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Review: Characteristics of Whole Wheat Grain Bread Quality

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ABSTRACT

Wheat breads share about 50% of human body calories in many developing communities. There are different kinds of breads differ with the different traditions of the society. Gluten and gliadin proteins play a major part of baking quality of wheat bread. Oriental bread is the most sensitive to quality and percent of gluten proteins in grains. Viscosity of dough helps making better oriental bread. Puffing, blisters on breads surface, and palatability of bread could be improved by mixing bread wheat flour with xylanase enzyme, vital wheat gluten, and some other additives. Whole grain wheat breads are more nutritious, for containing high quality of fibers, vitamins, minerals, proteins, antioxidants, and carbohydrates. Mixing an optimum percent of durum wheat flour with poor quality bread wheat enhances the baking quantity so well. The genetics of gluten and gliadin bread wheat is so complex. Polymorphism, multi-genes loci, epigenetics and epigenomics play several roles in this complicated trait. Splitted dozes of nitrogen enhances quality of wheat bread, although, it could not increase grain yield when added at anthesis or pre-anthesis. More research is still needed on wheat bread quality on farm, and into the laboratory.

Keywords: Glutenin, gliadin, antioxidants, fibers.

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INTRODUCTION

Whole-wheat (*Triticum aestivum* L.) flour (Graham flour) is the entire wheat grains ground, including all the bran of grains. This quality of flour is considered the healthiest flour. On the average, wheat kernels composition is 68% carbohydrates, 55% of it is starch, with 6% pentosans and 2% sugars. The wheat kernels contain also 2.3% crude fiber, 2% fat, 13% crude protein, and 2% minerals (Martin et al 1976).

One of the important factors in human general health, immunity, and intellectual ability is using healthy food. One criterion of healthy foods is that contains a high level of antioxidants. This quality of food that is rich in antioxidants will reduce the probability of having inflammatory and/or chronic diseases. For this reason, researchers and food processors have focused on this quality in foods in general, and in wheat flour in specific. Researchers are still trying to have high yield bread wheat cultivars of high protein content and quality. On the other hand, some wheat flour processors are using some additives to give the wheat flour and then its products the taste, aroma, colour and benefits required in the market. Protein plays a major role in wheat bread quality. This could be as in percent of protein in grains and/or quality of protein. Chaudhary et al (2016) stated that baking quality of wheat breads is complex and is determined not only by grain protein content but also by its composition. Proteins have different solubility according to different solvents. The major wheat flour protein types are classified into albumin, globulins, gliadins, and glutenins (Sherry and Halpord 2002). This review article will focus on the role of protein in the bread wheat grain, the quality of breads produced, and effects of some additives to improve quality in taste, aroma, nutrients and appearance of breads.

Bread wheat grain proteins:

As we have mentioned before, bread wheat grain proteins, or glutenin proteins are the main prolamins found in bread wheat grains. Gluten is a protein network, covalent (disulfide bonds) and noncovalent introductions between gliadin and glutenin chains in the grain flour of each of, bread wheat, rye, and barley. (Wang et al 2017). This development takes place when adding water to wheat flour and mix them well, give a time to rest, then continue mixing, then, we will have a viscoelastic dough suitable for bread making (Ortolan and steel 2017). In this process (dough making), probably we could have about 80%-90% of flour proteins. These proteins consist of gliadins and glutenins which are both hydrophobic. Gliadins are considered soluble in alcohol-water solutions, while glutenins are soluble in this medium by adding some acid (Ortolan and steel 2017).

In Iraq, when ladies make the oriental bread, and they realize that the dough is not viscous enough, they add a cup of vinegar and extra sodium chloride and continue mixing their dough. The well-known urea is also helpful, especially when bread quality intended is loaf, although it is still beneficial for oriental bread, giving nice looking and attractive blisters of the surface of the bread made in baked clay chimney (Plate l). This quality of bread could be obtained from high quality bread wheat flour, some baking powder, or urea, enough time for proofing, enough time of dough resting pre-baking, and hot enough chimney material that breads stick on to push enough gas into the bread.

Plate 1. Oriental bread baking chimney. It is made of baked clay. Dry twigs or cooking gas could be used to heat-up the chimney.

Presence of gliadins and glutenins:

The presence of these two important proteins, gliadins and glutenins in the tissue of grain endosperm. These two proteins are similar in their amino acids contents but are different in sequence of amino acids (Weiser 2007). However, gliadins have more proline, glutamic acid, isoleucine, and phenylalanine, while glutenins have more glycine, lysine, and tryptophan than gliadins have, knowing that both gliadins and glutenins are different in some major chemical and physical properties important in bread quality (Mc Cann and Day 2013). We can say that gluten proteins are responsible in making dough viscoelasticity while gliadin proteins act as plasticizers for glutenin proteins in the dough (Melnyk et al 2012).

Wheat flour hydrated

When wheat flour is enough hydrated with water to have viscous dough, suitable for leavening and baking, many reactions are taking place. Here, the gliadins and glutenin play the most important roles. Khatkar et al (2013) stated that gliadins upon hydration behave as a viscous liquid to provide expansion to the dough mass. This implies that high gliadins in the wheat flour could reduce the time required to have good stability dough.

Glutenins on the other hard share another property in dough mixing. Glutenins are the soluble parts of glutens, and they are of two classed according to their molecular weight; high molecular weight glutenins and low molecular weight glutenins (Legrains et al 2008). According to Delcour et al (2012), the main difference among them is the first amino acid residue that forms its primary structure, and it can be serine, methionine, or isoleucine.

The high molecular weight glutenins (67000-88000), the higher the molecular weight, the higher amounts of cysteine residues when compared to other gluten-forming proteins, such as low molecular weight gliadins (Ortolan and steel 2017). However, chains of gliadins and glutenins are so difficult to be explained and described completely, but it was known that when wheat flour hydrated with water, gliadins and glutenins form their first or initial chains (Schiedt et al 2013). Meanwhile, a sequential process that involves the insoluble proteins and their interactions occurs, including parts of the starch (Singh et al 2011). In general, wheat flour protein content, gluten quality, amount of water, salt, acid and some additives are sharing the final viscoelasticity of dough for bread making. The complete understanding of the final quality of dough to have better bread is not totally understood yet, but the major factors sharing that complex dough characteristics have been well defined.

Dough preparation

Dough preparation is an important step to have good breads from good quality bread wheat flours. Amounts of flour and other ingredients, such as water, salt, butter, vinegar or urea and yeast should be accurate. Mixing these ingredients well is so important to have a homogeneous dough suitable for that intended bread. After mixing, the dough should be left in room temperature covered with cloth. This time is called proofing. In the period of proofing, the dough will be leavened, and ready to bake. Some of the signs of leavened dough, bubbles of gas are clear on the surface, the smell, and the big volume of dough in that container. Yeast produces carbon dioxide, then gluten of dough will do expand too. Shah et al (2006) reported that wheat flour supplemented with some xylanase enzyme from *Aspergillus foefidus* has improved some quality properties of bread especially the volume of Iraqi bread. In period of proofing, gluten has enough time to develop and its structure remains stable for a while, but when mixing time exceeds this period, some proteins will be depolymerized (Scheidt et al 2013). Inter and intra molecular interactions between gliadins and glutenins favor the stability of generated polymer, and that will be reflected on quality of bread (Melnyk et al 2012). However, starchs breakdown and fermentation occur, and that contribute to dough to have enough bubbles and gas, especially in the initial phase of proofing (Cauvain 2015). As it was mentioned before, wheat flour of good quality gives high quality of bread, but these characteristics of all wheat flours are not well known yet. Meanwhile, Barak et al (2014) reported that wheat flours with an optimum gliadin-glutenin ratio provide an optimum bread quality, due to the gas-holding capacity of the gluten network developed in the dough through enough time of proofing. Period of proofing and temperature around the dough container have direct effect on this characteristic. At the same time, gliadins also play an important role in quality of wheat flour dough. The viscous gliadins have the potential to stability of gas vacuoles during bread making due to its surface-active properties (Wang et al 2015).

Gluten in dough baking

We have shown in the foregoing paragraphs that there are many factors affect wheat breads quality. When the period of proofing is over, it is the time to bake the dough. When a piece of dough is being in chimney, (Plate 1) and oriental bread is wanted (Plate 2), or in the oven when loaf is wanted, gluten and starch along with other components share together that baking process.

Plate 2. Oriental (Iraqi) bread watch the small blisters on the surface of bread. These pieces of bread were prepared from a new wheat multi-line cultivar (seven spikes). The original seeds of this cultivar came from mixing six selected spikes of *T. aestivum* with one spike of *T. durum* to guarantee a good bread wheat cultivar.

Temperature of the oven plays an important role, since through the gradual increase of oven and bread temperature, it is possible to observe a change in the appearance of the bread. Ortolan and Steel (2017) stated

that heat promotes several changes in wheat proteins, and that proteins denature, and starches gelatinize. These changes give the bread some of its properties in appearance, softness and taste. Wang et al (2015) reported that gliadins and glutenins will be denatured by heat through baking time, leading to cross-linking between glutenin polymers. At this moment, the dough will be no longer elastic, and that the shape and size of the bread will be determined. A few times later is needed for fully baked bread. Loaf will have the final volume, and attractive color, and oriental bread will have enough attractive blisters on the surface, with a dark brown color of the bread. These blisters will be a good appearance when protein content and quality are available in wheat flour, besides the heat of the material of the chimney is high enough, and not in the space of the chimney only.

Additives to enhance nutritional quality of bread

One of the most used additives to enhance quality to wheat bread is vital wheat gluten. This gluten is called "protein concentrate" but it contains in average about 78% proteins with other components such as minerals, moisture, and starch (Day et al 2006). This additive improves the quality of poor wheat flour and makes it better for loaf making. In general, 5% of this gluten is enough to make bread, but this percent could be increased to more than mentioned depending on wheat flour quality used. If we want to have a good bread quality without adding chemicals, Shah et al (2006) recommended the use of the enzyme xylanase. If we look at the markets of breads, most people prefer the white loaf and white oriental bread for their attractiveness, while the brown colour loaf and oriental breads are more nutritional. However, there are several other enzymes being used in bread making, but probably, the xylanase is of wider use.

Several researchers have tested many plant origin materials mixed with wheat flour to improve nutritional quality of bread. Whereas the appearance or outlook of that bread will be less than that made of wheat flour alone. Boz and Karaoglu (2013) tested the nutritional quality of wheat bread when they added vital gluten and malt flour. Percentages used were between 2%-2.5% of each added additive. They found that volume of bread was better, and also the texture. With another combination, they used 2.5% vital gluten, 2% malt flour and 0.5% defatted *Cephalaria syriaca* flour, and reported that they obtained the highest specific loaf volume.

On the other hand, other researchers thought of the importance of antioxidants in our daily food. This idea depends on the basis that food with high content of antioxidants will be very helpful to reduce damage on human body cells due to free radicals. Dziki et al (2014) suggested the use of wheat bread with added some other cereals for about 50% of daily energy are from bread in several developing communities. Elsahookie et al (2009) showed the role of water deficit on productivity and/or quality of crops. Kadom and Elsahookie (2009) reported the importance of variations to increase productivity of bread wheat. Elsahookie et al (2013 a,b and c) studied performance and tolerance of oats (*Avena sativa*) under water salinity and water stress. Soil practices can mitigate a remarkable level of crop tolerance to abiotic stresses (Esahookie an Al-Khafajy, 2014).

Quality of wheat flour is also affected by many growth variables such as, frequent irrigation and high nitrogen fertilization. According to nitrogen fertilization, Xue et al (2019) studied the splitting of nitrogen added to grown wheat. They added nitrogen to the wheat by splitting the recommended dose into three doses, a month between each application. They found that split nitrogen resulted in changes of proteins, such as globulin, and gliadins as well as amylase/ trypsin inhibitors. This treatment also has increased percent of proteins in grains of one wheat cultivar, but the grain yields of cultivars studied were not affected. They believed that the bread quality was improved, since the flour water absorption and loaf volume were increased.

There are too many additives being in use in wheat bread making. Dziki et al (2014) showed a long list of several plant origin materials added to wheat flour. Some of those materials are rye, and barley (30%), defatted rice up to 15%, barley flour and barley protein up to 15%, oat, rye, and buckwheat, mixture up to 25%, buckwheat flour up to 50%, buckwheat and oat mixture up to 25%, buckwheat, amaranth, and quinoa up to 30%, and finally, red and white sorghum grain flour up to 50%. There are too many plant origin mixtures are in experimentation and/or use. Soybean meal and maize is also added to wheat flour in low percent, since most cases of mixing non-wheat flour with wheat flour to marketing quality is less, but better nutritional value. This is still not encouraging in eating as compared to bread of high-quality wheat flours.

Spices, sesame, sunflower kernels, quinoa, amaranth seeds and some other seeds are spreaded on the surface of bread. This method gives better nutrition of bread and keeps the taste and plasticity of bread to the consumer. Again, Dziki et al (2014) showed a list of several spices and green plants added to bread. These include garlic powder, turmeric powder, ginger powder, onion powder, coriander leaf powder, ground green leaf tea, oregano, tomato paste, and green coffee. These components are usually used in low percentages ranging from 0.5% to 5% in general without affecting the marketing quality of breads. Same authors also reported some other additives such as chestnut flour, flaxseed flour, grape seed extract, cherry fruit powder, molasses, apple pectin, banana and yam flours. The percentage of mixing are significantly different from each other according to activity of plant material added.

Wheat species used for bread

Wheat bread is one of the important foods that supply energy and several elements and vitamins to human body. So, if this source of energy supply is good, the human body will get at least the minimum requirements of necessary energy, minerals, and vitamins. Wheat breads in general supply about 50% of calories or over than that in most developing countries. Gani et al (2012) reported that whole grain wheat flour bread is a rich source of fiber and bioactive compounds, such as oligosaccharides, fatty acids, sulfur amino acids, minerals, B vitamins, phytosterols, and antioxidants. These ingredients have been found in the flour, but under processes lead to bread, some parts of these ingredients could be lost. Mastromatteo et al (2012) stated that *Triticum durum* Desf., has been used to make several kinds of breads, and they are largely appreciated for their organoleptic attributes in the area of the Mediterranean. However, for my own feeling, the bread of durum wheat has attractive appearance, white to yellow color, but it is somewhat hard to chew, and hard in digestion. In this case, I really recommend mixing some 10-20% of durum wheat flower with flour bread wheat. This additive will enhance baking quality of bread wheat flour and makes it more attractive to eat. On the other hand, some researchers have interest in natural and organic food

products (Serpen et al 2008). Einkorn (*T. monococcum*), emmer (*T. dicoccum*) and spelt (*T. spelta*) wheats are the most common ancient wheat species. Today, einkorn production is limited to small, isolated regions within France, India, Italy, Turkey, and the Balkan countries (Troccoli and Codianni 2005). Emmer remains as an important crop in Ethiopia, and a minor crop in India and Italy (Serpen et al 2008). Spelt is now being rediscovered in Europe and North America (Gawlik-Dziki et al 2012). Serpen et al (2008) studied some characteristics of these old wheat species. They showed that they are higher in flavonoid and total antioxidants, so, this could lead to use these wheat species as novel grain rich in antioxidants, leutin and other carotenoids. According to these results and others formerly mentioned in this article, enrichment of common bread wheat flour with flour of these species could produce bread of higher nutritional values.

Wheat gluten genetics:

There are several species of wheat, but the most important one in use for bread making is *Triticum aestivum*. Meanwhile, thousands of cultivars belong to this species are grown around the world. This species of wheat has three genomes, A, B, and D. Only two of these genomes (A and B) are present in the tetraploid durum wheat (*T. durum*) and emmer wheat (*T. turgidum*), while einkorn (*T. monococcum*) is diploid with the A genome only (Shewry et al 2003). According to the gluten genetics, Payne (1987) reported that most loci are the Glu-1 loci which are located on the long arms of the group 1 chromosomes. Each of these loci comprises two genes which encode two types of high molecular weight subunits of glutenin (X-type and Y-type). Then, because not all of the Glu-1 genes are expressed in all genotypes, the number of high molecular weight subunit proteins in cultivars of bread wheat varies from 3 to 5. However, there are alleles encode for gluten proteins, as well as homeoalleles, the later are alleles on different genomes. In brief, the genetics of bread gluten proteins are so complex, and some analyses showed that low molecular weight protein subunits have variation as reviewed by Juhasz et al (2018). The complexity of genes encoding for gluten proteins and / or other proteins makes the analysis of this polymorphism so difficult to understand according to equipments available today. Huo et al (2018 a) assembled sequences of the α-gliadin loci on the three genomes of bread wheat, showing a total of 47 genes of which 26 encoded intact full-length protein products. Meanwhile, in another study, Qi et al (2009) reported the sequences of 29 putatively function ɑ-gliadin genes in one bread genome analyses (Clavijo et al 2017 and Huo et al 2018 b).

CONCLUSION

Whole grain wheat flour is the best source to make breads. This compound contains antioxidants, proteins, carbohydrates, vitamins, minerals, and a good quality fiber act as prebiotic in human guts. Glutenins and gliadins are major factors in bread quality beside their content in the flour. However, poor quality wheat flour can be enriched with many other plant origin materials. The easy one is mixing wheat flour with an optimum percent of durum flour. Some other additives such as, flours of oats, rye, barley, and sorghum could be used to improve nutrient value but not bread baking quality. Vital gluten is being used in about 5% - 10% of total wheat flour to improve baking quality. Some other additives spreaded on the surface of breads are also being used. These additives include seeds of sesame, quinoa, amaranth, flaxseed, and other seeds favoured in that society. The genetics of glutenins and gliadins are of complex traits. Polymorphism, multi-gene loci, epigenetics and epigenomics could be involved. More research on wheat bread quality is still needed. Split-N application at anthesis could improve quality of baking.

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