JAP&T TPA-Timisoara

Available on-line at www.japt.tpa.usab-tm.ro

Journal of Agroalimentary Processes and Technologies 2009, 15(2), 316-319

*Journal of Agroalimentary Processes and Technologies*

# Vacuum Impregnation Viability of Some Fruits

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***Abstract***

The aim of this work is to study the feasibility of applying vacuum impregnation to modify fruits and vegetable composition and structure for a number of industrial uses (minimal processing, freezing or drying pretreatments, etc.). 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 technology can be applied in order to better the texture of the product to reduce its level of oxidation and its exudates at defrosting, to maintain its color, and to strengthen the different vegetable products with all kinds of nutrients: vitamin E, vitamin C minerals salts, probiotics.

***Keywords***: vacuum impregnation, apple, strawberry, pear, quince

## 1. Introduction

Vacuum impregnation of porous food with an external solution is an interesting treatment to promote fast compositional changes by the action of the hydrodynamic mechanism. [1]

Salting process, osmotic dehydratation and other solid-liquid operations can be improved by applying vacuum pulses to the system, with a significant decrease in the processing time, depending on the product porosity and mechanical properties. There is a fast mass transfer mechanism that occurs when porous structures are immersed in a liquid throughout the capillary pores, controlled by the expansion / compression of the internal gas. The mechanism is responsible for the vacuum impregnation processes of porous products when low pressures are imposed in a solid – liquid system (vacuum step) followed by the restoration of atmospheric pressure. During the vacuum step, the internal gas in the product pores of the product is expanded and partially flows out. All this is coupled with the capillary penetration as a function of the interfacial tension of the liquid and the diameter of pores. In the atmospheric step, the residual gas is compressed, and the external liquid flows into the pores as a function of the compression ratio. [2, 3]

Vacuum impregnation can improve the mass transfer rate in many processes where solid – liquid operations are involved: salting, osmotic dehydratation, acidification, addition of preservatives etc.[4, 5]

The vacuum impregnation technique allows us to introduce the desired food ingredient directly into the product throughout its pores, in a controlled way.

Fruits and vegetable have a great part of their internal volume occupied by gas. In fruit processing, such as osmotic dehydratation or minimal processing, vacuum impregnation allows fast compositional changes to be made introducing appropriate solutions (with water activity and pH depressors, preservatives, antibrowning agents,

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nutraceuticals, etc.) into their porous structure. [6]

The aim of this work is to study the coupling of hydrodynamic mechanism with the deformation relaxation phenomena in some fruits to determine the feasibility of applying vacuum impregnation to modify products composition and structure for a number of industrial uses (minimal processing, freezing, drying pretreatments, etc.) [7]

## 2. Materials and Method

Te work method resides in the preparation of the studied products and their immersion in solutions, followed by their placement and storage in a precinct under vacuum. Fresh and vacuum impregnated samples were analyzed from the viewpoint of changes of mass, determining the quantity of impregnated liquid. Also soluble solid concentration in the liquid phase was determinate before ($S_{S1}$) and after impregnation ($S_{S2}$).

For determinations we have used the following fruit: apples (Ionathan, Starkrimson, and Golden Delicious), quinces (Champion), strawberries (Gorella) and pears (Bergamot.).

Since the process of impregnation under vacuum can be influenced by several factors, in the first part of the paper we tried to find the optimal parameters for the impregnation of apples. [8] For this, we observed the influence exerted by the processing duration and the vacuum pressure upon the degree of impregnation of apples, using a sucrose solution with a concentration of 20%.

The degree of impregnation was expressed through the percentage of solution impregnated in plant tissues.

Starkimson apples were purchased from a local store and washed with distilled water.

Apples were peeled and cut into in 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 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 was applied to the system.

The fresh product and the impregnated samples where characterized as to their weight and soluble solid concentration in the liquid phase. A refractometer (model Kruss AR 2008) was used to for the quantification of soluble solid content in the liquid phase of the samples

In order to observe the influence of processing duration upon the degree of vacuum impregnation, the apple samples were maintained under a constant vacuum of 400 mbarr for a different amount of time, from 4 to 16 min.

In order to observe the influence of the vacuum's intensity upon the impregnation, apple slices were maintained at different vacuum values, between $\Delta p$ = 0-700 mbarr ($\Delta p$ = difference between exterior and vacuum applied pressure) for 10 min.

The storage time was chosen based on the previous determination, since these were the values for which the impregnation degree reached a maximum point.

For the feasibility study of the other plant products, during the vacuum impregnation process, the samples were maintained at a vacuum pressure of 400 mbarr for 10 min. These work conditions were chosen based on the results obtained during previous determinations.

Before vacuum impregnation process, strawberries were sorted, washed, dried, detaching the petiole and they were cut in two halves across the longitudinal axis. The pears and the quinces were sliced, just like the apples.

## 3. Results and Discussion

Regarding the influence of the storage time of apples upon the degree of vacuum impregnation, the results are shown in Figure 1. It notes that the percentage increase in mass (ΔM) was significant in the first 6 minutes, when it reached a value of 12.58%. This happened because during the first stage of the process is the air in plant tissues is replaced with the solution to be impregnated. The maximum value of impregnation, of 14.63%, was achieved after 10 minutes, a relatively short time compared to the pursued aim.

As for the influence of the vacuum intensity upon the degree of vacuum impregnation, the results are exhibited in Figure 2. The proportion of impregnated solution increases proportionally with the augmentation of the vacuum intensity. As can be noted, the growth is significant for values between 300 and 500 mbarr.

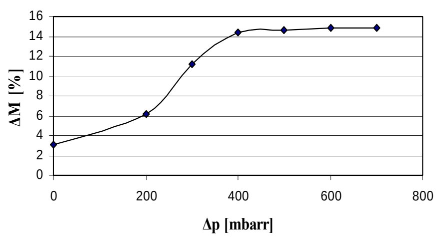


**Figure 1.** The influence of the vacuum's level upon the impregnation of apples

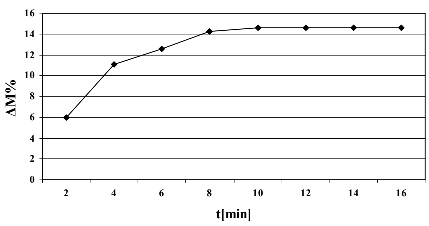


**Figure 2.** The influence of maintaining time under vacuum upon the impregnation of apple

From the results obtained in the cases of the other fruit, presented in Table 1, we can see they have a different behavior towards vacuum impregnation.

Among the fruits we analyzed, the largest quantity of impregnated liquid was obtained from apples, but there were differences between the types. The highest value was obtained for the Starkrimson variety which had a 17.7% mass increase.

The lowest value, 6.48% was obtained from strawberries and it was probably due to the lower porosity of the fruit.

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**Table 1.** Vacuum impregnation parameters obtained for different fruit

| Sample | Δm [%] | $S_{S1}$ [%] | $S_{S2}$ [%] |
|---|---|---|---|
| Apple 1 (Ionathan) | 14,63 | 11.6 | 12.9 |
| Apple 2 (Starkrimson) | 17,72 | 10.7 | 13.4 |
| Apple 3 (GoldenDelicious) | 11.07 | 13.2 | 15.3 |
| Strawberry | 6,48 | 5,6 | 7,3 |
| Pear | 9,36 | 14,2 | 15,8 |
| Quince | 11,72 | 13,11 | 16,22 |

The lowest value, 6.48% was obtained from strawberries and it was probably due to the lower porosity of the fruit.

The augmentation of soluble solid concentration content for each product is related to the weight increase, revealing the piercing of the sucrose solution in the fruit's structure.

## 4. Conclusion

Impregnation under vacuum can be viewed as a minimal processing method that can be used in order to better the sensorial, nutritional and technological quality of fruit by allowing various compounds such as antioxidants, vitamins, mineral salts, etc., to be incorporated in their internal structure.

Depending on their structure and composition, vegetal products have different reactions in which vacuum impregnation is concerned. However, the parameters can be optimized for each and every product.

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