem background

This millet grows under warm weather and needs only little amount of water. This grows during the hot and dry months of the year. This millet is developed mainly in the hot drought - pron arid and semiarid zones - and used mainly for food purposes particularly by people of economically weaker sectors. It is significant as a diabetic-friendly, highly nutritious and glutinous free. This has high nutritional value and it has many health benefits. It cures diarrhea, treats indigestion, dyspepsia, enhances vigor, treats bone fractures and rheumatism.

Objective of study

1. physicochemical, phytochemical analysis of grain.
2. Effect of conditioning on machinability of grain.
3. Process optimization for development of value-added product (Dosa, Idli).
4. Quality evaluation of the finished product.

Review of Literature

Antioxidant potential of foxtail millet

Introduction

Millet is a general word used for various group of cereal crops that usually having small seeds and contain several annual food and fodder grasses such as foxtail millet (*Setaria italic*), , finger millet (*Eleusine coracana*), proso millet (*Panicum miliaceum*), and pearl millet (*Pennisetum glaucum*) (Dwiedi 2012). Production about 90% of global millet is used in the developing countries (**FAO, 1990)** and India alone produce foxtail millet about 38.6% (F**AO, 1995.** Foxtail millet (*Setaria italic*) is one of the ancient cultivated millet crops and needs warm weather and less amount of water for the growth and are grown at hot and dry months of the year. In the global millet production, it has second position after pearl millet (FAOSTAT, 2005). It is one of the main food grains of the semi-arid tropics, starting in China, continuing through India and spreading over most of Africa and parts of southern U.S.A.. Comparing the major cereal crops like maize, wheat and sorghum, foxtail millet has higher water use efficiency (Zhang, 2007). China is the origin and diversity of foxtail millet (Sakamato, 1987). Foxtail millet has been the most significant cereal since early times in China. It turn into the main crop 4100 years ago (Cao, 1986). It is a grass having slim, vertical leafy stems, and straight and slender culms with hollow internodes. It is a self-pollinating true diploid (2n=2x=18), , C4 panicoid grain species with small amount of repetitive DNA content (30%) and highly conserved genome structure relative to the ancestral grass lineage making it a apt species for genetic and molecular studies (Sivaraman and Ranjekar, 1984). in India at present, the crop is cultivated on a very limited area in sporadic patches in the state of Andra Pradesh, Uttar Pradesh, Karnataka, Tamil Nadu, Maharastra, Rajasthan, Madhya Pradesh and North Eastern states.

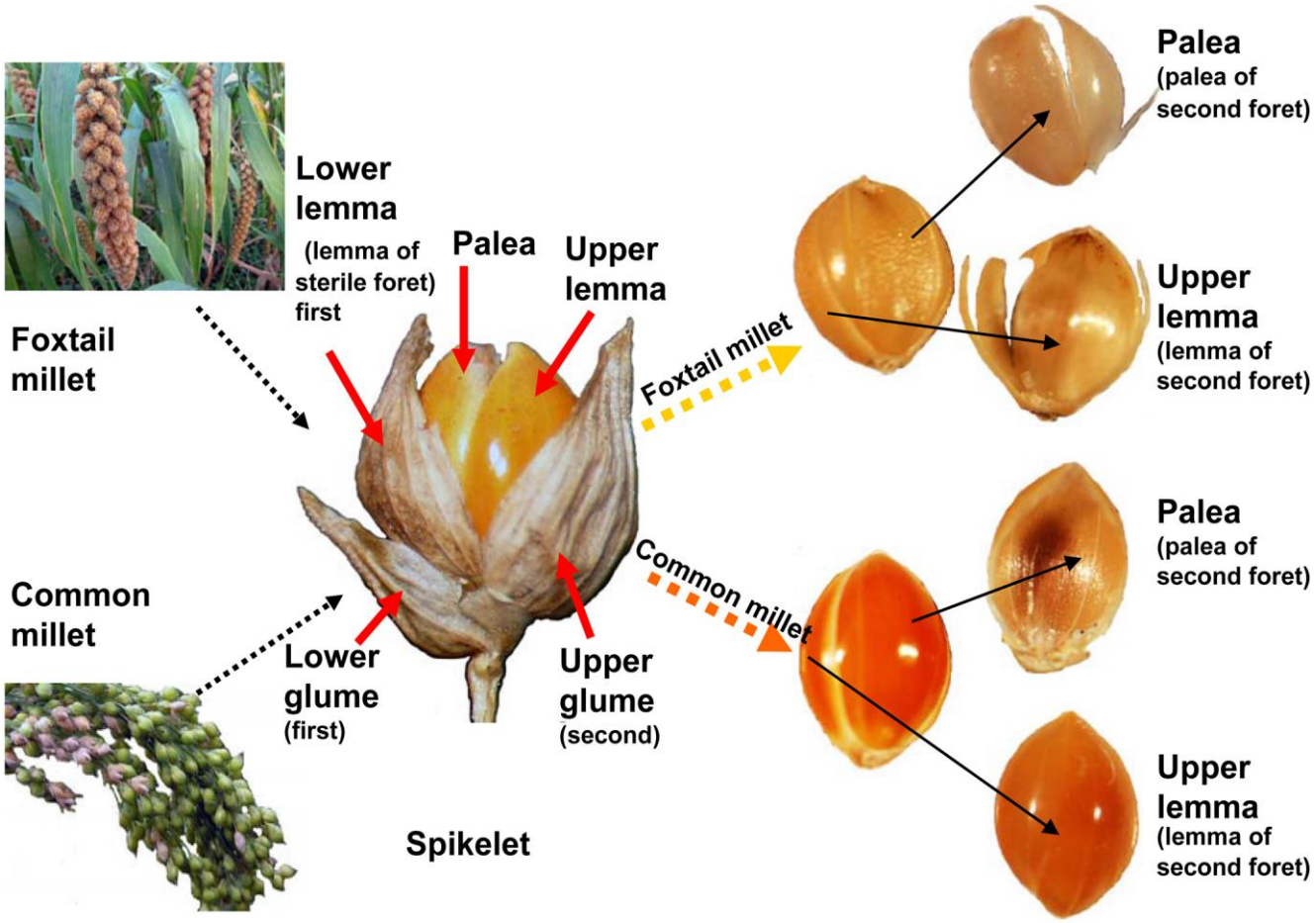

Figure 2. Diagram of spikelet and grain of millet (Zhang J, Liu KB Lu H and Xu D, et al. 2009).

Nutritional composition

Foxtail millet is rich in protein and iron along with calcium and zinc, Comparing to rice and wheat it has high digestible protein. It contains seven of the eight necessary amino acids, which cannot be produced by the human body (Zhang, 2007). Foxtail millet consists of seed protein (14-16%), crude fat (5-8%) and it has comparatively high minerals than finger millet (Ravindran, 1991). This consists 2.5 times Edible fiber than found in rice and it is good for intestine and stomach health (Liang, 2010). It contains 9.4% crude oil in its barn which is rich in linoleic (66.5%) and oleic acid (13.0%). This millet contains health benefit component which are unique among the other cereals, starch was found to be 65.59-74.12 g/100g, crude protein content were 11.85-20.58 g/100g, and amino acid content was 0.25-4.31 g/100g (Nitya Sharma and Keshavan Niranjan). It also contains Vitamin B1-0.26 mg vitamin E-0.78 mg, Vitamin B2-0.09 mg, Vitamin B6-0.23 mg, Niacin-2.21 mg, Folate-37.7 micrograms, Potassium-364 mg, Pantothenic acid-2.39 mg, Calcium-18.2 mg, Sodium-1.3 mg, Zinc-0.59 mg, Magnesium-143 mg, Iron-6.24 mg, Phosphorus-364 mg and Copper-0.59 mg in foxtail millet. In China, foxtail millet was considered as sacred and major among the "Five Grains" because of its enormous contribution to the prehistoric civilization. The five grains were foxtail millet, proso millet, rice, soybean and wheat (Austin, 2006). Considerable difference in the waxy phenotype (waxy and non-waxy) has been stated in foxtail millet providing prospects to develop its food uses using this locus-specific allelic difference (Fukunaga, 2002).

Table-1 Composition of foxtail millet (Deshpande and Mohaptra, 2015)

Nutritional composition	**Nutritional value of foxtail millet grain** (100 g^{-1}) **at 12% moisture content**
Protein (g)	10% to 12%
Lysine	2.29% to 2.7%
Fat (g)	4% to 5%
Energy	351 kcal
Thiamine (mg)	0.59 (mg)
CHO (g)	63.2
Fiber (g)	6.7
Minerals (g)	3.3
Iron (mg)	2.8
Calcium (mg)	31
Riboflavin (mg)	0.11

Table 2- Composition of total dietary fiber.

	Hull	**Endosperm**	**Bran**
Insoluble fiber	98.0%	5.8%	7.4%
Soluble fiber	-	3.8%	4.9%
Total dietary fiber	98.0%	9.6%	12.3%

Bran: The multi-layered exterior skin which protect the germ and endosperm from sunlight , water, pests, and disease. This layer also contain antioxidants, minerals like iron, zinc etc. Also contain B vitamins, fiber, and antinutrional factors.

Germ: The embryo, this is fertilized by pollen, this turns into new plant. It contains B vitamins, vitamin E, vitamin B, phytonutrients, antioxidants, and unsaturated fats.

Endosperm: This is the core part, this provides the food for germ. It is the largest portion of the kernel, consists of starchy carbohydrates, proteins, and small amounts of vitamins and minerals.

Starch

Starch content is 69.4 (Malleshi Desikachar, 1985). The type of foxtail millet determine the content of amylose and amylopectin. Foxtail millet can be waxy (high in amylopectin), normal (low in amylose) or nonwaxy (rich in amylose) (Nakamaya, 1998). It has been detected that there is a connection between gelatinization temperature and enthalpy in 13 varieties of the millet starch measured by different scanning calorimetry (DSC) (Fujita, 1989). The granular size of foxtail millet starch was found to be 8.0 to 15.0 pm (Ohara, 1981). From SEM observation the starch granules had comparable shapes to the maize starch granules. The digestive process of the millet starch attacked by a-amylase was also like to that of the non-waxy maize (commercial) used as a reference. After digesting for 3 hours, numerous pinholes seemed on the surface and subsequently the step-shaped structures in the inner portion of the non-waxy millet starch granules were detected on SEM, which were also detected in maize starch. Digested remains of the waxy millet starch, however, had shapes similar to sponge tissues.

Amylose content by spectrophotometry of iodine-starch complexes, for the millet starches were 591 to 600 nm except for two waxy varieties, the apparent amylose contents of non-waxy varieties were broadly distributed from 11.4 to 27.1% (Taira & Miyahara, 1983).

Sakamoto (1986) reported that amylose content of 32 non-waxy varieties were 5.0 to 25.1%, having two points, 10 and 22%, in the distribution. Amylose contents of two waxy varieties were 1.8 and 2.8 %. In the earlier research shown that fraction- I, that is the amylose fraction, by gel filtration of isoamylase debranched starches, was 1.3 and 2.7% (Fujita, 1989). The amount of amylose was 3.3 and 11.4%.

Fat

Germ contribute the major fat percentage. For the functional sensory characteristics fat play important role. Though bland in flavor, fats enhance and release the flavor of other ingredients. They also interact with other ingredients to develop good texture, mouthfeel and the overall sensation of lubricity and satiety of foods. Processing attributes and storage stability are also influenced by fat content (James, 1996). Besides their many functional roles in foods, fats also have positive nutritional aspects. Fats provide 9 Kcal/g which is a concentrated form of energy. They helps in absorption of fat-soluble vitamins A, D, E and K.

Fat is vital to the growth and development of the human body. Considered the number of cereals consumed, it is estimated that fat (free and bound) >50 percent of our essential fatty acid (EFA) requirement can be met by cereal diet. Cereals together with pulses can nearly meet the EFA requirement of an adult (Gopalan, 2004). Adrian and Jacquot (1964) stated that the oils of foxtail millet and proso millet were similar to maize (semi-drying / semi-liquid at ordinary temperature) but higher in acid value and hydroxyl value and about 80 percent of the extractable lipid consisted of (USFA), principally oleic and linoleic, among the 15 percent saturated, palmitic and stearic acids were dominant. Achaya (1986) reported that fat from the millets contain a higher proportion of USFA and supply essential fatty acids. Difference genetic variability and lipid extraction procedures, contribute to the differences in the fatty acid content. The fat content of the five minor millets namely barnyard millet, foxtail millet, little millet and Kodo millet which ranged from 3.5 to 4.75 g/100g was reported to be greater than fat content of all cereals and major millets except pearl millet (Geervani and Eggum, 1989). The fat contents of dehusked and milled minor millets and their bran and reported that the milled millet grains contained nearly 70 percent of the total fat of the whole seeds (Hadimani and Malleshi, 1993).

Fiber

A decrease in dietary fibre leads to an increased prevalence of disease such as diabetes mellitus and coronary heart disease (Trowell, 1973), diverticular disease of the colon, gallbladder disease, varicose veins, hiatus hernia (Burkitt, 1975, Findlay, 1974) and tumors of the colon (Painter and Burkitt, 1971), compared with population groups with higher fiber consumption. An increase in the fiber content in human diets is being encouraged and advocated.

Protein

The protein content on a dry grain ranged from 10.6 to 15.22. Foxtail millet is one of the main sources of energy and protein. Prolamin (setarin) is the major storage protein in

foxtail millet which is alcohol soluble. The setarin has a nutritionally adverse amino acid composition, being severely lacking in lysine and tryptophan (Monteiro, 1982). Main storage protein of foxtail millet is setarion. More than 60% of the total protein is stearin (K K Kumar, 1997). The protein content in millet seeds constitutes a significant portion of the total dry weight of the seed (Nitya Sharma and Keshavan Niranjan, 2017). In foxtail millet it contains, 56.1% of prolamine, 17.1% of albumin and globulin, and 8.9% of cross-linked prolamine, glutelinlike 9.2%, and glutelin 6.7% (Monteiro et al. 1982). Jing-Ke used the Osborne method, based on a improved method proposed by Lookhart and Bean, to illustrate the protein fraction in foxtail millet and recognized the isoelectric point of protein components in different varieties of foxtail millet. Albumin was found to be in high followed by gliadin, globulin, glutein and other proteins. The research by Monterio stated that the prolamine fraction varied between 41 and 77.5% of the total protein for different varieties of foxtail millet (Nitya Sharma, 2017). K K Kumar and K Parvathy Parameswaran conducted an experiment to find out the storage protein of some selected varieties of foxtail millet. Grains were gathered at 5, 10, 15, 20, 25, 36, and 42 days after flowering. The grains after drying were crushed into flour using a mortar and pestle and passed through an 80 mesh sieve and stored at 4^0C. Total protein in the samples was calculated by nitrogen estimated by the Micro Kjeldhal method (AOAC 1975).

Prolamin

Prolamin (setarin) is the chief storage protein in foxtail millet which is alcohol-soluble. The setarin has a nutritionally unfavorable amino acid composition, and is deficient in lysine and tryptophan (K K Kumar and K Parvathy Parameswaran). Prolamin is the storage proteins of maize, millets, and sorghum but it is soluble in alcohol/water mixtures (P R Shewry and N G. Halford). 60% (v/v) tertiary butanol (2-methyl-2-propanol) is a more efficient solvent for the prolamins of sorghum, which may show that they have a more water loving nature (P R Shewry and N G Halford. prolamins, are the major storage protein of Foxtail millet whereas in Kodo millet and Barnyard millet the alkali-soluble glutelin forms the major storage protein

(Sudharshana et al. and Monterio et al.). Even though all these grains belong to the broad group of minor millets there should be some homology among themselves in proteins (K. Parvathy Parameswaran & B. Thayumanavan).

Amino acid composition

The lysine is the deficient amino acid in foxtail millet. Not only foxtail millet all the millets are deficient in lysine. But it contains all other amino acids. The principle amino acida present in fox tail millet were glutamic acid, leucine, alanine and proline. composition between nonglutinous and glutinous types of foxtail millet were with no difference(Hirokadzu Taira, 1968). The grains and seeds of Panicoideae especially show the amino acid pattern characterized by high alanine and leucine contents in marked contrast to those of other subfamilies in Grami- neae. Even though the millet is deficient in lysine but not in tryptophan, though corn belonging to the same subfamily is limited in both lysine and tryptophan (WHO, 1965).

Phytochemical screening

Phytochemicals such as tannins and terpenoids were detected in solvent extraction of bran rich fractions, while steroids were tested negative in all the solvents used for extraction. On aqueous extract saponin was found. Phenolics, alkanoids ,phenolics, alkaloids, and reducing sugars were detected in methanol and aqueous extracts. Triterpenoid was detected in the benzene, methanol and aqueous extracts of bran rich fraction; however for petroleum ether and chloroform extracts triterpenoids were detected in whole flour as well as for bran rich fractions (J Food Sci Technol. 2012).Detecting of phytochemicals was tough due to difference in polarities of extracting solvents. Because methanol is a relatively polar organic solvent compared to other extracting solvents, most of the phytochemicals detected in this study are expected to be polar in nature. The health benefits of whole grains are attributed in part to their unique phytochemical composition (Adom and Liu 2002). Besides the health benefits associated with phytochemicals, these compounds have important functional properties. Phytochemicals in grains contribute to product quality in terms of color, flavor, and texture (Holtekjolen et al. 2006). Bound Phytochemicals could survive the stomach and intestinal digestion to reach the colon. This may partly explain the mechanism of grain

consumption in the prevention of colon cancer, other digestive cancers, breast cancer, and prostate cancer, which is supported by epidemiological studies.

Foxtail millet has polyphenols as phytic acids and oxalate as anti-nutritional factors. These can be decreased by a process such as dehulling, soaking and cooking (Pawar and Machewad, 2006). The total phenolic and carotenoid contents of foxtail millet were reported as 47 and 80 μg/100g (Choi, 2007). A methanolic extract of these compound was found to have good antioxidant activity. But comparing to Kodo millet, foxtail millet seems to have a lower free radical quenching potential (Hedge and Chandra, 2005).

Table 3- Composition of antinutritional factors in 2 varieties of foxtail millet (Rajesh Devisetti, Sreerama N. yadahally and Sila Bhattacharya, 2014)

Sample	Variety	Fraction	Total phenolic content (TPC)(mg/g)	Total flavonoid content (TFC) (mg/g)	Proanthocyanidin (PC) (mg/g)	Phytic acid (mg/g)
Foxtail millet	PS-4	Whole	1.70 ± 0.20	0.71 ± 0.01	0.59 ± 0.06	5.4 ± 0.3
		Brown	0.81 ± 0.03	0.75 ± 0.06	0.16 ± 0.02	11.7 ± 0.1
		Polished	0.50 ± 0.04]	0.14 ± 0.00	0.06 ± 0.01	1.9 ± 0.1
	SIA-3126	Whole	1.83 ± 0.14	0.78 ± 0.03	0.79 ± 0.06	9.9 ± 0.1
		Brown	0.79 ± 0.03	0.65 ± 0.04	0.11 ± 0.01	11.0 ± 0.2
		Polished	0.58 ± 0.08	0.16 ± 0.00	0.08 ± 0.01	4.9 ± 0.1

Table 4- Polyphenols and phytic acid contents in the foxtail millet on processing methods (Vithal Deorao Pawar and Girish Marotirao Machewad, 2005)

Treatment	Polyphenol content	Reduction%	Total phosphorus (mg/g)	Phytate phosphorus (mg/g)	Phytate phosphorus (% of total phosphorus)	Phytic acid (mg/g)	Reduction %
Control	0.052	-	2.83	1.94	69.00	6.93	-
Dehulled	0.029	41.49	2.70	1.46	54.18	5.20	15.49
Soaked	0.050	3.75	2.76	1.73	62.29	6.16	11.20
Dehulled and soaked	0.029	43.38	2.63	1.11	42.79	3.99	23.10
Dehulled and cooked	0.025	50.92	2.53	0.61	24.28	2.18	45.13
Dehulled, soaked and cooked	0.025	50.92	2.42	0.30	12.74	1.08	49.89

Calculated phytic acid assuming 28.20% phosphorus in the molecule.

It is Naturally Free off Gluten

Foxtail millet is gluten-free millet. A gluten-free diet is naturally good for the health, and then it helps digestion, rises energy levels and benefits in correcting the cholesterol levels in the body. Non Glutinous grains automatically remove harmful food that is high in glucose fat, and fatty acids. Moreover, you can also avoid treated food, which we all know is sternly prohibited for a health. Foxtail millets nutrition gives you your vital amount of vitamins and minerals. Moreover, foxtail millets being gluten-free mean that you can construct up a tough prevention against cardiovascular diseases, and heart-related complications, cancers. In conclusion, this sole benefit of foxtail millets aids you in eliminating microorganisms such as viruses and germs(Nukhe, 2016)

Antioxidants

The antioxidant potency of commercially presented foxtail millet also helps our body , as this is what the consumers are eventually going to consume. Vitamin B1 acts as an antioxidant which reduces down the process of age spots, wrinkles and other age-related difficulties that has a adverse effect on the organs. It is well known that free On the other hand, antioxidants are thought to break up the free radical chain of oxidation radicals cause oxidation of unsaturated lipids in food. and donate hydrogen thereby forming a stable end product, which does not propagate further oxidation of the lipids (Kaur and Perkins 1991; Sherwin 1978).

Anti-nutritional factors

In addition to the nutritional welfares, millets including foxtail and proso millets have certain phytochemicals with antinutrient properties (Saleh, Zhang, Chen, & Shen, 2013) which may delay efficient absorption, utilization, or digestion of nutrients, and thus decrease their nutrient bioavailability and nutritional quality (Lestienne, Buisson, Lullien-Pellerin, Picq, & Treche, 2007). Antinutrients are unevenly dispersed in the grain. Depending on their localization, the proportions of these anti-nutrients in the diet can be reduced by further processing like dehulling and germination, cooking and fermentation (Akingbala, Oguntimein, & Abass, 1991; Sharma & Kapoor, 1996). Although millets are nutritionally

superior; the nonavailability of refined and processed millets in ready-to-use form has restricted their wider use and acceptability. Millet grains contain higher proportions of husk and bran, requiring dehusking and rebranding prior to consumption. Dehusking of pearl and little millets in centrifugal sheller followed by debranning in huller yields the grain of satisfactory quality (Hadimani & Malleshi, 1993). Simple processing methods like dehulling, soaking and cooking are reported to result in significant reductions in anti-nutrients and increased bioavailability of minerals like iron and zinc and also protein digestibility (Vithal and Machewad 2006).

Traditional uses

The grain of Foxtail millet is used in China as a harsh and emollient in choleric affections and diarrhea,Pinellia and millet soup, a simple mix of Pinella rhizoma and Setaria italica, used for the treatment of insomnia and the seeds are used in India as a diuretic, to make stronger virility, treat indigestion, dyspepsia, enhance vigor, treat bone fractures and rheumatism. This was also used to treat diabetes. Cooked grains are used in Chhattisgarh as a cure for diarrhea.. In Aurangabad, the decoction took from the whole plant is used for rheumatism and decrease the pains caused due to parturition. In Western Himalaya,used to treat measles by combining it with cow's curd. . Mixture of bark decoction of Acacia modesta and oil of Setaria were used as a contraceptive tonic. This was also used to cure diabetes. Treated grains are used in Chhattisgarh as a medicine for many diseases, This millet also helps to treat food shortage and the seeds support to strengthen virility

Food Applications

Seeds are cooked and can be eaten same as rice is used, or crushed into flour for the prepration of cakes, puddings, etc. Green seeds used as strengthening virility and diuretic.It

are also used by crushing the seed and mixing with ghee for sexual vigor and potency. Tribal ladies use a bark decoction of Acacia modesta and oil of Setaria in a mixture as contraceptive tonic. In India, used for promoting vigor and medicine of bone fracture.In Chhattisgarh, cooked grains used to treat diarrhea. In combination with other herbs/grasses used as sex tonic. These millet are also used as pet foods. Because of the lack of processing methods consumption as food for human beings is less. The use of Foxtail millet (Setaria italica) along with other flour for production of ready-to-eat snack products using extrusion cooking. The ultimate objective is to blend the millet with other crops to enable their popularization, commercialisation and thereby provide value-added food products. Amalgamated flours were prepared using whole Foxtail millet flour and other flours namely; rice flour, chickpea, and flax seed flour, these combined flour was used to make extruded products (Geetha, Mathad, Udayakumar and Ramachandra, 2016).Foxtail puffs are product which is a resultant of explosive puffing or gun puffing where the foxtail grain is expanded to maximum expansion consistent with the grain identity (similar shape of the grain). It is the RTE (ready to eat) snack which is developed using puff gun machine. The puff gun machine is loaded with dehulled foxtail grain onto a rotating barrel and the mixture is roasted for and fired resulting in a puffed foxtail product. . Semolina are ready to cook foods,these can be made from combination of millet grains (Pearl Millet, Finger Millet and Foxtail Millet).Semolina is prepared by dry milling of these millets (Dayakar, Sangappa, Vishala, Christina and Tonapi, 2016). Flour is used as a main ingredient for various recipes. Millet grains (Pearl Millet, Finger Millet and Foxtail Millet) are processed by dry milling. The dry milling process starts with the cleaning of grains. The cleaned grain is milled by the hammer mills to separate the endosperm, germ and bran from each other to get fine flour. Ragi flour, Bajra flour and foxtail millet flour: These four flours (atta) have been developed. These developed flour can be used to make different type of food products, like roti, dosa etc. Vermicelli is prepared using cold extrusion. This is made by finger millet, foxtail millet, pearl millet semolina and refined wheat semolina are blended in the mixing compartment of the vermicelli-making machine and blended with water for 30 minutes and extruded using a round die. Pasta is also prepared using the vermicelli-making machine and blended with water for 30 minutes and extruded using a pasta die.

Material and methods:

1-Physical analysis of grains:

Principle: To assess the physical properties of Kodo millet grains (1000 grains weight, porosity, bulk density, true density, length, size), Physical analysis indicate about the grains health (sound, plumpy, free from damage, healthy, bulk density, true density, and thousand kernel weight (if more) indicates that the grain is healthy. physical properties of grains such as size, shape, 1000 kernel weight, bulk density, true density, and porosity are useful for their processing and storage. They are important parameters for grading and pricing of the product.

Equipment required: measuring cylinder, weighing balance, beaker, vernier calliper.

Procedure: 1000 kernel weight: 100 grains of Kodo millet are collected manually or grains are spread on counting plate with 100 dents equal to the size of the grain. Grains are carefully spread over the mounting plate so that all the dents are filled. Extra grains are removed from the plate the weight of these grains is noted by weighing on an analytical balance. Repeat the experiment at least ten times and then report the average value.

Bulk density: Bulk density determination take a measuring cylinder of 1000ml capacity and fill it with grains for which density is to be measured. The measuring cylinder should be filled to its highest mark. Adjust the level of grains by repeated tapping takes the weight of these grains in a digital/analytical balance. Repeat the reading five times.

True density: For true density determination, take 10 grains randomly from the lot. The exact volume of these grains is found by liquid displacement method. For this take a 100 ml capacity measuring cylinder and fill it with toluene to a predetermined level. Drop randomly, the selected 10 grams in the cylinder and note the change in volume accurately. This gives the volume of 10 grains. Now weigh these 10 grains in analytical balance/digital balance

General calculation:

$$\text{Thousand kernel weight} = \text{weight of 1000 grains}$$

$$Bulk\ density\ g/ml = \frac{weight\ of\ 10\ grains\ in\ gram}{volume\ of\ grains(ml)}$$

$$True\ density\ g/ml = \frac{\text{weight of 10 grains (g)}}{\text{Volume of 10 grains (ml)}}$$

$$Porosity = \frac{\text{True density} - \text{Bulk density}}{\text{True density}}$$

$$\text{Porosity\%} = \frac{1 - \text{Bulk density}}{\text{True density}} \times 100$$

2. Chemical analysis

2.1 <u>Estimation of moisture content</u>

Equipment and Apparatus required:

Moisture content: hot air oven (thermostatically controlled), weighing balance, desiccator(with active desiccant), weighing pots.

Theory: Moisture content of flour is an important parameter. It gives an idea about shelf life and milling conditions. The water is present in two forms free form and bound form. The free form of water is water which is freely available for the microbial growth and leads to spoilage of product and decreases the shelf life of the product. Inbound form, water is not available for microbial growth.

Procedure:

Weigh accurately 5 g of the material in a dish previously dried and weighed. Place the dish along with lid in an electric air oven maintained at 105°C. Cool the dish to room temperature in a desiccator and weigh with the lid on. Repeat the process until three consecutive readings are same. Note down the weight.

General calculation:

$$\text{Percentage moisture in material} = \frac{\text{The quantity of moisture in the material}}{\text{The weight of the material}} \times 100$$

2.2 <u>Estimation of ash content:</u>

Equipment and Apparatus required:

Ash content: crucibles, burner, muffle furnace, tongs, and desiccator, Silica dish, Chemical balance, Hotplate or burner, muffle furnace.

Ash: To determine the inorganic residues present in gain samples. Ash is the inorganic residue remaining after the water and organic matter have been removed by heating in the presence of oxidizing agents, which provides a measure of the total amount of minerals within a food.

Procedure

Ash Content: Ignite the dried material in dish left after the determination of moisture with the flame of a burner till charred. Transfer to a muffle furnace maintained at 550-560°C and

continue ignition till grey ash is obtained. Cool in a desiccator and weigh. Repeat the process of heating, cooling and weighing at half hour interval till the difference in weigh in two consecutive weighing in less than 1 mg. Note the lowest weight.

General calculation:

$$\text{Percent of ash in material} = \frac{W2-W1}{W1-W} X100$$

2.3 <u>Estimation of proteins</u>:

Material required: Kjeldahl flask**,** conc. Sulphuric acid, CuSO4.5H2O, K2SO4(2:1), 40%NAOH, 2%boric acid (10g boric in 470ml hot distilled water, cool and add 2ml of 0.1% alcoholic solution of bromo cresol green and 4 ml of 0.1% methyl red solution, make the volume 500ml), 0.01N HCl.

Principle: Digestion: The food sample to be analyzed is weighted into a digestion flask and then digested by heating in the presence of sulfuric acid (an oxidizing agent which digest the food), anhydrous sodium sulfate (to speed up the reaction by raising the boiling point) and a catalyst, such as copper, selenium, or mercury. Digestion converts any nitrogen in the food (other than that which is in the form of nitrates and nitrites) into ammonia, and other organic matter to CO2, and H2O. Ammonia gas is not liberated in an acid solution because the ammonia is in the form of ammonium ion, which binds to the sulfate ion and thus remains in the solution.

Neutralization: after the digestion has been completed the digestion flask has been connected to a receiving flask by a tube. The solution is in the digestion flask is then made alkaline by addition of sodium hydroxide which converts the ammonium sulfate into ammonia gas:

$$NH_4 + 2SO_4 + 2NAOH \rightarrow 2NH_3 + 2H_2O + Na_2SO_4 (2)$$

The ammonia gas that is formed is liberated from the solution and moves out of the digestion flask and into receiving flask- which contains an excess of boric acid. The low pH of

the solution in the solution in the receiving flask converts the ammonia gas into ammonium ion and simultaneously converts the boric acid into borate ion:

$$NH_3 + H_3BO_3(boricacid) \rightarrow NH_4^+ + H_2BO_3(borateions)(3)$$

Titration: The nitrogen content is then estimated by titration of the ammonium borate formed with standard sulfuric and hydrochloric acid, using a suitable indicator to determine the end point of the reaction.

$$H_2BO_3 + H^+ \rightarrow H_3BO_3(4)$$

Procedure: Weigh 1-2g sample into the Kjeldahl flask, add 10ml conc. H2SO4 and 200mg of catalyst mixture and digest the sample until the solution becomes clear. Cool it and transfer into the 50ml volumetric flask. Rinse the digestion flask several times with the small amount of water and pour washing in a volumetric flask. Make the volume 50 ml of distilled water. Take 10ml boric acid in a 100ml conical flask, place this receiving flask in such a way that outlet of condenser dips into boric acid solution.

Transfer 5ml of the acid-digested sample to the steam chamber. Add 5-8ml of 40% NaOH to the aliquot. Immediately close the stopcock and pass the steam to distill ammonia till about 30-40ml of distillate is collected. Titrate the content against 0.01N HCl till the bluish color changes to pink. Run a blank.

2.4 <u>Estimation of fat content</u>:

Equipment required: Burette, soxhlet apparatus, extraction filter paper thimble, analytical balance, sample grinder, food sample, organic solvent(hexane, isopropanol, diethyl ether), acetone.

Principle: Fat and oils are soluble in organic solvents like hexane, isopropanol but other constitutes are not. Hence, the fat present in a food sample is dissolved into the solvent and afterward, the solvent is removed by evaporation and distillation (boiling point of the solvent is much less than that of oils/ fats).

Procedure: Thoroughly wash the boiling flasks and rinse with commercial grade acetone to remove any residual oil/ fat. Dry the flask by placing in a hot air oven for 3-4 hours. Weigh the flask and label them. Weigh the extraction filter paper thimbles (in duplicate) and label them. Transfer 2-5g sample in pre-weighed thimbles and determine their accurate weight. Plugged this thimble with non-adsorbent cotton and place them straight in the Soxhlet extraction tube. Fill the extraction tubes with sufficient amount of solvent so the syphon system starts working. Now fix the soxhlet assembly properly and switch on the heaters. As soon as the initiation of the boiling indicated stars the water connected to condensers and allow the extraction for 8 hours. After 8 hours switch off the heaters and allow cooling.

The solvent is evaporated using vacuum ovens at 50C or a water bath and than flasks with oils are weighed.

General calculation:

The fat/ oil is calculated by the formula

$$\% \text{ of fat content} = \frac{W4 - W1}{W3 - W2} \text{X}100$$

2.5 <u>Estimation of Dietary fibers</u>.

Aim: To analyze dietary fibers by enzymatic methods.

Material required: Protease, Amyloglucosidase, ethanol, acetone, phosphate buffer, filtration assembly, driers.

Theory: An enzymatic-gravimetric method was developed in which the sum of the soluble and insoluble polysaccharides and lignin are measured as a unit and considered to be total dietary fibers.

Procedure: 1g of the defatted sample was taken, and phosphate buffer(50ml) PH-6 and add 0.2 ml alpha-amylase and keep the beaker on boiling water bath for 30 min, shake the beaker. Cool the solution to room temperature and adjust the pH to 7.5 with NaOH (0.2M) and add protease 5mg incubate the content for 30 min. at 60°C cool at room temperature.

Add 10ml phosphoric acid (0.2M) and adjust the pH of the solution at approx. 4.5 use NaOH (0.2m) to set the pH if necessary. Then add Amyloglucosidase (0.3ml) and incubation was given at 60°C for 30 min, cool the content. Then wash the precipitate with 4 volume of ethanol. Filtration of the sample.

2.6 Estimation of Antioxidant activity (DPPH assay):

Aim: To estimate antioxidant activity using DPPH assay**.**

Materials Required: Ethanol, DPPH(1, 1, Diphenyl-2-picrylhydrazyl), methanol**.**

Theory: Kodo millet had the highest DPPH quenching activity followed by great millet and finger millet. Methanol extracts of the Kodo millet flour are 70% DPPH (1, 1, Diphenyl-2-picrylhydrazyl) quenching in comparison to other millet extracts which showed 15–53%.

$$\text{Antioxidant activity}(\%) = \frac{\text{Absorbance of control} - \text{Absorbance of sample}}{\text{Absorbance of control}} \times 100$$

Procedure: Take 0.1g of the sample. Add 5ml of ethanol. Leave for 3 min. Take 0.1ml of it in another test tube. Add 3.9ml of DPPH. Keep in dark for 30min. Check O.D at 517nm. DPPH- is 0.0236g in 1000ml methanol (23.6mg in 1litre).

2.7 Determination of Vitamin C:

Aim: To estimate the Vitamin C present in the sample.

Materials Required: 3% Metaphosphoric acid, Dye: 0.05g dye (2,6-dichloroindophenol) + (150ml of hot distilled water + 0.042g of Sodium bicarbonate). Cool and dilute to 200ml. Std. ascorbic acid.

Procedure:

For dye factor: Take 5ml of HPO_3. Add 5ml of std. Ascorbic acid. Titrate against dye.

$$\text{Dye factor} = \frac{0.5}{\text{Titre value}}$$

For sample: Take a sample. Extract of with 100ml of 3% HPO_3. Filter it. Take 5ml extract (filtered) and 10ml of 3%HPO_3 and titrate it against the dye.

2.8 (a) Estimation of Tannin:

Aim: To determine the total tannin present in the sample.

Materials Required: Folins Denis reagent: 100g of Sodium tungstate + 20g of phosphomolybdic acid in 750ml of distilled water + 50ml of phosphoric acid. Reflex the mixture for 2hr and make up the vol. to 1ltr with water (Protect from light). Sodium carbonate solution: 350g Na_2Ca_3 in 1ltr of water at 70^0c. Leave for overnight standing.

Standard: 0.1g tannic acid in 100ml of distilled water (dilute 5ml of stock solution to 100ml with distilled water. 1ml contains 50µg tannic acid).

Theory: Tannins can be determined by the Vanillin-HCL modified method of Chang et al, 1994. The vanillin-HCl method is widely used for the determination of condensed tannins. The chemistry of the reaction involved, its specificity, and various assay procedures have been reviewed by Deshpande et al. (1986). Its unit is mg/100g.

$$\text{Tannin} = \frac{\text{C}\times 10\times \text{X}}{200}$$

Where,

C is Concentration corresponding to the optical density,

10 is the volume of extract (ml)

X is the sample weight (mg)

Procedure: Take 0.1g of the powdered sample in the 250ml conical flask. Add 75ml of water. Heat & boil for 30min and filter it. Collect the supernatant and make volume to 100ml in a volumetric flask. Transfer 1ml of this extract to 100ml volumetric flask having

75ml of water. Add 5ml of Folin Denis reagent + 10ml of Sodium carbonate solution and dilute to 100ml with distilled water. Shake well and read absorbance at 700nm after 30min.

(b) Estimation of Tannins by Folin- Denis method.

Reagents:

1. Folin-Denis reagent: Dissolve 100g of sodium tungstate and 20 g phosphomolybdic acid in 750ml distilled water in a suitable flask and add 50ml phosphoric acid. Reflux with the mixture for 2 hours and makeup to one liter of distilled water, protect the reagent from exposure to light.

2. Sodium carbonate solution: Dissolve 350g sodium carbonate in one liter of water at 70ºC-80ºC. Filter through glass wool after allowing it to stand overnight.

3. Tannic acid solution:

Stock standard: Dissolve 100mg tannic acid in 100ml of distilled water.

Working standard: Dissolve 5ml of stock solution in 100ml with distilled water (concentration 50µg/ml)

Procedure:

1. Extraction of Tannin: Weigh 0.5g of the powdered sample and transfer to the 250ml conical flask. Add 75ml of water. Heat the flask gently and boil for 30mins. Centrifuge at 2000rpm for 20mins and collect the supernatant in a 100ml volumetric flask and make up the volume.
2. Transfer 1ml of the sample extract to 100ml volumetric flask containing 75ml water.
3. Add 5ml of Folin-Denis reagent, 10ml of sodium carbonate solution and dilute to 100ml with water.
4. Shake well. Read the absorbance at 700nm after 30mins.
5. Prepare a standard graph using 0-100µg tannic acid.

Calculations:-

2.9 Estimation of Phytates:

Aim: To estimate the total phenolic content.

Materials Required: Folin reagent, 20% Na_2CO_2,

Theory: Phytates can be determined by the method described by Wheeler & Ferrel (1971).

$$\text{Phytate content}(^{\text{mol}}/_{\text{kg}}) = \frac{\text{T}\times 564.11}{\text{M}}$$

Where,

T = Titre value,

M = Molar mass of phytates

Procedure: Take 0.2 - 2ml of the sample in a test tube. Makeup to 3ml with distilled water. Add 0.5ml of Folin reagent. After 3min, add 2ml of 20% Na_2CO_2 solution to each tube. Mix thoroughly. Place the tubet in boiling water for 1min and cool. Measure the absorbance at 650nm against a reagent blank. Prepare a standard curve at different concentration.

2.10 <u>Determination of Flavonoid</u>

Materials Required: Ethanol, 5% Sodium nitrate, 10% $AlCl_3$, 1N NaOH,

Theory: Flavonoid content is determined using spectrophotometric methods.

Procedure: Weigh 0.1g of the sample. Macerate with 5ml of 80% ethanol. Centrifuge the extract at 6000rpm for 30 min. Take 0.25ml of extract in a test tube. Add 0.75ml of 5% Sodium nitrate. Allow standing for 5min. Add 0.15ml of 10% $AlCl_3$. Let it stand for 6min. Add 0.5ml of 1N NaOH. Add 0.275ml of distilled water. O.D is taken at 510nm.

Result and discussion

Moisture content % - 16.07

-Physical analysis of grain:-

% of moisture content	Length (mm)	Breadth (mm)
0%	2.56	1.26
	2.43	1.57
	2.37	1.53
	2.63	1.43
	2.52	1.36
20%	2.62	1.57
	2.52	1.63
	2.55	1.49
	2.47	1.51
	2.62	1.52
30%	2.47	1.57
	2.54	1.55
	2.62	1.65
	2.68	1.56
	2.65	1.61

Thousand kernel weight

% moisture content	Thousand kernal weight
0%	
20%	3
	2.5
	2.5
	2.5
	3
30%	4.5
	3.5
	3
	3
	3.5

PROPOSED WORK WITH PLAN TIMELINE

work plan	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov
Review of literature	√	√	√								
Report submission				√							
Product standardization									√	√	
Product development									√	√	
Product analysis										√	√
Result compilation											√

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