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Improvement bread characteristics of high level sunn pest (*Eurygaster integriceps*) damaged wheat by using transglutaminase and some additives☆

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ABSTRACT

The purpose of this study was to improve the baking quality of high level sunn pest damaged wheat (HLSPDW; 20.6%) sample by using at varying levels transglutaminase, and fixed additive combination (diacetyl tartaric acid esters of mono and diglycerides + citric acid + L-ascorbic acid) with or without transglutaminase. It was observed that transglutaminase plays an important role in baking quality of HLSPDW. The increase in transglutaminase caused very clear increase on bread characteristics of wheat. Bread yield, height, pore structure, and crumb softness values increased sharply; weight loss and wideness of bread samples decreased accurately depending on increasing transglutaminase level. This increase did not affect obviously on bread quality at a certain proportion (0.3%). However, when the transglutaminase was more than 0.3% and depend on increase of percentage, bread characteristics showed significant increase. It was determined that, in the absence of transglutaminase; other additives could not improve the bread qualities examined. The unique application of using transglutaminase was found to be considerably to improve the bread quality of the HLSPDW. Overall results indicate that the properties of the bread from HLSPDW can be restored by the addition of transglutaminase. The highly disrupted protein structure present in the HLSPDW gluten requires higher transglutaminase concentrations.

1. Introduction

In some wheat-growing countries, considerable amounts of commercial wheat are rendered unusable in standard baking because of pre harvest damage of the kernel by protease-injecting bugs (Köksel et al., 2001). Bug damage is usually associated with insects of the genera *Eurygaster*, *Aelia,* and *Nysius*. All these insects are sucking insects, piercing the developing grain with stylets. During feeding they inject saliva (particularly proteolytic enzyme) in to wheat grain to dissolve gluten proteins of wheat and cause important losses to millers, bakers, and country economies (Konarev et al., 2011; Kretovich, 1944; Lorenz and Meredith, 1988).

Sunn pest (SP) is the most important detrimental insect species for wheat in Turkey and some neighboring countries. SP reduce both yield and quality of wheat. In Turkey, thousands of dollars are spent annually for struggling with the SP (*Eurygaster* spp). In 2014, an area of 636,281 Ha was made SP control. According to the statistics the Turkish Ministry of Food, Agriculture and Livestock, in 2011, the national economy contributed about 370 million dollars to the fight against the SP in 22 provinces. However, farmers lost an amount of about 20 million dollars due to the SP damage cause allocated to coarse wheat (Dizlek and Özer, 2016a). SP damaged wheat causes reduction of flour quality, giving a softer dough and subsequently flat bread with low volume, rough crust surface, sharp edges to loaf and unsatisfactory texture (Every, 1992; Lorenz and Meredith, 1988).

There were various applications on improving SP damaged wheat and flour quality. One of the most important of these is usage

Abbreviations: SP, sunn pest; SPDR, sunn pest damage ratios; HLSPDW, high level sunn pest damaged wheat; AACCI, American Association of Cereal Chemists International; TG, Transglutaminase; L-AA, L-ascorbic acid; CA, Citric acid; DATEM, Diacetyl tartaric acid esters of mono and diglycerides.

☆ The actual work was done Çukurova University, Department of Food Engineering, Adana, Turkey.

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of some bread additives (e.g. dry gluten, potassium bromate, L-ascorbic acid [L-AA], citric acid [CA], transglutaminase [TG], diacetyl tartaric acid esters of mono and diglycerides [DATEM], glucose oxidase, hexose oxidase) to increase the quality and quantity of gluten during dough preparing stage (Bonet et al., 2005; Caballero et al., 2005; Dizlek et al., 2008; Dizlek and Özer, 2016b, 2017; Köksel et al., 2001).

Modification of proteins by enzymes such as TG has recently become of great interest to food scientists. TG (protein-glutamine γ-glut amyl transferase, EC 2.3.2.13) is an enzyme capable of catalyzing the formation of non-disulfide covalent crosslinks between peptide-bound glutamine residues and Ɛ-amino groups of lysine residues in protein. TG enzyme can be used to modify the functional properties of food proteins. As a consequence, TG has been widely used to alter the molecular structure and to improve the functional characteristics of food proteins such as gluten (Başman et al., 2002a; Bonet et al., 2005).

The purpose of this study was to improve the baking quality of high level sunn pest damaged wheat (HLSPDW; 20.6%) sample (being at a quality that can be used as animal feed) by using at varying levels TG (0% [control], 0.3%, 0.6%, 1%, 1.5%, and 2% as flour basis), and fixed additive combination (DATEM, CA, and L-AA) with or without TG. Therefore utilizing the HLSPDW in bread making and contributing to the economy by increasing the added value was determined the optimum TG based additive formulas to achieve the best bread quality.

2. Material and methods

2.1. Materials

An insect damaged wheat sample belonging to the Sagittario variety was used in this study. This sample purchased from Koca Agricultural Products Company (Salbaş-Karaisalı, Adana, Turkey). For the determination of the ratio of insect damaged kernel of wheat variety, 10 sets of 100 kernels were separated randomly from the wheat cultivar. The number of SP damaged kernels in each set was recorded and % damage ratio was reported as the average of ten determinations (Atlı et al., 1988). In the result, Sagittario variety had SP damage ratios (SPDR) as 20.6%. This proportion represent that wheat sample used in the study was high level SP damage. The wheat had 69% translucent, 24% vitreous, and 7% mealy kernel, hectoliter weight 72.5 kg, thousand kernel weight 30.2 g, and heterogeneous kernel size distribution (Williams et al., 1986).

Totally, one hundred SP samples were collected from damaged wheat bulk and their varieties were determined by a scientist from Agricultural Protection Research Institute (Adana, Turkey) specialized in identification of insect species. According to the obtained data, it was determined that 99% of them were *Eurygaster integriceps* and 1% was *Eurygaster maura*.

TG (TG Activa WM, 100 U/g) was kindly provided from Ajinomoto Co., Inc. (Tokyo, Japan), L-AA (food grade, ELCO C-100 K) and CA (EMCEtric AP) from Mühlenchemie GmbH & Co. KG (Ahrensburg, Germany), DATEM (SAFMILL T-310) and bread yeast were supplied from LeSaffree-Özmaya Co. (Adana, Turkey). Salt was purchased locally. Potable water supplied within the campus of University of Çukurova (Adana, Turkey). TG, L-AA, CA, and DATEM were selected to overcome the destroyed gluten proteins because of high level of SPDR in wheat bulk to flour. In the study, all these additives particularly TG enzyme used to alter the molecular structure and to improve the functional characteristics of gluten.

In bread making process; the dough was prepared in an electric kneading machine with spiral spindle (160 rev/min, Günsa Machine A. Ş. İzmir, Turkey). The fermentation procedures were carried out in the fermentation chamber made of heat-insulated material and equipped with heating system and steam unit. Baking was carried out in a "Wiesheu EBO 1–64R" model stone floor oven (Wiesheu GMBH, Affalterbach, Germany).

2.2. Methods

2.2.1. Preparation and properties of wheat flour

Wheat sample was mixed thoroughly so that it was homogeneous within itself. After that, wheat sample was conditioned to 16.5% moisture content for 32 h and was milled with a laboratory type mill ("Yücebaş" brand, "YM1" model tempered wheat grinding mill, including six rolls; Yücebaş Machine, İzmir, Turkey). Finally, obtained new milled flour sample was rested for one month at 20 °C for the ripening, and then used in bread making experiments.

The flour had 14.9% moisture, 11% dry gluten content, 0% gluten index, 30 ml Zeleny sedimentation value, 5 ml delayed Zeleny sedimentation value, 277 s falling number, 61.6% farinograph water absorption, 2.1 min development time, 2.3 min stability, 212 B.U. tolerance index, 278 B.U. softening degree; extensograph could not be drawn due to high SP damage (American Association of Cereal Chemists International [AACCI], 2000).

2.2.2. Dough preparation and bread making studies

This study consists of two stages. In the first step, dough formula was prepared including fundamental dough ingredients (flour, water, yeast, and salt) and using at varying levels TG (0% [control], 0.3%, 0.6%, 1%, 1.5%, and 2% as flour basis) (Table 1). In the second and last step, dough formula was prepared as the first step of the study (fundamental dough ingredients and varying levels TG) with different additives (DATEM, CA, and L-AA). In this step, additives except TG were used at fixed amount in the bread formulations (DATEM at 0.5%, CA at 250 mg/kg, and L-AA at 150 mg/kg were used as constant additives as flour basis). The amount of water in each formula was determined by the farinograms (AACCI Approved Method 54–21.02 [AACCI, 2000]). Farinograph water absorption values of flour samples produced from various levels blending ratio of TG and HLSPDW flour samples were as follows; 61.6%–0% TG, 61.3%–0.3% TG, 60.9%–0.6% TG, 61.1%–1% TG, 61.1%–1.5% TG, 60.5%–2% TG. Bread making experiments with 12 different formulations were carried out in triplicates (Table 1).

Bread was made according to the AACCI Approved Method 10–10.03 (AACCI, 2000) with some modifications. Dough was optimally mixed (16 min, 160 rev/min) until dough development, scaled into pieces of 100 g dough weight, hand-rounded, molded and rested (fermentation) at 25 ± 1 °C and 65–70% relative humidity for 120 min. Baking was carried out in an oven for 16 min at 260 °C. Samples were then cooled for 1 h at room temperature, and

Table 1
Experimental designs of the first step[a] and second step[b] of the study.

TG level (%, w/w)	%20.6 SP damaged Sagittario wheat flour
0 (control)	x
0.3	x
0.6	x
1.0	x
1.5	x
2.0	x

[a] The dough formula containing no additive (control) and varying levels TG additive were constant and consists of the following fundamental dough components: Flour (100 g) + Water (as farinograph water absorbtion value) + Yeast (3 g) + Salt (2 g).

[b] The dough formula containing no TG (control) and varying levels TG additive were constant and consists of the following components: Flour (100 g) + Water (as farinograph water absorbtion value) + Yeast (3 g) + Salt (2 g) + DATEM (0.5 g) + CA (0.025 g) + L-AA (0.015 g).