GEOMETRY EFFECT ON WATER DIFFUSIVITY ESTIMATION IN PROINTA-ISLA VERDE AND BROOM WHEAT CULTIVARS

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***Abstract* — The effect of geometry representation of the grain kernel in the estimation of the effective diffusion coefficient of water in wheat, cv. Broom, is studied. Isothermal thin layer drying is assumed. The two-dimensional diffusive mass transport equation is solved for spherical and ellipsoidal geometries. The effective diffusion coefficient was estimated for drying air temperatures of 64, 70 and 75°C and initial grain moistures of 0.22, 0.25 and 0.28 db. Results were correlated by means of Arrhenius-type functions, varying from 2.953×10^{-11} to 6.687×10^{-11} m^2/s for ellipsoidal geometry and from 3.336×10^{-11} to 7.772×10^{-11} m^2/s for spheres. An average ratio of diffusion coefficients for ellipsoid to those for spheres was calculated to be about 0.85, very close to the value of 0.86 obtained in a previous work for the "PROINTA-Isla Verde" wheat cultivar. This ratio can be considered to be equal to the wheat sphericity squared.**

***Keywords* — Wheat, Thin layer drying, Diffusivity estimation.**

I. INTRODUCTION

The estimation of effective transport parameters in grains is usually based on experimental data of the mean moisture content evolution (oven moisture determinations) and not on local intragranular values or measured gradients**.** Diffusive kinetic models are used to interpret the phenomenon of drying, and thus the estimated values will be affected by the model hypothesis: geometry, boundary conditions, constant or variable physical and transport properties, isothermal or non isothermal drying.

Recently, Gastón *et al*. (2002) reported a study of the effect of geometry representation of the grain kernel in the estimation of the effective diffusion coefficient of water in wheat, during desorption. The results obtained for wheat cv. "PROINTA-Isla Verde", by considering the grain as sphere and axisymmetric ellipsoid showed that differences between estimated parameters may be related with grain sphericity. Some authors (Aguerre *et al*., 1987; Kang and Delwiche, 2000) had proposed that diffusivities in both geometries are related to sphericity squared, but it is understood here that evidence was not yet provided to support that assumption. To verify this observation and the trend of Gastón *et al*. (2002), the present work extends the study by including measured data on a different variety, the spring wheat cv. *Broom*. Data was collected in a different thin layer drying rig, fitted with tray weighing "in situ" and infra-red pyrometry (Bruce, 1985, 1992). Isothermal thin layer drying of wheat is assumed, for the sake of consistency with previous work. Spherical and axisymmetric ellipsoidal geometry are assigned to the grain body and the two-dimensional diffusive mass transport equation is solved applying the Finite Element Method (FEM). The effective diffusion coefficient is estimated by minimizing the sum of squares of the residuals between numerically predicted and experimental average grain moistures.

II. MATHEMATICAL MODEL

If an isothermal process is considered, the variation of moisture content inside the grains can be represented by:

$$\frac{\partial W}{\partial t} = D\ \nabla^2 W \qquad in \quad \Omega, \tag{1}$$

$$W(t=0) = W_0 \qquad in \quad \Omega, \tag{2}$$

$$W = W_e \quad on \quad \Gamma, \tag{3}$$

where Ω represents the complete domain of the grain body and Γ its boundary surface. The grain is assumed as homogeneous and isotropic material experiencing negligible volume changes and keeping a constant mass diffusivity during drying. The boundary condition described by Eqn. (3) implies that at the grain surface the equilibrium moisture content W_e is attained instantaneously. This strict internal control for wheat drying was found for this conditions using a Biot number analysis (Giner and Mascheroni, 2001). The Modified Henderson-Thompson equation with parameters for hard wheat is applied to calculate the value for W_e (Brooker *et al*., 1992). The isothermal drying assumption was taken based on the knowledge that the relaxation rate of the heat transfer potential (represented by the thermal diffusivity) is about 6000 as high as that for the mass transfer potential (diffusion coefficient) (Giner and Mascheroni, 2001) and for