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AWARENESS OF THE EQUILIBRIUM MOISTURE CONTENT OF CHIA SEEDS IS AN IMPORTANT STEP TO PRESERVING IT

Abstract

The article presents the results of studies of hygroscopic properties of chia seeds, which is a relatively new culture for the Ukrainian industry. Chia seeds are a product with a high nutrient content and rich in trace elements, vitamins and minerals that can be of great benefit to human health. Therefore, the main task of post-harvest technology is to bring it to a state that will ensure long-term storage of chia seeds without loss in weight and poor quality. An important influence on the condition of the grain mass during storage and, in particular, during the initial treatment has its hygroscopicity, ie the ability to sorption and desorption of water vapor. Knowledge about the hygroscopic properties of grain are of practical importance for the scientific substantiation of the choice of rational modes of active ventilation, drying. The main characteristic of hygroscopic properties of grain materials is equilibrium moisture, so its determination is an important step for maintaining the quality of grain. The equilibrium moisture of chia seeds has been determined for the first time. The studies were carried out by the generally accepted tensimetric method in the range of air temperatures in the range of 5... 25 °C and relative humidity of 33...70 %, which model the conditions of storage of seeds and corresponding to the long-term average data, correspond to the warm and cold seasons in Odessa region.

The influence of relative humidity, air temperature and grain moisture on the equilibrium moisture of chia was investigated, numerical values of equilibrium moisture of chia seeds were determined according to environmental parameters: temperature 5, 15, 25 °C and relative humidity 33, 45 and 70 %.

The nature of the change in the equilibrium moisture of chia seeds was determined depending on the temperature and relative humidity. With increasing relative humidity and decreasing ambient temperature, the equilibrium moisture of chia seeds increases.

The empirical coefficients and the equation that describes the dependence of the equilibrium moisture of chia seeds on the parameters of ambient air - temperature and relative humidity at which its change can be predicted

The data obtained can be used to select drying and active ventilation modes, as well as storage conditions for chia.

Key words: chia seeds, hygroscopic properties, equilibrium humidity.

Introduction

Chia (lat. Chia) is a relatively new grain for Ukrainian industry. Chia seeds are considered "superfood", a product with a high concentration of nutrients and enriched with a large number of trace elements, vitamins and minerals that can bring huge health benefits: to help the body cleanse of toxins, to normalize the intestines, to lose weight and saturate the body with useful substances. Chia contains healthy omega-3 fatty acids, a high-quality vegetable protein; cellulose; antioxidants; phosphorus; potassium; iron; zinc; B vitamins [1]. A significant part of the work is devoted to the study of the biological value and useful properties of chia, and the question of its reliable storage is still not well discovered.

The great importance for the grain treatment and storage are the sorption properties of the grain mass. The moisture and odor of the grain that is stored or processed, most often change due to absorption or desorption of gases or water vapor [2-5].

Knowledge of the hygroscopic properties of grain

is more practical for the scientific justification of the choice of rational modes of active ventilation, drying and determines the necessary conditions for storage of seeds [6, 7].

Literary review

Equilibrium moisture content is the main characteristic of the hygroscopic properties of grain materials; therefore, its determination is an important step to maintain the quality of grain. For chia seeds, the determination of equilibrium moisture is carried out for the first time.

It is known that the hygroscopicity of the grain mass has the greatest effect on the stability of the grain during storage. Only the grain in which all moisture is in a state bound by colloids [8-10] retains its initial properties well [8-10].

Knowledge of the patterns of changes in the equilibrium moisture content of grain crops depending on air humidity and temperature is necessary to expose the



mechanism of the drying and moistening process. Drying and moistening is a typical irreversible process, which ultimately leads to a balance between the material and the ambient air [8, 11].

The sorption properties of the grain mass is its ability to absorb (sorb) steam, odors of various substances and gases from the environment, and also to emit (desorb) them [4, 6, 11].

Sorption phenomena such as absorption, adsorption, capillary condensation, and chemisorption are observed in the grain masses. The total result of adsorption, absorption, capillary condensation, chemisorption is called sorption, and the degree of an ability of the grain mass to absorb steam and gases under different conditions is called a sorption capacity. It is explained by the capillary-porous colloidal structure of the grain and the porosity of the grain mass. A single grain as a multicellular organism is a porous body with a large surface. The cells and tissues of grains have numerous macro- and microcapillaries, the former primarily in the membranes, and the latter in the endosperm. The walls of macro- and microcapillaries are involved in the sorption of vapor and gas molecules. The system of capillaries moves liquefied steam. The active surface of the grain is 20 ... 25 cm²/g, it is 20 times higher than its true surface. Therefore, a sorption phenomenon occurs not only on the surface of the grain, but also inside each capillary [2, 3].

Hygroscopicity of the grain mass means its ability to absorb water vapor from the air or to release it into the environment. Protein molecules of the grain can absorb up to 240%, and starch - up to 30 ... 38% of water relative to its mass. Hygroscopicity of the grain depends both on its properties and on the properties of air. As a result of the interaction of the grain mass with the environment, the moisture content of the grain is constantly changing to achieve equilibrium moisture content.

The moisture from the grain passes into the air during evaporation, desorption, drying, if the partial pressure of water vapor around the surface of the grain ($P_{v.g}$) exceeds the partial pressure of water vapor of air ($P_{v.a}$), that is, $P_{v.g} > P_{v.a}$. Moisture from the air is absorbed by the grain, if $P_{v.g} < P_{v.a}$. The greater the difference between the partial pressure of water vapor is in the air and around the grain surface (or vice versa), the faster the process of moisture redistribution is. After some time, as a result of the redistribution of moisture, the partial pressure of the vapor in the air and above the grain compares and dynamic equilibrium sets in ($P_v = P_{v.a}$). The moisture content of the grain, which corresponds to the state of equilibrium, is called equilibrium moisture. The latter depends on its sorption properties (structure, chemical composition) and on humidity and air temperature [2, 3].

Formulation of the problem

The object of the study is the hygroscopic properties of chia seeds.

The subject of the study is chia seeds. The initial moisture content of chia seeds is 7.55%.

The aim of the study is to establish patterns of change in the equilibrium moisture content of chia seeds depending on the temperature and relative humidity of

the ambient air, which will improve quality and ensure its long-term guaranteed storage.

To achieve this goal, the following tasks should be completed:

- determine the value of the equilibrium moisture content of chia at various environmental parameters (temperature and relative humidity);
- establish the dependence of the equilibrium moisture content of chia depending on the temperature and relative humidity of the ambient air;
- determine the empirical coefficients in the equation of sorption isotherms for predicting the equilibrium moisture content of chia depending on the parameters of the ambient air.

Materials and methods

The studies were carried out by the generally accepted tensimetric method in the range of air temperatures in the range of +5 ... +25° C and its relative humidity of 33 ... 70%, it simulates the storage conditions of seeds and the corresponding long-term average data, correspond to the warm and cold season in Odessa region.

For this, a sample of chia seeds in glass jars was placed in a desiccator with a solution of sulfuric acid of known concentration, in which the necessary parameters of relative air humidity were created artificially (using the appropriate sulfuric acid solution). Each concentration of sulfuric acid corresponds to certain air humidity [13]. Chia seeds stored in desiccators and a refrigerator at a temperature of plus (+5 ± 1)° C and in a thermostat at a temperature of plus (+25 ± 1)° C.

Weighing was carried out to establish equilibrium moisture content, that is, to a constant mass. According to the change in the mass of the weighed portions in glass jars at each particular instant of time, the intermediate moisture content of the grain was calculated. The initial, flow and final moisture content of the grain was determined according to DSTU 29144: 2009 (ISO 711-85).

The results of approximation and smoothing of the experimental data on the kinetics of hydration for chia seeds were performed on a PC using standard programs and programs developed at the Department of Grain Storage Technology of ONAFT [14].

Results of the study and their discussion

The studies showed that the duration of the experiments to achieve the equilibrium state of the grain was within 5 ... 7 days. The obtained Equilibrium moisture content is given in table. 1.

An analysis of the data showed that the equilibrium moisture content of chia increases with increasing relative humidity and temperature.

The timing of reaching equilibrium moisture content of chia seeds in various conditions also fluctuates. So, at a temperature of (+25 ± 1) °C, equilibrium occurs on the 7th ... 9th day, and at (+5 ± 1) °C - on the 5th...8th day of the experiment.

The most complete characteristic of hygroscopic properties is the sorption isotherm — the dependence of the equilibrium moisture content of seeds w_p on relative air humidity φ . It is known that the sorption isotherms of



Table 1 - The equilibrium moisture content of chia seeds

The conditions of the experiment		Equilibrium moisture content w_p , %
relative humidity %;	ambient temperature t , °C	
33	5	5,85
45	5	6,61
70	5	8,74
33	25	4,78
45	25	5,69
70	25	7,91

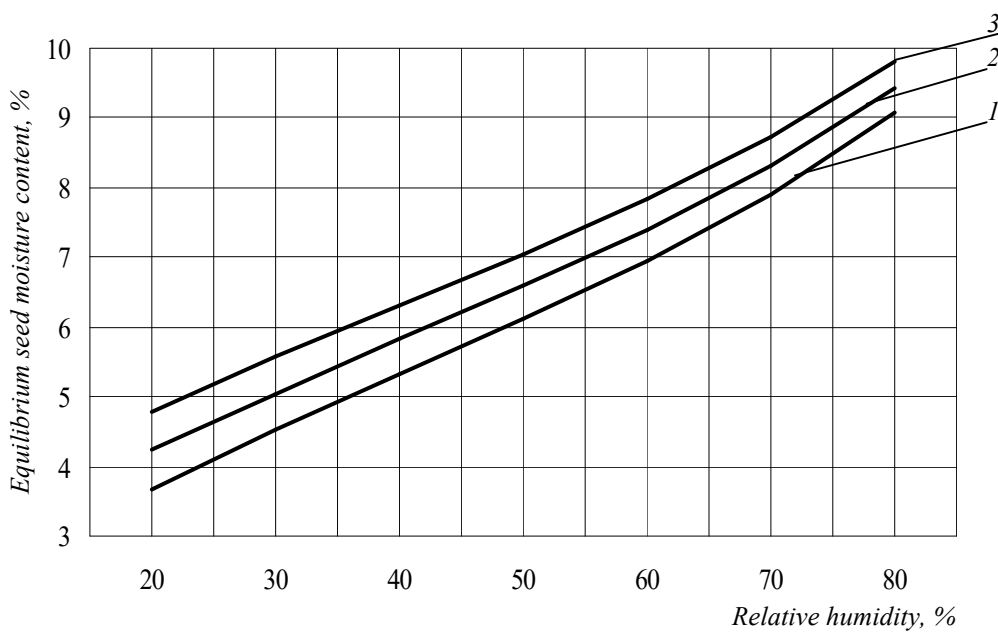


Fig. 1 - Isotherms of sorption of chia seeds at ambient temperature: 1 – 5 °C; 2 – 15 °C; 3 – 25 °C

grain can be quite accurately described by a well-known equation of the form [10]:

$$w_p = A - B \cdot t + (C - D \cdot t) \left[\lg \left(\frac{1}{1 - \varphi} \right) \right]^{0.5}$$

де w_p – equilibrium moisture content of seeds, %;
 t – ambient temperature, °C;
 φ – relative humidity, %;

A, B, C, D – constants, depend on the form of the connection of moisture with the dry matter of the grain and the temperature of the grain and are determined by the least squares method based on experimental data.

We have determined the values of the empirical coefficients A, B, C, D for chia seeds: $A = 0.1528, B = -0.0668, C = 10.4362, D = 0.0360$.

Sorption isotherms of chia seeds at various temperatures and environmental humidity are shown in Fig. 1.

As is known, factors such as temperature and relative humidity of air, the type of grain and its initial moisture content influence the equilibrium grain moisture [12], which is also characteristic of the chia seeds. We have confirmed that the determining factor affecting the magnitude and speed of reaching equilibrium grain moisture is the relative humidity - the more it is, the faster the grain absorbs moisture and the greater the equilibrium grain moisture. The equilibrium grain moisture also depends on air temperature: at the same relative air humidity and a higher temperature, lower equilibrium moisture corresponds and, conversely, a lower temperature leads to an increase in the equilibrium grain moisture.

Conclusion

1. Numerical values of the equilibrium moisture content of chia seeds were determined by the environmental parameters: temperature 5, 15, 25° C and relative air humidity 33, 45 and 70%.

2. The pattern of the change in the equilibrium moisture content of chia seeds depending on temperature and relative humidity is established. With an increase in relative humidity and a decrease in ambient temperature, the equilibrium moisture content of chia seeds increases.

3. The empirical coefficients are determined and an equation is proposed that describes

the dependence of the equilibrium moisture content of chia seeds on the parameters of the ambient air — temperature and relative humidity, by which it can be predicted its change.

4. The obtained data can be used to select the drying and active ventilation modes, as well as the conditions when put chia for storage.

It should be taken into account during daily temperature drops and temperature changes in granaries and the external environment, as well as beware of increasing the relative humidity of the air premium of 70%, especially in the warm periods of the year, since this leads to the rapid development of molds and activation of the enzyme complex.



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ЗНАННЯ ПРО РІВНОВАЖНУ ВОЛОГІСТЬ НАСІННЯ ЧІА — ВАЖЛИВИЙ КРОК ДО ЙОГО ЗБЕРІГАННЯ

Анотація

В статті наведено результати досліджень гігроскопічних властивостей насіння чіа, яке відносно новою культурою для української промисловості.

Насіння чіа є продуктом з високою концентрацією поживних речовин та збагаченим великою кількістю мікроелементів, вітамінів та мінералів, які здатні принести величезну користь для здоров'я людини. Тому основним завданням технології післязбиральної доробки є приведення до стану, що забезпечить тривале зберігання насіння чіа без втрат в масі і погіршення якості. Важливий вплив на стан зернової маси при зберіганні і, особливо, при первинній обробці має її гігроскопічність, тобто здатність до сорбції і десорбції парів води. Знання про гігроскопічні властивості зерна мають практичне значення для наукового обґрунтування вибору раціональних режимів активного вентилявання, сушіння.

Основною характеристикою гігроскопічних властивостей зернових матеріалів є рівноважна вологість, тому її визначення є важливим кроком для збереження якості зерна. Визначено вперше рівноважна вологість насіння чіа. Дослідження проводили загально прийнятим тензиметричним методом в діапазоні температур повітря в діапазоні плюс +5...25 °C та його відносної вологості 33...70 %, які моделюють умови зберігання насіння і відповідні до багаторічних середніх даних, відповідають теплій і холодній порі року в Одеській області.

Досліджено вплив відносної вологості повітря, температури повітря та вологості зерна на рівноважну вологість чіа, визначено чисельні значення рівноважної вологості насіння чіа за параметрами навколишнього середовища: температури +5, 15, 25 °C та відносної вологості повітря 33, 45 та 70 %.



Встановлено характер зміни рівноважної вологості насіння чіа залежно від температури та відносної вологості повітря. Зі збільшенням відносної вологості та зниженні температури навколишнього повітря рівноважна вологість насіння чіа зростає.

Визначено емпіричні коефіцієнти та запропоноване рівняння, яке описує залежність рівноважної вологості насіння чіа від параметрів навколишнього повітря – температури та відносної вологості, за яким можна прогнозувати її зміну

Отримані дані можна використовувати для підбору режимів сушіння й активного вентилявання, а також умов при закладанні чіа на зберігання.

Ключові слова: насіння чіа, гігроскопічні властивості, рівноважна вологість.

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