Environment & Ecology 35 (1A) : 313—317, January—March 2017
Website: environmentandecology.com ISSN 0970-0420

RVA Study of Stored Wheat under Hermetic Storage

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Received 8 April 2016 ; Accepted 11 May 2016 ; Published online 26 May 2016

Abstract Pasting characteristics of stored wheat are investigated to observe the effect of initial moisture content and storage duration. Wheat was stored in hermetic bags for nine months at two different moisture content i.e. about 12% and 14% (w.b.). The milled and sieved samples were analyzed using Rapid Visco-Analyzer (RVA). The results revealed the significant influence of moisture content and storage duration on pasting properties. Peak, trough, and final viscosity were found to be increased with the storage time except setback in both type of storage. The peak, trough and final viscosity were observed significantly higher in 14% hermetic storage. Gelatinization temperature, breakdown viscosity and peak time in both moisture content storages were same and remained constant throughout the storage period. A significant increase in pasting temperature with storage duration was observed in 14% hermetic storage.

Keywords Hermetic storage, Pasting characteristics, RVA, Wheat.

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Introduction

The pasting characteristics has significant role in baking industry regarding product shape and texture. Wheat flour consists of protein (6—14%), starch (70—80%), lipids (1%) significantly affects the rheological profiles, swelling power and retrogradation properties [1]. The distribution of starch granule types, size and structure of amylose and amylopectin and their relative ratios in starch granules play an important part in determining pasting, gelation, and retrogradation properties of starch and end-product quality and stability [2]. The Rapid Visco Analyzer (RVA) can be considered as a method that gives idea about the quality of products, in terms of its potential swelling and gelatinisation behavior.

The cereals are stored at three various levels i.e. government, private and farmer. It requires protection from insects, pest, fungi and high moisture content to maintain viability, nutritional and manufacturing properties. Although conventional storage practices with chemical control methods are used to control quality and quantity losses but various unit operations lead to 2.8–4.7% post-harvest losses in cereals [3]. Deregistration of chemicals, ozone depletion, developing resistance in insects and consumer awareness are the major reasons to find alternative methods for safe storage [4]. Hermetic storage systems are environment-friendly and effective in preventing post-harvest losses in tropical regions [5].

It has been adopted successfully in Asia, Africa and Latin American countries [6]. The respiration process of grain, insects, mites and microorganisms cre-

Table 1. Overview of the experimental setup. # Manual insect infestation.

Experiment name (one tonne each)	Start date	Moisture content % (w.b.)
Hermetic storage H1	24.07.2013	11.53%
Hermetic storage H2#	24.07.2013	11.80%
Hermetic storage H3	29.07.2013	13.43%
Hermetic storage H4#	29.07.2013	13.42%

ate oxygen deficient atmosphere which inhibits the biotic activity, promoting a safe environment for grain storage [7]. Experiments revealed that wheat stored in hermetic bags at 12% EMC maintains all processing quality parameters for 9—12 months [8]. In the present study the pasting characteristics of stored wheat in hermetic bags was compared on the basis of two different initial moisture content and storage duration.

(Financial support for the research work was provided by ADM Institute for the Prevention of Post harvest Loss and CCS Haryana Agricultural University, Hisar).

Materials and Methods

Wheat storage setup

In the third week of July, 2013 four metric tonnes of wheat (var WH-711) was filled in four hermetic silo bags of one tonne capacity each (Grain Safe II™, GrainPro Inc) for nine months' duration. In order to obtain the desired moisture content, it was spread uniformly on the floor and was sprinkled with the calculated amount of water and mixed thoroughly thereafter. The bag was rested on metallic frame (75 cm × 75 cm × 150 cm) with rodent proof measures on each leg. Each hermetic bag had an outer propathene jacket to act as a strength member. Hermetic bags were consistently monitored for any possible damage. The experimental design and related information is shown in Table 1.

Manual insect infestation

On August 13, 2013 the 80 adult specimens of insect *Rhyzopertha dominica* were introduced inside the hermetic bags to check the efficacy of modified environment against the insect infestation.

Sampling procedure

Wheat samples were collected in beginning of experiment and then at continuous interval of one month from all the hermetic bags. Sampling orifices were made on the top of bags to avoid the failure of structure due to propathene jacket around the bag and grain pressure in vertical plane. Samples were collected from each of the three layers by inserting sampling probe vertically through orifices. Later on these orifices were sealed using silicone sealant. All the samples from an individual storage structure were then pooled together to form representative samples for each month. These samples were sealed in the plastic bags and later used for qualitative analysis.

Sample preparation

The collected wheat samples were milled by the Brabender junior mill to produce white flour. These samples were kept in the polyethylene bag, sealed and stored in a refrigerator (4°C) for further analysis.

Pasting characteristics

Samples of wheat flour of different storage structures were assessed for various pasting characteristics viz. Peak viscosity, Peak time, Break down, Final viscosity, Set back and Pasting temperature using Rapid Visco Analyzer, Newport Scientific Australia [9]. Twenty-five ml of distilled water was filled into a canister. 3.5 grams of sample (14% moisture basis) was weighed and transferred on to the water in canister. Paddle was placed into the canister and jogged to disperse the sample. Canister with paddle was inserted into Rapid Visco Analyzer (RVA) and pressed down the tower. Test was run for 13 min Canister was removed on completion of test. From Thermocline windows following observations were recorded.

Peak viscosity: Maximum viscosity developed during or soon after the heating portion of the test.

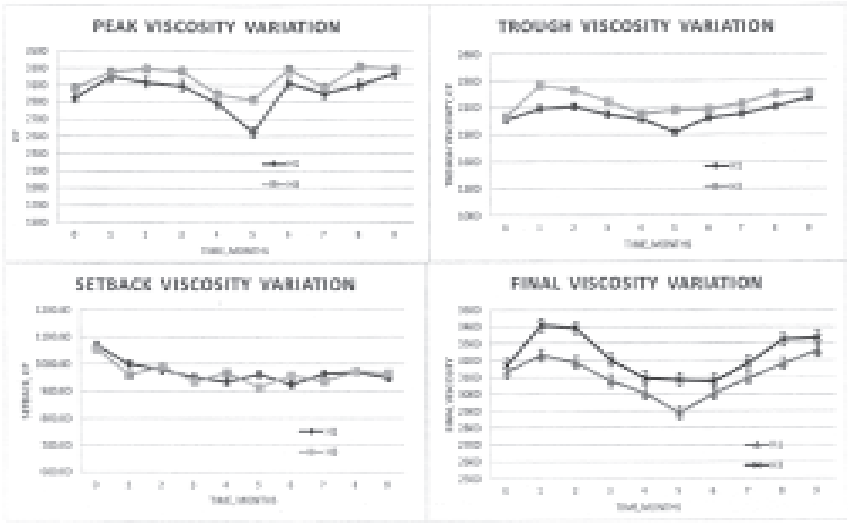

Fig. 1. The peak, trough, setback and final viscosity stored wheat in hermetic bags.

Trough viscosity: Maximum viscosity after the peak, normally occurring around the commencement of sample cooling.

Peak time: Time taken at which peak viscosity occurred.

Pasting temperature: Temperature where viscosity first increases by at least 25 cP over a 20 second period using the standard 1 profile.

Break down viscosities: Peak viscosity minus trough viscosity.

Final viscosity: Viscosity at the end of the test.

Set back: Viscosity where recrystallization of starch again starts.

Gelatinization temperature: Temperature on which heat crack intermolecular bonds and allow hydrogen bonding.

Statistical analysis

The difference between means was compared using the Duncan's new multiple range test in SAS software.

Results and Discussion

Pasting properties are used an index to show the cooking and baking qualities of flours [10]. Heating of starch in presence of water increases the viscosity due to irreversible swelling of starch granules with the application of heat [2]. The similar trends of pasting characteristics were observed in all structures. Peak, trough, and final viscosity were found to be increased with the storage time except setback viscosity (Table 2 and Fig. 1). Setback viscosity is a measure of starch quality in a food material. Decrease of setback viscosity shows a lower degree of retrogradation which indicates poor product firmness [11].

Introduced insect by manual infestation was found dead during monthly sampling. This indicates carbon dioxide enriched environment inside the structure which inhibited the insect proliferation. No significant differences were observed in replication of experiment because of manual insect infestation as per statistical analysis at 5% level of significance. Therefore, the results of H1 and H3 (hermetic structure without manual insect infestation) were presented in this paper. The respiration process of the biological agents in the grain ecosystem (grain, insects, mites and microorganisms) increases carbon dioxide (CO_2)

Table 2. Initial and final observations of pasting characteristics in all structures. Values are mean ± SD of three replicates. *Initial observations on the commencement of experiment (July, 2013). # Final observations in end of experiment (April, 2014).

Structure name	Peak viscosity, cP	Trough viscosity, cP	Breakdown viscosity, cP	Final viscosity cP	Setback viscosity cP	Peak time, minutes	Pasting temp °C	Gelatinization temp °C
H1*	2954 ± 48	2030 ±134	924 ± 182	3112 ± 99	1082 ±35	6.54 ± 0.115	67.23 ±0.491	95.02 ±0.029
H1#	3239 ± 108	2356 ±187	882 ± 81	3298 ± 156	942 ±33	6.58 ± 0.101	67.45 ±0.520	95.05 ±0.050
H3*	3067 ± 110	2108 ±42	959 ± 79	3169 ± 24	1051 ±23	6.52 ± 0.050	67.09 ±0.268	95.02 ±0.029
H3#	3299 ± 88	2361 ±139	938 ± 73	3336 ± 97	975 ±60	6.56 ± 0.103	68.05 ±0.482	95.05 ±0.000

and reduces oxygen (O_2) concentrations. This modified atmosphere inhibits the biotic activity (insect and molds) due to desiccation caused by enriched CO_2 and depleted O_2 concentrations [12].

Breakdown viscosity, gelatinization temperature and peak time in all storage were same and remained constant throughout the storage period (Table 2). Breakdown viscosity is difference between the peak viscosity and the trough viscosity and obtained on holding slurries at high temperature and mechanical shear stress which leads to further disruption of the swollen starch granules resulting in leaching of amylose into the solution [13]. Decreasing of breakdown value indicated that the lost ability of starch granules to rupture after cooking due to ageing process [11]. Higher breakdown viscosity lower will be the elasticity and firmness of end products [14]. Gelatinization temperature is the indicator of required heat to crack the intermolecular bonding and allow the hydrogen bonding. The peak time is the time to attain peak viscosity. It indicates the rate of absorption of water by swelling starch granules [13].

The peak, trough and final viscosity were observed significantly higher in 14% hermetic storage than 12% (Table 2 and Fig. 1). The peak viscosity is the maximum attainable viscosity during heating cycle. It represents the high water binding capacity of starch granules of flour to swell freely before breakdown [15]. Trough viscosity is also known as hot paste viscosity used to represent ability of the paste to with stand breakdown during cooling. It is developed on holding the paste at 95°C [13]. Final viscosity is used to shows the ability of flour to form gel on cooking. Higher final viscosity has positive effect on the end product firmness and elasticity [14]. Re-association of amylose of starch molecules leading to increase in viscosity and results in formation of a gel. It is obtained on cooling the cooked paste to 50°C. This phase is related to retro gradation and reordering of starch molecules [2—13]. A significant increase in pasting temperature was observed in 14% hermetic storage (Table 1). Pasting temperature is the indicator of minimum cooking temperature for a particular food material and the involved energy costs. Higher amylose content, bigger starch granules and high resistance towards swelling cause the high pasting temperature [15].

Conclusion

In the present study, variations in pasting characteristics were observed in between two different initial moisture content of stored wheat under hermetic storage. Peak, trough, and final viscosity were increased with the storage time except setback in nine months' duration. The higher initial moisture content (14%) yields higher peak, trough and final viscosity under hermetic storage. Gelatinization temperature, breakdown viscosity and peak time were same and remained constant throughout the storage period under both initial moisture content (12% and 14%). Higher pasting temperature was observed in 14%

hermetic storage than 12%. The grains were insect free, bright and sound after completion of storage period of nine months. The findings of this experiment might encourage processor for utilization of hermetic bags in place conventional chemical method. It is an environment benign and chemical free technique to save quality and quantity of agricultural produce. Further studies are needed to determine the effect of storage temperature and gas concentrations on stored product under hermetic bags.

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