7th INTERNATIONAL MULTIDISCIPLINARY CONFERENCE
Baia Mare, Romania, May 17-18, 2007
ISSN-1224-3264

ESTABLISHMENT OF A DATA PROCESSING SYSTEM FOR FREEZE DRIER

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Abstract: *The laboratory equipments are important in elaboration of technologies in freeze drying, for research of the product quality, amelioration, moreover determination of transport properties. Our department has a laboratory vacuum freeze drying equipment (Armfield FT 33). We can register all the data during the procedure. It's important to analyze this freeze drying procedure, because this is elementary for system designing. We have constructed the necessary measuring instruments, their arrangement.*
The automatization of this process isn't a simple problem. The principal measured characteristics are: mass of dried product, temperature of dried product layer, temperature of the heater, vacuum, freezing temperature. We can measure the dried product's weight by a load cell, with the necessary accuracy.
Keywords: *freeze drying, tomato, data processing system, heat and mass transfer, chemical composition, rehydration ratio.*

1. INTRODUCTION

Dehydration is one of the oldest methods of food preservation and it represents a very important aspect of food processing. Fruits and vegetables are composed mainly of water, vitamins, carbohydrates, proteins, and lipids. Drying of heat-sensitive biomaterials such as fruits, vegetables, and the so-called wellness, or functional foods, requires special techniques to avoid product degradation due to thermal decomposition, oxidation, or enzymatic browning.
Freeze drying is one of the most sophisticated dehydration methods. The freeze-dried foods are considered as having a quality higher than other dehydrated products mainly because they can be reconstituted with water rapidly to products closely resembling the original food. Another important advantage is that freeze drying is accomplished at relatively low temperatures and the various heat-sensitive biological compounds are not damaged. It is generally accepted that the flavor of freeze dried foods is better than the air dehydrated products. It provides dried products of porous structure and little or no shrinkage, superior taste retention, better rehydration properties, compared to products of alternative drying

process. However, its advantages are directly weighed against its corresponding high treatment cost **[1]**.

As inferred by its name (freeze-drying), moisture in products is first frozen to ice and then the ice is removed by sublimation at temperature and pressure below the triple point of water (273, 16 K and 611 Pa).

The mass determination under vacuum is not easy task, limitations to the operation of some sensors occur and the measure is affected by several disturbances, like buoyancy effects, vibrations, gas flows, temperature gradients.

The objectives of this study were to investigate the effects of vacuum freeze-drying (VFD) on the heat and mass transfer, drying velocity, rehydration, physical properties of tomato slices as compared to convective drying (CD).

2. MATERIALS AND METHODS

Materials

Tomato (*Lycopersicum esculentum*) is an important vegetable and fruit in daily dietary. Consumption of tomato products has been associated with decreased risk of some cancers, and the tomato antioxidant lycopene, is thought to be positive to the observed health. Tomato contains not only the nutritional antioxidants such as vitamin A, B, and C, but also a great quantity of non-nutritional antioxidants, such as beta-carotene, carotenoid, flavonoids, flavone, and total phenolics compound **[4]**.

Fresh, good quality of tomatoes were procured from local market and washed with running water. The washed tomatoes were sliced into circular discs of 3 and 5 mm thickness. The sample weight was in all cases 220g. Sliced tomatoes were dried using two different drying methods, namely, vacuum freeze-drying and convective drying.

Methods

Trials were performed with a pilot scale *vacuum freeze-dryer* (Armfield FT 33, United Kingdom) which has been described elsewhere **[2]**. The vacuum freeze-drier is composed of a refrigeration, heating, vacuum, scaling and data collecting system. The freeze-drier has the following characteristics: (a) the temperatures of condenser and specimen chambers, temperatures of the samples; (b) a precise platform cell (PAB-01 Emalog Inc., Hungary) was placed in specimen chamber, and connected with the data collecting system (ES-138 Emalog Inc., Hungary). The weight changes of samples can be recorded by a computer (Figure 1).

Fig. 1 *Data processing system of freeze drier*

The VFD treatment was operated at -50 °C, 2 mbar, for 33 h in a vacuum freeze-drier.
The parameters of the convective drying was the followings: hot air at 85 °C, air velocity 0,6 m/s, and 10 % air humidity. Drying was done in a *convection drier* equipped with 5 shelves, each diameter was 320 mm. The distance between the shelves was 15 mm. The hot air flow was directed to shelves. The drop of temperature along the shelves was about 2 °C, hence the drying was assumed to proceed at constant temperature.

3. RESULTS AND DISCUSSION

Heat and mass transfer

The curve of VFD reflects the relation between heating temperature, material temperature, dehydration rate and drying time during the freeze drying course. The Figure 2 shows the relation of heating temperature, average temperature of tomato, cooling-trap temperature, and pressure of the chamber along with the time change. The relation curve indicates that drying period is the longest process in the VFD course. (The temperature variation along the time was measured by four thermocouples inserted into the tray.)

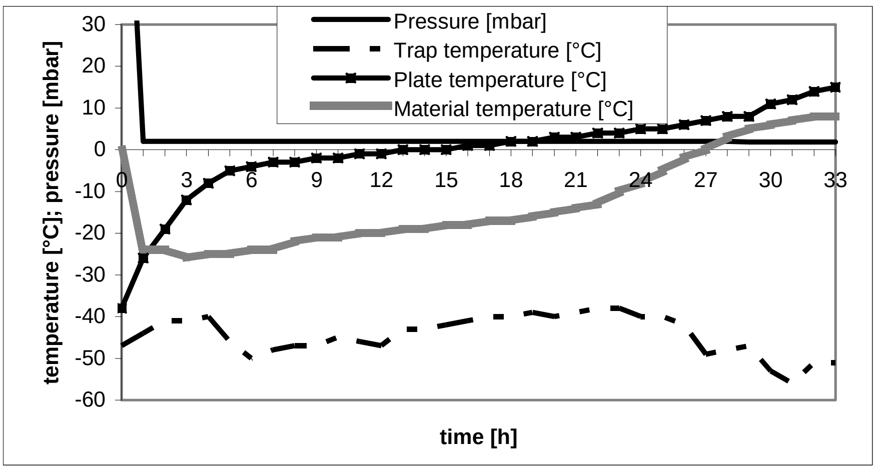

Fig.2 *The parameters of freeze-drying of tomato*

A tray of tomatoes was placed on the freeze-dryer plate at an initial temperature of -40 °C. The transparent perspex door was closed; the condenser and the vacuum pump were turned on. The plate started heating when the working pressure reached the operating value (2 mbar). On the basis of partial pressure measurement, changes in water vapor flow can be calculated and the residual moisture content in the product estimated such as the freeze-drying end-point. The trial was stopped when the temperature of the material remained constant. Thus, the residual moisture content in the dried tomato was about 0,09 kg of water per kilogram of dry matter. The corresponding water activity is 0,09.

The Figure 3 shows that increasing of the thickness of material, the drying time becomes longer and the Figure 3 also indicates that the thickness is not linear relation with drying time and influence of the thickness on the drying time is significant.

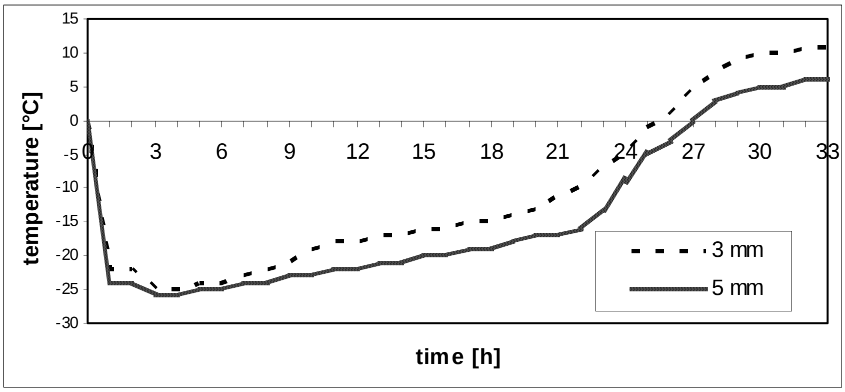

Fig. 3 *Influence of the thickness on the VFD*

As illustrated in Figure 4, the CD was considerably faster drying process than VFD. While it took 6 h for the convective drying to dry 220 g of the tomato (93,4 % moisture) to a final moisture content of 10%, 33h was required for freeze drying the samples. The maximum drying velocity in CD (0,23 %/min) was higher, than in VFD (0,04 %/min) experiment **[3]**.

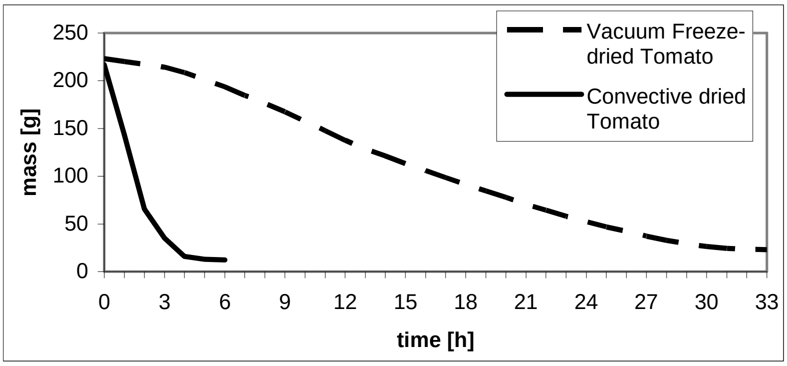

Fig. 4 *Dehydration curves of convective dried and vacuum freeze dried tomato slices*

The change in moisture content against drying time of tomato slices in vacuum freeze-drier is shown in Figure 5. The fitting of the polinom was close, with R^2= 99,87% for tomato.

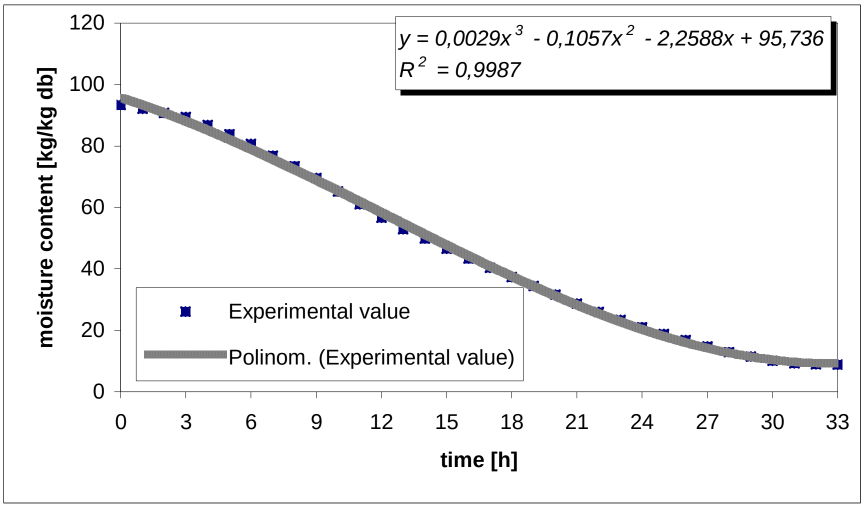

Fig. 5 *Relationship between moisture content and drying time of tomato slices in vacuum freeze-drier*

Rehydration potential

The capacity of freeze-dried tomatoes to rehydrate was measured by weighing about 1 g of freeze-dried product after soaking in distilled water for different times. The rehydration coefficient (CR%) was defined as the ratio of the amount of water taken up over the total amount of water removed by drying (1). The maximum rehydration coefficient is obtained when soaking the product in warm water and does not change its weight significantly.

Equation of rehydration ratio: $$R = \frac{m_{rehydrated}}{m_{dried}} \qquad (1)$$

The rehydration curves of dried tomato slices at 40 °C and 80°C are sown in Figure 6. At both 40 °C and 80 °C, the vacuum freeze-dried tomato slices exhibited higher rehydration ratios than convective dried tomato slices. The Freeze dried tomato slices, due to their porous structure, had the highest rehydration ratio. When the water temperature was increased, less rehydration time was required for reconstitution.

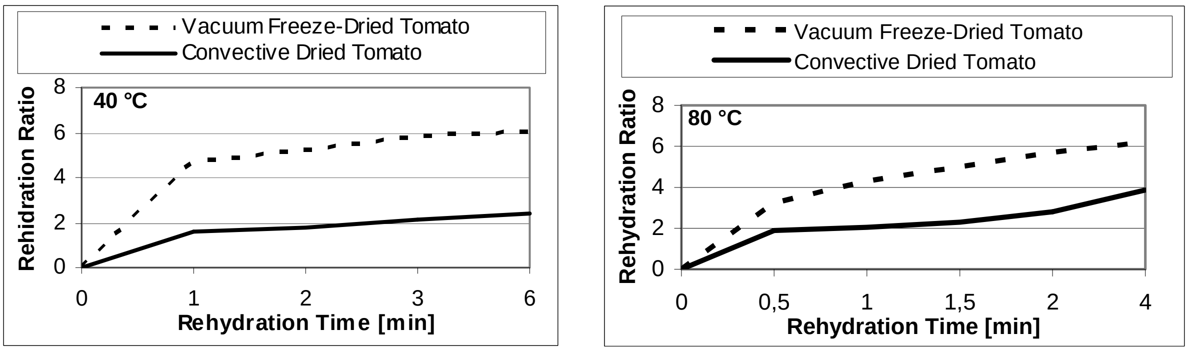

Fig. 6 *Rehydration curves of convective dried and freeze dried tomato slices at 40 °C and 80 °C*

Physical properties of tomato

The parameters of chemical composition are presented in Table 1.

Table 1. Chemical composition of tomato*

Samples Properties	Raw material	Convective Drying (CD)	Vacuum Freeze Drying (VFD)
Moisture content [%]	93,4	10	9
Protein [g/100g]	7,2	5,4	6,3
Lipid Fat [g/100g]	2,1	1,2	1,7
Calcium [mg/100g]	79,3	67,4	69,3
Phosphorus [mg/100g]	134,1	117,4	123,5
Magnesium [mg/100g]	122,2	110,4	114,6
Vitamin C]mg/100g]	135	67,2	118,5
Vitamin B_1]mg/100g]	0,64	0,22	0,31
Vitamin B_6 [mg/100g]	0,98	0,52	0,71

* The results of chemical composition produced by Agricultural and Molecular Research Institute (College of Nyíregyháza)

4. CONCLUSIONS

Carrying out on-line mass measurements of a product is very important during lyophilisation, for reaching an optimal performance.
The freeze-drying is performed at very low temperatures therefore the final product suffers little damage. For the reasons already mentioned and because the velocity of freeze-drying depends on the intensity in which the vapor flows through the dried superficial layer, each product requires an optimum cooling rate to provide effective dehydration and rehydration rates, thus ensuring good quality product.
The effectiveness of freeze-drying depends on the sample temperature and the thickness during the process.
At either temperature (40 °C or 80 °C), higher rehydration rates occurred at the beginning of the rehydration. It is especially noted with the freeze dried samples.
The results confirm that, concerning the considered quality attributes, freeze-dried samples are much superior to the convective dried ones.

5. REFERENCES

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