

# Desorption isotherms of Ajuga Iva leaves

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**Abstract**— Moisture sorption isotherms are valuable tool for prediction of the stability and shelf life of agricultural products. The aims of this work were to determine desorption isotherms of Ajuga Iva leaves experimentally and to compare the results by using models available in the literature. The equilibrium moisture contents of A.Iva leaves were measured using the static gravimetric method, at water activities and temperatures ranging from 0.057 to 0.97 and from 30 to 50 °C, respectively.

**Keywords**— Desorption isotherms, moisture sorption isotherms, static gravimetric method, equilibrium moisture contents, Ajuga. Iva leaves.

## I. INTRODUCTION

A. Iva is Small woolly, aromatic perennial herb which grows in rocky habitats in the western Mediterranean region particularly in Algeria, Morocco, Tunisia, and Egypt. [1]

A iva, locally known as Chendgoura, develops in deep soil of 2700m height. It grows in period from spring to late summer. The flowering period is between May and June.

A. iva (L.) Schreber known in Moroccan pharmacopoeia as a panacea (cure-all) because of its numerous beneficial is used in traditional medicine in Algeria to treat diabetes, and is known to have anti- inflammatory, antifungal, antimicrobial, antifebrile, anthelmintic activity and specifically for gastrointestinal disorders, hypertension and diabetes ([2], [3],[4]).

## II. MATERIALS AND METHODS

### A. Description of experimental Procedure

The A.Iva leaves used in the desorption isotherms experiment were grown in Bechar region. Harvest was between May and June 2014.

### B. Determination of sorption isotherms

Sorption isotherms of A. Iva leaves were determined by the gravimetric static method. Eight saturated salt solutions were prepared by dissolving an appropriate quantity of salt in distilled water (KOH, MgCl<sub>2</sub>, K<sub>2</sub>CO<sub>3</sub>, NaNO<sub>3</sub>, NaCl, KCl, BaCl<sub>2</sub>, K<sub>2</sub>SO<sub>4</sub>).The saturated solutions were prepared to obtain constant relative humidity environments([5], [6],[7],[8]). Water activities above the saturated solutions at 30°C, 40°C and 50 °C are listed in Table I.

TABLE I  
 SELECTED SALTS USED FOR PREPARING SATURATED SALT SOLUTIONS AND THEIR CORRESPONDING WATER ACTIVITIES

Salt	Water activity		
	30°C	40°C	50°C
KOH	0.0738	0.0626	0.0572
MgCl <sub>2</sub>	0.3238	0.3159	0.3054
K <sub>2</sub> CO <sub>3</sub>	0.4317	0.423	0.4091
NaNO <sub>3</sub>	0.7275	0.71	0.6904
NaCl	0,7511	0,747	0,744
KCl	0.8362	0.8232	0.812
BaCl <sub>2</sub>	0.898	0.891	0.8823
KNO <sub>3</sub>	0,9701	0,964	0,958

The experimental apparatus consisted of eight glass jars of 1 each with an insulated lid. Every glass jar was a quarter filled with a saturated salt solution [9].

Duplicated samples, each of 0.03g were placed into the glass jars .The glass jars, containing saturated salt solutions and A.Iva leaves samples, were then tightly closed and then put in an oven at a fixed temperature (30,40,50°C) for equilibration. The A.Iva leaves samples were weighted every 2 days, until there is no change in mass. The hygroscopic equilibrium of A.Iva leaves was reached in 10days.

### C. Modeling of sorption isotherms

The selected equations for the desorption isotherms modeling are shown in Table II:

TABLE II  
 EQUATIONS OF SORPTION ISOTHERMS MODELS

Model	Equation and parameters
CAURRIE	$x_{eq} = \exp(A + E a_w)$
GAB	$x_{eq} = \frac{A E C a_w}{(1 - E a_w)(1 - E a_w + E C a_w)}$
Modified OSWIN	$x_{eq} = (A + B T) \left( \frac{a_w}{1 - a_w} \right)^C$

The moisture content models were compared according to their standard error (S), correlation coefficient (r) and the percent average relative deviation (P). These statistical parameters were defined as follows:

$$S = \sqrt{\frac{\sum_{i=1}^{n_{\text{exp,data}}} (X_{ei} - X_{e\text{cali}})^2}{n_{\text{exp,data}} - n_{\text{param}}}}$$

$$r = \sqrt{\frac{\sum_{i=1}^{n_{\text{exp,data}}} (X_{ei} - X_{e\text{cali}})^2}{\sum_{i=1}^{n_{\text{exp,data}}} (X_{ei} - \bar{X}_{ei})^2}}$$

and

$$P(\%) = \frac{100}{n} \sum_{i=1}^{n_{\text{exp,data}}} \left( \frac{X_{e\text{cali}} - X_{ei}}{X_{ei}} \right)$$

Where  $X_{e\text{cali}}$  is the calculated value of equilibrium moisture content by using the tested model,  $X_{ei}$  is the experimental value of equilibrium moisture content,  $n_{\text{param}}$  is the number of parameters of the particular model and  $n_{\text{exp}}$  is the number of experimental points. The arithmetic average value of the experimental equilibrium moisture content ( $\bar{X}_{ei}$ ) is calculated as follows:

$$\bar{X}_{ei} = \frac{1}{n_{\text{exp,data}}} \sum_{i=1}^{n_{\text{exp,data}}} X_{ei}$$

### III. RESULTS AND DISCUSSION

#### A. Sorption isotherm of A.Iva

The experimental results of the desorption isotherm of A. Iva leaves (obtained at 30, 40 and 50 C) is given in Fig.1.

The desorption isotherms follow a sigmoidal curve and are of type II according to the BET classification. All isotherms show an increase of equilibrium moisture content with increasing water activity, at each temperature. This can be explained by the excitation states of molecules due to temperature augmentation. ([10], [11])

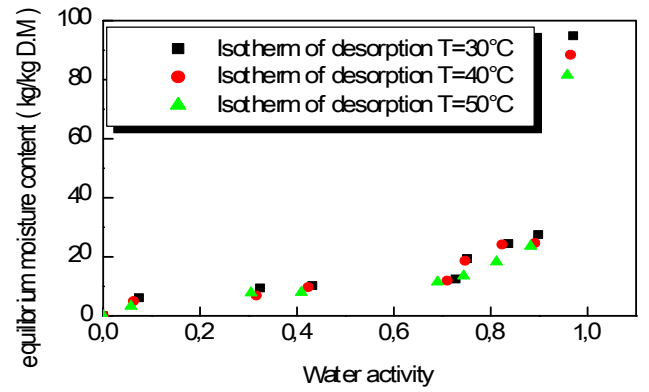


Fig. 1 Experimental desorption isotherms of A.Iva leaves at three different temperatures

#### B. Modeling sorption isotherms

According to their correlation coefficient and standard error of estimate S, the models equations were compared (Table II). From the gathered information's, it can be made out the goodness of fit of each of the models used (Fig. 2, 3 and 4). In addition, the OSWIN model fit which shows sigmoid shaped sorption isotherms appears to be the most adequate one (Table III, Fig. 2)

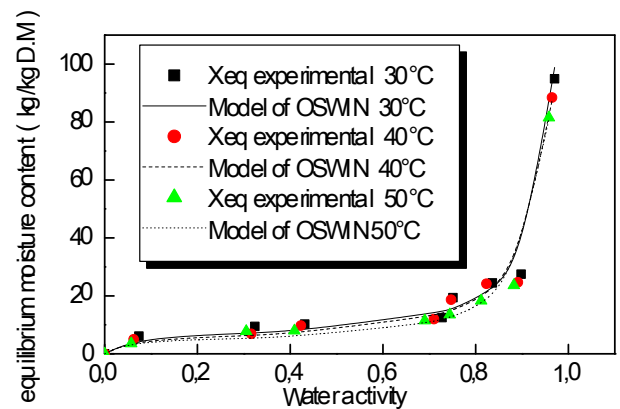


Fig. 2 Desorption isotherms of A.Iva leaves fitted with OSWIN model at different temperatures

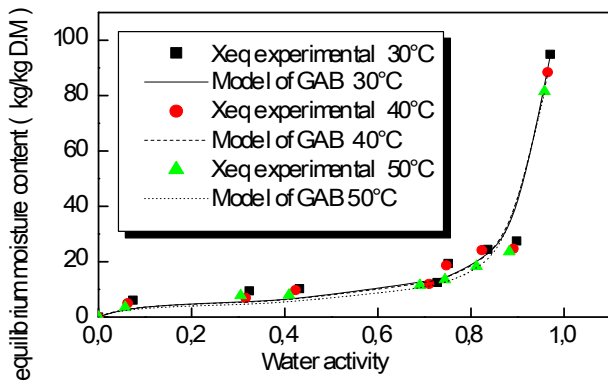


Fig. 3 Desorption isotherms of A.Iva leaves fitted with GAB model at different temperatures

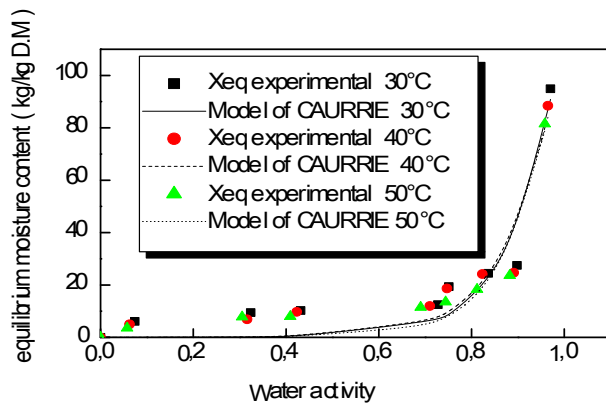


Fig. 4 Desorption isotherms of A.Iva leaves fitted with CAURRIE model at different temperatures

#### IV. CONCLUSIONS

The moisture desorption isotherm of the A.Iva leaves have been determined at 30°C, 40°C, 50°C by gravimetric method. The sorption isotherms had a sigmoid shape. Equilibrium moisture content decreases with increasing temperature at constant equilibrium relative humidity and increase with increasing equilibrium relative humidity at constant temperature. Among the sorption models selected to fit sorption isotherms the modified OSWIN equation seems to be the most appropriate.

#### NOMENCLATURE

Aw: Water activity  
 S: Standard error  
 r : Correlation coefficient  
 P : percent average relative deviation  
 Xeq: equilibrium water content, kg/kg  
 A, B, C, D: parameters of the models tested.

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TABLE III  
RESULTS OF FITTING OF THE DESORPTION ISOTHERMS of A.IVA LEAVES.

Models names	T (°C)	Parameters				r	S	P(%)
		A	B	C	D			
<b>GAB</b>	30	3.736	0.989	$8.691.10^{10}$	-	0.99	4.157	29,69
	40	3.655	0.993	$2.0995.10^{11}$	-	0.99	4.166	25,79
	50	3.128	1.003	$-3.516.10^{10}$	-	0.99	2.470	20,78
<b>CAURRIE</b>	30	-6.096	10.932	-	-	0.95	9.291	78,53
	40	-5.474	10.268	-	-	0.95	8.815	79,80
	50	-6.425	11.266	-	-	0.96	7.040	78,95
<b>Modified OSWIN</b>	30	5.221	0.125	0.908	-	<b>0.99</b>	<b>3.822</b>	<b>20,23</b>
	40	4.518	0.122	0.941	-	<b>0.99</b>	<b>4.123</b>	<b>18,72</b>
	50	4.235	0.008	1.089	-	<b>0.99</b>	<b>2.792</b>	<b>20,50</b>