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# Bread Wheat Gluten and Its Health Effects

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**ABSTRACT**

Glutens are the major constituents of bread wheat grain storage proteins and constituting 85% of the total. They are mainly responsible for the processing quality of wheat dough and were among the first proteins isolated and studied by human beings. Different compositions of wheat storage proteins confer different dough physical properties, which are required by different products. Gluten provides dough with unique extensibility and elasticity, which are essential for various wheat products. Gluten is one of the most commonly used proteins in food industry. Its characteristic properties make it an essential ingredient in the preparation of high quality dough, hence it is popular in the baking industry. Some wheat gliadin proteins are strong allergens that can cause various symptoms of food allergies and baker asthma. The most immune reactive ω-5 gliadin fractions are the main allergens in wheat dependent exercise induced anaphylaxis. Apart from their role in dough quality, gluten proteins can affect the health of genetically susceptible individuals. Many gluten proteins contain T-cell stimulatory epitopes that can cause celiac disease. The consumption of gluten proteins can trigger an immune response that damages the small intestine. Therefore, patients with celiac disease (CD) are restricted to a lifelong gluten-free diet.

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## Introduction

Proteins in bread wheat grain are generally divided into gluten and non-gluten proteins. Both gluten and non-gluten proteins are located mainly in the embryo, aleurone layer and endosperm of the grain, with the endosperm containing most gluten. The reduction of the amount in major T-cell stimulatory epitopes in food will especially benefit children in whom the onset of CD may be delayed or even prevented and in non-diagnosed CD patients (the vast majority of all CD patients) to strongly reduce their symptoms. Therefore, breeding wheat with considerably reduced T-cell stimulatory epitopes should be considered a serious option. Currently, the only effective treatment for CD is the strict lifelong renunciation of gluten-containing foods, although alternative treatments, such as oral doses of microbial endopeptidases to degrade wheat peptides, are under trial [1]. As gluten is the major structure-forming protein present in wheat bread, it is challenging to produce high-quality gluten-free bread. Therefore, ingredients that can mimic the properties of gluten are generally used. According to [2] the use of polymeric substances such as xanthan gum or hydroxypropylmethylcellulase (HPMC) is required for the production of gluten-free bread.

The gluten protein fraction accounted for approximately 85% of the total grain protein content. Based on their solubility in aqueous alcohols and acidic solutions, glutens are divided into polymeric glutenins and monomeric gliadins proportion of 40% and 60%, respectively [3]. According to their molecular weight distribution, glutenins are classified into high molecular weight (70000–90000 Da) glutenin subunits and low molecular weight (20000–45000 Da) glutenin subunits (HMW-GS and LMW-GS), which account for 40% and 60% of glutenin composition, respectively. On the basis of the order of mobility on electrophoresis at low pH, monomeric gliadins are classified into α/β-, g- and w-gliadins, which represent approximately 55%, 30% and 15% in gliadin fractions, respectively [4]. The non-gluten protein includes albumins (water-soluble protein) and globulins (salt soluble protein). These are mainly biochemical functional proteins such as chaperones and enzymes, which regulate the accumulation and synthesis of storage proteins, and grain growth [5].

## Gluten Protein Variations of Wheat

Glutens are the major constituents of bread wheat grain storage proteins and constitute 85% of the total. They are mainly responsible for the processing quality of wheat dough and were among the first proteins isolated and studied by human beings. Their biological function is to provide carbon, nitrogen and energy sources for seed germination and seedling growth. Mutations or silencing of such genes are not lethal for the plant, so the evolutionary selection pressure on these genes is much lower than for functional genes [6]. As a result, these genes can accumulate more mutations, making them ideal model molecules for studying a range of biological fundamental processes [7]. Extensive studies have provided substantial information about the relationship between gluten structures and properties in relation to product quality. The first systematic study was conducted by [8], who developed a classification for cereal-seed proteins based on their sequential extraction and differential solubility. Four different groups were classified. These are (1) albumins, soluble in water and dilute buffers, (2) globulins, not soluble in water but soluble in saline solutions, (3) gliadins, soluble in 70% to 90% ethanol and (4) glutenins, soluble in dilute acid or alkali. The two distinct

groups of the gluten polymer that were classified reflected their solubility in 70% ethanol, namely glutenins and gliadins [9]. The gliadins are single polypeptide chains and the glutenins are multichained structures of polypeptides that are held together by disulfide bonds.

In most dicotyledonous and some monocotyledon seeds, the globulin types predominate in the seed. However, in the Triticeae (wheat, barley and rye) the major portion of seed proteins are not globulins, but classes of protein characterized by regular repetitive domains with unique and fundamental functional features [10]. These proteins are glutenins in wheat and variation in them either quantitatively or qualitatively has major effects on end product quality [11]. It is worth noting that although some water-soluble proteins are also found present in the dough gluten matrix and have some impacts on wheat processing quality, the glutenins and gliadins are still the dominant proteins in defining wheat processing quality [12]. The predictive power of glutenin subunit proteins for flour processing properties has been demonstrated for dough rheological properties, such as dough extensibility and elasticity [11]. Strong dough will form a cohesive mass that has resistance to extension and can retain stability during mixing.

The investigation of glutenin proteins in relation to dough properties have indicated two key variables: (1) the nature of the protein allele and (2) the level at which the respective allele is expressed [13,14]. Moreover, loaf volume during the baking process has a negative relationship with acetic acid-soluble glutenin and a positive relationship with acetic acid-insoluble glutenin [15]. For extensibility suggested this was a more complex trait involving other parameters such as LMW-GS and gliadin compositions. However, gliadins appear to be less important in determining bread quality, and the addition of gliadins or the overexpression of certain gliadins can reduce dough strength [16-18] found that hydrated gliadins have little elasticity but contribute to the viscosity and extensibility of the dough system, whereas, hydrated glutenins are responsible for both cohesive and elastic properties.

The structure of gluten protein is determined by three general domains, one central domain rich in a repetitive structure constituting a β-reverse turn and two terminal α-helix domains [19]. A long repetitive domain of the glutenin is considered to have a positive influence on wheat flour quality due to the formation of more β-reverse turn structures [20]. The proportion of the consensus hexapeptides and nonapeptides in the repetitive domain also affect dough quality. Masci et al. reported that a large and regular repeated sequence domain increases the viscosity and elasticity of doughs through intermolecular interactions. Wang et al., reported that the hexapeptide motif is more important than the nonapeptide motif. In terms of secondary and high order structure, gluten protein can aggregate to form a complex protein network through disulfide bonds during the dough mixing process. In general, most y-type subunits contain seven cysteines (five in the N-terminal domain and one in each of the repetitive and C-terminal domains), the x-type subunits possess four cysteines (three in the N-terminal domain and one in the C-terminal domain) [21].

Different compositions of wheat storage proteins confer different dough physical properties that are required by different products [22]. For example, pasta making requires dough with high gluten strength, but dough for biscuit making needs low gluten strength with high extensibility. Bread making needs moderate gluten strength and high extensibility dough, while noodle making needs dough with a balance of gluten strength and extensibility in order to protect dough from tearing during the manufacturing process. In addition, confectionery products such as cake and cookies need flour with weak gluten [23]. The core factors affecting the dough storage protein composition and viscoelastic properties are due to the essential role of disulfide bonds, which are formed between sulfhydryl groups of cysteine residue [24-30].

## Conclusions

Based on the findings of gluten research, in the wheat genomic era, new HMW glutenins identified from wheat relatives and historical landraces with long central repetitive domains that contain high number of consensus hexapeptide and nonapeptide motifs as well as high content of cysteine and glutamine residues should be investigated for their potential to improve wheat end-use quality. This article is a review and does not contain any studies with human or animal subjects performed by any of the authors. Among the different gluten epitopes that have been identified, the α-gliadin epitopes are considered the most immunogenic. In HLA-DQ2.5-positive adults, responses to the α- and ω-gliadin-derived peptides are dominant, while responses to the γ-gliadins and LMW glutenins are much less frequently observed. In this respect, it is significant that the immunodominant α- and ω-gliadin peptides contain four proline residues, while the γ-gliadin peptides have two or three and the LMW glutenin peptides only one or two. It has been shown that the proline-rich nature protects gluten peptides from degradation in the gastrointestinal tract so that they will persist increasing the chance that they will bind to HLA-DQ and trigger T-cell responses.

## References

1. Ehren J, Govindarajan S, Morón B, Minshull J, Khosla C (2008) Protein engineering of improved prolyl endopeptidases for celiac sprue therapy. Protein Engineering, Design and Selection 21: 699-707.
2. Guarda A, Rosell CM, Benedito C, Galotto MJ (2003) Different hydrocolloids as bread improvers and antistaling agents. Food Hydrocolloids 18: 241-247.
3. Sapirstein HD, Fu BX (1998) Intercultivar variation in the quantity of monomeric proteins, soluble and insoluble glutenin, and residue protein in wheat flour and relationships to breadmaking quality. Cereal Chemistry 75: 500-5072.
4. Ahmad M, Griffin W, Sutton K (2000) Genetic evaluation of gliadin and glutenin subunits and their correlations to rheological properties in Wujun MA et al. Wheat gluten and quality 283 bread wheat. Journal of Genetics & Breeding 54: 143-147.
5. Majoul T, Bancel E, Triboï E, Ben Hamida J, Branlard G (2004) Proteomic analysis of the effect of heat stress on hexaploid wheat grain: characterization of heat-responsive proteins from nonprolamins fraction. Proteomics 4: 505-513.
6. Liu S, Gao X, Xia G (2008) Characterizing HMW-GS alleles of decaploid Agropyron elongatum in relation to evolution and wheat breeding. Theoretical and Applied Genetics, 116: 325-334.
7. Zhang Y, Hu X, Islam S, She M, Peng Y, Yet al. (2018) New insights into the evolution of wheat avenin-likeproteins in wild emmer wheat (Triticum dicoccoides). Proceedingsof the National Academy of Sciences of the United States of America 115: 13312-13317.
8. Osborne TB (1907) the proteins of the wheat kernel. Washington DC: Carnegie Institution of Washington.
9. Shewry PR, Casey R (1999) Seed proteins. In: Seed proteins. Shewry P Rand Casey R, eds. Dordrecht: Springer Netherlands 1-1013.
10. Shewry PR, Halford NG (2002) Cereal seed storage proteins:

structures, properties and role in grain utilization. Journal of Experimental Botany 53: 947-958.

11. Jiang P, Xue J, Duan L, Gu Y, Mu J, at al. (2019) Effects of high-molecular-weight glutenin subunit combination in common wheat on the quality of crumb structure. Journal of the Science of Food and Agriculture 99: 1501-1508.
12. Gao L, Wang A, Li X, Dong K, Wang K, at al. (2009) Wheat quality related differential expressions of albumins and globulins revealed by two-dimensional difference gel electrophoresis (2-D DIGE). Journal of Proteomics 73: 279-296.
13. Ma W, Appels R, Bekes F, Larroque O, Morell M K, at al. (2005) Genetic characterisation of dough rheological properties in a wheat doubled haploid population: additive genetic effects and epistatic interactions. Theoretical and Applied Genetics 111: 410-422.
14. Wang S, Yu Z, Cao M, Shen X, Li N, et al. (2013) Molecular mechanisms ofHMWglutenin subunits from 1S(l) genome of Aegilops longissima positively affecting wheat breadmaking quality. PLoS One 8: 58947.
15. Wrigley CW (1996) Giant proteins with flour power. Nature 381: 738-73912.
16. Cornish GB, Skylas DJ, Siriamornpun S, Békés F, Larroque OR, at al. (2001) Grain proteins as markers of genetic traits in wheat. Australian Journal of Agricultural Research 52: 1161-1171.
17. Fido RJ, Békés F, Gras PW, Tatham AS (1997) Effects of α-, β-, g- and w-gliadins on the dough mixing properties of wheat flour. Journal of Cereal Science 26: 271-277.
18. Wieser H (2007) Chemistry of gluten proteins. Food Microbiology 24: 115-119.
19. Tilley KA, Benjamin RE, Bagorogoza KE, Okot-Kotber BM, Prakash O, et al. (2001) Tyrosine cross-links: molecular basis of gluten structure and function. Journal of Agricultural and Food Chemistry 49: 2627-2632.
20. Belton P (1999) Mini review: on the elasticity of wheat gluten. Journal of Cereal Science 29: 103-107.
21. Shewry PR, Tatham AS, Lazzeri P (1997) Biotechnology of wheat quality. Journal of the Science of Food and Agriculture 73: 397-406.
22. Weegels PL, Hamer RJ, Schofield JD (1996) Functional properties of wheat glutenin. Journal of Cereal Science 23: 1-17.
23. Bangur R, Batey I, McKenzie E, MacRitchie F (1997) Dependence of extensograph parameters on wheat protein composition measured by SE-HPLC. Journal of Cereal Science, 25: 237-241.
24. Zhao FJ, Hawkesford MJ, McGrath SP (1999) Sulphur assimilation and effects on yield and quality of wheat. Journal of Cereal Science 30: 1-17.
25. Briani C, Samaroo D, Alaedini A, (2008) Celiac disease: from gluten to autoimmunity. Autoimmunity Reviews 7: 644-650.
26. Camarca A, Anderson RP, Mamone G, Fierro O, Facchiano A, at al. (2009) Intestinal T cell responses to gluten peptides are largely heterogeneous: implications for a peptide-based therapy in celiac disease. Journal of Immunology 182: 4158-4166.
27. Masci S, D'Ovidio R, Lafiandra D, Kasarda DD (1998) Characterization of a low-molecular-weight glutenin subunit gene from bread wheat and the corresponding protein that represents a major subunit of the glutenin polymer. Plant Physiology 118: 1147-1158.
28. Shan L, Molberg Ø, Parrot I, Hausch F, Filiz F, et al. (2002) Structural basis for gluten intolerance in celiac sprue. Science 297: 2275-2279. Slađana Žilić 84
29. Sollid LM (2002) coeliac disease: dissecting a complex inflammatory disorder. Nature Reviews Immunology 2: 647-655.
30. Vader W, Kooy Y, Van Veelen P, De Ru A, Harris D, et al. (2002) The gluten response in children with celiac disease is directed toward multiple gliadin and glutenin peptides. Gastroenterology 122: 1729-1737.