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Research Highlights

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Prof. S.P. Thyagarajan
Ph.D, M.D, D.Sc, FAMS, FNASc, FIMSA, FABMS, FFTM (Glasgow, UK)
Chancellor

Message

Millets have always been an integral part of India for over 5000 years. In addition to the plethora of nutritional benefits, millets offer a cost-effective alternative to improve food security and a sustainable agricultural food system. India's vision to raise awareness on millets has been phenomenal and commendable. The Director General of United Nations Food and Agriculture Organisation (FAO) approved and declared India's conceptualised vision to observe an International Year of Millets 2023. The concept of International Year of Millets 2023 has been adopted and supported by over 70 countries all over the world with India taking up the lead as 'Global Hub for Millets'.

Millet production has great potential to generate livelihoods, increase farmers income, promote diversity and ensure food and nutritional security, not just in India but also globally.

Indian millets are mainly Finger millet (*Eleusine coracana*), Sorghum (*Sorghum bicolor L.*), Pearl millet (*Pennisetum glaucum*), Little millet (*Panicum sumatrense*), Foxtail millet (*Setaria italica L.*), Barnyard millet (*Echinochloa crusgalli*), Kodo millet (*Paspalum scrobiculatum*) and Proso millet (*Panicum miliaceum L.*). A bird's eye view of the common millets with their benefits is outlined below.

Finger millet stands out among cereals for its exceptional nutritional qualities. Known as Ragi, finger millet is an excellent source of calcium, dietary fiber, phytates, protein, minerals and phenolics and is also rich in micronutrients like thiamine, riboflavin, iron and other essential amino acids. It possesses a variety of therapeutic health benefits, including anti-diabetic, anti-inflammatory, anti-tumorogenic, atherosclerogenic effects, antibacterial, and antioxidant qualities.

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Sorghum is usually referred to as the “King of millets” because it has numerous health advantages and is also used as a food by both people and animals. It has a high nutritional value, and its products are found to have anti-inflammatory, anti-cancer, anti-obesity, anti-diabetic, and antioxidant properties. Due to its anti-nutritional components, such as tannins, phytates, trypsin inhibitors and protein crosslinkers, sorghum has some limitations. Sorghum quality is improved by using technological methods for reducing or eliminating anti-nutritional components.

Pearl millet is the most extensively cultivated millet. Because of its excessive fiber content and ability to withstand satiety, Pearl millet is used in weight reduction process. The high fiber content of pearl millet helps to prevent gallstone formation. A good source of calcium and phosphorus, pearl millet also aids in achieving high peak bone density. It encourages healthy gut function and aids in the relief of constipation.

Little millet a food with a low glycemic index is a good source of dietary fiber and slowly digesting carbohydrates. It plays a major role in providing nutraceutical compounds like phytates and tannins. Majority of the beneficial polyunsaturated fatty acids are found in little millet, which is high in fat. Little millet contains flavonoids that function as antioxidants and have a variety of functions in the body’s immune defense system. Magnesium, which is present in millet, aids in heart health improvement. Niacin, a form of Vitamin B3, lowers cholesterol.

Foxtail millet shows health-promoting qualities as a result of its unique protein composition, which includes a significant amount of essential amino acids. The goodness of proteins, carbohydrates, vitamins like Vitamin A and Vitamin E, and minerals like phosphorus, calcium, magnesium and sodium are present in appreciable amounts in foxtail millet. The millet also possess anti-carcinogenic, hypolipidemic, low-glycemic index, and gastro-protective properties.

Barnyard millet is a short-lived crop whose grains are valued for their high nutritional value and lower cost compared to major cereals like rice, wheat, and maize. Barnyard millets are nutrient-dense and abundant source of protein, carbohydrates, fiber, and, most significantly, micronutrients like iron and zinc , which are linked to a variety of health advantages. In addition to being gluten-free, barnyard millet contains a lot of digestible protein. This millet’s health advantages aids in preventing diseases like celiac disease, diabetes, hypertension, obesity and blood pressure.

Kodo millet also called Varagu in Tamil Nadu, is a popular grain that is high in dietary fiber, antioxidant and minerals like iron. In comparison to other millets and other major cereals, Kodo millet has the lowest phosphorus content and the highest antioxidant capacity.

A higher concentration of antioxidants prevents oxidative stress and keeps glucose levels stable in type 2 diabetes. Cardiovascular disease patients with high blood pressure and high cholesterol levels, can benefit from regular consumption of Kodo millet.

Panivaragu is a common name for Proso millet. Proso millet grains are a good source of niacin, B-complex vitamins, folic acid, minerals (P, Ca, Zn, Fe), essential amino acids (methionine and cysteine), starch, and phenolic compounds such as antioxidants and beta glucans. Additionally, Proso-millet have medicinal properties that lessen liver damage and low-density lipoprotein cholesterol levels in the blood. They contain lecithin, which promotes the health of the nervous system.

The benefits millets provide is tremendous and as rightly envisaged they can make health and wellbeing possible by preventing diseases and can be used for dietary compliance in the personalised nutrition care of individuals.

The country has been currently associated with various millet centric activities including mahotsavs / melas and food festivals, awareness campaigns, workshops/ seminars and so on for sensitization and promotion of the International Year of Millets which will be very beneficial to galvanize interest about millets.

The Sustainable Development Goals namely Ending Hunger, Improving Food Security, Improving Nutrition and Promoting Sustainable Agriculture can be achieved through millet production and utilization.

Though the awareness of the health benefits of millets has improved post-Covid, there is still a long way to go. It is imperative that research is initiated in the area of millets like cultivation, diversification of processing technologies, nutritional evaluation, functional aspects and health benefits of millets from the seed to its processed products and consumption.

In this regard, a special issue release to commemorate the International Year of Millets 2023 will benefit the readers to understand about the diversity of Indian millets. I hope the publication will be read and used widely.

(Prof. S.P. THYAGARAJAN)
Chancellor

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Dr. V. Bharathi Harishankar, Ph.D., FRSA
Vice Chancellor

Message

An increase in food demands is seen globally owing to the rise in the world population. Approximately, 50% of the world's total calorie intake is derived from cereals. As the world is facing several issues including depletion of various resources, the chances of augmenting the production of the main staple cereals decreases. A sustainable option to tackle the crisis is the cultivation of millets, which play a big part in the traditional diets of many parts of the nation. Millets have a number of desirable qualities, including being resistant to drought, producing well in locations with limited water supplies and having high nutritional values. Millets are powerhouses of nutrients. They are rich in antioxidant, phytochemicals, protein content and a more balanced amino acid profile than wheat and rice, making them nutritionally superior.

When the United Nations has declared 2023 as the International Year of Millets it is imperative to understand the importance of millets in our daily life. This special issue on Millets will provide knowledge on this wonder food, which is a good source of nutrients and enable the research community to identify possible avenues to take up millet research and augment the knowledge resources.

(Dr. V. BHARATHI HARISHANKAR)
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Dr. (Mrs.) S. Kowsalya
M.Sc., M.Phil., Ph.D.
Registrar

Message

Millets are incredible ancestral crops. Millets produce an extraordinary food system that can secure India's food and farming for future generations in promoting healthy life. Millets are all season crops cultivated throughout the year where they meet multiple securities (food, fodder, health, nutrition, livelihood and ecological) for agricultural development.

In order to meet the cereal demands, sustainable crops can be substituted to satisfy the world's hunger and to boost the income of farmers. The year 2023 is declared as the International Year of Millets as they are considered Nutricereals. Nutricereals are a powerhouse of vitamins, minerals, essential fatty acids, phytochemical and antioxidants, which can help alleviate nutritional deficiencies. The nutritional content of millets is three to five times superior to the widely promoted rice and wheat in terms of protein, minerals and vitamins.

Millets are rich in polyphenols and other bioactive compounds; hence they have an impact in lowering the rate of fat absorption and decrease the release of glucose which helps in reducing the risk of metabolic diseases such as cardio vascular disease, diabetes and high blood pressure. The health of an individual starts from inside. Health consciousness has taken a shift from trendy lifestyle pattern to traditional food practices which includes millet intake in the regular diets. It increases the immune system that reduces the risk and fight against diseases.

I hope this special issue will help in disseminating the knowledge and research information on the benefits of millets consumption that will help the population to mitigate the non-communicable diseases and Nutritional deficiencies.

S. Kowsalya

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Res. High., JADU., (2023) 33, 81

AREA UNDER CULTIVATION, PRODUCTION AND PRODUCTIVITY OF MILLETS IN INDIA – A COMPARATIVE STUDY BETWEEN PRE AND POST-REFORM PERIOD

*** Gandhimathi, S.**

Abstract

The Government of India has notified millets as nutri-cereals in April, 2018. Millets are a rich source of Protein, Fibre, Minerals, Iron, and Calcium. The National Year of Millets was celebrated in 2018. To create domestic and global demand and to provide nutritional food to the people, the Government of India proposed to United Nations for declaring 2023 as the International Year of Millets (IYoM). Against this backdrop, the studies (Bamji *et al.*, 2020) (Government of India, 2014) analysed the production of millets in India from various angles. They did not compare the area, production and productivity of millets between the pre and post-reform periods. The present study compared the area, production and productivity of millets in India between pre and post-reform periods. The findings of the study showed that the area under cultivation of millet had declined in both pre and post-economic reform periods. The decline in the area under cultivation millet was higher in the post-reform period than in the pre reform period. Both production and productivity of millet crop had increased in both pre and post reform period. The major factor determining the increase in the productivity was the decline in the area under cultivation of millet in both pre and post reform period. The major recommendation of the study was to increase the area under cultivation of millet crop through the fixing of remunerative price.

Keywords: Area, Cultivation, Production, Productivity, Reform period.

Introduction

India is the largest producer of millets in the world. In India, Millets are grown in about 21 States. There is a major impetus in Rajasthan, Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu, Kerala, Telangana, Uttarakhand, Jharkhand, Madhya Pradesh, Haryana and Gujarat (Knowledge Paper on 'The millets, Super Food for India, Government of India', 2022).

In India, millets are cultivated in an area of 12.45 million hectares, producing 15.53 million tonnes with a yield of 1247 kg/ha. In 2021, Sorghum is the fourth most important food grain in India after rice, wheat and maize in terms of area (3.84 Mn.ha) and production (4.31 Mn.MT). Bajra 7.05mha) is contributing more than 50 percent of the country's area under millets within early equal

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percentage of production. It is interesting to note that, India is the top most producer of Barnyard (99.9%), Finger (53.3%), Kodo (100%), Littlemillet (100%) and Pearl millet (44.5%), producing about 12.46 million metric tonnes from an area of 8.87 million ha (Knowledge Paper on 'The millets, Super Food for India, Government of India, '2022). Rajasthan occupied first in the area under cultivation of millet (29.05%) followed by Maharashtra (20.67%), Karnataka (13.46%), Uttar Pradesh (8.06%), Madhya Pradesh (6.11%), Gujarat (3.94%) and Tamil Nadu (3.74%). The states of Gujarat and Madhya Pradesh had increased their area under millets over the recent years. However, the highest yields were recorded in Andhra Pradesh (2626.58kg/ha), Tamil Nadu (2153.22kg/ha), Haryana (1906.78 kg/ha), Gujarat (1762.05 kg/ha) and Madhya Pradesh (1729.70 kg/ha). The states like Gujarat and Andhra Pradesh had shown better productivity levels as compared to their counter parts (Knowledge Paper on 'The millets, Super Food for India, Government of India, '2022).

To increase the area, production and productivity of millet, the government of India implemented a Sub-Mission on Nutri-Cereals (Millets) under National Food Security Mission (NFSM). Under this Sub-Mission, bajra is being promoted in 89 districts of 9 states including 14 districts of Gujarat, North Eastern States, Himachal Pradesh and UTs of Jammu & Kashmir and Ladakh have been given flexibility to include the districts under programme (Ministry of Agriculture & Farmers Welfare, 2022.

In view of the nutritional value of the millets, the Government has notified millets as nutri-cereals in April, 2018. The Millets are a rich source of Protein, Fibre, Minerals, Iron, Calcium. The National Year of Millets was celebrated in 2018. To create domestic and global demand and to provide nutritional food to the people, Government of India had proposed to United Nations for declaring 2023 as International Year of Millets (IYoM). The proposal of India was supported by 72 countries. United Nation's General Assembly (UNGA) declared 2023 as Bamji, Murty and Sudhir, 2020, The Government is popularizing nutri-cereals through Research & Development support and has established 3 Centres of Excellence (CoE). Support is also given to start-ups and entrepreneurs for developing recipes and value added products that promote consumption of millets. 8 bio-fortified varieties/hybrids of Bajra have been released for cultivation from 2018 to till date (Report of the Ministry of Agriculture and Farmers Welfare, 2022).

In this backdrop, the studies (Bamji, Murty and Sudhir, 2020, Government of India,2014) had analysed the production of millets in India from various angle. They did not compare the area, production and productivity of millets between pre and post reform period.

Methodology

The study was mainly based on secondary data collected from the Agricultural Statistical at a Glance, 2021. The period of the study was confined to the period 1950-

51 to 2020-2021 as the five plan of India started from 1950-1951. The study period was divided in to pre and post economic reform period. The pre reform period covered the period of 1950-51- 1990-1991. The post reform period covered the period of 1991 -1992 to 2020 -2021. The compound growth rate and the regression analysis were used to fulfil the objectives of the study.

The compound growth rate was calculated based on the following formula

$$Y=AB(x)^t$$

Y = the variable under study for compound growth rate

A = constant

x = time period

t = number of years

B = co-efficient of time trend

Compound growth rate=Anti log (B-1)*100

The form of the regression equation estimated in the relationship between production of millet and area under cultivation was

$$Y = b0 + b1X$$

Y = Production of millet (Million Hectares)

X = Area under cultivation of millets (Million tonnes)

The form of the regression equation estimated in the relationship between yield of millet and area under cultivation was

$$Y1 = b0 + b1X$$

Y = Yield of millet (Million tonnes)

X = Area under cultivation of millets (Million hectares)

Results and Discussion

Millets are the traditional crops with superior nutritional value and health benefits. Millets are hardy crops grown in arid and semi arid environments and are resilient to higher temperatures and drought prone environments requires 350mm of water compared to 1200 mm for rice. They offer food, fodder, fuel, and nutrition security and can be grown in intercropping (or may be under mixed cropping with pulses and oil seeds. Millets stand for the local food system and culture in Asia and Africa and have a major contribution towards sustainable agriculture and a healthy world. As millets are climate-resilient crops and sustainable income sources for farmers, they provide economic security.

The area, production and yield of millets in India in the pre reform period is shown in Table-1.

The area under cultivation was 37.67 million hectares in 1950-51 which had declined to 36.32 million hectares in 1990-1991 in the pre reform period. The production of millet had shown an increasing trend from 15.38 million tonnes in 1950-1951 which had increased to 32.7 million tonnes. The decline in the area under cultivation of millet and increase in the production of millet had increased the productivity of millet in the pre reform period (Table 1).

Table 1. Area, production and yield of millets in India in the pre reform period

Year	Area (Million Hectares)	Production (Million Tonnes)	Yield (Kg./ Hectare)
1950-51	37.67	15.38	408
1951-52	38.88	16.09	414
1952-53	42.45	19.61	462
1953-54	45.37	22.97	506
1954-55	43.92	22.82	520
1955-56	43.45	19.49	449
1956-57	42.02	19.87	473
1957-58	42.91	21.23	495
1958-59	44.66	23.18	519
1959-60	43.79	22.87	522
1960-61	44.96	23.74	528
1961-62	44.73	23.22	519
1962-63	44.29	24.63	556
1963-64	43.93	23.72	540
1964-65	44.35	25.37	514
1965-66	44.34	21.42	483
1966-67	45.09	24.05	533
1967-68	47.34	28.8	608
1968-69	46.24	25.18	545
1969-70	47.24	27.29	578
1970-71	45.95	30.55	665
1971-72	43.57	24.6	564
1972-73	42.21	23.14	548
1973-74	46.24	28.83	623
1974-75	43.15	26.13	606
1975-76	43.8	30.41	694
1976-77	41.94	28.88	689
1977-78	42.28	30.02	710
1978-79	42.23	30.44	721
1979-80	41.36	26.97	652
1980-81	41.78	29.02	695
1981-82	42.45	31.09	733
1982-83	40.43	27.75	685
1983-84	41.71	33.9	813
1984-85	39.21	31.17	795
1985-86	39.47	26.2	664
1986-87	39.74	26.83	675
1987-88	36.55	26.36	721
1988-89	38.68	31.47	814
1989-90	37.69	34.76	922
1990-91	36.32	32.7	900

Source: Agricultural Statistics at a Glance 2021

In the post reform period, the area under cultivation was 33.42 million hectares in 1991-1992 which had declined to 23.83 million hectares in 2021. The production of millet had shown an increasing trend in the post. It had increased from 25.99 million tonnes in 1991 to 51. 15 million tonnes in 2021. As the area under cultivation of millet had shown declining trend and production had shown an increasing trend, the productivity of millet had increased in the post reform period (Table 2).

Table 2. Area, production and yield of millets in India in the post reform period

Year	Area (Million Hectares)	Production (Million Tonnes)	Yield (Kg./ Hectare)
1991-92	33.42	25.99	778
1992-93	34.42	36.59	1063
1993-94	32.82	30.82	939
1994-95	32.17	29.88	929
1995-96	30.88	29.03	940
1996-97	31.81	34.11	1072
1997-98	31.05	30.40	986
1998-99	29.34	31.34	1068
1999-00	29.34	30.33	1034
2000-01	30.26	31.08	1027
2001-02	29.52	33.38	1131
2002-03	26.99	26.07	966
2003-04	30.80	37.60	1221
2004-05	29.03	33.46	1153
2005-06	29.06	34.07	1172
2006-07	28.71	33.92	1182
2007-08	28.48	40.75	1431
2008-09	27.45	40.04	1459
2009-10	27.68	33.55	1212
2010-11	28.34	43.40	1531
2011-12	26.42	42.01	1590
2012-13	24.76	40.04	1617
2013-14	25.22	43.29	1717
2014-15	25.17	42.86	1703
2015-16	24.39	38.52	1579
2016-17	25.01	43.77	1750
2017-18	24.29	46.97	1934
2018-19	22.15	43.06	1944
2019-20	23.99	47.75	1991
2020-21*	23.83	51.15	2146

Source: Agricultural Statistics at a Glance 2021

Compound Growth Rate of Area, Production and Yield of Millet in the Pre and Post Reform Period

The growth of area, production and yield of millet was measured in terms of compound growth rate. The table 3 shows the compound growth rate of area, production and productivity of millet in the pre and post reform period.

In the pre reform period, the compound growth rate of area under cultivation of millet was -0.3 percent which was -1.2 percent in the post reform period. It showed that the area under cultivation of millet in both pre and post reform period were negative. It revealed that the area under cultivation of millet had declined in both pre and post reform period. But the decline in the area under cultivation of millet was higher in the post reform period compared to pre reform period. The growth of production and yield were positive in both pre and post reform period. Both of them were higher in the post reform period compared to pre reform period (Table 3).

Table 3. Compound growth rate of area, production and yield of millets in India in the pre and post reform period

Variables	Compound Growth (Percent)	t value	P value
Pre Reform Period			
Area	-0.3***	11.652	0.003
Production	1.3***	93.881	0.000
Yield	1.6***	264.118	0.000
Post Reform Period			
Area	-1.2***	273.256	0.000
Production	1.8***	77.068	0.000
Yield	3***	3.4.806	0.000

Source: Estimated based on the secondary data collected from Agricultural Statistics at a Glance 2021

*** Significant at one per cent level

Relationship between Area, Production and Yield in pre and post reform period

To assess the relationship between area, production and yield of millets in pre and post reform period, regression analysis was carried out. The results of regression pertaining to the relationship between area, production and yield of millet are shown in Table 4.

Table 4. Relationship between production and area under cultivation of millets–regression analysis

Variables	Regression Co efficient	t value	P value
Constant	35.040***	3.212	0.003
Area in the Pre reform period	-0.215	-0.839	0.406
Constant	-1.531***	-5.762	0.000
Area in the Post reform period	80.059***	-5.762	0.000

Source: Estimated based on the secondary data collected from Agricultural Statistics at a Glance 2021
Note: Dependent Variable: Production of Millet, Independent Variable: Area under cultivation
*** Significant at one per cent level

The results of the regression analysis shows that the regression co-efficient of area under cultivation in the pre reform period was statistically in significant. But it had exhibited significant relationship with the production in the post reform period. The regression coefficient of area under cultivation in the post reform period was positive. Increase in the area under cultivation had increased the production significantly (Table 4).

The results of regression analysis pertaining to the relationship between area under cultivation and yield of millet are shown in Table 5.

Table 5. Relationship between yield and area – regression analysis

Variables	Regression Co efficient	t value	P value
Constant	1503.453***	5.535	0.000
Area in the Pre reform period	-20.970***	-0.839	0.000
Constant	-1.531***	-5.762	0.000
Area in the Post reform period	-104.482***	-5.762	0.000

Source: Estimated based on the secondary data collected from Agricultural Statistics at a Glance 2021
Note: *** Significant at one per cent level

The results showed that area in both pre and post reform period, the area under cultivation had exhibited significant relationship with the yield of millet. The regression co efficient of area under cultivation was negative which revealed that reduction in the area under cultivation had increased the yield of millet in both pre and post reform period. One million hectare decline in the area under millet had increased the yield of millet to the extent 104.482 million tonnes in the pre reform period. In the post reform period, decline of one million hectare in the area under millet had increased the millet yield of 104.482 in the post reform period (Table-5).

Summary and Conclusion

To conclude, the area under cultivation had declined in both pre and post economic reform period. The decline in the area under cultivation millet was higher in the post reform period than in the pre reform period. Both production and productivity of millet crop had increased in both pre and post reform period. The major factor determining the increase in the productivity was the decline in the area under cultivation millet in both pre and post reform period. The major recommendation of the study was to increase the area under cultivation of millet crop through the fixing of remunerative price.

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Res. High., JADU., (2023) 33, 87

QUALITY CHARACTERISTICS, ANTIOXIDANT AND BIOACTIVE COMPONENTS OF COMPOSITE MILLET FLOUR VERMICELLI

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** RADHAI SRI, S.

Abstract

An improvement in millet processing provides millet based convenience food which would increase scope for millet utilization and ensure food security. Considering this, Ready-to-Cook Vermicelli was formulated using composite millet flour and its physio-chemical, antioxidant and bioactive properties were studied. Composite Millet Flour (CMF) prepared using sorghum, pearl and foxtail millet was substituted in refined flour at different proportions to develop vermicelli and assessed for its sensory acceptability and quality characteristics. Based on the sensory evaluation, variation II with 50 per cent CMF substitution was highly acceptable. The moisture, ash and acid insoluble ash content of the vermicelli (CMF – 50 %) were found to be 7.63, 1.649 and 0.09 % respectively. 100g of the selected vermicelli provided appreciable quantities of carbohydrates, protein, vitamin B_1, B_9, calcium and 278 kcals of energy. On storage (90 days), the moisture content (10.18 %) and the total plate count (<100cfu/g) were within the FSSAI limits (<10^5) and no significant changes were observed in organoleptic qualities except in texture. The DPPH free radical scavenging activity of the selected vermicelli is 234 mg% and it contains 0.56 mg% of g - Sitosterol. This study shows that the utilization of CMF for the development of RTC products like vermicelli would enhance the marketability and consumption of millets among all age groups and also improve the therapeutic value of formulated food products.

Keywords: millets, vermicelli, composite flour, health-foods, RTC

Introduction

In the fast-tracked modern life with an increased awareness towards health and preference for fast food items, millet based convenient foods are one of the highly demanded food products which can be widely accepted. Extrusion technology plays a major role in the production of convenient foods. Extrusion cooking is a continuous process which has high production capacity, versatility and low cost per product unit (Rao *et al*., 2018). Ready-to-Cook products like noodles, pasta and vermicelli can be made using extrusion technology.

Vermicelli is a product made using whole or refined wheat flour dough through

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cold extrusion and drying. Commercially, vermicelli is a convenient food available in various trade names providing high calorific value. It is produced through an extrusion process that involves unit operations such as mixing (hydration of protein and starch), kneading (homogenization) and shearing (extrusion) (Swami *et al.,* 2021). Production of value-added vermicelli is attracting food industry for its utilization due to increasing demand for naturally healthy and gluten free food (Devi *et al.,* 2015). Furthermore, the diet consumed by majority of people is found to be deficient in many nutrients. Consequently, there is a huge challenge to develop inexpensive foods that are nutritionally superior and at the same time highly acceptable to intended consumer. Millet crops are an inexpensive source of quality nutrients which are vital for proper physical and mental growth of body. Equipped with a number of health benefits, millets are a boon to fight against malnutrition, food insecurity and climate change. These millets have diversified high food value but the consumption of these millets has declined for want of standardized processing techniques to compete with fine cereals. Hence, the present study has focused on the utilization of different millets in the form of composite millet flour for the production of vermicelli and assess the physico-chemical properties, nutrient content, antioxidant property, bioactive components and storage stability of the developed novel Ready-to-Cook Vermicelli.

Methodology

Preparation of Composite Millet Flour (CMF)

Millets grains such as sorghum (*Sorghum bicolor*), pearl millet (*Pennisetum typhoides*) and foxtail millet (*Setaria italica*) were procured from the local shops of Coimbatore, Tamil Nadu, cleaned and roasted separately (80-90°C). The roasted millets were cooled to room temperature and ground into flour using Hammer mill. The individual millet flour was sieved (US 80 mesh) and equal quantities of each millet flour was mixed together to formulate composite flour which was used further for the formulation of vermicelli.

Formulation and sensory acceptability of CMF incorporated rusk

The composite millet flour was substituted in the standard vermicelli (refined flour - 100 per cent) at 25, 50 and 75 per cent as I, II and III respectively. To the flour mixture, adequate quantity of salt and water were added and extruded (Imperia Monferrina, Italy) into vermicelli. The extruded vermicelli was dried at 60°C for 2 hours and then packed.

Conduct of Sensory Analysis

The formulated composite millet flour incorporated vermicelli was cooked with vegetables and seasonings and were subjected to sensory evaluation using 9 - point Hedonic scale ranging from 1 (dislike extremely) to 9 (like extremely) by a panel of 20 semi- trained members after due approval from Institutional Human Ethics Committee (IHEC), PSG Institute of Medical Sciences & Research (PSG IMS&R), Peelamedu,

Coimbatore, Tamil Nadu (Approval No. PSG/IHEC/2019/Appr/FB/015 dated 23/01/2019). The sensory scores were statistically analysed using mean, standard deviation, ANOVA and Duncan's Multiple Ranking Test to find the most acceptable variation.

Quality analysis of the CMF incorporated rusk

The developed control and selected CMF incorporated vermicelli was subjected to the assessment of physico-chemical properties (moisture, ash and acid insoluble ash) (FSSAI, 2016), nutrient content (energy, carbohydrates, protein, fat, fibre, calcium, phosphorus, iron, vitamin B_1 and B_9) following the procedures provided by AOAC (2016). The DPPH free radical scavenging property (Mohanpatra, 2018) and the presence of bioactive components were also determined. The prepared vermicelli was packed in an air tight polyethylene pack and stored for a period of 90 days. The storage stability was assessed periodically (30 days) for moisture content, sensory tests and total microbial count (Total Plate Count Method - ISO4833:2003 (E) – section 3.1.4.5).

Results and Discussion

Organoleptic Evaluation

The mean scores of organoleptic evaluation of the composite millet flour incorporated vermicelli given in Table 1 indicates that the colour and appearance and texture of variation 1 with 25 per cent composite millet flour had the mean score of 8.25 ± 0.71 and 7.50 ± 0.76 respectively which was higher than other variations. However, variation 2 was appreciated for its taste and flavour and found to be highly acceptable than other variations. The ANOVA analysis revealed no significant difference between different variations of vermicelli formulated.

Table 1. Mean sensory scores of composite millet flour vermicelli

Formulated products	Mean sensory scores				
	Colour and appearance	Texture	Taste	Flavour	Overall acceptability
Control (RF:CMF – 100:0)	8.35 ± 0.81^{a}	7.70 ± 1.21^{b}	7.60 ± 1.04^{a}	7.70 ± 0.80^{a}	7.86 ± 0.85^{a}
Variation I (RF: CMF – 75:25)	8.25 ± 0.71^{a}	7.50 ± 0.76^{ab}	7.60 ± 1.23^{a}	7.75 ± 1.11^{a}	7.80 ± 0.81^{a}
Variation II (RF: CMF – 50:50)	8.05 ± 0.88^{a}	7.45 ± 0.99^{ab}	7.85 ± 1.08^{a}	7.95 ± 1.14^{a}	7.85 ± 0.92^{a}
Variation III (RF: CMF – 25:75)	8.05 ± 1.31^{a}	6.90 ± 1.11^{a}	7.10 ± 1.48^{a}	7.30 ± 1.38^{a}	7.37 ± 1.22^{a}
F value	0.487	2.176	1.320	1.161	1.406
P value	0.692^{NS}	0.098^{NS}	0.274^{NS}	0.330^{NS}	0.319^{NS}

RF – refined flour; CMF – composite millet flour

Values represent Mean ± Standard Deviation of sensory scores; *Significant at 1 % level (p<0.01%), NS Not significant. Mean followed by the same letter on the same column were not significantly different (P>0.05) by DMRT test

Analogous to the present investigation, Shobha *et al*., (2015) proved that vermicelli could be developed by incorporating maize flour to an extent of 50 per cent along with 10 percent of soya protein isolate. Similar to the present study, Pandey *et al*., (2017) also found that the vermicelli containing foxtail millet flour, black gram flour and fenugreek seed flour in the ratio of 50:20:10 was highly acceptable with better nutritional content and showed no appreciable changes in sensory characteristics even on 70 per cent substitution.

Quality Characteristics of the Composite Millet Flour Vermicelli

Physico – chemical properties and Nutrient Content of formulated Vermicelli

Moisture content of the composite millet flour vermicelli (7.63 ± 0.00 per cent) was lesser than that of control vermicelli (8.85±0.00 per cent) which was in line with the moisture content of the maize based vermicelli (6.56 per cent - 7.80 per cent) prepared by Shobha *et al*. (2015). The ash and acid insoluble ash content of the Ready-to-Cook vermicelli was 1.649 and 0.09 per cent respectively. Physico-chemical properties and Nutrient Content of formulated Vermicelli is given in Table 2.

Table 2. Physico – chemical properties and nutrient content of formulated vermicelli

Product	Control Vermicelli	CMF Vermicelli
Physico – chemical properties		
Moisture (%)	8.85 ± 0.004	7.63 ± 0.00
Ash (%)1.079 ± 0.03	1.649 ± 0.04	
Acid Insoluble Ash (%)	0.06	0.09
Nutrient Content (per 100 g)		
Energy (kcal)	266	278
Carbohydrates (g)	64.8	64.6
Protein (g)	0.4	2.0
Total fat (g)	0.6	1.3
Crude fibre (g)	0.1	0.4
Vitamin B_1 (mg)	0.43	0.34
Vitamin B_9–folic acid (mcg)	0.71	0.45
Calcium (mg)	3	4
Phosphorus (mg)	96	87
Iron (mg)	0.38	3.2

In the case of RTC vermicelli, the formulated CMF vermicelli had good quantities of protein (2 per cent) and fat (1.3 per cent) than the control vermicelli (protein - 0.4 and fat - 0.6 per cent). The calcium and iron content were also higher in millet vermicelli. It is observed that the high content of protein, fat, calcium and iron in the formulated products are due to the incorporation of composite millet flour having sorghum, pearl millet and foxtail millet. It was evident that there exist a positive relation of ash content and levels of mineral content in the formulated vermicelli. The results of the present study are tuned to the study of Ranganna *et al.* (2014) who stated that the protein content of the prepared vermicelli increased due to the addition of millet flour. The fiber content of RTC novel - vermicelli was higher (0.4 per cent) than its control product (0.1 per cent) which could be due to the addition of millets.

Antioxidant Property and Bioactive Components in the Composite Millet Flour Vermicelli

The DPPH activity of the composite millet flour (Table 3) incorporated vermicelli was 356 mg which was higher than that of its control vermicelli (210 mg). Pradeep and Guha (2011) stated that the free radical scavenging activity of the processed samples were higher

Table 3. Antioxidant property and bioactive components in selected millet products

Property	Control Vermicelli	CMF Vermicelli (CMF- 50%)
DPPH free radical scavenging activity		
DPPH free radical scavenging activity (mg)	210	234
Bioactive components		
Squalene (mg/100 g)	Not detected	0.23
❑ – Sitosterol (mg/100 g)	Not detected	0.56

than that of their raw counterparts which might be owing to the development of non-enzymatic browning elements like melanoids at high temperature treatments.

The bioactive compounds are essential and non - essential in nature which shows a positive effect on human health (Biesalski *et al,* 2009). Bioactive components are a vast group of biologically active compounds that not only improves the health of the people but also contributes to the sensory qualities of foods. The γ - sitosterol content of the composite milletflour incorporated vermicelli (CMF - 50 per cent) was found to be 0.56 mg per 100 g which was higher than control - vermicelli (0.23 mg) per 100 g. Gamma - sitosterol is an important sterol which was found to have anti-diabetic activity proven by various clinical studies (Tripathi *et al,* 2013). Similarly, Sharma *et al.* (2016) reported that the processing of barnyard millet improved the gamma sitosterol content from 1.56 to 4.00 per cent which may be due to the augmentation of endogenous enzymes activity such as hydrolases and polyphenol oxidases which lead to the synthesis of these phenolic compounds. Conversely, squalene was not detected in both the extruded samples despite all the individual millet flours and composite millet flour showed the qualitative presence of squalene. This may be attributed to its unsaturated structure, which is not very stable and gets easily oxidized (Senbagalakshmi *et al.,* 2019).

Storage stability of the formulated millet products

Changes in the moisture content and total microbial content of formulated products on storage

The moisture content of the control vermicelli increased from 8.85 to 9.97 per cent. Similarly, the formulated vermicelli also showed an increase in moisture content from 7.63 percent to 10.18 per cent. With reference to the FSSAI standards, the moisture content of the milletproducts should not exceed 13 per cent. Hence, it was inferred from the present study that the increase in moisture content of different millet products were found to be well within the limitsprescribed by FSSAI (2016).

The control and composite millet flour vermicelli had a microbial count not exceeding 6.81 x 10^1 cfu/g and 9.09 x 10^1 cfu/g respectively at the end of the storage period. This shows that the prepared products do not show any microbial contamination and were safe for consumption. It should be admitted that roasting and cooking at high temperature has aided in elimination of microorganisms due to which the microbial counts of the products were insufficient to cause any food spoilage. Similar line of work on the storage stability of the composite flour sev by Pandey *et al.* (2018) suggests that the developed millet based value added products could be stored up to a period of 90 days.

Changes in the free fatty acid content of the millet products

The increase in free fatty acid content was observed in control vermicelli (31 per cent) than the formulated composite millet flour vermicelli (6 per cent). Similar pattern of increase in free fatty acid content was also reported by Yadav *et al.* (2014) in the prepared vegetable blended wheat and pearl millet based pasta.

Changes in the free fatty acid content of the millet products

Changes in mean sensory scores of the selected CMF vermicelli on storage

The overall acceptability of the formulated vermicelli has decreased from 8.74±0.34 to 7.35±1.54. Analogously, mean scores for colour and appearance, texture, taste and flavourof the composite millet flour vermicelli also decreased from 8.85±0.37 to 7.80±1.20, 8.40±0.75 to 7.40±0.82, 9.00±0.00 to 7.00±1.84 and 8.70±0.73 to 7.20±1.77 respectively. The 90 days stored formulated vermicelli was moderately liked by the panellists. On storage, there is no significant change in the sensory qualities except texture. The results of the present study were in covenant with the work done on value addition of traditional wheat flour vermicelli by Mogra and Midha (2013) who indicated that the formulated products were acceptable even after 60 days of storage.

Techno – economic feasibility and cost calculation of the selected millet products

The cost of the composite millet flour vermicelli is Rs. 62.00 per Kg. On comparison with the commercially available millet based vermicelli, the formulated CMF was found to be lesser despite its combination of three millets. The commercial vermicelli cost around Rs. 299 per Kg (Thanai natural little millet vermicelli), Rs. 449 per Kg (Neotea Ragi vermicelli) and Rs. 144 per Kg (Ecocare foxtail millet vermicelli).

Summary and Conclusion

The present study was conducted to develop composite millet flour vermicelli. In the processing, different proportions of composite millet flour having sorghum, pearl millet and foxtail millet was made with refined flour and vermicelli was cold extruded. Among the proportions, Vermicelli made with equal quantity of refined flour and composite millet flour was selected as best due to its desired texture and organoleptic properties. The physicochemical parameters, nutrient content, antioxidant activity and bioactive properties were analysed for the developed product. The results concluded that the formulated composite millet flour vermicelli is highly nutritious exhibiting potential free radical scavenging activity and bioactive property.

The current study reveals that the adoption of appropriate processing technology with suitable would help in the development of novel foods from ancient millets. This would increase the utilization of millets among all age groups. In addition, the commercial scale production of various value-added millet products is boosted due to huge demand arising from the consumers. Thus, advancement in millet processing technologies unlocks new horizon and it will make millets a competitor for staple foods.

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DEVELOPMENT OF MILLET FLAKES BASED SNACKS AND DETERMINATION OF ITS ACCEPTABILITY AND NUTRIENT PROFILE

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Abstract

Millets are cereals which belongs to the grass family Gramineae and are rich in vital nutrients like proteins, minerals, fibre, B-complex vitamins, lecithin, polyphenols and other biologically active components that help in the management and prevention of diabetes, heart disease and high blood pressure. It further helps to delay gastric emptying, increases gastro intestinal bulk, prevents cancer and also helps in reducing the cholesterol levels. The major objective of the study is to develop millet-based snacks and determine its acceptability and nutritional profile. The millet grains were processed into millet flakes by adopting steaming, cooking, flaking and roasting as processing techniques. Various recipes were developed and its nutrient contribution was determined, also sensory evaluation was performed based on a five-point hedonic rating scale by semiskilled panel members. It was observed that most of the pearl millet flake-based recipes were highly acceptable and nutritious with high levels of energy, protein, iron and zinc. Most of the kodo millet recipes were rich in fibre. All the millet recipes were rich in certain micro nutrients when compared to that of the staple foods like rice and wheat. The findings of the study suggest that millets are also highly acceptable in the form of snack recipes.

Keywords: Millets, Millet flakes, Pearl millet, Kodo millet, Sorghum

Introduction

Millets were the initially cultivated cereals at the beginning of human civilization. These were one among oldest known foods to humans. Millets hold a substantial role in the food grain economy of India, they place sixth in world cereal production. For centuries, they have been a staple food for people living in the semi-arid tropics of Asia and Africa, where other crops do not thrive (Chandrasekara and Shahidi, 2010; Shree *et al.*, 2008).

Millets are cereal grains of the grass family Gramineae. The term millet refers to several species of small-seeded annual grasses belonging to the five genera of the *Setaria, Paspalum, Echinocloa, Panicu,* and *Pennisetum* in the tribe *Paniceae* and one genus *Eleusine,* in the tribe *Chloridea*e. They are known as coarse cereals beside sorghum (*Sorghum bicolor*), maize (*Zea mays*), barley

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(*Hordeum vulgare*) and oats (*Avena sativa*) (Bouis, 2000 and Kaur *et al.,* 2012).

According to Chandrasekara and Shahidi (2010), all over the world, around 6,000 varieties of millet are grown. In many urbanized countries, millets are underutilized. There is great potential for processing millet grains into value added food products. According to Parameswaran and Sadasivam (1994), apart from the cultivating advantages of millets, it was found to have high nutritional value comparable to major cereals such as wheat and rice. Millets are loaded with micronutrients and phytochemicals and they should be accepted as Nutraceuticals (Mal *et al.,* 2010; Singh *et al.,* 2012; Gupta *et al.*, 2012).

India is a treasure for many forgotten millets. Urbanization increased health awareness, and increased purchasing power of people are driving exponential growth in demand for processed and convenience foods. With proper value-addition and appropriate processing technologies, the millet grains can find a place in the development of several value-added and healthy food-products, which may result in high demand from large urban populations and nontraditional millet users. In consideration with the above facts millet flakes-based snacks were developed (Varsha, 2009).

Methodology

Selection of millets

Millets namely pearl millet, kodo millet and jowar were selected based on their nutritive value, availability and better acceptance among public compared to other millets. These millets were selected and developed in the form of snacks in order to increase its consumption since it is highly nutritious. This may increase the profitability of its producers and also provides income and employment opportunities in rural areas, which may ultimately contribute to the food basket of the nation in addressing the food security.

Processing of millets into flakes

The selected millets were processed into millet flakes. The process involved in converting millets into Ready To Eat flakes consists of following steps: steaming, partially cooking the grains, flaking and roasting.

Development of millet flake snacks

The millet flakes were used for development of nutritious and delicious snacks. Millets flakes-based snacks like chivda, millet flake chocolates and biscuits were developed. In each developed recipe, three variants using different millet were tried. The Variation I with Pearl millet, the Variation II with Sorghum flakes and the Variation III with Kodo millets were developed.

Sensory evaluation of the developed

The sensory evaluation was done with a five-point hedonic scale with a group of members for each variation. The groups mainly comprised of post graduate students of Food Service Management and Dietetics Department. The samples were evaluated by the panelists for appearance, colour, flavor, texture and taste.

Nutritive value of the developed

Nutritive value was determined for all the developed products.

Results and discussion

All the developed products were sensory evaluated to determine the acceptability of the products and the nutritional contribution of the products was also determined.

a) Sensory Evaluation of the developed millet flakes-based snacks

The developed recipes using millet flakes were evaluated for its sensory characteristics and the data are presented in Table 1.

The overall acceptability score of pearl millet flakes chocolate was higher in comparison with other flakes-based chocolate. The kodo millet flake biscuit was more acceptable than the pearl millet and sorghum millet flakes. From the above results it is clear that, most of the pearl millet flakes recipes are highly acceptable and nutritious with high levels of energy and protein.

Nutrient analysis of the developed recipes

Various micro and macronutrients namely carbohydrates, protein, fat, fibre, sodium, calcium, phosphorus, potassium, folate, vitamin C, B vitamins etc were determined from different developed millet flakes-based recipes and presented in Table 2.

The following table reveals the presence of selected nutrients in the millet flakes-based snack recipes.

Table 1. Sensory evaluation of the developed millet flakes-based snacks

Recipes / Variations	Type of millet flakes	Appearance	Colour	Texture	Flavour	Taste	Overall acceptability
MILLET FLAKES CHIVDA							
I	Pearl millet	4.20±0.63	4.30±0.67	4.20±0.63	4.30±0.67	4.60±0.51	4.32±0.26
II	Sorghum	4.00±0.63	4.10±0.70	4.20±0.66	4.00±0.66	4.40±0.66	4.14±0.29
III	Kodo millet	3.90±0.73	4.00±0.66	4.10±0.56	4.10±0.73	4.00±0.66	4.02±0.35
MILLET FLAKES CHOCOLATES							
I	Pearl millet	4.20±0.78	4.20±0.78	3.30±0.48	3.90±0.56	4.50±0.52	4.02±0.37
II	Sorghum	3.90±0.83	4.00±0.63	3.10±0.53	4.20±0.60	4.30±0.64	3.90±0.36
III	Kodo millet	3.60 ±0.48	3.90 ± 0.70	3.10±0.53	4.00±0.63	4.40±0.48	3.80±0.23
MILLET FLAKES BISCUITS							
I	Pearl millet	3.50±0.52	4.00±0.66	4.10±0.56	4.00±0.66	4.40±0.51	4.14±0.21
II	Sorghum	4.20±0.63	4.00±0.66	4.10±0.56	4.00±0.66	4.40±0.51	4.14±0.21
III	Kodo millet	3.90±0.56	4.30±0.67	4.40±0.51	4.10±0.56	4.40±0.51	4.22±0.28

Values are Mean±SD

Table 2 presents the macro nutrients and micronutrients present in all the developed snacks like Pearl millet Chivda, Pearl millet flakes Biscuits and Pearl millet flakes Chocolate.

The caloric contribution of the developed products is analyzed. The pearl millet flake chocolate provides the maximum energy that is 294.6 Kcal followed by sorghum flakes chocolate and pearl millet flakes biscuits respectively. Carbohydrate is an essential component in energy production. The sorghum flakes chocolate contains higher amount of carbohydrate, followed by sorghum flakes biscuits, pearl millet flakes chocolate and pearl millet flakes biscuit.

Fat is a macronutrient which provides energy. Among the developed products pearl

Table 2. Nutrients present in millet flakes-based snacks recipes

Nutrients	Millet Chivda (1cup)			Millet Flakes Biscuits (3-4No's)			Millet Flakes Chocolate (2 pieces)		
	Pearl millet flakes	Sorghum flakes	Kodo millet flakes	Pearl millet flakes	Sorghum flakes	Kodo millet flakes	Pearl millet flakes	Sorghum flakes	Kodo millet flakes
Energy (Kcal)	230.74	227.14	215.14	289.15	286.75	278.75	294.6	292.2	284.2
CHO (g)	26.65	28.18	26.17	46.33	47.35	46.01	46.35	47.37	46.03
Protein (g)	7.11	6.75	6.12	4.43	4.19	3.77	14.87	14.63	14.21
Fat (g)	10.9	9.94	9.79	9.41	8.79	8.69	5.53	4.91	4.81
Calcium (mg)	23.22	18.12	18.72	14.59	11.19	11.59	419.4	416	416.4
Phosphorus (mg)	146.39	124.19	113.99	122.2	107.4	100.6	359.2	344.4	337.6
Iron (mg)	3.36	2.19	1.11	2.42	1.64	0.92	2.02	1.24	0.52
Fiber (g)	2.3	2.42	4.64	2.51	2.59	4.07	1.72	1.8	3.28
Sodium (mg)	1.64	1.64	1.64	0.41	0.41	0.41	1.72	1.72	1.72
Potassium (mg)	122.1	122.1	122.1	62.2	62.2	62.2	0	0	0
Folate B9 (mcg)	20.01	20.01	20.01	5.84	5.84	5.84	0	0	0
Vitamin C (mg)	0.04	0.04	0.04	0	0	0	0	0	0
Beta-carotene (mcg)	53.37	27.87	13.77	26.93	9.93	0.53	26.4	9.4	0
Thiamine (mg)	0.16	0.17	0.16	0.15	0.15	0.15	0.07	0.07	0.07
Riboflavin (mg)	0.1	0.06	0.05	0.08	0.06	0.05	0.05	0.03	0.02
Niacin (mg)	1.46	1.7	1.37	0.93	1.09	0.87	0.46	0.62	0.4
Pyridoxine B6 (mg)	0.04	0.1	0.04	0.05	0.09	0.05	0	0.04	0
Folic acid (mcg)	6.31	6.1	4.12	5.34	5.2	3.88	2.94	2.8	1.48

millet flakes chivda was high in fat (10.9g). Also the other two chivda variants were high in fat. The biscuits had lesser fat content than the chivda variants. Among all the products, the chocolates had lesser fat content, especially the kodo millet flakes chocolate had the least amount of fat that is 4.81g.

Calcium is an essential nutrient for healthy and strong bones. Calcium was high in all three millet flake chocolate variants in comparison with all other products. The pearl millet flake chocolate had 419.4 mg of calcium, kodo millet flake chocolate had 416.4 mg of calcium and sorghum millet flake chocolate contains 416 mg of calcium.

Phosphorous was high in all three chocolates. The pearl millet flake chocolate had the highest amount of phosphorous which is 359.2 mg. Next to the chocolate variations, the millet flake chivdas had good amount of phosphorous in it. The kodo millet flake biscuit had the least amount of phosphorous.

Millets are rich sources of fibre. It plays a vital role in the management of diabetes, obesity and cardiovascular diseases. Among the developed products, the fiber content of Kodo millet chivda was higher followed by Sorghum flakes Biscuits and Sorghum flakes Chocolate. Vitamin C and potassium and folate was absent in Millet flakes Chocolate. And there was no Vitamin C in all three variants of Millet flakes Biscuits. The protein contribution of the chocolates were superior than other products. The protein content of pearl millet flakes chocolate (14.87g) was higher. The iron content was high in pearl millet flakes chivda.

Beta carotene is high in pearl millet chivda than other products. It contains 53.37 mcg of beta carotene. And it is also noted that beta carotene is not present in kodo millet flakes chocolate. All three variants of chocolate contain 0.07 mg of thiamine and all variants of biscuits contains 0.15 mg of thiamine, the pear millet flake and kodo millet flake chivda provides 0.16 mg of thiamine and sorghum millet chivda provides 0.17 mg of thiamine which is comparatively higher than all other variants.

Riboflavin was higher in pearl millet flake biscuit and least in pearl millet chivda. Niacin was higher in the sorghum millet flake chivda, followed by pearl millet flake chivda and kodo millet flake chivda. In regard with pyridoxine, the vitamin was not present in pearl millet flakes chocolate and kodo millet flakes. Comparatively biscuits made with sorghum flakes had higher pyridoxine content.

The Pearl millet flake chivda was high in folic acid content followed by sorghum millet flake chivda and pearl millet flake biscuit. The kodo millet flake chocolate had the least amount of folic acid.

Summary and Conclusion

Millets are rich in vitamins, minerals, essential fatty acids and fibre with other bioactive substances like resistant starch, oligosaccharides, lipid, antioxidants, hormonally active compounds, antinutrients and tannins which tend to have positive effects on the body. Now-a-days people seldom

wish to spend time in the kitchen to prepare elaborate nutritious meals. Rather they rely on snacks which are high on calories, salt and fat which are detrimental to health. Hence the development of snacks based on millet flakes is a healthier alternate.

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STANDARDIZATION AND ACCEPTABILITY OF RECIPES REPLACED WITH 100 PERCENT BARNYARD MILLET AND KODO MILLET

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Abstract

Good dietary practices are a significant resource and an important aspect of quality of life. People who eat more whole grains foods as a source of dietary fibre have a decreased chance of developing diabetes, coronary heart disease, obesity, and some gastrointestinal illnesses. Thus, Standardization of recipes replaced with Barnyard millet was carried out to promote healthy eating. Among the 42 breakfast recipes (14x3), Idli's replaced with barnyard millet was ranked first with the highest acceptability score of 42.1 ± 0.11, followed by Kuzhipaniyaram, Sevai, and appam. Among the 42 breakfast recipes (14x3), Idli's replaced with barnyard millet was ranked first with the highest acceptability score of 42.1 ± 0.11, followed by Kuzhipaniyaram, Sevai, and appam. Chapathi replaced with kodo millet showed the least acceptability ($35.2 \pm 0.53^{**}$), with a significant difference at one percent level ($p<0.01$). Compared to white rice the fiber composition in millets is superior (Nithiyanantham *et al.,* 2019), which marks it highly nutritious. Keerai Sadam - a common recipe prepared by south Indians by combing amaranth or palak variety of green leafy vegetables seasoned with onions and green chilies replaced with kodo millet recorded the least acceptability score ($34.5 \pm 0.11^{*}$), significant at one percent level ($p<0.01$). In general lunch recipes replaced with selected kodo millet showed moderate to high acceptability scores ranging from 34 to 41. As little millets or minor millets are a rich source of nourishment, long-term use of minor millets may provide several health benefits. Because it is high in magnesium and gluten-free, minor millets can help reduce the frequency of migraine attacks, atherosclerosis, and diabetic heart disease. It is time to incorporate small millets into your everyday diet.

Keywords: Standardisation, sensory evaluation

Introduction

Glycaemic Index of Recipes Replaced with Selected Millet - Barnyard Millet and

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Kodo millet, their Glycaemic Response in Type II Diabetics powerhouses, as they are non-glutinous and low in acidity. They also outnumbered rice and wheat in terms of mineral and nutraceutical compounds. Each millet has more fibre than rice and wheat. Minor millets offer higher levels of protein, minerals, and vitamins than rice and wheat. While cereals are a less expensive source of dietary calories, tiny millets supply essential micronutrients such as vitamin B, calcium, iron, folic acid, and sulphur, as well as dietary fibre. These miracle grains found to be favourable effect towards reducing blood glucose levels and aiding in blood glucose management in people, and these miracle millets help them battle against diabetes.

"Small millets, also known as minor millets, are a kind of cereal crop with small seeds that belongs to the Poaceae grass family. Finger millet, foxtail millet, prodso millet, barnyard millet, kodo millet, small millet, tef, fonio, job's tears, guinea millet, and brown top millet are the different type of millets cultivated" (Sexena *et al*., 2018 and Vetriventhan *et al*., 2020). Small millets grains are adaptable and may be readily introduced into existing rice or maize-based diets or used as rice alternatives in existing recipes. Though millets are slowly gaining prominence in day-to-day cooking they are not used in any recipes as sole ingredients and are used as one of the additional ingredients. Hence the present study aims at replacing recipes with hundred percent millets in selected recipes. The reintroduction of millets in our daily menu will benefit the society by large.

"Millets are seen to be healthier alternatives to refined cereals due to their increased fibre content and lower GI and GL. Minor millets such as foxtail millet, proso millet, tiny millet, Kodo millet, and barnyard millet provide more nutritional fibre than polished white rice". (Longvah *et al*., 2017).

Sharma and Niranjan, (2018) report barnyard millet as beneficial for Type II diabetics, due to their delayed glycaemic responses. "The soluble phenolic portions of Barnyard millet, mainly flavonoids, proven effective inhibition of α- glucosidase and α-amylase activities, and also showed effective antiglycation representing their potential to diminish postprandial hyperglycaemia by delaying carbohydrate digestion" (Ofosu *et al*.,2020).

Barnyard millet's hypoglycemic and hypolipidemic effects were studied in diabetic volunteers (30) for three months by Joshi and Srevatsa in 2021. Barnyard millet's Glycemic Index (GI) in the study was 35.9, placing it in the category of foods with a low GI. After supplementing with barnyard millet, diabetic participants' blood glucose levels (both fasting and post-prandial, glycosylated haemoglobin levels) and lipid levels (apart from HDL and VLDL levels) significantly decreased. The findings imply that barnyard millet is a safe choice for diabetic people due to its high nutritional content, hypoglycemic

qualities, and potential for progressive hypolipidemia.

Kodo millets are another type of little millet that is grown in several regions of Tamil Nadu. They are a good source of natural antioxidants and help to ward off diseases like diabetes, heart disease, and cancer (Rao *et al*., 2018 and Chauhan *et al*., 2018). The soluble phenolic components of barnyard, foxtail, and kodo millet, which are primarily flavonoids, showed effective inhibition of -glucosidase and -amylase activities as well as antiglycation, and they have a high potential to reduce postprandial hyperglycemia by delaying carbohydrate digestion (Ofosu *et al*., 2020). With a yield of 0.084 megatonnes, kodo millet is currently grown on 0.20 million hectares. Foxtail millet was once a significant crop in rainfed regions of India due to its drought resilience. With a current yield of 0.05 megatonne, it is grown on roughly 0.07 million hectares in India (Vetriventhan *et al*., 2020.

The present study aims at replacing the recipes with 100% of millets in selected recipes. Therefore, the reintroduction of millets has huge potential in our daily life.

Methodology

Documentation and identification of most frequently consumed recipes

To understand the dietary preference of the selected Type II diabetic subjects, the investigator developed an open-ended questionnaire cum interview schedule and elicited information on the most frequently and commonly consumed recipes. "Literature survey indicates a global availability of 13 types of millets namelypearl millet, finger millet, sorghum, little millet, proso millet, barnyard millet, brown top millet, foxtail millet, guinea millet, job's tears, fonio, and teff. Except for job tears, fonio, and teff, the other millets are being cultivated in India" (Bhat *et al*., 2018).

Out of the 13 millets varieties, barnyard millet with the highest fibre content (12.6gm), was selected to formulate recipes with 100% replacement. Barnyard millet has anti-diabetic properties due to the presence of Luteolin, N-(p-coumaroyl), serotonin, and tricin (Thakur and Tiwari, 2019) which alleviates many of the diabetic symptoms in vivo non-insulin-dependent diabetes mellitus and hence can be suggested in the development of new functional food (Je *et al.,* 2015).

"The presence of phenolics, tannins, and phytates as antioxidants in Kodo millet, has a beneficial role in maintaining glucose levels in Type II diabetes" (Hegde *et al*., 2005). Unpolished millets namely barnyard and Kodo millet were procured from the local farmers. Also, the selected polished millet of the above varieties was bought from an organic store in Coimbatore city, Tamil Nadu, India.

Processing of Millets

From the survey conducted in phase I, on the consumption of commonly consumed recipes by the selected 500 Type II diabetic subjects, 65 commonly consumed recipes were documented. The documented 65 recipes were categorized meal-wise as breakfast items (20 recipes), lunch items (18 recipes), snacks, and accomplishment (28 recipes). Out of the 65 recipes, 43 recipes-breakfast items (14 recipes), lunch items (15 recipes), and snacks (14 recipes), were identified as most frequently consumed and preferred. Hence the investigator selected 43 recipes for 100% replacement selected Barnyard millet. Thus, a total of 43 recipes replaced with 100% of selected millets as the basic ingredient in place of other cereals was carried.

Standardisation of recipes replaced with selected millets

"A standardized recipe has been tried, tested, and evaluated to yield a consistent product in terms of quality and quantity" (Sharma, 2019). As suggested by Geetha *et al*., (2020) and Kaur *et al*., (2020), keeping the standard requirement of available carbohydrate for Glycemic Index (GI) and Glycemic Load (GL), a single portion size of each millet replaced recipe was formulated to provide 50 g of available carbohydrate irrespective of millet varieties used. All 43 recipes replaced with millets (Banyard millet and Kodo millet) were prepared thrice to get a standard output in-terms of colour, flavour, texture, appearance, cooking volume/weight, and portion size.

Sensory evaluation of standardized recipes replaced with selected millets

All the standardized 86 recipes were subjected for sensory evaluation, using a nine-point hedonic scale by a panel of 20 semi-trained members. The members were asked to rate each sensory characteristic namely colour, appearance, consistency, flavour, and taste on a scale of nine points ranging from like extremely to dislike extremely with a maximum score of 45 and a minimum score of five. Depending on the acceptability score, the recipes were categorized as highly acceptable (35-45), acceptable (25-34) and not accepted.

Results and Discussion

Table 1 reveals that among 42 breakfast recipes (14x3), Idli's replaced with barnyard millet was ranked first with the highest acceptability score of 42.1 ± 0.11, followed by Kuzhipaniyaram, Sevai and appam. Among 42 breakfast recipes (14x3), Idli's replaced with barnyard millet was ranked first with the highest acceptability score of 42.1 ± 0.11, followed by Kuzhipaniyaram, Sevai and appam. Also, it was observed that irrespective of the millet varieties selected, none of the above-mentioned recipes showed a significant difference in the overall acceptability score compared to the standard cereals-based recipes in terms of colour, flavour, taste, texture, and consistency. Hence the four

Table 1. The overall mean acceptability score of breakfast recipes replaced with 100% of unpolished selected Barnyard millet

Recipes name	Standard recipes	Barnyard millet (14 No.)
Idli	43.3 ± 0.28	42.1 ± 0.11^{ns}
Dosa	42.5 ± 0.23	41± 0.63^{ns}
Uppuma	41.6 ± 0.28	37.7 ± 0.35*
Pongal	42.1 ±0.21	41.2 ± 0.26^{ns}
Kichadi	41.8 ± 0.24	40.7 ± 0.27^{ns}
Chappathi	41.3 ± 0.29	35.7 ± 0.16*
Poori	40.6 ± 0.31	36.8 ± 0.51*
Kuzhipaniyaram	42.2 ± 0.21	41.2 ± 0.46^{ns}
Kanji	40.9 ± 0.38	37.8 ± 0.29^{ns}
Kali	42.1 ± 0.23	38.4 ± 0.55*
Sevai	41 ± 0.37	40.2 ± 0.32^{ns}
Semiya	42 ± 0.16	40.2 ± 0.33^{ns}
Appam	42.5 ± 0.12	40.8 ± 0.43^{ns}
Parotta	43.1 ± 0.13	37. ± 0.33**

** One percent level of significance (p< 0.01);
* five percent level significance (p< 0.05);
ns - not significant (p>0.05).

recipes for Idli, Kuzhipaniyaram, Sevai, and appam replaced with 100%. Breakfast recipes replaced with barnyard millet namely Uppuma, chapati, puri and kali obtained lesser scores for sensory attributes compared to standard recipes which were significant at five percent level, the difference in acceptability can be attributed to the lack of gluten protein in millets, unlike wheat which gives unique texture due to the leavening effect.

Table 2 infers that chapathi replaced with kodo millet showed the least acceptability (35.2 ± 0.53**), with a significant difference

Table 2. The overall mean acceptability score of breakfast recipes replaced with 100% of unpolished selected Kodo millet

Recipes name	Standard recipes	Barnyard millet (14 No.)
Idli	43.3 ± 0.28	41.3 ± 0.17^{ns}
Dosa	42.5 ± 0.23	41.4 ± 0.10^{ns}
Uppuma	41.6 ± 0.28	38.3 ± 0.20^{ns}
Pongal	42.1 ± 0.21	39.4 ± 0.08^{ns}
Kichadi	41.8 ± 0.24	38.8 ± 0.36^{ns}
Chappathi	41.3 ± 0.29	35.2 ± 0.53**
Poori	40.6 ± 0.31	36. ± 0.47*
Kuzhipaniyaram	42.2 ± 0.21	41.5 ± 0.19^{ns}
Kanji	40.9 ± 0.38	38 ± 0.20^{ns}
Kali	42.1 ± 0.23	40.1± 0.43^{ns}
Sevai	41 ± 0.37	39.2 ± 0.48^{ns}
Semiya	42 ± 0.16	40.8 ± 0.43^{ns}
Appam	42.5 ± 0.12	41.3 ± 0.17^{ns}
Parotta	43.1 ± 0.13	36.7 ± 0.31**

** One percent level of significance (p< 0.01);
* five percent level significance (p< 0.05);
ns - not significant (p>0.05).

at one percent level (p<0.01). Compared to white rice the fiber composition in millets is superior (Nithiyanantham *et al.,* 2019), which marks it highly nutritious. At the same time, it greatly influences the sensory attributes of certain recipes like uppuma, chapati, puri and, kali. As rightly pointed out by Chellappa (2018), the fibre free starch present in milled rice allows effusion of flavour from other added ingredients or spices which improves the overall acceptability compared to millets. The absence of gluten and the presence of insoluble fibre in larger proportion make millet replaced recipe hard lethargy and less acceptable particularly in breakfast varieties such as chapati, puri, dosai, and parotha.

Table 3. Mean acceptability score of lunch recipes replaced with 100% of selected unpolished millets – Barnyard millet

Recipes name	Standard recipes	Barnyard millet (14 No.)
Tomato rice	40.9 ± 0.53	38.3 ± 0.20^{ns}
Tamarind rice	42.7 ± 0.78	40.8 ± 0.44^{ns}
Keerai sadam	39.8 ± 0.11	34.8 ± 0.14*
Carrot rice	40.4 ± 0.42	36.6 ± 0.21*
Sambar sadam	42.5 ± 0.21	41 ± 0.62^{ns}
Coconut rice	41.7 ± 0.09	40.6 ± 0.36^{ns}
Lemon rice	42.2 ± 0.29	41.8 ± 0.25^{ns}
Mango rice	41.3 ± 0.33	37.2 ± 0.59*
Vegetable rice	42.5 ± 0.07	41.8 ± 0.07^{ns}
Mint rice	41 ± 0.63	40.1 ± 0.43^{ns}
Coriander leaves rice	41.3 ± 0.56	39.6 ± 0.13^{ns}
Ghee rice	42.4 ± 0.32	40.2^{ns}
Jeera rice	41.1 ± 0.65	39.4 ± 0.15^{ns}
Pulao	42.4 ± 0.13	39.9 ± 0.08^{ns}
Fried rice	40.6 ±0.61	38.1 ± 0.55^{ns}

** One percent level of significance (p< 0.01);
* five percent level significance (p< 0.05);
ns not significant (p>0.05)

Table 4. Mean acceptability score of lunch recipes replaced with 100% of selected unpolished millets – Kodo millet

Recipes name	Standard recipes	Barnyard millet (14 No.)
Tomato rice	40.9 ± 0.53	38.2 ± 0.46^{ns}
Tamarind rice	42.7 ± 0.78	40.2 ± 0.31^{ns}
Keerai sadam	39.8 ± 0.11	34.5 ± 0.11*
Carrot rice	40.4 ± 0.42	38.8 ± 0.36^{ns}
Sambar sadam	42.5 ± 0.21	41.9 ± 0.22^{ns}
Coconut rice	41.7 ± 0.09	37.8 ± 0.19*
Lemon rice	42.2 ± 0.29	40.7 ± 0.62^{ns}
Mango rice	41.3 ± 0.33	37.1 ± 0.37*
Vegetable rice	42.5 ± 0.07	42 ± 0.11^{ns}
Mint rice	41 ± 0.63	40.8 ± 0.43^{ns}
Coriander leaves rice	41.3 ± 0.56	40.8 ± 0.43^{ns}
Ghee rice	42.4 ± 0.32	38.6 ± 0.27*
Jeera rice	41.1 ± 0.65	39.8 ± 0.48^{ns}
Pulao	42.4 ± 0.13	41.4 ± 0.16^{ns}
Fried rice	40.6 ± 0.61	38.5 ± 0.55^{ns}

** One percent level of significance (p< 0.01);
* five percent level significance (p< 0.05);
ns not significant (p>0.05).

Table 3 says that lunch items like mint rice, coriander leaves rice, jeera rice, and pulav replaced with selected millets showed no significant difference in taste, consistency, flavour, appearance and colour compared to standard recipes. Also, recipes replaced with barnyard millet like keerai sadam, carrot rice, mango rice scored lesser compared to standard recipes and showed a significant difference in sensory attributes at a five percent level of significance.

Keerai Sadam - a common recipe prepared by south Indians by combining amaranth or palak variety of green leafy vegetables seasoned with onions and green chilies replaced with kodo millet recorded the least acceptability score (34.5 ± 0.11*), significant at one percent level (p<0.01) (Table 4). In general lunch recipes replaced with selected kodo millet showed moderate to high acceptability scores ranging from 34 to 41.

Table 5 reveals though there was a slight difference in the score of snack recipe placed with 100% millets. The difference is statistically insignificant for puffed millet

Table 5. Mean acceptability score of snacks recipes replaced with 100% of selected unpolished millets – Barnyard millet

Recipes name	Standard recipes	Barnyard millet (14 No.)
Puffed millet bhel	42.1 ± 0.11	40.7 ± 0.27^{ns}
Cheedai	42.2 ± 0.36	40.9 ± 0.22^{ns}
Methupakoda	40.7 ± 0.24	36.4 ± 0.21*
Suthu murukku	41.5 ± 0.49	37.9 ± 0.52*
Ribbon Pakoda,	41.9 ± 0.05	41.1 ± 0.61^{ns}
Kai Murukku	41.1 ± 0.38	39.4 ± 0.42^{ns}
Karashev	41.6 ± 0.46	40.2 ± 0.30^{ns}
Thattai	41.1 ± 0.23	40.8 ± 0.31^{ns}
Omapodi	41.5 ± 0.38	40.5 ± 0.42^{ns}
Biscuit	41.8 ± 0.16	36.4 ± 0.11*
Ring murukku	42.1 ± 0.32	37.8 ± 0.12*
Mullu murukku	40.3 ± 0.72	35.9 ± 0.46*
Somosa	40.5 ± 0.35	34.8 ± 0.36*
Kara Kollukattai	43 ± 0.23	41.1 ± 0.19^{ns}

** One percent level of significance (p< 0.01);
* five percent level significance (p< 0.05);
ns not significant (p>0.05).

Table 6. Mean acceptability score of snacks recipes replaced with 100% of selected unpolished millets – Kodo millet

Recipes name	Standard recipes	Barnyard millet (14 No.)
Puffed millet bhel	42.1 ± 0.11	41.3 ± 0.48^{ns}
Cheedai	42.2 ± 0.36	40.5 ± 0.07^{ns}
Methupakoda	40.7 ± 0.24	36.1 ± 0.18*
Suthu murukku	41.5 ± 0.49	37.7 ± 0.58*
Ribbon Pakoda,	41.9 ± 0.05	40.4 ± 0.59^{ns}
Kai Murukku	41.1 ± 0.38	37.2 ± 0.38*
Karashev	41.6 ± 0.46	39.6 ± 0.27^{ns}
Thattai	41.1 ± 0.23	40.4 ± 0.30^{ns}
Omapodi	41.5 ± 0.38	40.2 ± 0.37^{ns}
Biscuit	41.8 ± 0.16	36.1 ± 0.13**
Ring murukku	42.1 ± 0.32	38 ± 0.17*
Mullu murukku	40.3 ± 0.72	36.2 ± 0.45*
Somosa	40.5 ± 0.35	34.3 ± 0.31**
Kara Kollukattai	43 ± 0.23	42.6 ± 0.61^{ns}

** One percent level of significance (p< 0.01);
* five percent level significance (p< 0.05);
ns not significant (p>0.05).

bhel, Cheedai, Ribbon murukku, Kai murukku Omapodi and Karashev. Thus, the recipes can be popularized for day-to-day consumption as a healthy snack for population of all age groups and Diabetes in particular.

From the above-mentioned table 6 it is clear that the kara kollukattai- a steamed traditional south Indian snack, prepared by gelatinizing the unpolished kodo millet flour in place of rice flour showed the highest acceptability (42.6 ± 0.61) followed by puffed millet bhel (41.3 ± 0.48). Also, the puffed millet bhel and kara kollukattai replaced with selected millets showed no significant difference in taste, consistency, flavor, appearance, and color compared to the standard recipe preparation. Hence these two recipes can be suggested as a healthy snack for the diabetic population.

Summary and Conclusion

- Except for fruit fibre, intake of dietary fibre, cereal fibre, and vegetable fibre are closely related to a lesser risk of diabetes
- Though not all dietary fibre, behave the same, cereal fibre is a more appropriate source for glycaemic control than other sources since they can decrease the rate

of absorption of glucose after consuming high GI foods, thereby leading to a diminished blood glucose response curve and less call for insulin, reducing the hazard of diabetes

- Millets, a type of whole grain cereal sometimes known as Nutri-cereals, are nutritionally superior to other cereal grains
- Dietary fibre and non-starchy polysaccharides are more prevalent in millets. Though these grains have numerous health effect on lowering glucose level in blood
- Recent studies claim that hypoglycaemic and hypolipidemic effects of millets due to the dietary fibre and resistant starch present in them. Because of these reasons the millets are currently gaining more significance in research and value addition than compared to other crops. Though researchers claim that majority of the millet has been explored to a greater extent as they are still underutilized
- As little millets or minor millets are a rich source of nourishment, long-term use of minor millets may provide several health benefits. Because it is high in magnesium and gluten-free, minor millets can help reduce the frequency of migraine attacks, atherosclerosis, and diabetic heart disease
- It is time to incorporate small millets into our everyday diet. Minor millets have anti-diabetic, anti-tumorigenic, and antioxidant effects. Small millets are a great crop and dietary diversity addition to main staple foods.

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DEVELOPMENT OF RTE MILLET MIXES WITH FRUIT PEEL

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Abstract

Fruits are important components of a healthy diet. Fruits are rich sources of vitamins and minerals, dietary fibre and a host of beneficial non-nutrient substances including plant sterols, flavonoids and other antioxidants. The millets have high fiber content and are least allergenic and most digestible grains available. Millets are also rich source of phytochemicals and micronutrients. The study was aimed at evaluation of millet based RTE mixes recipes incorporated with dehydrated fruit peel. The fruit peel namely, banana and grapes was dehydrated using different dehydration methods namely tray drying,microwave drying and sun drying. Nutrient analysis of fresh and dehydrated fruit peel was carried out. Formulation of RTE millet mixes namely adai mix,vegetable pulav mix and chappati mix was prepared. As tray dried sample had maximum retention of nutrients, tray dried peel was incorporated into RTE mixes. The level of incorporation of tray dried fruit peels was at 5,10 and 15 percent with variation 1, 2 and 3 respectively. The developed recipes were subjected to organoleptic evaluation by 20 semi- trained panel members. The organoleptic scores of the recipes were statistically analyzed for mean and standard deviation to find the best acceptable recipe. The study revealed that the RTE millet mixes incorporated with tray dried fruit peels were well accepted at 5 per cent level of incorporation into the selected recipes. Hence intake of millet – fruit peel combo must be widely promoted both for its content of fiber and other nutrients.

Keywords: RTE millet mix, fruit peel, drying, grapes, banana

Introduction

Fruits are important components of a healthy diet. Reduced fruit consumption is linked to poor health and increased risk of Non Communicable Diseases (NCDs). Fruits are rich sources of vitamins and minerals, dietary fibre and a host of beneficial non-nutrient substances including plant sterols, flavonoids and other antioxidants. Consuming a variety of fruits helps to ensure an adequate intake of many of these essential nutrients. Banana is rich in potassium and fiber; banana leaf is rich in potassium. Taking hot foods on the leaf regularly may prevent stroke. Being a good source of iron, banana can stimulate the production of hemoglobin in the blood and help in cases of anemia. They also help to

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reduce the risk of blood pressure and stroke (Janagi and Lakshmi, 2008). Grapes are known for having a high nutritional value. Grapes are rich in vitamin C and vitamin K. They contain low levels of cholesterol, fat and sodium. They contain high amounts of caffeic acid, which is a strong cancer - fighting substance. Grapes contain flavonoids, which are powerful antioxidants (www.arizona.edu).

Number of components having activities like antioxidant, antimicrobial, antiinflammatory, antiproliferative etc. have been isolated from different peels(Parashar*et al,* 2014) and ready-to-eat foods were also developed by incorporating into millet recipes (Balasasirekha and Santhoshini, 2016).Minor millets categorized as coarse cereals are staple food for the tribal people where cultivation of major cereals like rice, wheat and maize is either not popular or fail to produce substantial yield (Chandel*etal*., 2014).

Drying is a process of dehumidification in which moisture is removed from a solid using thermal energy. In the design of a drying system, product quality, economic viability and environmental concerns should be taken into consideration (Hawlader*et al.*, 2013). Drying is a significant step on food and food additive processing. The position of drying becomes more and more strategic due to the changes in life style of modern people who prefer to find high quality dry products close to the fresh or natural condition.(Birchal*et al.*,2005; Djaeni, 2008). Advancement in science and technology has paved the way in upsurge of food industry. Ready To Eat foods are those foods which are partially cooked and can be utilized in a very convenient form within a short duration and it can be considered as one of the alternative home cooked meal. Provision of such RTE foods based on nutritious grains such as millets would be more meaningful in the modern times in the management of lifestyle disorders (Takhellamban *etal.,*2015). Considering the above mentioned nutritional and health benefits of millets, fruits and RTE mixes, the objectives were Nutrient analysis of the selected fresh and dehydrated fruit peel, Sensory evaluation of RTE millet mixes incorporated with dehydrated fruit peels.

Methodology

Phase I - Standardization of the dehydration methods and nutrient analysis of fruit peel

Selection and procurement of fruits

After a thorough study of the available reviews and literature on fruits nutritive value, two fruits namely, banana (*Musa paradiaca*) and grapes (*Vitis vinifera*) having more nutrients such as vitamins, minerals, fiber and phytochemicals-carotenoids, flavonoids, limonoids and polyphenols which appear to have biological activities and health benefits were selected for the present study. Mature, ripe,fresh, intact fruits with no bruises namely banana and grapes were procured in bulk quantity from the pazhamudirnizhayam. Banana was washed under running tap water and the skin was peeled. Grapes was soaked in soft water for half an hour to remove the presence of any pesticide residue. The water was drained, washed again and peeled.

ii. Selection and standardization of dehydrated methods

Traydrying - Tray drying or cabinet drying is a dehydration technique where dehydration of the sample is carried out at a low temperature under reduced pressure (Rahuramulu *etal*., 2003). The color of the peels turned to a darker shade after dehydration.

Microwave drying - Microwave drying is a conventional method where heat is passed over the food sample which reduce the moisture content in food there by drying the food. Grapes and banana peels were subjected to microwave drying. The dehydrated fruit peels were stored in airtight ziplock covers and labelled. The color of the microwave dried peels turned to a darker shade after dehydration.

Sundrying - Sun drying is one of the oldest method and the process of sun drying depends on the intensity of the sunlight allows the product to reach optimum moisture and quality levels. Sun drying was done between 10 am to 3 pm. The fruit peels were placed in clean plates and were covered using perforated polyethylene cover to prevent it from sweating. All the peels were dehydrated until the moisture content reduced to less than 10 per cent. Sun dried samples almost retained the same color compared to other two dehydration methods.

All the dehydration methods were standardized by altering the time and temperature and were done in triplicates.

iii. Nutrient analysis of fresh and dehydrated fruit peel

The nutrient analysis was carried out for all the fresh and dehydrated fruit peels. The macro nutrients analyzed include carbohydrate, protein, fat, ash and micro nutrients analyzed include calcium, iron, vitamin C and vitamin A, using the standard procedures of AOAC methods (1990).

iv. Analysis of anti-nutritional substances in selected fruit peels

Phytic acid is an anti-nutrient that interferes with the absorption of minerals from the diet (Beecher, 2003). The tray dried fruit peels had maximum retention of nutrients. Hence, tray dried dehydrated peels were chosen for incorporating into the RTE mix. Also tray dried fruit peels were analyzed for the presence of anti-nutritional factor namely phytic acid.

Phase II - Development of RTE millet mixes using dehydrated fruit peels

i. Selection of millets

Based on the nutritional importance of millets, four millets rich in nutrients namely cholam (*Sorghum bicolor)*, kuthiraivali (*Echinochoo acolona)*, thinai (*Setaria itallica*) and samai (*Panicum-sumatrense)* were selected. The selected millets were procured from supermarket and cleaned to separate grits and other heavy particles.

ii. Selection of recipes

Three recipes one each from breakfast, lunch and dinner was selected for the study. The recipe for breakfast includes adai, for lunch vegetable pulav and for dinner chappati. All these recipes were standardized by altering the quantity of ingredients used in the formula. To the standardized recipe, the

tray dried dehydrated peels were incorporated at three levels. Based on the type of recipe selected and the texture of the mix, millets were either broken or powdered and sieved. For adai mix, coarse powder and for chappati mix, millet grains were used in the form of powder. The powder was sieved in a 40 mesh sieve of 0.42mm and was incorporated in to the chappati mix. For vegetable pulav, millet grains were cleaned and used as such.

iii. Formulation of millet based RTE mix

The RTE mixes for the three commonly consumed recipes namely adai, vegetable pulav and chappati were standardized. The procedure for recipe preparation in the study was standardized based on the procedure followed by RCT (Ramaswamy Chinnammal Trust) food industry in Coimbatore. To prepare RTE millet mix,weighed quantities of the ingredients were taken, dry roasted the ingredients separately in a pan, for a stipulated time and mixed. The mix was allowed to cool. The recipes were standardized by altering the quantity of ingredients in the standard recipe such that the dehydrated peels blends in to the mix.

iii.a. Incorporation of dehydrated fruit peels into standardized RTE mix

The dehydrated fruit peels were incorporated into the standardized RTE millet at three levels namely, 5, 10 and 15 percent. Standard I contains 5g of dehydrated peel and 95g of millet mix; standard II contains 10g of dehydrated peel and 90g of millet mix and standard III contains15g of dehydrated peel and 85g of millet mix.

iii.b. Sensory Evaluation of the dehydrated peel incorporated RTE mix

The fruit peel incorporated RTE millet mix were evaluated sensorily. Sensory evaluation was carried out using 9 point hedonic scale for all the sensory characteristics namely appearance, flavor, texture, taste, color and overall acceptability. Scoring 9 to 0 corresponds to from like very much to dislike very much.

iii.c. Statistical analysis and interpretation of the results

The data obtained for sensory attributes of the developed recipes with three variations was analyzed statistically and interpreted. The data was consolidated and tabulated in which mean and standard deviation were computed. The research design and the protocol used in the study was submitted for scrutinization and approval to the Institutional Human Ethics Committee and ethical clearance approval was obtained. The Ref. No. is AUW/IHEC/FSN-15-16/XMT-06.

Results and Discussion

i. Dehydration characteristics of the selected fruit peels

Five hundred grams of the fresh fruit and peels were taken each for dehydration techniques. Weight of the banana peel from 500g of fruit was 146 g; grapes peel was 214 g. It was seen that the peel quantity of the selected fruits differs with each variety because of the thickness of the peel. The temperature, time required for drying the peel and weight of the dehydrated peels is given in Table 1.

Table 1. Temperature, time and weight of the dehydrated peels

Drying method temperature	Fruits	Time (hours)	Weight (g)	
			Fresh peel	Dehydrated peel
Tray drying - 50˚C	Banana	20	146	10
	Grapes	20	214	14.5
Microwave drying - 40˚C	Banana	46	146	20
	Grapes	26	214	16
Sundrying - 30˚C to32˚C	Banana	28	146	15.6
	Grapes	28	214	16.1

Tray drying took 20 hours for dehydrating banana peel and grapes peel. From 146 g of the fresh banana peel, 10 g of dehydrated peel and from 214 g of fresh grapes peel 14.5 g of dehydrated peel was obtained.

It was seen that microwave drying took least time to dehydrate when the temperature was maintained at 40˚C for the selected fruit peels. Banana peel dehydrated in 46 minutes; grapes peel in 26 minutes and the final moisture content in the microwave dried sample was seen to be below 10 per cent. Weight of the dehydrated peels was weighed and obtained. 20 g of banana peel; 16 g of grapes peel; was obtained after dehydration.

The drying time taken for sun drying of each sample was longest. Banana and grapes peel dehydrated in 28 hours because of the high moisture content. Dehydrated weight of the banana peel was 15.6g; grapes peel was 16.1g.

ii. Nutrient content of fresh and dehydrated fruit peels

Table 2 reveals the nurient content of the fresh and dehydrated banana peel. The carbohydrate content of fresh banana peel was 24 g, tray dried 20 g, microwave dried18.3g and sun dried 15.00 g respectively. The protein content of fresh banana peel was 3.5 g, for tray drying 3.15g, for microwave drying and sun drying the protein content was 2.9 g and 2g respectively. The fat content was 1.65g for fresh peel; 1.53 g for tray dried peel; 1.2 g for microwave dried peel and one gram for sun dried peel.

Fiber present in fresh peel was 3.03g; tray dried peel was 2.9 g; microwave dried peel was 2.1 g and sun dried banana peel was 1.9g.Vitamins and minerals which were analyzed include calcium, iron, vitamin C and vitamin A. Calcium content in fresh peel was 19 mg whereas tray dried peel had 17 mg of calcium. Fourteen mg of calcium was present in microwave dried peel and 11mg in sun dried peel. The iron content of fresh and tray dried banana peel was 1.1 mg; one mg and 0.3 mg was present in microwave dried and sun dried banana peel. Vitamin C present in fresh peel was10.1mg followed by 9mg in tray dried peel; 7.5 mg in microwave dried peel and 5 mg in sun dried banana peel. 50 µg of vitamin A was present in fresh peel whereas tray, microwave and sun dried banana peel

Table 2. Nutrient content of fresh and dehydrated banana peel

Method of drying	Carbohydrate (g)	Protein (g)	Fat (g)	Fiber (g)	Calcium (mg)	Iron (mg)	Vitamin C (mg)	Vitamin A(µg)
Fresh	24.0	3.5	1.65	3.03	19.00	1.10	10.1	50.00
Tray drying	20.0	3.15	1.53	2.90	17.00	1.10	9.00	47.30
Microwave drying	18.3	2.9	1.20	2.10	14.50	1.00	7.50	43.00
Sun drying	15.0	2.0	1.00	1.90	11.00	0.30	5.00	39.00

had 47.3µg, 43 µg and 39 µg respectively. It was observed that tray dried banana peels had maximum retention of nutrients compared to other dehydration methods.

Table 3 shows the nutritive value of fresh and dehydrated grapes peel.

The carbohydrate, protein, fat and fiber content of fresh grapes peel found to be 17 g, 0.63g, 0.15g and 0.70g respectively. The minerals such as calcium and iron present in fresh peel was 10.00mg and 0.30mg. Vitamin C and A was found to be 9 mg and 35µg in fresh grapes peel. Tray dried grapes peel contain 15.60g of carbohydrate; 0.50g of protein; 0.12g of fat;0.60g fiber; 8mg of calcium; 0.26mg of iron; 7mg of vitamin C and 33µg of vitamin A. The microwave dried grapes peel had 11.70g of carbohydrate; 0.27g of protein; 0.07g of fat; 0.45g of fiber; 5.00mg of calcium; 0.22mg of iron; 5.10mg of vitamin C and 27µg of vitamin A. Sun dried grapes peel had9.3g of carbohydrate; 0.1g of protein; 0.04g of fat; 0.1g of fiber; 4mg of calcium; 0.15mg of iron;3mg of vitamin C and 23µg of vitamin A. Tray dried grapes peel had maximum retention of nutrients which was closest to that of the fresh grapes peel revealing that tray dried grapes peel retained more nutrients.

Anti-nutritional substance in dehydrated fruit peels

Grapes peel had a phytic acid of 18 mg and banana peel 12 mg. The safe upper limit of phytic acid was found to be 24 mg and 23 mg for banana and grapes respectively. The values obtained in the present study are safe within the upperlimits and hence can be incorporated in the RTE mix.

Table 3. Nutritive value of fresh and dehydrated grapes peel

Method of drying	Carbohydrate (g)	Protein (g)	Fat (g)	Fiber (g)	Calcium (mg)	Iron (mg)	Vitamin C (mg)	Vitamin A(µg)
Fresh	17.00	0.63	0.15	0.70	10.00	0.3	9.00	35.00
Tray drying	15.60	0.50	0.12	0.60	8.00	0.26	7.00	33.00
Microwave drying	11.70	0.27	0.07	0.45	5.00	0.22	5.10	27.00
Sun drying	9.30	0.10	0.04	0.10	4.00	0.15	3.00	23.00

Table 4. Organoleptic evaluation of adai prepared from RTE millet mix incorporated with tray dried banana peel

Criteria	Standard	Variation 1	Variation 2	Variation 3
Appearance	8.10 ± 0.72	8.10 ± 0.64	8.10 ± 0.72	7.40 ± 0.82
Color	8.10 ± 0.72	8.25 ± 0.84	7.65 ± 0.59	6.80 ± 0.62
Taste	8.45 ± 0.60	8.50 ± 0.51	7.40 ± 0.75	6.80 ± 0.77
Flavor	8.40 ± 0.68	8.60 ± 0.50	7.50 ± 0.61	6.90 ± 0.64
Texture	8.10 ± 0.64	8.00 ± 0.56	7.30 ± 0.57	6.95± 0.76
Over all acceptability	8.50 ± 0.61	8.20 ± 0.62	7.40 ± 0.88	6.80 ± 0.89

iii. Organoleptic evaluation of the developed RTE millet recipes incorporated with tray dried peel powder

Organoleptic evaluation of RTE adai incorporated with tray dried banana peel

Table 4 pictures the organoleptic evaluation of RTE millet adai incorporated with tray dried banana peel.

Organoleptic evaluation of RTE millet adai incorporated with banana peel revealed that the appearance for standard, variation 1 and 2 was 8.1 and for variation 3, 7.4. The mean values obtained for color was 8.10 for standard, 8.25 for variation 1, 7.65 for variation 2 and 6.8 for variation 3. The taste of variation 3 was maximum with 8.5 followed by 8.45 for standard, 7.4 for variation 2 and 6.8 for variation 3. The flavor of variation 1 was highest with 8.6 where as it was 8.4 for standard. This was followed by 7.5 for variation 2 and 6.9 for variation 3. The mean scores for texture was 8.1, 8.7, 7.3 and 6.95 for standard, variation 1, variation 2 and variation 3 respectively. The overall acceptability of the RTE millet adai mix revealed that variation 1 had a maximum score of 8.2 and was comparable withthe standard of 8.5.

Organoleptic evaluation of RTE vegetable pulav incorporated with tray dried banana peel

Table 5 shows the organoleptic evaluation of millet vegetable pulav incorporated with tray dried banana peel.

Vegetable pulav incorporated with tray dried banana peel powder, prepared from standard and variations 1, 2 and 3 showed that in terms of appearance, scores a mean value of 8.15 for variation 1 and 2, 8 for standard and 6.70 for variation 3. In terms of color, standard and three variations got scores between 6.80 to 8.35. Variation 1 scored maximum mean value of 8.35 followed by standard - 8.15, variation 2 - 7.90 and variation 3 - 6.80. Taste contributed scores from 6.70 to 8.35. The maximum mean value is obtained for variation 1 with mean value of 8.35, standard with 8.15, variation 2 with 8.10 and variation 3 with 6.70. The scores obtained for flavor in vegetable pulav with dehydrated banana peel ranged from 6.60 to 8.20, the maximum score obtained for standard with mean value of 8.20 followed by variation 2 with 8, variation 1with 7.70 and variation 3 with 6.60. With regard to texture standard showed the best result with mean value of 8.10 followed by mean scores

Table 5. Organoleptic evaluation of vegetable pulav prepared from RTE millet mix incorporated with tray dried banana peel

Criteria	Standard	Variation 1	Variation 2	Variation 3
Appearance	8.00 ± 0.46	8.15 ± 0.59	8.15 ± 0.93	6.70 ± 0.92
Color	8.15 ± 0.67	8.35 ± 0.59	7.90 ± 0.85	6.80 ± 0.62
Taste	8.15 ± 0.81	8.35 ± 0.75	8.10 ± 0.74	6.70 ± 0.57
Flavor	8.20 ± 0.70	7.70 ± 0.80	8.00 ± 0.45	6.60 ± 0.60
Texture	8.10 ± 0.72	7.90 ± 0.85	8.05 ± 0.52	6.95 ± 0.76
Over all acceptability	8.05 ± 0.60	8.25 ± 0.64	8.15 ± 0.93	6.80 ± 0.70

of 8.05, 7.9 and 6.95 for variation 2, variation 1 and standard respectively. In terms of scores obtained for overall acceptability standard obtained 8.05 scores followed by variation 1 with 8.25, variation 2 with 8.15 and variation 3 with 6.80.

Organoleptice valuation of RTE chappati incorporated with tray dried banana peel

Table 6 presents the organoleptic evaluation of millet chappati incorporated with tray dried banana peel.

The appearance of chappati prepared with tray dried banana peel powder was 7.75forstandard, 7.45 for variation 1, 6.80 for variation 2 and 6.65forvariation 3. The mean value of color for standard was 7.90, variation 1 and variation 2 was 6.70 and variation 3 was 6.50. The values obtained for taste was maximum in standard with 7.65 followed by variation 3 with 6.45, variation 2 with 6.10 and variation 1 with 5.90. The scores for flavor ranged between 7.75 to 6.20. The maximum mean value was obtained for standard with a mean value of 7.75 followed by variation 1 with 6.95, variation 2 with 6.65 and variation 3 with 6.20. The mean values were 7.75, 7.25, 6.40 and 6.10 for standard, variation 1, variation 2 and variation 3 for texture. In terms of overall acceptability, standard scored 7.70, variation1 scored 7.15, variation 2 scored 6.75 and variation 3 scored 6.40 respectively.

Table 6. Organoleptic evaluation of chappati prepared from RTE millet mix incorporated with tray dried banana peel

Criteria	Standard	Variation 1	Variation 2	Variation 3
Appearance	7.75 ± 0.64	7.45 ± 0.94	6.80 ± 0.89	6.65 ± 0.81
Color	7.90 ± 0.45	6.70 ± 0.73	6.70 ± 0.98	6.50 ± 0.61
Taste	7.65 ± 0.67	5.90 ± 0.64	6.10 ± 0.64	6.45 ± 0.94
Flavor	7.75 ± 0.64	6.95 ± 0.75	6.65 ± 0.84	6.20 ± 0.70
Texture	7.75 ± 0.79	7.25 ± 0.64	6.40 ± 0.88	6.10 ± 0.85
Over all acceptability	7.70 ± 0.80	7.15 ± 0.84	6.75± 0.85	6.40 ± 0.88

Table 7. Organoleptic evaluation of adai prepared from RTE millet mix incorporated with tray dried grapes peel

Criteria	Standard	Variation 1	Variation 2	Variation 3
Appearance	8.35 ± 0.49	8.34 ± 0.60	6.75 ± 0.55	6.55 ± 0.51
Color	8.45 ± 0.51	8.50 ± 0.51	6.90 ± 0.79	6.65 ± 0.49
Taste	8.40 ± 0.50	8.45 ± 0.60	6.90 ± 0.64	6.60 ± 0.50
Flavor	8.65 ± 0.49	8.42 ± 0.51	7.20 ± 0.77	6.10 ± 0.64
Texture	8.35 ± 0.67	8.30 ± 0.47	6.60 ± 0.50	6.50 ± 0.51
Over all acceptability	8.40 ± 0.50	8.45 ± 0.51	7.10± 0.72	6.55 ± 0.51

Organoleptic evaluation of RTE adai incorporated with tray dried grapes peel

Table 7 represents the organoleptic evaluation of millet adai prepared with tray dried grape peel.

From the results, it is evident that the mean score value for appearance of standard was 8.35, variation 1 was 8.34, variation 2 was 6.75 and variation 3 was 6.55 for adai incorporated with tray dried grapes peel. The score for color ranged from 6.65 to 8.50. The maximum score obtained for variation 1 was 8.50 followed by standard with 8.45, variation 2 with 6.90 and variation 3 with 6.65. The mean scores for the taste of standard was 8.40, variation 1 was 8.45, variation 2 was 6.90 and variation 3 was 6.60. The flavor of the standard observed a mean score of 8.65, variation 1 with 8.42, variation 2 with 7.20 and variation 3 with 6.10. With regard to texture, standard, variation 1, variation 2 and variation 3 got means cores of 8.35, 8.30, 6.60 and 6.50 respectively. The scores obtained for over all acceptability of variation 1 with incorporation of 10 per cent got mean value of 8.45 followed by standard with 8.40, variation 2 with 7.10 and variation 3 with 6.55 respectively.

Organoleptic evaluation of RTE vegetable pulav incorporated with tray dried grapes peel

Table 8 depicts the organoleptic evaluation of millet vegetable pulav prepared with tray dried grapes peel.

The standard vegetable pulav prepared from tray dried grape peel and variations 1,2

Table 8. Organoleptic evaluation of vegetable pulav prepared from RTE millet mix incorporated with tray dried grapes peel

Criteria	Standard	Variation 1	Variation 2	Variation 3
Appearance	8.15 ± 0.59	8.60 ± 0.50	7.05 ± 0.60	6.60 ± 0.50
Color	8.40 ± 0.50	8.55 ± 0.51	6.50 ± 0.51	6.55 ± 0.51
Taste	8.35 ± 0.59	8.30 ± 0.47	6.90 ± 0.72	7.20 ± 0.62
Flavor	8.30 ± 0.57	8.50 ± 0.51	7.15 ± 0.81	6.70 ± 0.47
Texture	8.25 ± 0.64	8.17 ± 0.43	6.70 ± 0.57	7.20 ± 0.52
Over all acceptability	8.45 ± 0.51	8.45 ± 0.63	6.65 ± 0.49	6.50 ± 0.51

and 3 showed that in terms of appearance, variation 1 i.e. 5 per cent incorporation scored best result with mean value of 8.60. Variation 3 scored least value of 6.60 and standard and variation 2 score mean values of 8.15 and 7.05 respectively. In terms of color, the minimum score obtained was variation 2 with mean value of 6.50 followed by variation 3 with 6.55, standard with 8.40 and variation 2 with 8.55 respectively. The mean values for taste of standard was 8.35, variation1was 8.30, variation 2 was 6.90 and variation 3 with 7.20. The scores for flavor was 8.30 for standard, 8.50 for variation 1, 7.15 for variation 2 and 6.70 for variation 3 correspondingly. Texture obtained a mean value of 8.25 for standard, 8.17 for variation 1, 6.70 for variation 2 and 7.20 for variation 3. The overall acceptability for standard and variation 1 was 8.45, variation 2 was 6.65 and variation 3 was 6.50 respectively.

Organoleptic evaluation of RTE chappati incorporated with tray dried grapes peel

Table 9 represents the organoleptic evaluation of millet chappti prepared with tray dried grapes peel.

From the above table, it is clear that the appearance of standard was maximum with mean value of 7.85 followed by variation 1 and 2 with 6.20 and variation 3 with 5.95 for chappati incorporated with tray dried grapes peel powder. Color contributes scores from 7.20 to 6.30. The maximum mean score obtained for standard with 7.2. In terms of taste and flavor standard got mean value of 6.80 and 7.35 respectively, variation 1 got 6.70 and 6.65 respectively variation 2 got 5.20 and 5.05 respectively and variation 3 got 5.30 and 6.10 respectively. Texture of standard, variation 1, variation 2 and variation 3 secured a mean values of 7.20, 5.60, 5.56 and 5.60 correspondingly. Overall acceptability of standard was 7.40, variation1 was 5.75, variation 2 was 5.50 and variation was 5.65.

Overall acceptability of RTE millet mix incorporated with tray dried samples

The overall acceptability of RTE millet recipes incorporated with tray dried fruit showed that, for banana peel incorporated adai mix, standard scored maximum value with 8.50 followed by variation 1 with 8.20, variation 2 with 7.40 and variation 3 with 6.80. For vegetable pulav, it was observed that variation 1 scored a maximum value of 8.25 followed by variation 2 with 8.15, standard

Table 9. Organoleptic evaluation of chappati prepared from RTE millet mix incorporated with tray dried grapes peel

Criteria	Standard	Variation 1	Variation 2	Variation 3
Appearance	7.85 ± 0.59	6.20 ± 0.89	6.20 ± 0.53	5.95 ± 0.94
Color	7.20 ± 0.62	6.60 ± 0.99	5.80 ± 0.65	6.30 ± 0.83
Taste	6.80 ± 0.83	6.70 ± 0.92	5.20 ± 0.70	5.30 ± 0.75
Flavor	7.35 ± 0.59	6.65 ± 0.75	5.05 ± 0.76	6.10 ± 0.56
Texture	7.20 ± 0.70	5.60 ± 0.88	5.56 ± 0.81	5.60 ± 0.53
Over all acceptability	7.40 ± 0.60	5.75 ± 0.91	5.50 ± 0.54	5.65 ± 0.63

with 8.05 and variation 3 with 6.80. For chappati the maximum overall acceptability secured for standard with mean value of 7.70, variation1with 7.15, variation 2 with 6.75 and variation 3 with 6.40.

The overall acceptability of grapes peel incorporated adai showed that variation 3 got minimum mean value of 6.55 followed by variation 2-7.10, standard-8.40 and variation 1-8.45. Acceptability of vegetable pulav prepared from grapes peel, standard and variation 1 scored maximum value of 8.45 followed by variation 2-6.65 and variation 3-6.50. In terms of chappati prepared from grapes peel, standard showed highest mean value of 7.40 followed by 5.75, 5.50 and 5.65 for variation 1, 2 and 3 respectively.

The overall results indicates that variation - 1 with 5 per cent incorporated tray dried fruit peel powder had an overall acceptability when compared with variation 2 and 3. Hence this level of incorporation can be included in the daily dietaries. This may enhance the nutraceutical potential of the food consumed.

Conclusion

The study revealed that the RTE millet mixes incorporated with tray dried fruit peels were well accepted at 5 per cent level of incorporation into the selected recipes. These RTE millet mixes/recipes can be prepared at home scale level by the working mothers, cooked and consumed whenever required. The millet – fruit peel combo is nutrition rich, calorie dense and packed with anti-oxidants and phytochemicals. Hence can be consumed by all age groups. Intake of millet - fruit peel combo must be widely promoted both for its content of fiber and other nutrients. Millet based RTE mixes will convey sensory attributes, convenience and shelf stable from economic point of view. Promotion and utilization of millet based food products in urban markets will create avenues for farmers economic stability.

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AWARENESS AND USAGE OF READY TO EAT NUTRI-CEREALS AND READY TO COOK NUTRI-CEREALS AMONG STUDENT TEACHERS

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Abstract

Nutri-cereals are considered highly nutritious, energy efficient foods with potential health benefits which is essential for student teachers. Due to this, the research study was conducted among student teachers to know their awareness and usage of "Ready to Eat Nutri-cereals" and "Ready to Cook Nutri-cereals" (Millets) in day to day lifestyle. Around 200 student teachers were selected for the study. The study data was collected using a Google form questionnaire. Percentage analysis was done and results of the study revealed that ninety percent of the student teachers are aware of Nutri-cereals and 57% of them consume "Ready to Eat Nutri-cereals" and 43% use "Ready to Cook Nutri-cereals"(Millets) for better health.

Keywords : Nuri-cereals, RTC, RTE, Health

Introduction

Nutri-cereals (millet) are termed smart food, highly nutritious,survive in high temperatures, and serve multiple uses from food, feed, and fodder to brewing and biofuels. In view of the nutritional value of the millets, the government has notified millets as Nutri-cereals in April 2018. During the launch ceremony of the International Year of Nutri-cereals organized by the Food and Agriculture Organization of the United Nations (FAO), Prime Minister Narendra Modi emphasized making millet a food choice for the future. In view of the UNGA resolution for declaring 2023 as International Year of Millets an attempt has been made to study the awareness and usage of "Ready to Eat Nutri-cereals" and "Ready to Cook Nutri-cereals" (Millets) among student teachers.

Methodology

The study was conducted in Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore institute and Government college of Education in Coimbatore. The sample consisted of 200 student teachers. Stratified random sampling technique was used to select and participate in the study. The data were collected with the help of Google form questionnaire. The first part of the tool included personal data sheet with demographic details and second part on the

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awareness and usage of Ready to Eat Nutri-cereals" products and Practice of "Ready to Cook Nutri-cereals" products among student teachers.

Results and discussion

Awareness of Nutri-cereals (Millets) among student teachers

Percentage analysis was done to know the Awareness of Nutri-cereals (Millets) among student teachers as detailed below (Table 1).

Table 1. Awareness of Nutri-cereals among student teachers

Awareness of Nutri-cereals	Yes	No
India celebrates 2023 as "The year of Millets'	191 95.5%	9 4.5%
Nutri-cereals are gluten-free and non-allergic	177 88.5%	23 11.5%
All Nutri-cereals are rich in dietary fibre	182 91%	18 9%
Nutri-cereals are expensive compared to rice	148 74%	52 26%
Nutri-cereals can easily blend with common foods without addition of flavours	168 84%	32 16%
Consuming Nutri-cereals food in the morning is easy for digestion	188 94%	12 6%
Do you like Nutri-cereals (millets)	180 90%	20 10%
Do you buy instant Nutri-cereal products	123 61.5%	77 38.5%
The packed food products are certified under the ACMARK symbol	170 85%	30 15%
Do you look into the nutrient level printed on the instant-packed food items?	161 80.5%	39 19.5%
Are you aware of the FSSAI organic logo on the pack of instant food product	162 81%	38 19%
Is it easy to prepare Nutri-cereal foods	170 85%	30 15%
Nutri-cereals (Millets) are available in the market	192 96%	8 4%

From the above table it is clear that 96% of the student teachers were aware that India celebrates 2023 as "The year of Millets", whereas, 4% were not aware. Around 88.5% were aware that the Nutri-cereals are gluten-free and non-allergic, whereas, 11.5 % of them were unaware .Majority of the student teachers were clear that 91% of all Nutri-cereals are rich in dietary fiber, as against 9%. Approximately 74% of student teachers were aware that Nutri cereals are expensive compared to rice, as against 26% of them who were not aware that Nutri cereals are expensive compared to rice. It is evident that 84% were aware that Nutri cereals can easily blend with common foods without the addition of flavors, whereas, 16% were not aware.

It is evident that 94% were aware that consuming Nutri cereals food in the morning as it is easy for digestion, whereas, 12% were not aware of that fact, it is evident that 90% of student teachers like Nutri cereals whereas, 20% of student teachers do not like Nutri cereals.it is evident that 90% of student teachers do buy instant Nutri cereals products whereas, 20% of student teachers do not buy instant Nutri cereals products. It is evident that 85% of student teachers were aware that the packed food products are certified under the ACMARK symbol, whereas, 15% of student teachers were not aware. It is clear that 80.5% of student teachers do look into the nutrient level printed on the instant-packed food items, whereas, 19.5% of student teachers do not look into the nutrient level printed on the instant-packed food items. It also reveals that 81% of student teachers were aware of

Table 2. Types of nutri cereals

Name of the Nutri cereals	Yes	%	No	%
Cholam	190	95	10	5
Kamboo	198	99	2	1
Kelvaragu	193	96.5	7	3.5
Samai	179	89.5	21	10.5
Varagu	183	91.5	17	8.5
Tenai	150	75	50	25
Kudiraivali	172	86	28	14

the FSSAI organic logo on the pack of instant food products, whereas, 19% of student teachers were not aware of it. The study shows that 85% of student teachers were aware that it is easy to prepare Nutri cereals foods whereas, 15% of student teachers were not aware of the same. The results shows that 96% of student teachers were aware that Nutri cereals were available in the market whereas, 4% of student teachers were not aware of it.

Familiarity with types of Nutri cereals among student teachers

The following table describes the familiarity of the types of Nutri cereals among student teachers (Table 2).

From table 2 it is clear that 95, 99, 96.5, 89.5, 91.5, 75 and 86 percent of the respondents were aware of the nutri cereals like Cholam, Kamboo, Kelvaragu, Samai, Varagu, Tenai and Kudiraivali respectively. Hence it could be said that the nutri cereals were popular amongst student teachers.

TABLE 3. Consumption of nutri-cereals

Nutri-cereals	N	%
Cholam	156	78
Kamboo	139	69.5
Kelvaragu	111	55.5
Samai	81	40.5
Varagu	75	37.5
Tenai	76	38

Consumption of Nutri-Cereals

The following table details about the consumption of Nutri-cereals among student teachers (Table 3).

As per the data shown in table 3, it is evident that all the student teacher respondence consumed most of the nutri cereals. The maximum consumption was observed for Cholam (78%) and minimum for Varagu (37.5%) respectively. It is surprising that in spite of having good number of awareness's about Varagu only limited number consumed it. This might be related to the availability of the nutri-cereals

Reasons For Consumption Of Nutri-Cereals

The major reasons for the consumption of Nutri cereals are expressed in Table 4.

From table 4 it is evident that 65% of student teachers consumed Nutri-cereals for gaining high protein and 36% Nutri-cereals for weight loss. Approximately 62% of student teachers consumed Nutri-cereals for a feeling

Table 4. Reasons for consuming nutri - cereals

		High Protein	Weight loss	Feeling healthy	Tasty	Good nutrition	Increase immunity
Reason for consuming Nutri cereals	N	130	71	123	64	136	104
	%	65	35.5	61.5	32	68	52

Table 5. Forms of ready-to-eat nutri-cereals consumed by student teachers

Forms of Food items	Cholam N	%	Kamboo N	%	Kelvaragu N	%	Samai N	%	Varagu N	%	Tenai N	%
Noodles	110	55	34	17	32	16	6	3	7	3.5	11	5.5
Snacks	60	30	61	30.5	45	22.5	12	6	9	4.5	13	6.5
Cookies	31	15.5	45	22.5	63	31.5	25	12.5	14	7	22	11
Cake	40	20	47	23.5	43	21.5	30	15	18	9	22	11
Muffin	27	13.5	46	23	64	32	16	8	28	14	19	9.5
Laddu	22	11	56	28	55	27.5	22	11	12	6	29	14.5
Sweet puri	57	28.5	45	22.5	38	19	21	10.5	18	9	21	10.5

of healthy and 32% its taste, 68% of student teachers consumed Nutri-cereals for good nutrition and 52% of them consumedNutri-cereals to increase immunity.

Forms of Ready-to-Eat Nutri-cereals consumed by Student teachers

Student teachers consumed Ready-to-Eat Nutri-cereals such as snacks, Puffs, cookie, cake, Muffin, Laddu, Sweet poori, Noodles as detailed below Table 5.

From the above table, it is evident that 55% of student teachers consumed noodles made up of cholam largely as against only 6% of student teachers least consumed noodles made up of Samai. Approximately 61% of student teachers consumed snacks made up of Kamboo largely and only 6% of student teachers least consumed snacks made up of samai. Around 32% of student teachers consumed Cookies made up of kelvaragu largely as against 7% of student teachers least consumed cookies made up of Kelvaragu. Approximately 24% of student teachers consumed cake made up of Kamboo and Only 9% of them least preferred cake made up of varagu. Around 28% of student teachers consumed laddu made up of Kamboo largely as against 6% of student teachers least consumed laddu made up of varagu. Around 23% of student teachers consumed sweet puri made up of cholam largely and only 9% of student teachers least consumed sweet puri made up of varagu

Usage of Ready to prepare Nutri-cereals among student teachers

Student teachers also use Ready to prepare Nutri-cereals as detailed below in Table 6.

From the above table, it is evident that 46% of student teachers used Puttupodi mix made up of cholam largely, and only 2% of student teachers least used Puttupodi made up of varagu. Around 44% of student teachers used the Idiyappam mix made up of kamboo largely as against only 4% of student teachers least used the Idiyappam mix made up of Tenai. Approximately 26% of student teachers used the Idli/Dosa mix made up of kamboo largely and only 6% of student teachers least used Idli/Dosa mix made up of varagu. Around 27% of student teachers used the Rotti mix made up of Kamboo largely

Table 6. Usage of ready to prepare nutri-cereals among student teachers Cholam

Ready to cook food items	Cholam N	%	Kamboo N	%	Kelvaragu N	%	Samai N	%	Varagu N	%	Tenai N	%
Puttupodi mix	91	45.5	44	22	50	25	5	2.5	4	2	6	3
Idiyappam mix	39	19.5	87	43.5	46	23	12	6	9	4.5	7	3.5
Idli/Dosa mix	44	22	51	25.5	72	36	7	3.5	12	6	14	7
Uppuma mix	37	18.5	54	27	42	21	42	21	16	8	9	4.5
Rotti mix	38	19	54	27	51	25.5	15	7.5	28	14	14	
Health mix	36	18	44	22	53	26.5	16	8	22	11	29	14.5

whereas only 7% of student teachers least preferred Rotti made up of Tenai. About 22% of student teachers used Health mix made up of Kamboo largely and only 8% of student teachers least preferred laddu made up of samai.

Summary and Conclusion

The study concludes that the majority of the student teachers are aware of the Nutri-cereals. They consume either "Ready to eat Nutri-cereals" or Ready to cook Nutri-cereals" and most of them intake Nutri-cereals for good health and to improve their immunity levels. They too prepare many items using Nutri-cereals. Regular consumption of Nutri-cereals leads to positive effects for all individuals. The intake of Nutri-cereals regularly leads to good health and improves immunity.

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QUALITY EVALUATION OF READY TO COOK MILLET BASED BREAKFAST MIXES USING PUMPKIN SEED POWDER

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Abstract

The present study aimed at incorporating pumpkin seed powder in four different ready to cook millet based breakfast food mixes in an attempt to increase the nutrient content. The powdered pumpkin seed powder was packed and stored. The pumpkin seed powder had shelf life of 45 days based on the sensory and microbial analysis. The pumpkin seed powder was added at different variations from 5% to 20% levels in the Ready To Cook breakfast mixes. The sensory analysis was done. The 10% pumpkin seed powder added ready to cook millet based breakfast mixes were highly accepted. The acceptable variation was taken for microbial, sensory analysis (period of 30days) and nutrient content along with standard products. Pumpkin seed powder added ready to cook millet based breakfast mixes can be better stored and consumed for 30 days without affecting its microbial and organoleptic properties by storing it in a suitable packaging material.

Keywords: Sensory evaluation, shelf life, ready to cook mixes.

Introduction

Food processing is the set of methods and techniques used to change raw food materials into food for humans and animals. (Earle *et al*., 2017). Consumers are mostly attracted to Ready to cook snacks in recent five years which is quickest growing food sector because of their convenience. (Sushant*et al.,* 2021). The increase in the intake of convenience food was owed to the energetic involvement of working women and their engagement in extended period external from home (Shantanu *et al.,* 2021). Millets are not only comparable to major cereals with respect to their nutritional features but are very good source of carbohydrates, micro nutrients and phytochemicals with nutraceutical properties. The millets contain 7-12% protein, 2-5% fat, 65-75% carbohydrates and 15-20% dietary fibre (Dayakar *et al.,* 2017). Millets because of its high amount of fiber and antioxidants have shown lowering of serum lipid profile along with the lowering of blood sugar. Studies stated that increased consumption of millet and its products are associated with decreased risk of chronic diseases, like raised serum cholesterol (Himanshu *et al.,* 2018). Millets act as a prebiotic feeding for

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micro flora in the inner ecosystem. These multigrains blends help to mix various whole grains to maximize their nutritional, functional and organoleptic properties. (Anwar, 2018). Pumpkin seeds can be used with value addition of food ingredients, which can be helpful in several health aspects like malnutrition, etc. (Sunidhi *et al.,* 2019). The objectives of the present study was formulating ready to cook breakfast mixes using pumpkin seed powder and analyse the best level of pumpkin seed powder added millet based ready to cook foods by sensory evaluation, nutrient and microbial analysis.

Methodology

Selection of the products

Epidemiological studies have rating that consumption of millets decreases risk of heart disease, protects from diabetes, improves digestive system, lowers the risk of cancer, detoxifies the body, improve immunity in respiratory health and are protective against several degenerative diseases like metabolic syndrome and Parkinson's disease (Tonapi *et al.,* 2018).

Four Ready To Cook mixes like multigrain dosa mix, multigrain pongal mix, multigrain adai dosa mix, multigrain paniyaram mix were selected for the present study. The products were prepared in Ramasamy chinammal trust using standard procedure.

Selection of the ingredients

In the present study, Pumpkin seed powder was selected as ingredient for incorporation of Ready to cook breakfast mixes. The pumpkin seeds were obtained from local wholesale shop in Coimbatore. Then the pumpkin seeds were dry roasted and cooled at room temperature. Then the roasted seeds were ground using mixie into fine powder. The pumpkin seed powder was packed in Transparent standard pouch. The packed pumpkin seed powder was used for further analysis.

Pumpkin seeds are commonly nutrient dense food but discarded as waste. Keeping in the economic and nutritional benefits of pumpkin seeds, the products added with them can be added in daily diet to enhance the nutritional status of people. (Kaur and Sharma, 2017).

Analysis of Pumpkin seed powder

Sensory analysis

Aisala, H. *et al* (2021), stated that the pumpkin seeds were subjected to shelf life study period of three months. The sensory analysis was carried out. After storage period of three month, the difference in flavour was observed. The rancidity increased in the pumpkin seed samples.

The packed pumpkin seed powder was taken for the sensory analysis on shelf life period of three months. The sensory analysis was done by 10 trained panel members using nine point hedonic rating scale. The sensory aspects were flavour, colour, texture and taste.

Microbial analysis

The pumpkin seed powder was packed in transparent standard pouch packaging material and stored. The microbial analysis

of pumpkin seed powder was carried on shelf life period upto 3 months. The total microbial load for pumpkin seed powder was analyzed using ISO 4833-1:2013 procedure.

Nutrient analysis

The pumpkin seed powder was analyzed for nutritional and non-nutritional components like energy, protein, carbohydrate, fat, fibre, iron, calcium, moisture and ash using AOAC 20th edition and 21st edition procedure.

Formulation of products

Based on the above mentioned studies, the pumpkin seed powder was added at the level of 5%, 10%, 15% and 20% which is 5g, 10g, 15g and 20g in the standard Ready To Cook breakfast mixes. The standard recipes were prepared first. The variations were prepared with the addition of formulated Pumpkin seed powder at different percentages.

Sensory evaluation of products

Selection of panel

Preparation and the sensory evaluation of the recipes were done in the Ramasamy Chinammal Trust, Vadavalli, Coimbatore. The prepared products were evaluated by 10 trained panel members.

Formulation of score card

The products prepared were evaluated using the score card by trained panel members with the help of nine point hedonic rating scale for each attributes like Appearance, colour, flavour, texture, taste and overall acceptability.

Selection of best products

The formulated and standard products were analyzed by 10 trained panel members and the best products of addition were selected based on the scores obtained through sensory evaluation and the standard was used for further analysis.

Nutrient content of the products

The Indian Food Composition Tables by K.Venkaiah et al. (2017) was used to compute the nutrient values of pumpkin seed powder added millet based Ready To Cook mixes products.

Shelf life study

The pumpkin seed powder added millet based ready to cook foods were packed in Transparent standard pouch and Biodegradable standard pouch and stored. Shelf life study was assessed by the microbial analysis and sensory evaluation.

Microbial analysis

The packed products were subjected to microbial analysis carried on first day, 15th day and 30th day. The procedure for the microbial load testing of pumpkin seed powder was used for the microbial testing of food products.

Sensory evaluation

The packed food products were subjected to sensory analysis carried out on First day, 15th day and 30th day for shelf life study.

Results and Discussion

Sensory evaluation of pumpkin seed powder

The packed pumpkin seed powder was used for the shelf life study period of 90 days. The changes in sensory aspects of the pumpkin seed powder may be due to the rancidity of fats. The colour of the pumpkin seed powder slightly changed which was light in colour. The mean scores for the sensory evaluation of pumpkin seed powder during shelf life study was presented in Table 1.

Table 1. Sensory evaluation of Pumpkin seed powder

Criteria	Pumpkin seed powder (Mean±SD)		
	Initial	45th day	90th day
Flavour	8.4 ± 0.52	7.8 ± 1.03	6.4 ± 0.84
Texture	8.2 ± 0.63	7.7 ± 0.48	6.4 ± 0.97
Colour	8.2 ± 0.79	8.1 ± 0.74	7.7 ± 0.67
Taste	8.6 ± 0.52	8.2 ± 0.63	6.6 ± 0.70

The packed pumpkin seed powder was analyzed for total microbial load in the interval period of initial, 45th day and 90th day. The microbial growth was increased above the permitted level (not recommended) on the 90th day. The results were given in Table 2.

Table 2. Microbial analysis of Pumpkin seed powder

Period of storage (day)	Transparent pouch material	
	CFU/g	Quality
Initial	2.0×10^2	Recommended
Day 45	3.5×10^3	Recommended
Day 90	1.01×10^6	Not recommended

Standard: upto 105/g is recommended (Adesiyun, 2002)

Table 3. Nutrient analysis of pumpkin seed powder (100g)

Nutrients	Result	Referred value (seed)*
Moisture (g)	1.74	5.23
Total ash (g)	4.93	4.78
Fat (g)	39.12	49.05
Total Protein (g)	33.26	30.23
Carbohydrate (g)	20.95	10.71
Energy (Kcal)	566.75	559
Iron (mg)	11.2	8.82
Calcium (mg)	40.5	46

* Source: USDA National Nutrient Data base, 2018

Nutrient content of pumpkin seed powder

The nutrients analysis of the 100g pumpkin seed powder is presented in table 3. The result indicates the pumpkin seed was rich in calcium and iron content. The nutrient value obtained through analysis was slightly similar to referred value of pumpkin seed.

Sensory evaluation of standard and of Pumpkin seed added millet based Ready to cook Breakfast foods

For the comparison purpose, the average score obtained for the standard and pumpkin seed powder added millet based Ready to cook breakfast foods. The figure shows that, the 10% addition of pumpkin seed powder added millet based Ready to cook foods were highly acceptable based on the sensory analysis.

Table 4. Nutrient content of standard and best product of pumpkin seed powder added millet based ready to cook breakfast mixes

(a) - multigrain pongal (100g)

Nutrients	Standard	Sample B
Energy (Kcal)	929.9	985.8
Protein (g)	12.48	15.51
Carbohydrate (g)	57.47	58.54
Fat (g)	3.12	8.03
Fibre (g)7.99	8.89	
Iron (mg)	5.82	6.7
Calcium (mg)	36.6	41.2

(b) - multigrain dosa (100g)

Nutrients	Standard	Sample B
Energy (Kcal)	1235.91	1309.81
Protein (g)	11.33	14.35
Carbohydrate (g)	61.36	62.43
Fat (g)	1.82	6.73
Fibre (g)	7.88	8.78
Iron (mg)	4.49	5.3
Calcium (mg)	25.36	29.96

(c) multigrain adaidosa (100g)

Nutrients	Standard	Sample B
Energy (Kcal)	701.54	757.44
Protein (g)	12.29	15.31
Carbohydrate (g)	54.39	55.46
Fat (g)	2.6	7.51
Fibre (g)	7.96	8.86
Iron (mg)	4.79	5.67
Calcium (mg)	55.13	59.73

(d) multigrain paniyaram (100g)

Nutrients	Standard	Sample B
Energy (Kcal)	895.2	951.1
Protein (g)	11.48	14.51
Carbohydrate (g)	58.62	59.69
Fat (g)	3.15	8.06
Fibre (g)	7.69	8.59
Iron (mg)	5.81	6.69
Calcium (mg)	24.4	29

Nutrient content of pumpkin seed powder added breakfast millet based ready to cook mixes

The pumpkin seed powder added millet based Ready to cook foods namely multigrain pongal, multigrain dosa, multigrain adaidosa and multigrain paniyaram were contain high amount of nutrients than the standard products.The nutrient content of products were given below in the Table 4.

Shelf life analysis of standard and pumpkin seed powder added breakfast ready to cook foods

The microbial analysis for standard and selected pumpkin seed powder added Ready To Cook Breakfast mixes were done shelf life period of one month. From the result, it can be concluded that the biodegradable pouch material was better packaging material for the standard and sample products than the transparent pouch material for the period of 30days. The results were given in the table 5.

Sensory analysis of standard and pumpkin seed powder added breakfast Ready To Cook foods during shelf life study

The sensory analysis of standard and formulated pumpkin seed powder added Ready To Cook breakfast foods prepared using instant mix stored in different packaging materials during shelf life study discussed.

Table 5. Microbial analysis of standard and pumpkin seed powder added ready to cook breakfast mixes

	Transparent pouch material						Biodegradable pouch material					
Foods	Initial		15th day		30th day		Initial		15th day		30th day	
	CFU/g	Quality	CFU/g	Quality	CFU/g	Quality	CFU/g	Quality	CFU/g	Quality	CFU/g	Quality
A1	-	Good	$2.1x10^3$	R	$3.1x10^3$	R	-	good	$4.5x10^2$	R	$2.8x10^3$	R
A2	$1.3x10^2$	R	$2.5x10^3$	R	$3.5x10^4$	R	$1.3x10^2$	R	$6.6x10^2$	R	$5.5x10^3$	R
B1	-	Good	$1.0x10^2$	R	$1.8x10^3$	R	-	good	-	good	$6.8x10^2$	R
B2	$3.2x10^2$	R	$4.8x10^3$	R	$6.2x10^4$	R	$3.2x10^2$	R	$1.8x10^3$	R	$5.2x10^4$	R
C1	-	Good	$4.6x10^2$	R	$5.3x10^3$	R	-	good	$1.6x10^2$	R	$4.3x10^3$	R
C2	1x102	R	$2.6x10^2$	R	$2.8x10^3$	R	$1.01x10^2$	R	$2.0x10^2$	R	$3.4x10^2$	R
D1	-	Good	$1.1x10^2$	R	$2.7x10^3$	R	-	good	$1.0x10^2$	R	$1.7x10^3$	R
D2	$2.4x10^2$	R	$6.0x10^3$	R	$8.6x10^3$	R	$2.4x10^2$	R	$2.1x10^3$	R	$4.6x10^3$	R

Standard: upto 105/g is recommended (Adesiyun, 2002) R – Recommended

A1 -Standard Pongal mix, A2 - Sample Pongal mix, B1 - Standard Dosa mix, B2 - Sample Dosa mix,
C1 - Standard Adai Dosa mix, C2 - Sample Adai Dosa mix, D1 - Standard Paniyaram mix, D2 - Sample Paniyaram mix

The standard and sample millet based ready to cook breakfast mixes stored in biodegradable pouch were scored slightly scored than transparent pouch. Based on this, the millet based ready to cook breakfast mixes can be better stored and consumed in biodegradable pouch in duration of 30days.

Conclusion

From the present study, it was concluded that the pumpkin seed powder had shelf life of 45 days based on the sensory and microbial analysis. The pumpkin seed powder was high in nutrients especially Protein, Fat, Iron and Calcium. The 10% pumpkin seed powder added millet based Ready To Cook breakfast foods were highly acceptable. The nutrient content of sample Ready To Cook breakfast foods were high than standard foods may be due to the addition of pumpkin seed powder. The pumpkin seed powder added Ready To Cook food products can be better stored and consumed for 30days without affecting its microbial and organoleptic properties by storing it in suitable packaging (biodegradable packaging).

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ACCEPTABILITY AND NUTRIENT ANALYSIS OF EDIBLE CHAAT CUP FORMULATED USING MILLETS AND VALUE ADDED WITH BEETROOT

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Abstract

Recent eco-friendly innovations such as biodegradable and edible packaging reflect the state of our society today. Replacing the plastic cutlery with edible cutlery, that are easily biodegradable is the need of the hour to save nature and nurture health of the consumers. Utilizing millets, a plant-based source would be the best alternative for minimizing the pollution and in creating wellness exploiting the millets that are termed as Nutri cereals. The utensils and dishes used to serve the fast food items are mainly non degradable that has adverse effects. Hence the present study focused on formulating chaat cups and spoons using pearl millet, barnyard millet, wheat flour and natural colorant beet root and study the acceptability and analyze the nutrient content. Higher mean sensory score (13±8.24) for overall acceptability of the value-added edible cups was obtained for 25:15:10:10 of pearl millet flour: barnyard millet flour: wheat flour: beetroot color extract. Edible cutlery satisfied the needs of the consumer and also balanced the nutrient level, so is nutritious and safe for consumption.

Keywords: Millets, Edible cups, Natural food colors, Ecofriendly, Nutritious

Introduction

Packaging, as a concept, grew out of the basic need for early humanity to store and transport their food from place to place. While there is no record of when the first packaging materials were used, historians believe that during the nomadic hunter or gatherer days, materials such as leaves, animal skins, nuts or gourds were used to store and transport items (www.crawfordpackaging.com).

With sustainability having become a major concern in recent years, today's packaging innovators are continuously coming up with new ways to reduce the packaging industry's impact on the environment. Recent eco-friendly innovations such as biodegradable and edible packaging not only reflect the state of our society today, but it also demonstrates the packaging industry's ability to adapt to the ever- changing needs and concerns of consumers. Plastic cutlery is used around the world in restaurants and food service businesses and replacing the plastic cutlery with edible cutlery, that are easily biodegradable and have the great potential to reduce the plastic waste is the need of the hour to save nature and nurture health of the consumers (Prema *et al*., 2020). Utilizing millets, a plant-based source would

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be the best alternative for minimizing the pollution created due to use of plastics and in creating wellness exploiting the millets that are termed as Nutricereals. Literature have reported high consumption of fast foods among school going and college students in spite on the awareness of the adverse consequences (Kesari and Mishra., 2017). As well the utensils and dishes used to serve the fast food items are mainly plastics plates, cups or thermocol, newspapers, aluminum foil coated. Consumption of foods in this material also has adverse effects which has to be taken care off. Hence the present study focused on formulating chaat cups and spoons using pearl millet, barnyard millet, wheat flour and natural colorant beet root and understand the acceptability and analyze the nutrient content. The ecofriendly natural mould coconut shell was used to obtain the desired shape and size of the cups.

Methodology

Selection of ingredients

The literature proves the limited usage of pearl and barnyard millet in ready to serve food products and are the most produced millet. In addition to the agronomic advantages, the grains are valued for their high nutritional value and lower expense as compared to major cereals. The major ingredients namely - wheat, pearl millet and barn yard purchased from the local market were cleaned to remove the impurities such as stones and dust. After removing the impurities, they were washed with water, spread on a plate and dried completely. The millets were dried by open pan roast in low flame until smoke starts to come.

They were ground to a fine powder in mixer jar at home level, sieved, discarded the coarse mixture and the fine flour was stored in a clean air - tight container at room temperature and it was used in the formulation of edible cutlery. Wheat grains and other cereals ground to a fine flour commercially was used in the preparation of edible cutlery (Roy and Morya, 2022).

Betalains responsible for intense red color in beet roots are used as natural colorants by the food industry, and also receiving attention due to possible health benefits in humans, especially their antioxidant and anti-inflammatory activities (Patil *et al.*, 2015). To enhance the visual appeal of the edible cups and spoons color extracted from beetroot was used and the edible cup was coated with cucumber seeds. Beetroot purchased from local market was washed and cleaned. The outer layer was peeled and then finely grated over a paper towel or thin, clean dish towel, making sure to setting the towel over a plate so that the beetroot juice does not stain the countertops. One beetroot should yield roughly 3tbsp (45ml) beetroot juice (www. minimalistbaker.com) (Patil *et al*., 2015).

Formulation of edible chaat cups and spoons

Based on trial and error method different variations of the chosen millets was used to prepare the edible chaat cups and spoons by the process of baking. The yield obtained was not accepted in appearance due to the more breakages. Hence wheat flour the standard ingredient for any baked product was

TABLE 1. Ingredients and variation used for the preparation of edible chaat cup

Ingredients	Variation-I	Variation-II	Variation-III	Variation-IV
Pearl millet flour	30g	25g	20g	15g
Barnyard millet flour	10g	15g	20g	25g
Wheat flour	10g	10g	10g	10g
Butter	5g	5g	5g	5g
Salt	3g	3g	3g	3g

included in variation. The ecofriendly natural mould coconut shell was used to obtain the desired shape and size of the cups. For spoons the mould purchased from the market in the length of 9.5cm was used.

Preparation Method

STEP1: The dough was prepared with a blend of Pearl millet flour, Barnyard millet flour, Wheat flour to establish four different variations. The variations are recorded as I, II, III and IV.

STEP 2: Half cup of warm water was added and the dough was kneaded by hand for30-60 seconds to form smooth shape.

STEP 3: Pre sheeting of the dough was carried out by hand of desired length and breadth fitting the mould.

STEP 4: The dough was pressed in the form of cup shape using the greased coconut shell as the mould in the chaat cups and also the spoon mould used to shape the spoon.

STEP 5: The cups and spoons were placed on a greased baking tray.

STEP 6: Baked at 180°C for 40 minutes. The product was cooled, removed from the mould.

Sensory evaluation of formulated chaat cups and spoons

Standard 5-point hedonic scale ranging from strongly disagree carrying1 point to strongly agree with 5 point was used to carry out the sensory (organoleptic) evaluation. Cutlery samples were served to 30 semi trained panelist to analyze the organoleptic score for parameters like appearance, texture, color, flavor, taste and overall acceptability. Based on the results obtained the best variation was value added with beetroot extract in various proportion and subjected to sensory analysis to understand the acceptability of the product developed.

Nutrient analysis

The nutrient analysis such as moisture content, crude fiber, dry washing, protein, fat content, crude carbohydrate and energy of the overall accepted edible cutlery was analyzed at the Laboratory Harman Institute of Science Education and Research, Thanjavur using standard procedure.

The Crude fibre, protein content was determined by following the method of Sadasivam and Manikam (1992), Total fat content by the method of Ranganna (1986), carbohydrate content of the sample was done using the formula (Janardhanan and Lakshmanan, 1985). The energy value of the samples was determined by multiplying the

Table 2. Yield and Cost of Formulated Value-Added Edible Cups

Code	Variation	Total Weight g	No.of Portions	Weight Per Serving (g)	Cost Per Serving (Rs)
PBWB1	PM+BM+WF+BC (25+15+10+5)	55	2	30g	6.5
PBWB2	PM+BM+WF+BC (25+15+10+10)	60	2	30g	6.5
PBWB3	PM+BM+WF+BC (25+15+10+15)	65	2	30g	6.5
PBWB4	PM+BM+WF+BC (25+15+10+20)	70	2	30g	6.5

Other ingredients: butter, salt [PBWB PM-Pearl millet flour: BM-Barnyard millet flour: WF-Wheat flour: BC-Beetroot color]

Table 3. Hedonic Score of value-added Edible cups using millet and Beetroot

Variations	Hedonic rating				
	Strongly Disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Appearance					
PBWB 1	0	0	4(13.3)	15(50)	12(40)
PBWB 2	0	1(3.33)	1(3.33)	4(13.3)	24(80)
PBWB 3	0	1(3.33)	2(6.66)	12(40)	12(40)
PBWB 4	0	0	7(56.6)	19(63.3)	4(13.3)
Colour					
PBWB 1	0	4(13.3)	8(26.6)	9(30)	6(20)
PBWB 2	1(3.33)	1(3.33)	0	14(33.3)	14(33.3)
PBWB 3	0	2(6.66)	5(16.6)	8(26.6)	4(13.3)
PBWB 4	2(6.66)	6(20)	7(56.6)	12(40)	5(16.6)
Taste					
PBWB 1	0	5(16.6)	7(36.6)	9(30)	4(13.3)
PBWB 2	1(3.33)	2(6.66)	2(6.66)	10(33.3)	15(50)
PBWB 3	0	1(3.33)	6(20)	9(30)	7(36.6)
PBWB 4	0	12(40)	5(16.6)	9(30)	4(13.3)
Flavor					
PBWB 1	0	6(20)	5(16.6)	11(36.6)	6(20)
PBWB 2	1(3.33)	0	2(6.66)	7(16.6)	20(66.6)
PBWB 3	0	0	5(16.6)	9(30)	16(53.3)
PBWB 4	0	1(3.33)	7(56.6)	8(26.6)	2(6.66)

PBWB1 (Pearl millet flour 25: Barnyard millet flour15: Wheat flour 10: Beetroot color 5)
PBWB2 (Pearl millet flour 25: Barnyard millet flour15: Wheat flour 10: Beetroot colour10)
PBWB3 (Pearl millet flour 25: Barnyard millet flour15: Wheat flour 10: Beetroot 15)
PBWB4 (Pearl millet flour 25: Barnyard millet flour 15: Wheat flour 10: Beetroot color 20)

protein content by 4, carbohydrate content by 4 and fat content by 9 (AOAC, 1990).

Results and discussion

In order to prepare value-added edible cutlery beetroot extract was incorporated along with the millets in different proportion. One variation of edible chaat cups yielded two cups with 30g of weight after baking. Thus, the prepared value of edible cutlery using Beetroot color without any additives per serving cost was Rs. 6.50 which is considered to be affordable for consuming.

Sensory evaluation of value added Edible chaat cups using millet and Beetroot

Eighty percent of the panel members rated "strongly agree" for the appearance of edible cups formulated with beetroot at the ratio of 10. Equal percentage of 13.3 percent rated Agree and Strongly agree for the attribute color for variation 2 (PBWB2). Among the four variations used to formulate the edible cups variation 2 tasted good as 50 percent panelists rated "strongly agree" and also a majority of 66.6 percent liked the flavor of the variation 2 edible cup. Thus, the overall acceptability was for the cup which had inclusion of 10 g of beetroot.

The table 4 shows the mean sensory score obtained for the sensory attributes and overall acceptability of the edible cups. The mean sensory score of sensory attribute taste has obtained the highest score as 5±3.55 for PBWB2 and the least mean sensory score for sensory attribute color (0.25±0.5) for PBWB1. Higher mean sensory score (13±8.24) for overall acceptability of the value added edible cups was obtained for variation PBWB2. The edible cutlery was plain red in color and the addition of cucumber seeds increased the beauty and enhanced the appeal and crispiness of the accepted variation edible chaat cups.

Nutrient analysis of the edible cutlery

The nutrient analysis was carried out for the overall acceptable variation PBWB2 of edible cutlery, which was prepared in the ratio of (25:15:10) of Pearl millet flour: Barynard millet flour: Beetroot. The table 5 represents the nutrient analysis such as moisture, fiber, protein, fat, total ash, carbohydrate and energy and texture of the edible cutlery.

The edible cup prepared with incorporation of beetroot color extract and millet contain more protein and the protein content of edible chaat cup is 27.27% and spoon contains 27.53%, the moisture content present in the pearl and barnyard millet, beetroot chaat cup is 1.13% and spoon as 1.11%, fat content is 0.51% for cups and the spoon is 0.53%. The energy level of the prepared

Table 4. Mean Sensory score for the value added Edible chaat cups using millet and beetroot

Variation	Mean Sensory score and overall acceptability of value added edible cups				
	Appearance	Color	Taste	Flavor	Overall acceptability
PBWB1	0	0.25 ± 0.5	3.5 ± 2.64	2.75 ± 2.75	9.75 ± 6.07
PBWB2	0.5 ± 1	3.25 ± 2.21	5 ± 3.55	12.75 ± 5.9	13 ± 8.24
PBWB3	0	2.5 ± 5.44	4.5 ± 3.10	3.25 ± 0.5	9.5 ± 7.72
PBWB4	0	1.5 ± 2.87	4.75 ± 2.06	9 ± 1.41	11.5 ± 7.32

Table 5. Nutrient analysis of millet based edible chaat cups and spoons

Analysis	Chaat Cups	Chaat Spoon
Moisture (%)	1.13	1.11
Fiber (%)	5.26	5.29
Protein (%)	27.27	27.53
Fat (%)	0.51	0.53
Total Ash (%)	5.01	5.04
Carbohydrates (%)	61.95	61.61
Energy (Kcal/100 g)	361.47	361.33

edible chaat cup is 361.47 (Kcal/100 g) and the spoon is 361.33(Kcal/100 g) so the prepared edible cutlery satisfied the needs of the consumer and also balanced the nutrient level, so its nutritious and safe for consumption.

Summary and conclusion

Thus, it can be concluded that wheat flour along with pearl millet flour, barnyard millet flour and beetroot color extraction can be used in developing eco-friendly edible cutlery with proportion of 25:15:10:10 and will be a best alternative for minimizing the usage of plastics that has been more prominent in for long years. Edible chaat cups were sturdy enough to eat anything from hot soups to bhelpuri, salads to ice cream, it does not wear out quickly. This edible cup is highly nutritious as the nutri cereals are used and will help in improving the health of the young adult population consuming fast foods.

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INCORPORATION OF ANNATTO SEEDS (*Bixa orellana*) AS NATURAL FOOD COLOURS IN SELECTED MILLET RECIPES

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Abstract

Millets are species of *Poaceae f*amily, having its origin from Asia for more than 4000 years ago where in Europe during the Middle Ages milletswere used as major grains for consumption. From the ancient times the major varieties of millets popularly consumed in India are: foxtail millet (thenai), pearl millet (kambu), finger millet (kezhvaragu), sorghum (cholam), little millet (samai), and barnyard millet (kuthiravaali). However, with genetically modified crops invading our healthier eating habits, people are turning back towards traditional foods such as millets, which provide them with basic nutrients like fiber, calcium, protein and antioxidants. India is significant for its cuisine, especially Indian sweets where every celebration in an Indian family is incomplete without sweets. Commonly prepared sweets in India are kesari, halwa and gulabjamun. In this study, these traditional sweets were prepared using two different traditional varieties of millets – foxtail millet **(***Setariaitalica***)** and pearl millet **(***Pennisetumglaucum***)**, as major ingredients. The prepared sweets were incorporated with annatto seeds **(***Bixaorellana***)** powder as natural food colorantin different variations of 0.25 mg, 0.50 mg and 0.75 mg in 50 g of millets. Products were evaluated using composite scoring test, considering their colour, consistency, taste, along with their nutrients. Gulabjamun prepared with pearl millet incorporated with natural food colourants was scored the least, whereas the other recipes hadgood scoresconsidering their attributes. The nutrients computed for the foxtail millet recipes gulabjamun had the highest amount of 79.5 mg of calcium and pearl millet gulabjamun with14.9 mg of iron. Compared to foxtail millet kesari and halwa, pearl millet kesari and halwa had higher amount of energy content 405 kcal and 428 kcal respectively.

Keywords: Foxtail millet, Pearl millet, Desserts, Kesari, Halwa, GulabJamun, Natural, Traditional, Food Colourant, Annatto, Organoleptic Evaluation, Nutrients

Introduction

Millets are considered to be mighty and supreme among all the other cereal grains, as they are widely consumed by more than one third of the global population. Millets are said to have their origin from northern China of over 10,000 years ago. In India, consumption of millets had been pre-dated to the Indian Bronze Age of around 4,500 BC.

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As for our ancestors millets were considered as local staple foods. But whereas for later generations, millets were just 'coarse grains', which were gradually replaced by genetically modified crops resulting in refined diet. Unfortunately, these refined diets lack nutrients that are crucially needed for a healthy human. Now, the techno population have become health conscious all over the world having a wider focus on healthy eating and setting its ultimate goal on millets, the tiny cereal grains as immune boosters.

Foxtail millet (*Setariaitalica*), also known as Italian millet, is regarded as a native of China and is recognized as one of the world's oldest cultivated crops. In the total world production of millets, foxtail millet ranks second. "In the northern area it has been widely used as a nourishing gruel or soup for pregnant and nursing women and has been applied to food therapy. It has been recorded this millet has many nutritious and medical functions" (*Sadhu et al., 2021*). Foxtail millet contains significant levels of protein, fiber, mineral and phytochemicals. Anti-nutrients such as phytic acid and tannin present in this millet can be reduced to negligible levels by using suitable processing methods. The millet is also reported to possess hypolipidemic, low glycemic index and antioxidant characteristics (*Nithya et al., 2017*).

Pearl millet (*Pennisetumglaucum*) is "food formulations and to achieve the better food security feature, it is necessary to useappropriate processing methods". These millets are rich in nutrients such as carbohydrates, proteins, fiber, fat, iron, calcium and magnesium. Pearl millet is nutria-dense grains and has health benefits of anti diabetic, anti cancer, anti ulcerative, reduces blood glucose and cholesterol level. It also helps in losing weight, strengthening bones and relieving constipation (Savita et al., *2018).*

Addition of food colours to the food substances has its origin from early Egyptian culture and later on the onset of industrial revolution in the early 1800's, to meet the flourishing need for food, food producers started adding colourants to make the food more attractive and amiable for consumption, even when it caused incurable diseases and death in some cases. Researchers have proved that these synthetic food colourants have a major impact on mental health, especially in children. Unstable emotions, depression and ill-mannerism have all been leading to one focal point, the Artificial Food Colours (AFCs) (*Eugene et al, 2012*).

On the other hand, natural food colourants are paving their way into the global commercial food industries. These naturally extracted food colourants are said to be filled with anti cancer, anti diabetic, biomarkers for heart diseases, mental health and immunity boosters. On one such account, the seeds of the *Bixaorellana* tree produce an orange-red food colouring condiment known as annatto. Bixin and norbixin, carotenoid pigments produce colours that are found in the reddish waxy coat of the seeds. Annatto (*Bixaorellana*) extracts are widely used in many processed food products as a coloring

agent andis also a natural alternative to synthetic food coloring compounds (*Food RGB, 2021).*

Methodology

The certified natural food colourant annatto seeds was selected and incorporated in millet based traditional sweets commonly prepared and their nutritive values were computed.

Natural Food Colorant: The raw annatto seeds were selected and stored in dry place. The seeds were then taken and pulverized into fine powder using sterilized blender and the powder was stored in zip lock covers.

Selection of Ingredients: Millets are rich sources of health balancing nutrients. Foxtail millet and pearl millet are nutrient dense consisting of high amount of iron, calcium, magnesium, protein and fiber that works as immunity booster. These millets also play an active role in normalizing blood glucose level and cholesterol level. These millets were selected as major ingredient for preparing the traditional products.To make the products more amiable other traditional ingredients like ghee and annatto, as natural food colourant were added (*Shweta, 2015*).

Preparation of the Traditional Recipes: The traditional recipes selected for preparation are prepared in variations with food colourants added to it and the recipes prepared are: kesari, halwa and gulabjamun.

Table 1. Formulation of traditional millet recipes

Name of the recipes	Foxtail Millet and Pearl Millet	
	Ingredients	Quantity (g)
Kesari	Millet	50
	Sugar	50
	Ghee	5
Halwa	Millet	50
	Sugar	50
	Ghee	7
GulabJamun	Millet	100
	Bengal gram flour	10
	Ghee	5
	Milk	10
	Sugar (for Syrup)	100

The ingredients from *table – 1* are used to prepare the traditional sweet recipes. The selected millets were either slightly roasted at medium flame or soaked and pulverized to get the coarse powder.

For kesari preparation, pulverized are roasted millets were added to the pan along with sugar and four cups of water. The mixture was stirred constantly until the water was evaporated, leaving behind thick consistency. Then the variations of natural food colour was added and mixed well. For preparing halwa, the millets were roasted and soaked for an hour and pulverized to coarse powder. In a pan ghee was added. Then the coarsely powdered millet along with sugar was added and stirred until the consistency became thick. In low flame, few drops of ghee along with the natural food colourant was added and mixed well, until the mixture became non-sticky in the pan.

Likewise for the preparation gulabjamun, the selected millets were powdered and soaked in water for a day along with bengal gram flour and milk. Later, water was drained out completely from the batter. Ghee and variations of natural food colourants were mixed and made into small balls. Sugar syrup was prepared and left for cooling. The balls were fried in refined oil over medium flame and were soaked in the sugar syrup for three hours.

Table 2. Incorporation of natural food colourant in millet based recipes

Natural Food Colourant	Variation - I	Variation - II	Variation - III
Annatto (Bixaorellana)	0. 25 mg	0.50 mg	0.75 mg

The ratio of the natural food colourants added in three different variations to the traditional recipes prepared. The rate of acceptance among the panel members are given in *table – 2*.

Organoleptic Evaluation: Ten Semi-trained panel members evaluated the prepared recipes with their colour, consistency, flavor, taste and texture using a score card withcomposite scoring method

Computation of Nutritive Value: The common nutrients such as: carbohydrates, protein, fat, fiber, iron, calcium and magnesium were calculated using ICMR guidelines (2019).

Results and discussion

Organoleptic evaluation

"Quality is the ultimate criterion of the desirability of any food product. The quality of a food product is assessed by means of human sensory organs, the evaluation is said to be sensory or subjective or organoleptic" (*Srilakshmi, 2018*).

Hence, the prepared products were evaluated through organoleptic evaluation. When every time the food was tasted, the food quality of food was assessed through the semi trained panel members' preference and the varieties of millets used in preparation were considered. The composite score card was used in evaluating the products according to their quality on colour, consistency, flavor, taste and texture with an overall possible score of 10.

In Table - 3, the mean of the individual recipe along with the mean of overall acceptance of the recipes are calculated and tabulated. As for the overall acceptance, variation - I of foxtail millet kesari, variation - II of foxtail millet halwa and variation - I of pearl millet halwa are rated with good 9 points in score cards. Variation - III of foxtail millet halwa, foxtail millet gulabjamun and variation - II of pearl millet gulabjamun tasted odd and the overall mean score is seven. Variation - III of pearl millet gulabjamun had the very low scoring.

Nutritive Value

The acceptability of the millets based recipes were moderate and so the nutrients of the products were calculated. The nutrients considered for calculation of nutritive value are: energy, carbohydrates, protein, fat, fiber, calcium and iron.

Table 3. Organoleptic evaluation of the formulated millet based recipes

Name of the products	Variations	Colour	Consistency	Flavour	Taste	Texture	Overall acceptability (Mean ± SD)
Foxtail Millet Kesari	I	9	8	9	9	9	9 ± 0.4
	II	8	8	8	9	9	8 ± 0.5
	III	8	8	8	8	8	8 ± 0
Pearl Millet Kesari	I	9	9	9	9	8	9 ± 0.4
	II	8	8	9	8	8	8 ± 0.4
	III	7	8	7	8	8	8 ± 0.5
Foxtail Millet Halwa	I	9	8	8	8	8	8 ± 0.4
	II	8	9	10	9	8	9 ± 0.8
	III	7	7	7	7	8	7 ± 0.4
Pearl Millet Halwa	I	9	9	8	9	8	9 ± 0.5
	II	8	8	8	8	7	8 ± 0.4
	III	9	8	7	7	8	8 ± 0.8
Foxtail Millet GulabJamun	I	8	6	7	8	8	7 ± 0.8
	II	8	7	7	8	8	8 ± 0.5
	III	7	6	7	7	8	7 ± 0.7
Pearl Millet GulabJamun	I	8	9	8	7	8	8 ± 0.7
	II	9	7	7	7	8	8 ± 0.8
	III	6	6	7	6	7	6 ± 0.5

Table 4 shows the analyzed nutrients of the prepared food item. In comparison between the two kesari varieties, pearl millet kesari is comparatively high with 405kcal of energy, 80g of carbohydrates and 5.6mg of iron, whereas foxtail millet kesari is comparatively high with 6g of protein, and 21.3mg of calcium. In the halwa prepared, foxtail millet halwa is higher in the nutrients with 6g of protein and 21.3mg of calcium, whereas pearl millet is higher in amount with 423kcal of energy, 80g of carbohydrates and 5.6g of iron. In comparison between the prepared gulabjamun, foxtail millet jamun is high in calcium of 81.6 mg. As for pearl millet gulabjamun, it is high with the following nutrients: energy - 491kcal, carbohydrates - 75g, protein - 12g, fat - 15g, fibre - 8g and iron - 14.9mg.

Table 4. Amount of nutrients present in millets based recipes

Names of the products		Energy (Kcal)	Carbohydrates (g)	Protein (g)	Fat (g)	Fibre (g)	Calcium (mg)	Iron (mg)
Foxtail Millet	Kesari	400	77	6	7	4	21.3	2.4
	Halwa	418	77	6	12	4	21.3	2.4
	GulabJamun	482	69	16	14	8	79.5	8.4
Pearl Millet	Kesari	405	80	3	7	4	14.3	5.6
	Halwa	423	80	3	12	4	14.3	5.6
	GulabJamun	492	75	12	15	8	65.5	14.9

Summary and Conclusion

Millets are the most consumed cereal grains all over the world. Especially in India millets are considered as local staple crops with their individual health benefits. Millet based traditional sweets incorporated with annatto as natural food colourant in different variations are prepared. Organoleptic evaluation and major nutrients of the recipes are calculated. According to the semi trained panel members, the prepared recipes of gulabjamun did not look appetizing. And also the composite score cards were evaluated by taking mean value of the overall aspects of the recipes. As for the overall acceptance, variation - I of foxtail millet kesari, variation - II of foxtail millet halwa and variation - I of pearl millet halwa are good. In nutritional analysis, pearl millet gulabjamun had the highest nutrient content for energy, carbohydrates, protein, fat, fibre and iron. Overall the millet products prepared, added with the natural food colourant is good. Variation - I (with natural food colourant of 0. 25 mg) in all the products are acceptable, variation - II (with natural food colourant of 0. 50 mg) is good and looks appetizing. As for variation - III (with natural food colourant of 0. 75 mg), pearl millet gulabjamun alone is highly not acceptable. But for kesari and halwa, the natural food colourant added, acted as an extra flavouring agent and the taste is liked by two third of the panel members. The findings of the study reveal that the traditional homemade sweets have a good acceptance rate when added with annatto food colours. Hence, it proves that annatto is an effective natural food colourants with health benefits such as antioxidant, antimicrobial and anticancer properties plays a vital role as biomarkers for diseases and annatto has been proved to be an excellent replacement for orange coloured, synthetic food colourants.

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MILLETS AND THEIR SIGNIFICANCE - A REVIEW

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Abstract

Millet is a form of cereal grain that was initially developed in Asia and later spread to Africa. Millets are used in the phrase "yesterday's coarse grains and today's nutri-cereals." Millets have the ability to withstand temperatures that are extremely low. Millet is grown in India on an area that is roughly equivalent to approximately 14 million hectares of land, and the annual millet production in the country is approximately 14 million tonnes (The Hindu 2020). Millets, due to their high nutrient content, are a potential solution to the growing problem of malnutrition as well as metabolic problems. In addition, they not only improve the nutritional status of the population as a whole but also food security of the country. Millets are an excellent source of antioxidants, which help eliminate free radicals that can cause cancer, reduce the risk of developing cancer, and flush other toxins found in the liver and kidneys, out of the body. Millets are beneficial for relieving gastrointestinal issues such as constipation, bloating, cramping, and excess gas due to the high concentration of fibre. They also help lower the risk of celiac disease,which is most commonly brought on by eating gluten. Millets contain a wide variety of nutritional benefits that can help to prevent a variety of health problems, including lowering blood pressure, reducing the risk of heart disease, preventing cancer and cardiovascular disorders, and reducing the incidence of tumours.

Keywords: Cereal grain, Asia, Africa, India, Hindu, Millets, risk, help, cancer, variety,reducing, problems, nutritional, million.

Introduction

Millets are used in the phrase "yesterday's coarse grains and today's nutri-cereals." This phrase describes millets as "nutri-cereals" rather than "coarse grains." Millets are considered to be "future crops" as a result of their resistance to majority of diseases and pests, as well as their capacity to grow in the extreme environmental conditions of the desert and semi-arid regions of Asia and Africa. This makes millets ideal for cultivation in these regions. Additionally, millets have the ability to withstand temperatures that are extremely low. The vast majority of millets that are grown are intended for human consumption, while only a small portion of it is used in the production of alcoholic beverages, feed for animals and birds, and malt. The millet that is cultivated specifically for human

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consumption makes up the majority of all millet that is cultivated (Cisse *et al.,* 2016). Millet is grown in India on an area that is roughly equivalent to approximately 14 million hectares of land, and the annual millet production in the country is approximately 14 million tones (The Hindu 2020).When it comes to the cultivation of millet, the regions of Indian states of Rajasthan, Maharashtra, and Karnataka have large area under millet cultivation. Indians consume a wide variety of millets like sorghum, pearl, foxtail, finger and kodo millet. India is ranked first in the production of nutrient-dense millet and secondin the production of rice and pulses around the world (Ashoka *et al.,* 2020). The most widespread and economically important species of millets are sorghum (Sorghum bicolor L.), pearl millet (Pennisetum glaucum), finger millet (Eleusine carocana), proso millet (Panicum miliaceum), kodo millet (Paspalum scrobiculatum), and foxtail millet. They are referred to as "superfoods" due to the fact that the vast majority of

These millets do not contain gluten and are three to five times more nutritious than the majority ofcereals (rice, wheat, corn) in terms of vitamins, fibre, proteins, and minerals (calcium,phosphorus, magnesium, manganese, potassium, and iron) (Anitha et. al, 2021). Millets, due to their high nutrient content, are a potential solution to the growing problem of malnutrition as well as metabolic problems. In addition, they not only improve the nutritional status of the population as a whole but also food security of the country. Millets are an excellent source of energy in addition to dietary fibre, and resistant starch and therefore release of glucose is slow and promote satiety.

In comparison to cereals, millet are a superior source of protein due to the sulphur containing amino acids (methionine and cysteine) and the composition of the fatty acids that can be found in millets is more favourable.

Eventful history of Millets

Millet is a form of cereal grain that was initially developed in Asia and later spread to Africa. Its origins can be traced back to the Indus River. It was first domesticated by the people who lived in those regions of the world, and it wasn't until much later that the practise spread to other areas of the planet. Additional attempts at domestication in different geographic locations led to the formation of secondary regions of diversity and adaptation. In the north-eastern region of Africa,between 5,000 and 8,000 years ago, sorghum was first made into a domesticated crop. This area of the continent is where the term "cradle of grain" originated, and as such, it is referred to as the"cradle of grain." Indian Subcontinent was not the initial location where sorghum was domesticated; rather, it was the secondary location. Around 4500 B.C., people in the northern-central Sahelian region of Africa were the first to domesticate pearl millet and bring it into use as a crop. In West African countries such as Ghana and Mali, pearl millet is recognized as one of the most significant cereal crops that can be cultivated. In addition to this, it is grown extensively in the areas of India that are classified as semiarid to arid, as well as

Table 1. Millets' roots and their Common names

Crop	Common names	Origin
Sorghum bicolor	Sorghum, great millet, guinea corn, kafir corn, aura, mtama, jowar, cholam, kaoliang, milo, milo-maize	Northeast region of Africa (Ethiopia-Sudan border)
Pennisetumglaucum	Pearl millet, cumbu, spiked millet, bajra, bulrush millet, candle millet, dark millet	Tropical West Africa
Setaroaotalica	Foxtail millet, Thenai, Italian millet, German millet, Hungarian millet, Siberian millet	Eastern Asia (China)
Panicumsumatrense	Little millet, Samai	Southeast Asia
Paspalumscrobiculatum	Kodo millet, Varagu	India
Panicummiliaceum	Proso millet, common millet, hog millet, broom-corn millet, Russian millet, brown corn, Panivaragu	Central and Eastern Asia
Echinochloa crus-galli and Echinochloa colona	Barnyard millet, sawa millet, Japanese barnyard millet, Kudhiraivali	Japan
Eleusinecoracana	Finger millet, African millet, koracan, ragi, wimbi, bulo, telebun, Ragi	Uganda or neighboring region

Sources : (1) FAO, 1995 (2) Rai *et al.,* 2006

in the eastern and southern regions of Africa. The first archaeo botanical evidence of the cultivation of pearl millet was discovered in Mali and has been dated to approximately 2,500 BC. According to Venkatesh Bhat *et al.* (2018), the following Table 1 presents botanical name and common names of millets.

Table-IMillets' roots and their Common names

Nearly every variety of millet is used in some capacity in the production of food in the countries that collectively make up the vast majority of the world's least developed nations. Millets, on the other hand, have traditionally been utilised in industrialised nations primarily for the purpose of producing animal feed.

Beneficial effects of millets on health

Millets contain a wide variety of nutritional benefits that can help to prevent a variety of health problems, including lowering blood pressure, reducing the risk of heart disease, preventing cancer and cardiovascular disorders, and reducing the incidence of tumours. Millets have a high concentration of antioxidants, which are substances that help shield cells from the damage that can be caused by free radicals in the surrounding environment. Millets have qualities that make them nutraceutical, which means that they have the potential to improve one's health in a way that is beneficial. The relaxing and alkaline properties of millet help the body keep a good pH balance, which is crucial for preventing diseases such as cancer and cardiovascular disease, preventing cases of tumours, and lowering the risk of heart disease. Two additional benefits that contribute to one's overall health are the amount of roughage that is provided as well as the longer amount of time that it takes for the stomach to empty.

Millet is an excellent source of fibre, which controls cholesterol levels in the body and also maintain healthy blood flow throughout the body and hence millet contributes to overall cardiovascular health. Proso millet and sorghum consumption is associated with elevated levels of high-density lipoproteins and adiponectin in the plasma. This is the result of the high levels of fibre found in both of these grains. Millets are an excellent source of the mineral magnesium, which can help in the control of blood pressure and reduce the likelihood of suffering a heart attack, particularly in people who suffer from atherosclerosis. The capacity of magnesium to relax blood vessels is one factor that contributes to the mineral's ability to prevent heart attacks. Both finger millets and proso millets contribute to reduction of cardiovascular disease as a result of their ability to lower plasma triglyceride levels. Millets are good source of potassium and a powerful source of vasodilation, help the body keep its blood pressure by maintaining a healthy level. Fruits, vegetables, grains, nuts, seeds, and some grains are good sources of antioxidants. Millets have the potential to be used both as a source of natural antioxidants and as functional dietary ingredients in the prevention and treatment of diseases.

Millets for weight reduction

Obesity is the biggest emerging problem in India and it is associated with several chronic diseases including diabetes and CVD. Recent studies show that intake of high dietary fibre decreases the incidence of obesity (Alfieri *et al.,* 2015). Foods rich in dietary fibre improves the bowel function and slows the process of digestion and absorption, thereby reducing the risk of chronic diseases (Ali *et al.,* 2022). The dietary fibre content present in millets is 22% which is comparatively higher than other cereals like wheat having 12.6%, rice having 4.6%, maize having 13.4%. Chethan, *et. al.,* (2017), reported that there is15.7% in soluble dietary fiber, 1.4% soluble dietary fiber, in finger millet grain. Shobana, *et al*., (2018) has reported that finger millet is having 22.0% total dietary fiber, 19.7% insoluble dietary fiber and 2.5% soluble dietary fiber. Millets helps in satiating hunger and helps in weight management reducing obesity. With high fibre content, millets help to reduce problems like constipation, flatulence, bloating and stomach cramping. With good digestion and absorption, the retention of gastro-intestinal illnesses like ulcers and colon cancers.

Therapeutic effect of Millets in Diabetes

Consuming millets helps in controlling the blood glucose level and also helps in dermal wound healing process with the help of antioxidants (Rajasekaran NS, *et al.,* 2018). National Institute of Nutrition (ICMR) in 2016 assessed Glycemic Index (GI) of sorghum based foods in collaboration with the Indian Institute of Millets Research, Hyderabad under National Agricultural Innovation Project (NAIP). The results showed that sorghum based foods are having low GI and reduces the postprandial blood glucose level. Finger millet diets showed low glycemic response due to high fiber content. Studies have strong evidence for finger millets protein in inhibiting the cataractogenesis in humans. Millets help in prevention of Type II.

Diabetes due to their significant levels of magnesium. Magnesium is an important mineral which helps in increasing the efficiency of Insulin and glucose receptors by producing many carbohydrate digesting enzymes, which manages insulin action. (David et.al., 2018).

Millets for CVD management

Research by Kyung et.al 2018 showed that by consuming the porso-millet protein concentrate, has the effect on plasma lipid levels and clearly showed that the plasma high-density Lipoprotein cholesterol and adiponectin levels are elevated. Millets are also a good source of magnesium which is known for the reducing of heart attack. Millets which are known to be richin phyto-chemicals which contains phytic acid helping in lowering cholesterol and preventing cardiovascular disease by reducing plasma triglycerides. Regular consumption ofwhole millet grains reduces the risk of CVD. Millet is a rich source of magnesium, which is an important mineral for reducing blood pressure and the risk of heart attacks and strokes, particularly in the case of atherosclerosis. Millets are also a great source of potassium, which further keeps blood pressure low by acting as a vasodilator. Decreasing blood pressure and optimizing circulatory system is one of the best ways to protect cardiovascular health.

Furthermore, the plant lignans of millets are prebiotic fiber which are fermented in intestinal gut by bacteria can be converted to animal lignans by the micro flora in digestive system. Upon fermentation, they yield enterolactone, a product which is known to protect against heart diseaseand also some forms of breast cancers. (O.S.K.Reddy, 2017).

Millets in Cancer

Millets are rich in phenolic acids, phytates and tannins which help in reducing the risk for colon and breast cancer. It is showed that phenolics in millets are effective in preventing the cance initiation and progression (Chandrasekara, A. *et al.,* 2021). Millet have linoleic acid which contain anti-tumor activity. The polyphenols and tannins present in sorghum have anti-mutagenic and anti-carcinogenic properties (Grimmer *et al.,* 2022) and can act against human melanoma cells, as well as positive melanogenic activity. China and indifferent parts of the world showed that incidence of oesophageal cancer was low with sorghum consumption.

In addition to their beneficial impact on neutralizing free radicals, which can cause cancer, they can also clean up other toxins from body, such as those in kidney and liver. Quercetin, curcumin, ellagic acid, and various other beneficial catechins help to remove foreign agents and toxins by promoting proper excretion and neutralizing enzymatic activity in those organs (Aliyar, R. *et al.,* 2015).

Millets in Celiac Disease

Celiac disease is a genetically susceptible problem triggered by the consumption of gluten. As the millets are gluten free, they help in reducing the celiac disease by reducing the irritation caused by the common cereal grains which contain gluten. (Saleh ASM, *et al.,* 2017). Regulating

digestive process can increase nutrient retention and reduce chances of more serious gastrointestinal conditions like gastric ulcers or colon cancer. Fiber content in millets helps in eliminating disorders like constipation, excess gas, bloating and cramping. (Catassi and Fasano, 2018). Replacing cereals like wheat, barley, rye-based foods made from gluten free grains, including rice, corn, sorghum, millet, amaranth, buck wheat, quinoa, wild rice help people adhering to gluten free diet (Thompson, *et al.,* 2019). As millets are gluten free, they have considerable potential in foods and beverages and can meet the growing demand for gluten free foods and will be suitable for individuals suffering from celiac disease. (Deshpande *et al.,* 2015).

Conclusion

Millets are important crops in semi arid and tropical regions of the world due to their resistance to pests and diseases, short-growing season, and productivity under heat and drought conditions when major cereals cannot be relied upon to provide sustainable yields. Millets are consumed traditionally as health and vitality foods by the poor segment of the population. Nutritive potential of millets in terms of protein, carbohydrates, and energy values are comparable to the popular cereals such as rice, wheat, and barley. Most of the health benefits associated with the millets are generally due to the presence of phytochemicals such as polyphenols, tocopherols, phytosterols, and dietary fiber and also due to the abundant presence of some of the minerals, vitamins, and trace elements. The energy content of millets and other types of grain is comparable, using millets offer more significant health benefits as a consequence of the high quantities of fibre, minerals, vitamins, macro- and micronutrients, and phytochemicals that they contain. Millets, when included in a person's diet on a regular basis, provide an alternative for ameal that is not only economical, but also comprehensive and healthy. When decorticating millets, caution is required because an excessive amount of dehulling lead to loss of micronutrients as well as a reduction in the amount of fibre that is present. Now it is an established fact that the whole world is facing many health challenges because of fiber-less foods. Some epidemiological studies have shown that regular consumption of millet grains and their products is associated with reduced risk of developing chronic diseases such as diabetes, cardiovascular disease, cancers, and all-cause mortality. Although millet foods are considered among the healthiest food choices that are available, their consumption remains well below in developed countries where diet-related chronic diseases are alarming. It is necessary to increase production and lower cost by introducing revolutionary improvements in production techniques. There is also a lack in the processing techniques, machinery, and standardization of products.

People still consider millets as poor man's food. Many processed products need to be optimized to give proper benefits to the consumer. Millets have a potential for the preparation of healthy foods. Because of their health benefits, these grains do need a great promotion to reach heights of the major cereals in terms of their utilization.

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POLYPHENOLIC COMPOUNDS IN MIGHTY MILLETS: ROLE IN CANCER PREVENTION AND TREATMENT

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Abstract

The United Nations at its general assembly declared 2023 to be the International Year of Millets with a view to glorifying millets' potential. Millets are gaining more focus as it could contribute to Sustainable Development Goals (SDGs) like Zero Hunger, Good health and Well-Being, Decent Work and Economic Growth, Responsible Consumption and Production, Climate Action, and Partnerships for the goals. India is the largest producer of millet' with a global share of 37.5% that could contribute to SDG's. In addition to all of the above-mentioned uses, millets can be helpful in the treatment of cancer and other non-communicable disorders. Since cancer is the leading cause of mortality in the world, researchers are exploring for sustainable, safe, and economical cancer treatments. Studies show that millets fulfil these criteria as it can grow in arid and semi-arid conditions, have cheap costs, require very less of water,are high in nutritional composition, and provides nutritional benefits. Apart from all of these, millets contain polyphenolic compounds which act as a novel anti-cancer drug. Studies reveal that millets show anti-cancer activities in both in vivo and in vitro investigations. This review aims to discuss the effect of polyphenolic compounds in millets against cancer.

Keywords: Mighty millets, polyphenolic compounds, cancer, novel anti-cancer agent, sustainability

Introduction

According to the World Health Organization, cancer is the leading cause of non-communicable disease-related death worldwide, accounting for over 10 million deaths in 2020, or nearly one in every six deaths. Cancer management and treatment is a major challenge in both developed and developing countries like India. Standard treatment options like surgery, chemotherapy and radiation therapy have its own pros and cons besides high costs. From then on, the major goal in cancer research is to develop a novel anti-tumor agent that is highly efficacious in preventing proliferation and thereby curbing metastasis.

Millets act as one such novel anti-cancer agent, which is both sustainable as well as cost-effective. It is said so because millets can be grown well even in arid and semi-arid regions as it is drought resistant

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crop. The Nutritional attributes of millets are noteworthy, which has helped it in gaining the status of "Mighty Millets". Apart from serving as a storehouse of both macro and micronutrients, the polyphenolic compounds in millets have gained attention in recent years. These polyphenolic compounds help to prevent and/or treat diseases like cancer that are brought on by oxidative stress. These polyphenolic compounds exhibit anti/pro-oxidant effects as their primary mechanism of action.

The International Year of Millets was established by the United Nations in March 2021 at the request of the Government of India, in recognition of the millets' many health benefits. Millets receive a full year of attention since it can be cultivated on arid soil and are tolerant of climate change. Millets are viewed as the best way for nations to enhance their level of self-sufficiency and decrease their dependency on imported cereal grains.

Indian scenario of using millets

Millet is a type of grain that acts as a reservoir for numerous macro and micronutrients. In many regions of the world, especially in Africa and Asia, millets serve as a staple meal. Around 1.2 billion people were thought to eat millet regularly, according to the World Food Programme. The world's largest producers and consumers of millets are Asia and Africa. Indians have traditionally produced and eaten a lot of millets. The fact that foxtail millet (priyangava), barnyard millet (aanava), and black finger millet (shyaamaka) are mentioned in some of the oldest Yajurveda texts demonstrates how widespread millet consumption was.

In India, millets were the main grain produced until 50 years ago. Meena R.P (2021) reported that India produces the most millet in the world, accounting for 37.5% of the total output, followed by Sudan and Nigeria. Despite not being a common food crop in affluent countries, millet is an essential part of many people's diet. India is the main producer of millet, and with Jowar, Bajra, and Ragi it also produces Kodon, Gangora, or Barnyard, and Brown Top. One or more millet crop species are grown in the majority of Indian states. However, during the green revolution, millet cultivation drastically decreased between 1950-1951 and 2018-19, falling by 41.65 percent. Sukumaran Sreekala *et al.,* (2022) sees the public distribution system (PDS) which provides fine cereals at subsidized prices to be one major factor for the decline in millet cultivation and consumption. Apart from this, she even reports that changes in customer preference, the short shelf life of millet flour, and the low social status attached to millets as other causes for the decline.

Despite the production reduction, India has produced between 13.71 and 18 million tonnes of millets during the past five years, with the maximum production occurring in 2020-21 and accounting for around 5% of the country's total grain production. India has recently seen an upsurge in millet output. One of the nations with the highest millet production is India, and Indian farmers are increasingly cultivating millet as a drought-resistant crop. The Indian government is promoting millet farming as a part of its National Food Security Mission.

Millets: Farmer-friendly crops

As the global average temperature is on a constant raise and global warming is a severe threat, farming has became difficult due to the increase in dry lands. This decreases the yield of crops like rice and wheat resulting in a negative impact on the lives of the cultivators. In addition, scientists have predicted that the dry lands will expand ten percent globally by the end of 21st century. Millets can pave the way to mitigate the decrease in production due to global warming. When compared to rice and wheat, which require 8,000-12,000 litres of water to produce 1 kg each, millet may be cultivated with ease utilizing just 200-300 litres of water. In addition, the investment and maintenance cost for millet cultivation is very low as it does not require more water, can grow in less fertile soil, does not require any fertilizers or pesticides, and can grow even in harsh weather conditions. Also, millets are all-season crops that require only 70-90 days to grow completely. This again serves as a benefit to the farmers as they can cultivate and produce more yield for approximately three cycles in a year. Throughout the year millets can benefit their livelihood. Care must be taken on the farmers' end to preserve or buy the best seed varieties which could give good yields. Since millets can lower CO_2 levels in the atmosphere, they can help mitigate climate change.

Bioactive constituents of millets

Millets being a great source of complex carbs, protein, fat, fibre and other micronutrients, they also include a variety of bioactive components that have the ability to scavenge free radicals. However, its effect on the human body could vary based on the types and forms of bioactive substances present in each variety. The common polyphenolic compounds identified in millets are as follows:

Effect of various polyphenolic compounds on cancer

Gallic acid

A well-known polyphenol called gallic acid has been shown to have impacts on apoptosis, anti-angiogenic activity, and antiproliferative activity in a variety of cancer cell lines, including those from the stomach, colon, prostate, lung, cervical, glioma, and leukaemia. (Verma *et al.,* 2013).

Gallic acid prevents angiogenesis, cell cycle progression, metastasis, apoptosis, migration, and oncogene expression. Thus gallic acid is a novel and secure anti-cancer medication candidate for the treatment of cancer.

Name of the millet	Polyphenolic compound present
Proso millet	Gallic, p-hydroxybenzoic, gentisic, vanillic, chlorogenic, sinapic, and ferulic acids
Foxtail millet	Ferulic, chlorogenic, caffeic, p-coumaric, and syringic acids
Finger millet	Quercetin, gallic, protocatechuic, vanillic, p-hydroxybenzoic, syringic, ferulic, trans-cinnamic, caffeic, sinapic, and p-coumaric acids
Pearl millet	Methyl vanillate, apigenin, ferulic, caffeic, p-hydroxybenzoic, and p-coumaric acids
Barnyard millet	Gallic, p-hydroxybenzoic, vanillic acid, caffeic, chlorogenic, ferulic, and p-coumaric acids

Gentisic acid

Altinoz *et al*., (2018) have reported that strong antioxidant properties make gentisic acid an effective free radical scavenger. In combination with a decline in free radical products and the stimulation of antioxidant molecules, gentisic acid inhibits the propagation of cancer in animal models. In vitro glioma cell invasion is also prevented by it. Additionally, gentisic acid inhibits OAT3/SLC22A8, which is involved in chemotherapeutic drug efflux from the brain and may help to achieve therapeutic anticancer drug concentrations in brain tumours. Consequently, gentisic acid opens up new possibilities for the treatment of brain tumours and systemic cancers.

Vanillic acid

"Lung cancer-bearing animals exhibited elevated levels of lipid peroxidation, ADA, AHH, -GT, 5'-NT, LDH, protein-bound carbohydrate components (protein-hexose, hexosamine, sialic acid, and fucose), and decreased activity of membrane-bound ATPases (Na+/K+ATPases, Ca2+ATPases, and Mg2+ATPases). The vanillic acid treatment significantly enhanced each of these actions. Overall, the findings of study are consistent with the claim that vanillic acid has powerful anti-inflammatory and free radical scavenging properties throughout Swiss albino mice's lung carcinogenesis." (Velli, 2020).

Chlorogenic acid

Reduced migration/invasion potential, proliferation rate, and mitochondrial ATP generation were seen in cancer cells treated with chlorogenic acid. In cancer cells but not in healthy cells, chlorogenic acid changed how differentiation-related genes were expressed. It stopped the growth of lung and hepatoma tumors in tumor-bearing animals and stopped the creation of new tumors in naive mice. Rats intraperitoneally injected with CA showed CA in the blood and brain. The most significant finding was the safety of chlorogenic acid, even at very high dosages. It might function as a secure and advantageous differentiation inducer for cancer treatment. Instead of only killing cancer cells, future cancer treatments might involve "educating" them to distinguish. (Huang *et al*., 2019).

Sinapic acid

Cereals contain large amounts of phytochemical sinapic acid. Antibacterial, anti-inflammatory, anti mutagenic, antioxidant, and anti-cancer effects are all known for it. Sinapic acid has been shown in numerous studies to selectively suppress the proliferation of breast cancer, prostate cancer, liver cancer, and pancreatic cancer.

Ferulic acid and P-coumaric acid

Because of potential benefits in the treatment and prevention of cancer, foods high in polyphenols are growing in popularity. "Foxtail millet is a crucial functional food that is abundant in a number of biologically active compounds. Ferulic acid (FA) and p-coumaric acid are the primary anticancer components of foxtail millet bran. Combining FA and p-CA prevents colorectal cancer cells from engaging in aerobic glycolysis, suggesting a

potential dietary intervention and treatment approach for the disease." (Cui *et al*., 2022).

Caffeic acid

Caffeic acid is used to treat breast tumor migration rate inhibition. Rosendahl *et al*., (2015) concluded in a study that breast tumor growth was suppressed by caffeic acid by reducing the growth of MDA-MB-231 and MCF-7 cells. It is a promising and useful clinical step toward making healthy cells less toxic and acting more aggressively against their malignant counterparts.

"Prostate cancer is the most prevalent disease in developed nations that is also resistant to cell death. This resistance necessitates the development of a unique therapeutic approach; phenolic acids have been associated with a decreased incidence of prostate cancer. Caffeic acid has been linked to a decreased risk of prostate cancer that has advanced." (Russo *et al*., 2017).

Due to the exceptional resilience of melanoma to conventional chemotherapy, a great deal of study has looked into novel treatment modalities and adjuvants. Studies show that caffeic acid inhibits cell migration and invasion. Additionally, research shows that caffeic acid has the capacity to inhibit cell growth, proliferation, and viability in a range of malignancies as well as to induce apoptosis. The results demonstrated that caffeic acid injection decreased cell viability, prevented colony formation, disrupted the cell cycle, and changed caspase gene expression. Also, research points to caffeic acid's ability to inhibit the growth of SK-Mel-28 cells.

Quercetin

It has been demonstrated that the polyphenolic bioflavonoid quercetin possesses anticancer and anti-inflammatory effects. Quercetin freezes breast cancer cells and closely monitors cell signaling abnormalities that may eventually lead to cancer. The transformation of healthy cells into cancerous ones can be stopped by this plant component. By shielding cellular DNA against cancer-causing mutations, this is accomplished. Breast cancer cells can be brought back to an early stage of growth by quercetin, even if the body is creating them quickly. This reversal procedure results in apoptosis, also known as cancer cell death."In breast cancer cells, quercetin significantly reduced the expression of COX-2 mRNA, COX-2 protein, prostaglandin (PG) E (2) synthesis, and COX-2 promoter activation." (Xiao *et al*., 2011)

Protocatechuic acid

All plants contain protocatechuic acid, a naturally occurring phenolic chemical. Recent research has shown that this phenolic molecule inhibits the growth of epithelial malignancy in different tissues. Xie *et al*., (2018) revealed that due to its ability to influence apoptosis and autophagy, protocatechuic acid may be used to treat and prevent ovarian cancer.

P-coumaric acid

p-Coumaric acid (*p*-CA) has anti-diabetic, anti-platelet aggregation, anti-inflammatory, antioxidant, and anti-cancer

effects. It was also found that human lung cancer A549 and colon adenocarcinoma HT29-D4 cells' ability to proliferate and migrate is significantly inhibited by p-CA in a dose-dependent manner.

Apigenin

A naturally occurring substance called apigenin not only has low toxicity but also serves a number of important purposes. Apigenin exhibits strong anti-cancer properties both on its own and in combination with other chemotherapeutic drugs. "Apigenin suppressed the survival of ACC-2 cells in ACC cells by dose- and time-dependently inducing both apoptosis and G2/M-phase arrest. Apoptosis and autophagy were both induced by apigenin therapy in human colon cancer HCT116 cells." (Lee, 2014). Thus, studies prove that apigenin can be developed as a dietary supplement and it can also serve as an adjunct anti-cancer agent.

Bioavailability of polyphenolic compounds from millets

The US FDA defines bioavailability as "the rate and extent to which the active ingredient or active moiety is absorbed from a drug product and becomes available at the site of action" (2012). According to definition, the polyphenolic compound's rate of absorption and its availability at the site of action is important for it to be bioavailable. There are many factors that affect the bioavailability of ingested dietary flavonoids such as its chemical structure.

The phenolic compounds are majorly present in a bound form on the bran of the millets. This makes it difficult for the gastrointestinal enzymes to act upon and thus its bioavailability is less. The growing awareness and health consciousness of people have made them move towards millets. To make it more appealing, palatable, and to increase its market share food industries involve in processing. But several studies have shown that processing techniques like fermentation, dehulling, decortication malting, blanching, boiling, thermal treatment, extrusion cooking, etc… reduce the phenolic compounds. More scientific studies are required to identify a processing technique that does not affect the polyphenolic content. The size of millets acts as a probable solution to make the polyphenols available. The whole grains without any processing treatment can be consumed as such or can be made into powders, health drinks, and complimentary foods thus making the polyphenolic compounds available.

Consumption pattern of millets and its impact on health

Soon after the green revolution, the consumption of rice and wheat increased and the consumption of millets had come down. This could be associated with people seeing rice and wheat as a social status as well as the ease of making a variety of dishes out of it. In a recent face-to-face survey coordinated by the International Crop Research Institute for Semi-Arid Tropics in 2017 to learn about consumers' understanding of millets.

The study was carried out in various main cities across India among general population who showed up at shopping

malls. The results showed that the majority of people were consuming millets since they had a health issue and they had perceived that millets could ideally be a solution for their health condition. Few other lifestyle enthusiasts consumed millets keeping in mind that consumption of millets could make them live a healthy lifestyle. The main reasons for not consuming millets were that people did not like the taste of millets, and did not know proper cooking methods. It was not usually prepared at home, the prices were high and it also takes longer time to cook.

Despite India being the largest producer of millets, the consumption rate is comparatively lower. Increasing awareness among public and making it available throughout the year at lower costs through public distribution system could be one effective strategy to improve the consumption rate. The mere thought of millet being consumed by diseased or sick people should be changed and millets should be consumed for its mighty nutritional properties as well as its numerous health benefits. The International Year of Millets (IYOM-2023) could bring a positive impact on millets among people, thus leading to increase production, and consumption, helping in curbing malnutrition and improving sustainability.

Recent trends and future perspectives of millets

The millet market was estimated to be worth USD 10.37 billion in 2021, and from 2022 to 2029, it is anticipated to increase at a rate of 4.82%, or roughly USD 15.11 billion.Due to enhanced water and nitrogen usage efficiency, tolerance to insects, pests, and illnesses, and resistance to climatic issues millets have been nicknamed “smart foods”/ “nutri-cereals”. Millets may be the preferred staple crop in countries where hunger is a problem, according to studies on the nutritional profiles and climate resilience of tiny millets, which have been recognized by the UN-FAO and UN-WFP. Due to the lack of food in unusual circumstances, these areas are severely afflicted by hunger, undernutrition, and untimely deaths. World Food Programme reports that the people experiencing food insecurity will triple as a result of the ongoing outbreak. This highlights the urgent need for agricultural reforms to permanently address the population issue. There doesn’t seem to be food scarcity at the moment given the adequate availability of essentials. But keeping nutritional security is just as important for protecting the well-being of the most vulnerable people. Given this, WFP has emphasized the urgent necessity for mainstreaming millets in the areas of the world most in danger from food shortages and has offered a timeline for doing so. Technological advancements will also be crucial in addressing some of the existing issues facing small millets.For instance, the high-fat content of millet grain causes rancidity when it is stored. To encourage improved shelf-life, the establishment of lines with ideal lipid contents will be crucial. Secondly, significant amounts of antinutrients, such as phytic acid, are present in millet grain, which reduces the bioavailability of nutrients (such as iron intake by the body).

Breeding techniques based on transgenes or genomics-assisted breeding could be used to create elite lines with reduced phytic acid concentration. The identification of genes and novel allelic variants for the discovery of traits and subsequently their use in trait enhancement will be made easier by whole-genome sequencing and resequencing of existing germplasm collections. Utilizing such next-generation genomic methods in neglected crops like millets should be encouraged. Precise editing of pathway genes by the CRISPR / Cas9 approach also helps the production of superior cultivars.

Although accelerated, crop development programmes are not currently used in millets, speed breeding has the potential to shorten breeding cycles and allow the early introduction of varieties. The year 2023 has been declared as the "International Year of Millets" as a result of the UN's acknowledgment of the potential of this crop. By the time, it may be expected that governmental and non-governmental groups' efforts to start or restart millet farming will lead to a rise in millet production. In the event of any future atypical conditions, this could be effective in reducing hunger and malnutrition among the vulnerable population.

Summary and Conclusion

The existing scientific research shows that eating foods high in polyphenols, especially millets, can have a variety of positive effects on one's health. In addition to preventing cancer, millets can help improve general cardiac health and regulate diabetes. With cancer treatments posing a high financial burden, millets are proven to serve as a cost-effective, safe, potential prevention and treatment option. In particular, the polyphenolic compounds present in millets help in preventing proliferation, suppresses the onco genes, and triggers apoptosis thus making it to be a novel, potential, and safe anti-cancer drug candidate. The major composition of polyphenolic compounds is present in the bran of millets, which might get affected during mechanical processing. Consuming whole millets with very minimal processing can be a probable solution for mankind to get benefitted from mighty millets. In addition, millets could help in contributing to Sustainable Development Goals. Thus, the status of millets as poor man's food, its consumption limited to only rural low-income families should be changed and hereon be seen just as "NUTRI CEREALS".

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A PRE-POST INTERVENTION STUDY ON MILLET USAGE AMONG ADULTS (30-50 YEARS) OF KOLKATA AND DEVELOPMENT OF A MULTI-MILLET FLAVOURED RICE

*** SUDESHNA PRAMANIK**
**** RACHAITA JALAN**

Abstract

The people of Kolkata have prevailing rice-based diets which imparts long term health as well as environmental implications, embarking the need for diet supplementation and revival of millets in Eastern India as nutri-cereals to help secure the nation's food and nutrition security. Hence, a pre-intervention survey was carried out using KAP questionnaire to assess the millet consumption pattern of the adult population (N=200) in Kolkata, followed by an awareness program conducted through various audio-visual means. Subsequently nutrient rich multi-millet rice was developed based on the preferences of the respondents and their organoleptic properties were evaluated by 50 semi-trained panel members and acceptance of the developed multi-millet flavoured rice (VF2) scored highest with a mean overall acceptability score of 8.87. The nutrient composition of most accepted variation of multi millet rice was assessed. Eventually a post-intervention survey was carried out to assess the effectiveness of the awareness program.

Keywords*:* Food security, health, millets, nutri-cereal, rice

Introduction

The global scenario is facing agricultural as well as nutritional challenges. The world population is expected to reach 9.1 billion people by 2050. Around 2 billion people in the world suffer from moderate or severe food insecurity. 820 million people suffer from hunger, globally, with India accounting for a quarter of the world's hungry people. Thus, with the aim of 'Zero Hunger' and to fulfil the nutritional needs of the global population and combat malnutrition, there is a crucial need for 'food for all'. (FAO, 2019)

In order to meet the increasing demands, grain production needs to be increased by shifting the focus on dry lands, yet with low fertility, utilization of dry lands to produce sufficient quality grains is a big challenge. (Kumar, 2018)

Further, nutritionally adequate food quality is the most important parameter to maintain human health and complete physical wellbeing. Hence, food diversification must be encouraged both at national and household levels.

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Meanwhile, despite being packed with nutritional and medical properties and India being the largest producer, millets are underutilized and neglected due lower cooking quality, taste and so on. Resolving these problems, they can serve as a valuable food source for poor families to overcome malnutrition and generate income. (Singh E, 2016) Also known as nutri-cereals, they are rich in vitamins, minerals, essential fatty acids, phytochemicals and antioxidants that can help combat the prevalence of nutritional deficiency diseases. Millet cultivation can therefore, keep the dry lands fecund, secure future food and nutritional security. (Turkmen and Velioglu, 2014).

Thus, provided the various benefits of increasing the agricultural diversity and sustainability, reducing the carbon footprint, being climate change compliant with the enrichment of diet with essential micronutrients and altogether contributing to the food security of the nation, millet adaptation is a pressing priority. (Saleh and Zhang, 2013).

The present study aimed to make an approach to enliven this innate wonder by assessing the awareness, knowledge and usage of millets amongst adult respondents (30-50 years) of Kolkata and develop a nutrient rich multi-millet product based on the availability and popularity of the millets in the city and food preferences of the respondents.

Methodology

Pre-Intervention Survey

A survey was conducted using a structured KAP questionnaire, which was pretested via pilot study to check the reliability using a sample of N=50 respondents, aged 30-50 years. Following this, pre-intervention survey using a modified KAP questionnaire was conducted for 200 respondents selected through random sampling from Kolkata.

An awareness program was further conducted on the potential need, health benefits and culinary uses of millets using posters, videos and power point presentation.

Product Development

Based on the pre-intervention survey and the perception of the respondents for rice-based diets, an attempt to develop nutrient rich flavoured multi-millet rice was made

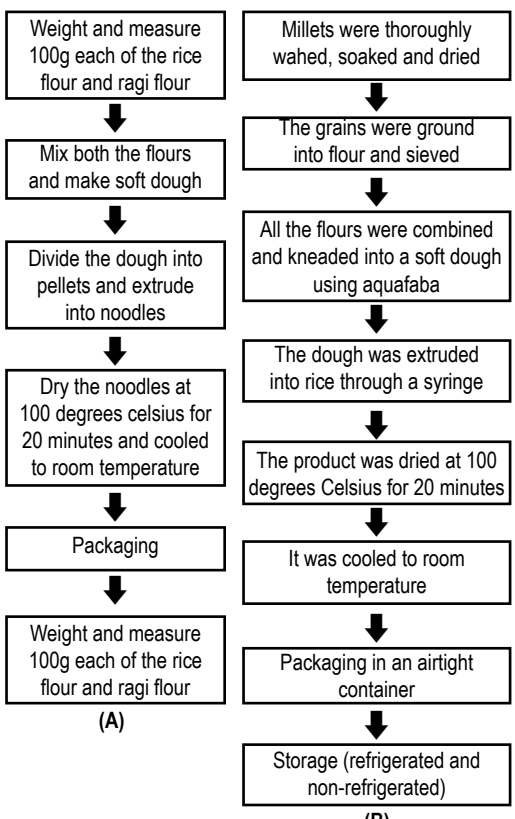


Figure 1: (A) Flowchart for the basic recipe (jayawardena h, 2016);
(B) Flowchart for the developed product

using the three most popularly available millet varieties in the city (Ragi, Jowar and Bajra). The basic recipe for rice-ragi noodles was referred from previous study.

The composition of ingredients in the above-mentioned recipe (Figure 1A and 1B) remains constant with dough variations of basic, sprouted, fermented and flavoured (Table 1). Though the name Multi-Millet rice, the product prepared was completely devoid of rice flour and it only resembled that of grains of rice in terms of shape and size.

The product consisted of soya flour to enhance the protein content and along with aquafaba (egg replacer) it helped in forming a better shape. The prepared product variations were boiled until tender, strained and subjected to sensory analysis which was carried out amongst 50 semi-trained respondents from the survey.

Following this, the nutritive value of the most acceptable flavoured variation (VF2) was calculated using Indian Food Composition Tables and compared with normal parboiled rice owing to the pandemic. The uncooked grains were then subjected to shelf-life testing in two ambient conditions of refrigerated and non-refrigerated for 5 months and the colour, appearance, texture and odour was monitored at an interval of 15 days. The costing for the best credited product was also taken into consideration.

Table 1. Composition of developed Multi- Millet Rice

Code	Description	Ingredients & Amounts						
		Rice Flour	Finger Millet	Foxtail Millet Flour	Sorghum Flour	Soybean Flour	Aquafaba (Egg-Flour	Flavour replacer)
B	Basic	100g	100g	-	-	-	-	-
V1	Multi Millet Rice	-	50g	50g	50g	50g	50ml	-
V2	Sprouted Multi- Millet Rice	-	50g	50g	50g	50g	50ml	-
V3	Sprouted and Fermented Multi-Millet Rice	-	50g	50g	50g	50g	50ml	-
VF1	Best out of V1/V2/V3	-	50g	50g	50g	50g	50ml	Asafoetida (2.5 g)
VF2	Best out of V1/V2/V3	-	50g	50g	50g	50g	50ml	Lemon Zest Powder (2.5 g) + Coriander Leaf Powder (5 g)

Post Intervention Survey

A post- intervention survey was conducted after 6 weeks of conducting the awareness program using the same pre-intervention questionnaire and the survey respondents to reassess the millet consumption pattern of the respondents and check the effectiveness of the awareness generation.

Data Analysis

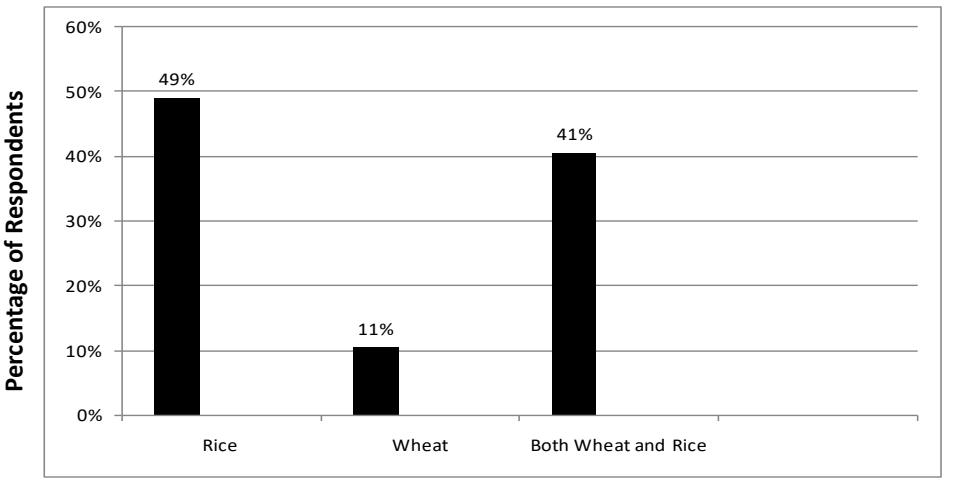
The data obtained from Pre-Post Intervention and Sensory Evaluation was analysed using statistical tools like t-test, paired sample test, regression and correlation and represented in the form of tables, graphs and figures.

RESULTS AND DISCUSSION

Pre-Intervention Survey

The knowledge section of the questionnaire assessed the preferred cereal grain amongst the respondents and the various reasons for consuming it. It notably depicted the prevailing rice-based diets amongst the surveyed population. An extremely adamant factor was habit and family tradition followed by a combination of multiple factors like price and easy accessibility. A consideration of rice being healthy and its predominant taste also affected their preferred choice moderately as seen in Graph 1.

Taste, cost, traditions, culture and geographical locations can influence food choices of people. A food choice is closely connected to the cultural and traditional practices of people. The ingredients and methods of preparation, preservation techniques and food types consumed vary with culture, the geographical location, and also the ancestral origin. (Berkman, 2015) Taste is a major influencer of food behaviour and is referred to as the sum of all the sensory stimulation produced by the ingestion of



Graph 1. **Preferred Staple**

Table 2. Regression Analysis of staple preferences and the reasons for consumption

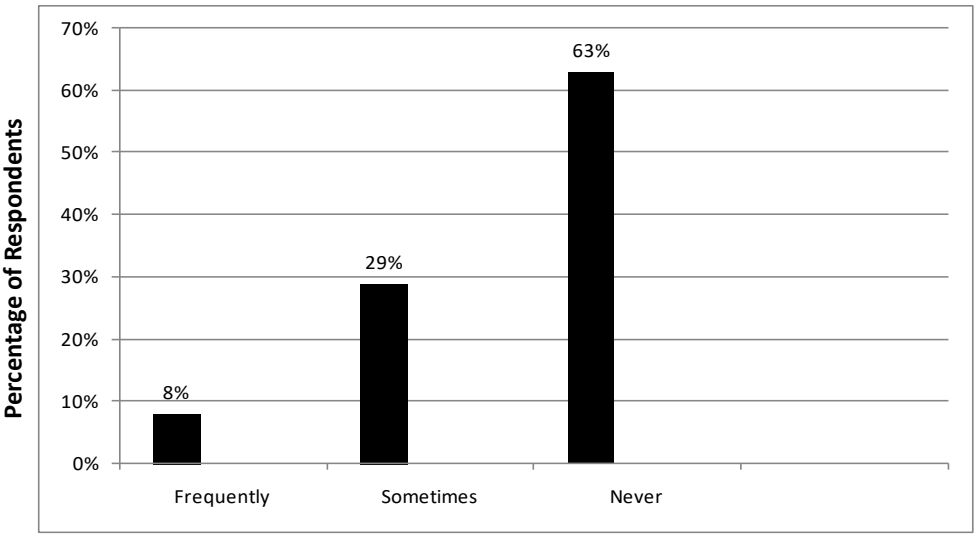
	Coefficients	Standard Error	t-Statistic	P-value
Intercept	0.497	0.058	8.580	0.000
X Variable 1	0.441	0.015	28.503	0.000

Y= 0.441 X + 0.497

a food. Development of a particular taste profile is an innate trait, present from birth. Preferences and aversions develop through experiences and are influenced by our traditions, beliefs, attitudes and expectations. (Sorensen, 2013). Food cost is a primary determinant affecting one's food choices. It truly depends upon a person's income and socio-economic status. (Eestevez and Shulman, 2018).

Table 2 stipulates a linear dependency of the staple preference (Y) of respondents over the factors affecting it (X), that is, both X and Y change linearly and in proportion. The data was scrutinized using ANOVA the result of which showed p-value < 0.05, indicating a significant relationship between the selection and the reasons for consuming the preferred staple.

A notable 63% of the respondents were seen to have never consumed millets (Graph 2). Of those, a striking number had not even come across the term "Millets". Moreover, all they were found to have known is the 'pigeon feed' available in local shops. The most predominant reason behind the low millet consumption was found to be the unawareness of the goodness of these forgotten coarse grains, followed by taste factor and the tradition of millets being used as a bird feed. Apart from a few, the respondents did not seem to be acquainted with the array



Graph 2. **Frequency of Millet Consumption**

of innovative culinary applications they could explore and reap all the nutritional healthfulness hidden in these grains.

A high positive assent was shown on the curiosity and the willingness to try out millet products when compatible with affordability and if made available in a different flavour and taste.

Sensory Evaluation

The sensory attributes of foods are widely considered to be the most important determinant of acceptability. (Miller and Lyon, 2011) Based on the 9-point hedonic scale, Product V2 was prepared with two varieties of flavours and VF2 with a mean overall acceptability score of 8.87 was finalised as the best product (Table 3).

The hedonic score for the "appearance attribute" was the highest for VF2 at 8.34. The presence of colour is ubiquitous and the initial interaction with food largely affects one's appetite. (Sraiheen, 2018).

The odour factor was extremely appreciable at mean score of 8.89 for the VF2 variation due to the addition of lemon zest powder and coriander leaf powder which imparted an outburst of freshness into the product. The d-limonene compound concentrated in the lemon peel is known for its pleasant odour and food preservation attributes (Vieira, 2018). The purpose behind adding flavours was to mask the off flavour of ragi and soyabean flours.

The highly acceptable odour enhanced the taste and flavour attributes of VF2 as well, with a hedonic mean score of 8.78 and 8.9, respectively. Along with the freshness of lemon, coriander leaf further imparts an earthy and citrus like flavour to the product. The variation also incorporates a combination of germinated millet flours. Germination has been known to improve the functional properties of cereals and pulses. The breakdown of high molecular weight polymers during the process of germination

Table 3. Mean and Standard Deviation (SD) of Sensory Attributes

	Sensory parameters						
	Appearance	Colour	Odour	Flavour	Taste	Texture	Overall Acceptability
Control (Parboiled Rice)	7	7.88	7.1	8	7.9	8	7.88
V1	7	7	6	6.24	6.6	6.26	5.72
V2	8.28	8.02	7.32	8.14	8	8.18	8.1
V3	6.78	6.76	5.84	7.02	7.02	6.44	7.4
VF1	8.01	8.3	8	8.51	7.99	7.8	8.1
VF2	8.34	8.6	8.89	8.9	8.78	8.03	8.87
Mean ± SD	7.56 ± 0.71	7.76 ± 0.72	7.19 ± 1.16	7.80 ± 0.99	7.7 ± 0.78	7.45 ± 0.86	7.6 ± 1.07

Table 4. Nutritional Comparison of 100gms of Multi-Millet Rice (VF2) and Parboiled Rice (Control)

Nutrient	Multi-Millet Rice (VF2)	Parboiled Rice
Protein (g)	32.72	7.81
Fat (g)	3.55	0.55
Carbohydrate (g)	104.65	77.16
Energy (kcal)	494	352
Iron (mg)	11.76	0.72
Calcium (mg)	33.18	8.11
Vitamin C (mg)	1.79	-

causes the generation of bio-functional substances. This leads to softening of the texture and an increase in the flavour of cereals, thus improving their organoleptic qualities. (Tyler and Stone, 2014).

Nutritive Analysis, Product Costing and Shelf-life Testing

Nutritive value (Table 4) of 100 g of multi millet rice when compared with 100 g of normal parboiled rice (control) was found to be superior.

Also, Value for money is the most important factor that affects a consumer's buying attitude. Therefore, priced per kg at Rs. 27.95/- the developed Millet rice (VF2) serves as a great supplementation to the parboiled rice which costs approximately around Rs. 50/- depending upon variety.

Table 5. Paired t-test for Pre and Post Intervention Survey

	Pre-intervention	Post- intervention
MEAN	122.7142857	183.2857143
SD	35.8781005	11.11626864
t- test	-4.26661	
p test	.000547.	

The shelf life testing too displayed promising results. After 5 months of storage, both the refrigerated and non-refrigerated versions showed no change in the sensory attributes namely colour, appearance, texture and odour. This is possibly because of the low moisture content of the product attributed to the dehydration process which was carried out before storage. Using the principle of heat and mass transfer, it helps lower the food moisture content by adding one or more forms of energy and render an improved shelf life. (Digvir, 2016) Cooling is also known to preserve colour and the storability of food grains. Low temperature storage below 5 degrees Celsius prevents food spoilage and the growth of microorganisms, activity of enzymes and purely chemical reactions. (Erkmen, 2016) Further, the d-limonene compound of lemon is known for its anti-microbial properties. At a concentration of 1 gm, limonene has been shown to inhibit the growth of *Salmonella seftenberg, Escherichia coli, Staphylococcus aureus* and *Pseudomonas* species. It also keeps grain weevils at bay. This has been attributed to its ability of penetrating into their respiratory system, digestive system and the cuticle. (Erasto and Viljoen, 2011) Studies show that grains stored properly in airtight containers keep up well for over 6 months in a cool, dry place and for over a year when refrigerated. (Prabhutas, 2012)

Post Intervention survey

Post the awareness program a survey was conducted with a gap of 6 weeks and the data obtained from pre and post intervention

was compared and the effectiveness of the study was hypothetically tested via t-test and paired sample test.

Since, the p-value is < 0.05 as seen in Table 5, thus, there was a significant difference seen between the responses of Pre and Post Intervention Survey, indicating that the awareness program was effectual in generating awareness, imparting knowledge and acclimate the surveyed population to take up sustainable diet consciously and nitrify their health and well-being with millets.

Conclusion

The findings from the present study on intervention proved to be successful in generating awareness, changing the attitude of people towards millets and creating willingness amongst the respondents for usage of the age-old goodness in diet supplementation to help reap its benefits. After getting enlightened on the various uses and health benefits of the nutri-cereals through the various awareness sessions, an appreciable level of knowledge on the coarse grains was witnessed through the post intervention survey. The respondents were better informed of the types, availability and various disease fighting properties of millets.

Further, a new colour with a refreshing flavour infused in the grain was found to be a fascinating attribute of the developed product which held up the attempt to remodel the rice eating perception of the respondents. Finally, resultant effectiveness of enriching their diets with millet consumption amongst the respondents in successful weight and health management enabled them to cling on to their diet intervention.

The study however, suffered a few drawbacks as the product could not be developed via a commercial extruder on account of its inaccessibility during the ongoing pandemic scenario. A detailed physico-chemical and biochemical analysis and market survey of the developed product could not be carried out as well for the same reason.

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