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Interactions of Hydrocolloid and Emulsifier on Rebuilding Gluten Network of Damaged Wheat and Taftoon Bread Quality

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ABSTRACT: Many factors can affect wheat gluten properties and functionality. One of the most important, of these factors, is wheat bug damages. Insect injects a salivary proteinase into wheat kernel that results a significant weakening effect on the gluten, in substantial losses in physical quality, dough properties and baking performance. Bread baked with the insect – damaged flour had poor quality and low sensory scores. In this study enzyme inactivation, and rebuilding or replacing gluten network by chemical method were investigated. Effects of guar gum and ascorbic acid on improving chemical, rheological and baking properties, of bug damaged flour were investigated. Guar and ascorbic acid were added in 3 levels respectively: 0.5, 1, 1.5 percent and 100,150,200 ppm. Data were analyzed in factorial experiment design and the means were evaluated in the form of mathematical models with 3d surface charts. The results showed that the addition of guar and ascorbic acid could improve dough and bread quality. Additives improved water absorption, dough stability, extensibility, and resistance to extension. Bread baked from bug damaged flour treated by additives had better texture, specific volume, and appearance. The best treatment was the addition of 0.5 percent guar and 200 ppm ascorbic acid together.

Keywords: *Ascorbic Acid, Dough Properties, Guar Gum, Taftoon Bread, Wheat Bug*.

Introduction

The technological properties of wheat flour strongly depend on the structure and quality of gluten. Wheat gluten has unique viscoelastic properties due to its components (gliadins and glutenins). Various factors can affect gluten and its functional properties. One of the most important reasons is wheat damaged by bug (Every *et al*., 2005).

Bug damage to wheat caused by *Eurygaster spp*. and *Aelia spp*. results in substantial losses in the yield and quality of the product. This occurs in most countries of the Middle East, Eastern Europe, and North Africa (El Bouhssini *et al*., 2009). Insect attackes wheat grain and injects salivary proteolytic enzymes. Proteases specifically hydrolyze the high molecular weight glutenin subunits (Anon, 2011). The resulting flour is uniformly contaminated with proteases that are particularly active in dough, causing hydrolysis of gluten proteins to low molecular weight peptides, and produce slack, sticky dough and subsequently giving bread with low volume, unsatisfactory texture, poor sensory quality and an irregular shape (Olanca *et al*., 2009). Many treatments have been devised to counteract the effete of insect enzyme damaged wheat (Kinaci and Kinaci, 2007).

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Currently the most used way to minimize losses is to separate damaged from sound grain. The introduction of cross links and new s-s bonds are methods widely used to stabilize proteins, since loss of protein function is closely related with loss of thermodynamic stability (Saeed and Howell, 2004).

Thus formation of crosslinks between wheat proteins in insect damaged wheat flours could be a method for recovering the strengths of the gluten network and in consequence, by employed dehydroascorbic acid derived from ascorbic acid with oxidizing properties, oxidise thiol groups to disulphide bonds, strengthen the gluten network, and improves dough elasticity and baking quality (Rosell *et al*., 2002; Cauvain and Yang, 2005).

Hydrocolloids are important group of additives that are used in baking for their capability to control the rheology and the textures of aqueous suspensions. Guar gum is a galactomannan derived from the seed of a leguminous plant *Cyamopsis tetragonolobus* (Elke and Dal Bello, 2008). Its solutions are highly viscous at low concentrations and useful in thickening, stabilisation and water binding applications (Kohajdova *et al*., 2009). In bakery products guar is used to improve mixing and recipe tolerance to extend the shelf life of products through moisture retention and to prevent syneresis in frozen foods and pie fillings (Selomulyo and Zhou, 2007). In low gluten or free gluten guar is widely used to increase the specific volume and porosity of bread (Lazarido *et al*., 2007).

The aim of this work is to improve rheological and baking properties of Taftoon bread made from insect damaged flour with guar gum and ascorbic acid and whether damaged wheat might recover its functional properties and rebuilding or replacing gluten network by treatment with guar gum, and ascorbic acid.

Materials and Methods

- *Materials*

Insect damage and normal flour samples (cvs, Alvand) with 11.59% moisture, 13.5% proteins, 0.44% ash, 23.5% wet gluten and 59.6 gluten index for damaged flour and 12% moisture, 0.4% ash, 14% protein, 28.1% wet gluten and 79% gluten index for normal was obtained from silo No.3, Mashhad, Iran. Guar gum and ascorbic acid were purchased from Rodia and Merck Chemical Co. respectively. Bread recipes also contained active dry yeast (Razavi Co., Mashhad, Iran), vegetable oil was provided by Ladan Co. Behshahr, Iran), salt and sugar were obtained from local market.

- *Methods*

Wheat samples were milled with experimental mill (laupen 863, 5) after conditioning (Extraction rate was 15%).

- *Flour Analysis*

Moisture, ash, fat and wet gluten were determined according to AACC-approved methods (AACC 2000). Flour protein was determined using Kjeltec apparatus (model 1030, Tecator Co., Hoeganaes, Sweden).

- *Dough rheology*

The effect of guar, ascorbic acid and guar- ascorbic acid on dough rheology were determined using farinography (Duisburg, Germany) following AACC (2000) NO 54-21 method. The parameters tested for analysis were: water absorption, dough development time (DDT), stability, mixing tolerance index (MTI), and valorimeter value. Textural properties of dough were evaluated using a QTS texture analyzer (CNS Farnell, Hertfordshire, UK) according to Pourfarzad *et al*. (2009).

- *Preparation of bread with damaged flour*

Taftoon bread was baked using standard method as described by Maleki *el al*., (1981). All ingredients (100% flours, 1%

sugars, 1% salt, 1% fresh yeast and 1% vegetable oil), were mixed for 10 minutes. Guar gum and ascorbic acid were added to the flour, at 3 levels (0.5, 1 and 1.5% and 100, 150 and 200ppm respectively). Fermentation was carried out at 30^{o}C on baking sheets for 60 minutes and the baking was carried out in an electric oven with an incorporated proofing chamber (Zuccihelli, forni, Hal, Italy) at 190^{o}C for 30 minutes followed by steaming process for 10 seconds. After cooling, bread samples were packed in polyethylene bags and stored at room temperature (25 $^{°}$C). For specific volume evaluation, bread was prepared with the same formulation in brotchen shape.

- *Bread quality*
- *Specific volume*

Specific volume was determined by rapeseed displacement method, 1 hour after baking (Barceanas & Rosell, 2006).

- *Texture evaluation*

Textural properties of Taftoon bread made from normal and damaged wheat were measured by using the penetration test. A QTS texture analyzer (CNS farnell, Hertfordshire, UK) was used to measure the force required for penetration of a round bottom (2.5 cm diameter × 1.8 cm height) probe at a velocity of 30 mm/min and descended 30 mm (a sufficient distance to pass through the slice of 10×10 cm of bread) into the bread (height: 25 mm) at trigger value of 0.05 N (Pourfarzad *et al*., 2009). Three replicates from three different sets of baked bread were analyzed.

- *Sensory analysis*

Sensory evaluation of the bread was carried out by 10 trained panellists (Selection of faculty research center, by triangle test) using a hedonic scale of five points for overall acceptability (Gacula *et al*., 1984). Bread staling was evaluated following AACC method 64-301(2000).

- *Statistical analysis*

The data obtained were statistically treated by a complete randomized design (factorial) analysis while the means were compared by the Duncan's test at a significance level of 5%, in both cases using MSTATC statistical software (version 1.41).

Results and Discussion

- *Dough characteristics*
- *The effect of gum and oxidant on farinograph parameters*

The results of the effects of guar and ascorbic acid on farinograph properties of damaged flour are summarized in Table 1 and Figure 1. The values were significantly (P<0.05) different ranging from 56% to 69.3%. It can be observed that water absorption is increased by using guar and ascorbic acid alone or in combination, when compared to the control. These results matched those of Ribotta *et al*. (2005), Selomulyo and Zhou (2007) and Cauvian and Young (2005), who reported that ascorbic acid is able to increase the water absorption. Guar is the novel gum that can absorb water. The effect has been attributed to the hydrophilic properties of guar. Hydrophilic groups in guar structure and chain conformation, allow more water interaction. Through hydrogen bonding the addition of ascorbic acid also increases water absorption however in higher concentration the effect is not significant (P<0.05). Its effect is related to the formation of new s-s bonds between wheat proteins. The time required for dough development (DDT) or time necessary to reach 500BU of dough consistency is increased by all the additives, alone or in combination.

Stability value is an indication of flour strength. It was clearly observed that the addition of guar has increased the stability (Figure 2). This shows that guar could be a novel and a useful gluten substitute. By increasing the ascorbic acid concentration

Table 1. The effect of guar gum and ascorbic acid on farinograph characteristics of dough

Guar (%)	0				0.5				1.0				1.5				LSD
Ascorbic acid (ppm)	0	100	150	200	0	100	150	200	0	100	150	200	0	100	150	200	
Water absorption (%)	56	58	58.7	58.7	58.7	63	61.7	62.7	62.7	64.3	63.7	64.7	64.3	68.3	68.7	69.3	1.11
Stability (min)	3.6	3.9	3.8	4.4	3.9	4.1	4.3	4.9	5.2	5.6	5.8	5.9	5.8	5.9	6	6.1	0.17
Dough Mixing (min)	2.3	2.4	2.8	2.9	2.5	2.9	3	3.2	2.8	3.3	3.4	3.5	3	3.3	3.3	3.1	0.14
Tolerance (brabender)	116.7	98.3	86.7	76.7	103.3	91.7	81.7	76.7	113.3	96.7	85	76.7	95	90	80	75	7.96

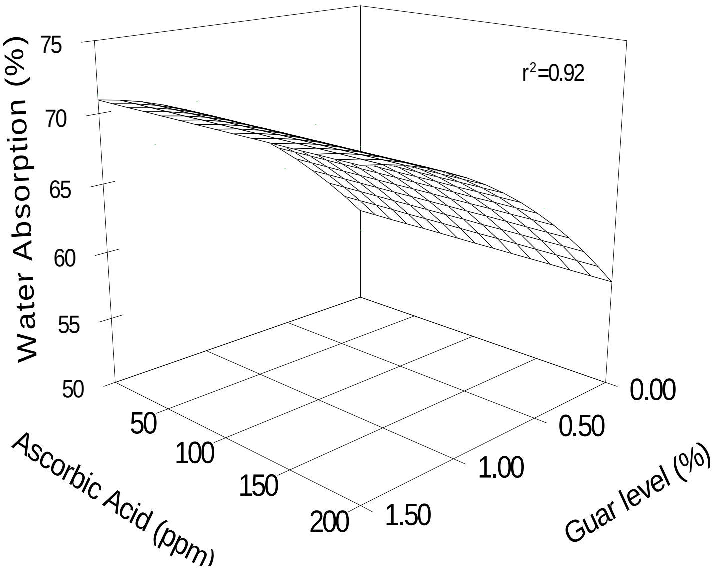

Fig. 1. The effect of guar gum and ascorbic acid on water absorption of bread dough.

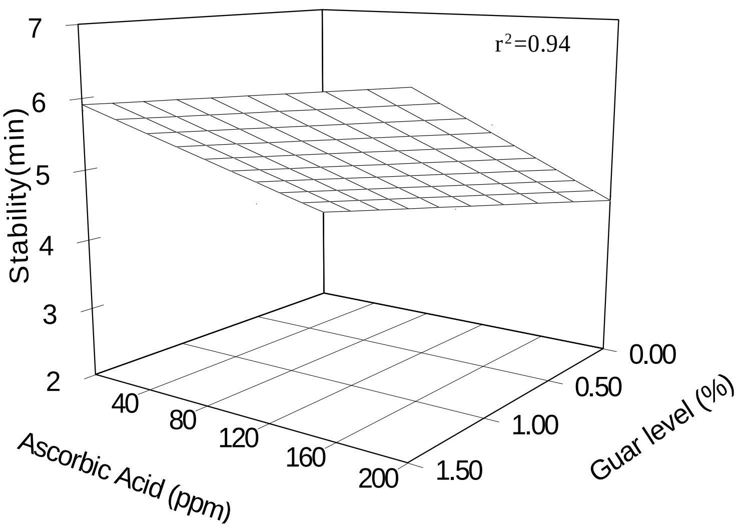

Fig. 2. The effect of guar gum and ascorbic acid on stability of bread dough.

the stability was increased, but the effect of guar and combination of guar and ascorbic acid on the stability were more significant (P<0.05). The result indicated the lowest stability (3.6 min) was obtained in control and highest (6.1 min) in the sample with 200 ppm ascorbic acid and 1% guar. However, in damaged flours, due to weakened gluten network, the resulting dough's has various problems (Hariri *et al*., 2000). Replacement of gluten network by guar and reinforce it by ascorbic acid is a good reason for increasing the stability. Mixing tolerance index (MTI) that is an indicator of dough strength was decreased by increasing the concentration of guar and ascorbic acid alone and in combination. This decrease indicated that dough became stronger as compared to the control sample. The lowest mixing tolerance index was observed when the combination of 1.5% guar and 200 ppm ascorbic acid were added to the damaged flour (Figure 3).

Mixing time in insect damaged flour, decreased. The result showed that guar and ascorbic acid addition, increased the mixing time (figure 4). The sample with 1% guar and 200ppm ascorbic acid had the highest (3.5 min) mixing time. The valorimeter value increased by different concentration of hydrocolloid. This effect was more pronounced when guar and ascorbic acid were used in combination.

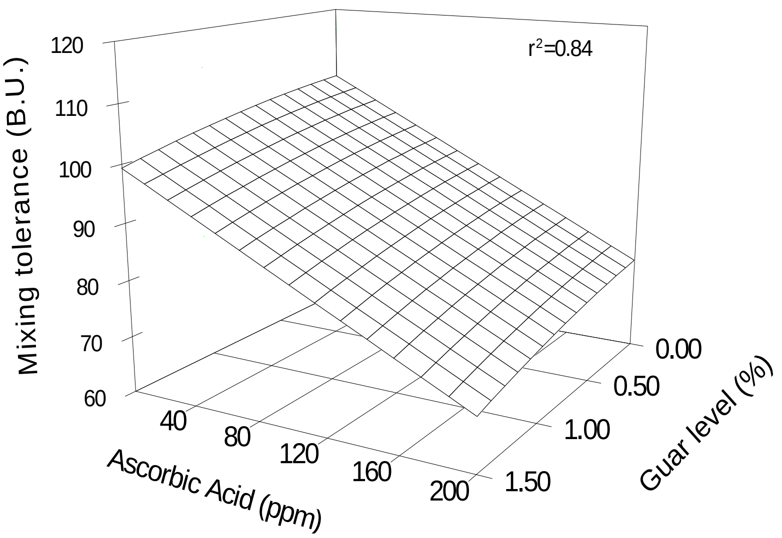

Fig. 3. The effect of guar gum and ascorbic acid on mixing tolerance index of bread dough.

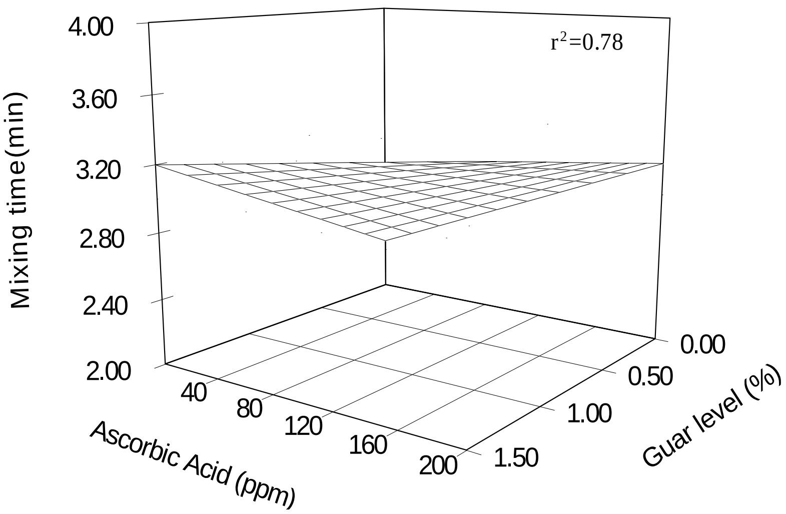

Fig. 4. The effect of guar gum and ascorbic acid on mixing time of bread dough.

- *The effect of gum and oxidant on dough firmness*

Hydrocolloids and oxidizing agent strengthen dough through different mechanism (Bollain and Collar, 2004). Dough firmness was increased by the addition of guar and ascorbic acid (Figure 5). Ascorbic acid increased the firmness and prevents the stickiness. Guar gum increased dough firmness and its good handling properties, but at high concentration had inverse effect and made the dough stickier and not proper for handling. The best treatment was at 0.5% guar and 200 ppm ascorbic acid concentrations.

- *Bread quality*
- *Crumb firmness*

The resistance of the bread crumb to deformation is the textural attribute referred to as firmness and it is an important factor in bakery products since it is strongly correlated with consumers' perception of bread freshness (Ahlborn *et al*., 2005). The effect of guar and ascorbic acid on crumb firmness is shown in Figure 6. Bread firmness is significantly (P<0.05) decreased by the addition of hydrocolloid and oxidant. It is related to hydrocolloid ability to the water binding and improves moisture and also interaction with starch that makes proper water distribution in the bread. Ascorbic acid addition didn't show significant (P<0.05) effect on the firmness, but in combination with guar, had synergistic effect on crumb firmness. Treatment with 0.5% guar and 200 ppm ascorbic acid showed the best result. High level of guar had negative effect on crumb firmness.

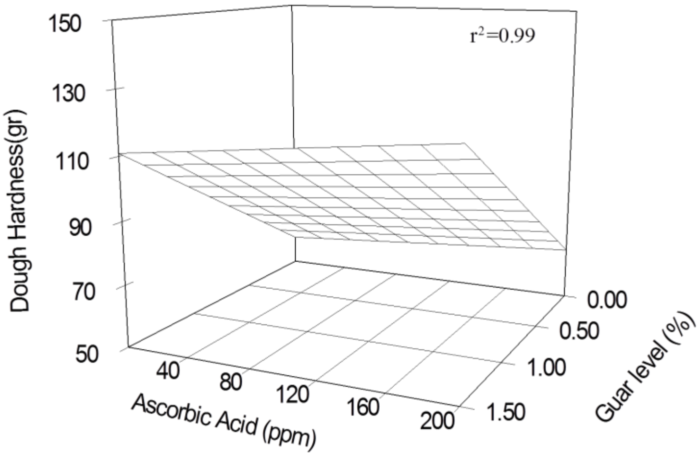

Fig. 5 The effect of guar gum and ascorbic acid on dough firmness of bread.

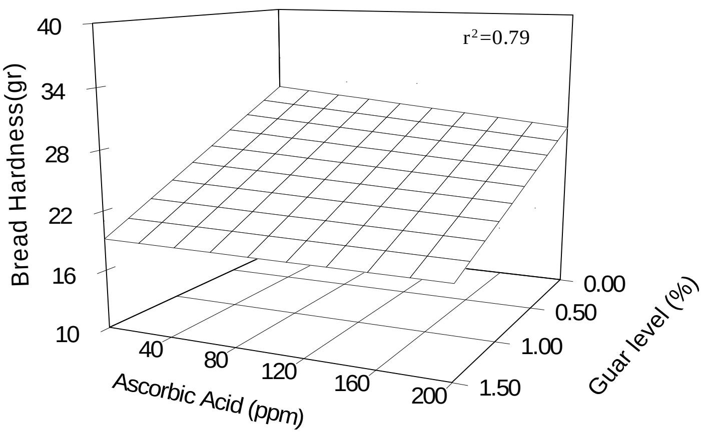

Fig. 6. The effect of guar gum and ascorbic acid on bread firmness.

- *Specific volume*

Specific volume is one of the most important quality properties of the bread that indicates dough inflating ability and oven spring. Bread volume is the most important factor that is affected by bug damage. As it is presented in Figure 7 the addition of guar increased the specific volume till 0.5% and in high concentration the volume decreased as Sahraiyan *et al*, (2013) indicated. A possible explanation for this result is that hydrocolloids can improve dough development and gas retention by increasing dough viscosity. Gum made the walls of air bubble stronger, and at high concentration dough viscosity became higher than normal and dough became sticky. Ascorbic acid showed similar results. Combination of ascorbic acid and guar gum at 0.5% and 200 ppm ascorbic acid showed the best result.

- *Sensory evaluation*

The values reported are the mean values of each descriptor contributing to color, texture, taste and overall acceptance ratings. The results of bread staling are summarized in Table 2. Sensory scores of bread made from bug damaged flour, were very low. The addition of guar and ascorbic acid alone and in combination improved and increased sensory scores.

- *Bread staling*

Table 2, has presented the effect of ascorbic acid and guar gum on bread staling after 24 h. Guar gum at 0.5 and 1% concentrations delay the staling for 24h after baking, but at 1.5% concentration, the staling score decreased. It was shown that hydrocolloids delay the staling in bread by interaction with starch, and also water holding capacity (Kohajdova *et al*., 2009).

Conclusion

The result of this study has shown that textural, farinography and sensory properties of dough and bread made with damaged flour are poor. The addition of guar gum to damaged flour increased water absorption, dough development time, dough stability, specific volume and sensory score of dough and bread. Guar gum at 1% and ascorbic acid at 200 ppm concentrations were more effective and it could be introduced as a substitute for damaged gluten. When guar gum is used in combination with ascorbic acid, the synergistic effect was observed and the best result was obtained at 0.5% guar and 200 ppm ascorbic acid concentrations.

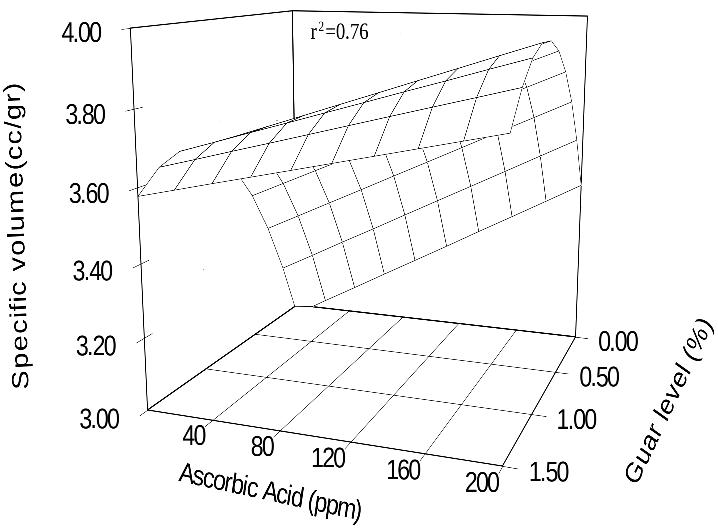

Fig. 7. The effect of guar gum and ascorbic acid on specific volume of bread.

Table 2. The effect of guar gum and ascorbic acid on sensory parameters of bread

Guar gum (%)	Ascorbic acid (ppm)	Texture (1-5)	Crumb color (1-5)	Overall appearance (1-5)	Staling (0h) (1-6)	Staling (24h) (1-6)
0	0	1.75^{c}	1.50^{d}	1.50^{f}	1.50^{e}	1.00^{d}
	100	2.75^{ab}	2.25^{cd}	2.50^{e}	2.75^{d}	1.50^{d}
	150	3.25^{ab}	2.75^{bc}	3.50^{ad}	3.25^{cd}	1.75^{cd}
	200	3.25^{ab}	3.25^{ab}	3.75^{ac}	4.50^{ab}	2.50^{bc}
0.5	0	3.50^{a}	3.25^{ab}	3.50^{ad}	3.50^{bd}	2.75^{ab}
	100	3.25^{ab}	3.50^{ab}	4.00^{ab}	4.25^{ac}	2.75^{ab}
	150	3.25^{ab}	3.50^{ab}	3.75^{ac}	4.75^{ab}	3.00^{ab}
	200	3.25^{ab}	4.00^{a}	4.25^{a}	4.75^{ab}	3.00^{ab}
1.0	0	2.75^{ab}	3.75^{a}	3.75^{ac}	4.25^{ac}	3.00^{ab}
	100	2.75^{ab}	3.25^{ab}	3.50^{ad}	4.25^{ac}	3.50^{a}
	150	2.50^{bc}	3.25^{ab}	2.75^{de}	4.25^{ac}	3.50^{a}
	200	2.75^{ab}	3.75^{a}	3.50^{ad}	3.75^{ad}	3.50^{a}
1.5	0	2.75^{ab}	2.75^{bc}	3.25^{be}	4.25^{ac}	3.50^{a}
	100	2.50^{bc}	3.50^{ab}	2.75^{de}	3.50^{ad}	3.25^{ab}
	150	2.75^{ab}	2.75^{bc}	2.75^{de}	3.50^{bd}	3.25^{ab}
	200	2.75^{ab}	3.25^{ab}	3.00^{ce}	3.00^{d}	3.25^{ab}

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