STUDIES ON THE PHYSICAL CHANGES OF VEGETABLES SUBJECTED TO DRYING

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Abstract

Vegetables are of significant importance in human nutrition, containing beneficial micro and macro elements for the daily diet. Vegetables are important sources of vitamins, proteins, carbohydrates and mineral salts. However, due to their seasonal growth and short shelf life, they can be consumed at certain times of the year, depending on their nature. For this reason, the vegetable sector requires additional knowledge to manage the quantities obtained seasonally, throughout the year. Although these efforts are made, large quantities of vegetables are wasted annually, which lead, on the one hand, to large losses for processors and, on the other hand, to the waste of food beneficial to the human body. In order to reduce the amounts lost annually, storage and preservation methods are studied and developed, in order to extend the shelf life, aiming to preserve the benefits of the vegetables. One of these conservation methods is drying, this has been practiced since ancient times, using the sun as a heat source. Over time, modern drying techniques have been developed in such a way as to obtain a product of high quality, to be microbiologically stable, to have the appearance and properties as close as possible to the fresh product and to have production costs as low as possible. Drying is the operation that not only extends the shelf life considerably, but also reduces transport prices for dried vegetables, as they reduce their volume by 52-80%. Although the dehydration of vegetables has a number of benefits, for its realization it is important to take into account a lot of factors, because not observing them favors the loss of micro and macro elements in the product and can lead to the destruction of their appearance.

Key words: drying, convection, vegetables

Drying is one of the most complex and poorly understood processes involving the simultaneous and coupled transport of heat, mass, and momentum in a working environment (Krokida M.K *et al*, 2000a).

Typically, drying a solid is thought of as the process of removing water or another liquid from the solid until a low enough value is reached (McCabe W.L. *et al*, 1993). Many authors refer to "drying" as the natural process of water loss by exposure to the sun and "dehydration" as the artificial drying under controlled circumstances (Potter N.N., Hotchkiss J.R., 1998).

Drying is the operation that aims to extend the shelf life of the product, without losing its organoleptic, structural, chemical, and microbiological properties, to obtain a higher quality product suitable for human consumption (Abano E.E. *et al*, 2011; Barbosa G.V, Mercado H.M., 1996).

In the drying process, the aim is to reduce the humidity, which leads to the slowing down of the biochemical processes in the product, through which the organic substances are broken down enzymatically in living cells, through oxidation-reduction reactions with the release of heat (Stanley D.W *et.al*,1999).

For these reasons, in this paper we proposed to analyze three dry products by two different methods

MATERIAL AND METHOD

In this study, the physical changes undergone during the drying operation of white Champignon mushrooms, *Agaricus Bisporus* variety, leeks, *Mercury* variety and broccoli, *Monaco F1 CMS* variety were analyzed.

The research on the physical changes of the vegetables subjected to drying was carried out by two methods, using the drying plant with air currents by natural convection and the drying plant with transmission of air currents by convection with steam injection.

These two drying methods were used to compare the drying methods and to highlight the characteristics of each method and its impact on each product.

Drying methods are based on the transmission of heat through natural convection. Before drying, thermobalance determinations were

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made for both methods to determine the initial moisture content of the product and its mass.

After determining the amount of water in the product, the characteristics of the product were determined to set the drying parameters. According to GD no. 957 21.08. 2007, dried vegetables should have a moisture content between 7-14%, these values also being confirmed by Food Technology Department (Veleșcu I.D., 2014).

So, following the determination of the initial moisture in the thermobalance and the initial mass, the products were subjected to moisture check during drying. Checks were made every 45 minutes, continuing until the final humidity was reached. Checks were carried out to establish the approximate drying time, after which the dehydration was repeated without opening the enclosure of the drying facility.

Several variables were monitored both before and during the drying process. These are moisture, mass, color, and tissue condition.

Moisture varies according to the amount of water in the vegetables, the distribution of water in the tissues, and the nature of the vegetables.

The mass and volume fluctuate due to the evaporation of a significant amount of water from the tissues of the product, as a result, the mass decreases along with its volume. Their decrease is directly proportional to the amount of water extracted from the product. Mass measurement is done with the electronic scale.

Color change is another parameter that shows changes during the drying process, this is due to the deterioration of some pigments in the upper tissues of the product. It is recommended to select a drying method that changes the color as little as possible. The color is determined with the RGB 2000 spectrophotometric analyzer.

The RGB value refers to the correlation of the analyzed color to 3 colors with which it is compared, as follows: R- expresses the color red; G- expresses the color green; B- expresses the color blue (Cârlescu P.M., 2005).

The following relationship were used to calculate the color difference for dried vegetables compared to fresh ones

$$\Delta E_1 = \sqrt{(L - L_0)^2 + (a - a_0)^2 + (b - b_0)^2}$$

where: $\Delta E1$- is the color difference between the vegetable before drying and after drying process

L_0, a_0, b_0 – values for fresh vegetables

L, a, b - values for dried vegetables

The color change parameter is dimensionless

The condition of the tissues is determined by rehydrating the vegetables after they have been dried. If, during drying, the tissues were destroyed due to the high temperature, they no longer have the ability to rehydrate. To avoid it, you must set the parameters or the drying method in such a way that it does not damage the vegetable tissues.

The technological stages of drying vegetables are as follows:

Selecting samples of the same size and dividing them, where appropriate, into equal parts.

Determination of the initial moisture content of the products on the AGS210 thermobalance (figure 1). To determine the moisture, the products were placed at a temperature of 120°C for 3-5 hours, depending on the product.

After determining the humidity, we determined the mass of the samples and the initial color RGB value.

Figure 1 **Thermobalance AGS210**

After that, we made the drying of previously prepared samples at a temperature of 70°C. The installation works on the basis of electric resistances, powered from the 220V, having the capacity to operate at temperatures between 60-105ºC (*figure 2*).

Figure 2 **Drying oven**

After drying the vegetables, the samples were cooled and weighed in hermetically sealed containers to equalize the final moisture.

After their cooling, their color was determined in order to determine the changes obtained during drying.

After drying, The moisture content was determined using a thermobalance to determine the final moisture content after drying.

After performing all the determinations, the samples were subjected to the rehydration process to determine the state of their tissues. The rehydration was carried out in distilled water, at a temperature of 21°C, for 8 hours.

The rehydration index of vegetables subjected to drying represents the relationship between the mass of the rehydrated product over the mass of the dry product. After draining, they were weighed in order to determine the rehydration coefficient.

In the case of drying vegetables using blanching pretreatment, the order of operations is the same, except that blanching is carried out before drying for 16 minutes at a temperature of

116°C. This unit operation was carried out with Convection Air Dryer with Steam Injection.

RESULTS AND DISCUSSIONS

To carry out the studies, the changes in the appearance of the vegetables during the drying process were followed, monitoring the humidity, the weight lost during dehydration, the drying time, the speed of rehydration, and the color. The data obtained from the study are presented in *table 1* and *table 2.*

Table 1

Results obtained from simple convection drying

Drying variables / Samples	T°C	Drying time (min.)	Humidity (%)		Weight lost (%)	Color variation (RGB)	Rehydration index
			Initial	Final			
Mushrooms	70 °C	360	91.25	10.58	80.67	16.97	2.68
Broccoli		450	88.38	10.69	77.69	29.98	2.15
Leek		670	87.81	11.39	76.45	83.35	2.14

Table 2

Results obtained from simple convection drying with blanching heat pretreatment

Drying variables / Samples	T°C	Drying time (min.)	Humidity (%)		Weight lost (%)	Color variation (RGB)	Rehydration index
			Initial	Final			
Mushrooms	70 °C	315	90.11	10.61	79.50	40.72	2.12
Broccoli		390	89.12	10.73	78.39	19.12	2.86
Leek		540	87.34	11.49	75.81	118.83	2.04

The results obtained in the drying process are presented graphically in the following figures for a better analysis of the drying parameters. In the graphs are represented initial moisture (*Figure 3*), final moisture (*Figure 4*), color variation (*Figure 5)* and rehydration capacity (*Figure 6*).

As we can see in figure 3, the initial moisture of the vegetable samples subjected to drying differs both according to the nature of vegetables, the variety, the pedo-climatic factors in which the vegetable was grown and the storage conditions. Because of these factors the vegetables have different initial moisture content.

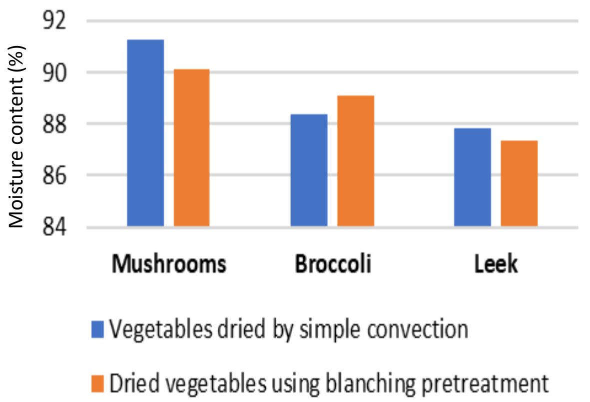

Figure 3 **Average moisture content of the vegetable samples before drying**

As before dehydration, the vegetables after drying recorded different moisture values even if they were dried for the same time and were subjected to moisture equalization after drying. This is due to the difference in moisture content of the vegetables before drying and their properties to react differently to the drying process. Differences in final moisture also occur due to their mass, which varies for each individual sample. And last but not least, due to their contact surface and their position in the drying installation. The average moisture content of the vegetable samples after drying is represented in figure 4.

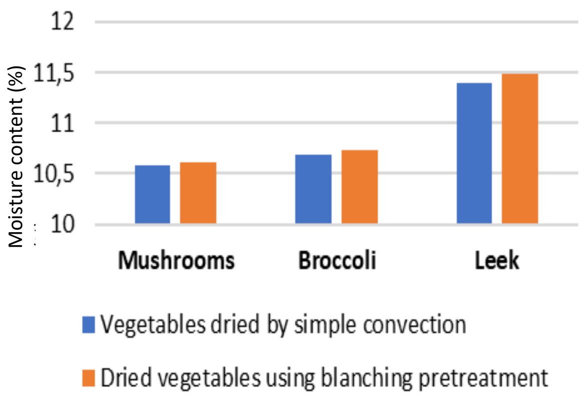

Figure 4 **Average moisture content of the vegetable samples after drying**

The color of vegetables subjected to drying shows changes *(Figure 5).* This is due to the fact that essential oils volatilize easily at temperatures above the limit of 50-60°C, and vegetable pigments change their color, for example, green vegetables (broccoli) change their color to green-yellow, and yellow vegetables (leek) browns or discolors through dehydration. The causes of these changes are either enzymatic or thermal.

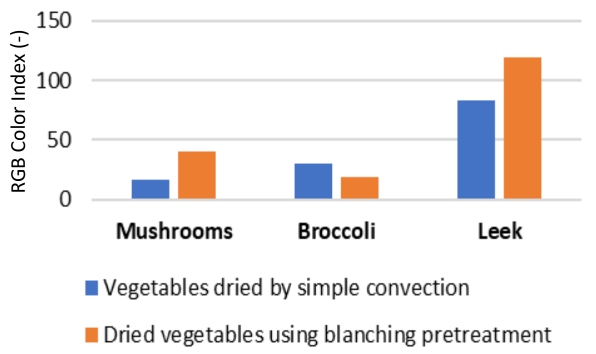

Figure 5 **RGB color index during drying process**

The rehydration index of vegetables subjected to drying represents the relationship between the mass of the rehydrated product over the mass of the dry product. After the rehydration of the dried vegetable samples with the use of drying pretreatments (blanching), they absorbed moisture more quickly through the phenomenon of capillarity (*Figure 6*). Which means that the use of blanching in the drying process helps to keep the tissues whole during the operation.

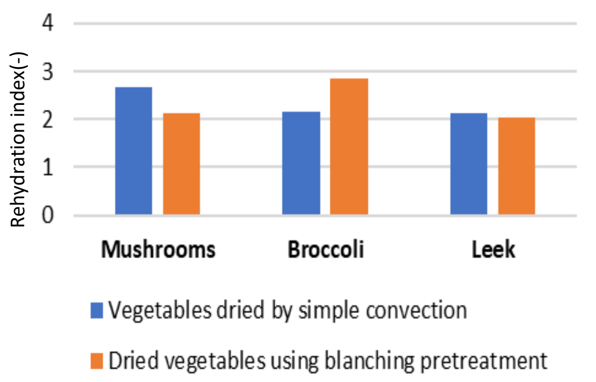

Figure 6 **Rehydration index of vegetables subjected to drying**

After the analysis and interpretation of the results obtained from the study of the physical changes of the vegetables subjected to drying, we can conclude that the humidity, color and rehydration index of the samples subjected to drying registered the established norms.

CONCLUSIONS

The initial moisture of the vegetables and the distribution of water in their tissues defined the drying parameters of the finished products. We notice that in the case of leeks, where the moisture is distributed on the rings, the drying time was much longer, compared to mushrooms, where the moisture is evenly distributed throughout the product.

Analyzing the rehydration index and the color variation we can state that we have obtained a compliant dry product. It did not register major changes in physical properties during drying.

As a final conclusion of the study, Blanching had a beneficial effect on the product, preserving its physical capabilities and at the same time reducing the drying time.

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