

# Hydration characteristics of wheat grain

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**Abstract:** The hydration characteristic of wheat was studied by soaking in water at temperatures of 30 (room temperature) 50, 60 and 70°C in constant temperature water bath. The weight gain due to the hydration process was determined in terms of moisture content (% d.b). Water absorption rate was high at the early stage of hydration (10-30 min depending on temperature) followed by a decreased rate and finally approaching equilibrium condition. Peleg's equation adequately described the hydration characteristics of wheat under the experimental condition ( $R^2 = 0.95$  to  $0.99$ ). The Peleg rate constant  $k_1$  decreased while Peleg capacity constant  $k_2$  increased significantly with an increase in temperature from room temperature to 70°C, demonstrating that the water absorption rate increased and water absorption capacity decreased with increase in temperature. The agreement between experimental and estimated values of the hydration data ( $R^2 = 0.97$  to  $0.99$ ) confirmed that Peleg's equation could be used to describe the hydration characteristics of wheat under the experimental conditions considered.

**Keywords:** soaking, hydration, EMC, model

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## 1 Introduction

Wheat is one of the world's most important grains and most extensively grown crop with annual world production of about 690 MT (2010). It contributes about 38% of the total annual cereal production of India. It has been reported that the production of wheat in the year 2010-11 was 85.59 million tonnes. Approximately 70% of Wheat is used for food production and India emerged as the second largest producer after China. Wheat is major cereal in India after rice. It is extensively used as a staple food and prime source of energy. The per capita availability of wheat is 135.8 g in India. Wheat through the centuries has been intimately associated with human food. It is a major component of most diets of the world because of its agronomical adaptability, ease of sustained nutritional

qualities in storage and the ability of its grits to produce a variety of palatable, interesting and satisfying food. Wheat products are mainly taken as a source of carbohydrates. Cereals grains contribute 50% of the world's dietary calories. Wheat provides slightly less than 20% of total calories (Pomeranz, 1988). A wide range of food products such as bread biscuit, cake, pasta, fortified cereals pet foods and other special food products are prepared from wheat. Precooking of wheat is that the heat treatment given during preparation kills the germ, thus the eliminating the scope for; hydrolysis of lipids due to inactivated responsible enzymes. Increasing the shelf life of products parboiling treatment imparts requisite hardness too. In general, three major steps in pre-cooking process i.e. soaking, steaming and drying have great influence on the final characteristics and quality of the end product. Several physico-chemical changes take places within the grain during parboiling. It is necessary to exercise proper control over the process parameters like temperature and time so as to obtain the desired changes in the grain during parboiling. Since

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water is absorbed at different by cereal grains, there has been interest in characterizing the absorption process of the material. Thus the absorption data in the form of water content verses time have been fitted and interpreted by different mathematical models based on diffusion and theories (Becker, 1960) performed a quantitative analysis of water uptake by wheat grain employing a simplified solution of Fick's diffusion equation. Soaking is the important unit operation which facilitates for further processing. Hence there is a need of to study the hydration characteristics of wheat grain for development of value added products from wheat. There is a need to know hydration characteristics wheat. So the study of hydration characteristics of wheat was taken up.

## 2 Materials and methods

Wheat (*Triticum aestivum*, local name: Kalyan) of proper maturity procured from the local market was used in the study. The raw wheat was subjected to conventional cleaning by screening to remove foreign matter, broken kernels, chaff etc.

### 2.1 Moisture content

Moisture content of raw wheat was determined by standard air oven method. About 10 g of representative sample was weighed and kept in oven at  $105 \pm 2^\circ\text{C}$  for 24 hours. The moisture content loss after 24 hours was measured and the moisture content of the material was expressed in percent (w.b.) and (d.b).

### 2.2 Experimental setup

A constant temperature water bath (Figure 1) was used for soaking experimental consist of a water holding chamber with an immersion heating coil for heating the water and a thermostat for control of water temperature. The required temperature can be obtained by adjusting the knob.



Figure 1 Water bath oven

### 2.3 Hydration characteristics of wheat

Clean raw wheat was soaked at different temperatures in constant temperature water bath, under atmospheric condition, to determine the hydration behavior of wheat.

### 2.4 Experimental procedure

The soaking test was conducted in an aluminum container. The constant temperature water bath was adjusted to a temperature of  $2^\circ\text{C}$  higher than the required temperature of soaking. Water uptake of wheat grain was determined by soaking 10 g samples in screw-tap flasks containing 150 mL of distilled water. The soaking temperatures studied were 30, 50, 60 and  $70^\circ\text{C}$ . Before performing hydration experiments the flasks with water were placed in thermostatically controlled oven fixed at the required soaking temperature for several hours to reach thermal equilibrium. Then, the grains were poured into the screw-tap flasks and experimental procedure was started. These were placed in a constant temperature stirred water bath, controlled within  $\pm 0.5^\circ\text{C}$  of the testing temperature. At regular intervals the flasks were withdrawn from the bath for moisture content determination. The soaked grains were filtered through an 80 mesh sieve to remove the surface water and weighed to an accuracy of  $\pm 0.1$  mg. This procedure was established based on the preliminary test results and other previous studies (Abu-Ghannan and McKenna, 1997; Haros, Viollaz and Suarez, 1995; Muthukumarappan and Gunasekaran, 1991). Then, the grains were placed in an oven for moisture content determination (AOAC, 1995).

## 3 Results and discussion

The results of the water absorption measurements in plain water at 30, 50, 60 and  $70^\circ\text{C}$  are given in Figure 2. It can be concluded that temperature drastically affected the water absorption. It is observed that for each tested temperature the rate of water absorption was highest during the initial stages, decreasing gradually as moisture content approaches saturation. Water absorption curve at  $70^\circ\text{C}$  exhibited atypical behavior as the amount of water absorbed increased to a maximum, at about 90 min and progressively decreased for higher soaking time. This would be due to the loss of solids during the hydration of the grain.

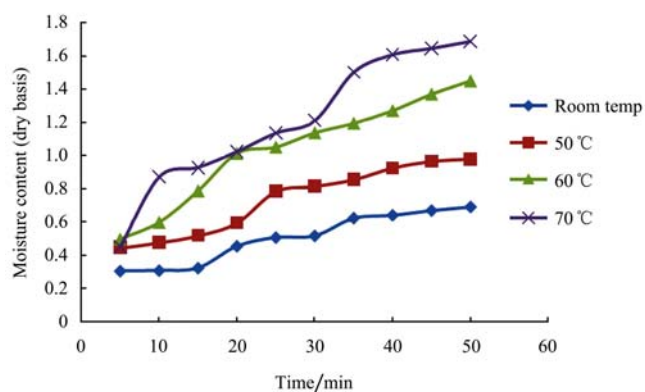


Figure 2 Water absorption curves during soaking of wheat grain

$$\frac{u(t)}{u_s} = 1 - \frac{6}{\pi^2} \sum_{n=1}^{\infty} \frac{1}{2} \exp\left(-\frac{n^2 \pi^2 D t}{a^2}\right) \quad (1)$$

Water absorption in food products has been described in the literature by models assuming that the process is controlled by water diffusion inside the material. When this occurs, the analytical solutions of Fick's second law were often used. For spherical geometry this model can be expressed in terms of the fraction of total absorption,  $u(t)/u_s$  as stated in Crank (1975):

Where  $u(t)$  is the mean moisture content;  $u$  is the saturation or equilibrium moisture content;  $a$  is the radius;  $t$  the time and  $D$  the diffusion coefficient. A quite simple non exponential empirical equation was proposed to model water absorption and desorption by food materials and became known as the Peleg equation (Peleg, 1988):

$$u(t) = u_0 + \frac{t}{k_1 + k_2 t} \quad (2)$$

where,  $u_0$  is the initial moisture content, and  $k_1$ ,  $k_2$  constants. This equation is usually written in a rather simple way to test its ability to fit experimental curves:

$$\frac{t}{u(t) - u_0} = k_1 + k_2 t \quad (3)$$

According to Peleg (1988), one of the main advantages of Equation (3) is to predict water absorption kinetics for a relatively long time of absorption, i.e., equilibrium moisture content from short-time experimental data. However, criteria to define the so called "short-time experimental data" was not established. In this work Peleg's equation was used to fit the experimental data within the curvilinear segments of absorption curves and away from the equilibrium

conditions (i.e., during the period of increase in moisture content). The results of the linear regression analysis of Equation (3) fitted the data at hydration temperatures of 30-70°C are shown in Table 1. The correlation coefficient,  $r^2$  varied from 0.953 to 0.989 with  $P$  less than 0.001, indicating to good fit to the experimental data. This suggests that Peleg's equation suitable for describing the absorption kinetics of wheat grain at hydration temperature of 30 to 70°C.

Table 1 Values of  $k_1$  and  $k_2$  of Peleg's equation and correlation coefficient  $r^2$  for wheat grain soaking in water

Temperature/°C	$K_1$	$K_2$	$R^2$
30	61.355	0.962	0.980
50	26.769	0.763	0.956
60	16.490	0.495	0.953
70	14.070	0.391	0.957

For the four soaking temperatures tested, the constants  $k_1$  and  $k_2$  show a net tendency to decrease with increase of temperature. These observations are in contrast with finding the observations in the literature for other products. Abu-Ghannan and McKenna (1997) found that the Peleg constant  $k_1$  was fairly constant with temperature during water hydration of red kidney beans. Similar results were reported by Sopade and Kaimur (1999) for hydration of soybean and peanuts and by Maskan (2002) during water soaking of wheat flour. Andrea, Roberto and Constantino (2006) confirmed the same for hydration kinetics of Amaranth grains.

## 4 Conclusions

The following conclusions were drawn within limitation of the present study.

- 1) The moisture content and the moisture uptake rate increases with increase in soaking temperature.
- 2) The hydration study of Kalyan variety of wheat showed linear relationship between soaking time and moisture content with correlation coefficient value more than 0.90.
- 3) Peleg's equation adequately described the hydration characteristics of wheat under the experimental condition.

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