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FULL PAPER

# Studies on development of low gluten cookies from pearl millet and wheat flour

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**Abstract**

India is one of the highest-ranking countries in the world for the number of children as well as women suffering from malnutrition. Celiac is a major disease in the developed countries consuming gluten food. Hence, to add nutrition to the diet and to surpass the gluten intolerance, a diet with gluten-free or low gluten food is advisory. In order to combat the present problem, an investigation was undertaken to develop low gluten cookies from composite flour consisting of pearl millet and wheat flour with better nutritional and sensory characteristics. The cookies were prepared by replacing wheat flour with Pearl millet flour (PMF) by 20, 40, 60, 80 and 100% respectively. The prepared cookies were then evaluated for various physicochemical, nutritional, textural and sensory parameters. The study revealed that, as the per cent addition of PMF increases, the cookies resulted in a significant decrease in weight, diameter and spread factors. However, the hardness, breaking strength and cutting strength increased with the increase in the addition of PMF in the cookies. The nutritional analysis showed that an increase in moisture, fat, fibre, calcium, phosphorus and iron was recorded in all the samples of the cookies prepared. Moreover, the cookies prepared from PMF (60%) exhibited the highest score for overall acceptability. It can be concluded that the cookies prepared by replacement of whole wheat flour with PMF (60%) found significantly superior with respect to overall quality characteristics over the rest of the combinations.

## 1. Introduction

Millets are known as ‘Gods own crops’ belongs to family *Gramineae*, are one of the oldest, small-sized cereal grains known to human from pre-historic time to be used as bird and animal feed. It has proved to have high nutritional as well as medicinal properties reported (Yang *et al.*, 2012). Millets consist of slow-releasing carbohydrates and thus lowers the risk of diabetes. Also found to be rich in dietary fibres, minerals like iron, magnesium, phosphorous and potassium (Michaelraj and Shanmugam, 2013). Millets are gluten-free hence best suited for celiac patients (Thompson, 2009). India is the foremost producer of minor millets namely, Finger millet, Kodo millet, Barnyard millet, Pearl millet and Little Millet (Majumdar *et al.*, 2006).

Millets are grown in different regions of the world. Millets are important crops for nutrition and food. Millet proteins are good sources of essential amino acids and are also rich sources of phytochemicals and micronutrients (Singh *et al.*, 2012). Although Millets are adapted to a wide range of ecological conditions, mostly ignored and under-utilized because of inadequate production and processing practices. Traditionally Millets are habitually ground into flour, consumed as porridge with milk, rolled in the form of flatbread such as *Roti* (FAO, 2009). Considering the rising population and decrease in per capita land, it is the need of the era to meet the food demand through the development of millet -based novel functional food products. Millet promotion through utilization in urban and rural areas breach new markets for farmers, processors, and other related businesses to improve their income.

Pearl millet (*Pennisetum glaucum* L.) *Bajra* is the fourth most important cereal of India after rice, wheat and sorghum. It is an important Kharif food crop of the arid and semi-arid crop in western India, Gujarat, Rajasthan and Haryana. It is considered as the wholesome cheapest food for poor people and animals. Pearl millet production in Africa and Asia is around 56% and 41% of total world production (Chandrasekara, 2013). In India, 46% of Pearl millet used for human food

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use, 37.5% for animal feed, 7.7% for poultry feed, 8.8% for the brewing industry and a small amount (0.4%) is used for seed purposes (Saha *et al.*, 2011). It is a good source of energy, protein, essential minerals and dietary fibre. The chemical analysis of Pearl millet showed that it contains moisture 12%, protein 12 g, fat 5 g, mineral 2 g, fibre 1 g, carbohydrate 67 g, calcium 42 mg, phosphorus 242 mg, iron 8 mg and accounts energy 360 calories. The values of nutritional composition are higher than rice and wheat. Although scientists (Abdalla, 1998) studied the diversity of cultivation of 22 varieties of the Pearl millet stated that concentrations of major and minor nutrients varied widely. The variations were dependent on both millet variety and the production environment.

Besides these nutrients, they also have some phytochemicals with nutraceutical properties and hence are also termed as 'nutri-cereal'. There are some anti-nutritional factors also present in pearl millet limiting its bioavailability in the human gut but the digestibility can be improved by processing (Singh *et al.,* 1993). Mainly it is used in both leavened and unleavened bread, porridge and can also be boiled or steamed. Pearl millet helps in various diseases. It may help in anaemia by increasing Hb as the iron and zinc content is 8 mg/100 g and 3.1 mg/100 g respectively. Constipation can be overcome with high fibre content (1.2 g/100 g). The anti-cancer property of pearl millet inhibits tumour development. It helps in diabetes as it has a low glycemic index. Being gluten-free is good for celiac patients. The grain has hypo allergic property, it can be admixed in the diets of infants, lactating mothers, the elderly, and convalescents. The high fibre content of pearl millet reduces the risk of gall stone occurrence by reducing the production of excessive bile in our system. The high fibre content aids the process of weight loss as a result of absorption of more water in the large intestine and thus satiates the hunger for a long period of time. Pearl millet contains high amounts of magnesium which control blood pressure and helps to reduce the severity of respiratory problems. The antioxidants, lignin and phytonutrients prevent heart-related diseases and thus pearl millet is considered good for heart health. Pearl millet can cure stomach ulcers by turning the stomach alkaline and thus reduces the effect of ulcers. Pearl millet is rich in phosphorus, essential for bone growth and development as well as for the development of ATP which is the energy currency of our body (Malik, 2015).

Due to the lack of institutional support for millet crops in contrast to the institutional promotion of wheat, rice and maize continue to shrink the millet-growing region. It is underutilized in developed countries due to non-availability inconvenient/ready to eat form (Obilana, 2004). Pearl millet contains fibrous seed coat and grey to yellow colour which imparts a bitter taste and the products prepared from whole flour have low consumer acceptability. This is one of the reasons for its poor acceptability by rice/wheat eaters.

The assimilation of Pearl millet to the convenience foods like cookies not only increases the nutritive value but also increase its production too. Replacement of whole-wheat flour with millet flour for health-conscious people is conceivably one more addition to the proliferating list of healthy foods. It is in need of time to include millets in the daily diet, hence there is a necessity to amplify the consumption of Pearl millet by incorporating it into food products like cookies. Cookies are Ready-To-Eat (RTE), convenient, inexpensive and shelf-stable food products for all age groups (Iwegbue, 2012). Cookies hold an important position in the snack food industry due to variety in taste, crispiness and digestibility. The present work involves the utilization of pearl millet in cookies and evaluating its effect on the physicochemical, textural and sensory properties.

## 2. Materials and methods

The pearl millet and wheat grains obtained from the local market were subjected to processing such as sorting, cleaning, grading and finally processed into semolina using Brabender Junior (Brabender Unit, Italy), sieved using a standard sieve (40 mesh). The other ingredients like sugar, fat, ammonium bicarbonate and sodium bicarbonate were procured from the local market of Aurangabad, MS, India.

### *2.1 Preparation of cookies*

The plain cookies were prepared from wheat flour as per the standard method suggested by (Olaoye, *et al.*, 2007; Sanfu, 2010) and treated as a control sample. The Pearl millet flour (PMF) was incorporated in wheat flour at different levels (20%, 40%, 60%, 80%, and 100%) and prepared cookies were treated as samples (A, B, C, D and E) respectively. The cookies were prepared using the following ingredients such as flour, shortening (vegetable ghee, Dalda), cane sugar, skim milk powder, common salt, sodium bicarbonate, and water. Shortening and sugar were mixed well to form a cream, then added to the mixture of flour, sodium bicarbonate, and skim milk powder, and mixed thoroughly to form the dough. The dough was then kneaded and sheeted to a uniform thickness followed by cutting into circular shapes. The cookies were then baked at 165°C for 15 mins in a horizontal deck oven (TECHMATE, India). Cookies samples were cooled and stored in airtight containers.

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### 2.2 Physicochemical and textural characteristics

Weight, diameter, thickness, spread ratio and spread factor of cookies were estimated as per AACC (1976) methods. Moreover, the moisture, crude protein, fat, ash, crude fibre, iron and calcium were determined by the standard method (AOAC, 1980). Textural characteristics of cookies such as hardness, gumminess, chewiness, breaking strength and cutting strength of cookies were measured using Instron Universal Texturometer (Shimadzu AG-Xplus). Each cookie was placed on the loading cell and compressed with a sharp blade-cutting probe as per the standard procedure given by Singh *et al.* (1993). Moreover, the calorific value of the prepared cookies was estimated using the sum of the product of respective physiological fuel values and contents of protein, carbohydrate and fat and expressed in kcal/100 g (Thompson, 2009).

### 2.3 Sensory evaluation of cookies

The cookies prepared from different combination of wheat and pearl millet flour along with control was subjected to sensory evaluation for various quality attributes like colour, appearance, flavour, taste, texture and overall acceptability, with the help of a semi-trained panel of judges using 9-point Hedonic scale (Agrahar, *et al.*, 2014).

### 2.4 Statistical analysis

The analyses of physico-chemical, textural and sensory characteristics were done using triplicate samples. The data obtained from various experiments were statistically analysed using one way ANOVA and Duncan's test at 95% (P≤0.05) level of significance (Das and Giri, 1988).

## 3. Results and discussion

The cookies were prepared by substituting whole wheat flour with PMF at levels of 20%, 40%, 60%, 80%, and 100% as shown in Figure 1 and were evaluated for their physicochemical, textural and sensory characteristics and results are presented below.

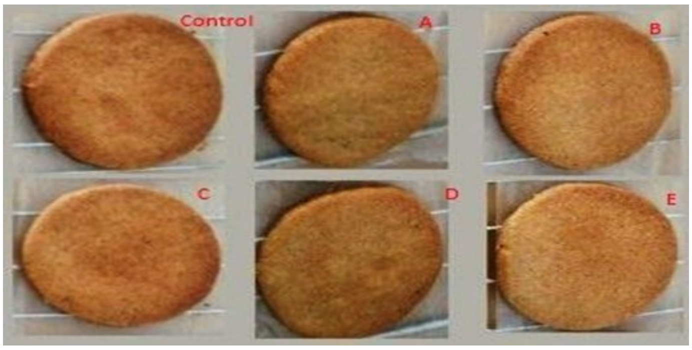


Figure 1. Cookies prepared in different combinations

### 3.1 Physical properties of cookies

The data regarding physical properties found statistically significant (P<0.05) with respect to weight, diameter, thickness, spread ratio, and spread factor of cookies is presented in Figure 2. It was observed that the weight of cookies decreased gradually from 9.90±0.02 to 9.54±0.02 g with the increasing proportion of PMF, with respect to control (9.95±0.02g). Also, there was a simultaneous decrease in diameter from 49.80±0.02 to 44.66±0.01 mm. The spread ratio of cookies firstly increased from 3.81±0.04 to 5.05±0.02 then decreased significantly to 3.44±0.03 with an increasing level of PMF. A similar pattern was observed for the spread factor. The spread factor of the control sample was considered as standard (100%). In comparison to the control sample, there was an initial increase in the spread factor of cookies with 20% PMF. This might be due to the combined effect of sugar and fibres in the dough. In cookies containing 20% PMF, the high sugar and low fibre content resulted in increased diameter and reduced thickness of cookies during baking. Among the PMF based samples, the spread factor significantly decreased from 136.50±0.07 to 92.97±0.05% with increased addition of PMF. As the level of PMF increased there was an increase in water-absorbing fibre content that retards the spreading of cookies thus reducing the diameter with subsequent increase in thickness of cookies (Agrahar-Murugkar *et al.*, 2014).

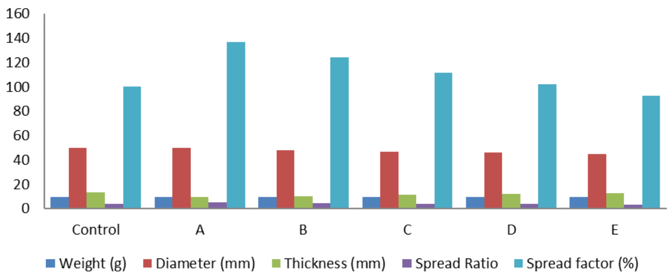


Figure 2. Physical characteristics of pearl millet cookies

### 3.2 Textural characteristics of cookies

The results with respect to textural characteristics were also statistically significant (P<0.05) of cookies like hardness, chewiness, gumminess, breaking strength and cutting strength are presented in Table 1. It was observed that there was a significant increase in the hardness of cookies from 19.24±0.04 to 28.91±0.01 N with increasing levels of PMF in cookies. The hardness of cookies is due to the strong interaction between pearl millet proteins with wheat proteins that made cookies compact. Similar results were observed by Singh *et al.* (1993). The breaking strength is also one of the criteria to measure the hardness of the cookie. The results indicated that the breaking strength of cookies significantly increased from 28.91±0.01 to 43.00±0.02 N

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Table 1. Textural profile of cookies incorporated with Pearl millet flour

| Treatments | Hardness (N) | Chewiness (N) | Gumminess (N) | Breaking strength (N) | Cutting strength (N) |
|---|---|---|---|---|---|
| Control | 19.24±0.04 | 10.21±0.01 | 12.47±0.03 | 29.78±0.02 | 31.39±0.02 |
| A | 20.21±0.03 | 10.80±0.02 | 12.55±0.03 | 33.28±0.01 | 34.65±0.04 |
| B | 22.24±0.02 | 11.00±0.01 | 14.23±0.01 | 36.50±0.02 | 37.90±0.01 |
| C | 24.13±0.02 | 11.47±0.03 | 18.92±0.05 | 38.71±0.03 | 39.98±0.05 |
| D | 27.98±0.03 | 12.92±0.05 | 21.86±0.02 | 40.74±0.04 | 42.30±0.04 |
| E | 28.91±0.01 | 13.68±0.02 | 24.42±0.01 | 43.00±0.02 | 44.20±0.03 |

A: 20% PMF, B: 40% PMF, C: 60% PMF, D: 80% PMF, E: 100% PMF. Values are expressed as mean±SD, n = 3.

with increasing levels of PMF in cookies. The cutting strength of cookies increased from 31.39±0.02 to 44.20±0.03 N with increasing levels of PMF in cookies. This may be due to relatively higher water content in PMF incorporated dough (Gaines, 1990). In conclusion, the results of this study indicate that the physical and textural characteristics of cookies were affected by the addition of PMF at different levels.

### *3.3 Sensory evaluation of cookies*

Results of sensory evaluation of cookies prepared with PMF presented in Table 2 revealed that the overall acceptability of cookies significantly ($P<0.05$) decreased with increasing levels of PMF from 8.4±0.01 to 7.3±0.33 to that of the control sample (8.7±0.04). However, cookies with substitution levels up to 60% PMF were found to be more acceptable for their sensory characteristics. Increasing the PMF level caused grittiness in cookies. The control samples had lighter colours and crisper textures. On the other hand, pearl millet cookies differed significantly. Sensory panellists opined that cookie incorporated PMF had undesirable grey colour but desirable baked millet aroma. Thus, on the overall acceptability score, cookies with a 60% substitution level (sample C) were considered as standardized and can be used for further supplementation.

### *3.4 Chemical composition of cookies*

Statistically significant ($P<0.05$) results were found for most of the chemical parameters. The chemical composition of pearl millet-based cookies regarding moisture, ash, fat, protein, crude fibre, carbohydrate, calcium, iron and phosphorus are presented in Table 3. It was observed that with the increase in PMF level in cookies, there was an increase in moisture. This may be due to the high moisture retention capacity of PMF than wheat flour (Singh *et al.*, 2012). The increase in ash content of cookies supplemented with PMF might be due to their appreciably higher content in PMF containing more ash than wheat flour. Pearl millet is well-identified for its high-fat content compared to other grains like wheat and rice (Abdalla *et al.*, 1998) and also high fat content could be due to the addition of visible fat in the cookie's recipe. It was observed that the fibre content of pearl millet cookies from samples A to E was attributed

Table 2. Sensory evaluation of cookies incorporated with Pearl millet flour

| Treatments | Appearance | Colour | Texture | Flavour | Taste | Overall acceptability |
|---|---|---|---|---|---|---|
| Control | 8.6±0.24 | 8.6±0.24 | 8.8±0.20 | 8.8±0.78 | 8.8±0.10 | 8.7±0.04 |
| A | 8.2±0.19 | 8.2±0.19 | 8.6±0.24 | 8.6±0.24 | 8.6±0.24 | 8.4±0.01 |
| B | 7.8±0.58 | 7.6±0.51 | 7.8±0.58 | 7.8±0.58 | 8.2±0.19 | 7.8±0.01 |
| C | 7.8±0.58 | 7.6±0.51 | 7.8±0.58 | 7.6±0.51 | 7.8±0.58 | 7.7±0.05 |
| D | 7.8±0.58 | 7.8±0.58 | 7.6±0.51 | 7.8±0.58 | 8.2±0.10 | 7.5±0.03 |
| E | 7.0±0.36 | 6.9±0.92 | 7.3±0.51 | 7.5±0.51 | 7.7±0.61 | 7.3±0.33 |

A: 20% PMF, B: 40% PMF, C: 60% PMF, D: 80% PMF, E: 100% PMF. Values are expressed as mean±SD, n = 3.

Table 3. Physical and nutritional analysis of cookies incorporated with Pearl millet flour

| Treatments | Moisture (g) | Protein (g) | Carbohydrates (g) | Fat (g) | Crude Fibres (g) | Ash (g) | Calcium (mg/100 g) | Phosphorus (mg/100 g) | Iron (mg/100 g) | Calorific value (kcal/100 g) |
|---|---|---|---|---|---|---|---|---|---|---|
| Control | 2.3±0.02 | 6.8±0.03 | 66.1±0.8 | 23.8±0.02 | 0.15±0.04 | 0.9±0.01 | 18.3±0.01 | 86.8±0.01 | 2.5±0.03 | 505.5±0.03 |
| A | 3.6±0.01 | 6.7±0.02 | 64.2±0.6 | 24.1±0.01 | 0.35±0.05 | 1.0±0.02 | 19.2±0.04 | 108.1±0.03 | 3.0±0.04 | 500.1±0.01 |
| B | 3.8±0.02 | 6.6±0.02 | 63.4±0.2 | 24.5±0.03 | 0.54±0.04 | 1.2±0.01 | 20.1±0.02 | 131.2±0.04 | 3.1±0.02 | 500.1±0.02 |
| C | 3.9±0.03 | 6.5±0.01 | 62.6±0.4 | 24.9±0.05 | 0.74±0.03 | 1.4±0.04 | 21.0±0.05 | 153.3±0.02 | 3.8±0.04 | 500.0±0.04 |
| D | 4.4±0.02 | 6.3±0.05 | 61.5±0.9 | 25.4±0.02 | 0.94±0.05 | 1.5±0.03 | 21.8±0.01 | 175.2±0.02 | 4.3±0.04 | 499.6±0.04 |
| E | 4.7±0.01 | 6.2±0.04 | 60.5±0.7 | 25.8±0.05 | 1.14±0.06 | 1.7±0.01 | 22.8±0.04 | 197.2±0.04 | 4.9±0.02 | 499.3±0.05 |

A: 20% PMF, B: 40% PMF, C: 60% PMF, D: 80% PMF, E: 100% PMF. Values are expressed as mean±SD, n = 3.

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to the high inherent fibre proportions in the pearl millet grains (Gaines, 1990). Majumdar (2006) observed a similar trend of increased fat and ash content of pearl millet cookies. The proteins and carbohydrate content of cookies were found to be decreased with increasing levels of PMF in cookies. There was a significant increase in the mineral content of cookies with an increasing level of PMF. The calcium, phosphorous and iron contents of cookies increased from 18.26±0.01 to 22.75±0.04 mg/100 g, 86.76±0.01 to 197.18±0.04 mg/100 g and 2.48±0.03 to 4.84±0.02 mg/100 g, respectively. Meanwhile, the calorific value of cookies decreased from 505.53±0.03 to 499.25±0.05 Kcal/100g with increased levels of PMF in cookies. The values were found at par with the study of Majumdar (2006).

## 4. Conclusion

The cookies with the incorporation of Pearl millet flour (PMF) were successfully prepared with low gluten content. The addition of pearl millet flour by replacing wheat flour in various bakery products is a useful strategy to increase the consumption of important nutrients in the human diet. Pearl millet flour as a replacement for wheat flour in the preparation of cookies was found effective in improving its nutritional and sensory quality characteristics. It can be concluded that the cookies prepared from wheat flour and PMF blend in the ratio of 40:60 were found acceptable with respect to almost all sensory parameters and economically feasible. Thus, Pearl being low-cost millet can be explored effectively and efficiently in the development of various nutritionally enriched value-added healthier products in order to combat the problem of malnutrition.

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