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Development of cookies and bread from cooked and fermented pearl millet flour

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The probiotic bacteria are found to be developed in the spontaneously fermented pearl millet. Bakery products are used as a vehicle for incorporation of different nutritionally rich ingredients. Fortification of wheat flour with non wheat proteins increases protein quality by improving its amino acid profiles. The anti nutrients phytic acid was reduced from 858.4 mg/100 g in the raw pearl millet to 380.3 mg/100 g in the cooked fermented pearl millet. Tannin did not show any reduction in its amount after cooking and fermentation of the pearl millet from the raw pearl millet. The cooked fermented pearl millet was utilized for the production of bread and cookies substituting refined wheat flour. The bread substituted with 10, 15 and 20% of the cooked fermented pearl millet flour showed good textural and physical properties and the quality was comparable to the market bread. Cookies were prepared from the 50 and 100% replacement of wheat flour and the cookie with 50% cooked fermented pearl millet flour showed good acceptability.

Key words: Cooked fermented pearl millet, anti nutrients, fortification, bakery products.

INTRODUCTION

Pearl millet (*Pennisetum glaucum*) is one of the important crops in semi-arid areas of Africa and India. Pearl millet crop has a wide adaptability to local environments for its properties of been tolerant to drought and heat. For this reason, it is widely grown in tropical regions of the world including Africa and Asia. Pearl millet is currently the world's sixth most important cereal grain and is grown extensively in Africa, Asia, India and the Near East as a food grain and is the staple source of nutrition for millions of people. India is the largest producer of pearl millet, both in terms of area and production.

Fermentation of foods has been practiced for improving the flavour, texture and palatability of foods. Pearl millet has a high nutrient content but bioavailability is low, inherently due to the presence of antinutritional factors, such as phytic acid, polyphenols and tannins. Fermentation is one of the processes known to reduce these anti-nutrients.

The changes associated with the fermentation process are as a result of action of enzymes produced by micro-organisms. Lactic acid bacteria (LAB) are commonly involved in the fermentation of carbohydrate based sub-strates. In lactic acid fermented foods, the acidity is usually below pH 4.5. Most pathogenic microorganisms

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Table 1. Process parameter for bread and cookies.

Independent variable	Dependent variables
Ratio of refined wheat flour and fermented flour (10, 15, 20 and 25% for bread; 50 and 100% for cookies)	Colour Loaf volume for bread Spread ratio for cookies Textural properties Sensory evaluation

Table 2. Effect of cooked fermented pearl millet flour addition on specific volume and textural attributes of composite bread.

Parameter	Control	10% of CFPM flour	15% of CFPM flour	20% of CFPM flour	25% of CFPM flour
Loaf weight(g)	154	154	152	152	153
Loaf volume (cc)	913	866	836	832	772
Loaf specific volume (cc/gm)	5.93	5.61	5.55	5.47	5.04
Hardness(N)	11.48	12.22	16.7	19.65	21.15
Cohesiveness	0.71	0.69	0.7	0.63	0.61
Springiness	0.9	0.85	0.82	0.87	0.81
Gumminess (N)	8.19	8.48	11.65	12.42	12.9
Chewiness (N)	7.41	6.35	9.61	10.8	10.45

CFPM, Cooked fermented pearl millet.

found in food cannot survive at this low pH, hence, lactic acid fermentation of food has been found to reduce the risk of growth of pathogenic microorganisms in the food. Probiotics are beneficial bacteria in that they favourably alter the intestinal microflora balance, inhibit the growth of harmful bacteria, promote good digestion, boost immune function and increase resistance to infection. Examples of probiotics that have found application in probiotic products include some strains of *Lactobacillus* and *Bifidobacteria* genera.

MATERIALS AND METHODS

Fermentation of cooked pearl millet

The completely cooked pearl millet was allowed for spontaneous fermentation by adding various ratios of 1:2, 1:3 and 1:4 of water with the cooked pearl millet. The growth and survival of probiotic bacteria (*Lactobacillus* sp.) is continuously enumerated by plate count method in selective medium Man, Rogosa and Sharpe (MRS) for every 6 h until fermentation for 48 h. Table 1 shows the process parameter for cooked fermented probiotic pearl millet. The cooked fermented probiotic millet water was incubated at 37°C by keeping in a BOD incubator (Genuine Equipment MFRS, Coimbatore) for 48 h for encouraging faster multiplication of probiotic bacteria. The fermented cooked pearl millet was stored under both refrigerated and ambient temperature and the survival of probiotic bacteria was noted for consecutive days of storage.

Preparation of value added products

The cooked fermented pearl millet flour is used for the preparation of bakery products like bread and cookies. The details of process parameter for bread and cookies are highlighted in the Table 2.

Preparation of bread

The bread is prepared with the cooked fermented flour in different ratio along with the refined wheat flour. The pearl millet flour which is rich in fiber makes the composite bread rich in fiber. Due to the negligible amount of gluten in the pearl millet flour, the higher ratio of the cooked fermented pearl millet flour lowers the raising volume of the bread. So the percentage of the cooked fermented pearl millet flour with the refined wheat flour in the development of value added composite bread was limited to 10, 15, 20 and 25%.

Preparation of cookies

Cookies were prepared from the cooked fermented pearl millet flour together with the wheat flour in 1:1 ratio and also without mixing it with the wheat flour.

Specific volume of bread

The specific volume of bread was calculated according to the AACC method 10- 05.01 (AACC, 2000) by dividing volume (cc) by weight (g). Loaf volume was measured by rapeseed displacement immediately after removal from the oven and weighing. Loaves were placed in a container of known volume into which rapeseeds were run until the container was full. The volume of seeds displaced by the loaf was considered as the loaf volume. Loaf specific volume (LSV), was calculated according to the following formula:

$$L.S.V = \text{Loaf volume (cc)}/\text{Loaf weight (g)} \quad (1)$$

Physical properties of cookies

Cookies diameter (D) and thickness (T) were determined using a vernier caliper while weight of cookies was determined by using electronic analytical weighing balance. Spread was calculated using the formula given by Akubor (2004):

Spread ratio = Diameter/thickness (2)

Texture analysis

The texture of the product is of great importance in determining the quality and acceptability of fermented pearl millet and value added products from pearl millet. The textural property of value added bread and cookies were determined using texture analyzer.

Firmness

Bourne (1982) defined firmness in terms of hardness as the maximum force recorded during first compression stroke. Firmness is defined in this method as the force (in grams, kilograms or Newtons) required to compress the product by a pre-set distance (force taken at 25% compression of 25 mm) (AACC, 1983). Firmness tests were carried out in the texture analyzer using compression plate with a diameter of 75 mm (P/75) by compressing the sample to a depth of 10 mm. A probe adapter was used to connect the compression plate to the movable bar. Calibration of the probe was done before conducting the experiments, ensuring the space between the compression plate and the heavy-duty platform.

Determination of firmness of composite bread

Firmness tests were conducted on a single bread slice at a time and then the required values were gotten from the graph. The probe was moved to compress the sample to a specified distance of 10 mm. Once the probe touched the sample, the maximum force required to penetrate the spent layer chicken piece was observed and compared between the samples. The bread firmness is determined by using the AACC (74-09) standard method. TA-XT2 Settings, Mode: measure force in compression; Option: return to start; pre-test speed: 1.0 mm/s; Test Speed: 1.7 mm/s; Post-Test Speed: 10.0 mm/s; Strain: 40%; Trigger Type: Auto: 5 g; Data Acquisition Rate: 250 pps; Probe: AACC 36 mm cylinder probe with radius (P/36R) using 5 kg load cell

Edges of the cylinder are 'rounded' to remove sharpness of the perimeter of the probe, hence reducing tendency of the probe to cut the sample upon penetration. The bread loaf is sliced mechanically into equal slice thickness of 12.5 mm. The probe calibration was done by carrying out the test using '% strain' measurement. To do this the probe was lowered, so that it is close to the test surface. The T.A. in the menu bar was clicked and then CALIBRATE PROBE to specify the distance of about 30 mm that the probe return to, after sample compression which is suggested. Within the 'Run a Test' window, the auto height box was checked before commencing the tests. The sample was placed centrally under the cylinder probe, avoiding any irregular or non-representative areas of crumb and the test is commenced. Once the trigger force is attained, the probe proceeds to compress the sample until it has compressed it by 40% of the product height. It then withdraws from the sample and returns to its starting position. The result is obtained in a texture expert exceed plots. Then the observation is made from the graph and result window.

Determination of hardness and resistance of composite cookies to bend

The maximum force required to fracture the cookies was referred to as the 'hardness' of the sample. The distance at the point of break is the resistance of the sample to bend and so relates to the 'fracturability' of the sample, that is, a sample that breaks at a very short distance has a high fracturability. TA-XT2 settings, mode: measure force in compression; option: return to start; pre-test speed: 1.0 mm/s; test speed: 3.0 mm/s; post-test speed: 10.0 mm/s; distance: 5 mm; trigger force: auto - 50 g; data acquisition rate: 500 pps; probe: 3 point bending rig (HDP/3PB) using 5 kg load cell with a heavy duty platform (HDP/90)

The two adjustable supports of the rig base plate are placed a suitable distance apart so as to support the sample of 40 mm. For comparison purposes, this gap should be noted and kept constant. The base plate is then secured onto the heavy duty platform. The heavy duty platform was maneuvered and locked in a position that enables the upper blade to be equidistant from the two lower supports. The sample was removed from its place of storage and was placed centrally over the supports just prior to testing. Once the trigger force is attained the force was seen to increase until the time when the biscuit/cookie fractures and falls into two pieces. This was observed as the maximum force and can be referred to as the 'hardness' of the sample. The distance at the point of break was the resistance of the sample to bend and so relates to the 'fracturability' of the sample. The result is obtained from the graph window.

Sensory evaluation

The sensory analysis for the composite bread with the incorporation of 10, 15, 20 and 25% of cooked fermented pearl millet flour with refined wheat flour was given to the 50 semitrainned sensory panelists at normal room temperature and humidity keeping the bread prepared from complete refined wheat flour as control. The attributes evaluated for bread was colour, flavour, taste, chewiness and overall acceptability. Similar procedure was followed for the composite cookies incorporated with the cooked fermented pearl millet flour with wheat flour of 50%and cookies prepared without incorporation of wheat flour. During sensory evaluation, panelists were instructed to drink water or rinse their mouths to clear the palate after each evaluation.

Semi trained panelists were given a hedonic scale questionnaire to evaluate the composite bread using a 9 points scale (1- extremely dislike, 2- dislike very much, 3- dislike moderately, 4- dislike slightly, 5- neither like nor dislike, 6- like slightly, 7- like moderately, 8- like very much, and 9 - extremely like). Composite bread was evaluated for general appearance, crumb grain, odour, softness, taste, mouth feel and overall acceptability measures.

RESULTS AND DISCUSSION

Studies on composite bread

Specific volume of composite bread

The effect of cooked fermented pearl millet (CFPM) flour on specific volume of composite bread is presented in Table 3. Bread specific volume decreased significantly with increasing CFPM flour substitution level. The volume of bread made from composite flours, were lower than those made from pure refined wheat flour. The highest bread specific volume was 5.93 cc/g obtained from

Table 3. Effect of adding cooked fermented pearl millet flours on refined wheat flour bread and bread crumb colour.

Colour value	Bread crumb				
	Control	10% of CFPM flour	15% of CFPM flour	20% of CFPM flour	25% of CFPM flour
L-value	64.54	60.58	58.18	57.29	55.47
a-value	- 0.75	- 0.67	- 0.47	- 0.23	- 0.13
b-value	29.51	20.40	19.45	15.53	12.67
Bread					
L-value	72.54	71.58	69.18	65.29	62.47
a-value	- 0.62	- 0.58	- 0.35	- 0.21	- 0.09
b-value	9.51	10.45	11.83	12.37	11.92

CFPM- Cooked fermented pearl millet.

Table 4. Sensory evaluation of composite bread.

Sensory attribute	Control	10% of CFPM flour	15% of CFPM flour	20% of CFPM flour	25% of CFPM flour
Appearance	8.44	8.12	8.4	7.5	6.00
Colour	8.5	8	7.99	6.86	4.89
Taste	8.8	8.2	7.11	6.92	5.59
Softness	8.6	7.76	6.94	6.51	5.22
Mouth feel	8.7	7.59	7.5	6.23	5.44
Over all acceptability	8.6	7.48	6.98	6.8	5.41

CFPM- Cooked fermented pearl millet.

control bread, while flour containing 25% CFPM flour resulted in the lowest bread specific volume of 5.04 and 5.27 cc/g, respectively. This finding was in agreement with that reported by Aluko and Olugbemi (1989), who found lower volumes associated with composite as opposed to 100% wheat, while the specific volume of commercially available bread loaf in the market is 6 cc/g.

This can be attributed to lower levels of gluten network in the dough and consequently less ability of the dough to rise; due to the weaker cell wall structure. However, the specific volumes of the 10, 15 and 20% levels of substitution were not significantly different from each other.

Textural properties of composite bread

Bread firmness, cohesiveness, springiness, gumminess and chewiness values was found for the composite bread with the ratio of 10, 15, 20 and 25% of cooked fermented pearl millet (CFPM) flour with the refined wheat flour. Table 4 illustrates the textural properties of composite bread. From the table, it was shown that the hardness of the composite bread increases with increase in percenttage concentration of the CFPM flour. The higher value of 21.15 N was observed for the bread with 25% incorporation of the CFPM flour to the refined wheat flour. While the hardness of the remaining percent of incorporation shows lower value. The hardness value of bread with 10% incorporation of CFPM flour show less deviation from the control sample whose hardness was 11.48 N and the hardness of 10 per cent bread was 12.22 N. There was no remarkable difference in the values of cohesiveness and springiness in spite of any percent of incorporation.

The higher value of 0.71 and 0.9 cohesiveness and springiness was seen for the control as compared to the prepared composite bread. The lower value of cohesiveness and springiness was shown by the composite bread with 25% of CFPM flour with the refined wheat flour. The gumminess and chewiness for the refined wheat flour bread is 8.19 and 7.41 N and it was found to increase with the increase in percent of incorporation of CFPM flour. Higher value of 12.9 and 10.45 N for gumminess and chewiness, respectively, was shown by 25% CFPM flour composite bread. Abdelghafor et al. (2011) stated that increasing the level of sorghum flours decreased cohesiveness, springiness and resilience, and increased hardness, gumminess and chewiness of pan bread made with whole or decorticated sorghum-wheat composite flour.

Effect of adding cooked fermented pearl millet flours on refined wheat flour bread and bread crumb colour

The colour values L (light-dark), a (red-green), and b (yellow-blue) of the bread and crumb samples of blended

Table 5. Effect of addition of cooked fermented pearl millet flour on the physical and textural properties of composite cookies.

Parameter	Control	50% CFPM flour	100% CFPM flour
Mass (g)	7.25	6.80	6.78
Diameter (mm)	40.00	36.95	36.21
Thickness (mm)	30.80	34.14	34.36
Spread ratio	7.70	9.45	9.47
Hardness (N)	19.24	24.13	28.91
Gumminess (N)	12.47	13.92	15.22
Chewiness(N)	10.21	11.47	13.68
Fracturabilty (N)	19.53	24.42	27.94

CFPM- Cooked fermented pearl millet.

Table 6. Effect of addition of cooked fermented pearl millet flour on the colour of composite cookies.

Sample	Colour		
	L	a	b
Control	74.12	2.74	25.51
50% CFPM flour	60.69	5.45	19.31
100% CFPM flour	59.35	8.19	11.25

L (light-dark), a (red-green), and b (yellow-blue).

flour are provided in Table 5. The results indicate that, as the percent of CFPM flour replacement increased, L-values shifted significantly from white to gray, a values shifted from green to red, and b values shifted from blue to yellow.

Overall, the L values of the bread and bread crumb samples substituted with CFPM flour decreased from 72.54 to 62.47 and from 64.54 to 55.47, indicating a significant increase in grayish color. The highest *a*-value was that of bread made with 25% CFPM flour (-0.13); whereas, the lowest value was observed in bread made from 100% refined wheat flour (-0.75) as indicated by a higher intensities of green color. On the other hand, the lowest b value was associated with bread made from the 100% refined wheat flour 9.51, whereas the highest value 12.67 was associated with bread made with 25% CFPM flour. The effects of CFPM flour substitution on the colour of the bread crumb were more obvious than that of bread colour. The bread crumb samples made with 100% refined wheat gave lower L values and higher a and b values as compared to the samples made with added CFPM flour. In contrast, Torres et al. (1993) reported that the addition of decorticated pearl millet flour did not significantly ($p<0.05$) affect the color of flour for tortillas. However, tortillas containing sorghum flour had undesirable black specks that affected their appearance. Also, Morad et al. (1984) studied the effect of millet variety on baking properties of U.S. conventional bread, Balady bread and cookies. They found that the colour values of pocket bread made from whole wheat flour was similar to those made from brown and yellow millet at 30%. Bread crumb colour, especially of samples made with brown sorghums could compete with whole wheat bread. The results from this study indicate that CFPM flour darkened crumb colour. This may be due to the fact that the fibers and pigments reduced the green component in crumb color and shifted the colour somewhat towards the gray to red.

Sensory evaluation of composite breads

Semi trained panelists were given a hedonic scale questionnaire to evaluate the composite bread using a 9 points scale (1- extremely dislike, 2- dislike very much, 3- dislike moderately, 4- dislike slightly, 5- neither like nor dislike, 6- like slightly, 7- like moderately, 8- like very much and 9 - extremely like). Composite bread was evaluated for general appearance, crumb grain, odour, softness, taste, mouth feel and overall acceptability measures.

The sensory properties of composite breads made from blends of wheat and cooked fermented wheat flours as well as the 100% wheat bread are presented in Table 6. All sensory scores of general appearance, colour, taste, softness, mouth feel and over all acceptability were significantly different among blend of CFPM flour.

From Table 6, it can be predicted that there was significant difference in the overall acceptability with increasing level of CFPM flour with the refined wheat flour. The colour of the composite breads made with 5 and 10% substituted CFPM flour was similar to the control (100% refined wheat flour); whereas at higher levels of substitution, samples were significantly darker. The mouth feel score decrease significantly as the level of CFPM flour increased. The mouth feel score of 10 and 15% composite bread was found to be similar to each other with the mean score of 7.59 and 7.5. The sensory evaluation score for the composite bread prepared from the 25% substitution of CFPM flour in the refined wheat

Table 7. Sensory evaluation of composite cookies.

Sensory attribute	Appearance	Colour	Taste	Texture	Over all acceptability
Control	8.44	9	8.2	8.5	8.8
50% CFPM flour	8.5	8.5	7.99	6.86	7.9
100% CFPM flour	8.6	8.2	5.11	6.2	5.2

flour ranges from 5.22 to 6 for the sensory attributes. These results are in agreement with those reported by Summer and Nielsen (1976), who concluded that incorporation of 25% millet flour in bread formulation darkened the internal and external loaf colour. In this study, overall bread quality at the different levels of cooked fermented pearl millet flour to the substitution levels from 10 to 20% was found to be acceptable. However, acceptability increased as the level of substi-tution of CFPM flour decreased. These results are in agreement with the work of Kyomugisha (2002).

Studies on composite cookies

Spread ratio of composite cookies

Table 7 shows the difference in spread ratio for the composite cookies prepared with the 50 and 100% of cooked fermented flour with the wheat flour. The cookies prepared from the whole wheat flour were taken as the control. The thickness was found to increase significantly with the increase in replacement ratio of cooked fermented pearl millet flour with the whole wheat flour resulting in decrease in the weight of the composite cookies. The diameter increased for the composite cookies as compared to the control. The thickness and diameter of the whole wheat flour cookies is 30.80 and 40 mm. Higher mass of 7.22 g was observed for the control while the cookies made from the cooked fermented pearl millet flour reduced to 6.45 g. This reduction in mass may be due to reduction in bulk of the flour due to fermentation. Similar result was observed by Chinma and Gernah (2007) for the composite cookies produced from cassava, mango and soya bean flour.

Textural properties of composite cookies

Textural properties like firmness, gumminess, chewiness and fracturability or breaking strength (resistance offered by the cookies to bend) with the mixing ratio of 50 and 100% (CFPM) flour with refined wheat flour was seen for the composite cookies. All the textural properties of hardness, gumminess, chewiness and fraturability were increased with increase in incorporation of the cooked fermented pearl millet flour. The composite cookies with 50% substitution of cooked fermented pearl millet flour showed slight deviation in the textural properties from the control, while the 100% shows higher value of 28. 9 N hardness, 15.22 N gumminess, 13.68 N gumminess and 27.94 N fraturability. There was no remarkable difference in the hardness and fracturability within the samples. Lesser hardness value of 19.24 N was observed in the case of the control sample. The result suggests that the increase in incorporation level of cooked fermented pearl millet flour increases textural properties value. These results are in agreement with the result given by Chinma and Gernah (2007).

Colour difference in composite cookies

The cookies substituted with the cooked fermented pearl millet showed difference in colour with respect to the control. Table 6 shows colour values of whiteness (L), redness (a) and yellowness (b) measured for crust colours. L value declined in the cooked fermented pearl millet flour samples as compared to the control. It was confirmed that the CFPM flour substituted cookies were darker and redder (a-values) and with higher browning index (BI) than the control samples. The results showed that the a-values (redness) are getting higher in the composite cookies samples with enhanced levels of CFPM flour from 50 to 100%. These results are consistent with those obtained by Barron and Espinoza (1993), Ahmed (1999), Kenny et al. (2000) and Eissa et al. (2007). Furthermore the data indicated that the composite cookies show decrease in b value with increase in substitution with CFPM flour. Higher b value was found for the cookies produced with 100% cooked fermented pearl millet flour.

The data given in the Table 6 shows that the colour of the composite cookies was darker in colour as compared to the control cookies which were produced from wheat flour.

Sensory evaluation of composite cookies

The effect of addition of 50 and 100% of cooked fermented pearl millet flour for the production of composite cookies on the sensory characteristics is presented in the Table 7. The score for the sensory attributes reduced sharply with increase in substitution level of cooked fermented pearl millet flour of the composite cookies when compared with the control sample.

The taste of cookies produced from 100% CFPM flour was impaired. So the score for the taste of the cookies was 5.11 while the taste of 50% was 7.99 which do not show significant difference from control which was 8.2. The data presented in the Table 7 for the colour and appearance of the cookies was not significant and it ranges from 8.2 to 9 in the 9 point hedonic scale. It can be noticed from the results recorded in Table 7 that the overall acceptability was decreased with increase in the substitution of cooked fermented pearl millet flour with wheat flour. These results given are in good agreement with those reported by Takumil et al. (2006) who found that millet seeds have bitter taste when compared with the wheat flour cookies.

Conclusion

The cooked fermented pearl millet (CFPM) was also utilized for preparing bakery products. The bakery products are usually made of refined or whole wheat flour, due to the less availability of fiber, frequent consumption of them leads to constipation problem and colon cancer for consumers. The substitution of cooked fermented pearl millet flour for the refined whole wheat flour finds utilization of pearl millet in bakery. The bread with 10% incorporation of CFPM flour with wheat flour finds no remarkable change in the physciochemical and textural properties with the commercially available one in the market whose hardness is 11.48 N and for 10% CFPM is 12.22 N. The 25% incorporation was unacceptable in terms of both textural and physical attributes. The non glutinous nature of cooked fermented pearl millet flour shows reduction in raising level during the preparation of bread. Hence the substitution level of cooked fermented pearl millet (CFPM) flour for refined wheat flour was limited to 25%.

The composite cookies were produced using the cooked fermented pearl millet flour with substitution of 50% and with complete replacement of wheat flour. The cookies with 50% substitution of CFPM flour show better colour and textural properties as compared to cookies produced from 100% of CFPM flour. The colour of the cookies produced from 100% of CFPM was dark as compared to the composite cookies produced from 50% CFPM flour with refined wheat flour. The hardness and fracturability increased with the increase in percentage of CFPM flour. Though cookies were produced from 100% of CFPM flour, good sensory score and acceptability was shown by the cookies prepared from 50% of CFPM flour. The higher hardness and fracturability of 28.9 and 27.9 N, respectively for cookies produced from 100% CFPM flour was due to high fiber and absence of gluten content. The darker colour for it was due to high phenol and tannin content.

The 10% of CFPM flour with refined wheat flour of bread is acceptable and 50% of CFPM flour with refined wheat flour of cookies is good for consumption.

Conflict of Interest

The author(s) have not declared any conflict of interests.

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