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Research Article

EXPERIMENTAL DETERMINATION AND MODELIZATION OF SORPTION CURVES OF ORIGANUM MAJORANA AND MENTHA PULEGIUM LEAVES

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Abstract:

The determination of sorption isotherms is a necessary step and a preferred way to know the distribution and intensity of water connections in food products. These isotherms are used to determine the final water content in reach to optimize the conditions of storage and drying of these products and for providing valuable information about the hygroscopic equilibrium of the product to dry and store. This study aims both to experimentally determine the desorption isotherms and adsorption of two medicinal plants namely Marjoram (Origanum Majorana) and Mint Pennyroyal (Mentha pulegium). The experimental results are then smoothed by the GAB model for the description of equilibrium state of these products and their isosteric heats.

Keywords: Modeling, marjoram, isosteric heat, conservation, sorption isotherms, pennyroyal mint.

INTRODUCTION

Experimental determination of sorption curves, development and use of mathematical models can help improve the quality of treatment of medicinal and aromatic plants. Many equations have been suggested in the literature to represent the relationship between equilibrium moisture content and relative humidity [1]. The choice of these two plants is justified by their abundance and importance in the area of herbal Marrakech (Morocco). They are widely used as an infusion with tea and in the cosmetic and pharmaceutical industry. We first experimentally determined the sorption isotherms of leaves of marjoram and pennyroyal. Indeed, knowledge of such information can be dried [2] under conditions that ensure their preservation without altering their essential oils and their active ingredients. The GAB model [3], based on a theory of multimolecular adsorption localized and homogeneous, perfectly describes these isotherms in the range of activity ranging from 0 to 90%. Finally, the isosteric heat of sorption was determined.

EQUIPMENT AND PROCEDURE

We chose the static gravimetric method, and we used saturated salt solutions: KOH, ($MgCl_2$ $6H_2O$), K_2CO_3, $NaNO_3$, KCl and ($BaCl_2$ $2H_2O$). These solutions are prepared in sealed jars and are kept in a temperature controlled oven [4]. The sample is suspended in the jar, above the salt, and therefore remains in a stable atmosphere

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temperature and humidity. The experiment was performed for three temperatures 30, 40 and 50 ° C. The mass of product used for desorption is 0.400 ± 0.001 g and 0.100 ± 0.001 g for the adsorption. Monitoring of weight losses for desorption and mass gain for the adsorption is provided by a precision balance ± 0.001 g. The hygroscopic equilibrium is obtained when the exchange between the product and the ambient air is over. Once the wet masses are determined, the samples are introduced in an oven at 105 ° C for 24 h to determine their dry weights.

The product is undergoing pre-drying for the adsorption. The pre-drying is carried out in an oven heated to a temperature of 50 ° C and to this maximum dehydration of the product.

MODELING CURVES SORPTION

Several authors have proposed mathematical models in empirical form to describe the relationship between the graph of equilibrium water content, the equilibrium relative humidity and temperature. In this work, we chose the GAB model (Table 1).

Table 1: Mathematical model applied to two plants's sorption curves

Autors	Model	Parameters	References
Guggenheim Anderson Boer (GAB)	$X_{eq} = \frac{ABCa_w}{[1-Ba_w][1-Ba_w+BCa_w]}$	$B = B_0 e^{\left(\frac{h_1}{RT}\right)}$ $C = C_0 e^{\left(\frac{h_2}{RT}\right)}$	[3]

The correlation coefficient (r) is one of first criteria to predict best equation describing sorption isotherms. In addition to r, the average relative error (EMR) and standard error of moisture (ESH) are used for the same purpose. These statistical parameters are calculated as follows:

$$ESH = \sqrt{\frac{\sum_{i=1}^{N}\left(Xeq_{i,exp} - Xeq_{i,pre}\right)^2}{d_f}}$$

$$EMR = \frac{100}{N}\sum_{i=1}^{N}\left|\frac{Xeq_{i,exp} - Xeq_{i,pre}}{Xeq_{i,exp}}\right|$$

RESULTS AND DISCUSSION

The hygroscopic equilibrium is reached for marjoram after 12 days to 9 days for desorption and adsorption and mint for 13 days for desorption and adsorption for 9 days. The hysteresis phenomenon is observed for the sorption isotherms of the two plants at 40 ° C (Figure 1). The adsorption-desorption curves show that for a constant relative humidity, the water content of desorption is higher than adsorption. Figures 2 and 3 show that the sorption isotherms have a sigmoidal shape, similar to those commonly presented by the aromatic and medicinal products [5, 6, 7], Figure 4 illustrates the modeling of these curves of sorption and the isosteric heat is given in Figure 5. The experimental curves obtained show that for a given relative humidity,

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equilibrium moisture content increases as the temperature decreases, which is consistent with other results presented in the literature [7].

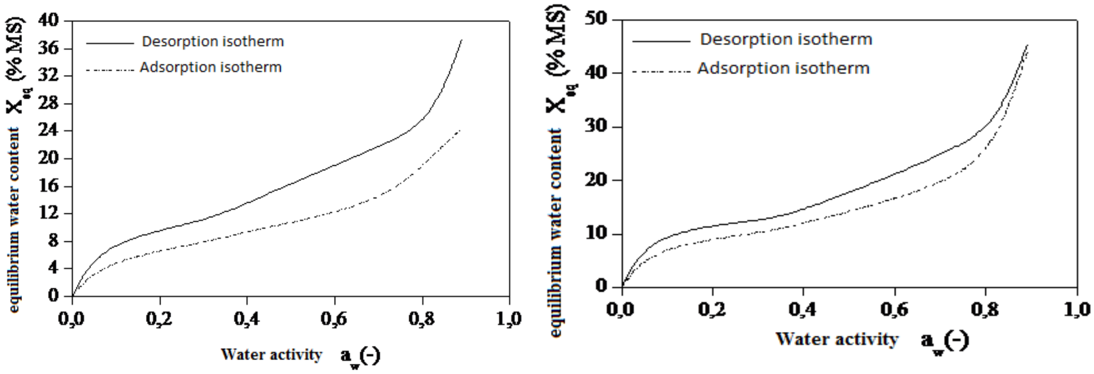

Figure 1: Demonstration of sorption hysteresis effect observed for two plants at 40 ° C.

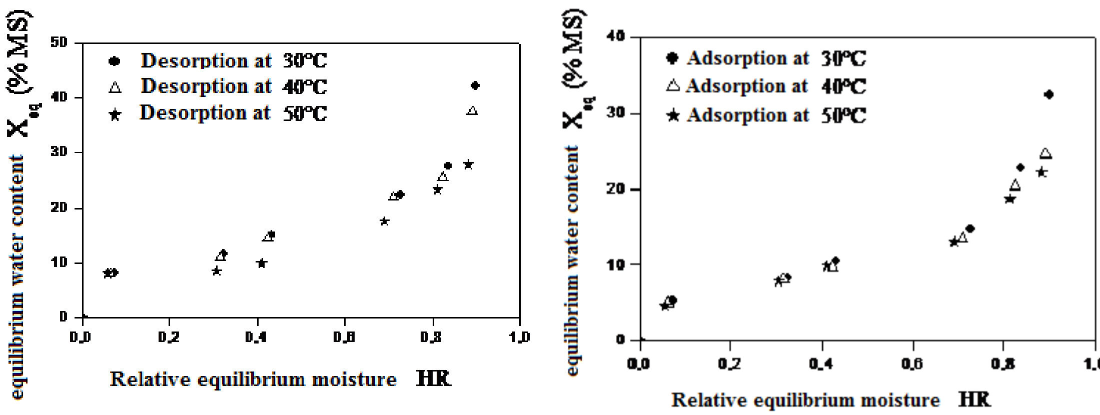

Figure 2: Adsorption - desorption isotherms marjoram

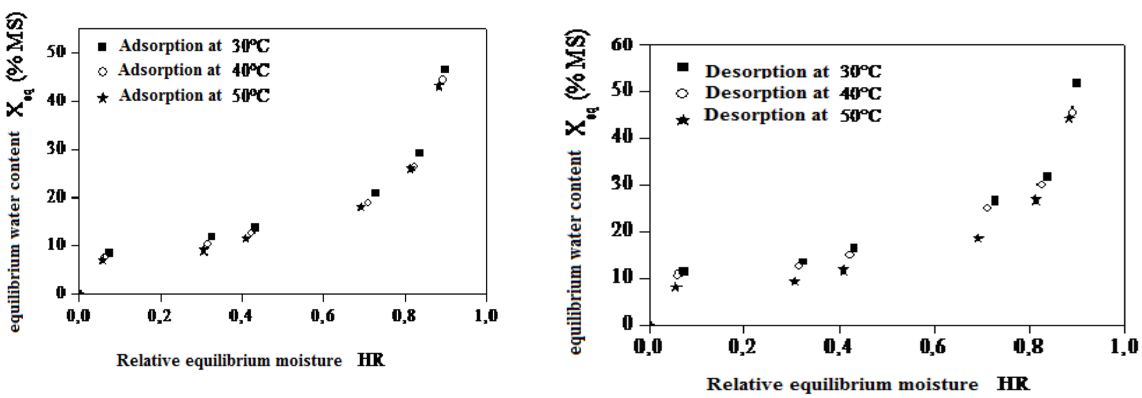

Figure 3 : Adsorption - desorption isotherms OF Mentha pulegium.

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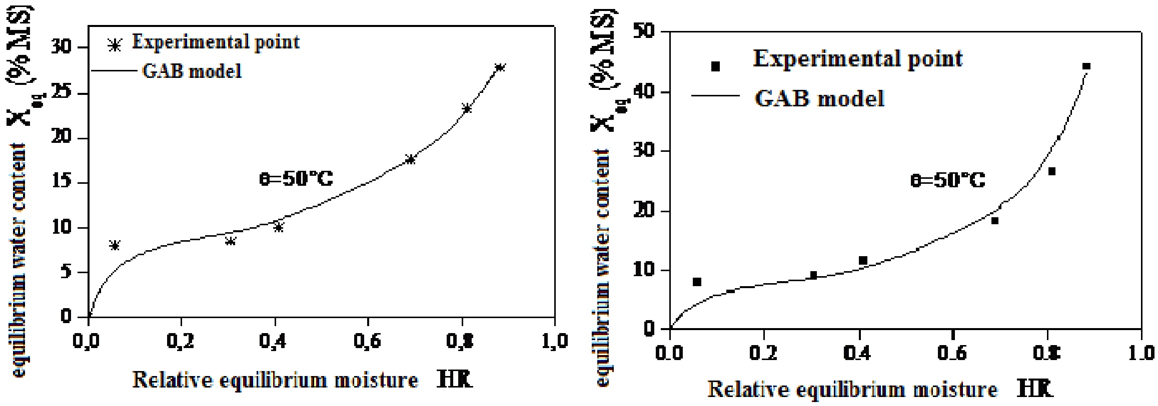

Figure 4: Comparison between the experimental curves of sorption and predicted by the GAB model for both plants.

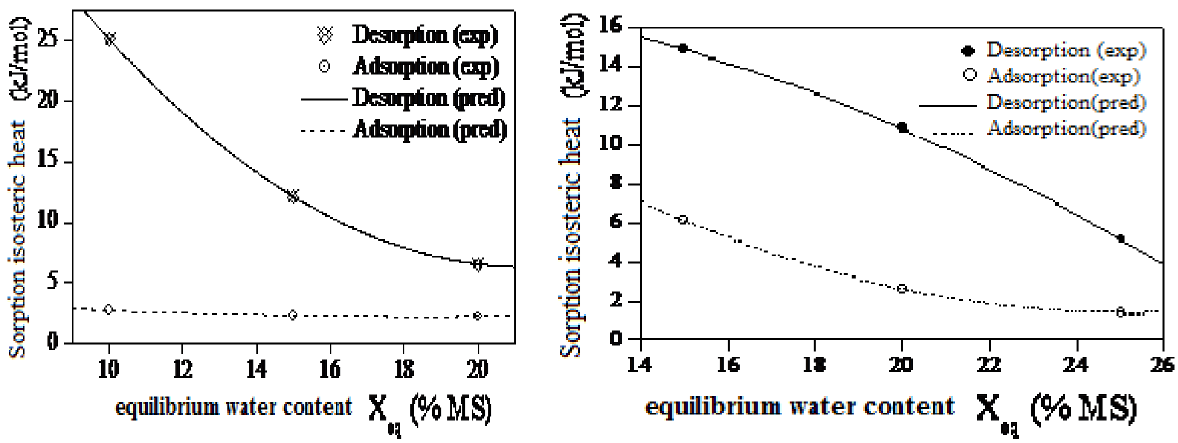

Figure 5: Net isosteric heat of sorption of marjoram (a) and pennyroyal (b)

CONCLUSION

Determination and modeling of sorption isotherms constitute an essential step in any process of drying. Their knowledge is a necessary step to better understand and comprehend the problems of conservation, experimentation and modeling of drying process. From the results, we conclude that the sorption isotherms of the two plants do follow the general shape of the sorption curve and the GAB model describes the sorption isotherms for different temperatures. We also note that the net isosteric heat of mint decreases slowly while that of marjoram decreases rapidly. Finally, knowing the equilibrium moisture contents of the two plants, we can now consider determining their drying kinetics in a solar drier operating in forced convection.

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