Tempering Conditions on White Sorghum

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Sorghum can be a good gluten-free replacement for those suffering from celiac disease, a disorder that induces gluten intolerance. Currently, the only cure for this autoimmune digestive disease is to consume a gluten-free diet throughout their life. Hence, the increasing demand for gluten-free bread from the groups of celiac disease and the challenges involved in making gluten-free bread, have led to increased research on gluten-free bread production. Much of the research on gluten-free bread production has focused on ingredients and product formulation, with less on the role of milling and flour properties. Flour particle size has been reported to play a significant role on gluten-free bread quality, which is dependent to a great extent on the milling technique performed. The other factors that affect the quality of bread are ash content of flour, which also depends on bran separation during milling, and water absorption capacity of flour during dough formation, which is affected by the damaged starch content in flour. These flour characteristics are affected by milling to a great extent due to the involvement of size reduction and separation of bran and germ from endosperm to procure flour.

Keywords: white sorghum ; tempering ; roller milling ; kernel properties ; flour properties ; bread properties

1. Overview

The effects of room temperature water, hot water, and steam tempering methods were investigated on sorghum kernel physical properties, milling, flour, and bread-making properties. Overall tempering condition and tempering moisture content were found to have a significant effect on the physical properties. Milling properties were evaluated using a laboratory-scale roller milling flowsheet consisting of four break rolls and eight reduction rolls. Room temperature tempering (18% moisture for 24 h) led to better separation of bran and endosperm without negatively impacting flour quality characteristics i.e., particle size distribution, flour yield, protein, ash, damaged starch, and moisture content. Bread produced from the flour obtained from milling sorghum kernels tempered with room temperature water (18% m.c for 24 h) and hot water (16% m.c at 60 °C for 18 h) displayed better bread-making properties i.e., high firmness, resilience, volume index, higher number of cells, and thinner cell walls when compared to other tempering conditions. Room temperature water tempering treatment (18% m.c for 24 h) could be a better pretreatment process for milling white sorghum kernels without negatively impacting the flour and bread-making quality characteristics.

2. Sorghum

Although sorghum has advantages from some nutrition aspects and a crop production standpoint, the commercialization of sorghum-baked products is limited due to the lack of standard milling processes. The technology of milling sorghum is not as developed as that of wheat, rice or maize [1][2]. Traditional methods of hand pounding and dehulling followed by hammer milling are still widely used for producing sorghum flour [3]. These methods result in coarser flour with low ash and oil content [4]. Moreover, abrasive decortication-hammer milling results in higher endosperm loss during bran removal [1]. The structural similarity of sorghum kernels with that of corn has enabled wet milling of sorghum using similar procedures to that of corn [5]. However, the smaller kernel size of sorghum when compared to corn does not support wet milling and has resulted in low extraction rate and loss of starch. In addition, the fragile and friable pericarp of sorghum may cause it to easily break during wet milling and produces undesirable specks of bran in the final product [6].

The similarity in kernel size of sorghum with that of wheat has led to the study of roller milling on sorghum [1]. Kebakile et al. [1] utilized two pairs of roller mills to mill sorghum using the first pair of rolls to break the sorghum kernels to smaller fragments with the bran intact and the second pair of rolls to grind the fragments to flour by separating it from bran particles. This research also compared the performance of roller milling sorghum with abrasive decortication-hammer milling where the former resulted in a higher production rate of fine-grained flour with greater oil, ash, and protein content than the latter. However, roller milled sorghum flour exhibited greater bran contamination when compared to sorghum flour produced by abrasive decortication-hammer milling.

In order to overcome bran contamination, the effect of tempering on sorghum kernels has been studied. Tempering, conditioning with water, is known to toughen the bran and soften the endosperm of grains to facilitate easy scratching of endosperm [7]. Additionally, tempering facilitates proper separation of bran and endosperm during milling. Tempering of sorghum positively influenced flour extraction rate and particle size distribution of flour during abrasive decortication-hammer milling [5]. The effect of different tempering conditions (room temperature water, hot water, and steam tempering) on physical and mechanical properties of red sorghum kernels and its milling quality were reported by Zhao and Ambrose [8][9]. In their study, the steam tempering was found to be efficient in strengthening the pericarp and softening of endosperm compared to the hot and room temperature water-tempering methods. Also, a study conducted by Chen et al. [10] to understand the effects of steam tempering on wheat quality found that the steam accelerated the migration of water through the kernel, resulting in a decreased tempering time period with improved rheological properties of the resultant wheat flour.

Sorghum can be a good gluten-free replacement for those suffering from celiac disease, a disorder that induces gluten intolerance. Currently, the only cure for this autoimmune digestive disease is to consume a gluten-free diet throughout their life [11]. Hence, the increasing demand for gluten-free bread from the groups of celiac disease and the challenges involved in making gluten-free bread, have led to increased research on gluten-free bread production [12][13][14]. Much of the research on gluten-free bread production has focused on ingredients and product formulation, with less on the role of milling and flour properties. Flour particle size has been reported to play a significant role on gluten-free bread quality [15], which is dependent to a great extent on the milling technique performed. The other factors that affect the quality of bread are ash content of flour, which also depends on bran separation during milling, and water absorption capacity of flour during dough formation, which is affected by the damaged starch content in flour. These flour characteristics are affected by milling [16][17] to a great extent due to the involvement of size reduction and separation of bran and germ from endosperm to procure flour. Previous research has indicated that roller milling was more efficient in extracting sorghum flour and good baking properties [1][18].

3. Conclusions

The developed flowsheet using laboratory-scale roller milling produced an average of 60.24% flour from the white sorghum used to evaluate the tempering treatments. Steam tempering for 15 s produced white sorghum flour with greater total starch, least bran contamination, brightest color, and low ash content. However, this tempering method produced the lowest flour yield, protein content, and high damaged starch. Tempering white sorghum with room temperature water for 24 h to a final moisture content of 18% (w.b.) produced better flour yield without compromising the protein content of flour and with the lowest ash content and damaged starch. More than 98% of the total milled sorghum flour produced from all tempering methods was less than 212 µm and as such could be claimed to be flour under the current CFR. Tempering white sorghum with room temperature water for 24 h could be a suitable tempering method to obtain good flour yield and flour characteristics. However, the scaling up, cost estimation, and energy consumption assessment of the developed technique need to be evaluated.

Tempering was also found to influence flour characteristics and, subsequently, sorghum bread characteristics. For example, sorghum bread made from flour using steam-tempered grains produced bread with higher brightness, which was attributed the lowest bran and ash content. Both room temperature-tempered grain (18% moisture) and grain tempered with hot water for 18 h (16% moisture) produced bread with a greater number of crumb cells and high firmness and resilience. As tempering conditions influenced flour properties such as starch damage, color, etc., tempering may be one avenue to impact sorghum food product quality, especially when considering interactions with ingredients such as hydrocolloids. Manipulating starch damage to alter water absorption and batter viscosity for example, may help reduce the use of expensive ingredients such as hydrocolloids or other additives in gluten-free breads. Further research on the interactions between tempering, milling, and flour functionality would benefit the gluten-free flour-baking industry.

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