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GLUTEN FREE SNACKS FOR CELIAC PATIENTS: SENSORY AND NUTRITIONAL EVALUATION

Shiwali Bhatia[1]* and Paramjeet Kaur Chawla[2]

[1]Department of Home Science, Devki Devi Jain Memorial College for Women, Ludhiana-141008, Punjab
[2]Department of Food and Nutrition, Punjab Agricultural University, Ludhiana-141004, Punjab

ABSTRACT

The present research work was planned to develop the gluten free products for celiac patients. Three different types of products i.e. biscuits, cake and *namakpare* were prepared by substituting the wheat and semolina (control) with oats (20-35%), sorghum (20-25%), rice (20-25%), corn (5%) and soya flour (20-25%) (experimental) with different combinations. The developed products were tested organoleptically on a nine point hedonic scale for five different parameters as colour, taste, texture, flavour and overall acceptability. Further, developed products were passed through the nutrition analysis in terms of proximate composition as moisture, ash, crude protein, crude fat, crude fibre and carbohydrate content. The results showed that gluten free products like cake, biscuits and *namakpare* were acceptable at 35%, 30% and 25% level of oats, respectively. Similarly, sorghum was acceptable at 20% level in all the three products. Incorporation of oats increased the sensory and nutritive value as compared to control (wheat and semolina) samples. Moreover, preparation of these products at home is easy to make and safe to consume with low cost to high benefit ratio.

Keywords: Celiac Disease, Gluten Intolerance, Organoleptic evaluation, Proximate composition, Wheat substitution

Celiac disease is an immune reaction to gluten, a protein found in wheat, barley and rye. The immune reaction to gluten creates inflammation that damages the small intestine's lining, leading to medical complications. When people with celiac disease eat foods or use products containing gluten, their immune system responds by damaging or destroying villi - the tiny fingerlike protrusions lining the small intestine. Villi normally allow nutrients from food to be absorbed through the walls of small intestine into the blood stream. Without healthy villi, a person becomes malnourished, no matter how much food one eats (Fasano *et al.,* 2003). The only treatment for celiac disease is a gluten free diet. For most people, following this diet will stop symptoms and prevent further damage. According to Green and Cellier (2007), celiac disease is one of the most common genetic disorders, affecting approximately 1% of individuals worldwide. Sood *et al*. (2001) reported the prevalence of celiac disease in north Indian community to be 1.04% or one in ninety six. Barada *et al.* (2010) reported high prevalence of celiac disease among populations in Turkey, Egypt, Iran, Tunisia, Israel, Jordan, Lebanon, and Kuwait. According to Catassi *et al.* (1999), the highest prevalence rate of celiac disease worldwide has been reported in North Africa. According to Canadian Society of Intestinal Research, symptoms of celiac disease can appear at any age from infancy to senior adulthood. The average age of diagnosis is between the 4th and 6th decades of life, with approximately 20% of cases diagnosed in those who are more than 60 years of age. Guandalini (2019) reported that classic Celiac disease which appears in children aged 9-18 months, in people older than 60 years, may also occur in adults and is usually precipitated by an infectious diarrheal episode. Many macro and micronutrient deficiencies have been reported in celiac disease patients. Farfaglia (2015) reported severe calcium deficiency in celiac disease patients. Babio *et al.* (2017) reported higher intake of sugar than recommended. Sue *et al.* (2018) reported higher fat intake by celiac disease patients than recommended. Oats, sorghum, soybean, maize, rice and *besan* are some of the alternatives to common gluten containing grains. These grains are nutrient dense and thus, incorporation of these gluten free grains in the gluten free diet not only adds variety but also improves its nutritional quality. Although a variety of gluten free products are available in market still a small amount of gluten is present in additives such as modified food starch, preservatives and stabilizers made with wheat; moreover these products are very costly. According to De Simas *et al*. (2009), gluten replacement is nowadays one of the most challenging issues for food technology and has prompted food scientists in the world to search for gluten-free alternatives to wheat flour for breads and cake making. Panagiotou and Kontogianni (2017) reported that the availability of gluten free foods, their value for money, and clear

*Corresponding author : bhatiashiwali1@gmail.com
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labelling are among the major factors affecting dietary compliance. The availability of gluten free products has dramatically grown over the past five years and can be purchased in major supermarkets, health food stores and online shops. Silvester *et al*. (2016) reported that gluten is typically not listed separately in the product label, hence foods that contain gluten might be difficult to identify. Moreover, it may be present as a hidden food component. Due to its technological properties, it is used as a flavor enhancer, thickener, emulsifier, filler and fortifier, and might be hidden under the terms "flavorings", or "hydrolyzed vegetable proteins". Farage *et al.* (2017) assessed the safety of gluten-free bakery products for consumption by celiac patients and found a total of 21·5 % of contamination among the bakery product samples. Sixty-four per cent of the bakeries sold at least one contaminated product. Thus there is a need for development of nutritious gluten free products for celiac disease patients which are easy to prepare at home. According to Market research report (2020), bakery emerged as the largest and the fastest growing product segment in the gluten-free products market, followed by dairy enterprise in 2019.

MATERIALS AND METHODS

The present investigation was carried out on the organoleptic and nutritional evaluation of gluten free products for celiac disease patients. The materials and methods used for the study have been discussed under the following headings:

Procurement of raw material

Raw material like oats, sorghum, rice flour, soyabean flour and *besan* were purchased from local market.

Development of gluten free products

Three gluten free products namely cake, biscuits and *namakpare* were prepared and standardized in laboratory.

Organoleptic evaluation of gluten free products

The prepared products were evaluated thrice for their acceptability by a panel of ten judges selected at random. The products were organoleptically evaluated in terms of colour, taste, texture, flavor and overall acceptability using nine point hedonic rating scale by a panel of ten judges. The judges were served with four samples of each product having one control and three experimental samples. The samples were coded to avoid any bias.

Nutritional analysis

The best acceptable and the control samples were analyzed for proximate composition namely moisture, total ash, crude protein, crude fibre and crude fat by the method of AOAC International (2002). Carbohydrate content was calculated by adding all above and subtracting from 100. Energy was calculated by multiplying proteins and carbohydrates by 4 and fats by 9 and finally adding them up.

Statistical analysis

The data was analyzed with the help of various statistical tools such as mean, standard deviation of mean. Anova was applied to test the significance difference between the organoleptic scores of samples at different levels and Student's t–test was applied to access the difference between proximate composition of test and control samples.

RESULTS AND DISCUSSION

Organoleptic evaluation of gluten free products

Cake

Four samples of cake were prepared using refined wheat flour as control and in test samples refined wheat flour was substituted with oats, sorghum, corn flour, soya flour and rice flour at different levels. The mean scores of acceptability trials of cake are presented in Table1. The highest score for colour and flavor was obtained by S1 (35% oats, 20% sorghum, 20% soya flour, 20% rice flour and 5% corn flour) i.e. 8.0 which was liked very much. The highest score for texture was obtained by S3 (25% oats, 20% sorghum, 25% soya flour, 25% rice flour and 5% corn flour) i.e. 7.9 which was liked very much. The highest score for taste for both S1 and S3 was 7.6 which was liked very much. The score for overall acceptability ranged from 7.7 to 7.9 with a very less difference with each other, scoring highest for S1 i.e. 7.9 which was liked very much followed by S3 and S2, both liked very much. All the parameters for the three test samples showed non significant difference as compared to each other. The test samples also showed non significant difference as compared to control except flavour where S2 and S3 showed a significant difference as compared to control. Grewal (2001) reported that incorporation of oats for making gluten free snacks had the highest organoleptically accepted scores.

Biscuits

Four samples of biscuits were prepared using wheat flour as control and in test samples wheat flour was substituted with oats, sorghum, corn flour, soya flour and rice flour at different levels. The mean scores of acceptability trials of biscuits are presented in Table 1. The highest scores for colour and flavour were obtained by S2 (30% oats, 20% sorghum, 25%

Table 1. Organoleptic scores of gluten free cake biscuits and *namakpare* (Mean± SE)

Cake

Sample	Colour	Flavour	Texture	taste	Overall Acceptability
S1	8.00±.15	8.00±.15	7.60±.22	7.60±.27	7.90±.18
S2	7.90±.18	7.60±.27	7.80±.20	7.20±.27	7.70±.30
S3	7.60±.16	7.40±.22	7.90± .18	7.60±.27	7.80±.29
S4	7.90±.23	8.30±.21	8.10±.23	8.20±.25	8.20±.25
F-Ratio	0.88**	3.41**	0.99**	2.34**	.70**
CD at 5%	NS	.673	NS	NS	NS

S1 – 35% oats, 20% sorghum, 20% soya flour, 20% rice flour and 5% corn flour
S2 – 30% oats, 20% sorghum, 20% soya flour, 25% rice flour and 5% corn flour
S3 – 25% oats, 20% sorghum, 25% soya flour, 25% rice flour and 5% corn flour
S4 – 100% white flour (control)

Biscuit

Sample	Colour	Flavour	Texture	Taste	Overall Acceptibility
S1	7.72±.16	7.61±.16	7.44±.14	7.50±.15	7.50±.15
S2	7.94±.17	7.89±.16	7.77±.19	7.78±.15	7.72±.16
S3	7.61±.16	7.33±.18	7.56±.14	7.33±.19	7.50±.15
S4	8.00±.19	8.11±.16	8.06±.17	8.00±.23	8.11±.16
F-Ratio	1.12**	4.11**	2.57**	3.45**	3.49**
CD at 5%	NS	.509	NS	NS	.465

S1 – 25% oats, 20% sorghum, 25% soya flour, 25% rice flour and 5% corn flour
S2 – 30% oats, 20% sorghum, 25% soya flour, 20% rice flour and 5% corn flour
S3 – 20% oats, 25% sorghum, 25% soya flour, 25% rice flour and 5% corn flour
S4 – 100% wheat flour (control)

Namakpare

Sample	Colour	Flavour	Texture	Taste	Overall Acceptibility
S1	7.24±.16	7.18±.18	7.00±.21	7.23±.18	7.29±.77
S2	6.82±.21	6.94±.20	7.12±.19	6.94±.20	7.06±.83
S3	6.65±.21	6.47±.24	6.47±.19	6.41±.23	6.45±.24
S4	8.41±.12	8.35±.17	8.47±.15	8.53±.12	8.41±.12
F-Ratio	18.00**	15.21**	19.25**	21.69**	14.42**
CD at 5%	.580	.640	.600	.601	.617

S1 – 25%oats, 20% sorghum, 20% urad dal and 35% besan
S2 – 30%oats, 20% sorghum, 20% urad dal and 30% besan
S3 – 35%oats, 25% sorghum, 10% urad dal and 30% besan
S4 – 100% white flour (control)

Key to scores

9 = Like extremely, 8 = Like very much, 7 = Like moderately, 6 = Like slightly, 5= Neither like nor dislike, 4 = Dislike slightly, 3 = Dislike moderately, 2 = Dislike very much, 1 = Dislike extremely

**Significant at 5% level

soya flour, 20% rice flour and 5% corn flour) i.e. 7.94 and 7.89, respectively which was liked very much. The highest score for texture and taste was also obtained by S2 i.e. 7.77 and 7.78 respectively and was liked very much. The mean score for overall acceptability of test samples ranged from 7.5 to 7.72, scoring highest for S2 i.e. 7.72 and was liked very much followed by S1 (25% oats, 20% sorghum, 25% soya flour, 25% rice flour and 5% corn flour) and S3 (20% oats, 25% sorghum, 25% soya flour, 25% rice flour and 5% corn flour) scoring equally i.e. 7.5 and were liked very much. It was observed that highest level of oats was highly acceptable as compared to the lower levels due to increased crispiness in the biscuits. All the sensory parameters of three test samples showed non significant difference as compared to each other except flavour where S2 showed a significant difference ($P<0.05$) as compared to S3. Colour, texture and taste

of the test samples showed nonsignificant difference as compared to control whereas in case of flavour and overall acceptability S3 showed a significant difference (P<0.05) in comparison to control. Kercknoffs (2001) prepared biscuits supplemented with 20% oats which were highly acceptable by the panelists. Corey *et al.* (2004) reported bitter taste and burnt flavour in biscuits supplemented with 10g of beta glucan. It was concluded that depolymerisation of beta glucan during baking procedure due to action of enzymes caused bitter taste and burnt flavour. Kathleen and Suyong (2007) prepared cookies with 10% oat beta glucan which had good textural and sensory results. Sharma (2009) developed biscuits using oats at 15%, 20% and 25% level with highest acceptability for 15% oats with a score of 7.94 and was liked very much. Ergin and Herken (2012) developed gluten-free biscuits using rice, corn, chickpea and potato flours, corn starch and potato starch as the main ingredients and the results showed that the sample containing 35% rice flour, 35% corn starch, 10% potato flour, 10% chickpea flour and 10% potato starch was the favourite sample of the sensory evaluation with high acceptance. Sharoba *et al.* (2014) also prepared gluten free biscuits using corn flour and starch with functional properties.

Namakpare

Four samples of *namakpare* were prepared using refined wheat flour as control and in test samples refined wheat flour was substituted with oats, sorghum, *urad* dal and *besan* at different levels. The mean scores of acceptability trials of *namakpare* are presented in Table 1. The highest score for colour and flavour was obtained by S1 (25% oats, 20% sorghum, 20% *urad* dal and 35% *besan*) i.e. 7.24 and 7.18, respectively which was liked moderately. The highest score for texture was obtained by S2 (30% oats, 20% sorghum, 20% *urad* dal and 30% *besan*) i.e. 7.12 and was liked moderately. Among the gluten free samples, S1 obtained higher score for taste (7.23) as well as overall acceptability (7.29) which was liked moderately, followed by S2 and S3. In case of test samples flavour, taste and overall acceptability of S1 showed a significant difference as compared to S3 and in case of texture S2 showed a significant difference as compared to S3. Increasing oats to 30% - 35% and sorghum to 25% resulted in bitterness in *namakpare*, thus caused decrease in scores of sensory parameters. Scores for all the sensory parameters of all the three test samples showed a significant difference as compared to control. Malhotra (1985) prepared similar product named *matter* from triticale flour which was found to be highly acceptable. Shah (2005) developed *namakpare* using 20%, 30% and 40% defatted soy flour where 20% level was best acceptable with a score of 7.72 and was liked very much. Kanupriya (2007) developed *namakpare* using maize flour, bengal gram and refined wheat flour in ratio of 2:1:1 which was highly acceptable with an overall acceptability score of 8.0 and was liked very much. Sharma (2009) developed *namakpare* using oats at 15%, 20% and 25% level with highest acceptability for 15% oats scoring 7.88 and was liked very much.

Proximate composition of gluten free products

Cake

The proximate composition of test and control sample of cake is given in Table 2. Data revealed that the gluten free cake prepared with 35% oats, 20% sorghum, 20% soya flour, 20% rice flour and 5% corn flour had a moisture content of 5.8% with a non significant difference in comparison to 5.6% in control (100% refined wheat flour). The ash content in the test and control cake was 1.6% and 1.4%, respectively with non significant difference. Soya flour and oats in test cake increased the protein content significantly (P<0.01) to 13.25% as compared to 10.5% in control. A higher fibre content of 5.1% was observed in the test cake with a significant difference (P<0.01) as compared to 3.8% in control. Due to higher fat content of soya flour, the fat content in the test cake was significantly (P<0.05) higher (27.4%) as compared to control (26.0%). The test cake had a lower carbohydrate content of 47% while the control had 52%. The energy content in the test and control cake was 471 kcal and 485 kcal/100g, respectively. Antarlina (1994) reported 6% protein, 17% fat, 47% carbohydrates and 364 kcal energy in cakes prepared with 50% supplementation of sweet potato flour. Gambus *et al.* (2009) prepared gluten-free confectionery products using linseed meal, amaranth and buckwheat and observed a significant rise in the protein content and dietary fiber. They reported that all supplemented gluten-free products received high consumer scores, exceeding in some cases those of control samples.

Biscuits

The proximate composition of test and control sample of biscuits is given in Table 2. Data indicated that the moisture content in the gluten free biscuits prepared with 30% oats, 20% sorghum, 25% soya flour, 20% rice flour and 5% corn flour was 1.1% having a nonsignificant difference as compared to 1.0% in control. Ash content in test and control biscuits was 0.62% and 0.58%, respectively with non-significant difference. Addition of Soya flour and oats in test biscuits increased the protein content significantly (P<0.01) to 10.5% as compared to 6.13% in control. Oats significantly increased (P<0.01) the fibre content of test biscuits to 2.5% as compared to 1.1% in control. Soya flour significantly increased (P<0.01) fat content of test biscuits to 33.8% as compared to 22.3% in control. Carbohydrate content of

test biscuits was lower i.e. 51% as compared to 69% in control. Test biscuits had an energy content of 552 kcal and control had 501 kcal/100g. Devi *et al.* (2000) reported 5.8% crude fibre, 39.7% fat, 14.4% protein, 5.8% ash in biscuits supplemented with greengram. Kercknoffs (2001) analysed biscuits supplemented with 20% oat bran and reported 6.9% crude protein, 16.3% crude fibre and 35.2% fat. Neerkomal (2009) prepared salty biscuits by supplementing refined wheat flour with defatted soy flour in 4:1 ratio and reported 1.4% moisture, 11.3% protein, 29.7% fat, 0.37% fibre, and 1.1% ash. Shah (2005) prepared sweet and salty biscuits by supplementing 20% defatted soya flour and reported 0.53% moisture, 11.58% protein, 29.71% fat, 0.37% fibre, 0.68% ash, 57.13% carbohydrates and 542 kcal energy in sweet biscuits and 0.73% moisture, 11.34% protein, 28.5% fat, 0.32% fibre, 0.91% ash, 58.2% carbohydrates and 535kcal energy in salty biscuits. Sharma (2009) developed salty biscuits by supplementing oats at 15% level and reported 6.0% moisture, 7.9% protein, 39.4% fat, 1.53% fibre, 0.45% ash, 44% carbohydrates and 565 kcal energy. Comparatively higher values of protein and fibre have been observed in present study, which could be due to addition of higher percentage of oats and soya flour.

Namakpare

The proximate composition of test and control sample of *namakpare* is given in Table 2. The moisture content of 5.1% was observed in the gluten free *namakpare* prepared with 25% oats, 20% sorghum, 20% *urad* dal and 35% *besan* with non significance difference as compared to 5.0% in control (100% refined wheat flour). A significantly lower (P<0.05) value of 1.6% of ash was observed in the test *namakpare* as compared to 2.4% in the control. Use of *urad* dal and *besan* significantly increased the protein content to 19.25% in test namakpare as compared to 13.13% in the control. A three-fold increase (P<0.01) was observed in the fibre content of test *namakpare* (3.9%) due to oats as compared to a lower value of 1.3% in the control. A significantly higher (P<0.01) fat content of 31% was observed in the test *namakpare* as compared to 25% in control. This was due to higher fat absorption during frying as well as higher fat content of *besan* and *urad dal*. The carbohydrate content of test and control *namakpare* was 39% and 53% respectively. The energy content of 512 kcal in the test *namakpare* and 490 kcal in the control *namakpare* was observed. Sharma (2009) reported 2.0% moisture, 0.54% ash, 6.2% protein, 2.8% fibre, 39.1% fat, 49% carbohydrates and 574 kcal energy in *namakpare* supplemented with 15% oats. Khattak and khan (2003) reported 5.7% protein, 28.0% fat, 58.6% carbohydrates, 510 kcal energy/100g of namakpare prepared from wheat flour. Kanupriya (2007) reported 4.1% moisture, 8.4% protein, 37.6% fat, 1.0% ash, 1.6% fibre and 47.0% carbohydrates in *namakpare* prepared from maize flour, Bengal gram flour and refined wheat flour in ratio of 2:1:1. Shah (2005) reported 7.09% moisture, 11.82% protein, 25.57% fat, 0.84% fibre, 0.99% ash, 53.69% carbohydrates and 492 kcal energy in *namakpare* supplemented with 20% defatted soy flour.

The study concludes that incorporation of oats for the preparation of gluten free snacks such as cake (35%), biscuits (30%) and *namakpare* (25%) was organoleptically highly acceptable and increased content of crude protein and crude fibre. The results further revealed that preparation of gluten free products

Table 2. Proximate composition of gluten free products on dry weight basis.

Product	Moisture (%)	Total ash (%)	Crude protein (%)	Crude fibre (%)	Crude fat (%)	Carbohydrate	Energy
Cake							
Control	6.0±0.20	1.4±0.17	10.5±0.23	3.8±0.14	26.0±0.20	52	485
Test	5.8±0.21	1.6±0.21	13.25±0.30	5.1±0.14	27.4±0.26	47	471
t value	0.7^{NS}	0.62^{NS}	7.84*	7.46*	4.44**		
Biscuit							
Control	1.0±0.07	0.58±0.02	6.13± 0.09	1.1±0.07	22.3±1.16	69	501
Test	1.1±0.12	0.62±0.05	10.5±0.29	2.5±0.11	33.8±0.43	51	552
t value	1.47^{NS}	0.25^{NS}	14.45*	10.48*	9.43*		
Namakpare							
Control	5.0±0.06	2.4±0.20	13.13±0.31	1.3±0.26	25.0±0.88	53	490
Test	5.1±0.06	1.6±0.20	19.25±0.36	3.9±0.26	31.0±1.16	39	512
t value	1.22^{NS}	2.79**	3.54**	6.1*	4.36*		

*Significant at 1%
**Significant at 5%

at home is easy, healthy and cost effective as well. Moreover, these products are better in taste and boost with nutritive value.

Authors' contribution

Conceptualization of research work and designing of experiments(PKC); Execution of field/lab work and data collection (SB); Data analysis and interpretation of results (SB, PKC); Preparation of manuscript (SB).

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