INFLUENCE OF COOKING IN SORPTION ISOTHERMS OF *PINHÃO* (*ARAUCARIA ANGUSTIFOLIA* SEEDS)

F. CLADERA-OLIVERA[†], C.P.Z. NOREÑA[†], A.C. PETTERMANN[†] and L.D.F. MARCZAK[‡]

† Institute of Food Science and Technology, Federal University of Rio Grande do Sul, (ICTA-UFRGS), Porto Alegre, RS, Brazil. florencia.cladera@ufrgs.br, czapatan@ufrgs.br, apettermann@hotmail.com

‡ Department of Chemical Engineering, Federal University of Rio Grande do Sul (UFRGS), Porto Alegre, RS, Brazil. ligia@enq.ufrgs.br (Corresponding author)

***Abstract* -- The seeds of *Araucaria angustifolia*, commonly known as *pinhão*, are widely consumed in both Southern and Southeastern Brazil due to their high nutritious value. Moisture desorption isotherms of cooked *pinhão* were determined at 15, 25, 30 and 40 ^oC and modeled using well know isotherm models. Results show that Chirife model most appropriately represents the experimental data as reported previously for raw *pinhão*. The differential enthalpy was calculated and decreased as moisture content increased, becoming almost constant at 0.3 kg water kg^{-1} dry solids. Values, for each moisture content, were smaller than those reported for raw *pinhão*. The enthalpy-entropy compensation theory was applied to desorption isotherms providing the isokinetic temperature (401 ± 17 K). It was found that the desorption process investigated was enthalpy controlled as previously reported for raw *pinhão*.**

***Keywords* -- *Pinhão, Araucaria angustifolia*, seed, sorption isotherms, thermodynamic properties, enthalpy-entropy compensation.**

I. INTRODUCTION

Brazilian Pine (*Araucaria angustifolia*) belongs to the Araucariaceae family and is the most economically important native conifer species in Brazil (Zandavalli *et al.*, 2004). It is found in both Argentina and Brazil, stretching from southern states of Paraná, Santa Catarina and Rio Grande do Sul in Brazil to northern Argentina. People in the south of Brazil usually consume the seeds of this tree - known as *pinhão* - after being cooked and peeled. *Pinhão* is considered a source of starch, dietary fiber, magnesium and copper and its intake produces a low glycemic index (Cordenunsi *et al.*, 2004). *Pinhão* is a seasonal product, which is produced from April to August. Since the seeds have a high moisture content, they can be easily contaminated by fungi during the stockpiling, hindering its commercialization. Nutritional and technological aspects of *pinhão* are scarcely found in scientific literature. We have previously reported desorption isotherms of raw *pinhão* (Cladera-Olivera *et al*., 2008) showing that temperature has little effect on the desorption behaviour and the Chirife model was found to best represent the experimental data.

The *pinhão* seeds can also be used to produce flour, after being cooked, peeled, dried and grinded. Cladera-Olivera *et al*. (2009) have reported the adsorption isotherms, for temperatures between 10 and 40^{o}C, and applied the enthalpy-entropy compensation theory for *pinhão* flour. The authors found that the Chirife model was the most appropriate to describe the isotherms and that the adsorption processes was enthalpy controlled.

Another important and promising use that can be given to *pinhão* seeds is the use of its starch. The seeds have a starch content around 35% (wet basis) which can be easily extracted. Recently, Thys *et al.* (2010) presented the sorption isotherms for *pinhão* starch at temperatures ranged from 10 to 40^{o}C and found that Peleg model most appropriately represents the experimental data and that the adsorption process investigated was spontaneous and entalphy-controlled.

The sorption isotherms describe the relationship between water activity (equilibrium relative humidity) and the equilibrium moisture content of a given food at constant temperature; these represent an extremely valuable tool for food scientists and technologists since it can be used to predict potential changes in food stability, for storing method determination, packaging and ingredients selection, design and optimization of drying equipment. Several mathematical equations can be found in literature describing water sorption isotherms and nine of these equations are used in this work.

Thermodynamics is one of the approaches used in order to understand the properties of water and calculate energy requirements associated with heat and mass transfer in biological systems. Some thermodynamic functions employed in the analysis of sorption behavior in biological systems include the total heat of sorption, differential enthalpy, differential entropy and enthalpy-entropy compensation, which are calculated from sorption isotherms. The total heat of sorption (ΔH) is the total energy required to transfer water molecules from vapor state into a solid surface or vice-versa. It is useful, for example, in predictive drying models and in the design of drying equipment (Fasina, 2006). The isosteric heat of sorption or differential enthalpy (Δh) is the total heat of sorption minus the latent heat of vaporization for water and is a measure of the water-solid binding strength (McMinn and Magee, 2003). This is an important property which is employed for both design work and qualitative understanding of the water state on the food surface (Tolaba *et al.,* 2004). The differential entropy (Δs) of a material is proportional to the number of available sorption sites at a specific energy level (Madamba *et al.,* 1996). Gibbs free energy (ΔG) may be an indicative of the affinity of sorbents for water and provides a criterion to whether water sorption occurs as