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Short Communication

Frequent occurrence of high molecular weight glutenin subunit (HMWGS) combinations in high yielding popular Indian bread wheat and their impact on end-usages

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Abstract

Grain quality data of 546 high yielding bread wheat entries evaluated in different zones of India during the period 2005-16 was examined to identify the frequently occurring HMWGS combinations and the ones suited for the end-usages. Although 24 HMWGS combinations occurred in the studied material, only six had frequency of more than 5%, namely, 5+10, 2*, 17+18; 2+12, 2*, 17+18; 5+10, 2*, 7+9; 2+12, 2*, 7+9; 5+10, 1, 7+9 and 2+12, 2*, 7+8. Out of these, only two viz., 5+10, 2*, 17+18 and 2+12, 2*, 17+18 had distinction of making good quality bread as well as *chapati.* Another combination, 2+12, 2*, 7+9 suited well for bread making but it lacked in *chapatti* quality. Impact of HMWGS combinations could be seen on biscuit quality also as spread factor in 2+12, 2*, 7+8 was significantly higher than all other combinations. Gluten strength and gluten quality was best observed in 5+10, 2*, 17+18 combination. Besides gluten properties and end-products quality, differences were also observed in the inter-product relationship. In the combinations best suited for bread and *chapatti* i.e., 5+10/ 2+12, 2*, 17+18; quality of bread and *chapati* remained unrelated. The well-known inverse relationship between biscuit and bread/*chapati* could only be observed in 5+10, 2*, 17+18 combination. Negative association between biscuit and bread/*chapatti* was also observed in the best biscuit suited combination i.e. 2+12, 2* 7+8. Study underlined that spread of HMWGS is not uniform under Indian conditions and only few combinations are needed to facilitate value addition in the country.

Key words: Gluten properties, high molecular weight glutenin subunits, Indian wheats, value addition, wheat products

High molecular weight glutenin subunits (HMWGS) are crucial for end-use quality in bread wheat (*Triticum aestivum* L.) as they influence the gluten requirements to make good dough (Payne et al. 1981; Pena 2008). Information about different variants of these subunits and the related loci namely *Glu-A1, Glu-B1* and *Glu-D1* had also been generated in India and their relevance in bread quality of the Indian wheat's had been investigated (Ram 2003, Chowdhury et al. 2006; Sharma et al. 2012; Mohan and Gupta 2013, 2013[a] & 2015; Sarkar et al. 2015). Quality effect of HMWGS composition differs and it is generally stated that subunits 1, 2* (*Glu A1*); 7+8, 17+18 (*Glu B1*) and 5+10 (*Glu D1*) contribute positively to high dough strength (Payne et al. 1987; Pena 2008; Guo et al. 2010). Since wheat in India is grown under different production environments, it seems quite natural that composition of these subunits might not be the same in all conditions. As the process of developing new genotypes progress, certain HMWGS variants might be missed or added in the new high yielding genotypes. Chowdhury et al. (2006) had reported earlier that *Glu 1* score 10 was missing in the Indian wheats but several genotypes with perfect *Glu 1* score 10 are now available in the system (Mohan et al. 2017). Mohan and Gupta (2015) have mentioned that in the modern-day bread wheat varieties of India; genotypes with superior bread quality have matched in two subunits of the locus *Glu-D1* i.e. 5+10 and 2+12 which is at variance with some earlier findings (Payne et al. 1987; Pena 2008; Guo et al. 2010). Another study from India (Sharma et al. 2012) has highlighted 2*, 17+18 and 5+10 as the most suited subunit combinations for stronger gluten. Since reports on relevance of gluten loci are divergent, it is essential

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to redefine implications of these subunits in accordance with the kind of high yielding genotypes prevail in different Indian environments. Besides bread, the other two important products like *chapati* and biscuit should also be included in such studies. The present investigation examines gluten properties and the quality of bread, biscuit and *chapati* in most prevalent HMWGS compositions noted in high yield wheat genotypes of India with the focus to identify the most suited combination for value addition under Indian conditions.

All India Coordinated Research Project on Wheat and Barley had evaluated several pre-released and released bread wheat varieties in the form of final year test entries and checks in the irrigated Advance Varietal Trials (AVT's). Grain quality data pertaining to gluten properties and end-products quality was examined in this elite group of high yielders belonging to five mega zones of the country namely northern hills zone (NHZ), north-western plains zone (NWPZ), north-eastern plains zone (NEPZ), central zone (CZ) and peninsular zone (PZ). Since data on gluten properties was available only from the year 2005 onwards; this exercise was restricted only to the period 2005 to 2016 during which 546 entries were evaluated in the system. The study material expressed two variants of *Glu D1* (5+10 and 2+12), three of *Glu A1* (2, 1 and N) and four of the locus *Glu B1* (7+8, 7+9, 7 and 17+18). Based upon this distribution, there could be 24 different combinations but only six compositions were more frequent registering more than 5% share in the study materials. Overall gluten properties and the end-products quality observed in these six combinations are presented in the Table1.

could be seen only in one out of the six most prevalent combinations. In fact, 2* of *Glu A1* was most frequently observed subunit (65%) in the whole study material. In comparison, subunit 7 of *Glu B1* occupied place of the least prevalent HMWGS with frequency as low as 10.8%. Number of entries possessing 5+10 and 2+12 subunits was almost equal across the country (270: 276) but in the six most frequently occurring combinations; 2+12 outscored 5+10 in terms of number entries. As per the norms laid out by Payne et al. (1981 & 1987), bread quality in 5+10, 2* and 17+18 combination was highest amongst all six groups. In this combination, quality (gluten index) and strength of the gluten (sedimentation volume) was also significantly better than rest of the groups. Deviation from the norms was observed in two other combinations where 2+12 was clubbed with 17+18 and 7+9. Although 2+12 and 7+9 are not the preferred subunits for bread quality, loaf volume in these two combinations was at par with the best combination i.e. 5+10, 2*, 17+18. Even when sedimentation volume and gluten index in these two sub groups of 2+12 was significantly lower in comparison to the check 5+10, 2*, 17+18; higher grain protein content or wet gluten content might have contributed in elevated bread quality of 2+12 group. Additive and epistatic effects of allelic variation in bread making quality had been reported in the wheat breeding lines by Kolster (1991) and Sarkar et al. (2015).

Besides quality the bread; *chapati* score also improved when 17+18 clubbed with 2* in 5+10 and 2+12 compositions. It underlined that the gluten requirement to make dough suitable for good *chapati*

Table1. Quality characteristics in different HMWGS compositions

Glutenin subunits combination (*Glu D1,Glu A1,Glu B1*)	No. of entries	Bread loaf volume (cc)	*Chapati* quality score	Biscuit factor	Protein spread (%)	Wet gluten content (%)	Sedimentation content (ml)	Gluten volume (%)	*Glu 1* index	score
5+10, 2*, 17+18	55	**568**	**7.71**	7.19	11.8	29.4	**52**	**68**	10	
5+10, 2*, 7+9	39	560	7.55	6.78	11.9	30.2	44	**67**	9	
5+10, 1, 7+9	49	559	7.47	6.96	11.7	29.9	41	60	9	
2+12, 2*, 17+18	92	**564**	**7.71**	6.87	11.8	**31.2**	43	58	8	
2+12, 2*, 7+8	101	552	7.57	**7.47**	11.5	30.1	41	56	8	
2+12, 2*, 7+9	29	**568**	7.58	6.65	**12.6**	**33.8**	41	54	7	

Values in bold indicate the subunits at par with the best composition

Study revealed that subunit N (*Glu A1*) and 7 (*Glu B1*) were rarely observed in the Indian wheats. Occurrence of subunit 1 (*Glu A1*) was also less as it

making was met in the 2* and 17+18 glutenin subunits. Although gluten index and sedimentation volume in the 2+12, 2*, 17+18 combination was significantly less

when compared with the 5+10 counterpart, higher wet gluten content must have contributed in enhancing the bread loaf volume. Grain protein content in these two groups was similar (11.8%). Under such situation, protein-gluten ratio in 2+12 must have been higher than the 5+10 composition. Like an earlier study of Mohan and Gupta (2013[a]), this investigation also noted significantly higher protein-gluten ratio in 2+12 combinations (2.64) in comparison to 5+10 (2.49). Traditionally, gluten strength of subunit 7+8 is considered at par with 17+18 (Payne et al. 1981 & 1987). In the Indian wheats however, 7+8 was not frequently observed in combination with 5+10 but its presence along with 2* and 2+12 was not suited for good bread/ *chapati* making. Instead, this combination expressed clear edge over all other HMWGS compositions in biscuit spread factor.

An attempt was made to examine inter-product relationship in these most prevalent groups, especially the ones where difference emerged in gluten properties and end-products quality. Generally, bread and *chapati* qualities are positively correlated in the irrigated Indian wheats whereas biscuit and *chapati* qualities are inversely related (Mohan and Gupta 2008; Mohan et al. 2013). In this investigation, three HMWGS combination were noted good for bread making (5+10, 2*, 17+18; 2+12, 2*, 17+18 and 2+12, 2*, 7+9) but they did not express similar relationship with other products. Biscuit quality in the 5+10, 2*, 17+18 combination was inversely related with bread and *chapati*. In the other groups, there was no association between the three end-products.

Results underlined that when selection is exercised for bread in the bread superior compositions (5+10 with 2*, 17+18; 2+12 with 2*, 17+18/ 7+9), it may or may not have any bearing on *chapati* score but biscuit quality is drastically reduced in the 5+10, 2*, 17+18 combination. Likewise, any attempt to improve *chapati* score further in the *chapati* superior compositions (5+10 / 2+12 with 2* and 17+18) may or may not alter bread characteristics, but quality of the cookies will decline. Positive correlation between bread and *chapati* could be observed only in the group where average loaf volume and *chapati* score were poor i.e. 2+12, 2*, 7+8. This composition was best suited for biscuit quality but it showed inverse relationship with *chapati* or bread. Selection for cookies would definitely impair quality of bread and *chapati* in this group. Negativity between bread/*chapati* and biscuit was apparent only when 17+18 occurred with 5+10 and 7+8 with 2+12.

Table 2. Relationship with different products

HMWGS combination (*Glu D1, Glu A1, Glu B1*)	Pearson correlation coefficient		
	Bread and *chapati*	Bread and biscuit	*Chapati* and biscuit
5+10, 2*, 17+18	0.22	-0.52**	-0.49**
2+12, 2*, 17+18	-0.15	-0.21	-0.10
2+12, 2*, 7+8	0.41**	-0.53**	-0.56**
2+12, 2*, 7+9	0.18	-0.02	0.06

Improvement in wheat grain quality has become an important component of wheat research in India and HMWGS can play an important role in this endeavour. Although they are not the only governing factor in grain quality, they act as true marker because HMWGS composition of a genotype remains unaffected by the environmental variations. This study has indicated that relevance of HMWGS in the Indian wheats is not exactly similar to other parts of the world and all combinations of HMWGS are not equally spread in the country. Focus on the few most desirable combinations of HMWGS, as identified in this investigation, can strengthen efforts in enhancing quality of the Indian wheats.

Author's contribution

Conceptualization of research (DM, RKG); Designing of the experiment (DM, RKG); Contribution of experimental material (RKG); Execution of lab experiments and data collection (RKG); Analysis of data and interpretation (DM); Preparation of the manuscript (DM).

Declaration

The authors declare no conflict of interest.

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