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PRELIMINARY EVALUATION OF COLOR STABILITY OF DATE FRUIT TABLETS

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KEY WORDS:
adsorption isotherm, color, date (Phoenix dactylifera L.) fruit, model, storage, water activity

ABSTRACT

This paper reports on preliminary qualitative evaluation of relationship between color change and water activity (a_w) of date (*Phoenix dactylifera* L., *var. Mech-Degla*) fruit tablets (DFTs) as natural supplement, in view to optimize their storage conditions. Eight types of DFTs were obtained, according to: i) mean particle size (225 and 282 µm) of the used fruit powder, and ii) compression pressure (5, 10, 15 and 20 kN) applied during the tableting process. The experimental adsorption curves, determined at 25 °C using static-gravimetric method, were fitted to GAB (Guggenheim–Anderson–de Boer) and BET (Brunauer–Emmett–Teller) models. Results showed that the DFT color is significantly sensitive to a_w since beyond the a_w threshold value of 0.44, the DFT color changes from light grey to dark brown, independently of the particle size of fruit powder and compression pressure. Concerning the isotherm modeling, the both models tested seem especially suitable ($R \approx 0{,}96$ $0.3 \leqslant MRE \leqslant 5$ and $SE \approx 0.03$) for describing the experimental data for DFT obtained under a compression pressure of 5 kN from date fruit powder with mean particle size of 225 µm. The DFT color stability is considerably influenced by the environmental humidity. Considering the importance of color for consumer acceptance, the study deserves to be deepened concerning the quantitative analysis of the color (CIELab system), packaging of the tablets, etc.

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ПРЕДВАРИТЕЛЬНАЯ ОЦЕНКА СТАБИЛЬНОСТИ ЦВЕТА ТАБЛЕТОК ИЗ ФИНИКОВ

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КЛЮЧЕВЫЕ СЛОВА:
изотерма адсорбции, цвет, финики (Phoenix dactylifera L.), модель, хранение, активность воды

АННОТАЦИЯ

В данной статье сообщается о предварительной качественной оценке взаимоотношения между изменением цвета и активностью воды (a_w) таблеток из фиников (*Phoenix dactylifera* L., *var. Mech-Degla*) (DFT) как натуральной добавки с целью оптимизации условий их хранения. Было получено восемь типов DFT в соответствии с: i) средним размером частиц (225 и 282 µm) используемого порошка плодов и ii) давлением сжатия (5, 10, 15 и 20 kN), примененном во время процесса таблетирования. Экспериментальные кривые адсорбции, определенной при 25 °C, используя статический гравиметрический анализ, были приспособлены к моделям GAB (Гугенгейма — Андерсона — Де Бура) и BET (Брунауэр, Эммет и Теллер). Результаты показали, что цвет DFT в большой степени чувствителен к a_w, т. к. за пределами порогового уровня a_w порошка плодов цвет DFT изменяется от светло серого до темно коричневого, независимо от размера частиц порошка плодов и давления сжатия. Что касается изотермического моделирования, то обе тестированные модели особенно пригодны ($R \approx 0{,}96$ $0{,}3 \leqslant MRE \leqslant 5$ и $SE \approx 0{,}03$) для описания экспериментальных данных для DFT, полученных при давлении сжатия 5 kN из порошка фиников со средним размером частиц 225 µm. Влажность окружающей среды оказывает значительное влияние на стабильность цвета DFT. Что касается, значения цвета для принятия потребителями, то исследование необходимо углубить в отношении количественного анализа цвета (система CIELab), упаковки таблеток и т. д.

1. Introduction

The COVID-19 pandemic has a significant impact on the increase of food supplement consumption [1]. In this context, dried fruits as healthy foods constitute good snacks, in alternative to sweet ones and food ingredients [2]. Especially, food tablets as dietary supplements may be great value-added products for getting healthy bioactive components [3]. Much work has been devoted in recent years to tablets made from raw fruits, including date fruit of naturally dry varieties [4]. It must be recalled that the date fruit is rich in essential nutrients such as potassium, zinc, magnesium, selenium, etc. [5]. This said, the efficacy of healthy products in preventing diseases depends on the stability of the active compounds [6,7].

The a_w as an indicator of water availability is an important parameter which determines the suitability of food for storage. It is linked to water through sorption isotherms. The sorption isotherms in food science is an important tool for the design and optimization of drying equipment, design of packages, predictions of quality, stability, shelf-life and for calculating moisture changes that may occur during storage [8], while the color is one of the important sensory attributes of foods [9].

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The present paper reports on preliminary qualitative evaluation of relationship between moisture adsorption and color change of tablets from date *(Phoenix dactylifera L., var. Mech-Degla)* fruits. It may be helpful to specify that Adiba et al. [4] and Iguergaziz et al. [10] have already investigated the date fruit tablets as a dietary supplement and as a pharmaceutical excipient, respectively. But, to our knowledge, the study of their stabilities has never been-addressed.

2. Objects and methods

— The *Mech-Degla* date fruits were first sorted, cleaned and pitted. They were then cut into small pieces of dimensions 15 mm × 15 mm × 2 mm, then dried to constant weight at 65 °C under vacuum of 200 mbar using a laboratory dryer (type HERAEUS) fitted with a thermometer and a KNF Laboport brand vacuum pump (type N840.3FT.18). The dried fruit pieces were ground and then sieved using Lab Impact Test Sieve with sieve perforation dimensions of 200, 250 and 315 µm. Thus, two grain size classes (200–250 µm and 250–315 µm) were obtained.

The tablets were obtained by direct compression using the HERZOG type pelletizer at the UR-PME research laboratory of the University of Boumerdes. Four pressures were applied: 5, 10, 15 and 20 kN. Accordingly, eight types of tablets were prepared.

The adsorption isotherms of DFTs were measured using the gravimetric method as described by Labuza et al. [11]. For this, various saturated saline solutions ($MgCl_2$ $6H_2O$, K_2CO_3, NaBr, $NaNO_2$, NaCl and KCl) were prepared so as to obtain relative humidities ranging from 33 to 84.8% (at 25 °C) [11,12,13]. Each DFT type to be analyzed was placed in a desiccator containing a given saturated solution. The samples were weighed at regular time intervals (24 h) until the constant weight (variation in weight between two successive measurements less than 1%) was reached, which corresponds to the equilibrium between the DFT water content and the relative humidity of the surrounding atmosphere.

The experimental data were fitted to the GAB (Guggenheim–Anderson–de Boer) and BET (Brunauer–Emmett–Teller) isotherms models, which are the most used in food products [14].

The goodness of the model fit was tested using the coefficient of correlation (R), relative mean error (RME) and standard error (SE). RME and SE were calculated as follows:

$$RME = \frac{100}{N}\sum_{i=1}^{N}\left|\frac{X_{ei,e} - X_{ei,p}}{X_{ei,e}}\right| \quad (1)$$

$$SE = \sqrt{\frac{\sum_{i=1}^{N}\left(X_{ei,e} - X_{ei,p}\right)^2}{N-1}} \quad (2)$$

where

$X_{ei,e}$ is the i^{th} equilibrium water content,
$X_{ei,p}$ is the i^{th} predicted equilibrieum water content,
N is the number of experimental observations.

The adjustment of the experimental values to the GAB and BET models was performed using Statistica software version 8.0, using the nonlinear regression program. A model is considered more suitable for describing experimental data when the value of R is closer to 1 and the values of MRE and SE closer to 0.

3. Results and discussion

The date tablets obtained weigh 1.9 g and are 2 cm in diameter and 0.5 cm in thickness. They have a light gray initial color.

The effect of a_w on color tablets is shown in Figure 1.

As can be seen, the DFT color is very sensitive to a_w, since beyond the threshold value of 0.44, the color changes from light grey to dark brown, independently of the powder granulometry and compression force. This color deterioration may be due to enzymatic and non-enzymatic (Maillard) reactions. It is a phenomenon which is well known as being one of the main causes of alteration of date fruit color [15]. These results could mean that both enymatic and non-enzymatic browning reactions are responsible for the color alteration of DFTs. We can assume that each of the reactions is dominant depending on the relative humidity of the ambient air and, therefore, the a_w of DFT. Indeed, it has been established that enzymatic browning generally takes place at high a_w and medium temperatures, while non-enzymatic browning occurs at high temperatures and low a_w [16]. In particular, these findings highlight the fact that the Maillard reaction can occur even at room temperature (applied here), proving the influence, in addition of a_w, of storage time and other factors [17,18].

It might be worth pointing out that the date fruits are known to be rich above all in simple sugars (~ 75%) [15], which are (with amino acids) the substrates for non-enzymatic reactions. They

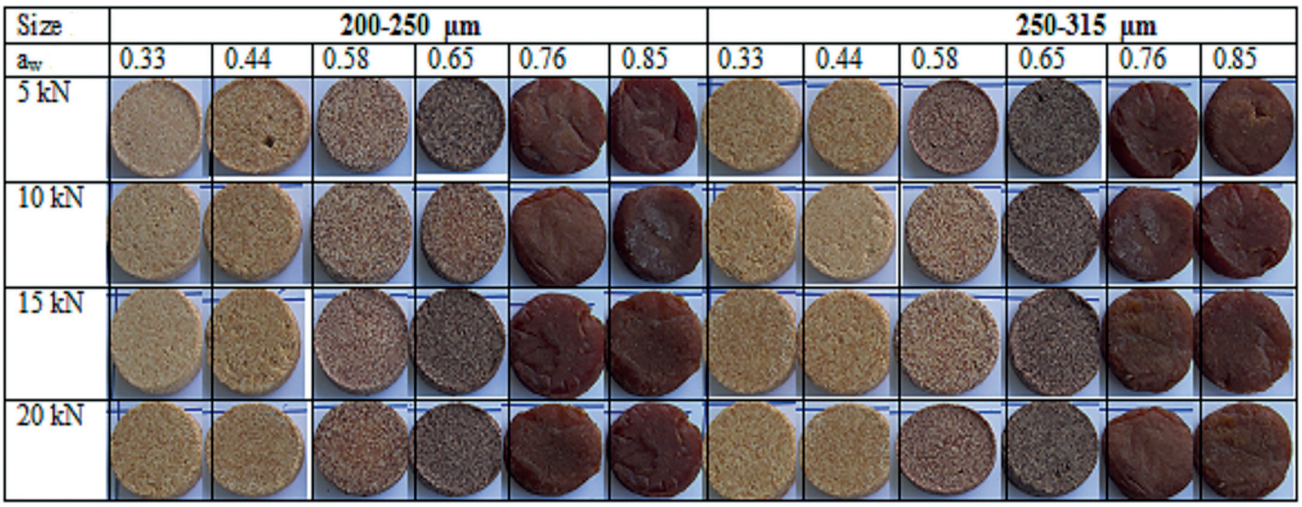

Figure 1. **DFT color, according to particle size of original raw date fruit powder, a_w and compression pressure applied during tableting process**

Рисунок 1. **Цвет таблеток из фиников в соответствии с размером частиц исходного порошка сырых фиников, a_w и давлением сжатия, примененным во время процесса таблетирования**

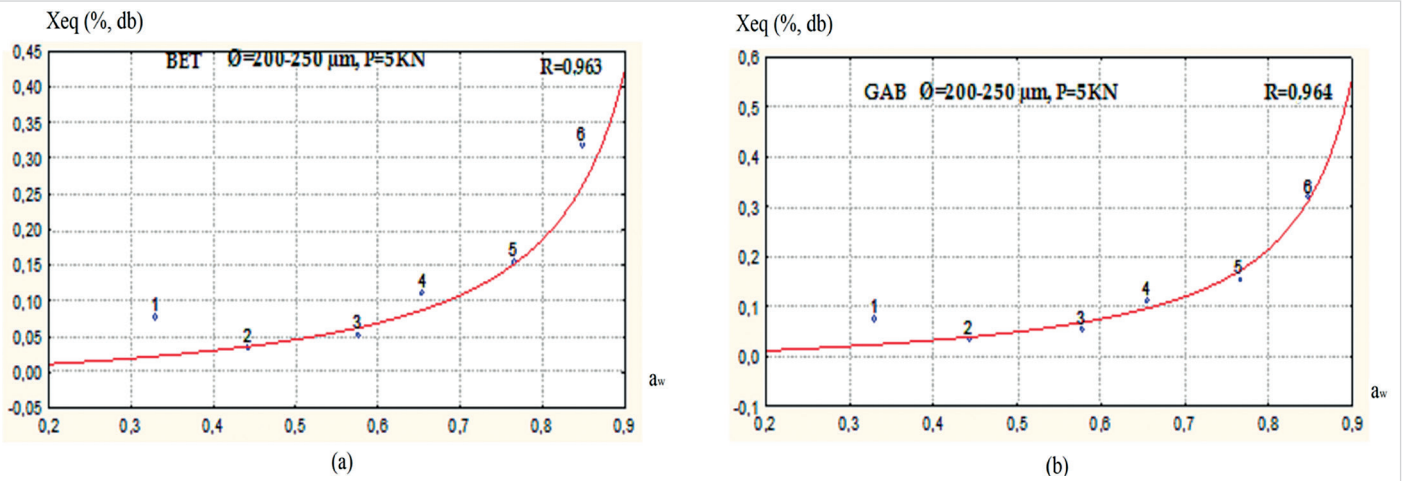

Figure 2. Adsorption isotherms of DFTs at 25 °C, according to BET (a) and GAB (b) models
Рисунок 2. **Изотермы адсорбции порошка фиников при 25 °C, в соответствии с моделями BET (a) и GAB (b)**

are also rich in polyphenols (~ 1.5%) [19], which are the substrate for enymatic browning catalyzed by polyphenol oxidase in the presence of oxygen from air.

The most interesting results in terms of adsorption isotherm modeling are shown in Figure 2. The two tested BET (Figure 2a) and GAB (Figure 2b) models seem above all appropriate ($R \approx 0{,}96$ $0.3 \leqslant MRE \leqslant 5$ and $SE \approx 0.03$) to describe the experimental data for DFT obtained under a pressure of 5kN from powders of particle size ranged between 200 and 250 µm. The two isotherms are of type III, which is a characteristic of high-sugar food products [20] and plasticisers [8]. It is worth mentioning here that sugars and their inverted form are used as plasticisers to regulate, for example, the mechanical properties of starch edible films [21,22]. This shape is itself linked to the BET multilayer adsorption isotherm [8].

4. Conclusion

The results show that the DFT color is significantly sensitive to a_w, since beyond the threshold value of 0.44, the color changes from light grey to dark brown, independently of the particle size of original raw date fruit powder and compression pressure. Concerning the isotherm modeling, both models (BET and GAB) tested seem especially suitable ($R \approx 0{,}96$ $0.3 \leqslant MRE \leqslant 5$ and $SE \approx 0.03$) for describing the experimental data for DFT obtained under a compression pressure of 5kN from date fruit powder with mean particle size of 225 µm.

Considering the nutritional and practical importance of DFTs, the study deserves to be deepened concerning the quantitative analysis of the color (CIELab system), the packaging of the tablets, etc.

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