

MODELING WATER ABSORPTION OF SORGHUM DURING SOAKING

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Abstract— Water absorption of sorghum during soaking in water at temperatures of 10, 20, 30, 40 and 50 °C was simulated using Peleg's model. The weight gain during soaking process was determined in terms of moisture content. Peleg's equation was adequately capable to predict water uptake of sorghum under the experimental conditions. The Peleg rate constant, k_1 , and capacity constant, k_2 , decreased from 11.8×10^{-2} to 0.95×10^{-2} h %⁻¹ and 2.46×10^{-2} to 2.06×10^{-2} %, respectively, with increasing temperature. The effective diffusivity was evaluated by fitting experimental absorption data to Fick's second law of diffusion. Effective diffusivity of water varied from 8.376×10^{-12} to 2.22×10^{-12} m².s⁻¹ over the temperature range studied, with an energy activation of 24.21 kJ.mol⁻¹. The temperature dependence of the diffusivity coefficient was described satisfactorily by Arrhenius-type relationship.

Keywords— Peleg's model, Soaking, Sorghum, Water absorption.

I. INTRODUCTION

Sorghum (*Sorghum bicolor* L. Monench) is an important crop in semiarid tropics of Africa and Asia, and constitutes a major source of carbohydrates and proteins for people living in these regions. In developing countries the commercial processing of this locally grown grain into value-added food and beverage products is an important driver for economic development (Good *et al.*, 2002). Lately there has been a growing research in sorghum with respect to its potential for starch production (Buffo *et al.*, 1998). Recently, production of malt from wheat, sorghum and other cereal grains rather than barley has begun in the world. In the malting process, carefully selected grains are soaked in water until saturation before germination. In malting process, steeping time and temperature had a highly significant effect on malt quality (Briggs, 1997). Adding water is also a pre-treatment for the flour milling process (tempering). The kinetics of water absorption has been extensively studied for traditional food products such as cereal grains and legumes (Abu-Ghannam and McKenna, 1997; Hung *et al.*, 1993; Sopade *et al.*, 1992; Turhan *et al.*, 2002).

Mathematical modeling of hydration process is known to be important for the design and optimization of food process operations. These models are classified to theoretical, empirical and semi-empirical, and despite

of the widespread application of computers and their associated softwares, empirical equations are still extensively used in view of their simplicity and ease of computation (Turhan *et al.*, 2002; Sopade *et al.*, 2007). Peleg's equation is popular empirical non-exponential model and some of its parameters are of immense practical significance in hydration kinetics that applied to weight gain during rehydration (Peleg, 1988; Singh and Kulshrestha, 1987; Turhan *et al.*, 2002; Sopade *et al.*, 2007; Cunningham *et al.*, 2007)

Peleg (1988) proposed a two-parameter sorption equation and tested its prediction accuracy during water adsorption of food products. The original form of the Peleg model is as in Eq. (1), which can be rearranged to Eq. (2):

$$M_t = M_0 \pm \frac{t}{K_1 + K_2 t} \quad (1)$$

$$\frac{t}{M_t - M_0} = K_1 + K_2 t \quad (2)$$

It follows that the absorption rate at the beginning of soaking process is expressed subsequently as showing that k_1 is linked to water absorption rate, R_0 (Peleg 1988).

$$R_0 = \left. \frac{dM}{dT} \right|_{t \rightarrow 0} = \frac{1}{K_1} \quad (3)$$

The Peleg capacity constant, K_2 , relates to maximum attainable moisture content. As $t \rightarrow \infty$, Eq. (4) gives the relation between equilibrium moisture content (M_e) and K_2 :

$$M \Big|_{T \rightarrow \infty} = M_e = M_0 \pm \left(\frac{1}{K_2} \right) \quad (4)$$

To authors' knowledge there is no information about soaking of sorghum. Therefore, this study was carried out to evaluate the physical properties of sorghum kernel and determine the applicability of Peleg's equation in modeling of water absorption and also to find out the diffusivity and activation energy of sorghum kernel during soaking at different temperatures.

II. MATERIALS AND METHODS

A. Sample preparation

Sorghum (*Sorghum bicolor* L. Monench) samples harvested in 2007 were obtained from the Karaj field crops Research Institute, Tehran, Iran. Samples were cleaned manually to remove foreign materials and broken, cracked and damaged grains, then sealed in polyethyl-