http://journal.unoeste.br/index.php/ca/index
DOI: 10.5747/ca.2023.v19.h523
ISSN on-line 1809-8215

Colloquium Agrariae

Submetido: 08/08/2022 Revisado: 19/06/2023 Aceito: 21/06/2023

DETERMINATION OF WATER CONTENT IN GRAINS WITH MICROWAVE OVEN

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Abstract

The determination of water content is essential for the maintenance of grain quality, and an evaluation of alternative methods for quantification allows to increase the efficiency of the process and bring benefits to the productive sector. The study aimed to analyze the efficiency of using microwave ovens to determine the water content in grains. The study was carried out in a completely randomized design in a 5 x 6 factorial scheme, with five species (peanut, sunflower, corn, soybean and wheat) and six microwave drying periods (0.5, 1, 1.5, 2, 2.5, and 3 min), with four replications. Data were subjected to descriptive analysis to characterize the samples, and regression analysis to analyze differences between methods as a function of drying time. The determination of water content in peanut, sunflower, corn, soybean and wheat grains in microwave is technically feasible, showing correlation with the determination in an oven by the standard method. The drying time in the microwave influences the water removal capacity of the grains. For peanut, sunflower, corn, soybean and wheat grains, the microwave drying time of 3 min showed greater similarity with the determination by the standard method.

Keywords: *Arachis hypogaea*; *Helianthus annuus*; *Glycine max*; postharvest; *Zea mays*.

DETERMINAÇÃO DO TEOR DE ÁGUA EM GRÃOS COM FORNO MICRO-ONDAS

Resumo

A determinação do conteúdo de água é fundamental para manutenção da qualidade de grãos, sendo que a avaliação de métodos alternativos para quantificação permite elevar a eficiência do processo e ocasionar benefícios ao setor produtivo. O estudo teve como objetivo analisar a eficiência da utilização de forno micro-ondas para determinação do teor de água em grãos. O estudo foi conduzido em delineamento inteiramente casualizado em esquema fatorial 5 x 6, sendo cinco espécies (amendoim, girassol, milho, soja e trigo) e seis períodos de secagem em micro-ondas (0,5; 1; 1,5; 2; 2,5 e 3 min), com quatro repetições. Os dados foram submetidos a análise descritiva para

caracterização das amostras, e análise de regressão para análise das diferenças entre métodos em função do tempo de secagem. A determinação do teor de água em grãos de amendoim, girassol, milho, soja e trigo em micro-ondas é tecnicamente viável, apresentando correlação com a determinação em estufa pelo método padrão. O tempo de secagem no micro-ondas influencia na capacidade de remoção de água dos grãos. Para os grãos de amendoim, girassol, milho, soja e trigo, o tempo de secagem por micro-ondas de 3 min apresentou maior similaridade com a determinação pelo método padrão.
Palavras-chave: *Arachis hypogaea*; *Helianthus annuus*; *Glycine max*; pós-colheita; *Zea mays*.

Introduction

The determination of water content in grains is essential for the quality maintenance of product, from harvest to the post-harvest stages, which involve drying, storage and processing (BEFIKADU, 2014; GALINDO *et al.*, 2019; SÁ *et al.*, 2020, SAATH *et al.*, 2021).

The determination of water content in agricultural products can be performed by direct and indirect methods, with the gravimetric method in forced air circulation oven standardized for the grains (MABASSO *et al.*, 2019; SILVA *et al.*, 2021). Although the determination of water content by the gravimetric method presents greater precision, alternative methods that involve dielectric properties of the grains can present high efficiency and low cost, with correlation to the values obtained by the recommended method (USMAN *et al.*, 2015; TRABELSI *et al.*, 2016).

Technologies involving the adoption of microwaves to quantify the water content, require specific modeling for each species, and for accurate determination factors related to the product, such as moisture and size must be considered (RAHMAN *et al.*, 2019; SHEN *et al.*, 2020; SILVA *et al.*, 2021). The adoption of a domestic microwave oven to determine the water content is already viable in studies developed by Nirmaan *et al.* (2020) and Nunes-Zolini *et al.* (2022). Thus, the study aimed to analyze the efficiency of using microwave oven to determine the water content in grains of peanut, sunflower, corn, soybean and wheat.

Material and methods

The study was conducted in Post-harvest Technology laboratory of the State University of Maringá (UEM). The experiment was carried out in completely randomized design in factorial scheme (5 x 6), with five species (peanut, sunflower, corn, soybean and wheat) and six microwave drying periods (0.5, 1, 1.5, 2, 2.5, and 3 min), with four repetitions.

The material was prepared by removing impurities and foreign matter. Samples with a mass between 10 and 20 g of grains were placed in petri dishes and subjected to drying in the microwave equipment. Domestic microwave equipment with capacity of 27 L, power of 950 W, voltage of 110 and consumption of 1.7 Kw h^{-1} was used. The samples were submitted to continuous drying, without interruption of the determined time.

The water content of the grains was calculated by the difference of initial and final mass (equation 1), being expressed in percentage dry basis (% db). To verify the efficiency of the method, the determination of the water content was carried out by the standard method, using a forced air circulation oven at 105±2 °C for 24 hrs, with content calculated by the difference in mass (Equation 1).

$$\text{Water content} = \left(\frac{(Frsh\ mass - Dry\ mass)}{Dry\ mass}\right) x100 \quad \text{(Equation 1)}$$

Where,

Water content = grain moisture (%db).

Fresh mass= initial mass of the sample (g).

Dry mass = sample mass after drying (g).

The difference between the methods was determined with the values obtained from the standard method and the microwave method. Data were subjected to descriptive analysis to characterize the samples, and regression analysis to analyze differences between methods as a function of drying time.

Results and discussion

In determining alternative methodologies for quantification of grain content, the analysis must be comprehensive of water with different ranges of values. In the present study, variations were made with an interval ranging from 4 to 33% db with differences in relation to the species, presented in the descriptive analysis of the data (Table 1).

Table 1. Descriptive analysis of water content in peanut, sunflower, corn, soybean and wheat grains.

Parameter	Peanut	Sunflower	Corn	Soybean	Wheat
Mean	7.12	11.44	17.78	12.62	18.63
Median	6.23	9.64	16.44	11.89	18.92
Standard deviation	1.89	4.81	11.52	2.44	6.81
Kurtosis	0.19	0.94	0.32	4.33	5.80
Asymmetry	1.21	0.89	1.23	1.81	1.40
Minimum	4.94	3.11	11.00	10.11	4.74
Maximum	11.45	24.52	28.56	20.82	33.25

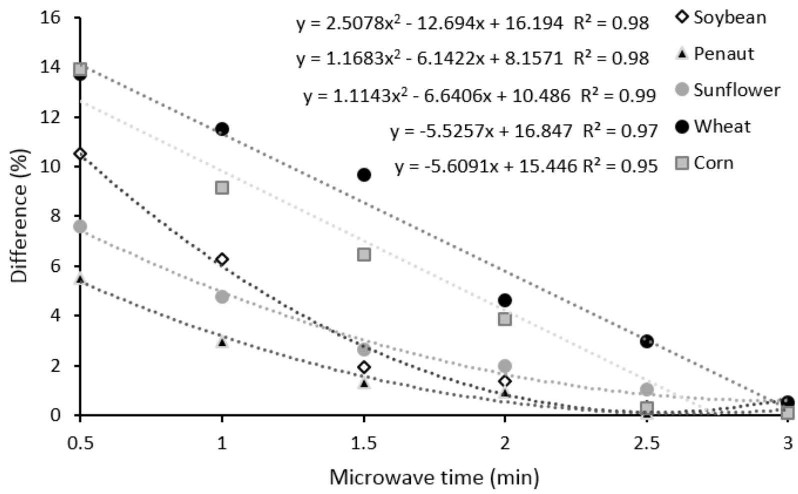
The analyze water content ranges for the different species reflect conditions obtained in the field, mainly at harvest and pre-processing (Table 1).The determination of water content is relevant in harvesting, storage, processing and marketing practices, considering the effect of water on maintaining product quality and its role in biochemical reaction (GALINDO *et al.*, 2019; SÁ *et al.*, 2020, SAATH *et al.*, 2021).

In the standard method using a forced air circulation oven, there is total removal of the water mass in the grains, being adopted the same temperature and humidity conditions for different species. Microwave technology can be used for indirect determination of moisture, using the dielectric properties and with low cost (TRABELSI *et al.*, 2016). However, when drying with the use of a microwave oven, the removal of water occurs as a result of the excitation of water molecules, and depending on the composition of the grain, it causes changes in the product.

According Silva *et al.* (2021), the drying of the product with microwaves is influenced by the initial humidity, geometry and power used, the higher the power, the shorter the time for water removal, but there is a change in the properties of the product such as discoloration in rice. The interaction between microwave power and product moisture causes physical changes in the grains (RAHMAN *et al.*, 2019). Thus, in the present study, constant power was adopted with variation associated only with time.

The use of microwave drying requires modeling and simulation for use without damage to the product (SHEN *et al.*, 2020). In the study, the power adopted was constant, with the time varying from 0.5 to 3 min, and the efficiency of the method determined by the difference in the water content obtained with the microwave in relation to the standard method. Under these conditions, the increase in drying time, on microwave, reduced the difference in the water content obtained in relation to the standard method for all evaluated species, as shown in Figure 1.

Figure 1. Difference in percentage values of humidity determined in microwave in relation to the standard method.



As shown in Figure 1, with the adoption of a microwave drying time of less than 2 min, there is a greater difference in relation to the standard method, with a difference of up to 14% being obtained in time of 0.5 min, resulting from the cumulative physical process of excitation of water molecules present in the product, whether in free form or in composition. The differences obtained, between the water content of microwave and the standard method, in lower drying periods (< 2 min) are due to the presence of water mass remaining in the material after drying. This indicates that in periods of less than 2 min there is only partial removal of the water content of the products.

Differences observed between species (Figure 1), such as a linear reduction trend for corn and wheat, and polynomial reduction for peanuts, sunflowers and soybeans, result from the characteristics of the products, mainly composition and initial moisture content of the samples.

Regardless of the evaluated species, when drying the beans in a microwave oven for 3 min, the difference in relation to the standard method was less than 1%, presenting correlation and technical feasibility.

In studies developed by Nirmaan *et al.* (2020) and Nunes-Zolini *et al.* (2022), the microwave also showed technical feasibility for moisture determination in rice and soybean grains. In this way, the using microwave is efficient in obtaining the water content in peanut, sunflower, corn, soybean and wheat grains, obtaining results close to those obtained in the standard method. It should still be considered that the microwave present the advantage of obtaining the results in a shorter period of time and using accessible equipment.

Considering the results obtained in the present study, the microwave oven can be used to determine the water content in the grains. However, it is necessary to develop new studies aimed at analyzing other species, moisture ranges, potency, as well as the possibility of intermittent drying and combination of factors, enabling advances in the sector with potential for practical application.

Conclusion

The determination of water content in peanut, sunflower, corn, soybean and wheat grains in microwave is technically feasible, showing correlation with the determination in an oven by the standard method.

The drying time in the microwave influences the water removal capacity of the grains.

For peanut, sunflower, corn, soybean and wheat grains, the microwave drying time of 3 min showed greater similarity with the determination by the standard method.

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