

(An ISO 3297: 2007 Certified Organization)

Website: <u>www.ijirset.com</u> Vol. 6, Issue 7, July 2017

Effect of Gluten in Addition on Dough Mixing Characteristics of Wheat Varieties

Priya Dangi¹, B. S. Khatkar²

Research Scholar, Department of Food Technology, GJUS&T, Hisar, Haryana, India¹ Professor, Department of Food Technology, GJUS&T, Hisar, Haryana, India²

ABSTRACT: The consequences of addition of 1 % (w/w) glutenin of selected commercial wheat varieties, differing in their quantitative and qualitative gluten profile, to the base flour were investigated. The study was accomplished by employing an advanced 4 g bowl of MicrodoughLab (MDL). The elementary torque-time functions such as peak resistance, dough development time, dough stability, softening and energy at peak were observed with remarkable differences. Peak resistance, dough development time, stability and energy at peak were considerably increased with the addition of glutenin of different varieties. In addition, toughening of dough was observed by the addition of glutenin of all the varieties. The strongest effects on dough rheology were noticed from glutenins of HI 977, followed by DBW 16 and lastly HW 2004 in comparison to control.

KEYWORDS: Glutenin, MicrodoughLab, Rheological properties.

I. INTRODUCTION

Wheat is exclusively largely cultivated plants in consideration of its agronomic adaptability, ease of storage, nutritional superiority and its unique capability to reconstruct into multiple range of products. In India, wheat is predominantly consumed in the form of chapattis (unleavened flat bread) using whole wheat flour or in the form of bakery products such as pan breads, cakes, biscuits, cookies and crackers prepared from refined flour (Khatkar *et al.*, 2016).

The wheat kernel proteins can be categorized broadly into structural/ metabolic (non-gluten; about 15 to 20 % of total wheat protein) and storage proteins (gluten; about 80 to 85 % of total wheat protein). The former group comprises of albumins and globulins, which are water soluble and salt soluble, respectively. On the contrary, the gluten proteins are generally accredited as 'prolamins' by virtue of high levels of proline and glutamine. This group of proteins includes gliadins and glutenins(Veraverbeke & Delcour, 2002). Wheat proteins portray an imperativerole in regulating the dough rheological properties. Any change in the protein content or chemical structure of wheat protein considerably transforms rheological and bread making characteristics of the wheat flour dough (Finney *et al.*, 1971; Orth & Bushuk, 1972).

Glutenins, being the polymeric proteins, form the largest and most networked protein polymers in nature with molecular weights of more than 10 million, thus making wheat glutenins outstanding proteins in the plant kingdom. Glutenins are composed of Low Molecular Weight glutenin subunits (LMW-GS) and High Molecular Weight glutenin subunits (HMW-GS), occupying approximately 40 % and 10 %, respectively of the gluten proteins (Schofield, 1994). Based on the SDS-PAGE mobility, the molecular mass of HMW-GS and LMW-GS were identified as 70-90 kDa and 30-45 kDa respectively (Wieser, 2007). HMW-GS and LMW-GS exists largely in the polymerized, aggregated form being linked through hydrogen bonds, hydrophobic and ionic interactions, and disulphide linkages (Fu & Sapirstein, 1996). This networked structure possessed a more extended conformation which impart elasticity (or strength) to the dough.Thus, any kind of deviation in the glutenin quality is possibly resulted from variations in its (1) structure, (2) size distribution, and (3) subunit configuration (Veraverbeke & Delcour, 2002).

Wheat storage prolamins tend to form a network, mainly due to association of gliadins and glutenins through noncovalent bonds during hydration of flour. The end-use quality characteristics of a wheat variety is derived from an adequate balance of viscosity and elasticity/ strength. Glutenin polymers, being large in size, provides continuity and



(An ISO 3297: 2007 Certified Organization)

Website: <u>www.ijirset.com</u>

Vol. 6, Issue 7, July 2017

elasticity to the dough system (Ewart, 1972), particularly, by non-covalent interactions, mainly hydrogen bonds, between and within individual glutenin chains. Despite of this, gliadins act as plasticizers thereby hindering interactions between glutenin chains, which raises dough viscosity(Chaudhary *et al.*, 2016b). Hence, it can bepostulated that the ratio of monomeric gliadin to polymeric glutenin regulates the equilibrium between dough viscosity and elasticity, which in turn, affects gluten protein quality. Glutenins are the conclusive factor in governing the texture and rheology of dough. The rheological properties of the dough were considerably affected by gliadin/glutenin ratio and size of glutenin polymers (Cornec *et al.*, 1994).

The relevance of glutenins in deciding the functionality of wheat flour is a matter of concern over the years. Thus there is a need to perform experimentation with gluteninsin context to their role in dough rheology. This research work was laid down to investigate the differential effects of addition of gluteninof varieties differing in their baking characteristics, to the base flour.

II. MATERIALS AND METHODS

A. Wheat grains

The commercial wheat varieties viz. DBW16, HI977 and HW2004 were selected for the research work. The varieties were collected from different research institutes and stations. The grains of each variety were tempered at 15.5 g/100 g moisture content for overnight and later passed to Chopin laboratory mill (Model CD1, Villeneuve la Garenne, France) for milling. The individual flourswere packed in air-tight containers and stored at -18 °C for further analysis.

B. Isolation of wheat gluten

Wheat flours were defatted by successive extraction with chloroform (MacRitchie, 1987). Chloroform (200 ml) was added to flour (100 g), and the solution was allowed to filter through filter paper at room temperature. The whole process was repeated thrice and the defatted flour obtained was dried at room temperature. Gluten was isolated from defatted flour using Glutomatic instrument as per standardAACC (2000) method. The gluten balls collected were freeze dried. Freeze-dried gluten samples were finely powdered in a pestle mortar and stored in air-tight pouches at -18 $^{\circ}$ C.

C. Extraction of gliadin and glutenin fractions

Powdered gluten (50 g) was dissolved in 70 % ethanol (200 ml) and the mixture was stirred on a magnetic stirrer for 3 h at 25°C. The mixture was centrifuged for 30 min at 1000 xg at 4°C and the process was repeated thrice. The pellet contained the glutenins which was freeze dried and powdered in pestle and mortar.

D. Dough rheological analysis

Glutenin of three selected varieties were added to the base flour (HW 2004) on 1 % (w/w) flour basis in orderto demonstrate their effects on dough mixing properties. A 4 g Microdoughlab (Perten Instruments, Huddinge, Sweden) was used for the experimentation. The dough was mixed for a total run time of 15 minutes. Various mixing parameters i.e. peak resistance (mNm), dough development time (min), dough stability (min), dough softening (mNm) and peak energy (Wh/kg) were determined.

E. Data Analysis

Statistical analysis was carried out using SPSS software version 16.0 (SPSS Inc.). The mean comparison was carried out using one way ANOVA with Duncan's multiple range test and the statistical significance was observed at p<0.05.

III. RESULTS AND DISCUSSION

The dough mixing properties of base flour and fortified flours with glutenins (1 % w/w flour basis) are illustrated in Table I. On the basis of the physicochemical characteristics and gluten quality, HW 2004 variety was considered as the weakest variety among the selected varieties. In light of this, variety HW 2004 was chosen as the base flour, to which were added glutenins of DBW 16, HW 2004 and HI 977. Base flour, when run on Microdoughlab, took least period of time (2.85 min), torque (100 mNm) and energy (4.10 Wh/kg) to develop dough to optimum consistency. The developed dough remains stable for 2.90 min with maximum softening values (19 mNm) indicating that the dough formed was most pliable.



(An ISO 3297: 2007 Certified Organization)

Website: <u>www.ijirset.com</u>

Vol. 6, Issue 7, July 2017

Table I: Dough rheological properties as affected by addition of glutenins to the base flour

| MDL parameters | Control | HW 2004 | DBW 16 | HI 977 |
|----------------|------------------|-------------------|-------------------|-------------------|
| | | Glutenin | Glutenin | Glutenin |
| PR (mNm) | 100 ^a | 105 ^b | 116 ^d | 109 ^c |
| DDT (min) | 2.85^{a} | 3.02^{b} | 3.22 ^c | 3.30 ^d |
| DS (min) | 2.90^{a} | 3.30 ^b | 3.40 ^c | 3.50^{d} |
| SO (mNm) | 19 ^c | 18^{b} | 18 ^b | 16^{a} |
| EP (Wh/kg) | 4.10^{a} | 4.30° | 4.20^{b} | 4.90^{d} |

PR- Peak resistance; DDT- Dough development time; DS- Dough stability; SO- Softening at 5 min and EP- Energy at peak. Values followed by different letters are significantly different at p<0.05

The rheological properties of the base flour dough got altered on addition of 1 % (w/w) glutenins of different varieties. In all the three cases, addition of glutenins increased the dough strength considerably. The dough developed by incorporating parent flour glutenin increases the PR (105 mNm), DDT (3.02 min), DS (3.30 min) and EP (4.30 min). The toughening of the dough increases as indicated by a decrease in softening values (18 mNm). DBW 16 glutenin also tends to increase the torque (116 mNm) applied by kneading bladesto reach an optimum consistency, alongwith a marked increase in DDT (3.22 min) and DS (3.40 min). The flour's resistance to mixing was also noticed in this case. Subsequently, addition of glutenin from HI 977 brings about the most pronounced effect in context to PR, DDT, DS, SO and EP.The dough took longest time to develop (3.30 min) and remained stable for longer period (3.50 min). The energy supplemented to the dough was also maximum (4.90 Wh/kg), with registering amaximum toughening of 16 mNm.

A possible explanation for observing such effects is that addition of glutenins assimilated larger polypeptides in a dough system. These polypeptides have numerous active sites for inter-molecular disulphide linkages which resulted in the development of extensive strong and firm gluten matrix. This implicates a rise in mixing requirements, stability and toughening of the dough on addition of glutenins(Barak et al., 2013; Chaudhary et al., 2016a, 2016d). However, the extent of the effects produced by glutenins is not same in all the cases and the trend was as follows: control <HW 2004 glutenin<DBW 16 glutenin<HI 977 glutenin. In other words, the addition of HI 977 glutenin showed the strongest effects on dough rheology. The consequential incongruity recognized among the dough rheological profiles can be attributed to the discrete mixing requirements of individual polypeptides owing to the disparities in their HMW-GS composition. HW 2004 expresses Null, 20 and 2+12 HMW-GS at Glu-A1, Glu-B1 and Glu-D1, respectively. HI 977 expressed subunits 2*, 17+18 and 5+10 at Glu-A1, Glu-B1 and Glu-D1, respectively(Chaudhary et al., 2016c; Chaudhary et al., 2017). However, DBW 16 has alike composition as HI 977, only differing at Glu-B1 loci, with the expression of 7+8 subunit. Khatkar (2006) concluded that HMW-GS 2*, 7+8, 17+18 and 5+10 are superior in terms of bread-making quality than Null, 20 and 2+12. Certainly, the significantly higher effects of former set of subunits on dough rheology was proclaimed due to their large molecular size and presence of extra cysteine residue which provides site for inter-molecular disulphide bonding(Wieser, 2007). Thus, the prime differences in HMW-GS composition of these varieties can be subjected to explain the diverse effects of glutenins on dough rheology.

IV. CONCLUSIONS

Marked differences were observed in rheological properties of dough on addition of 1 % glutenin of three varieties. Glutenins increases the strength of dough significantly in the order of control < HW 2004 glutenin < DBW 16 glutenin < HI 977 glutenin. The effects observed were in correlation to the HMW-GS composition of these varieties. With increase in the quantity of glutenins, stronger, tough and elastic dough was developed by the virtue of intensive disulphide linkages. It is evident from the results that the glutenins of strong varieties affected the mixing characteristics notably in comparison to glutenins of weak varieties.



(An ISO 3297: 2007 Certified Organization)

Website: <u>www.ijirset.com</u>

Vol. 6, Issue 7, July 2017

REFERENCES

- 1. AACC. (2000). Approved methods of the American Association of Cereal Chemists (Vol. 10th). St. Paul, MN, USA: American Association of Cereal Chemists.
- Barak, S., Mudgil, D., & Khatkar, B. S. (2013). Relationship of gliadin and glutenin proteins with dough rheology, flour pasting and bread making performance of wheat varieties. *LWT- Food Science and Technology* 51(1), 211-217.
- 3. Chaudhary, N., Dangi, P., & Khatkar, B. S. (2016a). Assessment of molecular weight distribution of wheat gluten proteins for chapatti quality. *Food Chemistry*, 199, 28-35.
- 4. Chaudhary, N., Dangi, P., & Khatkar, B. S. (2016b). Effect of gliadin addition on dough mixing properties of wheat varieties. *International Journal of Innovative Research in Science, Engineering and Technology* 5(6), 10942-10947.
- Chaudhary, N., Dangi, P., & Khatkar, B. S. (2016c). Evaluation of molecular weight distribution of unreduced wheat gluten proteins associated with noodle quality. *Journal of Food Science and Technology*, 53(6), 2695-2704.
- Chaudhary, N., Dangi, P., & Khatkar, B. S. (2016d). Relationship of molecular weight distribution profile of unreduced gluten protein extracts with quality characteristics of bread. *Food Chemistry*, 210, 325-331.
- 7. Chaudhary, N., Dangi, P., & Khatkar, B. S. (2017). Fractionation of unreduced gluten proteins on SEC and their relationship with cookie quality characteristics. *Journal of Food Science and Technology*, 1-7.
- 8. Cornec, M., Popineau, Y., & Lefebvre, J. (1994). Characterisation of gluten subfraction by SE-HPLC and dynamic rheological analysis in shear. *Journal of Cereal Science*, *19*(2), 131-139.
- 9. Ewart, J. A. D. (1972). A modified hypothesis for the structure and rheology of glutelins. *Journal of Science Food and Agriculture*, 23, 687-699.
- 10. Finney, K. F., Tsen, C. C., & Shogren, M. D. (1971). Cysteine's effect on mixing time, water absorption, oxidation requirement, and loaf volume of Red River 68. *Cereal Chemistry*, 48(4), 450-455.
- 11. Fu, B. X., & Sapirstein, H. D. (1996). Procedure for isolating monomeric proteins and polymeric glutenin of wheat flour. *Cereal Chemistry*, 73(1), 143-152.
- 12. Khatkar, B. S. (2006). Effect of high Mr glutenin subunits on dynamic rheological properties and bread making qualities of wheat glutenin. *Journal of Food Science & Technology*, 43(4), 382-387.
- 13. Khatkar, B. S., Chaudhary, N., & Dangi, P. (2016). Production and Consumption of Grains: India. In C. Wrigley, H. Corke, K. Seetharaman & J. Faubion (Eds.), *Encyclopedia of Food Grains* (2nd ed., pp. 367-373): Oxford: Academic Press.
- 14. MacRitchie, F. (1987). Evaluation of contributions from wheat protein fractions to dough mixing and breadmaking. *Journal of Cereal Science*, 6, 259-268.
- 15. Orth, R. A., & Bushuk, W. (1972). A comparative study of the proteins of wheats of diverse baking qualities. Cereal Chemistry, 49, 268-275.
- 16. Schofield, J. D. (1994). Wheat proteins: structure and functionality in milling and breadmaking. In W. Bushuk & V. F. Rasper (Eds.), *Wheat: Production, Properties and Quality* (pp. 73-106). Boston, MA: Springer US
- 17. Veraverbeke, W. S., & Delcour, J. A. (2002). Wheat protein composition and properties of wheat glutenin in relation to breadmaking functionality. *Critical Reviews in Food Science & Nutrition*, 42(3), 179-208.
- 18. Wieser, H. (2007). Chemistry of gluten proteins. Food Microbiology, 24(2), 115-119.