Physico-Functional, Nutritional and Sensorial Features of Psyllium Husk Enriched Gluten-Free Oat Cookies

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ABSTRACT

Objective: Gluten-free (GF) cookies are usually deficient in dietary fibers as compared to traditional wheat cookies. So, we aimed to formulate GF cookies with different levels of psyllium husk (fiber) from oats flour. Methods: Three types of GF cookies were made; T_0, T_1, and T_2 containing 0%, 2.5%, and 5% psyllium husk respectively. Analysis of functional properties of the dough, physicochemical andsensory characteristics of the cookies was performed. Results: Addition of 5% psyllium husk (T_2) led to enhanced functional properties of dough (% swelling capacity SC =635.0±15.00, % water absorption capacity WAC =132.33±2.51, % oil absorption capacity OAC =28.00±2.00, % emulsion activity =59.93±0.25, % emulsion stability =60.23±0.25) and the most desirable spread factor (8.71±0.572). The total fiber content of T_2 cookies was 19.41%. The mean sensory evaluation score for the overall acceptability of T_2 cookies (6.32±1.096) was significantly (P=0.050) higher than the T_1 cookies (5.49±0.785). 5% psyllium husk cookies (T_2) surpassed 0% and 2.5% psyllium husk cookies in all parameters under study. Conclusion: The integration of psyllium husk into oat-based GF cookies resulted in excellent properties and acceptability and it can be added as a healthy snack option in diets of people with gluten intolerance.

Keywords: *Cookies, Celiac disease, Gluten-free, Oat, Psyllium Husk.*

1. INTRODUCTION

Celiac disease (CD) is an autoimmune disorder of the gastrointestinal tract (GIT) triggered by gluten protein; present in various foods such as wheat, barley, and rye, to name a few. It takes a long time for the CD to develop and reflect its full metamorphic nature. So timely diagnosis and identification of CD have remained a challenging task. A large volume of clinical and experimental studies deciphered that over activated immune system prompted by gluten is the basis for bowel abnormalities leading to the damaged intestinal villi (Fasano & Catassi, 2012) and affect the absorption of vitamins, minerals, proteins, and fat. Moreover, CD cases may also present with secondary lactose intolerance, bone health issues, type 1 diabetes mellitus, Crohn's disease, and thyroid problems (Rodrigo, 2006). Over the past 50 years, the prevalence of undiagnosed cases of CD has increased tremendously in United States (Larson et al., 2017). Around 6 million people are suffering from this disease in Europe and the US combined (Singh et al., 2018). It is also common inSouth Asian countries, 26 to 49% of Indian children presenting with the classical symptoms of diarrhea are diagnosed with celiac disease (Bhatnagar et al., 2005). Although the epidemiological data on the prevalence of CD in Pakistan is not available currently, yet there can be nearly 2 million undiagnosed cases in the country, according to the fact that 1% of the world population suffers from this disease (Rashid & Rashid, 2019).

To manage CD, adjuvant therapies that include a gluten-free (GF) diet in combination with a pharmacological agent such as larazotide acetate are the approaches that improve intestinal barrier function, and gluten detoxification (McCarville, Caminero, & Verdu, 2015). Despite the evidence for a significant role of fiber in metabolic health, commonly used GF diets are starch-based and lack dietary fiber (Taetzsch et al., 2018). Individuals must replace the whole wheat grains with other fiber-rich GF alternatives like oats instead of starchy nutritionally inadequate choices like rice and potatoes thatfurther aggravate GI disorders and causes constipation (McRorie Jr, 2015). Adequate dietary fiber intake has always been a challenge in strict GF diets due to the lack of food choices and low fiber content of market-based GF products (Cornicelli, Saba, Machello, Silano, & Neuhold, 2018). Currently there are only few GF snacksavailable in market, which are low in fiber and nutrients

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and does not fulfil the requirements of consumers. Following four important features should be kept in consideration while formulating GF product; a) it should be cost effective and easy to prepare; b) it should be nutrient dense and rich infiber; c) it should have functional and textural stability; d) it should have sufficient sensory acceptability.
The present study was conducted to formulate psyllium husk enriched oat-based GF cookies keepingin view the above-mentioned essential features of an excellent GF snack. Oatmeal is naturally gluten-free and contains soluble fiber (β-glucan) that boosts probiotics. Psyllium husk is a bulk- forming laxative and resolves GI disorders (Semeco, 2017). The objective of this study was to makeGF cookies with such a recipe that have good nutritive quality complemented with dietary fiber andsensory appeal.

2. MATERIAL AND METHODS

2.1. Raw Material Procurement

All the ingredients including, psyllium husk, oats flour, pumpkin seeds flour, brown sugar, honey, salt, butter, eggs, dates and milk powder were collected from the local market. Oats and pumpkin seeds were grounded to a fine texture. Dates were chopped into equal size chunks.

2.2. Dough Formulation

The dough was prepared by the standardized recipe of Qaisrani, Butt, Anjum, and Sheikh (2013). using the weighed ingredients mentioned in Table 1 with help of an electric hand mixer. Three different types of dough were made based on different concentrations of added fiber. T_0 means no extra fiber was added, inT_1, 2.5% of fiber of the total weight of dough was added while in T_2 treatment 5% of fiber was added(Figure 1). As the amount of fiber increased, the number of oats was decreased to make approximately 208 g of the total weight of the dough.

2.3. Determination of Functional Properties of Dough

Functional properties of dough including swelling capacity (SC), oil absorption capacity (OAC), water absorption capacity (WAC), emulsion activity, and stability were determined using the methods of Okezie and Bello (1988). Percentage swelling capacity was calculated by measuring the rise in the dough volume placed in the graduated measuring cylinder overnight. For oil and water absorption capacity, the sample was mixed in a centrifuge tube with oil and water, respectively. Tubes were centrifuged at 3000 rpm for 10 minutes, the supernatant was weighed andused to determine percentage OAC and WAC. Emulsion activity was determined by adding both water and oil to the sample in the centrifuge tube. The height of the emulsion layer after centrifugation was used to calculate the percentage emulsion activity. Emulsion stability was calculated by the same method but the tubes we placed in the water bath for 30 minutes at 80^{o}C before centrifugation.

2.4. Baking Process of Cookies

50 g of dough was weighed on the weighing scale and then it was molded to the final shape by handand placed on the baking tray lined with butter paper. Cookies were baked in the preheated oven at 1800C for 16-18 minutes (Figure 2).

2.5. Physical Analysis

Physical analysis of all three types of cookies including diameter, thickness, spread factor, and weight was performed. Diameter and thickness were determined with the help of Vernier caliper and were measured up to 0.01cm. The weight of the cookies was measured with the help of an electronic weight scale in grams up to 0.01 g. The following formula was used to determine the spread factor of cookies:
Spread factor= Diameter/ Thickness

2.6. Proximate Analysis

Proximate analysis was performed using the standard methods of AOAC (1990) to determine moisture, protein, fat, ash, and fiber content of the cookies. Drying oven was used to determine moisture content, ninhydrin reagent was used to determine protein content by using UV spectrophotometer, Soxhlet apparatus was used for fat analysis, for ash content muffle furnace was used and standard acid-alkali wash treatment for fiber analysis.

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2.7. Sensory Evaluation

A double-blind sensory evaluation of the cookies was performed by a semi-trained test panel of 25members that were randomly selected to fill a 10cm unstructured line scale-based sensory evaluation proforma. Data was converted to the numerical score using a standard metric scale by taking 1cm as highly unacceptable and 10cm as highly acceptable. Parameters included in the sensory evaluation were color, flavor, taste, crispiness, and overall quality.

2.8. Statistical Analysis

Microsoft Excel 2016 and Statisticx version 10 was used for the statistical analysis to calculate mean and standard deviation and the analysis of variance along with significance was checked in Statisticx by using factorial design followed by Tukey's test. P value= 0.05 was considered significant in all analyses. SigmaPlot version 14.0 was used to draw the standard curve for protein analysis.

3. RESULTS

3.1. Functional Properties of Dough

The functional properties of the dough are given in Table 2. According to the results, SC of the dough T_0, T_1, and T_2 was 243%, 351%, and 635% respectively. Regarding the WAC of the dough, T_0, T_1, and T_2 showed 185%, 171 %, and 132% respectively. OAC for T_0 and T_1 are higher such as 95%, 77% as compared to T_2 that has oil absorption capacity least of all (28%). The emulsion stability and activity for all three kinds of cookie dough were high and they were in the range of 50% to 61%. All the results were statistically significant ($P<0.05$).

3.2. Physical Analysis

T_1 had the highest mean spread factor (9.296±1.270) and T_0 had the smallest mean spread factor (7.67±0.3697) but the highest value of mean thickness (1.025±0.041). The spread factor was high inT_1 and T_2 due to psyllium husk addition. The results based on mean diameter and weight showed a non-significant difference ($P\geq0.05$) (Table 3).

Table 1. Ingredients of gluten-free cookies dough with different psyllium husk levels

Ingredients	T_0 (0% psylliumhusk)	T_1 (2.5% psylliumhusk)	T_2 (5% psylliumhusk)
Psyllium Husk	0g	5g	10g
Oats Flour	70.5g	65.5g	60.5g
Pumpkin Seeds Flour	33.5g	33.5g	33.5g
Brown Sugar	19g	19g	19g
Honey	15.85g	15.85g	15.85g
Salt	1.3g	1.3g	1.3g
Butter	8g	8g	8g
Egg	23.8g	23.8g	23.8g
Dates	27.8g	27.8g	27.8g
Milk Powder	8.2g	8.2g	8.2g
Total	208g	208g	208g

Baking powder and vanilla essence were also used in minute quantity.

3.3. Proximate Analysis of Cookies

T0 cookies had 19.21% moisture, 15.18% moisture was present in T_1 cookies and T_2 cookies had 15.39% moisture. Protein concentrations of the cookies, T_0, T_1, and T_2 were 0.28%, 0.27%, and 0.26%respectively. The fat content of T_0, T_1, and T_2 was 4.97%, 4.96%, and 4.95% respectively. Ash content in the T_0, T_1, and T_2 cookies

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was 2.08%, 2.72%, and 2.94% respectively. Regarding the total fiber content in cookies, it was found that T0 i.e., 0% added psyllium husk had 4.80% fiber content and T1,which contains 2.5% added psyllium husk had 12.20% fiber present in these cookies while T2, having 5% added psyllium husk had 19.41% fiber content. Fiber percentage increased gradually as the added psyllium husk (g) increased in these cookies. (Table 3)

3.4. Sensory Evaluation

Overall acceptability showed a significant difference ($P \leq 0.05$) between cookies having different levels of psyllium husk but other attributes such as color, aroma, taste, and crispiness showed non-significant difference on a 10 cm non-constructive hedonic scale. Overall acceptability of the T0 washighest (6.88±1.628) but the score of T1 and T2 was still comparable to the control group (Table 3).

Table 2. Functional properties of gluten-free cookies dough with different psyllium husk levels

Functional properties (%)	T0(0% psyllium husk)	T1(2.5% psyllium husk)	T2(5% psyllium husk)	P-value
Swelling capacity	243.33 ± 16.07^{c}	351.66 ± 7.63^{b}	635.0 ± 15.00^{a}	0.000
Water absorption capacity	185.00 ± 5.00^{a}	171.66 ± 2.88^{b}	132.33 ± 2.51^{c}	0.000
Oil absorption capacity	95.66 ± 4.041^{a}	77.66 ± 2.51^{b}	28.00 ± 2.00^{c}	0.000
Emulsion activity	61.43 ± 1.20^{a}	50.93 ± 0.87^{b}	59.93 ± 0.25^{a}	0.000
Emulsion stability	61.56 ± 0.30^{a}	51.70 ± 0.43^{c}	60.23 ± 0.25^{b}	0.000

Data are represented as mean ± SD for n=3.
a, b and c represent significantly different means in the ascending order. The same letter in the row represents the non significantly different mean.

4. DISCUSSION

The objective of this study i.e., to formulate GF fiber-enriched cookies with improved functional, physical, sensory, and nutrition value, was successfully achieved. T2 cookie has the highest SC due to the addition of 5% psyllium husk which is soluble fiber and swells upon contact with water. Increasing psyllium husk reduced WAC which is good for the prevention of microbial growth and stable shelf-life (Rolfe & Daryaei, 2020). However, other researchers (Liu, Zhao, Wang, & Liu, 2020) reported an increase in water absorption capacity in response to the addition of wheat bran dietary fiber. T2 hasthe lowest WAC and OAC because of the reduction in oat flour with the addition of psyllium husk. When a lesser amount of oat flour was used in making cookies, starch and protein, which are the two main components responsible for water and oil binding (Wolter, Hager, Zannini, Czerny, & Arendt, 2014) also decreased (Table 3) leading to low WAC and OAC in T2 cookies. Overall rheological properties of dough come from a variety of variables bringing to the dough cohesive and viscoelastic features (Laguna et al., 2014). The highest emulsion activity and stability were found in 5% fiber cookie dough. As the recipe was egg-based, which is an excellent natural emulsifier, the resultant dough also had good emulsion activity and stability (Daimer & Kulozik, 2009; Santipanichwong & Suphantharika, 2009). Artificial emulsifiers are predominantly added into dough formation to improve its overall quality (Hoque, Hossain, & Akter, 2009) but can also aggravate hypersensitivity symptoms (Laura et al., 2019) thereforethis recipe is superior to other market-based GF products with numerous chemical additives.

The visible diversification in the crumb size, spread factor, and thickness of the cookies is also attributed to the additional psyllium husk. Although the highest spread factor is desirable (Barak, Mudgil, & Khatkar, 2013) and T2 cookie spread factor (8.71±0.572) was moderately in between T0 and T1, yet it is very close to the optimized spread factor (8.5 ± 0.14) of similar soluble fiber cookies with good overall acceptability (Mudgil, Barak, & Khatkar, 2017).

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Table 3. Physical properties, sensory evaluation, and proximate analysis of gluten-free cookies with different psyllium husk levels.

Parameters	T_0(0% psyllium husk)	T_1(2.5% psyllium husk)	T_2(5% psyllium husk)	P-values
Physical properties				
Diameter (cm)	7.85±0.104^{NS}	8.025±0.088^{NS}	7.891±0.165^{NS}	0.0668
Thickness(cm)	1.025±0.041^{a}	0.875±0.108^{b}	0.908±0.049^{b}	0.0071
Spread factor	7.67±0.3697^{b}	9.296±1.270^{a}	8.71±0.572^{ab}	0.0131
Weight (g)	46.21±0.58^{NS}	46.67±0.005^{NS}	46.21±0.084^{NS}	0.0514
Sensory evaluation				
Color	7.4±1.260^{NS}	6.12±1.216^{NS}	6.67±1.653^{NS}	0.138
Aroma	6.46±0.953^{NS}	6.23±1.403^{NS}	6.42±1.158^{NS}	0.898
Taste	7.05±1.312^{NS}	6.17±1.523^{NS}	6.29±1.496^{NS}	0.351
Crispiness	5.31±1.326^{NS}	5.66±1.033^{NS}	5.25±0.985^{NS}	0.682
Overall acceptability	6.88±1.628^{a}	5.49±0.785^{b}	6.32±1.096^{ab}	0.050
Proximate analysis				
Moisture (%)	19.21	15.18	15.39	-
Ash (%)	2.08	2.72	2.94	-
Fat (%)	4.97	4.96	4.95	-
Protein (%)	0.28	0.27	0.26	-
Fiber (%)	4.80	12.20	19.41	-

Data are represented as mean ± SD for n=6. NS stands for not significantly different means.
a and b represent significantly different means in descending order.

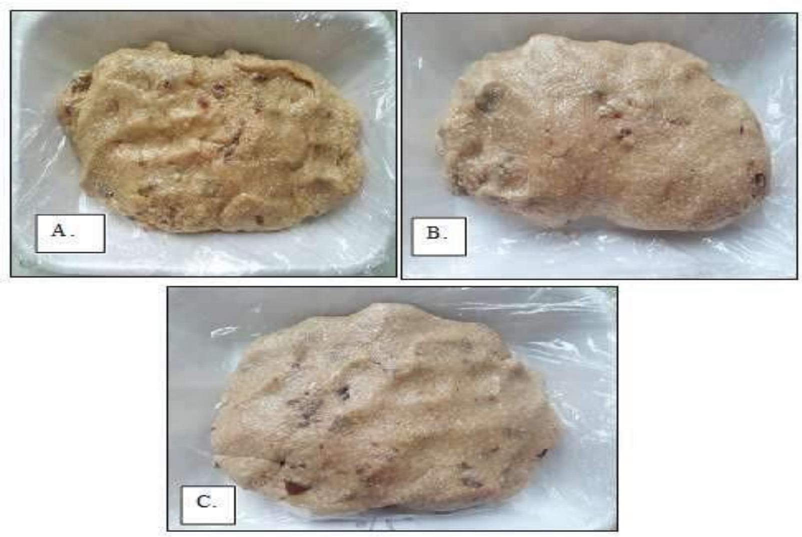

Figure 1. GF cookie dough with different psyllium husk levels: A. T_0 (0% psyllium husk), B. T_1 (2.5% psyllium husk), C. T_2 (5% psyllium husk).

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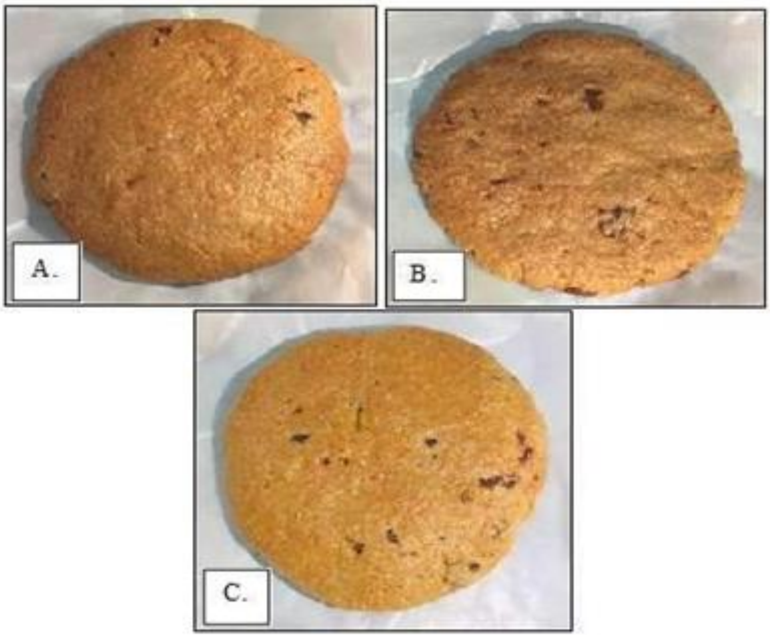

Figure 2. GF cookies after baking with different psyllium husk levels: A. T_0 (0% psyllium husk), B. T_1(2.5% psyllium husk), C. T_2 (5% psyllium husk).

Moisture content was lower in psyllium husk cookies as the WAC of the dough was also significantly lower as compared to T_0. As expected, the amount of protein decreased in fiber-treated cookies (0.26% in T_2). Decrease in protein percentage was due to decreased amount of oats in T_1 and T_2 cookies, but the effect was not visibly different. Another research supports our findings, in which psyllium husk cookies were compared with cookies made with different variety of flours. The protein content of psyllium husk cookies (0.52 ± 0.14) was significantly lower than the others (Bashir et al., 2020). Psyllium husk itself is very low in fat (0.04% ± 0.11) (Guo, Cui, Wang, & Young, 2008) that's why our cookies (T_1 and T_2) had lower fat content as compared to other oat-based GF cookies (18.21 ± 0.10)(Duta & Culetu, 2015). Ash content of T_2 cookies was highest (2.94%) suggesting a greater amountof inorganic minerals and better nutritive quality. The crude fiber content of T_2 cookies with 5% enrichment of psyllium husk was 19.41% which is remarkably greater than the average fiber content of GF biscuits (2.72%) or snacks (2.56%) available in the market (Cornicelli et al., 2018). One T_2 cookie can sufficiently provide almost 35% (8.77g) of an adult's daily recommended dietary allowance (RDA) of dietary fiber (i.e. 25-30g) (Marlett, McBurney, & Slavin, 2002). These high fiber cookies will alleviate the long-term health complications of CD including gastrointestinal disorders and extra-intestinal complications (Fischer et al., 2004; Saghir, Iqbal, Hussain, Koschella, & Heinze, 2008). Dietary fiber not only lowers blood glucose (Giacco et al., 2000) and cholesterol levels (Soliman, 2019) but it also lowers low-density lipoproteins (LDL), that initiate several inflammatory responses, worsening the CD prognosis (Verma & Mogra, 2013; Verspreet et al., 2016).

No statistically significant difference in the mean score for the color, aroma, taste, and crispiness of fiber-enriched cookies (T_1 and T_2) from simple oat cookie (T_0), suggested that the addition of psyllium husk did not affect the sensory appeal of cookies. However, the overall acceptability of T_2 (6.32±1.096) was significantly higher than T_1. These results are notably higher as compared to the similar oat-based GF (Duta & Culetu, 2015) and psyllium husk cookies (Qaisrani et al., 2013).

5. CONCLUSION

CD may have detrimental impacts on the nutritional status of the patient if not properly managed. This research study was successful not only in formulating the recipe for psyllium husk enriched oat- based GF cookies but also led to desirable functional, physical, nutritional, and sensory properties. Hence it is concluded that these high fiber cookies can serve as a valuable alternative to wheat- based snacks for CD patients and may contribute to dietary variety, palatability as well as nutrition.

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REFERENCES

AOAC. (1990). Official methods of analysis of the association of official's analytical chemists (14th ed., pp. 223-225, 992-995). Washington D.C: Association of Official Analytical Chemist.

Barak, S., Mudgil, D., & Khatkar, B. S. (2013). Effect of composition of gluten proteins and dough rheological properties on the cookie-making quality. *British Food Journal, 115*(4), 564-574.Available at: https://doi.org/10.1108/00070701311317847.

Bashir, S., Yaseen, M., Sharma, V., Purohit, S. R., Barak, S., & Mudgil, D. (2020). Rheological and textural properties of gluten free cookies based on pearl millet and flaxseed. *Biointerface Research in Applied Chemistry, 10*(5), 6565-6576.Available at: https://doi.org/10.33263/briac105.65656576.

Bhatnagar, S., Gupta, S. D., Mathur, M., Phillips, A. D., Kumar, R., Knutton, S., . . . Mukhopadhyaya, S. (2005). Celiac disease with mild to moderate histologic changes is a common cause of chronic diarrhea in Indian children. *Journal of Pediatric Gastroenterology and Nutrition, 41*(2), 204-209.Available at: https://doi.org/10.1097/01.mpg.0000172261.24115.29.

Cornicelli, M., Saba, M., Machello, N., Silano, M., & Neuhold, S. (2018). Nutritional composition of gluten-free food versus regular food sold in the Italian market. *Digestive and Liver Disease, 50*(12), 1305-1308.Available at: https://doi.org/10.1016/j.dld.2018.04.028.

Daimer, K., & Kulozik, U. (2009). Oil-in-water emulsion properties of egg yolk: Effect of enzymatic modification by phospholipase A2. *Food Hydrocolloids, 23*(5), 1366-1373.

Duta, D. E., & Culetu, A. (2015). Evaluation of rheological, physicochemical, thermal, mechanical and sensory properties of oat-based gluten free cookies. *Journal of Food Engineering, 162*, 1-8.Available at: https://doi.org/10.1016/j.jfoodeng.2015.04.002.

Fasano, A., & Catassi, C. (2012). Celiac disease. *New England Journal of Medicine, 367*(25), 2419-2426.

Fischer, M. H., Yu, N., Gray, G. R., Ralph, J., Anderson, L., & Marlett, J. A. (2004). The gel-forming polysaccharide of psyllium husk (Plantago ovata Forsk). *Carbohydrate Research, 339*(11), 2009-2017.Available at: https://doi.org/10.1016/j.carres.2004.05.023.

Giacco, R., Parillo, M., Rivellese, A. A., Lasorella, G., Giacco, A., D'Episcopo, L., & Riccardi, G. (2000). Long-term dietary treatment with increased amounts of fiber-rich low-glycemic index natural foods improves blood glucose control and reduces the number of hypoglycemic events in type 1 diabetic patients. *Diabetes Care, 23*(10), 1461-1466.Available at: https://doi.org/10.2337/diacare.23.10.1461.

Guo, Q., Cui, S. W., Wang, Q., & Young, J. C. (2008). Fractionation and physicochemical characterization of psyllium gum. *Carbohydrate Polymers, 73*(1), 35-43.Available at: https://doi.org/10.1016/j.carbpol.2007.11.001.

Hoque, M., Hossain, K., & Akter, F. (2009). The effect of lecithin–a non absorbing emulsifying agent on cookie production. *Pakistan Journal of Nutrition, 8*(7), 1074-1077.Available at: https://doi.org/10.3923/pjn.2009.1074.1077.

Larson, S. A., Khaleghi, S., Rubio-Tapia, A., Ovsyannikova, I. G., King, K. S., Larson, J. J., . . . Murray, J. A. (2017). Prevalence and morbidity of undiagnosed celiac disease from a community-based study. *Gastroenterology, 152*(4), 830-839. e835.Available at: https://doi.org/10.1053/j.gastro.2016.11.043.

Laura, A., Arianna, G., Francesca, C., Carlo, C., Carla, M., & Giampaolo, R. (2019). Hypersensitivity reactions to food and drug additives: Problem or myth? *Acta Bio Medica: Atenei Parmensis, 90*(Suppl 3), 80.

Liu, S., Zhao, L., Wang, L., & Liu, H. (2020). Microstructure-modified products from stone-milled wheat bran powder improve glycemic response and sustain colonic fermentation. *International Journal of Biological Macromolecules, 153*, 1193-1201.Available at: https://doi.org/10.1016/j.ijbiomac.2019.10.249.

Marlett, J. A., McBurney, M. I., & Slavin, J. L. (2002). Position of the American dietetic association: health implications of dietary fiber. *Journal of the American Dietetic Association, 102*(7), 993-1000.

McCarville, J. L., Caminero, A., & Verdu, E. F. (2015). Pharmacological approaches in celiac disease. *Current Opinion in Pharmacology, 25*, 7-12.Available at: https://doi.org/10.1016/j.coph.2015.09.002.

McRorie Jr, J. W. (2015). Evidence-based approach to fiber supplements and clinically meaningful health benefits, part 1: What to look for and how to recommend an effective fiber therapy. *Nutrition Today, 50*(2), 82-89.Available at: https://doi.org/10.1097/nt.0000000000000082.

Mudgil, D., Barak, S., & Khatkar, B. (2017). Cookie texture, spread ratio and sensory acceptability of cookies as a function of soluble dietary fiber, baking time and different water levels. *LWT, 80*, 537-542.Available at: https://doi.org/10.1016/j.lwt.2017.03.009.

Okezie, B. O., & Bello, A. (1988). Physicochemical and functional properties of winged bean flour and isolate compared with soy isolate. *Journal of Food Science, 53*(2), 450-454.Available at: https://doi.org/10.1111/j.1365-2621.1988.tb07728.x.

Qaisrani, T. B., Butt, M. S., Anjum, F. M., & Sheikh, M. A. (2013). Color tonality and sensory response of psyllium husk based cookies. *Pakistan Journal of Nutrition, 12*(1), 55-59.Available at: https://doi.org/10.3923/pjn.2013.55.59.

Rashid, M., & Rashid, H. (2019). Coeliac disease in Pakistan: A bibliographic review of current research status. *The Journal of the Pakistan Medical Association, 69*(12), 1883-1888.

Rodrigo, L. (2006). Celiac disease. *World Journal of Gastroenterology, 12*(41), 6577.

Rolfe, C., & Daryaei, H. (2020). Intrinsic and extrinsic factors affecting microbial growth in food systems. In Food Safety Engineering (pp. 3-24). Cham: Springer.

Saghir, S., Iqbal, M. S., Hussain, M. A., Koschella, A., & Heinze, T. (2008). Structure characterization and carboxymethylation of arabinoxylan isolated from Ispaghula (Plantago ovata) seed husk. *Carbohydrate Polymers, 74*(2), 309-317.Available at: https://doi.org/10.1016/j.carbpol.2008.02.019.

Santipanichwong, R., & Suphantharika, M. (2009). Influence of different β-glucans on the physical and rheological properties of egg yolk stabilized oil-in-water emulsions. *Food Hydrocolloids, 23*(5), 1279-1287.Available at: https://doi.org/10.1016/j.foodhyd.2008.10.006.

Semeco, A. (2017). Seven benefits of psyllium. *Medical News Today*.

Singh, P., Arora, A., Strand, T. A., Leffler, D. A., Catassi, C., Green, P. H., . . . Makharia, G. K. (2018). Global prevalence of celiac disease: Systematic review and meta-analysis. *Clinical Gastroenterology and Hepatology, 16*(6), 823-836. e822.

Soliman, G. A. (2019). Dietary fiber, atherosclerosis, and cardiovascular disease. *Nutrients, 11*(5), 1155.Available at: https://doi.org/10.3390/nu11051155.

Taetzsch, A., Das, S. K., Brown, C., Krauss, A., Silver, R. E., & Roberts, S. B. (2018). Are gluten-free diets more nutritious? An evaluation of self-selected and recommended gluten-free and gluten-containing dietary patterns. *Nutrients, 10*(12), 1881.Available at: https://doi.org/10.3390/nu10121881.

Verma, A., & Mogra, R. (2013). Psyllium (Plantago ovata) husk: A wonder food for good health. *International Journal of Science and Research, 4*(9), 1581-1585.

Verspreet, J., Damen, B., Broekaert, W. F., Verbeke, K., Delcour, J. A., & Courtin, C. M. (2016). A critical look at prebiotics within the dietary fiber concept. *Annual Review of Food Science and Technology, 7*(1), 167-190.Available at: https://doi.org/10.1146/annurev-food-081315-032749.

Wolter, A., Hager, A.-S., Zannini, E., Czerny, M., & Arendt, E. K. (2014). Influence of dextran-producing Weissella cibaria on baking properties and sensory profile of gluten-free and wheat breads. *International Journal of Food Microbiology, 172*, 83-91.Available at: https://doi.org/10.1016/j.ijfoodmicro.2013.11.015.

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