SORPTION ISOTHERMS AND THERMODYNAMIC ANALYSIS OF SEED FRUITS USED TO OBTAIN VEGETABLE OIL

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Abstract - Sorption isotherms of papaya, melon and grape seeds were determined and thermodynamic properties compared. The experiments were carried out at different temperature using the gravimetric method. The Henderson and GAB models were the best which represented the experimental data. Papaya and grape seeds are more stable with larger moisture content than melon seeds at 30°C. Grape seeds presented more resistance to lose water during the dehydration. The differential enthalpy and entropy decreased with increasing moisture content and satisfied the compensation theory. It was found that the sorption process investigated was enthalpy-driven.

Keywords — seeds, grape seeds, melon seeds, papaya seeds, thermodynamics.

I. INTRODUCTION

Much of the fruit production is destined for processing candies, extracts, juices and pulps. Each processing, tonels of waste are generated and discarded, causing problems to the environment and to the companies. Some studies emphasize the use of seeds from industrial discharges to obtain vegetable oils (Arvanitoyannis et al., 2006; Jorge and Malacrida, 2008; Jorge et al., 2009). Besides being consumed in the food, this vegetable oil can be used in the chemical industry, pharmaceutical and biodiesel production. Malacrida (2009) noted high lipid content in Papaya seeds (Carica papaya L.) and melon seeds (Cucumis melo inodorus) when compared to the content found in soybean seeds and indicated the studied seeds as a good source of oil. The study showed that the papaya and melon seeds presented higher protein content than that found in rice, corn, oats and wheat. According to Crews et al. (2006), grape seed oil has a high content of unsaturated fatty acids and phytosterols, suitable for a diet to reduce cholesterol levels. For a large scale production is necessary to know some characteristics of seeds and their stability attributes, as well as the process variables, because to obtain vegetable oil is necessary that the seeds are dehydrated. The knowledge of the existent relations between the temperature and the air relative moisture is very important to control microbial growth and ensure seed quality during storage, because these tend to exchange moisture with the atmosphere surrounding them. This exchange of moisture content can be increased or reduced according to the hygroscopicity of the seeds and the gradient of potential hydric between the air atmospheric and the seeds (Rizvi, 1986).

The relationship between the water activity and equilibrium moisture content of a product subject to a specific temperature are expressed graphically by the curves of sorption isotherms (Rizvi, 1986). These curves are obtained at constant temperature and pressure and vary with the physical and chemical structure of food (Chirife and Iglesias, 1978). When the product is a solid, the water interactions occur not only in aqueous solution, but also depend on factors such as capillarity and hydration forces, responsible for binding more strongly the water to insoluble macromolecules of food. For this reason the relation between the equilibrium moisture and the water activity in solid foods is usually determined experimentally for each product. From the graphs of sorption isotherms point it is possible to determine thermodynamic functions such as enthalpy differential, which provides informations on the state where water is present in a biological material (Fasina et al., 1997) and the differential entropy, which informs the number of sorption sites for a given level of energy inherent in biological materials (Madamba et al., 1996). This manner it is possible to predict the required energy consumption for the dehydration process as well as the more stable conditions of seeds to the storage.

According to Ferro-Fontan et al. (1982), some foods present a linear correlation between the enthalpy and entropy for water sorption. This linearity is represented by the compensation theory and confirmed by several researchers (Madamba et al., 1996; Telis et al., 2000; McMinn et al., 2005; Fasina, 2006). The slope of the straight represents the temperature at which all reactions in series proceed at the same rate: the isokinetic temperature (T_B).

This work aimed to determine and model the sorption isotherms of papaya seeds, melon seeds and grape seeds using several mathematical models, to determine and compare some thermodynamic properties of the studied seeds and to evaluate the application of the enthalpy-entropy compensation theory.

II. MATERIALS AND METHODS

A. Materials

Sorption isotherms of seeds of grape (Vitis vinifera), papaya (Carica papaya L.) and melon (Cucumis melo inodorus) were accomplished. The seeds were maintained in cold chamber (5°C) until the experiment. Saturated aqueous salt solutions were prepared using NaOH, LiCl, KCl, NaCl, MgCl₂, K₂CO₃, Mg(NO₃)₂, NaNO₃, NaCl, KCl, BaCl₂ and CuSO₄ (all analytical grade) and commercial formaldehyde (40%) was used for cleaning the material and preventing microbial spoilage of samples.