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The Usage of Vacuum Impregnation Pretreatment to Improving the Quality of Frozen Fruits

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Abstract

Conservation of fruits by freezing is o good method of ensuring the long-term retention of original characteristics, in almost unchanged state, especially of perishable materials. But freezing destroys cell integrity, thereby increasing the opportunity of undesirable physical, chemical and biochemical reactions like browning, texture changes, loss of flavor, etc. Prefreezing treatments of fruits can minimized the deteriorative reactions. The aim of this study is to improve the quality of frozen fruits with a new technology: vacuum impregnation. We used this technique to introduce cryoprotectant solutes into the studied fruits structure making them more suitable for resisting damages caused by the frozen-thawing process.

Keywords: vacuum impregnation, apple, frozen, cryoprotection

1. Introduction

Preservation of food by freezing is a good method of ensuring the long-term retention of original characteristics, in almost unchanged state in fruits and vegetable. This quality retention is achieved by the combined effect of the low temperature, slowing down both biochemical and microbial activities, and the decrease in the water chemical potential (ice formation). [1]

Freezing of fruits results in various favorable effects with respect to the shelf life and availability throughout the year; nevertheless, various undesirable changes occur because of this process. Freezing destroys cell integrity and compartmentation, thereby increasing the opportunity of undesirable physical, chemical, and biochemical reactions (browning, texture changes, loss of flavor).[2]

The consequence is that during frozen storage, a gradual cumulative and irreversible loss of quality occurs in time.

Prefreezing treatments, selection of the optimum freezing rate, adequate packing, correct and uniform storage temperature, and rate of subsequent thawing are crucial if the full benefits of food freezing have to be realized and the deteriorative reaction minimized.

Cryostabilization technology represents a conceptual approach to a practical industrial technology for the stabilization during processing and storage of frozen foods. The key of cryoprotection lies in controlling the physical state of the freeze-concentrated amorphous matrix surrounding the ice crystals in a frozen system, where deteriorative reactions mainly occur. There are two possibilities for achieving an adequate food cryoprotection. [3] One is the reduction in the water content of the product by dehydrofreezing, osmotic dehydratation or a combination of both. Another is the formulation of food with appropriate ingredients to elevate the freezer temperature. [4]

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The specific role of some solutes in protecting cell membranes during cell water loss in drying or cryoconcentration during freezing has been reported. [5] Nevertheless the possibility of introducing solutes into structured food such as fruit is not easily feasible. Vacuum impregnation technique can offer interesting prospects in developing pretreatments to modify the initial composition of porous fruits, introducing cryoprotectant solutes and making them more suitable for resisting damages caused by the frozen-thawing processes.

Vacuum impregnation technology consists in the immersion of vegetable products, characterized through high porosity (apple, quince, 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. [6]
The aim of the work was to evaluate the effect of sucrose as cryoprotectants, pectin as a possible cryostabilizer and sodium izoascorbate as antibrowning agent [7] applied by vacuum impregnation in various form and combination, an the quality of frozen apple samples.

2. Materials and Method

Raw material and sample preparation

Golden Delicious apples were washed, peeled and cut into in round shapes using a stainless steel tubular cork borer and a knife, following their vertical axis. The samples where 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 desicator at room temperature. A vacuum pump (Model RL-2: REFCO manufacturing Ltd. Switzerland) was connected to the desicator, and a vacuum pressure of 400 mmHg was applied to the system for 20 min. and then an atmospheric pressure restoration for 20 min. [8]

We prepared six samples:1) Reference – untreated apple (R); 2) Vacuum impregnation with a solution with 60% sucrose (VI/S); 3)Vacuum impregnation with a solution that contains 60% sucrose and 2% sodium erythorbate (VI/S+SE); 4) Vacuum impregnation with a solution that contains 60% sucrose and 2% pectin (VI/S+P) 5) Vacuum impregnation with a solution that contains 2% pectin (VI/P); 6) Vacuum impregnation with a solution that contains 2% pectin and 2% sodium erythorbate (VI/P+SE);

The fresh and vacuum impregnated samples were characterized by measuring the weight, their color and the soluble solid concentration in the liquid phase.

The fruits were packed in flat polyethylene containers were frozen and stored for one month at -18 ^{0}C.

After storage, the samples were defrosted at 20^{0}C for 4 hours, determining the color and the exudates.

Physicochemical property analysis

A refractometer (model Kruss AR 2008) was used for the quantification of soluble solid content in the liquid phase of the samples.

Color changes were evaluated by measuring CIE L*a*b* coordinates with a Minolta CM 3220d spectrocolorimeter. 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. [9]

This determination of exudates was done by weighting the samples before and after thawing. Thus we determined the amount of liquid lost and expressed it in percentages.

3. Results and Discussion

Compositional changes of fruits by vacuum impregnation

By impregnating porous plant products under vacuum, the air from intercellular spaces is replaced with the impregnation solution. This will cause changes in physical and chemical characteristics of the samples.

In Table 1 we presented the changes that occur in the weight and soluble solid concentration in the liquid phase (S_C) in vacuum impregnated products

Tabel 1. Vacuum impregnation parameters of apple samples

Sample	ΔM [%]	S_C [%]
R	-	13.2
VI/S	9,8	26.6
VI/S+SE	10.1	25.4
VI/S+P	9.5	27.3
VI/P	18.58	10.5
VI/P+SE	17.34	11.2

ΔM – the difference between the weight of the samples before and after impregnation.

Vacuum impregnation causes a weight increase for all the samples due to the liquid which penetrates the plant tissue. The largest increase was recorded in the isotonic solution of pectin VI/P and VI/ P + SE. Because of their lower viscosity, they broke into the plant's tissues more easily.

The solution which penetrated the apples' structure caused the modification of the soluble solid concentration, by increasing it in the cases of hypertonic sucrose solutions and decreasing the content for diluted solutions of pectin.

Color changes for frozen and vacuum impregnated products

Vacuum impregnation causes changes of color for vegetal products.

In this study, L* (lightness), a* (redness), b* (yellowness) and ΔE (total color difference) values are used as color indicators for apples samples. Tabel 2 presents the color coordinates for the fresh sample and for the vacuum impregnated samples. The colours of the products are altered due their impregnation with solutions, which leads to a mild decrease of L* value and a slight increase of the other two paramethers a* and b* The modification of this value cause some small differences of colour between fresh and impregnated samples but this change did not have a negative effect on consumer perception.

Although apples are characterized through a high level of sensitivity towards the action of atmospheric oxygen, due to their high content of poliphenoloxidase and phenol compounds, which represent the substrate of these enzymes, no significant changes occurred during the storage of the samples in frozen state.

The data which we obtained show a slight change of color for all the samples, probably due to partial dehydration, which led to an increased concentration of pigments. The stability of color can be explained by the fact that by freezing, enzymatic activity is inhibited, and the time between the processing of the samples and the freezing operation was very short.

After thawing, the samples rapidly started browning, except for samples impregnated with sodium erythorbate: VI/S+SE and VI/P+SE, due to the antioxidant protection given by these substances.

An explanation for the color changes that occurred after thawing resides in the destruction of the cellular wall integrity by ice crystals. This allowed the oxygen, the enzymes and polyphenolic compounds to come into contact with one another and generate undesirable enzymatic reactions. The browning of the samples led to intense growth of the parameter a* (redness) which caused a corresponding increase of total color difference Figure 1. The most important difference in color was registered in the sample VI/P.

The determination of the exudates

The amount of exudates resulting after defrosting plant products is a method of measuring the degree of destruction of the cellular walls and it depends on the size of the ice crystals which are formed during freezing and storage.

Table 2. Color parameter of apples samples after vacuum impregnation, freezing and thawing

Sample	L*			a*			b*		
	A	B	C	A	B	C	A	B	C
Reference	79.57	76.21	70.98	-0.65	0.73	14.21	16.54	19.45	36.61
VI/S	78.21	76.74	71.62	0.16	0.26	15.43	18.23	21.37	39.54
VI/S+SE	78.47	78.06	75.61	-0.82	0.21	0.89	17.87	22.57	27.49
VI/S+P	77.75	76.35	70.24	0.26	0.62	14.08	18.43	24.67	40.33
VI/P	78.31	77.19	69.11	0.22	0.59	15.37	18.11	22.57	40.62
VI/P+SE	79.26	77.86	76.43	0.19	0.24	1.21	18.51	21.47	29.85

A – color parameter value after vacuum impregnation; B – color parameter value after freezing; C – color parameter value after thawing;

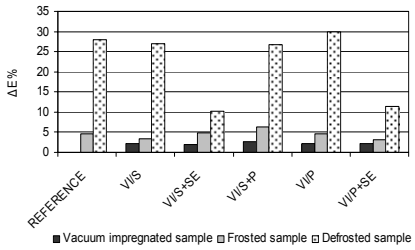

Figure 1. Total color difference of vacuum impregnated, frosted and defrosted apple samples

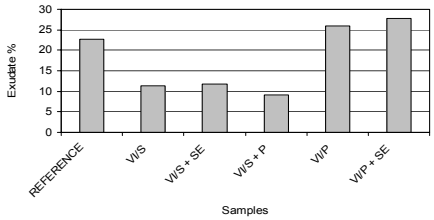

Figure 2. Apples samples exudates after thawing

The results which we obtained after defrosting can be seen in Figure 2.

The largest quantities of exudates were obtained from samples impregnated with isotonic solutions of pectin VI/P and VI/P+SE due to large amount of water introduced by impregnation under vacuum.

The smallest amount of exudates was obtained from samples impregnated with sucrose and pectin solution, therefore confirming their cryoprotector and cryostabilizator effect. By impregnation under vacuum with the two substances, the amount of exudates was reduced 2.5 times compared to the reference sample.

4. Conclusion

Vacuum impregnation with polymers such as pectin, and hypertonic law molecular carbohydrate solution seems to improve the resistance of apple samples to freezing injuries. By freezing, small ice crystals can be obtained, which will prevent the destruction of cell membranes so that the amount of exudates released after thawing is reduced.

The usage of sodium erythorbate as an antioxidant prevents enzymatic browning of apples during freezing but especially after thawing.

Impregnation with isotonic solution did not enhance frozen stability probably because of the introduction of a greater amount of water in the product pores without limiting the ice crystal growth, because of their low viscosity.

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