Pressure and vacuum cyclic processing of strawberry impregnated in sugar syrup

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Abstract
The paper presents interdisciplinary research studies concerning the influence of cyclic pressure and vacuum process to obtain a concentrated strawberry comfiture impregnated in sugar syrup by using non-thermic preservation method, with similar characteristics obtained by using traditional thermic method. The paper presents experimental equipment and the results obtained by using the successive pressure (up to 10 bar) and vacuum (up to -0.85 bar) cyclic process concerning the dried soluble mater increasing in impregnated strawberry and dried soluble mater decreasing in sugar’ syrup, depending on the successive pressure and vacuum processing total time.

Keywords: experimental equipment, successive pressure/vacuum cycles, non-thermic impregnation

1. Introduction
In food industry a main research activity is focused on the existing natural compounds presser-vation either through the minimum processing of the raw materials or through the strengthening of the foods with multiple physiologic active compounds such as vitamins, fiber, mineral salts etc. The consumer interest increasing for healthy foods consumption has oriented the research and the food industry too, towards the goal of obtaining such products.[1,2,3,8,15]

Consumers increased demand for better food nutritional and sensorial characteristics, with no "fresh taste loss", made necessary extensively food industry researches 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 HPP, MPP and VIP can improve the mass transfer rate in many processes where solid-liquid operations are involved: salt infusion, sugar or honey concentration, addition of preservatives, acidification, osmotic dehydration, etc.[3,4,5,8,15]

Due to the high cost of the HPP equipments, the 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 concerning impregnated fruits obtained by using
MPP, or VIP, or both MPP and VIP methods, respectively.[7,9-13,14,15]

In principle, impregnation process is based on porosity and mechanical properties of the fruit and 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 and liquid into the fruit.

A great part of fruits and vegetable internal volume is occupied by gas. In fruit processing, such minimal processing, MPP and VIP permit fast compositional changes by introducing appropriate solutions (water activity and pH depressors, concentrated solution with sugar or honey, preservatives, etc.) into their porous structure.

During the MPP or VIP steps, 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’s characteristics and the pores diameter. During the de-vacuuming / relaxation steps up to atmospheric pressure, the residual gas is com-pressed, and the external liquid flows into the pores as a function of the compression / relaxation ratio. [1,2,3,5,6,8,15]

2. Materials and Methods

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

In order to determine the influence of MPP and VIP to obtain concentrated strawberry comfiture impregnated in sugar syrup, experimental research by using commercial strawberries were realized.

The same quantity of strawberry fruit (200g) and sugar syrup (200ml) were introduced into pressure / vacuum processing cylinder of the experimental equipment.

After buying, before MPP and VIP both fruits and concentrated syrup were stored in controlled atmosphere 2-4°C into a refrigerator.

To observe the influence of MPP or VIP to obtain concentrated strawberry comfiture impregnated in sugar syrup, concentrated sugar syrup with 75 ±0.5 % dried soluble mater content, and strawberries with 8.9 ±0.1 % dried soluble mater content were used.

To determine the total soluble substance in strawberries (before MPP and VIP) a portable refractometer KRUSS (0-30°R) was used.

After MPP and VIP, the dried soluble mater content in infused strawberry, and the dried soluble mater content in syrup respectively, were determined with ABBE refractrometer (model ABBE 90), within specific laboratory of Dolj Departmental Sanitary and Veterinary Agency.

In order to put in evidence the quantitative and qualitative information by using MPP and 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 MPP and VIP is composed in a pressure / vacuum processing hydraulic cylinder (Figure 1) consisting in a cylindrical vessel (inner diameter \( \varnothing \) 80; length 180 mm) made in stainless steel W1.4571 and a piston made in Teflon (food grade)

The pressure / vacuum processing hydraulic cylinder is provided with a manovacuometer gauge (-1…1,5 bar; 2,5 precision class) and a manometer gauge (0…12 bar; 1,6 precision class).

In order to evacuate the liquid / gas excess before and after MPP and VIP, the piston is provided with G1/4” tap connected to a Rilsan \( \varnothing 8 \) tube.

In order to actuate the pressure or vacuuming process into experimental equipment, a testing machine LLOYDS INSTRUMENTS Plus 5kN (cell accuracy 0,5) was used (Figure 1).

The cyclic impregnation processes to obtain concentrated strawberry comfiture impregnated in sugar syrup realized during experimental researches consists in several successive pressuring step and vacuuming step cycles.
Each pressuring and vacuuming process (PVP) cycle step (3 minutes) consists in one pressure process cycle step (Figure 2) up to 10 bar (1.5 min / cycle), followed by one vacuum process cycle step (Figure 3) up to -0.85 bar (1.5 min / cycle).

In order to observe the influence of the PVP cycles number’s concerning the sugar syrup impregnated in fruit there realized 5, 10, 15 and 20 PVP cycle steps.

3. Results and discussion

The pressure process cycle step up to 10 bar (equivalent maximum compression force 4950 N) is presented in Figure 4, and the vacuum processing cycle step up to -0.85 bar (equivalent maximum traction force 950 N) is presented in Figure 5.

The dried soluble mater content in strawberry before and after PVP, and in the concentrated sugar syrup before and after PVP is presented in Table 1.

After 4 and 8 cycles PVP, the amount of dried soluble mater decreasing in sugar’ syrup was 5.06% and 7.86% respectively, when the dried soluble mater decreasing in sugar’ syrup reach to 71.2°R and 69.1%, respectively (Table 1).

Instead after 12 and 16 cycles PVP, the amounts 92.13% and 110.11%, respectively of dried soluble mater increasing in strawberry was observed; and in the same time 66.8°R and 65.2%, respectively of dried soluble mater in sugar’ syrup (representing 10.93% and 13.07%, respectively, decreasing) was observed (Table 1).

The dried soluble mater in sugar’ syrup obtained by using 8, 12 and 16 cycles PVP is comparable with the recommended amount for commercial traditional orange confiture (65...70°R).

The impregnated strawberries obtained by using PVP were translucent, with good texture and shape (Figure 6 and Figure 7), with typical organoleptically standard properties comparable with confiture obtained by using classical thermic preservation method.
Figure 4. Medium pressure process cycle step produced by compression force up to 4950 N (equivalent maximum pressure 10 bar)

Figure 5. Vacuum processing cycle step produced by traction force up to 950 N (equivalent maximum vacuum pressure -0.85 bar)
Table 1. Dried soluble mater before and after PVP

<table>
<thead>
<tr>
<th>Variant</th>
<th>Dried soluble mater in strawberry, [R]</th>
<th>Dried soluble mater increasing in strawberry, after PVP, [R / %]</th>
<th>Dried soluble mater in sugar’ syrup, [R]</th>
<th>Dried soluble mater decreasing in sugar’ syrup, after PVP, [%]</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>before PVP</td>
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<td>before PVP</td>
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<tr>
<td>PVP 4</td>
<td>8,9</td>
<td>12,7</td>
<td>3,8 / 42,69</td>
<td>71,2</td>
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<tr>
<td>PVP 8</td>
<td>14,8</td>
<td>5,9 / 66,29</td>
<td>69,1</td>
<td>7,86</td>
</tr>
<tr>
<td>PVP 12</td>
<td>17,1</td>
<td>8,2 / 92,13</td>
<td>66,8</td>
<td>10,93</td>
</tr>
<tr>
<td>PVP 16</td>
<td>18,7</td>
<td>9,8 / 110,11</td>
<td>65,2</td>
<td>13,07</td>
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4. Conclusions

The paper presents experimental results during cyclic impregnation processes to obtain strawberry comfiture by using a non-thermic impregnation method. The cyclic impregnation processes to obtain concentrated strawberry comfiture impregnated in sugar syrup consists in several successive pressuring step and vacuuming step cycles. Each pressuring and vacuuming process (PVP) cycle step (3 minutes) consists in one pressure process cycle step (1,5 min / cycle) up to 10 bar, followed by one vacuum process cycle step (1,5 min / cycle) up to -0,85 bar.

In order to observe the influence of the PVP cycles number concerning the sugar syrup impregnated in fruit there realized 5, 10, 15 and 20 PVP) cycle steps.

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

According to these experimental researches schedule, it can be observed that PVP is more intensively than MPP or VIP methods those experimental results were presented in previous papers.

Further experimental researches can be proposed using higher pressure process amount (up to 40 bar) or higher vacuum process amount (up to -0,95bar), respectively, and shorter total PVP cycles, to obtain strawberry orange comfiture by using this non-thermic method.

Figure 6. Strawberry comfiture made by using 12 cycles PVP

Figure 7. Strawberry comfiture made by using 16 cycles PVP
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