MEASUREMENT OF QUALITY PROPERTIES OF DRIED PLUM VARIETIES

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ABSTRACT

This paper deals with a comparison between two different drying processes. Hot air and a vacuum-freeze drying processes were used for drying samples of plum [Prunus domestica L.] varieties ('Cacanska lepotica', 'Cacanska rana' and 'President'). The main objective of our research was to analyse and simulate the change of the quality parameters formed during dehydration by comparing two known drying procedures convective dehydration and lyophilisation.
The study shows the heat and mass transfers of the two drying methods, and examines some special parameters which characterize the quality of dried products, including the chemical components, rehydration, and surface hardness

1. INTRODUCTION

Drying is one of the possible ways of processing vegetables and fruits. The most frequently applied method of this ancient preservation procedure is the artificial convective drying. This procedure became popular mainly as a result of its simple use and low operational costs; however, we should not forget its disadvantages, which are related to the quality of the dried product. These disadvantages include significant decreases in nutritional value, shrinkage, formation of a hard, non-permeable layer, and denaturation of proteins (Karel, 1980; Bouraout et al., 1994; Lewicki, 1998).
Research has been conducted for a long time on preserving fruits and vegetables in such a way that they keep their original properties for the cold winter months as well. Nowadays, in the 21st century the requirements set out for dried fruits and vegetables including that they should be microbally stable, keep their physical, chemical and mechanical parameters and have excellent storage, packaging and transportation properties. In addition, they should have high nutrient contents suitable for producing functional foods and food supplements. Only a few drying methods are suitable for satisfying the above-mentioned demands on preservation. According to our present knowledge, the most tolerant dehydrating method is vacuum freeze-drying. Better quality of lyophilized products results from the fact that the temperatures applied during lyophilization are much lower than during traditional drying and that the denaturation processes typical of the traditionally dried products does not occur. During lyophilization, no internal diffusion takes place because the sublimation starting from the surface gradually spreads to deeper layers; the ice directly passes into steam (Karathanos et al., 1996; Kerekes et al., 2008).

2. MATERIAL AND METHODS

2.1. Description of the materials used in the trials

During the measurements we tested plum varieties (*Prunus domestica* L.) ('Cacanska rana', 'Cacanska lepotica', 'President') of exactly known origin purchased from local producers and traders (Nyíregyháza, Hungary). d the material to be dried and cut it to size then placed it on the tray of the dryer in one layer. The samples were cut into 20 mm pieces, and total mass of the samples were 300 grams. We performed the drying test of the varieties both simultaneously and separately. The analyses were replicated three times.

2.2. Description of the dryers applied in the experiments

We performed the dehydration of the horticultural products (plum varieties) used in the experiments with the following dryers:

1. Convective drying - LP 302 laboratory cylindrical drying cabinet (drying parameters: 9-11 h; 75-80 °C; 1,1-1,5 m/s).
2. Lyophilisation – Armfield FT 33 laboratory vacuum freeze drier (drying temperature from -50 to 20°C; the pressure ranged from 80 to 150 Pa, drying time: 24-26 h).

In order to exactly analyse the processes taking place during the drying, we equipped the laboratory freeze dryer with a data recording system. The described apparatus with the data recording system (platform cell – scale instrument – DATPump software) can be seen in Figure 1.

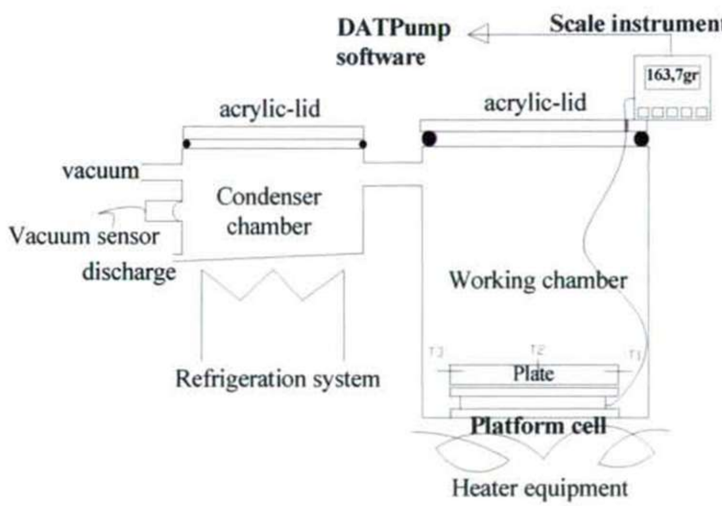

Figure 1. Armfield FT33 lyophilisation apparatus with data recording system

2.3. Description of measuring instruments and measuring techniques

The characteristics influencing the quality of the dried products were measured and evaluated with the following instruments and methods:

- Moisture content measurement: PRECISA HA 60 type quick moisture meter.
- Measurement of the drying parameters of the convective method: TESTO 4510 type measuring instrument.
- Detection of the chemical composition of the material: with analytical procedures and instruments (HPLC, Mobil XRF Analyzer).

- Measurement of the rehydration activity of the dried material in moistening agent (Tein et al., 1998).
- Determination of the product strength: MGA-1091 type electronic penetrometer (Fekete et al., 1994).

3. RESULTS AND DISCUSSION

3.1. Results of the tests of heat and mass transition

During the drying process one of the most important tasks was to determine the drying diagrams (change of water content in function of the time).
Figure 2 demonstrates the change of moisture level in plum samples ('President'), during freeze drying and convective dehydration.

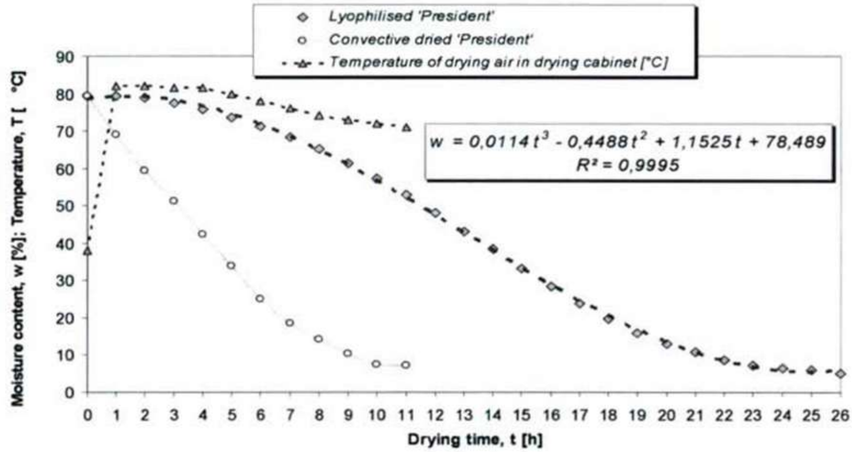

Figure 2. Drying curve of convectively and vacuum freeze dried plum slices

The figure indicates that the drying period of the vacuum-freeze drying process is longer than the convective dehydration, because of the minor drying rate.
The drying curve of the lyophilization is a higher degree polynomials; the formula can be read in the figure and Table 1.

Table 1. Coefficients of the third-degree polynomial

Description	Coefficients			
	a [-]	b [-]	c [-]	k [-]
Plum varieties				
Cacanska rana (d.t.=24 h)*	0,0126	0,441	0,1702	83,017
Cacanska lepotica (d.t.=24 h)*	0,0145	0,5345	1,5046	78,523
President (d.t.=26 h)*	0,0114	0,4488	1,1525	78,489

* drying time

3.2. Analytical results of dried plum

The most important chemical components of the dried plum samples were determined in the Agricultural and Molecular Research Institute of the University College of Nyíregyháza. The results can be studied in Table 2.

The main conclusion from the data presented in the tables is that all the components of the lyophilised samples have a significantly higher value, compared with the conventionally dried fruits.

Table 2. Chemical components of dried 'Cacanska lepotica' samples

Component	Raw material	Convective dried	Lyophilised
General characteristics [%]			
Water	79,27	8,6	5,88
Protein	0,58	0,23	0,39
Carbohydrate	9,8	4,33	7,84
Vitamins [mg/100g]			
Vitamin-B_1	2,2	1,17	1,74
Vitamin-B_2	1,86	1,12	1,44
Vitamin-C	15,2	7,75	11,2
Phenoloids [mg/100g]			
Coumaric-acid	5,82	0,61	4,73
Gallic-acid	1,23	0,54	1,11
Chlorogenic-acid	15,7	4,52	12,6
Minerals [mg/100g]			
Na	16	12,1	15
K	374,1	333,6	352,1
Ca	21,45	19,8	20,39

3.3. Results of the rehydration tests

The process of the experiment was as follows: we measured the weight of the samples dehydrated by various methods, then placed them in pots filled with water of 35 °C and 75 °C. During the experiment, we ensured the permanent temperature of the liquid by means of liquid supply. We removed the samples from the liquid after 0.5, 5, 10, 15, 30, 60 min periods and eliminated the surplus moisture from their surfaces with an absorbent. At the end of the experiment we measured the weights of the rehydrated samples and calculated the rehydration rate (RR). The value of the rehydration rate (RR) shows how much the amount of the water absorbed again can increase the weight of the dried product.

The rehydration curves of the dried plum samples ('Cacanska rana') are illustrated in Figure 3, at 35 and 75 °C water temperature.

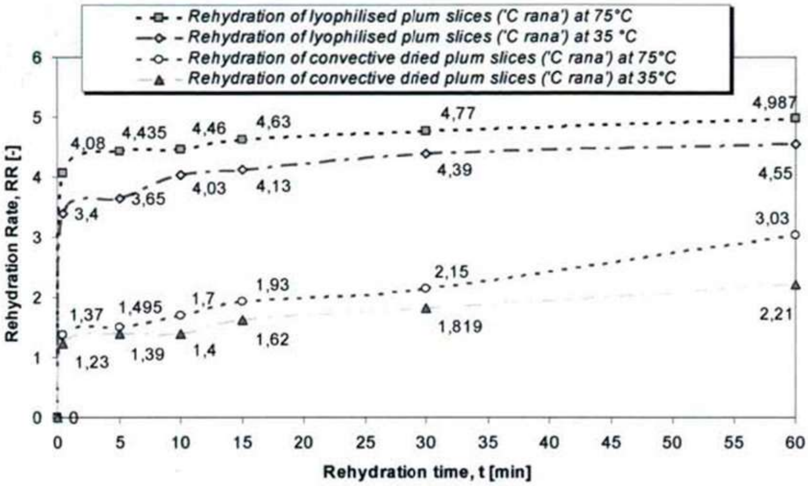

Figure 3. Rehydration curves of the dried plum ('Cacanska rana')

The rehydration rate (RR) can be calculated in the following way:

$$RR = \frac{m_{rh}}{m_d}$$

where:

m_{rh} – mass of the rehydrated material [g],
m_d – mass of the dried material [g].

It can be seen in the figure that the lyophilized samples have a higher rehydration rate than the conventionally dried fruits.

Moreover, the tests proved that rehydration at a higher temperature resulted in a faster moisturing process and larger rehydration rate.

In the Table 3, we indicated the percentage moisture content of the rehydrated product as compared to the original moisture content.

Table 3. Moisture content of rehydrated dried fruits

Description	Moisture content, w [%]		
	Raw material	Convective dried	Lyophilised
Plum varieties			
Cacanska rana	82,71	70,93	82,18
Cacanska lepotica	79,27	62,37	79,41
President	79,43	67,37	79,17

3.4. Surface hardness of dehydrated fruits

Besides the quality features (chemical and physical properties), it is important to discuss the mechanical parameters, with special regard to the hardness of the fruit. In order to ensure the quality during harvest and post-harvest technologies (drying, storing), it is essential to know the hardness of the yield.

Results of the hardness of the dried plum samples are as shown in Figure 4.

The penetration tests confirmed that the surface of the convection-dried materials is significantly harder than that of the freeze-dried products.

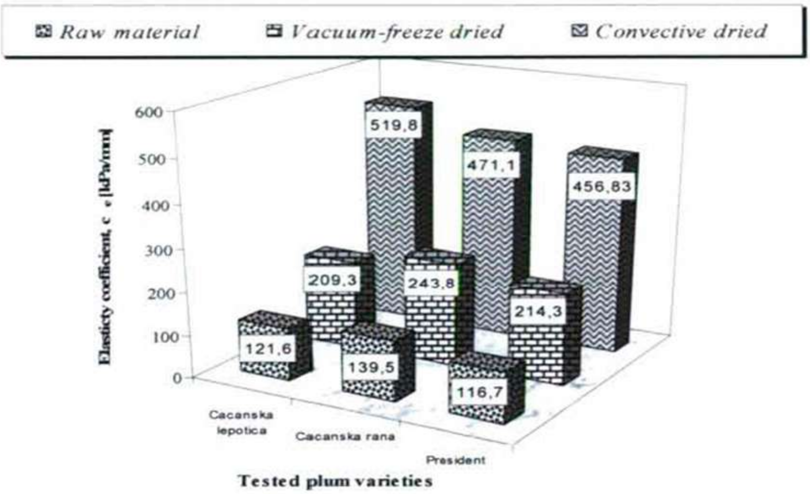

Figure 4. Comparison of the surface hardness of dried fruits to the surface hardness of the raw material

4. CONCLUSIONS

With regard to the results of the heat and mass transports, we found that the temperature and pressure applied for the freeze-drying is much less while the drying time is much longer than those for the convection drying.

We defined a relationship for the characterisation of the drying processes of lyophilised plums. The processes can be approximated with third-degree polynomials. The functions representing the moisture content reduction of the drying materials can be described with the following equation: $w=at^3-bt^2+ct+k$, where: w – moisture content of the product [%]; t – drying period [h], a, b, c, k – coefficients of the third-degree polynomial the values of which depend on the characteristics of the material: the variety, the freezing speed, the ripeness and the tendency to lose water.

Through the analytical inspection of dried plum varieties we stated that the nutrient contents – carbohydrates, proteins, phenoloids, and vitamins – were reduced by 10-33% for the lyophilized samples, while 20-89% reduction was measured for the materials dehydrated by convection, as compared to the initial status.

We proved that during their rehydration the freeze-dried materials regain almost at their original water content and keep their original shape and size as well. The reason for this is that the lyophilised products have porous, spongy structure which is able to absorb moisture and regenerate.

Through the rehydration tests we revealed that small amount of freeze-dried materials seemed to be softer after rehydration than the raw material. The samples dried with the convective method kept their hard, solid surface at the end of the rehydration process, so they could not recover their original shape and moisture content.

Through the penetration tests, we noted that the surface of the plum varieties dried with the convection method is at least 1,93 – 2,48 times as hard as that of freeze-dried products. The reason for this is that during the drying the water leaves the surface of the product by evaporation and the evaporated water is supplied by diffusion from the internal layers. During its movement, the water diffusing from the internal parts takes dissolved materials along with it, which remain on the surface after the evaporation of the water, are concentrated and form a hard layer. During lyophilisation, no internal diffusion occurs since the sublimation starts from the surface, spreads to the deeper layers step by step and the ice is directly transformed into steam without a liquid phase.

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