Vacuum impregnation of orange fruit in honey syrup

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Abstract

The paper presents experimental equipment special made for interdisciplinary research studies concerning the influence of vacuum impregnation process (up to -0.99 bar). The aim of this interdisciplinary research is to study a non-thermic preservation method to obtain a concentrated orange comfiture impregnated in honey syrup, with similar characteristics obtained by using thermic traditional method. The paper presents experimental results to obtain the vacuum impregnation process speed increasing, the fruit quality too, depending on the vacuum values, and the process duration and succession.

Keywords: equipment, vacuum impregnation, texture, non-thermic preservation

1. Introduction

The consumer interest increasing for healthy functional foods consumption has oriented the research and the food industry too, towards the goal of obtaining such products.

One of the main directions in the alimentary industry is focused on the existing natural compounds preservation either through the minimum processing of the raw materials or through the strengthening of the foods with multiple physiologic active compounds such as prebiotics, probiotics, vitamins, fiber, mineral salts etc. [1,2,3,8,13,15].

Consumers increased demand for better food nutritional and sensorial characteristics, with no "fresh taste loss", made necessary extensively studies for functional food industry research concerning non-thermal preservation methods such as high pressure process (HPP), medium pressure process (MPP) and vacuum impregnation processing (VIP). During these non-thermal preservation methods, the food product is immersed into an incompressible liquid which transmits uniformly the pressure into the food product, and isostatic process is realized. [5]

Isostatic process realized by using high pressure process (HPP), medium pressure process (MPP) and vacuum impregnation processing (VIP) can improve the mass transfer rate in many processes where solid-liquid operations are involved: salting, osmotic dehydration, addition of preservatives, acidification, etc. [3,4,5,13,14,15].

Due to the HPP equipments high cost, the functional food products obtained by using this method are still very expensive. Medium pressure process equipments (MPP) and vacuum impregnation processing (VIP) too, are not very expensive, thus this methods are research subjects to obtain cheaper...
functional foods products. There are known experimental research data obtained by using MPP, or VIP, or both MPP method VIP, respectively.\[7,9,10,11,12\]

A great part of fruits and vegetable internal volume is occupied by gas. In fruit processing, such minimal processing, vacuum impregnation permits fast compositional changes by introducing appropriate solutions (water activity and pH depressors, concentrated solution with sugar or honey, preservatives, antibrowning agents, etc.) into their porous structure. [5,6]

Impregnation process is based on porosity and mechanical properties of the fruit.

The fast mass transfer mechanism during MPP or VIP occur when porous structures are immersed in liquid throughout the pores capillary, controlled by the expansion / compression of the internal gas into the fruit.

During the MPP or VIP step, the internal gas into product pores is exhausted and partially flows out. All this is coupled with the capillary penetration as a function of the internal cells tension that occurs between the liquid and the pores diameter. During the vacuuming steps relaxation or up to atmospheric relaxation, the residual gas is compressed, and the external liquid flows into the pores as a function of the compression/relaxation ratio. [1,2,3,5,6,13,15]

2. Materials and Methods

The aim of this inter-disciplinary research is to study a non-thermic preservation method based on VIP to obtain concentrated orange comfiture impregnated in honey syrup, with similar characteristics of commercial products obtained by using thermic traditional method.

In order to determine the influence of VIP to obtain concentrated orange comfiture impregnated in honey syrup, experimental research using commercial oranges were performed. The selected fruits were peeled and sliced in natural shape pieces, then weighted to be introduced in honey syrup.

The same quantity of orange fruit and honey syrup were put in transparent food grade plastic bags to be introduced into vacuum processing vessel of the experimental equipment.

To observe the influence of VIP to obtain concentrated orange comfiture impregnated in honey syrup, honey syrup with $80^{0.5}\%$ dried soluble mater content, and oranges with $10.8^{0.1}\%$ dried soluble mater content were used.

Before and after VIP, the dried soluble mater content in orange, and the dried soluble mater content in syrup after the non-thermic impregnation process was determined with ABBE refractometer (model ABBE 90), within specific laboratory of Dolj Departmental Sanitary and Veterinary Agency.

The proposed low vacuum processing is a non-thermic preservation method; therefore, the impregnation process temperature was permanently monitored with FLIR infrared camera.

In order to put in evidence the quantitative and qualitative informations by using VIP, experimental equipment was made. The experimental equipment was designed and made by Unconventional Technologies and Equipment for Agro-Food Industry Laboratory within Faculty of Agriculture and Horticulture, in collaboration with Environmental Protection in Industry within Faculty of Electrical Engineering, within the University of Craiova.

In main, the experimental equipment for VIP is composed in vacuum pump, vacuum processing vessel, and condensed gases dryer module (figure 1).

The main characteristics of the vacuum pump (HYVAC type): maximum flow rate up to 40 l/min; absolute pressure up to 50 milibar.

The condensed gases dryer module, in main, consists in a stainless steel vessel (designed and made according to Romanian ISCIR norms), containing 13X and 5A type molecular sieve.

The vacuum processing vessel (designed and made according Romanian ISCIR norms: stainless steel W1.4571; welding coefficient 1; 100% ultrasonic control for welding assemblies) permits vacuum experiments for absolute pressure up to 0.5militorr.

To observe the inlet vessel during vacuum process, one of the flanges is made in transparent visor (high resistant polycarbonate).

The experimental equipment fitting accessories (ISO/NW/NPT type) are made in AISI 316L stainless
steel. In order to observe the vacuum losses, the condensed gases dryer module and the processing vessel are provided with special 1,6 precision class manovacuumeter gauges made in stainless steel W1.4571 (Figure 1).

![Figure 1. VIP experimental equipment](image1)

A rotative mixing device (stainless steel W1.4571) can be mounted into the vacuum processing vessel, when is necessary (Figure 1). The rotative mixing device can be put in operation for 1-60 rot/min rotational motion by a special electromechanical transmission speed variator.

Transparent plastic boxes or thin transparent plastic bags can be placed inside the rotative mixing device during the experiments (Figure 2).

![Figure 2. Transparent plastic boxes placed into the rotative mixing device](image2)

3. Results and Discussion

The paper presents two types of experimental research concerning the influence of VIP to obtain concentrated orange comfiture impregnated in honey syrup:

- A short variant consisting in 6 cyclic processing steps (Table 1 and Figure 3), during 10 minutes processing;
- A medium variant consisting 2 repeated short variants, during 20 minutes processing
- A long variant consisting 3 repeated short variants, during 30 minutes processing.

**Table 1. VIP steps to obtain concentrated orange comfiture impregnated in honey syrup**

<table>
<thead>
<tr>
<th>Cyclic processing steps</th>
<th>Vacuum / Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. High vacuuming</td>
<td>Vacuum rate, [bar] 0 ↓ - 0,95</td>
</tr>
<tr>
<td></td>
<td>Time rate, [min] 0,7</td>
</tr>
<tr>
<td>2. Maintaining</td>
<td>Vacuum level, [bar] - 0,95 → - 0,95</td>
</tr>
<tr>
<td></td>
<td>Time rate, [min] 4</td>
</tr>
<tr>
<td>3. Middle vacuuming</td>
<td>Vacuum rate, [bar] - 0,95 ↑ - 0,5</td>
</tr>
<tr>
<td></td>
<td>Time rate, [min] 0,3</td>
</tr>
<tr>
<td>4. High vacuuming</td>
<td>Vacuum rate, [bar] -0,5 ↓ - 0,95</td>
</tr>
<tr>
<td></td>
<td>Time rate, [min] 0,6</td>
</tr>
<tr>
<td>5. Maintaining</td>
<td>Vacuum level, [bar] - 0,95 → - 0,95</td>
</tr>
<tr>
<td></td>
<td>Time rate, [min] 4</td>
</tr>
<tr>
<td>6. Pressurization</td>
<td>Vacuum rate, [bar] -0,95 ↑ 0</td>
</tr>
<tr>
<td></td>
<td>Time rate, [min] 0,4</td>
</tr>
</tbody>
</table>

![Figure 3. Short VIP cyclic variant](image3)

The dried soluble matter content in orange and the dried soluble matter content in concentrated honey syrup before and after the impregnation by using the described variants are presented in Table 2.

During each VIP variant gas evacuation (osmosis process stages) was observed (Figure 4).

![Figure 4. Gas evacuation during each VIP variant](image4)
4. Conclusions

The paper presents experimental results to obtain the speed vacuum impregnation process increasing, the fruit quality too, depending on the vacuum values, and the processing duration and succession.

The non-thermic impregnation process is based on the osmosis process between fruits and concentrated honey syrup. During this process the honey content in fruits is gradually increasing, and in the same time the fruits juice dilutes the honey syrup, until the equilibrium stage is realized.

The impregnated oranges pieces obtained by using cyclic VIP were translucent, with no browning, with good texture and shape, with typical organoleptically standard properties comparable with comfiture obtained by using classical thermic preservation method.

Compliance with Ethics Requirements: Authors declare that they respect the journal’s ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human and/or animal subjects (if exists) respect the specific regulations and standards.

References

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