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Review Article

A study on rice and buckwheat based diet and its role in celiac disease: an overview

Junaid Abid[1]*, Muhammad Usama Ayub[1], Saleha Ahmed[2], Hafiz Umair Ali[2], Maria Zeb[3], Rana Shahzaib Zahid[2], Shahrukh Khan[4]

[1]Department of Food Science and Technology, University of Haripur, Pakistan
[2]Institute of Food and Nutritional Sciences, PMAS Arid Agriculture University, Rawalpindi, Pakistan
[3]Faculty of Agricultural Sciences, University of the Punjab, Lahore, Pakistan
[4]University of Veterinary and Animal Sciences, Lahore, Pakistan

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***Correspondence:**
Junaid Abid,
E-mail: junaidabid2017@gmail.com

ABSTRACT

Celiac disease results in inflammatory damage to the small intestine mucosa that is immunologically mediated. The nutritious value of the diet and how well it treats diseases like gluten sensitivity have drawn the attention of health professionals. By reviewing the literature we aim to prepare a clear image of the current justifications behind the use of gluten-free diets for celiac disease, as well as the role of rice and buckwheat based gluten-free diet and its development. Rice and buckwheat flours don't possess gluten, therefore can be used in gluten-free products formulation and are suitable and safe ingredients for celiac patients. Both rice and buckwheat have prominent nutritional value with number of health benefits and has been used since long period of time in gluten-free and non-gluten-free diets. Different processing strategies have also been developed to reduce the gluten content of flours that include gluten and enhance the rheological characteristics of products that don't contain gluten.

Keywords: Celiac disease, Rice, Buckwheat, Gluten-free, Product development

INTRODUCTION

The principle shape-forming protein, responsible for giving flour its shape is called gluten. It also gives dough its elastic properties and crumb shape of many baked goods.[1] Gluten intolerance, or celiac disease, results in inflammatory damage to the small intestine mucosa.[2] The prevalence of celiac disease is increasing worldwide. The increased prevalence is due to the lack of knowledge about this predominantly immune-based disease.[3] Based on positive results from analysis of anti-tissue transglutaminase and/or anti-endomysial antibodies, the estimated global prevalence of celiac disease was 1.4% (95% confidence interval, 1.1%-1.7%) in 275,818 people (called seroprevalence).[4] According to studies, the cost of a positive diagnosis of celiac disease range from $1,300 in Canada to more than €44,000 in the Netherlands.[5] The financial impact of celiac disease outside of Europe has not been studied. According to a retrospective studies conducted in the USA, the estimated annual expense for celiac disease was $12,217 which covered both outpatient care and hospitalisation.[6]

Gluten-free diet is a part of treatment for celiac disease, but it is widely consumed around the world besides patient care.[7] Specifically for newborns and young children, process of increasing the nutritional value of gluten-free diets should be performed to lower the risk of later chronic degenerative diseases.[8] One of the best cereals for gluten-free food preparations is rice, due to its soft taste, properties of hypoallergenic, having no color, sodium in low quantity and easy digestible carbohydrates.[9-11] The rice (*Oryza sativa*) yields flour that is hypoallergenic, colourless, and has highly special nutritional properties.[12] Compared to other cereals, rice has a higher lysine

concentration, and its gluten has a more uniform distribution of amino acid than wheat prolamin, which contain poor quantity of lysine and tryptophan.[1] Buckwheat (*Fagopyrum esculentum*) is a pseudocereal becoming more popular as human food because of their potential health benefits.[13] Buckwheat flour has a high protein content and therefore serves as an important source of dietary protein.[14] Large levels of flavonoids and polyphenols has been reported in buckwheat.[15] Buckwheat contains phenolic compounds such 3-flavanol, rutin, phenolic acids, and their derivatives, which are all potential antioxidants.[16] This review paper briefly discusses celiac disease and role of rice and buckwheat based diets and their development.

METHODS

A celiac-related review paper has been developed by philanthropist researchers' works and their renowned articles. To collect the research work, authors have searched for three-dimensional papers on celiac disease, role of rice and buckwheat based diet and its development. The information outlined in this review has been accumulated from over forty works. All the works were extensively reviewed by the authors as group work and they decided to write up such a paper. This review paper tried to establish the benefits of rice and buckwheat based diets as a part of treatment for celiac disease among the people worldwide.

CELIAC DISEASE

Celiac disease represents a long-standing intolerance to the gliadin fraction of wheat and the prolamin of rye (secarin), barley (hordein), and possibly oats (avenin). Celiac disease is a persistent intolerance to ingested gluten, causing immunologically mediated inflammatory damage to the small intestinal mucosa.[17] Numerous symptoms, both gastrointestinal (diarrhoea, steatorrhea, weight loss, bloating, flatulence, and abdominal pain) and non-gastrointestinal (bloating, flatulence, and abdominal discomfort) which include abnormal liver function tests, iron deficiency anemia, skin disorders, and many other protean manifestations, can be brought on by celiac disease.[18] Delays in diagnosis, particularly in patients who come with severe symptoms, are linked to an increased risk of death, primarily due to malignancy.[19] Celiac disease is typically identified through the use of celiac-specific antibodies in serologic testing. Biopsies of the duodenal mucosa confirm the diagnosis. A gluten-free diet should be followed during both serology and biopsy.[18] The longest follow-up research of 45 years found that accumulated extra mortality does not occur until 25 years after the blood sampling date, indicating that if a person is diagnosed with celiac disease later in life, it may take considerably longer to ascertain whether or not excess mortality occurs.[19]

The prevalence of celiac disease has significantly increased over the past 50 years, and the number of diagnoses has increased over the past 10 years.[18] In Asia, the combined prevalence of biopsy-proven celiac disease was 0.5% in 43,955 people. Women, as expected, had a higher prevalence of celiac disease than men (0.5% vs 0.4%). In Iran, 0.3% of the population had celiac disease, and Turkey, India and Israel had 0.5%, 0.6%, and 0.7% respectively.[20] In South America, the prevalence of celiac disease was 0.4%, in North America and Africa it was 0.5%, in Asia it was 0.6%, and in Europe it was 0.8%. Children had a considerably higher prevalence percentage of celiac disease than adults (0.9% vs 0.5%).[4] According to conducted research, the cost of a celiac disease diagnosis is estimated to range from $1,300 in Canada to more than €44,000 in the Netherlands.[5] There is no report on the economic burden of celiac disease in non-European countries. In a retrospective research conducted in USA, the estimated direct cost of celiac was $12,217 year (including outpatient expenses and hospitalization).[6]

CELIAC DISEASE DIET (WHY AND HOW?)

Celiac disease is now treated by avoiding gluten-containing foods, drinks, sauces, and dressings for the rest of one's life. Scientists and technicians continue to work to improve gluten-free product quality.[21] Due to the increased expense and restricted accessibility of gluten-free products, celiac disease patients may experience difficulty, which may negatively impact their mental well-being and health-related quality of life. Furthermore, there is a significant proof that, as a result of the nature of the condition and/or adherence to a gluten-free diet, celiac disease is linked to depression, anxiety, social pressure, and challenges in daily social interactions.[22]

Gluten-free products have proven to be highly popular in recent years, and the industry is being fueled by them because they are not only entertaining to those with medical needs but also to customers who follow a gluten-free diet.[8] The diet's nutritional adequacy, as well as its efficiency in managing gluten-related diseases and other conditions, has piqued the curiosity of health specialists. Gluten-free alternatives, on the other hand, are frequently inferior than gluten-containing products in terms of quality.[23] The viscoelastic properties of gluten have been achieved using a variety of flours, starches, and other substances. As a result, the various combinations of these substances result in a significant variation in the nutritional profiles of gluten-free products and those of their gluten-containing equivalents.[8] Furthermore, while nutritional imbalances have been documented, the gluten-free diet has demonstrated advantages in treating a number of disorders linked to gluten.[23] The worldwide food sector relies heavily on new product development (NPD). Food firms are typically driven by shifting consumer demands and market developments. Consumer demand for food is complex, influenced by a variety of external influences, and changes over short, often unpredictable time periods.[24]

RICE

Oryza is the scientific name for rice, which is a monocotyledon plant. Nearly half of the world's population eats rice, as one of the most important staple foods. Rice

has grown to be a significant crop in parts of North and South America, Africa, and Europe.[25] A mean proximate analysis of rice grain after milling at 14 percent moisture shows that it contains 77% starch, 0.4% crude ash, 0.4% crude fat, 7% protein (N×5.95), and 0.4% crude fibre (1% dietary fibre). Vitamin B (thiamine), Vitamin B2 (riboflavin), calcium, niacin and iron are also abundant in rice.[26] In human diets, milled rice supplements sulfur-amino-acid-deficient but lysine-rich legume proteins, resulting in a higher amino acid capacity than either rice or legume.[27] One of the best cereals for gluten-free product formulations is rice flour., due to its soft taste, properties of hypoallergenic, having no color, sodium in low quantity and easy digestible carbohydrates.[9]

Rice flour has highly special nutritional qualities due to its hypoallergenic properties, colorless characteristic and bland taste. Rice grain has more quantity of lysine content than other cereals grains, and its glutelin has a more uniform amino acid profile than wheat prolamin, which contain low quantity of lysine and tryptophan.[10] The network that is required to retain the gas during the fermentation process cannot be formed by rice proteins. However, rice has a low prolamin content (2.5-3.5%) and when rice flour is mixed with water it is difficult to form viscoelastic dough.[1]

To improve the properties of the protein network and make the dough as similar to wheat dough, a variety of structuring agents are usually applied to gluten-free formulations, which include hydroxyl-propylmethylcellulose, carboxymethylcellulose, pectin, agar, xanthan gum, and other starches.[28]

BUCKWHEAT

Buckwheat is a member of the polygonaceae family and the most widely accessible buckwheat is diploid common buckwheat (*Fagopyrum esculentum Moench*).[29] Buckwheat is mostly grown in Japan, Korea, India, China, Nepal, Bhutan, Austria, Russia, Italy, France, South Africa, Canada, the United States of America, and some other countries.[30]

Buckwheat inner layer flour contains 6.0 g protein, 1.6 g lipid, 77.6 g non-fiberous carbohydrate, and 1.8 g dietary fibre per 100 g of flour. Buckwheat straight flour contains 12.0 g protein, 3.1 g lipid, 69.6 g non-fiberous carbohydrate, 4.3 g dietary fibre, and 1.8 g ash per 100 g of flour.[29] Buckwheat grain is a good candidate for food industry and can be used to increase processing and marketing potential because of its broad spectrum of nutritional benefits.[13]

In comparison to other cereals like rice and wheat, buckwheat flour has higher levels of protein, dietary fiber, minerals, and vitamins.[29] Buckwheat protein is mainly composed of globulin (up to 50%) and albumin (low molecular weight chain polypeptide, about 25%).[14] Significant levels of flavonoids and polyphenols are present in buckwheat.[15] Several authors have also studied the antioxidant properties of buckwheat. Particular attention was paid to identifying the individual components of the phenolic fraction and their antioxidant activity.[31] Buckwheat flour is thought to be an innovative component for gluten-free recipes. Although buckwheat flour enhances the nutritional content of gluten-free products, the usage of such alternative flours is limited due to their poor baking properties and the sensory characteristics of the baked goods.[32] Interest in gluten-free foods has increased over the past few years. There are now several buckwheat gluten-free products available, including gluten-free breads, pasta, noodles, biscuits, and beer. However, it's crucial to take into account how nutritious these items are.[33]

DEVELOPMENT OF RICE AND BUCKWHEAT BASED GLUTEN-FREE PRODUCTS

According to data provided by global market, sales of gluten-free goods are expected to increase between 2015 and 2020 at a compound annual growth rate of 10.4%.[34] There are already many gluten-free options available for the traditional gluten-containing food items, that use gluten-free cereals and pseudocereals, such as buckwheat, quinoa, rice, millet, corn, and amaranth as their basic ingredients.[35] Rice and buckwheat flours don't contain gluten and may be used to make gluten-free bread and cookies.[15,36] These both flours are suggested as the best ingredients for celiac sufferers.

In addition to rational selection of ingredients and/or additives, various processing routes have also been investigated to modify the gluten portion of gluten-containing foodstuffs and improve the rheological properties of dough.[34]

An overview on the study of gluten-free product formulations carried out by scientists and their results is given in Table 1.

Table 1: Recent development of rice and buckwheat based gluten-free products.

Products	Flours	Conclusion
Pasta	Rice flour and buckwheat flour	Optimum rice-buckwheat pasta (30% of moisture content, 120°C for temperature) resulted good quality, high nutritional composition and high scores for overall acceptability.[37]
Wafer	Corn flour, rice flour and buckwheat flour	Fragilities of gluten-free wafer sheets containing rice, corn and buckwheat had similar texture as compared to the control (wheat flour wafer).

Continued.

Products	Flours	Conclusion
		However the hardness of wafer sheet made with buckwheat flour was increased.[38]
Bread	Buckwheat flour and rice flour	Higher amounts of buckwheat flour enhanced the parameters i.e.; mean bread volume, specific volume of bread, dough and bread yield.[39]
Cookies	Rice flour and buckwheat flour	Addition of rice flour to buckwheat flour resulted decrease product hardness, fracturability and an increase in percent spread and eccentricity. Higher scores for overall acceptability were given to buckwheat enriched cookies.[40]
Cookies	Rice flour and buckwheat flour	Addition of buckwheat flour to rice flour increased the mineral content total phenolic content and rutin content, scavenging activity against (DPPH) and antioxidant activity.[41]
Cookies	Corn flour, rice flour and buckwheat flour	The protein and ash content of buckwheat cookies and also the crude fiber content of buckwheat-corn cookies were higher than the others.[42]
Pasta	Amaranth flour, rice flour and buckwheat flour	The partial substitution of buckwheat flour by amaranth flour and rice flour positively affect the chemical and sensory composition of the pastas, demonstrating that it is possible to develop gluten-free pasta with high protein content.[43]
Bread	Amaranth flour, buckwheat flour, chickpea flour, corn flour, millet flour, quinoa flour and rice flour	The most positive impact on rice dough and bread characteristics was investigated by the addition of buckwheat flour, especially 30 g/100 g and 50 g/100 g of blend.[44]
Bread	Rice flour, quinoa flour, buckwheat flour and potato starch	Quinoa flour enhanced technological properties of bread due to higher amount of soluble dietary fiber. 25% quinoa flour is best for positive effect on sensory properties of bread.[45]
Cookies	Rice flour, buckwheat flour	Decrease in total phenolics and rutin content in cookies, as well as an increase in total aldehydes content were noticed during storage.[46]
Snacks	Peanut flour, buckwheat flour and rice flour	It has been proved that peanut and buckwheat could effectively utilize the basic extrusion conditions to produce extruded snacks by selecting suitable extrusion parameters.[47]
Biscuits	Rice flour and buckwheat flour	Flours were tested for amylose, gluten and moisture content and found suitable for making gluten free biscuit by substituting wheat flour with rice flours.[48]

CONCLUSION

The desire to follow a gluten-free lifestyle goes beyond its original application for celiac disease management. Individual decisions to avoid gluten are affected by perceived health benefits and relief of negative symptoms on the diet. It is difficult to substitute gluten as a necessary and important component in the majority of food products. Numerous different ingredients and processing methods have been explored and analyzed up until now. However, the quality of products without gluten is frequently inferior as compared to products containing gluten. The value of nutrition and health benefits of rice and buckwheat are very prominent. Both rice and buckwheat flours are best flours to incorporate into gluten-free diets.

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