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Effects of sunn pest (*Eurygaster integriceps*) damage ratios on rheological characteristics of wheat flour

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RESEARCH ARTICLE

Abstract

The effects of sunn pest (*Eurygaster integriceps*) damage ratios (SPDR) on flour properties and dough characteristics of wheat were investigated in this study. The flours obtained from sound (control), medium damage (2% and 4%) and high damage (from 8 to 100%) samples of 2 bread wheat cultivars (Golia and Sagittario) were analysed for rheological characteristics. As the SPDR increased, farinograph water absorption, dough development time and stability, as well as extensograph resistance, energy, and ratio values of both cultivars decreased significantly ($P<0.05$) probably due to deteriorative effects of sunn pest (SP) damage on gluten quality. Farinograph tolerance index and softening degree values of the damaged samples were considerably higher, while extensograph dough extensibility value was partially higher compared to those of sound samples in both wheat cultivars, due to proteolytic degradation. The strength and breaking force of the dough samples decreased significantly with increasing SPDR indicating that they were susceptible to spreading and not suitable for handling, bread making and blending application. Deterioration in gluten quality supported the significant decreases in all farinogram and extensogram values of the dough samples with increasing SPDR. Decrease in quality characteristics started at 2% SPDR and flour-dough properties reduced very obviously after 4% SPDR in both wheat varieties. This study showed that although the features of 2 wheat varieties were different from each other, dough characteristics of varieties were negatively (resistance and energy values decrease) and similarly affected by SP damage. The extensograph test also demonstrated a clear distinction between damaged and undamaged wheat samples by SP, due to increasing SP protease activity in the dough during the progress of time in the extensograph test.

Keywords: sunn pest damage ratios, wheat quality, dough rheological characteristics, farinograph, extensograph

1. Introduction

Damage to wheat and its baking quality due to insects has been reported from Middle East, Central and West Asia, North Africa, and parts of Europe. It is particularly damaging when developing grain is infested, as salivary proteinases are injected into the grain which specifically digest (dissolve) wheat gluten proteins. This type of insect damage has led to important losses to millers, bakers, and country economies (Dizlek and Islamoglu, 2015; Hosseininaveh *et al.*, 2009; Konarev *et al.*, 2011; Kretovich, 1944; Lorenz and Meredith, 1988). This insect salivary (secretion) is not a problem for wheat flour. However, when flour becomes dough by kneading with water, together with suitable temperature and provided moisture, the enzymes (proteinases) become activated and degrade gluten proteins. Hence, the dough softens and its viscoelasticity decreases, resulting in poor hand and machine processing properties. Moreover, the gas absorption capacity of dough in the fermentation decreases, and swelling and the other quality characteristics of the bread are detained (Aja *et al.*, 2004; Diraman *et al.*, 2013; Dizlek and Islamoglu, 2015; Hariri *et al.*, 2000; Kinaci and Kinaci, 2004; Köksel *et al.*, 2002; Ozberk *et al.*, 2005).

Different researchers reported sunn pest damage ratios (SPDR) in the range between 0.3 to 10%, causing confusion on the determination of the ratio where the technological quality of wheat is destroyed (Dizlek and Özer, 2016). On this subject, it has been well documented that when the percentage of sunn pest (SP) damaged kernels increases in wheat bulk, the quality characteristics of wheat decrease (Dizlek and Özer, 2016; ICARDA, 1983; Karababa and Ozan, 1998; Ozderen *et al.*, 2008; Yuksel, 1969).

The structure and biochemical properties of SP proteinases hydrolysing gluten proteins, the differences of the protein complexes in various wheat bugs of *Eurygaster* genus, the character of variability of component composition of these enzymes and the effect of SPDR on fundamental quality characteristics of different wheat varieties have not yet been clarified (Konarev *et al.*, 2013). The aim of this study was to determine the effects of SPDR on bread wheat quality (parameters particularly related to important dough characteristics) in order to predict the maximum allowable amount of damaged kernels in the wheat varieties. For this purpose, artificially created SPDR groups from Golia and Sagittario wheat were investigated on rheological properties.

2. Materials and methods

Wheat groups

Two SP damaged bread wheat (*Triticum aestivum* L.) cultivars, Golia and Sagittario, purchased from Deveciogullari and Demir Trading Companies (Nurdagi, Gaziantep, Turkey), respectively, were used. In order to determine the ratio of SP damaged kernels, 10 sets of 100 kernels were randomly taken from each cultivar, the number of SP damaged kernels recorded and % damage ratio calculated as the average of 10 determinations (Atli *et al.*, 1988a). The Golia and Sagittario cultivars were found to have an SPDR of 3.92 and 7.8%, respectively. The experimental wheat groups were prepared as follows: SP damaged and sound kernels were manually separated for each cultivar (by 3 scientists, 2 of them from Agricultural Protection Research Institute [Adana, Turkey] specialised in identification of SP damaged kernels). Sound kernels were mixed with damaged kernels to create artificial groups with an SPDR of 0 (only sound kernels), 2, 4, 8, 12, 16, and 100% (no sound kernels). Each wheat group was mixed thoroughly to make them homogeneous. Great attention was given in choosing almost the same sized damaged kernels to form groups, whereas the weak and broken kernels were eliminated.

Also, a hundred SP were collected from the damaged wheat mass and their species were determined by a specialist from the Agricultural Protection Research Institute. 98% were identified as *Eurygaster integriceps* and 2% as *Eurygaster maura.*

Methods

Prepared wheat groups were tempered to 16.5% moisture content for 32 h and separately milled with a laboratory type mill ('Yucebas YM1' model tempered wheat grinding mill, including six rolls; Yucebas Machine, Izmir, Turkey). Obtained flour samples were sifted to keep the low ash content of flour. These flour samples were used for determination of rheological parameters (physical dough tests) in terms of baking quality of wheat.

In this study, the damaged groups (2, 4, 8, 12, 16 and 100%) were compared to an undamaged (0%) control. All analytical results were corrected to 14% moisture basis. For this purpose, moisture content of both wheat flour groups was determined according to AACCI Approved Method No 44-19.01 (AACCI, 2000).

Farinograph measurements

American Association of Cereal Chemists International (AACCI) Approved Method 54-21.02 (AACCI, 2000) was followed to determine the following farinograph properties: water absorption (WA), dough development time (DDT), stability (ST), tolerance index (TI), and softening degree (SD). A mixing bowl for 300 g flour was used.

Extensograph measurements

AACCI Approved Method 54-10.01 (AACCI, 2000) was used for extensograph studies. Resistance to extension (R_5), maximum resistance to extension (R_{max}), extensibility (EX), ratio (between resistance and EX; R_{max}/EX) and energy values at 45, 90 and 135 min were measured. The average of 3 measurements was used.

Statistical analysis

Analyses were carried out in triplicates. Analyses of variance (ANOVA) were calculated using SAS v6.12 for Windows (SAS, Cary, NC, USA). When a significant difference was found among treatments, Duncan's multiple range tests were performed to determine the differences among the mean values ($P<0.05$).

3. Results and discussion

Farinograph measurements

The effects of different SPDR on the farinograph properties of flour are presented in Table 1. SPDR significantly affected all farinogram values ($P<0.05$). Flour characteristics were clearly deteriorated with an increasing percentage of SP infected kernels in wheat mass.

A reduction in WA value occurred in the flour groups, due to the degradation of proteins and starch caused by SP damage (Kretovich, 1944), resulting in decreased water holding capability of these components. It has been speculated that increasing the SPDR also affects other farinogram criterions, such as gluten structure (i.e. a decreased molecular weight of gluten) (Olanca *et al.*, 2009).

The flour quality of both 100% SPDR wheat flour variety groups of both was heavily deteriorated, such that the dough could not be drawn from the farinograph device. The extensive SP damage causing the destruction of the flour gluten, made it impossible take farinograph measurements. The elasticity and strength of the dough decreased, while softening and adhesive properties of the samples increased. Hence, dough samples were slack, runny and showed spread characters. Therefore, we concluded that dough samples of 100% SPDR groups could not be used for mixing (farinograph kneading palette).

Rheological parameters provide considerable preliminary information about bread making (Diraman *et al.*, 2013); hence, they are very important tests for the cereal and milling industries. The rheological characteristics of the wheat flour dough were evaluated through various methods. Generally, the farinograph test is used to determine the rheological behaviour during dough mixing (Basar *et al.*, 2015; Rao and Rao, 1993). The farinograph measures the resistance of dough samples to mixing. It is used to evaluate absorption of flours and to determine ST and other characteristics of dough samples during mixing (AACCI, 2000). Farinograph DDT is a good indicator of the protein quality of flour. Stronger flours generally require longer DDT than weaker flours (Karababa and Ozan, 1998). Dough ST is an indication of the tolerance of flour to mixing, with higher values suggesting stronger flour (Basar *et al.*, 2015).

It was found that the increase in SPDR in Golia and Sagittario wheat bulks caused a significant ($P<0.05$) decrease in WA, DDT and ST values, and a significant increase in TI and SD. Reduced DDT and ST relates to weak gluten properties of damaged flours. Control samples of both wheat flour varieties showed (very) different WA, DDT, ST, TI, and SD compared to SPDR groups (Table 1). This indicates that wheat destruction by SP is caused by SP nymphs injecting digestive secretions into the grains and feeding particularly on gluten (storage protein), thereby leading to quality losses of gluten (Atli *et al.*, 1988a,b; Rashwani, 1984).

As expected, 0% SPDR group had the best bread making quality, while the 16% SPDR group had the worst bread making quality in terms of all farinogram parameters. In samples of the Golia variety, TI and SD values of 16% SPDR group increased 11- and 5-fold compared to the control group, respectively (Table 1). Similarly, other studies reported that DDT and ST decreased, and TI increased with an increasing percentage of SP damaged kernels in

Table 1. Effects of sunn pest damage ratios (SPDR) on the farinogram values of the wheat flour varieties.[1]

	SPDR (%)	Water absorption (%)	Dough development time (min)	Stability (min)	Tolerance index (BU)[2]	Softening degree (BU)[2]
Golia	0 (control)	59.2[a3]	2.5[a]	14.4[a]	21[e]	60[e]
	2	58.0[b]	1.9[b]	7.6[b]	34[d]	129[d]
	4	56.5[c]	1.5[c]	7.2[c]	31[d]	122[d]
	8	55.7[d]	1.8[c]	4.4[d]	96[c]	206[c]
	12	55.4[d]	1.6[c]	3.6[e]	130[b]	264[b]
	16	56.0[d]	1.7[c]	3.2[f]	233[a]	315[a]
	100	Could not be drawn due to high sunn pest damage				
Sagittario	0 (control)	59.4[a]	5.8[a]	7.5[a]	68[d]	103[d]
	2	58.8[b]	4.4[b]	7.0[b]	62[d]	142[c]
	4	58.5[b]	4.5[b]	6.2[c]	82[c]	146[c]
	8	56.6[c]	3.5[c]	3.8[d]	162[b]	265[b]
	12	56.5[c]	3.4[d]	3.7[e]	171[a]	274[b]
	16	56.0[d]	2.5[e]	2.5[f]	171[a]	288[a]
	100	Could not be drawn due to high sunn pest damage				

[1] Adjusted to 14% moisture basis.

[2] Brabender units.

[3] Mean values in the table for the same column and same variety (Golia or Sagittario) shown with different superscript letters are significantly different ($P<0.05$).

the samples (ICARDA, 1983; Karababa and Ozan, 1998). In these studies, damaged kernels were also separated and added back to the sound wheat, but in different proportions than our study (2, 5, 10, 20 and 50% in the study of ICARDA, 1983; 1, 3, 5, 7, 9 and 15% in the study of Karababa and Ozan, 1998; 5, 10 and 15% in the study of Basar *et al.,* 2015). When SPDR increases, farinogram DDT was reduced from 5 min to 2 min, ST value was reduced from 9.5 min to 1.4 min (ICARDA, 1983). Karababa and Ozan (1998) reported that the significant differences (P<0.05) were observed between sound and damaged flour samples in terms of the farinograph parameters except for WA. Basar *et al.* (2015) showed that the addition of both SP damaged wheat and *Cephalaria syriaca* flour to sound wheat flour affected all farinograph characteristics significantly (P<0.01). They reported that, in general, as the ratio of the SP damaged wheat increased in the wheat mass; WA, DDT, TI, and SD values increased linearly and the ST value decreased. For the most part of the results obtained from the present study were consistent with the above explanations, but there were little differences (such as WA and DDT value) between the studies. These differences could be explained by the different SPDR levels used in the trials, a variation derived from the genetically differences between wheat varieties (wheat cultivar characteristics), duration of the crop growing period, occurring stage of insect damage, sucking degree (1/4, 2/4, 3/4, and 4/4) and sucking number on a kernel (single, double, triple) by insects (Dizlek and Islamoglu, 2015).

SP damage resulted in a decrease in ST of up to 77.8% for Golia and 66.6% for Sagittario, and in DDT up to 32% for Golia and 56.9% for Sagittario, compared to undamaged control samples (Table 1). The difference between the control and 16% SP damaged group was 11.2 min and 5 min for the ST values for the Golia and Sagittario varieties, respectively. There was nearly 255 BU difference in Golia and 185 BU difference in Sagittario between control and 16% SPDR group for SD.

The Canadian Grain Commission (2009) reported that the DDT values were lower than 2 min for weak flour, 2-3 min for medium strong flour, 3-5 min for strong flour, and 5-12 min for very strong flour. ST values were lower than 4 min in weak flour, 4-7 min in medium strong flour, 7-14 min in strong flour, and higher than 14 min in very strong flour. TI values were higher than 150 BU in weak flour, 30-150 BU in medium strong flour, 0-30 BU in strong flour, and 0 BU in very strong flour. According to these data, average evaluation of control groups of both wheat flour varieties is strong (Canadian Grain Commission, 2009; Williams *et al.*, 1986).

In bread production, wheat flour has 3 fundamental functions: protein (particularly gluten) quantity and quality, amylase activity, and WA capacity. Among them, gluten quantity and quality are unique and important functional properties that greatly determine the baking quality (Dizlek and Özer, 2016; Dizlek *et al.*, 2006). It was observed that when SPDR increased, gluten quality (DDT values) of the flour samples decreased very sharply, while WA capacities of flour samples only decreased to a limited extent (P<0.05; Table 1).

Extensograph measurements

There are several methods available for the detection of SP damage in wheat and flour. These are bake tests, Brabender farinograph method, delayed Zeleny sedimentation test, Pelshenke test, and various gluten softening tests (Diraman, 2010; Karababa and Ozan, 1998; Lorenz and Meredith, 1988). In this study, we not only used the Brabender farinograph method but also the extensograph method. The extensograph test gives important clues about bread making as the implementation of this test covers a long period of time (135 min) as in regular bread making.

The extensograph records a force-time curve for a piece of dough stretched until it breaks. Characteristics of force-time curves, or extensograms, are used to assess the general quality of flour and its response to improving agents. The four most common measurements are: R_5 or R_{max}; EX; energy (evaluates area under curve with planimeter and report in square cm); and the ratio between resistance and EX (AACCI, 2000).

The effects of different SPDR on the extensograph properties of wheat flour varieties are given in Table 2 and 3. There was a significant (P<0.05) difference observed between R_5 and R_{max} of the dough groups (Table 2). Accordingly, when SPDR in wheat bulk increased, the resistance of dough samples was found to decrease very sharply in both wheat varieties. The main factors attributing to this situation were dough softening and decrease of viscoelasticity, due to SP damage to wheat gluten proteins. Already the quality of the 2% SPDR flour (Table 1) and dough (Tables 2 and 3) was significantly deteriorated (P<0.05). Also, the characteristics of the 8% SPDR dough could not be measured from 90 min onwards by the extensograph device, as was the case for all 12% and 16% SPDR groups of both varieties. At 45 min, dough overflow was outward from banquet, widely spread, and showed a tendency to break. The dough could not be drawn as it could not adhere to the hook of extensograph device. As expected, drawings at 90 and 135 min were also not possible for these groups. Also Diraman (2009) and Dizlek and Özer (2016, 2017) found that extensograph measurements could not be drawn at ≥8% SPDR level due to the intensive SP damage.

We found that R_5, R_{max}, energy, and ratio values of the control group were high in both wheat varieties (Table 2). The 0% SPDR flour sample had good quality features in

Table 2. Effects of sunn pest damage ratios (SPDR) on the extensogram values of the wheat flour varieties.[1,2]

	SPDR (%)	R_5 (resistance to extension, 5 cm) (BU)[3]	R_{max} (maximum resistance to extension) (BU)[3]	Extensibility (mm)	R_{max}/extensibility (BU/mm)	Energy (cm^2)
Golia	0 (control)	554[a4]	603[a]	101[c]	50.97[a]	81[a]
	2	292[b]	308[b]	120[a]	20.57[b]	60[b]
	4	256[c]	262[c]	117[b]	20.24[c]	52[c]
	8	20[d]	21[d]	92[d]	0.23[d]	4[d]
	12	Could not be drawn due to high sunn pest damage				
	16	Could not be drawn due to high sunn pest damage				
	100	Could not be drawn due to high sunn pest damage				
Sagittario	0 (control)	205[a]	259[a]	171[b]	10.51[a]	68[a]
	2	122[b]	142[b]	185[a]	0.77[b]	46[b]
	4	90[c]	96[c]	171[b]	0.56[c]	30[c]
	8	19[d]	20[d]	169[b]	0.12[d]	6[d]
	12	Could not be drawn due to high sunn pest damage				
	16	Could not be drawn due to high sunn pest damage				
	100	Could not be drawn due to high sunn pest damage				

[1] The average values of 45, 90 and 135 min measurements are given.
[2] Adjusted to 14% moisture basis.
[3] Brabender units.
[4] Mean values in the table for the same column and same variety (Golia or Sagittario) shown with the different superscript letter are significantly different (P<0.05).

terms of rheological characteristics (Table 1 and 2). These findings indicated that the quality of the control flour was strong (Canadian Grain Commission, 2009; Williams *et al.*, 1986). With the increase in SPDR in wheat bulk, the strength, fermentation tolerance, and gas (carbon dioxide) holding capacity of dough samples significantly declined (P<0.05) (Tables 2 and 3). The runny, slack, softer, and spreadable structure of the SPDR dough may result from SP damage to the wheat. Table 3 shows that SP protease activity increased in parallel with the progress of time. In both wheat flour varieties, limited statistical significance was found (particularly for the Sagittario variety) between the control and 2-8% SPDR groups for dough EX.

The 2% SPDR (relatively low SP damage) flour and dough characteristics decreased rapidly. A decrease of about 24% in DDT (for both wheat varieties); of about 43% in ST (Golia variety); of about 60 and 56% (for Goia and Sagittario, respectively) in R_{max} at 135 min; and of about 47 and 49% (for Golia and Sagittario, respectively) in 135 min energy values was found. Similarly, Diraman and Boyacioglu (1997) showed that the addition of 40% sound wheat (American HRW [hard, red, winter] wheat) to wheat with an SP damage ratio of 10-12%, (40% sound wheat + 100% SP damaged wheat) could not improve the quality of the blend. The sedimentation and alveograph values of this blend (final SPDR level 7.14-8.57%) showed comparable values to the SP damaged wheat sample. Kocak and Atli (1996) researched dough characteristics, suitable for bread making, by blending bread wheat varieties of different qualities. They formed blending groups by adding high quality varieties to low quality ones at 20, 40, 60 and 80%. They reported that addition of the hard red varieties to low quality varieties increased the quality of flour/dough characteristics (decrease in SD; increase in DDT, ST, R_5, R_{max}, and energy). The results of Kocak and Atli (1996) are consistent with the findings of present study.

Köksel *et al.* (2009) rheologically (mixograph) analysed semolina samples and found that the gluten quality substantially deteriorated as SPDR increased. Diraman (2010) reported that alveogram W (deformation energy, 10^{-4} J), P (dough elasticity, mm), L (dough EX, mm), S (Swelling index, cm^3), P/L (alveograph ratio), P/S values in sound and damaged samples were significantly different (P<0.05). Similarly, Atli *et al.* (1988b) showed that SP damage caused a reduction in farinogram ST, alveogram W, P, S, and L values.

Along with the increase of SPDR (from 0 to 100%) in wheat bulk, rheological characteristics of wheat declined (P<0.05). The ratio of SP damaged wheat used in blends is more decisive than the ratio of sound wheat in determining the

Table 3. The raw data of extensogram values of different sunn pest damage ratios (SPDR) in wheat flour groups.

SPDR (%)	R_5 (Resistance to extension, 5 cm) (BU)[1]			R_{max} (Maximum resistance to extension) (BU)[1]			Extensibility (mm)			Energy (cm^2)		
	45 min	90 min	135 min	45 min	90 min	135 min	45 min	90 min	135 min	45 min	90 min	135 min
Golia												
0 (control)	383	622	656	413	687	708	114	95	95	68	85	90
2	266	328	283	300	341	283	147	110	103	72	60	48
4	245	280	243	256	287	243	144	108	100	64	50	42
8	60	Could not be drawn		64	Could not be drawn		92	Could not be drawn		11	Could not be drawn	
12	Could not be drawn to high sunn pest damage											
16	Could not be drawn to high sunn pest damage											
100	Could not be drawn to high sunn pest damage											
Sagittario												
0 (control)	156	221	239	214	280	283	191	169	154	63	74	68
2	122	129	115	156	146	125	220	176	158	58	45	35
4	102	91	77	112	95	81	191	169	154	38	29	23
8	57	Could not be drawn		60	Could not be drawn		169	Could not be drawn		19	Could not be drawn	
12	Could not be drawn to high sunn pest damage											
16	Could not be drawn to high sunn pest damage											
100	Could not be drawn to high sunn pest damage											

[1] Brabender units.

quality of the flour and dough. In addition, the ratio of the SP damaged wheat in the wheat bulk is dominant in specifying the quality of the first (wheat) and intermediate (flour and dough) products. A very low ratio of poor quality wheat sample has a great effects on a good quality wheat sample, eventually deteriorating the dough and consequently the finished product quality.

Upon comparing both wheat varieties, dough samples of Sagittario – including the control – had too low resistance values (R_5 and R_{max}), as well as high EX values (Table 2 and 3), where dough samples of Golia had high resistance values and low EX. Average R_{max} value of Golia and Sagittario control doughs were 603 BU and 259 BU, respectively. Average EX value of Golia and Sagittario control dough groups were 101 mm and 171 mm, respectively. In addition, while farinograph stability value of the control group of Golia was 14.4 min, the value for Sagittario was 7.5 min. Thus, both wheat varieties used in this study had generally very different dough characteristics, specifically gluten, from each other. However, although the characteristics of both wheat varieties were different from each other, dough characteristics were similarly negative affected by SP damage.

In general, the results obtained from both wheat flours were in good accordance with each other. However, there was a variation in terms of flour qualities of both varieties. SPDR had a stronger effect on the farinogram and extensogram values of Golia, whereas Sagittario values were less affected (R_5, R_{max}, and ST values decreased very sharply when SP damage occurs [2% SPDR] in Golia). Our findings were in accordance with Cressey *et al.* (1987), Diraman (2009), Dizlek and Islamoglu (2009), Dizlek *et al.* (2008), Every *et al.* (1998), Hariri *et al.* (2000), Karababa and Ozan (1998), Kinaci and Kinaci (2004), Kinaci *et al.* (1998), Kretovich (1944), Paulian and Popov (1980), Sivri *et al.* (1998, 2002, and 2003). Deleterious effects of SP damage on farinograph parameters were found to be similar to those on extensograph parameters.

Flour-dough characteristics were significantly weakened depending on the level of SPDR and the resulting degradation of protein structure. It has been proposed that the fragmentation in the character of gluten occurs due to SP damage. In a similar way, Olanca *et al.* (2009) suggested that SP protease caused depolymerisation and/or disaggregation of polymeric proteins, lowering their average molecular size. The results in Table 1-3 show a clear decrease in DDT, ST, R_5, R_{max}, energy, and ratio, and a clear increase in TI and SD, which could be attributed to the effect of enzymes injected to the kernels by SP (Every *et al.*, 1989; Kretovich, 1944).

Evaluating all farinograph and extensograph properties together, it was observed that both wheat varieties examined had quality loss which became significant after 2% SPDR and wheat-flour properties that reduced significantly after 4% SPDR. Briefly, a critical threshold value of 2% SPDR will be appropriate.

4. Conclusions

In this research, rheological parameters that can provide considerable preliminary information about the bread making were examined. The results of this study clearly demonstrated that the ratio of damage by SP in wheat bulk played an important role in rheological quality characteristics of wheat varieties. SPDR affected farinogram and extensogram values of wheat flour varieties significantly (P<0.05) and an increase in SPDR in wheat bulk caused a clear and significant decrease in the farinogram and extensogram values of the varieties due to deteriorative effects of SP damage on gluten quality. TI and SD of flour samples increased sharply; WA and DDT values decreased partially; ST, R_5, R_{max}, ratio, and energy values decreased accurately depending on increasing level of SPDR in wheat bulk. Increase in the ratio of infected kernels in wheat bulk did have negative effects on flour and dough quality at a certain proportion (2%). However when the percentage of SP damaged kernels in wheat bulk was more than 2% and depending on increase of percentage, flour and dough characteristics showed a significant (P<0.05) decrease. The strength and breaking force of the dough samples decreased significantly with increasing SPDR indicating that they were susceptible to spreading and not suitable for handling, bread making and blending application. Also, it was found that although attributes of 2 wheat varieties were different from each other, dough characteristics of varieties were negatively (resistance and energy values decrease) and similarly affected by SP damage. At the same time in the study, we determined that the extensograph test demonstrated a clear distinction between damaged and undamaged wheat samples as SP protease activity increased obviously in the dough in parallel with the progress of time in extensograph test.

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