Original Research Article

Optimization and Shelf-life study of finger millet-based cookies premix

ABSTRACT

Multigrain cookie premixes were developed using finger millet (*Eleusine coracana*) to provide a nutritious food option for vulnerable groups, especially preschool children facing micronutrient malnutrition. Three types of cookie premixes were formulated with varying proportions of grains and evaluated for sensory parameters using a 9-point hedonic scale. The best combination of calcium and iron-rich ingredients was found to be finger millet flour, refined wheat flour, grain amaranth, garden cress seed, milk powder in the ratio of 40:25:20:5:10. This premix was also evaluated for nutritional composition and shelf life. The cookies made from this premix were rich in essential nutrients, with 319.8 mg of calcium and 8.89 mg of iron per 100 g. The sensory evaluation showed that all the premixes were well accepted (sensory score >7) and the selected premix remained acceptable over a storage period of 90 days.

Keywords: Hidden hunger, Calcium-iron rich cookies, Cookies premix, Finger millet, Micronutrient deficiency.

1. INTRODUCTION

Micronutrients are essential nutrients required in small amounts (<100 mg/day) for the proper development, production, and functioning of enzymes, hormones, and growth regulator proteins. They also play a crucial role in the reproductive and immune system, bone and membrane structure, and oxygen binding, among others (Gernand et al., 2016; Godswill et al., 2020). Calcium and Iron are critical elements for growth and development, especially in the primary phase of life (Pasricha et al., 2010). Micronutrient deficiencies, also known as "hidden hunger," are highly prevalent and can have devastating effects. They go beyond the well-known effects like anaemia, goiter, and stunted growth. They are often hard to recognize, mimic many diseases, and have fewer signs, but have a range of symptoms (Bailey et al., 2015). The main cause of micronutrient deficiencies is the lack of bioavailable minerals and vitamins from basic meals (Lowe, 2021). Hidden hunger affects overall development, as affected populations are unable to achieve their full mental and physical potential, have low work capacity, and are prone to infections (Plessow et al., 2018). In severe cases, hidden hunger can cause impairment of childhood development, such as stunted growth, blindness, low IQ, and even increased mortality in children below the age of five (Faber, 2005: WHO 2008).

According to WHO 2023, the most common micronutrient deficiencies globally with a higher incidence of iron, iodine, vitamin A, and zinc. The estimated global prevalence of deficiency in at least one of the three micronutrients (iron, zinc, vitamin A) was 56 % among preschool children.About 30 % of the world's population has insufficient iodine consumption; 17 % of children do not consume the necessary amount of zinc and 18 % of children under five years of age have iron deficiency anemia (Das and Padhani, 2022) (Stevens et al, 2022).Veiga et al. (2013) found inadequacies for calcium in more than 95 % of adolescents, phosphorus in 54-69 %, vitamins A in 66 - 85 %, E in 100 %, and C in 27-49 % of adolescents.

The world has been engulfed with micronutrient deficiencies for decades now and although multiple strategies and programs have been implemented by national and international communities, they have been incapable of tackling this holistically and sustainably.Hence, the Food and Agriculture Organization (FAO) has emphasized the importance of developing homemade wholesome weaning and supplementary foods using local food resources to promote good health and ensure sustainability in our food systems. Such food-based approaches are the most desirable and sustainable way to prevent micronutrient malnutrition by increasing the intake of micronutrients through the diet (WHO 2001).

Millets and other pseudo cereals are highly nutritious and rich in micronutrients, antioxidants, polyphenols, and phytochemicals (Singh et al., 2012; Gupta et al., 2017) with nutraceutical properties (Kulkarni et al., 2021). Finger millet (Eleusine coracana) is rich in calcium (344 mg), and potassium (408 mg) and contains phosphorus and iron (Gopalan et al., 2009). The grain of the amaranth species is very nutritious with gluten-free properties (Sneha and Haripriya, 2018) and has a high lysine content (Bressani, 1989) as well as being rich in polyunsaturated fatty acids (Yánez et al., 1994). Moreover, it has twice the level of calcium in milk, five times the level of iron in wheat, and higher levels of different minerals and vitamins like calcium, sodium, potassium, and vitamins A, E, C, and folic acid than cereal grains (Becker et al., 1981). It also has low levels of anti-nutritional factors (Zapotoczny et al., 2006) and very good antioxidant activity (Escudero et al., 2011). Garden cress (Lepidium sativum L.) seeds are a rich source of proteins, dietary fiber, omega-3 fatty acids, iron, and other essential nutrients and phytochemicals (Agarwal and Sharma, 2013; Chaudhary and Gupta, 2017; Adera et al., 2022).

Cookies are a popular bakery product that are widely consumed as supplementary food. They are favoured for their nutrient availability, palatability, convenience, and longer shelf life (Akubor and Ukwuru, 2003: Yousaf et al., 2013). They are also resistant to microbial spoilage. However, cookies made with refined wheat flour are a refined product that contains a high proportion of starch, low minerals, and dietary fibre. To improve the nutritional qualities and functionalities of cookies in a cost-effective manner, healthier and natural functional products have been developed using whole grains such as finger millet, grain amaranth, garden cress seeds, and other locally available natural ingredients (Goswami et al., 2020). These ingredients help to incorporate different nutritionally rich components into cookies, making them more diverse and nutritious. To combat micronutrient deficiencies, especially among preschool children and vulnerable groups, this study aims to optimize the methodology of finger millet-based cookie premix and study its shelf-life.

2. MATERIALS AND METHODS

2.1 Standardization of the cookies premix

A list of ingredients rich in calcium and iron was prepared, and based on availability, affordability, and ease of processing, a few ingredients were selected. Finger millet, refined wheat flour, amaranth seeds, garden cress seeds, and skimmed milk powder were chosen from the list and procured from the local market of Udaipur, Rajasthan in one lot. The cookies premixes, rich in calcium and iron, were prepared by using the above ingredients in the food laboratory of the Department of Food Science and Nutrition, College of Community and Applied Sciences, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan between 2017-2020. The finger millet, grain amaranth, and garden cress seeds were ground finely in an electric grinder and passed through a 60-mesh size sieve. To standardize the recipe, ingredients like finger millet flour (FMF), refined wheat flour (RWF), amaranth seed flour (ASF), garden cress seed (GSF) and skimmed milk powder (SMP) were blended to achieve the desired nutrient content and homogenized in three combinations as cookies premixes, i.e., T1: FMF:RWF:ASF:GSF:SMP at 50:20:10:10:10, T2: FMF:RWF:ASF:GSF: SMP at 40:32:10:8:10, T3: FMF: RWF: ASF: GSF: SMP at 40:25:20:5:10. The cookies premix samples were stored in an airtight container until further use.

To conduct the acceptability test, cookies were made using the premix combination mentioned abovewhile keeping the other ingredients like milk, butter, sugar, and sodium bicarbonate constant. First, 30g butter and 35g ground sugar were creamed in a mixer with a flat beater at a slow speed. Then, the cookie premix was added to the cream and mixed at a medium speed in a dough mixer to obtain a homogenous dough. Creaming and mixing can also be done manually. After that, the dough was rolled out into a uniform thickness, cut into desired shapes using a cookie cutter, and baked in a preheated oven at 170°C for 15-20 minutes.

2.2 Sensory analysis of cookies developed from premix

To evaluate the cookies prepared from standardized premixes, a panel of 10 trained judges conducted an organoleptic evaluation. They scored the samples for colour, flavour, taste, texture, appearance, and overall acceptability using a scorecard on a 9-point hedonic rating scale. The scale had corresponding descriptive terms ranging from 9 'like extremely' to 1 'dislike extremely' (Agrahar-Murugkar et al., 2015).

2.3Proximate analysis and shelf-life study of developed premix

The premix with the highest acceptability score was chosen for further study. It was weighed, homogenized, and oven-dried at 60°C. The dried samples were then stored in high-density polyethylene packets for future analysis. The nutritional parameters evaluated were moisture, crude fat, crude fibre, ash, calcium, iron, and phosphorus, using standardized AOAC protocols (AOAC 2010). The total carbohydrate content was calculated using the difference method, which is Total carbohydrate = 100 - (Moisture + Protein + Fat + Ash content). The energy values of the premix were determined by multiplying protein, carbohydrates, and fat content by the factors 4, 4, and 9, respectively. Mineral solutions of premixes were prepared using the wet ashing method. The mineral elements like calcium and iron were analysed using the atomic absorption spectrophotometer (ECIL, model AAS 4141). The phosphorus content of the samples was analysed using the method given by USDA, 1954.

2.4 **Storage and shelf life of developed products**

The premixes of standardized products were prepared in large quantities and stored to assess their shelf-life. These premixes were packed in high-density polyethylene (HDPE) packets with a thickness of 0.1 mm and a density of 0.65 g/cm3. They were heat-sealed and kept under ambient storage conditions (temperature between 20°C to 30°C and relative humidity of 35-70%) for three months. The storage stability of the product needs to be assessed to determine the maximum duration of storage in which the food will be safe for consumption without significant loss of quality. Therefore, the storage qualities of the cookies premix were measured in terms of moisture uptake, Peroxide Value (PV) (AOAC 2010), organoleptic quality, total viable cell count (TVC), yeast, and mold (APHA, 1984) at monthly intervals for three months. The microbial quality was estimated in triplicate using standard protocols at monthly intervals. The total viable count was determined using Nutrient Agar media, total fungi using Potato Dextrose Agar media (Hi Media, India) and yeast through Sabouraud's Dextrose Agar. The appropriate dilution of samples was used for each test. Inoculated plates were incubated at the required time and temperature combinations under suitable growth conditions (Agarwal and Hasija, 1986: FAO 1979).

2.5Statistical analysis

The experiments were conducted in three independent trials, and the data is presented as mean ± standard deviation. To differentiate among the means of different samples ($P \leq 0.05$), Duncan's Multiple Range Test was applied. Organoleptic parameters were compared using analysis of variance and critical difference (CD) with the help of SPSS 16 software.

3. RESULT AND DISCUSSION

3.1 Sensory evaluation

During trials to standardize the cookie premix by adding various calcium and iron-rich ingredients, it was found that all treatments were rated from "like moderately" to "like very much" However, Treatment 3 (T3) received the highest scores in terms of colour (8.5±0.52), flavour (8.6±0.51), texture (8.4±0.51), appearance (8.3±0.48), taste (8.4±0.51), and overall acceptability (8.4±0.51) when compared to other treatments. These values differed significantly ($p<0.05$) in all parameters (as shown in Table 1). Therefore, the premix (consisting of Finger Millet Flour (FMF), Refined Wheat Flour (RWF), Grain Amaranth Flour (GAF), Garden Cress Seed Flour (GSF), and Skimmed Milk Powder (SMP) in the proportion of 40:25:20:5:10) that was developed using these ingredients was considered to be the best and was selected for further study.

Table 1.Acceptability of cookies premix

Treatments	Colour	Flavour	Taste	Texture	Appearance	Overall Acceptability
T1	7.4^{b}±0.51	7.7^{c}±0.48	7.5^{c}±0.52	7.5^{c}±0.52	7.4^{c}±0.51	7.5^{b} ±0.52
T2	7.5^{b}±0.52	7.9^{b}±0.73	7.7^{b}±0.48	7.8^{b}±0.42	7.8^{b} ±0.63	7.6^{b} ±0.51
T3	8.5^{a}±0.52	8.6^{a}±0.51	8.4^{a}±0.51	8.4^{a}±0.51	8.3^{a} ±0.48	8.4^{a} ±0.51
SE	0.07	0.08	0.07	0.07	0.08	0.07
CD (0.05)	0.15	0.17	0.15	0.14	0.16	0.15

T1: FMF: RWF: ASF: GSF: SMP: (50:20:10: 10:10) T2: FMF: RWF: ASF: GSF: SMP (40:32:10: 8:10), T3: FMF: RWF: ASF: GSF: SMP (40:25:20:5:10); Mean±SD with different notation (a, b, c and d) indicates significant difference at 5% level.

The findings of the present study support the results of previous research on cookies made with sprouted ragi flour (SRF) and supplemented with garden cress seed powder (Agrahar-Murugkar et al., 2015) andreported that the recipe incorporating 5% garden cress seed powder was acceptable and had the highest score for colour, texture, taste, flavour, and overall acceptability, which is consistent with the results of the present study. Similarly, in the development of an instant dhokla mix using soybean, ragi, and garden cress seed, Agarwal and Sharma (2013) and Lohekar and Arya (2014) found that the addition of 5% garden cress seed resulted in the highest scores for colour, texture, taste, flavour, and overall acceptability. Finger millet, grain amaranth and garden cress seed are rich in essential micronutrients but should be standardized in proper ratio before adding to any food products.

3.2 Proximate composition of standardized cookies premix

The nutrient composition of standardized cookie premixes was compared with that of refined wheat flour, which is commonly used to prepare cookies. The comparison was made, which showed that the developed cookies premix had higher calcium and iron content than refined wheat flour. Specifically, the premix had 319.80 mg/100 g of calcium and 8.89 mg/100 g of iron, compared to 23 mg/100 g and 2.7 mg/100 g respectively, for refined wheat flour. This is important because children who are still growing have the highest dietary requirement for calcium in their bodies (Table 2).Agrahar-Murugkar et al. (2015) documented higher calcium contained (312 mg/100g) in cookies prepared by fortifying refined flour with sesame and dried moringa leaves. The values obtained for the iron content of premixes were in accordance with the value mentioned by Lohekar and Arya (2014) where they observed an increase in iron content i.e., 8.52 mg/100g of instant *dhokla* mix by utilizing nutritious ingredients such as soy, *ragi*, and garden cress seed powder.

According to the data, the cookies premix has a moisture content of 9.12%, total ash content of 2.82%, crude protein content of 14.92%, fat content of 3.86%, fiber content of 3.44%, and carbohydrate content of 67.84%. The protein and energy content of the premix is 14.92 g and 357.78 kcal per 100 g respectively. The phosphorous content of the premix is 296.17 mg/100 g. This cookies premix meets the BIS i.e. Bureau of Indian Standards specification for all components, such as moisture (maximum 10%), crude protein (minimum 14%), total ash (maximum 5%), crude fat (maximum 7.5%), crude fiber (maximum 5%), and carbohydrate (minimum 45%) for cereal-based complementary food. The calcium-iron-rich cookies premix has more than 50% calcium and iron content per 100 g of premix, which is greater than one-third (1/3) of the Recommended Dietary Allowances for preschool children. Although the fat and energy RDA for preschool children are low in the developed cookies premix, they can be increased by adding fat (vegetable fat and butter) and sugar to the premix while preparing the cookies.

Table 2. Proximate and mineral composition of refined wheat flour and Cookies premix

Nutrient compositions	Refined wheat flour	Cookies premix	**BIS specification
Moisture (%)	9.90±0.29	9.12±0.07	max. 10%
Total ash (%)	0.48±0.02	2.82±0.03	max. 5%
Crude protein (%)	7.87±0.29	14.92±0.08	min. 14%
Crude Fat (%)	0.65±0.04	3.86±0.03	max. 7.5%
Crude Fibre (%)	0.45±0.02	3.44±0.16	max. 5%
Carbohydrate (%)	74	67.84±0.11	min. 45%
Energy (Kcal)	348	357.78±2.44	-
Calcium (mg/100g)	23±2.0	319.80±0.10	-
Iron (mg/100g)	2.7±0.5	8.89±0.03	-
Phosphorus (mg/100g)	121±10.0	296.17±0.03	-

*BIS (Bureau of Indian Standard), 2006 - Guideline for cereal-based complementary foods

3.3 Shelf-life study of developed premix

3.3.1 Effect of storage on organoleptic parameters of formulated premix

An organoleptic evaluation was carried out during the storage of calcium-iron-rich premixes. The results are presented in Figure 1. It was observed that there was a decreasing trend in all the parameters of cookies mix over a period of 90 days. The sensory score for overall acceptability decreased from 8.4 to 7.8 on the 90th day of storage. The panel members reported a significant reduction in the sensory score for color (from 8.5 to 7.7), flavor (from 8.6 to 7.7), taste (from 8.4 to 7.9), texture (from 8.4 to 7.6), appearance (from 8.3 to 7.6) and overall acceptability (from 8.4 to 7.8). However, the data indicated that even though the scores decreased after 90 days of storage, the premix remained organoleptically acceptable at the end of the storage period.

The findings of the study are consistent with the observations made by Itagi et al. (2013) on halwa mixes made from cereals, millets, legumes, nuts, and condiments. It was reported that there was a significant change in the specific sensory characteristics of all four samples during a 6-month (180-day) storage study under ambient conditions, which affected the shelf life of the product.

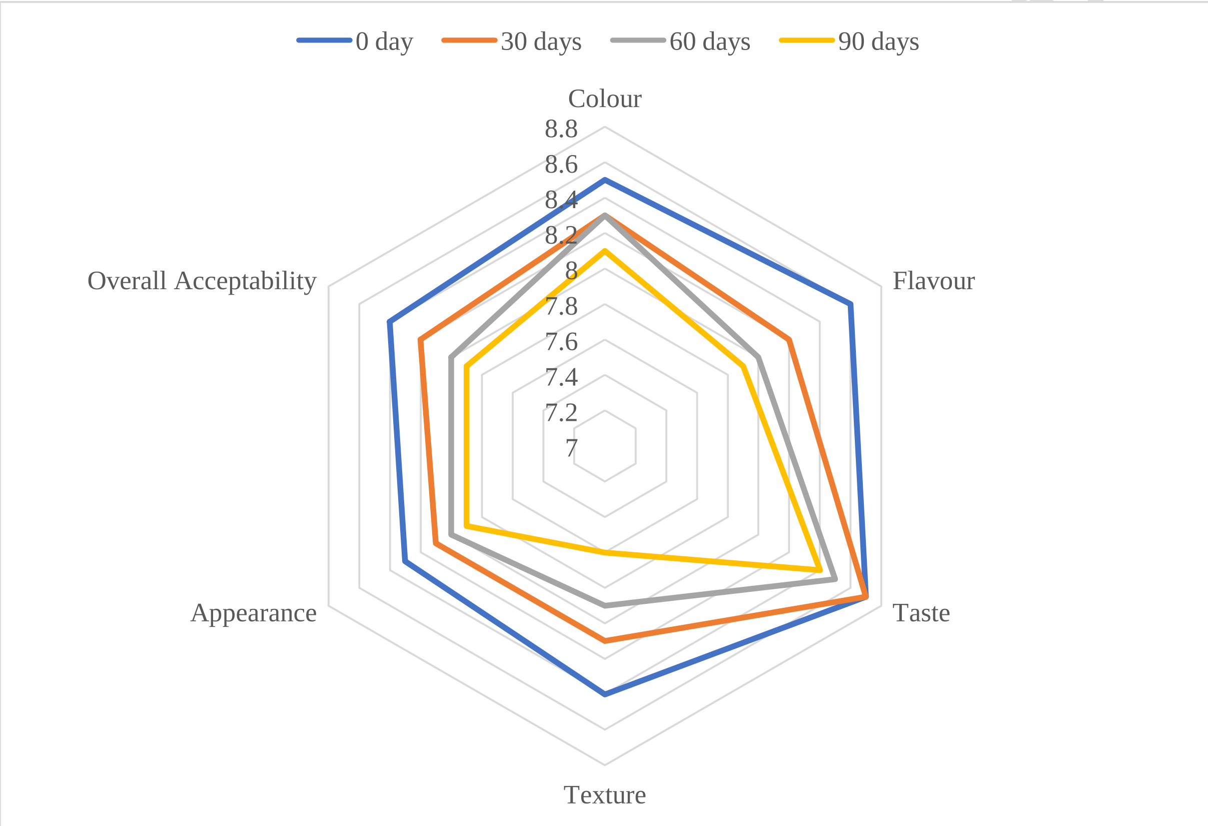

Fig. 1 Effect of storage on sensory parameters

3.3.2 Effect of storage on moisture, peroxide value and microbial load of formulated mixes

3.3.2.1 Moisture

During a 90-day storage period, the initial moisture content of the cookie premix increased from 9.12% to 9.30%, with a slow and insignificant difference.

Table 3. Effect of storage on moisture, peroxide value, total viable count, yeast and mould.

Attributes	Storage period				CD
	0 day	30 days	60 days	90 days	(0.05)
Moisture	$9.12^{a}\pm0.07$	$9.17^{a}\pm0.10$	$9.26^{b}\pm0.03$	$9.30^{b}\pm0.10$	0.08
Peroxide value	Nil	$0.96^{a}\pm0.02$	$1.88^{b}\pm0.02$	$2.96^{c}\pm0.04$	0.03
Total viable count	2.4×10^{2} a	5.0×10^{2} b	9.0×10^{2} b	16.3×10^{2} c	0.69
Yeast and mould	0.06×10^{2} a	0.09×10^{2} b	0.11×10^{2} c	0.15×10^{2} d	0.01

Although the moisture content increased during storage, it remained within acceptable limits. Nagi et al. (2012) suggested that this increase might be due to the hygroscopic nature of food products, as well as the storage environment (relative humidity and temperature) and the type of packaging material used. These findings are consistent with the study conducted by Itagi et al. (2013), which found a significant increase in moisture content in multigrain halwa mixes.

3.3.2.2 Peroxide Value (PV)

The development of off-flavour in low moisture food caused by lipid peroxidation is a major reason why processed foods are rejected by consumers. To check the effect of storage on peroxide values of premixes at ambient temperature, samples were analysed for 90 days. The results showed that peroxide value was not initially detected in the cookies premix. However, with time, peroxide values in cookies premix increased gradually, ranging from 0.96 to 2.96 meq/kg during the 30–90days of storage period. Despite this, the peroxide values remained within the permissible limit of 10 meq/kg of extracted fat (ISI, 1981) even after three months of storage. The increase in peroxide values during storage is due to the degradation of fat and the oxidation of fat which leads to the formation of peroxides.

3.3.2.3 Total Viable Count (TVC)

The study analysed the distribution and number of microorganisms present in formulated cookie premixes during a storage period of three months (90 days) and revealed that the mean value of total viable cell count in formulated premixes was significantly ($P\leq0.05$) influenced by storage period.The results revealed that the total viable cell count (TVC) in the premixes was significantly influenced by the storage period, with the count increasing from 2.4 to 16.3×10^{2} cfu/g from day 30 to day 90. Similarly, yeast and mold contamination in the premixes increased from 0.06 to 0.15×10^2 over the same period. Microbial quality is an important factor in determining the shelf life and acceptability of dehydrated plant-based products. Although some microorganisms are destroyed during the drying and roasting process, it does not eliminate all of them. The microbial count in dehydrated foods depends on the quality of utensils used during processing (Jayathunge et al., 2012).

4. CONCLUSION

Micronutrient deficiency is a serious issue caused by modern food habits, particularly the lack of calcium and iron among preschool children and other vulnerable groups. To address this, there is a need for the development of products that are rich in micronutrients, promote growth and development, and are easily accessible. In this study, a calcium-iron-rich cookies premix has been created using locally available and affordable food materials. The premix has excellent nutritional value and is well-liked by consumers, making it an excellent option to meet the recommended dietary allowance of preschool children. By promoting the use of this cookies premix, the health and nutritional status of children and other vulnerable groups can be improved and micronutrient malnutrition and the dual burden of malnutrition may be reduced.

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