

THE USAGE OF VACUUM IMPREGNATION FOR IMPROVING THE QUALITY OF DRIED VEGETABLES

UPOTREBA VAKUUM IMPREGNACIJE ZA UNAPREĐENJE KVALITETA SUŠENOG POVRĆA

Claudiu URSACHI, MSc*, Dr. Rodica SEGAL**

*Department of Technical Science and Technology, "Aurel Vlaicu" University of Arad, Romania, Str. Elena Drăgoi nr. 2,

**Faculty of Food Science and Engineering, "Dunarea de Jos" University of Galati, Romania

e-mail: ursachi70@yahoo.com

SUMMARY

Our goal in this study is to point out a possibility of improving the quality of the dried vegetables with the help of a new technology, vacuum impregnation.

As we all know, a large proportion of vegetal products are characterized through a high level of sensitivity towards environmental factors and towards the alterations they are subjected to during the processing. This leads to their degradation in terms of both sensorial and nutritional point of view.

The vegetable products which were studied had been impregnated under a vacuum pressure of 300-500 mbar for 10 min, with a solution of ascorbic acid and afterwards they were dried under different conditions. During the exsiccation, as well as after the process reached its end, ascorbic acid stability, color and selected physicochemical properties of vegetable products were analyzed.

Key words: vacuum impregnation, vegetable products, drying.

INTRODUCTION

Fruit and vegetables are seasonal products, generally characterized as extremely perishable goods. In order to be consumed throughout the year, anywhere in the world, at a satisfactory nutritional value (close to the nutritional value of fresh products), vegetal products are preserved with the help of artificially controlled dehydration.

In air drying of foods, together with the partial evaporation of the water content, some physical and chemical changes in the tissue structure occur. Destructuration of natural tissue, shrinkage, loss of nutritional value and changes in physical properties such as texture and color, are some of the alteration that may occur during dehydration process.

One of the most undesirable defects occurring during dehydration, particularly in the case of fruit, is brunification due to enzymatic oxidation. To prevent the development of this flaw, current technology involves the sulphitation of fruit. Sulphur dioxide is an additive which is restricted by law and rejected by a large number of consumers.

We tried to find another method to prevent enzymatic browning of dehydrated products, namely the introduction of antioxidants in the internal structure of fruit through a relatively new technology, vacuum impregnation [5, 9].

Vacuum impregnation technology consists of the immersion of vegetable products, characterized by high porosity (apples, quinces, strawberries, apricots, peaches, peppers, mushrooms, etc) in solutions which contain dissolved substances meant to impregnate the product, and followed by their storage in a place under a certain vacuum pressure. This provokes the partial or total elimination of the gas from the pore of product, which is replaced by the surrounding solution when the atmospheric pressure is restored [10].

For impregnation we used sucrose solutions of non-reducing disaccharide, in which we dissolved antioxidants such as ascorbic acid and sodium isoascorbate, in different proportions [3].

We used sucrose solution because it is recognized as a desiccation protectant. It was reported that apple cylinders osmotically dehydrated and rehydrated with trehalose, fructose or sucrose solution tended to shrink less throughout dehydration

and showed a better solute retention during rehydration. According to a number of authors rehydration can be considered as a means to quantify the cellular disruption suffered by the material [1].

MATERIAL AND METHOD

Raw material and sample preparation

Golden Delicious apples were purchased from a local store and washed with distilled water. Apples were peeled and cut into round shapes (3-5 mm high and 70-80 mm diameter) using a stainless steel tubular cork borer and a knife, following their vertical axis. The fresh product was characterized by measuring the weight, the moisture content and soluble solid concentration in the liquid phase. Also the acid ascorbic content was determined. The samples were immediately immersed into the impregnation solution to avoid contact with oxygen. The solution – sample mass ratio was higher than 10:1. Immersed apple samples were placed in a desiccator at room temperature. A vacuum pump (Model RL-2: REFCO manufacturing Ltd. Switzerland) was connected to the desiccator, and a vacuum pressure of 400 mmHg was applied to the system for 10 min. and then an atmospheric pressure restoration for 10 min. Impregnated samples were characterized as to their weight, moisture content, soluble solid concentration in the liquid phase and acid ascorbic content.

We prepared six samples: 1) Reference – untreated apple (R); 2) Impregnation at atmospheric pressure with a solution composed of 20% sucrose and 1% ascorbic acid (AP/S+AA); 3) Vacuum impregnation with a solution with 20% sucrose (VI/S); 4) Vacuum impregnation with a solution that contains 20% sucrose and 1% ascorbic acid (VI/S+AA); 5) Vacuum impregnation with a solution that contains 20% sucrose and 1% sodium erythorbate (VI/S+SE); 6) Vacuum impregnation with a solution that contains 20% sucrose, 0.5% ascorbic acid and 0.5% sodium erythorbate (VI/S+AA+SE).

Hot air drying and rehydration

All six apple samples were dried in a pilot scale air dryer (Armfield U0P8 Tray Drier, UK) at 40°C and 60°C under a rate of 1.5 m/s, up to 18% moisture content.

Isotonic sucrose solutions (11%) were used to rehydrate the dehydrated slices. Rehydration was carried out at 22°C for 8 h. After rehydrataion time, the total mass of the samples were monitored, as well as the solute concentration. Mass balances of water and solutes were applied to assess the composition of the samples throughout the process. At the end of the rehydratation step the samples were analyzed to check the reliability of the balances.

Physicochemical property analysis

Moisture content was gravimetrically determined, through drying at 75°C on the drying stove until it reaches a constant weight. A refractometer (model Kruss AR 2008) was used for the quantification of soluble solid content in the liquid phase of the samples and in the solutions.

Color changes were evaluated by measuring CIE L*a*b* coordinates with a Minolta CM 3220d spectrophotometer. Total color difference:

$$\Delta E = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2}$$

was calculated to determine the color intensity and color difference from fresh apples [7].

Vitamin C in fresh, vacuum infused and dried apples was measured by a chemical method involving titration with dichlorophenolindophenol. A 1% solution of oxalic acid was used in the extraction and homogenizer process to inhibit further degradation of the vitamin C. After homogenization, the slurry was filtered, and the chemical procedure was applied to filtrate [3, 8].

For all afore mentioned parameters four measurements were performed in each of the three replicates.

RESULTS AND DISCUSSION

Color

It is well known that enzymatic browning catalyzed by polyphenol oxidases is one of the most undesirable quality changes in fresh cut apples. In this study, L*, a*,b* and ΔE values are used as color indicators for apples and are reported in Table 1.

Table 1. Color coordinates of fresh and dried apples at 40°C and 60°C

Tabela 1. Kolor koordinate sveže i sušene jabuke na 40° i 60°C

No.	Sample	L*		a*		b*		ΔE	
		40°C	60°C	40°C	60°C	40°C	60°C	40°C	60°C
1	Fresh	79.57		-0.65		16.54		0	
2	Reference	70.36	70.98	12.07	13.04	37.79	40.52	25.79	28.91
3	AP/S + AA	71.88	72.77	3.74	4.37	37.52	39.43	22.77	24.40
4	VI/S	69.32	71.16	9.23	9.43	39.45	42.19	26.97	28.81
5	VI/S + AA	76.34	76.51	0.16	0.33	34.51	34.93	18.27	18.66
6	VI/S + SE	77.42	76.22	0.31	0.58	33.97	34.41	17.56	18.22
7	VI/S+AA+SE	74.92	75.19	0.21	0.48	34.05	35.18	18.13	19.18

A decrease of the level of lightness (L*) can be observed for all the dried samples because of pigments concentration. Sample (6) is the most similar to the reference sample, with a reduction of L* value of 4.2%. The greatest loss of lightness was recorded at samples (2) and (4), which had not been treated with antioxidants and sample 3 which had not been impregnated under vacuum, therefore the value of L* was reduced with 8.5 to 10.8%.

In comparison to fresh products, the value of b* for all dried samples is higher, indicating an increase in shades of yellow. The differences between the dehydrated samples are not significant. The values were only higher for samples (2) and (4) that

were not treated with antioxidants and for the sample (3), impregnated at atmospheric pressure.

There are very big differences between the dried samples for value a* (redness). One can see, Figure 1, a huge increase in the cases of samples (2) and (4) which do not contain antioxidants, in comparison to the fresh sample as well as in comparison to the samples which had been impregnated under vacuum with solutions of antioxidants.

With respect to total color differences between fresh and dried samples, (5), (6) and (7) have the lowest values, which are the samples treated with antioxidants solutions under vacuum. Important differences regarding color were obtained from sample witness (2) and (3), impregnated at atmospheric pressure and to sample (4), impregnated under vacuum but in the absence of antioxidants.

Results in drying at 40°C and 60°C are similar, higher values for all four units L*a*b* and ΔE were recorded when drying occurred at a higher temperature.

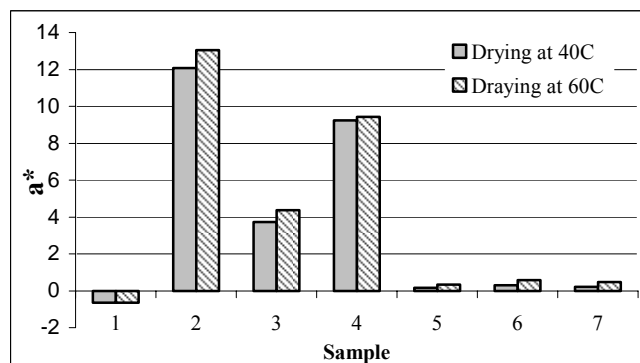
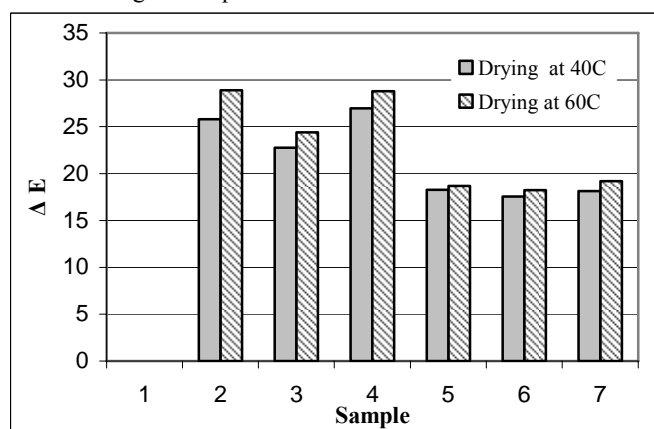


Fig. 1. Total Color Difference (ΔE) and redness (a*) value of dried apple samples

1 - Fresh apple; 2 - R; 3 - APS/AA; 4 - VI/S; 5 - VI/S+ AA; 6 - VI/S+AA+SE; 7 - VI/S+AA+SE;

Sl. 1. Ukupne vrednosti razlike u boji (ΔE) i crvenilo (a*) suvih uzoraka jabuke

1 - Sveža jabuka; 2 - R; 3 - APS/AA; 4 - VI/S; 5 - VI/S+ AA; 6 - VI/S+AA+SE; 7 - VI/S+AA+SE;

Vitamin C analysis

As can be seen in Figure 2 the sample which was impregnated under vacuum with a solution of 20 % sucrose and 1 % ascorbic acid led to an increase of vitamin C content in the product, 20.2 times compared to fresh sample and 3 times compared to the sample impregnated with the same solution but at atmospheric pressure.

However, vitamin C is characterized through high sensitivity towards various factors such as the presence of oxygen, temperature, pH, water content, the metallic ions, being therefore easily destroyed during the processing of plant products.

From this study one can observe an increased stability of vitamin C for the samples which had been impregnated under vacuum. When the products were dried at 40°C, 50.5% of the initial vitamin C was preserved, and for the products dried at 60°C, 39.3 % were preserved. For the sample which remained untreated, no traces of vitamin C were identified in the dried product. In the case of the sample treated at atmospheric pressure, the amount of ascorbic acid determined was 23.41% for drying at 40°C and 19.17% for drying at 60°C.

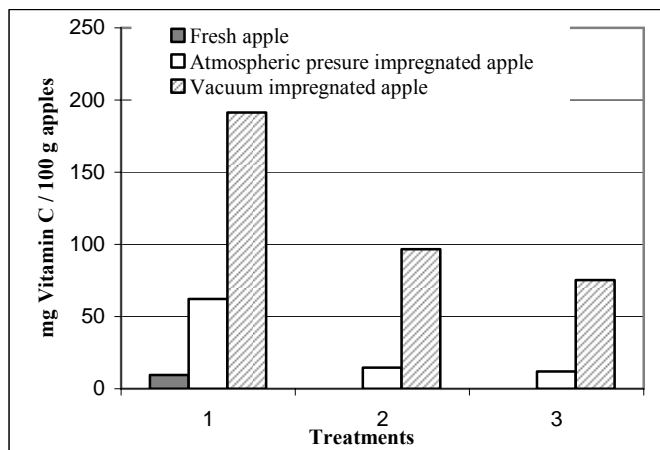


Fig. 2. Vitamin C content in apples samples

1 - Before drying, 2 - After drying at 40°C, 3 - After drying at 60°C

Sl. 2. Sadržaj vitamina C u uzorcima jabuke

1 – Pre sušenja 2 – Posle sušenja na 40°C, 3 – Posle sušenja na 60°C

Greater stability of ascorbic acid in the cases of products impregnated under vacuum could be explained by the fact that it penetrates the internal structure of the product, replacing the air in the tissues thereby avoiding contact with oxygen.

Water absorption capacity WAC

Water absorption capacity refers to the amount of water that can be absorbed by dried product. The value generally ranges from 0 to 1. Water absorption capacity is calculated according to [6]:

$$WAC = \frac{Mr(100 - sr) - Md(100 - sd)}{Mo(100 - so) - Md(100 - sd)} \quad (1)$$

where is: Mo – mass of sample before drying, Md - mass of dried sample, Mr – mass of rehydrated sample, so - % dry matter content of sample before drying, sd - % dry matter content of dried sample, sr - % dry matter content of rehydrated sample.

The study shows an improvement of the water absorption capacity for samples impregnated under vacuum with sucrose solution certifying the fact that sucrose may have a protective role upon the plant tissue during the process of thermal dehydration. The results, Table 2, show values that are close to this parameter for products dried at 40°C and 60°C, but higher in comparison to the reference sample obtained for untreated apples.

Table 2. Water absorption capacity (WAC) of dried apples samples

Table 2. Kapacitet apsorpcije vode(WAC) suvih uzoraka jabuke

No	Sample	Mo [g]	so [%]	Md [g]	sd [%]	Mr [g]	sr [%]	WAC
1	Reference dried at 40°C	27.31	14,34	5.27	81.65	20.15	15.36	0.71
2	Reference dried at 60°C	28.65	14,34	5.83	81.89	21.17	15.20	0.72
3	VI/S + SE dried at 40°C	38.12	15.56	7.12	82.17	32.91	17.27	0.83
4	VI/S + SE dried at 60°C	39.31	15.56	8.56	81.75	32.28	17.31	0.79

CONCLUSION

Impregnation under vacuum allows a series of compounds to be incorporated in controlled quantities in porous vegetal goods in order to improve their sensorial, nutritional and technological characteristics.

Unwanted changes of color during dehydration due to brunification can be controlled and minimized. With respect to color, the best result was obtained after having impregnated the product with VI / S + ES solution. Satisfactory results were obtained when using VI / S + AA solution, which led to a higher stability of ascorbic acid during dehydration, thereby improving nutritional value of dried products.

Vacuum impregnation is recommended as pretreatment technology for manufacturing dehydrated apples by using heat, in order to prevent damages upon color, to improve water absorption capacity, to increase the level of stability of antioxidants.

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Primljeno:21.03.2009.

Prihvaćeno:01.04.2009.