

Influence of *Tribolium castaneum* (Herbst) Infestation on Farinographical Properties of Wheat Flour Dough

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Abstract The effect of *T. castaneum* infestation on farinographical properties of dough made from wheat flour infested by initial 0, 2, 4, 6, and 8 *T. castaneum* adults for 0, 30, 60, and 90 d at 15, 25, and 30°C and 75% RH was investigated. The water absorption and softening degree of dough made from wheat flour infested by *T. castaneum* increased with increasing initial adult population density, storage temperature, and storage time, but the dough development time and stability time decreased significantly at 25 and 30°C. The water absorption, development time, stability time and softening degree of dough made from wheat flour infested by initial 8 *T. castaneum* adults respectively reached 75.40±0.30%, 1.23±0.25 min, 1.17±0.15 min, and 182.67±1.53 FU after 90 d of storage at 30°C. The farinographical quality of wheat flour infested by adult *T. castaneum* population changed little at 15°C. Therefore, wheat flour should be stored at low temperature and insect-free environment.

Keywords: wheat flour, *tribolium castaneum*, farinographical quality, infestation

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1. Introduction

Wheat (*Triticum aestivum* L.) is one of the staple food crops in China and the world. Usually, wheat flour is processed into noodles, tortillas, breads, pastas, and so on, which is an important part of the human diet [1].

Stored wheat flour and its products are vulnerable to stored product insects. Stored product insect infestation results in adverse effects on grain quality. Nonreducing sugars, gluten, protein quality, and sedimentation value decreased in wheat infested by *Trogoderma granarium* and *Rhizopertha dominica* [2,3,4,5].

Tribolium castaneum (Herbst) (Coleoptera: Tenebrionidae), one of the main pest insects in food processing and wheat flour storage spaces, can multiply rapidly in stored wheat flour at favorable conditions. *Tribolium castaneum* infestation frequently causes severe weight loss by feeding and quality loss by contaminating stored wheat flour with their cast skins, secreting benzoquinone, and insect fragments [6].

Rheological parameters were very important tests for cereal and milling industries. The rheological characteristics of the wheat flour dough were evaluated through various methods. Generally, farinograph test is used to determine the rheological behaviour during dough kneading. The farinograph measures and records resistance of dough samples to kneading. It is used to evaluate absorption of flours and to determine stability time and other characteristics of dough samples during kneading [7].

However, relatively little is known about the effect of *T. castaneum* infestation on farinographical properties of wheat flour dough. Therefore, this study aims to investigate the effect of insect infestation on farinographical properties of dough made from wheat flour infested by different initial adult *T. castaneum* population densities for different times at different storage temperatures, which is in favor of implementing measures for maintaining quality of wheat flour.

2. Materials and Methods

2.1. Insect

Tribolium castaneum has been cultivated on food medium (wheat flour: yeast = 9:1, by weight) for several generations at 27±2°C and 70±5% RH at the Institute of Stored Product Insects of Henan University of Technology, Zhengzhou, China. The males and females of *T. castaneum* were distinguished in pupae stage, then reared separately. The healthy *T. castaneum* adults (1 week old) were taken for the experiments.

2.2. Experimental Procedure

Fresh wheat (Zhengmai 583 cultivar), commercially grown in Zhengzhou, Henan, China, was obtained from Henan Academy of Agricultural Sciences, and processed into whole wheat flour with a lab mill. Every 500 g wheat

flour was put into a glass jar (2500 ml), and then 0 (as a control), 2, 4, 6, and 8 *T. castaneum* adults (male: female =1:1) were respectively introduced into a glass jar. Subsequently, the jars were respectively maintained at 15, 25, and 30°C and 75% RH. The farinograph quality of dough made from the wheat flour infested by *T. castaneum* adults was determined after 0, 30, 60, and 90 d of storage. Three replicates were conducted.

Water absorption, development time, stability time, and softening degree of dough made from the wheat flour infested by *T. castaneum* adults were analyzed in a Brabender Farinograph-Resistograph using the constant flour weight procedure (Method 54-21, AACC 1995).

2.3. Statistical Analysis

Means and standard errors of the wheat flour quality were calculated by using SPSS Statistics 20. Data on the wheat flour quality were subjected to analysis of variance (ANOVA) with storage temperature and time as fixed

variables, and quality indices as response variables. Treatment means were compared and separated by Tukey's test at $p = 0.05$.

3. Results

3.1. Effect of *T. castaneum* Infestation on Water Absorption of Dough

The water absorption of dough made from the wheat flour infested by *T. castaneum* adults slightly decreased from 67.27% to 69.23% after 90 d of storage at 15°C, but significantly increased with increasing initial adult population density and storage time at 25 and 30°C ($df=3,59$, $F=12.540$, $p<0.01$) (Figure 1). The water absorption of dough made from wheat flour infested by initial 0, 2, 4, 6, and 8 *T. castaneum* adults respectively increased to 68.50 ± 0.10 , 70.83 ± 0.21 , 72.43 ± 0.12 , 73.87 ± 0.60 , and $75.40\pm 0.30\%$ after 90 d of storage at 30°C.

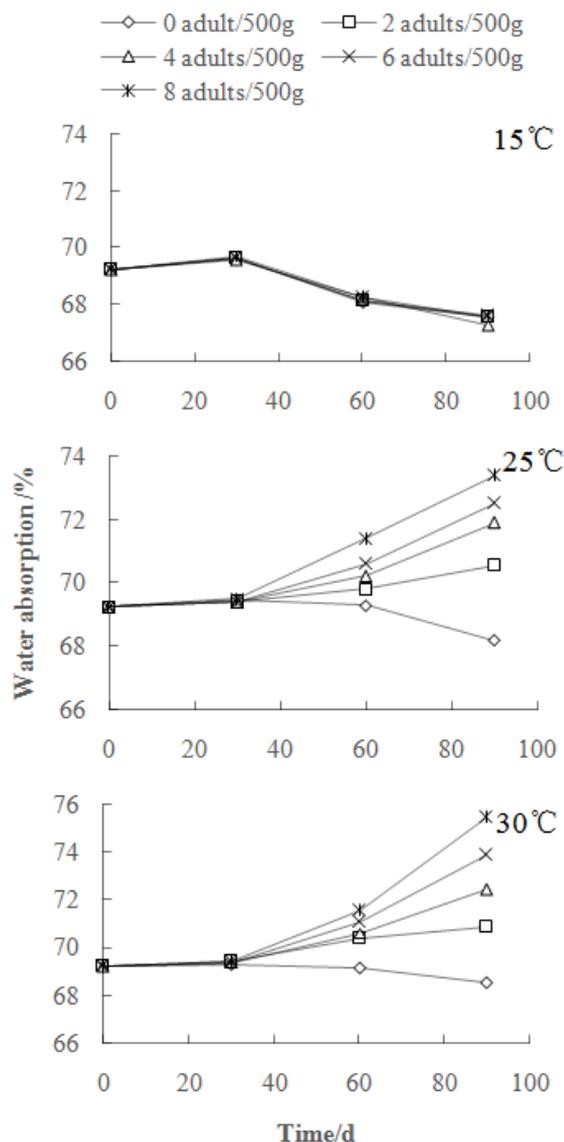


Figure 1. Changes of water absorption of dough made from wheat flour initially infested with 0 (as a control), 2, 4, 6, and 8 adults of *T. castaneum* over time at 15, 25, and 30°C

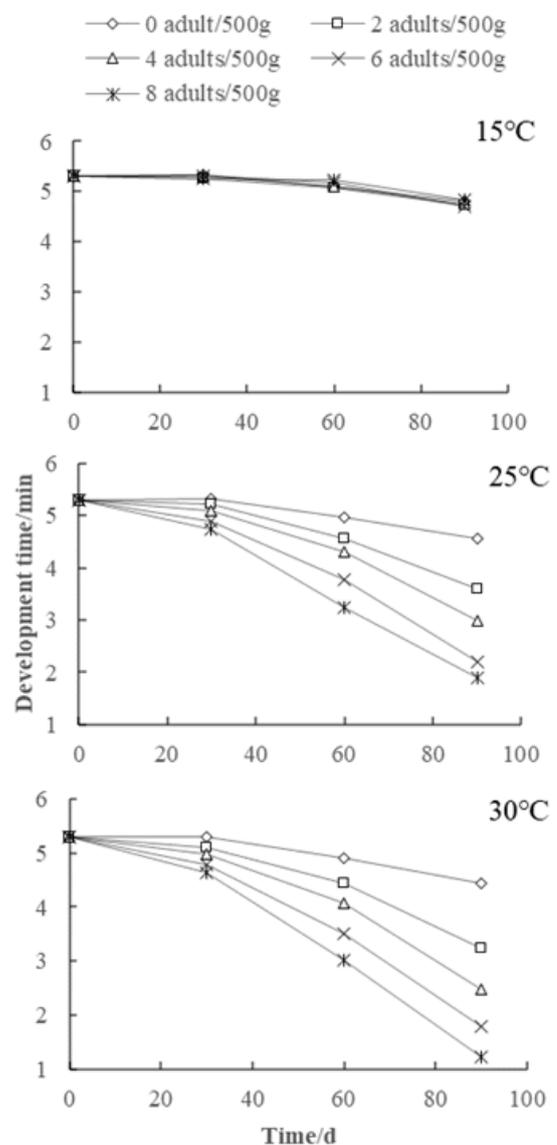


Figure 2. Changes of development time of dough made from wheat flour initially infested with 0 (as a control), 2, 4, 6, and 8 adults of *T. castaneum* over time at 15, 25, and 30°C

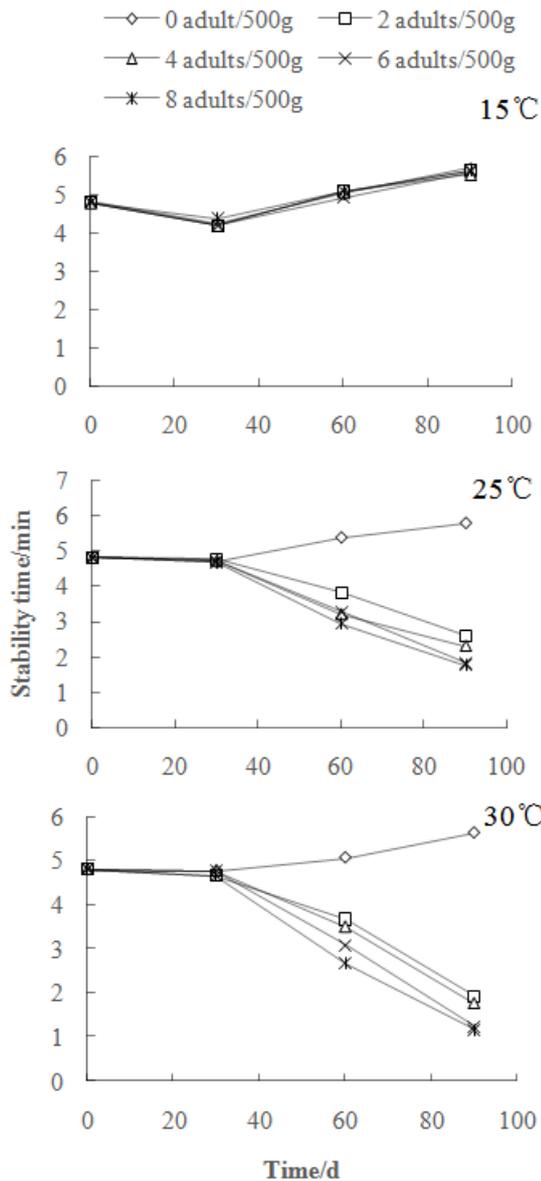


Figure 3. Changes in stability time of dough made from wheat flour initially infested with 0 (as a control), 2, 4, 6, and 8 adults of *T. castaneum* over time at 15, 25, and 30°C

3.2. Effect of *T. castaneum* Infestation on Dough Development Time

The development time of dough made from the wheat flour infested by *T. castaneum* adults decreased slightly during 90 d of storage at 15°C, but significantly decreased with increasing initial adult population density and storage time at 25 and 30°C ($df=3,59$, $F=40.652$, $p<0.01$) (Figure 2). The development time of dough made from the wheat flour infested by initial 0, 2, 4, 6, and 8 *T. castaneum* adults respectively reached 4.43 ± 0.12 , 3.23 ± 0.25 , 2.47 ± 0.32 , 1.80 ± 0.26 , and 1.23 ± 0.25 min after 90 d of storage at 30°C.

3.3. Effect of *T. castaneum* Infestation on Dough Stability Time

The stability time of dough made from the wheat flour infested by *T. castaneum* adults slightly decreased after 30 d storage, then slowly increased after 90 d of storage at 15°C. There was no significant difference among the

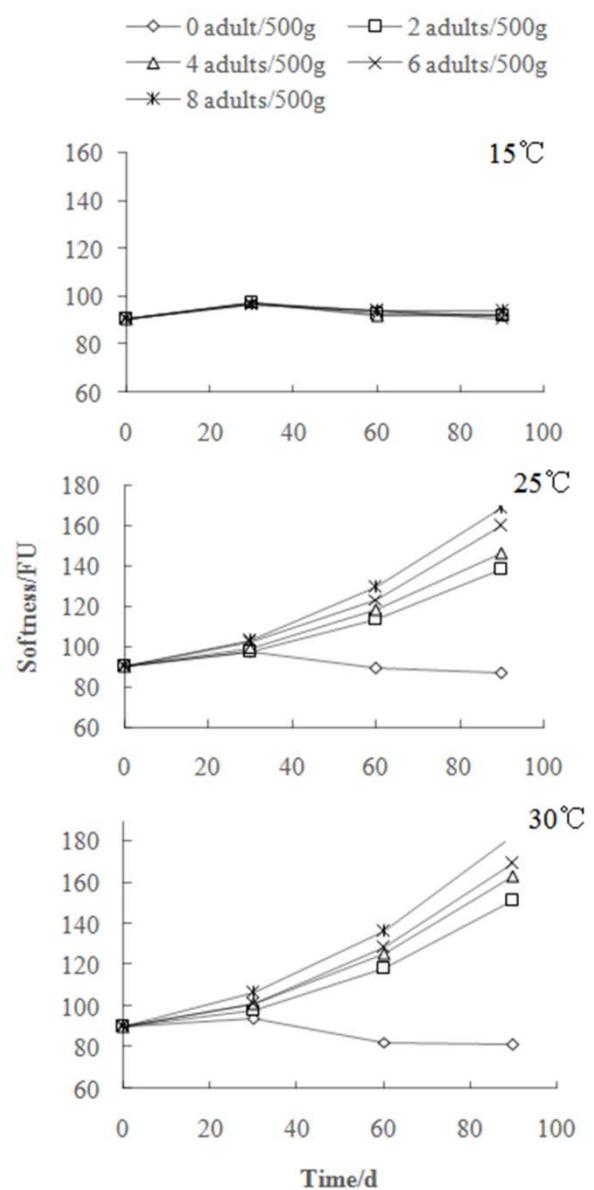


Figure 4. Changes in softening degree of dough made from wheat flour initially infested with 0 (as a control), 2, 4, 6, and 8 adults of *T. castaneum* over time at 15, 25, and 30°C

stability times of dough made from wheat flour infested by initial 0 (as a control), 2, 4, 6, and 8 *T. castaneum* adults at 15°C. The stability time of dough made from wheat flour without infestation slightly increased during 90 d of storage at 25 and 30°C. However, the stability time of dough made from wheat flour infested by initial 2, 4, 6, and 8 *T. castaneum* adults slightly decreased within 30 d storage, then significantly decreased with increasing initial adult population density and storage time at 25 and 30°C ($df=3,59$, $F=11.448$, $p<0.01$) (Figure 3). The stability time of dough made from wheat flour infested by initial 0, 2, 4, 6, and 8 *T. castaneum* adults respectively reached 5.63 ± 0.35 , 1.93 ± 0.15 , 1.77 ± 0.15 , 1.23 ± 0.06 , and 1.17 ± 0.15 min after 90 d of storage at 30°C.

3.4. Effect of *T. castaneum* Infestation on Dough Softening Degree

The softening degree of dough made from wheat flour infested by initial 0, 2, 4, 6, and 8 *T. castaneum* adults

changed little during 90 d storage at 15°C. The softening degree of dough made from wheat flour without infestation increased within 30 d storage, then slightly decreased during 90 d storage at 25 and 30°C. However, the softening degree of dough made from wheat flour infested by initial 2, 4, 6, and 8 *T. castaneum* adults markedly increased after 90 d of storage at 25 and 30°C (df=3,59, F=17.738, p<0.01) (Figure 4). The softening degree of dough made from wheat flour infested by initial 0, 2, 4, 6, and 8 *T. castaneum* adults respectively reached 81.67±1.15, 151.33±3.06, 162.33±4.16, 169±4.00, and 182.67±1.53 FU after 90 d of storage at 30°C.

4. Discussion

Tribolium castaneum infestation in stored wheat flour frequently caused significant changes in dough farinographical properties, including water absorption, dough development time, stability time, and degree of softening. The water absorption and softening degree of dough made from wheat flour infested by *T. castaneum* increased with increasing initial adult population density, storage temperature, and storage time, but the dough development time and stability time decreased significantly. The present results are similar to previous researches [1,8,9]. The farinographical quality of dough made from wheat flour infested by *Sitophilus oryzae*, *Sitophilus zeamais* and *Rhizopertha dominica* also significantly decreased with the increasing initial adult population density of *T. castaneum* and storage time [10].

The stability time and water absorption of dough directly determine the gluten strength of dough, which is the most direct and accurate index of food processing quality [11]. The quality (such as bread yield, pore structure, height, and crumb softness value) of bread made from wheat infested by *Eurygaster integriceps* was significantly improved by adding transglutaminase [12]. The prolamine and glutenin in wheat are respectively responsible for dough extensibility and tensile resistance, then further affect rheological property of wheat flour [13]. Whether the saliva secreted by *T. castaneum* feeding can cause the change of wheat flour quality remains to be further investigated.

Previous research mostly focused on the effects of infestation on the quality of raw grain [3,4,14]. In fact, stored product insects occasionally invade stored wheat flour and cause damage, or a small amount of residual eggs in wheat flour will also cause damage after hatching at suitable conditions. Therefore, the effect of stored product insect infestation in wheat flour on quality of flour products is worthy of further study.

Low temperature storage can effectively maintain wheat flour at a stable state, which is in favor of maintaining wheat flour quality. The present results showed that farinographical quality of dough made from wheat flour infested by adult *T. castaneum* population changed little during 90 d storage at 15°C, but significantly decreased with increasing initial adult population density and storage time at 25 and 30°C. Thus, wheat flour should be kept in a low temperature, and insect free environment.

5. Conclusion

The water absorption and softening degree of dough made from wheat flour infested by *T. castaneum* increased with increasing initial adult population density, storage temperature, and storage time, but the dough development time and stability time decreased significantly at 25 and 30°C. The farinographical quality of wheat flour infested by adult *T. castaneum* population changed little at 15°C. Thus, wheat flour should be stored at no more than 15°C.

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Statement of Competing Interests

The authors declare that there is no conflict of interest.

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