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ORIGINAL ARTICLE

Quality characteristics of gluten free cookies prepared from different flour combinations

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Abstract The present investigation was undertaken on the utilization of alternate flours/meals (rice (*Oryza sativa*), maize (*Zea mays*), sorghum (*Sorghum vulgare*) and pearl millet (*Pennisetum glaucum*) for the preparation of gluten free cookies as compared to conventional wheat (*Triticum aestivum*) flour cookies. The physicochemical parameters, sensory qualities and functional properties of flours/cookies were studied and compared with control cookies. The blend of maize and pearl millet had best pasting qualities followed by blend of pearl millet and sorghum flour. The control cookies showed a higher yield (186.8%) but stronger peak force (2.69 kg). The cookies prepared from rice and maize combination had highest spread ratio whereas, the lowest spread ratio was observed in rice and sorghum combination. The cookies with pearl millet and sorghum flour combination had higher fat, protein, ash and calorific values as compared to control cookies. The maximum sensory overall acceptability scores were found for cookies prepared from combination of pearl millet and sorghum flour followed by rice and sorghum, maize and sorghum, rice and maize, maize and pearl millet, rice and pearl millet and control cookies. All gluten free cookies had higher nutritional value as compared to control cookies and were acceptable by panelists.

Keywords Gluten free · Cookies · Chemical composition · Functional properties · Sensory quality

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Introduction

During recent years there has been a slow and steady increase in consumer interest for wheat (*Triticum aestivum*) free foods for minimizing the risk of relatively unfamiliar condition known as celiac disease (CD) (Lovis 2003). The celiac disease in susceptible people is gluten induced/sensitive entropy characterized by damage of small intestinal mucosa caused by gliadin fraction of wheat (Murry 1999; Fasano and Catassi 2001; Farrell and Kelly 2002). These researchers suggested that the celiac disease can be treated by avoiding of gluten ingestion. Presently persons with celiac disease are unable to consume some of the most commonly available products of the market including breads, baked goods, and other food products made with wheat flour (Lovis 2003). During January 2007, the FDA proposed the rule for labelling gluten free products to satisfy the demand for high quality gluten free cookies/breads having similar quality of wheat flour based cookies and breads. As per rule the "Gluten free" is a voluntary term and defined as food containing less than 20 ppm of gluten. The gluten is a protein complex found in the triticeae tribe of wheat, barley (*Hordeum vulgare*) and rye (*Secale cereale*), which provides desirable organoleptic properties (texture and taste) to many bakery and other food products. Gluten is known as "heart and soul" of bakery for providing the processing qualities familiar to both the home baker as well as the commercial food manufacturer. Since gluten plays a limited role in defining the processability and end product quality of cookies, it can be complemented through some alternate flours in various combinations.

The present investigation provides an ingredient delivery system and methods of producing gluten-free cookies that were comparable to wheat cookies. The rice (*Oryza sativa*) flour, maize (*Zea mays*) meal, sorghum (*Sorghum vulgare*) flour, pearl millet (*Pennisetum glaucum*) flour and their blends in formulations were used for the preparation of gluten free cookies. The blend may reduce protein-energy malnutrition in the developing countries because of the expected improved nutritive value of the blend. The objectives of our study were to prepare formulations of different gluten free flours for using in cookies making, to determine chemical and functional properties and to evaluate these formulations for cookie making of acceptable quality.

Materials and methods

The wheat (*Triticum aestivum*) flour, rice (*Oryza sativa*) flour, maize (*Zea mays*) meal, sorghum (*Sorghum vulgare*) flour and pearl millet (*Pennisetum glaucum*) flour were milled to suitable size using the commercial stone grinding mill. Other materials like sugar, fat, common salt, sodium bicarbonate and soy lecithin used in the study were bought from a commercial stock.

Analytical methods Protein (Micro Kjeldahal, $N\times6.25$), fat (solvent extraction), moisture and ash were determined by the AOAC (1990) methods. The energy values were calculated by using factors of 4, 9 and 4 for total carbohydrates, fat and proteins, respectively.

Functional properties Oil absorption and hydration capacities were determined by the method of Rosario and Flores (1981). 1 g sample was mixed with 10 ml distilled water or 10 ml oil (refined ground nut oil) for 30 s in a mixer. The samples were allowed to stand for 30 min at 30 °C in a water bath and centrifuged at 3,000 rpm for 20 min. The volume of supernatant was recorded to calculate the amount of hydration or oil absorption capacity. Least gelation concentration of samples was determined by the method of Lyne and Singh (1997). Suspension containing 8–15% (w/v) sample in 0.5% increments were prepared in 15 ml of distilled water. The test tubes were heated for 1 h in boiling water and refrigerated for 3 h at 5 °C. The least gelation concentration was determined as that concentration at which the sample did not fall down or slip from inverted test tube.

Pasting properties Pasting properties of flour and meal combinations were determined using a rapid visco analyser (RVA) starch master R&D pack V 3.0 (Newport Scientific Narrabeen, Australia). The RVA parameters measured were pasting temperature, peak viscosity, holding viscosity, final viscosity, break down viscosity and set back (Batey et al. 1997).

Preparation of cookies Cookies dough prepared from wheat flour (control) and gluten free flours combinations using flour (100%), sugar (58%), shortening (28%), salt (0.9%), sodium bicarbonate (1.0%), dextrose (13.8 ml, 8.9 g glucose in 150 ml water) and distilled water optimum. The dough was mixed in a Hobart mixer, sheeted to a thickness of 5 mm, cut into circular shapes of 5.5 cm diameter, transferred on a baking tray and baked in an oven pre-heated to 204 °C for 10 min. The cooled biscuits were packed in low density polyethylene (LDPE) pouches and were evaluated after 24 h.

Evaluation of cookies Cookies were weighed and measured for their width, thickness, spread ratio and peak force. Average values obtained with four cookies were recorded. The sensory evaluation of cookies was carried out by a panel of nine experienced judges using 9-point hedonic scale. The data were analyzed using ANOVA technique of Snedecor and Cochran (1968) using completely randomized design.

Results and discussion

Proximate composition The chemical composition and energy content of the raw materials are summarized in Table 1. The flour produced from white sorghum hybrids is light in color and has a bland, neutral taste that does not impart unusual colors or flavors to food products (Ciacci et al. 2007). These attributes make it desirable for use in wheat-free food products for diabetic, celiac and ethnic groups of people.

Functional properties of raw materials The hydration capacity was highest (2.23) for pearl millet flour and lowest (1.58) for sorghum flour and hence the pearl millet flour was best for hydration capacity (Table 1). Oil absorption ranged from 0.9 ml/g (wheat flour) to 1.1 ml/g (maize meal) whereas the least gelation concentration of raw materials ranged from 8.0 (wheat flour, rice flour and maize meal) to 8.9 (pearl millet flour). So it can be concluded that the oil absorption capacity of all the alternate flours increased over control wheat flours. Also the least gelation concentration of pearl millet flours has found to be best over the all other alternate flours/control wheat flours.

Pasting properties of gluten free flours combinations The blend of maize: pearl millet flour had highest pasting temperature (86.9 °C) whereas the control wheat flour had lowest pasting temperature (72.7 °C) (Table 2). The peak viscosity was maximum for control wheat flour and minimum for maize: pearl millet flour. The hold viscosity

Table 1 Chemical composition and functional properties of raw materials

	Wheat flour	Maize flour	Rice flour	Sorghum flour	Pearl millet	CD ($P \geq 0.05$, $n=3$)
Chemical composition						
Moisture,%	13.2	14.3	12.5	12.4	12.3	NE
Protein,%	10.5	11.1	6.4	11.7	11.5	NE
Fat,%	0.9	3.4	0.4	4.0	4.5	NE
Ash,%	0.58	1.22	0.52	2.20	1.54	NE
Starch,%	66.9	63.9	78.5	72.2	67.6	NE
Fiber,%	0.40	2.68	0.75	2.30	1.20	NE
Calorific values, Kcal/100 g	377.6	343.2	330.6	371.6	356.9	NE
Functional properties						
Hydration capacity, ml/g	1.80	1.75	1.88	1.58	2.23	0.33
Oil absorption, ml/g	0.90	1.10	0.98	1.00	1.10	NS
Least gelation concentration, w/v	8.0	8.0	8.0	8.5	8.9	0.28

NE Not Estimated; *NS* Non-Significant

was maximum for rice: sorghum flour combination and minimum for maize: pearl millet combined flour. The final viscosity was highest for rice: sorghum flours and lowest for maize: pearl millet flour combination. The setback viscosity was lowest and the break down viscosity was highest for control wheat flour as compared to blended

Table 2 Quality characteristics of different gluten free flour mixtures and cookies

	Flour combinations (50:50)							
	C	R:M	R:S	R:P	M:S	M:P	P:S	CD ($P \geq 0.05$)
Pasting properties ($n=3$)								
Pasting temp., °C	67.7	79.2	77.4	82.7	84.2	86.9	86.3	0.32
Peak viscosity, cP	2243	1809	2580	1751	1414	1156	1639	26.51
Hold viscosity, cP	1651	1580	2202	1432	1277	1033	1352	2.96
Final viscosity, cP	2913	5022	5211	3285	4107	2570	2812	4.58
Break down viscosity, cP	592	229	378	319	137	123	287	2.65
Setback viscosity, cP	1262	3422	3009	1853	2830	1537	1460	2.96
Cookies making quality ($n=3$)								
Yield,%	186.8	180.3	185.2	181.8	185.2	179.2	183.8	0.17
Width, cm	22.6	24.1	23.5	23.4	24.9	25.5	25.3	0.29
Thickness, cm	3.83	3.61	4.07	3.73	3.87	4.11	3.91	0.03
Spread ratio	5.89	6.69	5.77	6.26	6.44	6.23	6.49	0.03
Peak force, Kg	2.69	1.76	1.91	1.44	1.71	1.59	1.43	0.003
Sensory quality ($n=6$ panalists)								
Top grain	7.4	7.6	8.0	7.2	7.7	8.0	8.6	0.03
Texture	6.8	8.1	8.1	7.5	7.9	7.8	8.7	0.14
Flavor	7.3	8.1	7.8	8.3	8.4	7.9	8.5	0.14
Overall acceptability	7.6	7.9	8.0	7.7	8.0	7.9	8.6	0.03
Proximate composition and calorific value ($n=3$)								
Moisture,%	4.08	3.43	3.55	3.06	3.18	3.14	3.01	0.03
Fat,%	16.00	15.45	15.93	16.07	18.19	18.52	19.17	0.03
Protein,%	6.91	5.77	6.78	7.3	6.78	7.30	7.4	0.23
Ash,%	1.03	1.09	1.11	1.59	1.12	1.60	1.62	0.13
Calorific values kcal/100 g	439.24	446.93	471.89	466.03	463.03	458.88	481.73	0.001

C Control (Only wheat flour), *M* Maize, *P* Pearl, *S* Sorghum, *R* Rice, *W* Wheat combination of flour. The pasting temperature of all combination of flour increased significantly ($p \leq 0.05$) over control flour and hence may be recommended their combination for preparation of cookies/meal. The peak and hold viscosity relatively decreased in all combined flours (except rice: sorghum) as compared to control flour and hence blend of rice and sorghum flour was best for pasting quality. The breakdown viscosity of all blended flour reduced over control flour whereas set back viscosity of all combined flour increased significantly ($p \leq 0.05$) over control flour and hence the blended flour may be used for preparation of cookies efficiently. Thus it can be safely concluded that the pasting qualities of all combined flours (except rice: sorghum) were better than the control wheat flour. But the maize: pearl millet flour had advantage over other combined flours because of its highest pasting temperature, lowest peak viscosity, lowest hold viscosity, lowest final viscosity and lowest break down viscosity. Ragaee et al. (2006) reported significant differences between cereals (barley, millet, rye and sorghum) in starch peak, breakdown and setback viscosities as well as in protein peak viscosity.

Cookies making quality of gluten free flour combinations The yield was highest (186. 8 g/100 g) in wheat control sample and lowest (179.2 g/100 g) in maize: pearl millet flour combination (Table 2). However, the width was found to be minimum (22.6 cm) in control wheat flour and maximum (25.5 cm) in gluten free combination of maize: pearl millet flour. The maize: pearl millet flour had highest and desirable thickness of 4.11 cm whereas the thickness of cookies prepared from combination of rice: maize was lowest (3.61 cm). Spread ratio was minimum in cookies prepared from rice: sorghum flour combination and maximum in rice: maize flour combination. The peak force required to puncture the cookies prepared from combination of pearl millet: sorghum flour was found to be minimum (1.43 kg) whereas the cookies for prepared from wheat (control) required maximum peak force to puncture. Badi and Hoseney (1975) reported that the texture (fragility) of cookies containing part soft wheat flour was much better than the texture of those made from 100% sorghum or millet flour and Cookies with 100% sorghum/pearl millet did not spread during baking, had a poor top grain character, and were dense and compact. Morad et al. (1984) revealed that the spread factor of sugar cookies increased with increasing levels of sorghum. Akapapunam and Darbe (1994) reported that cookies based on blends of corn flour (75%) and bambara groundnut (25%) had good spread and significantly lighter than wheat flour based control cookies. Patel and Rao (1996) summarized that diameter and thickness of biscuits gradually decreased with increasing level of black gram flour in wheat flour. Hooda and Jood (2005) concluded that the thickness of fenugreek supplemented biscuits increased, whereas width and spread ratio of biscuits decreased with the increasing level of fenugreek flour.

Sensory quality of cookies The sensory scores were highest for pearl millet: sorghum flour and lowest for control wheat flour (Table 2). In agreement with our findings, Ciacci et al. (2007) reported that the sorghum derived cookies had an excellent palatability as shown by answering the questionnaire assessing food quality and taste. Rajput et al. (1988) investigated that incorporation of different unconventional protein concentrates affected the crispness, taste and overall acceptability by the sensory scores but increased the spread ratio and spread factor, which depended on the level of incorporation. Patel and Rao (1996) reported that optimum acceptable levels of black gram flour were 10% untreated, 15% treated and 10% germinated for cookies preparation by substituting wheat flour. Rodrigues et al. (2009) reported that cookies prepared with 58 and 67% of sorghum flour, 8 and 17% of rice flour, 33 and 17% of corn starch, respectively had satisfactory sensory characteristics.

Proximate composition and calorific value The moisture content ranged between 3.0 and 4.1% with minimum moisture content in pearl millet: sorghum combination of cookies (Table 2). The maximum (19.1%) fat content was in pearl millet: sorghum cookies and minimum (15.4%) in rice: maize flour. Protein content ranged from 5.8% (rice: maize) to 7.4% (pearl millet: sorghum). The pearl millet: sorghum cookies had highest fat (19.2%), protein (7.4%), ash (1.6%) and calorific value (481.7 Kcal/100 g) with minimum moisture content and found to be best for nutritive value. Similarly, Rajput et al. (1988) reported that biscuits containing unconventional protein sources increased the protein content in biscuits from 5.9 to 11.5–18.1%. Semwat et al. (1996) reported that maximum variation was found in moisture (2.47–8.75%) and fat content (1.04–14.82%) in different commercially available biscuits. Gupta and Singh (2005) reported that both protein quality and quantity improved in wheat flour and wheat flour with quality protein maize based biscuits with supplementation of processed defatted maize germ cake at the cost of slight decrease in vitro protein digestibility.

Conclusion

Gluten free flours combinations could be used to produce good quality cookies with acceptable physical and sensory qualities. These cookies are advantageous for people suffering from gluten intolerance and low income groups. All the blends of flours (sorghum, pearl millet) had significantly ($p \leq 0.05$) improved the pasting qualities, functional properties, sensory qualities and nutritional values of cookies whereas the mixing of rice flour had improved marginally some of these parameters.

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