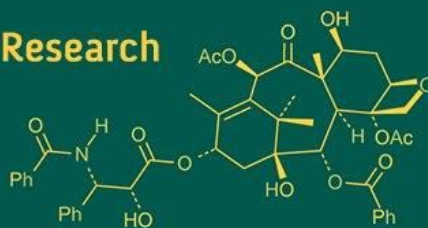


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Nutritional quality and safety assessment of millet based edible cutleries

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Abstract

Millet is a major food source in arid and semi-arid parts of the world. Millets are nutritionally rich and superior to cereals. This study was undertaken to evaluate millet based edible cutleries for nutritional quality and food safety properties. Proximate of WFF (white finger millet flour) had notably higher protein content (12.48g) compared to the other products, while LMF (Little millet Flour) had higher fat (4.9g) and FMF (Finger Millet Flour) had more crude fiber (7.69g) content. Additionally, Control had higher moisture (8.71) and carbohydrate (79.13) contents compared to the other products. Mineral compounds in millet flours indicated that, FMF had the highest amount of phosphorus (290.4), while WFF had the highest amount of potassium (413.9 mg), magnesium (144.06 mg), iron (13.63mg), manganese (6.4 mg) and calcium (363.66 mg). Sodium content was highest in Refined wheat flour (17.7 mg) and zinc content was highest in LMF (4.13) compared to other flours. Proximate components of millet-based edible cutleries revealed that highest moisture (4.08g), fat (7.19g) and fiber (8.79g) contents found in LMEC. Highest ash (2.58g) and protein (8.05g) were demonstrated by WREC. Refined wheat flour-based edible cutleries showed more carbohydrates (78.07g) and energy compared to millet-based edible cutleries. Mineral compounds in edible cutleries recorded higher phosphorus (45.1mg) but Magnesium (1.73mg) Iron (9.03mg) and Calcium were recorded higher in WFEC (267.6mg) compared to other types. Sodium was highest in Control cutleries (1.06mg). Increased value of Zinc was observed in LMEC (1.49mg). The highest free fatty acid content has noted in the FMEC stored both aluminium silver foil (0.49 mEq O₂/kg) and MPP (0.42 mEq O₂/kg) packaging material at 90th day of storage period. There was no growth of total bacteria count was observed up to the 50th day of storage in aluminium silver foil packaging material. overall study suggested that millet-based cutleries were nutritionally rich and safe for consumption. Hence it could be used as an alternative to plastic cups and bowls to serve food products.

Keywords: Millets, edible cutlery, proximate composition, macro and micro minerals

Introduction

Millet is a major source of human food in arid and semi-arid parts of the world, and their production has been steadily increasing in the last decades to meet the dietary requirements of the increasing world population. Millets are nutritionally rich and occupy an important place in the diet of people in many regions of the world. India is top producer of millets but still lack in consumption of millets. Millet are the set of complete nutrients, hence provide nutritional security (Kulkarni *et al.*, 2018) [11]. The world's total production of millet grain was 7, 62, 712 metric tonnes and India tops the ranking with a production of 173 lakh tonnes in 2020-21 (FAO 2021) [5]. India dominates the global production of millets with a total share of about 40.62 per cent and an estimated production of about 10.91 million tonnes during 2018–2019 (Ashoka *et al.*, 2020) [2]. Millets are an excellent source of all essential nutrients. It is the good energy source because it provides good protein, mineral, fatty acid, vitamins, dietary fiber and polyphenols and bioactive compounds. However, the nutrients, bioactive compounds and functions of cereal grains can be influenced by the food preparation techniques such as decortications/dehulling, soaking, germination/malting, milling and fermentation (Yousaf *et al.*, 2021) [19]. Due to high nutritional value and functional properties, the cultivation of millet got increased as well as the value-added product comes into the market circle (Mohamed *et al.* 2012) [12]. Value addition of millets through some processing technique makes the commercialization of millet traditional and convenience foods

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foods including ready to eat products. Product developed from millets can promote millet utilization as food for a growing population (Kulkarni *et al.*, 2018) ^[11]. It gives so many health benefits like it serves as a prebiotic, probiotic and antioxidant hence safe for gluten allergy and celiac disease patients.

Daily utilization of plastic products has several beyond-description losses like air pollution caused by incinerating plastic, pollution of the marine environment and micro plastics damaging internal organs of animals and indirectly harming humans by consuming the sea-food, meat and other products which rife with micro-plastic (Roy *et al.* 2022) ^[13]. The edible cutlery has qualities like biodegradability, eco-friendliness, and edibility. It can be used in ice creams, hot beverages, salads and sweets like gulab jamun and rasmalai also during conflicts and at disaster-prone places where food is scarce owing to a lack of resources, edible cutlery can be offered. Because, it is good in calories and nearly fat-free and diet-friendly. It consists of several nutritional content-like vitamins B₁, B₂, B₃, B₉, vitamin E and minerals like iron (Fe), and calcium (Ca). They are also a good source of energy with the nutritional supplement. So, cutlery can help to change the system of unhealthiness into a better lifestyle by minimizing the plastic.

There is successful outcome attributes which can expand the spectrum for millet grain applications. Edible cutlery that is available currently is durable to consume any type of food like hot soups to bhel puri, salads to ice-cream, it does not wear down easily. They also believe that it is a matter of time that the doubt of durability may also minimize. While edible cutleries have gained popularity, it is essential to address their limitations, such as their relatively short lifespan before becoming soggy. It is pertinent to mention that not much work has been done on the preparation of edible containers using the millet crops and other ingredients. In the proposed research paper, edible containers were made out of White Finger millet, little millets and Foxtail millet. It is essential to address their limitations by analysing the nutritive value of the developed various types of millet based edible cutleries.

Materials and Methods

Procurement of Raw Materials

White finger millet, little millet, foxtail millet, wheat flour, rice flour, sorghum flour, sugar, margarine, milk powder, salt, vanilla essence, guar gum and packaging materials such as Metalized Polyester Polyethylene (MPP) and aluminum silver foil packaging materials were procured from local market of Bangalore.

Processing of raw materials

The procured millets such as white finger millet, little millet, foxtail millet grains were subjected to manual cleaning, washing in potable cold water to remove dust and other foreign materials. Cleaned and dried grains were ground in a commercial food processing pulverizer and passed through BS 40 mesh sieve to get a fine and uniform flour.

Formulation and Preparation of Millet based Edible Cutleries

The control edible cutlery was prepared by following a method mentioned according to Rajendran *et al.* (2020) ^[14] with slight modifications. The ingredients like, refined

wheat flour, rice flour, wheat flour, sugar, margarine, corn starch, xanthan gum, milk powder, sorghum flour, salt and vanilla essence were mixed together by adding 10ml of water. All the ingredients were mixed well and kneaded to form soft dough. The dough was allowed to rest for 10minute. Later the soft dough is spread to make a sheet of thickness 2.5mm. The prepared soft dough sheet was cut into round shape using cutlery cutter followed by moulding. The prepared soft dough moulds were baked in baking oven at temperature of 140 °C for 45 minutes. After baking the cutlery was allowed to cool naturally. The cooled cutlery was packed airtight and preserved for further study (Table1). Four formulations were standardized by incorporating 40 percent of refined Wheat flour (RWF) and millet flours like White Finger Millet Flour (WFMF), Little millet flour (LMF), and Foxtail Millet Flour (FMF) to develop different millet based edible cutleries (Control, WFEC, LMEC and FMEC).

Table 1: Formulation of millet based edible cutleries

Ingredients (g)	Control	WFEC	LMEC	FMEC
Flour	40	40	40	40
Rice Flour	1	1	1	1
Wheat Flour	20	20	20	20
Sorghum	15	15	15	15
Other ingredients (Fat, gum, starch, sugar, Salt, essence)	24	24	24	24
Total	100	100	100	100

Nutrient analysis of best accepted white finger millet, little millet and foxtail millet based edible cutleries

White finger millet, little millet and foxtail millet flour-based millet based edible cutleries were powdered and sieved through 40 meshes and stored in airtight stainless steel containers. Analysis was done for the nutrients such as moisture, protein, fat, crude fibre, ash and minerals by using standard procedure, carbohydrate was calculated by difference method and energy was computed. Results were expressed on a dry weight basis.

Estimation of moisture (AOAC, 2005)

Moisture content was determined by taking approximately 10 g of powdered sample in a moisture cup and drying in an oven at 105 °C till the weight of the moisture cup with its content was constant. After removing from the oven, before weighing the moisture cup, the sample was cooled in a desiccator. The moisture content of the sample was expressed in per cent.

$$\text{Moisture(\%)} = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

Where,

W₁= Initial weight of the empty crucible

W₂ = Weight of crucible + food sample before drying

W₃=Final weight of crucible + food sample after drying

%Total solids (Dry matter) =100 -% Moisture

Estimation of protein (AOAC, 2005)

The protein content of the dried samples was estimated as per cent total nitrogen by the Micro - Kjeldhal procedure. Protein per cent was calculated by multiplying the per cent nitrogen by the factor 6.25.

$$\text{Protein per cent} = \frac{(\text{Titre value} - \text{Blank}) \times \text{Normality of HCl} \times 14.007 \times 6.25}{\text{Sample weight(g)}} \times 100$$

Estimation of fat (AOAC, 2005)

Fat content was estimated in a dry sample following the removal of moisture. The procedure involves an 8-hour extraction of an accurately weighed dry sample (5 g) in a Soxhlet apparatus. The solvent ether of the fat extract obtained was evaporated to dryness and the residue was further dried in an oven at 70-80 °C. Cooled in a desiccator and finally weighed accurately. The fat content is expressed as g/100 g.

$$\text{Fat content(\%)} = \frac{\text{Weight of ether extract (g)}}{\text{Weight of the sample (g)}} \times 100$$

Estimation of crude fiber (AOAC, 2005)

Fat free edible cutlery samples were hydrolyzed with dilute sulphuric acid and dilute alkali to estimate crude fiber.

$$\text{Crude fibre} \left(\frac{\text{g}}{100\text{g sample}} \right) = \frac{100 - (\text{moisture} + \text{fat}) \times (\text{We} - \text{Wa})}{\text{Wt. of a sample taken (moisture and fat free)}}$$

Computation of carbohydrates (g)

The total carbohydrate content of millet based edible cutlery was calculated by difference method.

$$\text{CHO (g/100g)} = 100 - [\text{Protein (g)} + \text{Fat (g)} + \text{Fibre (g)} + \text{Ash (g)} + \text{Moisture (g)}]$$

Computation of energy (Kcal/100 g)

The energy was calculated using the computed method

$$\text{Energy (Kcal)} = [\text{Protein (g)} \times 4] + [\text{Carbohydrate (g)} \times 4] + [\text{Fat (g)} \times 9]$$

Estimation of ash (AOAC, 2005)

Total ash was estimated by taking about 5 to 10g of the powdered edible cutlery sample was weighed accurately into previously ignited, cooled and weighed crucible. That was heated gently over the burner until the food was charred. The crucible was transferred to a muffle furnace at about 600 °C and left until a white or light grey ash resulted.

$$\text{Ash content(\%)} = \frac{\text{Weight of the ash (g)}}{\text{Weight of the sample (g)}} \times 100$$

Preparation of mineral sample

The mineral solution was prepared by dissolving the ash obtained after ashing, the sample in a muffle furnace and the ash was mixed with dilute hydrochloric acid.

Estimation of calcium (AOAC, 2005)

The calcium content was estimated by precipitating it as calcium oxalate and titrating it against the solution of oxalate in dilute acid against standard potassium permanganate

Estimation of Magnesium (AOAC, 1980)

The magnesium content of the sample was calculated by preparing a mineral solution and titrated against 0.01N EDTA in the presence of buffer and then subtracting this titre value from the titre value of calcium.

$$\text{Mg + Ca(\%)} = \frac{\text{T. V for Mg + Ca} \times \text{N. of EDTA} \times 0.02 \times \text{Vol. of dig. sample}}{\text{Aliquot took} \times \text{weight of sample}} \times 100$$

Estimation of iron (AOAC, 2005)

The iron was estimated using an Atomic Absorption Spectrophotometer (AAS).

Estimation of Sodium (AOAC, 1980)

Feed the digested sample solution to the Flame photometer and record the reading (if dilution is required, it should be done before feeding to the instrument). Compare the unknown sample readings with the standard curve to determine the per cent Na in the sample.

$$\text{Na(\%)} = \frac{\text{Graph ppm} \times \text{Vol. of digested sample} \times \text{Vol. made up}}{\text{weight of sample} \times \text{Aliquot taken for dilution}} \times 106$$

Estimation of Phosphorous (AOAC, 1980)

The phosphorus in the aliquot of the digested sample was measured in the presence of vanadium (V5+) and molybdenum (Mo6+). Orthophosphate forms a yellow colored "Phospho Vanado Molybdate" complex which was read using a spectrophotometer at 430 nm.

$$\text{Potassium (mg /100g)} = \frac{\text{Graph ppm} \times \text{volume of digested sample}}{106 \times \text{aliquot taken} \times \text{weight of sample}} \times 100 \times \text{dilution}$$

Estimation of Zinc (AOAC, 1980)

Suitable dilutions of di acid extract and feed standard/sample to atomic absorption spectrophotometer having appropriate hollow cathode lamps. Values were recorded and plotted on graph paper.

$$\text{Micro nutrient conc (ppm)} = \frac{\text{Graph ppm} \times \text{volume of sample digested}}{\text{weight of sample}} \times 100$$

Estimation of Potassium (AOAC, 1980)

Potassium was estimated using flame photometer. The Potassium content of the edible cutlery sample was estimated from standard curve with standard sodium solution (range 0 to 150 ppm solution).

Potassium (mg /100) = Graph ppm × volume of digested sample × dilution if any × 100

Weight of the sample × 10₆

$$\text{Potassium (mg /100)} = \frac{\text{Graph ppm} \times \text{volume of digested sample} \times \text{dilution if any} \times 100}{\text{Weight of the sample} \times 10^6}$$

Shelf-life study of best accepted millet based edible cutleries

The products were stored for up to 90 days at ambient temperature. Two types of packaging materials were used. Each product was stored in aluminium silver foil and metalized polyester polyethylene (MPP) was kept in ambient condition. The products were evaluated for their organoleptic acceptability, quality parameters (moisture, free fatty acid peroxide and value texture analysis) and total microbial load at 7 days interval of three-month duration.

Peroxide value

In the oxidative rancidity, oxidation of fat due to the combination of oxygen with unsaturated fatty acids takes place and results in the formation of compounds with a peroxide structure.

$$\text{Peroxide value of oil (mEqO}_2\text{/kg)} = \frac{(\text{Titre} - \text{blank}) \times \text{N} \times 1000}{\text{Wt. of oil (g)}}$$

Free fatty acid

Free fatty acid content of the sample was determined according to the AOAC, 2005 method. The percentage of free fatty acids was calculated using oleic acid as a factor and expressed per cent of oleic acid/100 g of sample.

Microbial analysis of best accepted white finger millet, little millet and foxtail millet based edible cutleries

All products were stored for a period of three months in aluminium silver foil and metalized polyester polyethylene pouches under ambient conditions. Initial packing was done at 0th day and after 30 days of interval for up to 3 months. Products were tested for total bacterial and fungal counts. The media used was nutrient agar (NA), Martin Rose Bengal Agar (MRBA) and Eosin methylene blue agar (EMB). It was carried out by serial dilution and pour plate method.

Statistical analysis

The data was tabulated and analyzed by keeping in view of

the objectives and parameters of the study. All the analyses were performed in triplicate and the data was analyzed using excel.

Results and Discussion

Proximate composition of refined wheat flour, white finger millet flour, little millet flour and foxtail millet flour edible cutleries

Table 1 shows the moisture content ranges from 8.11±0.25 g to 9.17±0.30 g for all flours. Ash content exhibits notable variations, with WFF displaying the highest ash content at 2.47±0.11 g. Fat content varies from 1.73±0.14 g in control to 4.9±0.2 g in LMF. Crude fiber is highest in FMF at 7.69±0.17 g. Protein content ranges from 10.59±0.14 g in control to 12.48±0.34 g in WRF. Carbohydrate content varies, with control having the highest at 79.13±0.32 g. Energy content ranges from 339.13±0.8 Kcal to 367.53±0.55 Kcal across the flours.

Table 1: Proximate composition of different flours

Nutrients	Control	WFF	LMF	FMF	F-value	SEm±	CD at 5%
Moisture (g)	8.71±0.55	9.17±0.30	8.11±0.25	8.21±0.10	*	0.10	0.34
Ash (g)	1.21±0.10	2.47±0.11	2.37±0.06	1.72±0.03	*	0.50	0.23
Fat (g)	1.73±0.14	1.77±0.06	4.90±0.20	3.83±0.06	*	0.07	0.24
Crude fiber (g)	1.13±0.06	4.87±0.06	7.27±0.15	7.69±0.17	*	0.07	0.23
Protein (g)	10.59±0.14	12.48±0.34	10.72±0.10	11.65±0.16	*	0.12	0.39
#CHO (g)	79.13±0.32	68.5±0.87	66.46±0.40	64.34±0.15	*	0.29	0.98
##Energy (Kcal)	367.53±0.55	341.99±1.17	358.47±0.74	339.13±0.80	*	0.49	1.63

Control- Refined wheat flour, WFF-White finger millet flour, LMF-Little millet flour, FMF-Foxtail millet flour

By difference, ## By computation

Values expressed as Mean ±SD *Significant ($P<0.05$)

NS - Non significant, Values are mean of triplicates

Hazra and Sontakke (2023) [7] examined the proximate composition of Indian Ginseng induced edible cutlery of 3 different formulations *i.e.*, S₀ (refined wheat flour edible cutleries), S₃ (3% ginseng powder), S₄ (4% ginseng powder). Here (4% ginseng powder) showed more ash (2.53%), fat (1.68%) and crude fiber (2.60%) content compared to S₀ (refined wheat flour edible cutleries) and S₃ (3% ginseng powder). These findings were comparable with present findings related to control and WFF. Higher values when compared to LMF and FMF.

Millet is reported to be sustainable in adverse climatic situation and it considered being a source of macro and micro nutrients (Ushakumari, Latha *et al.* 2004) [18]

Mineral composition of refined wheat flour, white finger millet flour, little millet flour and foxtail millet flour

Table 2 showed mineral content of white finger millet, little millet and foxtail millet flour. White finger millet and little millet flour, compare to other flours. These variations can

have implications for dietary choices and nutritional value, making it essential to consider these differences when selecting flours for specific dietary or nutritional needs.

Different types of flour have varying mineral content. FMF has the highest amount of phosphorus (290.4), while WRF has the highest amount of potassium (413.9 mg), magnesium (144.06 mg), iron (13.63mg), manganese (6.4 mg) and calcium (363.66 mg). Sodium content is highest in control (17.7 mg) and zinc content is highest in LMF (4.13) compared to other flours.

Meherunnahar *et al.* analyzed the nutrient composition of foxtail millet flour and compared with the rice, wheat and maize flour. The result indicated that the foxtail millet had higher amount of energy and fat (382.01 kcal, 5.01g) compared to other cereals. The protein content of foxtail millet was 9.06 per cent while rice, wheat and maize flour has 10.39, 6.31 and 6.68 per cent and iron, copper, phosphorous content of foxtail millet was found to be 7.01, 1.43, 595.12 mg respectively.

Table 2: Mineral composition of control, white finger millet, little millet and foxtail millet flours

Minerals (mg/100g)	Control	WRF	LMF	FMF	F-value	SEm±	CD at 5%
Phosphorous	135.47±0.55	148.2±0.87	219.9±1.55	290.4±1.2	*	0.64	2.12
Potassium	242.5±0.64	413.9±1.70	126.5±0.60	251.7±0.6	*	0.58	1.93
Magnesium	98.06±0.95	144.06±1.80	131.3±1.60	81.9±0.78	*	0.77	2.55
Calcium	24.06±0.85	363.66±2.41	27.5±0.40	40.16±1.01	*	0.80	2.66
Sodium	17.70±0.66	12.50±0.51	8.70±0.30	5.20±0.43	*	0.28	0.95
Zinc	2.73±0.07	2.80±0.26	4.13±0.40	3.33±0.37	*	0.17	0.59
Iron	3.93±0.15	13.63±0.25	9.77±0.32	4.03±0.20	*	0.13	0.46
Manganese	1.87±0.04	6.40±0.30	1.16±0.22	0.73±0.02	*	0.10	0.36

Control- Refined wheat flour, WRF-White finger millet flour, LMF-Little millet flour, FMF-Foxtail millet flour * Significant

Proximate composition of developed edible cutleries

Table 3 represents different types of millet-based edible cutleries have varying moisture content (highest in LMEC of 4.08 g and lowest in WFEC 3.21 g), ash content (highest in WFEC of 2.58 g and lowest in LMEC of 1.57 g), fat content (highest in LMEC of 7.19 g and lowest in control of 4.04 g), fiber content (highest in LFMEC of 8.79g and lowest in Control of 1.66 g), protein content (highest in WFEC of 8.05g and lowest in Control of 2.77g and refined

wheat based edible cutleries provide more carbohydrates (78.07 g) and energy compared to millet-based edible cutleries. This statement is likely true because refined wheat flour which is refined wheat flour edible cutleries, is primarily composed of carbohydrates and provides a higher energy yield compared to whole millet-based products. All the sensory attributes results were observed for all the sensory attributes expect texture, refined wheat flour scored better and statically significant.

Table 3: Nutrient content among different millet based edible cutleries

Nutrients	Control	WFEC	LMEC	FMEC	F-value	S.Em±	CD at 5%
Moisture(g)	4.04±0.12	3.21±0.09	4.08±0.07	3.91±0.09	*	0.05	0.18
Ash(g)	1.59±0.09	2.58±0.08	1.57±0.06	1.81±0.08	*	0.04	0.14
Fat(g)	4.04±0.06	4.16±0.11	7.19±0.17	5.95±0.05	*	0.06	0.21
Fiber(g)	1.66±0.21	5.30±0.30	8.47±0.40	8.79±0.18	*	0.16	0.54
Protein(g)	2.77±0.04	8.05±0.13	5.33±0.15	7.57±0.06	*	0.06	0.20
CHO(g)	78.07±1.71	71.27±1.16	77.57±0.66	78.10±0.10	*	0.63	2.08
Energy(Kcal)	387.3±0.81	357.9±0.15	374.3±4.9	373.4±1.01	*	1.48	4.91

Control -Refined wheat flour edible cutleries, WFEC- White finger millet edible cutleries, LMEC- Little millet edible cutleries, FMEC- Foxtail millet edible cutleries

Values expressed as Mean ±SD,*Significant ($P < 0.05$)

The findings of the present study were on par with observation reported by Iqbal *et al.*, 2022^[9]. They prepared edible cutleries which was found to contain 2.68 per cent, 1.75 per cent, 1.82 per cent 4.7 per cent and 0.8 per cent of moisture, ash, crude fat, crude protein and crude fiber respectively. The energy value was obtained as 334.4 kcal/100 gram of the sample. significant at 5%, NS - Non significant, Values are mean of triplicates.

Jan *et al.* (2022)^[10] reported the foxtail millet was found to be a rich source of nutritional components. Moisture, fat, fiber, ash, protein and carbohydrates content of foxtail millet, which was found to be 7.30, 4.20, 7.57, 2.67, 12.38 and 65.89 per cent respectively. Which was lower than my present finding i.e., (3.91, 5.95., 8.79, 1.81, 7.57) g and

78.1(kcal) respectively.

Food quality can be maintained by maintaining less moisture content in the food commodities; that will reduce the deterioration of food by decreasing microbial growth. There was a significant decrease in fat content during storage. The decrease in fat content during storage might be due to lipolytic activity in the products. Similar results were reported by Butt *et al.* (2014)^[4].

Mineral composition of developed edible cutleries

Table 4 showed that different flour based edible cutleries vary significantly in their mineral content with white finger millet, little millet and foxtail millet flour edible cutleries often having the highest mineral concentrations.

Table 4: Mineral composition of different millet based edible cutleries

Minerals ((mg/100 g)	Control	WFEC	LMEC	FMEC	F-value	S.Em±	CD at 5%
Phosphorous	32.30±1.30	45.1±1.05	21.63±0.35	3.64±0.13	*	0.49	1.63
Magnesium	11.60±0.37	31.73±0.25	28.26±0.94	10.41±0.26	*	0.31	1.02
Calcium	18.10±0.17	267.6±0.56	24.5±0.39	31.86±0.65	*	0.27	0.91
Sodium	1.06±0.20	0.80±0.02	0.76±0.06	0.87±0.03	*	0.18	0.61
Zinc	0.44±0.30	0.48±0.015	1.49±0.00	0.05±0.06	*	0.09	0.31
Iron	1.55±0.27	9.03±0.15	5.62±0.45	1.63±0.24	*	0.17	0.57

Control -Refined wheat flour edible cutleries, WFEC- White finger millet edible cutleries, LMEC- Little millet edible cutleries, FMEC- Foxtail millet edible cutleries

Values expressed as Mean ±SD,*Significant ($P < 0.05$)

White finger millet based edible cutleries had higher phosphorus content (45.1mg) while foxtail millet based edible cutlery has the lowest phosphorus (3.64mg). Magnesium was highest in white finger millet based cutleries (1.73mg) and lowest in foxtail millet based cutleries (10.41mg). Calcium was significantly higher in white finger millet based cutleries (267.6mg) compared to other types. Sodium was highest in refined wheat flour edible based cutleries (1.06mg). Zinc was highest in little millet based cutleries (1.49mg) and lowest in foxtail millet based cutleries (0.051mg). Iron was highest in white finger millet based edible cutleries (9.03mg) and lowest in refined wheat flour based edible cutleries (1.55 mg).

Itagi *et al.* (2003)^[8] revealed that, little millet (*Panicum miliare*) is nutritious and has a significant role in providing nutraceutical components such as phenols, tannins and phytates along with macro and micro-nutrients. It contains protein (7.70 to 16.50%), fat (2.45 to 9.04%), carbohydrates (62.50 to 76.30%), an excellent source of dietary fibre (15.90 to 18.10%) with good amount of soluble (3.15 to 5.70%) and insoluble fractions (10.20 to 14.95%). Besides, it also contains appreciable amounts of minerals such as iron (9.30 to 20.00 mg/100 g), magnesium (133 mg/100 g) and zinc (3.70 mg/100 g), exhibited hypoglycaemic, hypolipidemic effects and faecal bulking effects.

Effect of storage on sensory characteristics of developed millet based edible cutleries stored in different packaging material

Effect of storage on sensory quality of best accepted refined wheat flour, white finger millet, little millet and foxtail millet edible cutleries are depicted. The sensory characteristics of the best accepted refined wheat flour, white finger millet, little millet and foxtail millet edible cutleries on storage period (0th, 30th, 60th and 90th day) at room temperature were assessed by semi trained panelists.

Mean sensory scores for the appearance of developed millet based edible cutleries during storage period

The mean sensory scores for appearance of edible cutleries prepared from refined wheat flour, white finger millet flour, little millet flour and foxtail millet flour edible cutleries at regular intervals during 90 days at ambient temperature is depicted in Table 5. From this data it was evident that appearance was found to decline gradually over storage period which was significant ($P < 0.05$). The mean sensory scores for appearance of C, WFEC, LMEC and FMEC stored in aluminum silver foil packaging material decreased from 8.03 to 7.79, 7.72 to 7.59, 8.32 to 8.15 and 7.56 to 7.32 respectively. Similar results are reported by Nagi *et al.* (2012) [15] found that aluminum paper packaging was best to pack products up to three month of storage. whereas the same had a reduction from 8.03 to 7.89, 7.72 to 7.63, 8.32 to 8.18 and 7.56 to 7.50 respectively for those stored in MPP material.

Edible cutleries were less affected by storage period when packed in MPP material compared to aluminum silver foil packaging material. There is a statistically significant difference between the packaging materials in terms of their impact on quality during storage. Overall, the data suggests that the choice of packaging material plays a crucial role in preserving the quality of the stored items, and significant changes occur over the 90th day storage period.

Chemical composition of developed millet based edible cutleries under different interval of storage

Storage study was carried out to check the keeping quality

of the white finger millet, little millet and foxtail millet edible cutleries. Based on the sensory parameters the best accepted products were selected and packaging material such as aluminium silver foil and metallised polypropylene (MPP) and was used under ambient condition at different intervals of storage days such as initial, 0th, 30th, 60th and 90th day.

One of the study gave evidence that aluminium packaging was found to be the best because these packaging bags are impervious to moisture, light and other gases. This increase was due to the respective porosity of the packaging material. Similar results were also reported by Nasir *et al.* (2004) [16]. Changes in the lipid peroxidation of developed millet based edible cutleries during storage intervals were observed by estimating the peroxide value and free fatty acid values.

Moisture content of developed millet based edible cutleries at different intervals of storage

The effect of moisture content on the developed refined wheat flour edible cutleries, white finger millet, little millet and foxtail millet based edible cutleries at different intervals of storage period are presented in Table 5. The mean value for the moisture content of developed refined wheat flour edible cutleries is 3.23g whereas the moisture content of white finger millet edible cutleries is 3.28, for little millet edible cutleries and foxtail millet based edible cutleries moisture content was 3.39 and 3.43 during initial period of storage.

The moisture content of developed refined wheat flour edible cutleries, white finger millet, little millet and foxtail millet based edible cutleries sample stored in aluminium silver foil packaging under room temperature varied from 3.15 to 3.25, 3.21 to 3.32, 3.29 to 3.39 and 3.40 to 3.79. For edible cutleries stored in metalized polyesters pouches (MPP) under room temperature. Moisture content varied from 2.96 to 3.19, 3.19 to 3.25, 3.22 to 3.38 and 3.30 to 3.49 respectively at 0th, 30th, 60th and 90th day of storage interval. The gain in moisture content during storage might be due to hygroscopic nature of products or storage environment. These results are in accordance with Nagi *et al.* (2012) [15].

Table 5: Effect of moisture content of best accepted millet based edible cutlery samples at different intervals of storage

Millet edible cutleries	Aluminium silver foil packaging material				MPP packaging material			
	Storage intervals (days)				Storage intervals (days)			
	0 th day	30 th day	60 th day	90 th day	0 th day	30 th day	60 th day	90 th day
Control	3.23±0.03	3.28±0.01	3.39±0.00	3.43±0.01	3.19±0.01	3.25±0.04	3.29±0.01	3.31±0.00
WFEC	3.15±0.03	3.21±0.00	3.29±0.01	3.40±0.00	2.96±0.05	3.19±0.09	3.38±0.05	3.46±0.05
LMEC	3.22±0.01	3.30±0.01	3.36±0.05	3.41±0.01	3.14±0.03	3.20±0.02	3.24±0.04	3.30±0.02
FMEC	3.25±0.05	3.32±0.00	3.39±0.00	3.79±0.26	3.12±0.00	3.19±0.00	3.22±0.017	3.49±0.35
F-value	*	*	*	*	*	NS	*	*
S.Em±	0.02	0.00	0.01	0.07	0.02	0.03	0.02	0.10
CD at 5%	N/A	0.02	0.05	0.25	0.06	N/A	0.06	N/A

Control -Refined wheat flour edible cutleries, WFEC-White finger millet edible cutleries, LMEC-Little millet edible cutleries, FMEC-Foxtail millet edible cutleries.

Values expressed as Mean ±SD,*Significant ($P < 0.05$), NS - Non significant, Values are mean of triplicates

Table 5 depicts that Effect of moisture content of developed millet based edible cutlery samples at different intervals of storage. The increase in the moisture content was observed among the millet based edible cutleries with the increase in the storage period. Significant difference was observed among all four developed edible cutleries stored in

aluminium silver foil and MPP packaging materials during storage intervals (0th, 30th, 60th, 90th day). The highest moisture content has observed for the foxtail millet edible cutleries stored both aluminium silver foil (3.79) and MPP (3.49) packaging material at 90th day of storage period. The developed edible cutleries stored in MPP showed significant difference between the developed edible cutleries and compared to aluminum silver foil packaging, MPP contained lower moisture content

Peroxide content of developed millet based edible cutleries at different intervals of storage

Table 6 depicts that Effect of peroxide content of developed millet based edible cutlery samples at different intervals of storage. The peroxide content of developed refined wheat flour edible cutleries, white finger millet, little millet and foxtail millet based edible cutleries sample stored in aluminium silver foil packaging under room temperature varied from 0.84 to 0.88, 0.89 to 0.92, 0.94 to 0.95 and 1.22 to 1.32 mEqO₂/kg. For edible cutleries stored in metalized polyesters pouches(MPP) under room temperature, peroxide content varied from 0.75 to 0.76, 0.8 to 0.82, 0.89 to 0.95 and 0.97 to 0.98 mEqO₂/kg respectively at 0th, 30th, 60th and 90th day of storage interval. The similar findings were also reported by Hafez *et al.* (2012) [6] showed increases in moisture, peroxide value and decreases in free fatty acid

values during storage days.

The increase in the peroxide content was observed among the millet based edible cutleries with the increase in the storage period. Significant difference was observed among all four developed edible cutleries stored in aluminium silver foil and MPP packaging materials during storage intervals (0th, 30th, 60th, 90th day). The highest peroxide content has observed for the little millet edible cutleries stored both aluminium silver foil (1.32 mEqO₂/kg) and MPP (0.98 mEqO₂/kg) packaging material at 90th day of storage period. The developed edible cutleries stored in MPP showed significant difference between the developed edible cutleries and compared to aluminum silver foil packaging, MPP contained lower peroxide content. The results indicated that peroxide value of cake gradually increased as storage days increased.

Table 6: Effect of peroxide content (mEq/Kg of fat) of developed millet based edible cutlery samples at different intervals of storage

Millet edible cutleries	Aluminium silver foil packaging material				MPP packaging material			
	Storage intervals (days)				Storage intervals (days)			
	0 th day	30 th day	60 th day	90 th day	0 th day	30 th day	60 th day	90 th day
Control	0.84±0.00	0.89±0.00	0.94±0.00	1.22±0.02	0.75±0.00	0.8±0.00	0.89±0.00	0.97±0.00
WFEC	0.86±0.01	0.92±0.01	0.95±0.00	1.31±0.01	0.75±0.00	0.81±0.00	0.91±0.01	0.97±0.00
LMEC	0.88±0.00	0.91±0.00	0.95±0.00	1.32±0.01	0.76±0.00	0.82±0.00	0.95±0.03	0.98±0.01
FMEC	0.88±0.01	0.91±0.00	0.95±0.00	1.30±0.02	0.75±0.00	0.82±0.01	0.92±0.01	0.97±0.00
F-value	*	*	*	*	NS	NS	*	NS
S.Em±	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00
CD at 5%	0.01	0.01	0.01	0.01	N/A	N/A	0.03	N/A

Control -Refined wheat flour edible cutleries, WFEC-White finger millet edible cutleries, LMEC-Little millet edible cutleries, FMEC-Foxtail millet edible

* Significant at 5%, NS - Non significant, Values are mean of triplicates. cutleries

Values expressed as Mean ±SD

Free fatty acid content of developed millet based edible cutleries at different intervals of storage

Effect of free fatty acid content of developed millet based edible cutlery samples at different intervals of storage is presented in Table 7. The free fatty acid content of developed refined wheat flour edible cutleries, white finger millet, little millet and foxtail millet based edible cutleries sample stored in aluminium silver foil packaging under room temperature varied from 0.21 to 0.24, 0.28 to 0.29, 0.37 to 0.38 and 0.45 to 0.49 mEqO₂/kg. For edible cutleries stored in metalized polyesters pouches(MPP) under room temperature, peroxide content varied from 0.16 to 0.18, 0.22 to 0.23, 0.31 to 0.33 and 0.39 to 0.42 mEqO₂/kg respectively at 0th, 30th, 60th and 90th day of storage interval. The present study results were comparable with the study by Hafez (2012) [6] and Akter (2021) [1] reported that increases in acid value when compared to refined wheat flour edible cutleries at zero time is explained by hydrolysis of the oil to free fatty acid which lead to further formation of aldehydes and ketones.

Acid value measures free fatty acids and usually considered to be one of the main parameters reflecting the quality of food during the storage period (Rao *et al.*, 2009) [17].

The increase in the free fatty acid content was observed among the millet based edible cutleries with the increase in the storage period. Significant difference was observed among all four developed edible cutleries stored in aluminium silver foil and MPP packaging materials during storage intervals (0th, 30th, 60th, 90th day). The highest free fatty acid content has observed for the little millet edible cutleries stored both aluminum silver foil (0.49 mEqO₂/kg) and MPP (0.42 mEqO₂/kg) packaging material at 90th day of storage period. The developed edible cutleries stored in aluminium silver foil cover and MPP showed significant difference between the developed edible cutleries without 30th day which shown non-significant difference and compared to aluminium silver foil packaging, MPP contained lower free fatty acid content. The results indicated that free fatty acid value of cutleries gradually increased as storage days increased.

Table 7: Effect of free fatty acid content of developed millet based edible cutlery samples at different intervals of storage

Millet edible cutleries	Aluminium silver foil packaging material				MPP packaging material			
	Storage intervals (days)				Storage intervals (days)			
	0 th day	30 th day	60 th day	90 th day	0 th day	30 th day	60 th day	90 th day
Control	0.21 ±0.01	0.28±0.00	0.37±0.00	0.45±0.00	0.16±0.00	0.23±0.01	0.31±0.00	0.39±0.00
WFEC	0.23±0.00	0.29±0.00	0.38±0.00	0.47±0.00	0.17±0.00	0.22±0.00	0.32±0.00	0.40±0.00
LMEC	0.23±0.01	0.29±0.01	0.38±0.00	0.49±0.01	0.18±0.00	0.23±0.00	0.33±0.00	0.42±0.00
FMEC	0.24±0.01	0.29±0.00	0.37±0.00	0.48±0.00	0.18±0.00	0.23±0.00	0.33±0.00	0.40±0.00
F-value	*	*	NS	*	*	NS	*	*
S.Em±	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CD at 5%	0.01	-	-	0.01	0.01	-	0.01	0.01

Control -Refined wheat flour edible cutleries, WFEC-White finger millet edible cutleries, LMEC-Little millet edible cutleries, FMEC-Foxtail millet edible

* Significant at 5%, NS - Non significant, Values are mean of triplicates. cutleries

Values expressed as Mean ±SD

Microbiological parameters of millet based edible cutleries packed in different packaging material during storage

The data given in Table 8 reflect the mean total bacterial count, fungi count and coli form count of best accepted edible cutleries. Generally, the total viable count indicated that the microbiological quality of any food product and the presence of high number of total viable counts is an indication for low expected shelf life of the product. Microorganisms play significant role in the determination of shelf life of food products.

The present study showed that growth of total bacteria count was not observed up to 50th day of storage in aluminium silver foil packaging material. However, on 60th day growth of bacterial count was observed in Control (0.81 × 10² cfu/g), WFEC (0.82 × 10² cfu /g), LMEC (0.81 × 10² cfu /g), and FMEC (0.82 × 10² cfu /g) and on 90th day of storage growth of bacterial count in refined wheat flour edible cutleries (0.90 × 10² cfu /g), WREC (0.88 × 10² cfu/g), LMEC (0.87 × 10² cfu /g), and FMEC (0.87 × 10² cfu /g).

In case of MPP packaging material there was no growth of total bacterial count was observed up to the 50th day of

storage in metalized polypropylene packaging material. However, on 60th day of edible cutlery storage showed a growth of bacterial count in Control (0.42 × 10² cfu/g), WFEC (0.43 × 10² cfu /g), LMEC (0.43 × 10² cfu /g), and FMEC (0.44 × 10² cfu /g) and on 90th day noticed a growth of bacterial count in refined wheat flour edible cutleries (0.49 × 10² cfu/g), WFEC (0.51 × 10² cfu/g), LMEC (0.52 × 10² cfu/g), and FMEC (0.52 × 10² cfu/g).

Results on yeast/ mould populations indicated that there were no counts of yeast/ mould in all the formulated edible cutleries during initial to 50th day of storage period in aluminium silver foil packaging material. However, the mould counts were observed on 60th day of storage and the refined wheat flour edible cutleries count was (0.13 × 10² cfu/g), (0.19 × 10² cfu/g), (0.16 × 10² cfu/g) and (0.51 × 10² cfu/g) for Control, WFEC, LMEC and FMEC respectively. On 90th day, the mould count was recorded in refined wheat flour edible cutleries (0.17 × 10² cfu/g), WFEC (0.23 × 10² cfu/g), LMEC (0.16 × 10² cfu/g) and FMEC (0.20 × 10² cfu/g). This might be due to the moisture content present in edible cutlery, encourages the growth of microorganisms.

Table 8: Effect of storage on different packaging materials for microbial population

Attributes	Millet based edible cutlery samples	Aluminum silver foil packaging material				MPP packaging material			
		Storage intervals (days)				Storage intervals (days)			
		0 th day	30 th day	60 th day	90 th day	0 th day	30 th day	60 th day	90 th day
Total bacterial count (cfu × 10 ⁴ /g)	Control	ND	ND	0.81 ± 0.01	0.90 ± 0.01	ND	ND	0.42 ± 0.02	0.49 ± 0.00
	WFEC	ND	ND	0.82 ± 0.00	0.88 ± 0.00	ND	ND	0.43 ± 0.02	0.51 ± 0.01
	LMEC	ND	ND	0.81 ± 0.00	0.87 ± 0.00	ND	ND	0.43 ± 0.00	0.52 ± 0.005
	FMEC	ND	ND	0.82 ± 0.00	0.87 ± 0.00	ND	ND	0.44 ± 0.01	0.52 ± 0.00
	F-value	-	-	NS	*	-	-	NS	*
	S.Em ±	-	-	0.00	0.00	-	-	0.01	0.00
	CD at 5%	-	-	-	0.017	-	-	-	0.01
Yeast and mould count (cfu × 10 ² /g)	Control	ND	ND	0.13 ± 0.01	0.17 ± 0.00	ND	ND	0.09 ± 0.00	0.11 ± 0.02
	WFEC	ND	ND	0.19 ± 0.00	0.23 ± 0.00	ND	ND	0.11 ± 0.00	0.12 ± 0.00
	LMEC	ND	ND	0.16 ± 0.00	0.16 ± 0.00	ND	ND	0.09 ± 0.00	0.11 ± 0.01
	FMEC	ND	ND	0.51 ± 0.50	0.20 ± 0.01	ND	ND	0.11 ± 0.01	0.12 ± 0.01
	F-value	-	-	NS	NS	-	-	NS	NS
	S.Em ±	-	-	0.07	0.12	-	-	0.08	0.08
	CD at 5%	-	-	-	-	-	-	-	-

MPP: Metalized Polypropylene ND: Not detectable

Control - Refined wheat flour edible cutleries, WFEC - White finger millet edible cutleries, LMEC - Little millet edible cutleries,

In case of MPP packaging material there was no growth of total yeast/ mould count was observed up to the 50th day of storage in metalized polypropylene packaging material. However, on 60th day of edible cutlery storage showed a growth of mould/ yeast count in refined wheat flour edible cutleries (0.09 × 10² cfu/g), WFEC (0.11 × 10² cfu /g), LMEC (0.09 × 10² cfu /g), and FMEC (0.11 × 10² cfu /g) and on 90th day noticed a growth of yeast/ mould count in refined wheat flour edible cutleries (0.11 × 10² cfu /g), WFEC (0.12 × 10² cfu /g), LMEC (0.11 × 10² cfu /g), and FMEC (0.12 × 10² cfu /g).

Yeast and mould count was not detected in all the products during the storage period up to 50th day and after 60th day yeast/ mould count found that is to in very little amount in MPP material under ambient condition within the acceptable limit. All the products packed in aluminum silver foil packaging material showed the total microbial population value were still within the acceptable limit.

According to WHO standard (1994) the maximum permissible limits in baked products (cake, cutlery, bread and biscuits) for total plate count (TPC) is 2.0 × 10⁵ cfu g⁻¹,

coli form bacteria <200 MPN g⁻¹, coliform absent, yeast and mould is <1.0 × 10⁴ cfu/g.

Conclusion

Millet is considered as super food. Proximate composition of millet based edible cutleries have varying moisture content. Refined wheat flour based edible cutleries provide more CHO and energy compared to millet based edible cutleries. WFEC had higher phosphorous, magnesium, calcium and iron mineral content. During the storage interval even though increase in the moisture content, free fatty acid content and peroxide value but rancid or off flavour was not observed. Highest free fatty acid content had observed for the foxtail millet edible cutleries stored both aluminium and MPP packaging material at 90th day. Products stored in MPP showed lower free fatty acid content and microbial growth at 50th day of storage.

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