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Determination of desorption isotherms using the DVS apparatus (dynamic vapor sorption system) at different temperatures on unblanched and blanched samples of potato

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ABSTRACT

Knowledge of the evolution of thermo-physical parameters of food especially desorption isotherms is necessary for the quality control of the finished product by facilitating its conservation. The objective of this work is to determine in a first phase of desorption isotherms of potato on blanched and unblanched samples at different temperatures (30 °C, 35 °C and 40 °C) using the DVS equipment (dynamic vapor sorption System). It was found sigmoidal shaped desorption isotherms characteristic of type II sorption isotherms in BDDT classification, and which are functions of temperature. The second phase deals with the modeling of these desorption isotherms. The fit of the experimental values to the different models is done using the Excel Solver, minimizing the mean squared error (MSE). The model Oswin shows a better match between the simulated results and the experimental results.

Keywords : Desorption isotherms, Drying, Mathematical models, potato.

INTRODUCTION

The majority of food products developed or preserved for long, necessarily pass through a drying operation. During the process, the coupled transfers of heat and mass that take place in the product cause physical, chemical and biological changes. These changes are strongly influenced by the water content and the internal temperature during the process. Thus, knowledge of the evolution of thermo-physical parameters of its food especially desorption isotherms is necessary if we are to control the quality of the finished product to facilitate its conservation.

The usefulness of isotherms is twofold: on the one hand, they help know the final water content of a product exposed to defined drying conditions (temperature and humidity), called equilibrium moisture content, on the other, they provide information about the conditions limits in modeling, especially when the materials are highly hygroscopic [1]. From the isotherms, it is also possible to determine the isosteric heat of sorption, which is a measure of the degree of binding water and the amount of energy required to release this water. This energy contribution must be taken into

account when sizing dryers for treating highly hygroscopic products. Works relating to the determination of desorption isotherms of potato, by gravimetry method, have been widely developed by several researchers: Diamante (1991) [2], Wang (1995) [3], LiYe (1996) [4], Rovedo (1998) [5], Chemkhi and Zagrouba (2011) [6]. Many equations have been proposed to model isotherms. Some are based on a theoretical adsorption model, while others are empirical in It was also found in literature that some authors (Keijbets, 1974. Lee and al. 1979; Moledina nature. *etal* 1981; Lamberg & Hallström, 1986; Agblor & Scanlon, 1998), [7-10] are blanch the potato before making experimental tests.

Blanching is a unit operation widely used in the processing industry to remove air from the tissue, to induce leaching of accumulated sugars in order to control the Maillard reaction Subsequent during frying, to gelatinize the starch and to inactivate enzymes that are present in the plant tissue. This study focuses on modeling the desorption isotherms of potato samples unblanched (raw) and blanched potato at three different temperatures. Determining desorption isotherms was carried out using the apparatus DVS (dynamic vapor sorption system). Mathematical models have been tested to model the desorption isotherms.

MATERIALS AND METHODS

Description of the Dynamic System of vapors sorption (DVS)

The equipment used for the determination of desorption isotherms is the DVS system. The heart of the DVS system is a microbalance continuously recording sensitivity capable of measuring changes (mass of sample) of less than 1 µg. This type of microbalance main characteristic is to have a very good long-term stability and is therefore ideal for measuring vapor sorption phenomena that last from minutes to days. This microbalance is placed in an incubator to generate a constant and accurate temperature measurement. The required relative moistures are generated by mixing a flow of dry vapor and a stream of saturated vapor in the appropriate proportions using precision flow meters. Combined probes of humidity and temperature are located just below the sample and reference platforms to enable independent verification of system performance. The microbalance mechanism is very sensitive to sorption and desorption of moisture. The DVS instrument is connected to a computer with the AMR-CONTROL software via an RS-232 type acquisition center for storing and processing data. Each measurement file saved to a fixed temperature, shows the evolution of the mass of the sample of the potato depending on the humidity and time.

The oven of the apparatus is programmed to perform a rapid rise in the temperature of the desired isotherm. After a few minutes stabilization of the oven temperature, mass loss recording can begin. The gas flow is adjusted so as to be higher (at least five times) the steams flow from the sample. For each isotherm point at a fixed temperature, the DVS maintains the constant relative humidity for a while. The DVS goes to the next step only when humidity sample mass (m) is stable for some time.

At the end of each test the dry matter (ms) is determined by placing the sample in an oven at 105 ° C for 24 hours, until a constant mass is obtained. The mathematic formulation of content of water in equilibrum (Xeq) balance is calculated as follows:

$$Xeq = \frac{m - ms}{ms} (Kg water / Kg ms) \quad (1)$$

The determination of the desorption isotherms on blanched and unblanched potato samples, will be performed at three given temperatures: 30°C, 35°C and 40°C.

Samples preparation

Potatoes (*Solanum tuberosum*) Ballerina variety was stored in a refrigerator at 4 ° C, in 5 kg bags for the duration of the tests. Potato tubers were peeled and washed with tap water, then cut (45mmx20mmx10mm) and blanched in boiling water (100 ° C) for 3 min [11]. The samples are then immediately cooled with cold water and then drained in a colander [12].

RESULTS AND DISCUSSION

Presentation of results

The desorption isotherm is defined from a number of points obtained for different relative moistures ranging from 0 to 80%. It was noted during our experiments, for 90% humidity the mass was not completely stabilized at the end of the level (the level has been stopped after a while). The value found for 90% is not correct because unstabilized. It is quite usual for a product with a high moisture content and under high relative moisture conditions.

The sorption isotherms have a sigmoidal shape characteristic of type II sorption isotherms in BDDT classification [13]. The same type of desorption isotherms was observed in previous studies [6, 14-15].

The results obtained on the potato samples blanched and unblanched, for three different temperatures (30, 35 and 40 ° C) are shown in Figures 1, 2.

Figures 1 and 2 clearly show that the desorption isotherm is a function of temperature. For a given value of relative moisture, the water content in equilibrium decreases when the temperature increases. This confirms previous research in this area, [6, 14-15]. It is also noted that for a given temperature, the water content in equilibrium increases as the relative moisture increases.

Figures 3, 4 and 5 show that, for a given temperature the water content in equilibrium of blanched potato are lower than that of unblanched potato. Indeed, blanched potato has undergone a structural change in such starch polymers. The degree of hydrogen bonding in such polymers is reduced thus causing a significant loss of water from the product.

Determination of the isothermal model

Several mathematical models have been developed in the literature to correlate the water content in equilibrium with the surrounding relative moisture [16- 19].

The most commonly used models to determine food isotherms (Halsey, Gab and Oswin) were tested in their range of validity. The adjustment of the experimental values to the different models is done using the Excel Solver, minimizing the mean squared error (MSE) given by the formula:

$$X_{eq} = k\left(\frac{Hr}{1-Hr}\right)^{n} \quad (2)$$

$$MSE = \frac{1}{N}\sum_{1}^{N}\left|X_{eqcal} - X_{eq\exp}\right|^{2} \quad (3)$$

The quality of the adjustment of the models is assessed by examining the distribution of the experimental points from the curves of the models and by the values of mean square errors [20].

Given the low validity ranges or poor performance, the Halsey and Gab models have not been retained. The model shows a better match Oswin results for blanched potato and unblanched potato. The Oswin mathematical expression model is given by the water content in equilibrium (*X*eq) depending on the relative moisture (*Hr*). Table 1 shows the mean square errors of the values obtained after adjusting for different desorption isotherms models tested.

The model results were compared with the experimental results. The values of the models show a good agreement with the experimental results (Table 2).

These results are comparable to those recorded by other workers, with Mc Laughlin and TRA Magee (1998) [15], reporting that the Hasley and Oswin model gave a good fit with the experimental sorption isotherms of potatoes. Wang and Brennan (1995) [3], showed that the GAB and Oswin models gave a good fit for the sorption isotherms of potatoes in the range O-88% Sorption isotherms potatoes show that moisture, and the BET model in the range O-60% moisture. increasing the temperature leads to a decrease of the moisture content for all water activities.

CONCLUSION

The study of desorption isotherms of blanched and unblanched potato was made with the DVS system. It was found sigmoidal shaped desorption isotherms characteristic of type II sorption isotherms in BDDT classification, and are functions of temperature. The blanched potatoes water content in equilibrium is lower than that of unblanched potato.

The Oswin model was used to fit the experimental results. Thus, the model results compared with experimental results show very good agreement.

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