Study on the influence of preservation in metallic packages on the vegetable quality

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Abstract
The stability of system food product-package, when preserving foods in metallic cans is influenced by multiple factors which refer to the manufacturing materials of metallic cans and lids, protection materials of metallic cans and lids, the characteristics of packed food products, foods’ preservation processes in these types of packages, the interaction product-package by determining the migration processes of compounds.

To adapt the hygienic-sanitary testing methodology of metallic packages for food products to the new regulations is to focus mainly on the testing of can protection lacquers.

“Rehydrated pea in can” and “Tomato paste” were organoleptically and physico-chemically analyzed throughout the storage period in order to study the interaction product-metallic package. The cans of rehydrated peas and tomato paste were stored under the conditions provided by product standards, at the maximum temperature of 20°C and air relative humidity of max. 80%. Canned food was periodically analyzed, during storage, from the organoleptic and physico-chemical point of view, in order to study the interaction product-metallic package. After 6 and 12 month-storage, the content of heavy metals of rehydrated pea preserved in metallic cans has varied significantly. Changes in the iron and tin content can be seen in all cans, after 6 and 12 month-storage time.

Keywords: preservation, package, metals

1. Introduction
Analytical measurements made on packaging materials have generally three aims:

1. to identify packaging compounds;
2. to identify and measure the present substances that may migrate to packed food and cause health problems to consumers. This is usually also accompanied by migration measurements of some substances, either to food or to food simulants;
3. to identify and measure the substances present that may migrate to packed food and have counter effects on the organoleptic properties such as smell and taste.

In today’s world of global markets and stiff competition in every product along with increasing consumer demand, it becomes imperative for companies to explore ways to improve their productivity in terms of maintaining safety, using sustainable packaging materials, implementing flexible and standardized technology, and adopting proven management principles.
In this paper, we look into the state-of-the-art in the food processing and packaging industry in the light of recent advancements in the fields of (i) smart packaging and materials including the application of nanoscience and technology, (ii) automation and control technology, standards, and their application scenarios, and finally (iii) production management principles and their improvements for the food industry. A comprehensive review on the above and related areas is presented in appropriate order [1].

A very common material for food packaging is steel, in the form of metallic containers (cans), in particular for beverage packaging. The corrosion degradation of the packaging must be carefully controlled, not only because the packaging integrity must be preserved, but also in order to avoid any significant contamination of the food or drink, compromising the flavour. In order to increase the coating performance and the food compatibility, new organic coatings are under development with very high protective properties, with the final aim to increase the shelf life of the product.

Metallic containers (cans) are often used for food, and in particular for beverage packaging [2]. The corrosion degradation of the packaging must be carefully controlled, not only because the packaging integrity must be preserved, but also in order to avoid any significant contamination of the food or drink, compromising the flavour. Even very low concentration of iron ions (0.5 ppm) can modify strongly the beverage perception [3].

The steel cans are generally obtained by mechanical deformation from tin plated steel sheets and coated with an organic lacquer in order to increase the corrosion protection [4]. In order to increase the coating performance and the food compatibility, new organic coatings with very high protective properties are under development, with the final aim to increase the shelf life of the product [5,6].

2. Materials and methods

2.1 Can quality control. The control was made for each batch sampled from a vegetable can producer (peas and tomato paste).

A sample was taken from each batch according to STAS 3730-92 requirements. The cans were stored under the conditions provided by product standards. Can quality control was made according to STAS 3730-92 requirements. The following characteristics were checked:

- exterior aspect (curved, leaking cans);
- hermeticity;
- organoleptic properties;
- physico-chemical properties.

2.2 Testing scheme. The testing scheme consisted of the following steps:

- to test under normal storage conditions, on shelf, time: 6 months; 12 months;
- the sample taken from each packed product was analyzed, piece by piece, to characterize the exterior aspect and can hermeticity.

The organoleptic, physico - chemical and microbiological properties were tested according to the methodology of product standards.

2.3 Physico-chemical analyzing methods of vegetable and mixt products

- Determination of NaCl content (STAS 5953-85)
- Determination of titratable acidity (STAS 5952-79) Titrimetric method
- Determination of soluble dried substance (STAS 5956-71) refractometer method
- Determination of metal content

Sample mineralization (dehydrated pea and tomato paste) was made accordingly to STAS 5954/1-86: the organic substance is destroyed by carbonization and then incineration in electric oven at 450...500 °C, and the ash is turned into solution by solving it into diluted hydrochloric acid (drying mineralization).

The analysis of metal content was made by AAS spectrometry, the results being given by the apparatus soft and expressed in ppm (mg metal/ kg product).

An air-acetylene flame atomic absorption spectrophotometer "AAnalyst 400", with background absorption correction (lamp D₂), was used to analyze all metals, excepting tin which was analyzed by a ICP-AES spectrophotometer.
3. Results and discussion

Organoleptic properties during storage period of “Rehydrated pea in can” packed in metallic cans, are shown in table 1.

Organoleptic properties during storage period of “Tomato Paste” packed in metallic cans, are shown in table 4.

Physico-chemical properties throughout storage of the product “Tomato Paste” packed in metallic cans are shown in table 6.

After 6 month and 12 month storage, the organoleptic properties of rehydrated pea preserved in metallic cans, do not undergo significant changes, the product complying with the requirements set by the Order of Health Ministry no. 975/1998. The only modifications refer to the aspect of filling liquid of cans, which initially is light opalescent, and after 6 month-storage it becomes opalescent with light sediment, whereas after 12 month-storage it becomes slightly turbid with sediment, phenomenon caused by starch diffusion from smashed or broken pea beans into the filling liquid.

After 6 month-storage, the content in sodium chlorine of filing liquid of the rehydrated pea preserved in metallic cans decreases by 12,8-14 % as a consequence of sodium chlorine diffusion from the filling liquid in pea.

Table 1. 3 PIECE- WELDED Ø 99X118 CANS

<table>
<thead>
<tr>
<th>Product / lacquering system</th>
<th>Pea / 1</th>
<th>Pea / 2</th>
<th>Tomato Paste / 1</th>
<th>Tomato Paste / 2</th>
<th>Tomato Paste / 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of filled cans of which:</td>
<td>129</td>
<td>133</td>
<td>131</td>
<td>138</td>
<td>127</td>
</tr>
<tr>
<td>- defects (squashed+leaked+curved cans)</td>
<td>-</td>
<td>-</td>
<td>12 (8+2+2)</td>
<td>19 (15+2+2)</td>
<td>12 (8+2+2)</td>
</tr>
<tr>
<td>- oven testing at 50 °C</td>
<td>35</td>
<td>35</td>
<td>22</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td>- testing under shelf-storage conditions</td>
<td>94</td>
<td>98</td>
<td>97</td>
<td>97</td>
<td>93</td>
</tr>
</tbody>
</table>

Table 2. Organoleptic Analysis of the product “Rehydrated pea in can”

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Initial</th>
<th>6 months storage</th>
<th>12 months storage</th>
</tr>
</thead>
</table>
| Container Aspect
  - exterior | clean, hermetically closed, uncurved, rustless lid, without body or wallet deformations, without cracks or content leakages; | clean, hermetically closed, uncurved, rustless lid, without body or wallet deformations, without cracks or content leakages; | clean, hermetically closed, uncurved, rustless lid, without body or wallet deformations, without cracks or content leakages; |
  - interior | metallic lid and can without black or rust spots, without delaminations or festooning of lacquer film; | metallic lid and can without black or rust spots, without delaminations or festooning of lacquer film; | metallic lid and can without black or rust spots, without delaminations or festooning of lacquer film; |
| Content Aspect
  - pea aspect | whole pea of almost uniform size; about 30% of pea beans sprout; | whole pea of almost uniform size; about 30% of pea beans sprout; | whole pea of almost uniform size; about 30% of pea beans sprout; |
  - liquid aspect | light opalescent; | opalescent with light sediment; | easy turbid, with sediment; |
| Pea colour | yellowish -green | yellowish -green | yellowish -green |
| Pea Texture | well boiled pea | well boiled pea | well boiled pea |
| Smashed pea (as against total weight of pea), % | 2 | 2,3 | 2,55 |
| Foreign bodies | lack | lack | lack |
| Taste and smell | characteristics of boiled pea, off-foreign odour and smell (fermentation or mould etc.) | characteristics of boiled pea, off-foreign odour and smell (fermentation or mould etc.) | characteristics of boiled pea, off-foreign odour and smell (fermentation or mould etc.) |
Table 3. Physico-chemical analysis of the product “Rehydrated pea in can”

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Results</th>
<th>Initial</th>
<th>After 6 month-storage</th>
<th>After 12 month-storage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Rec.1</td>
<td>Rec.2</td>
<td>Rec.3</td>
</tr>
<tr>
<td>Pea beans (as against the net nominal weight), %</td>
<td></td>
<td>52,8</td>
<td>53,5</td>
<td>53,3</td>
</tr>
<tr>
<td>Sodium chlorine (in liquid), %</td>
<td></td>
<td>1,40</td>
<td>1,42</td>
<td>1,41</td>
</tr>
</tbody>
</table>

Table 4. Analysis of heavy metal content in the product “Rehydrated pea in can”.

<table>
<thead>
<tr>
<th>Heavy metal content</th>
<th>Results (ppm)</th>
<th>Initial</th>
<th>After 6 month-storage</th>
<th>After 12 month-storage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Rec.1</td>
<td>Rec.2</td>
<td>Mean</td>
</tr>
<tr>
<td>Cadmium (≤0,06)</td>
<td></td>
<td>≤0,06</td>
<td>≤0,06</td>
<td>≤0,06</td>
</tr>
<tr>
<td>Lead (0,09)</td>
<td></td>
<td>0,09</td>
<td>0,13</td>
<td>0,11</td>
</tr>
<tr>
<td>Copper (2,28)</td>
<td></td>
<td>2,28</td>
<td>2,20</td>
<td>2,24</td>
</tr>
<tr>
<td>Iron (12,50)</td>
<td></td>
<td>12,50</td>
<td>13,50</td>
<td>13,00</td>
</tr>
<tr>
<td>Zinc (6,67)</td>
<td></td>
<td>6,67</td>
<td>6,89</td>
<td>6,78</td>
</tr>
<tr>
<td>Tin (≤0,20)</td>
<td></td>
<td>≤0,20</td>
<td>≤0,20</td>
<td>≤0,20</td>
</tr>
</tbody>
</table>

Table 6. Physico-chemical analysis of the product “Tomato Paste”

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Results</th>
<th>Initial</th>
<th>After 6 month-storage</th>
<th>After 12 month-storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soluble dried substance at 20ºC, %</td>
<td></td>
<td>Rec.1</td>
<td>Rec.2</td>
<td>Rec.3</td>
</tr>
<tr>
<td>Total acidity citric acid/g/100g d. s.)</td>
<td></td>
<td>7,60</td>
<td>7,60</td>
<td>7,60</td>
</tr>
<tr>
<td>Sodium chlorine %</td>
<td></td>
<td>1,34</td>
<td>1,34</td>
<td>1,34</td>
</tr>
</tbody>
</table>

4. Conclusions

After 12 month-storage, the product “Rehydrated pea in can”, packed in metallic cans, is stabilized and the content of sodium chlorine in the filling liquid remains constant.

After 6 and 12 month storage, the content of heavy metals of rehydrated pea preserved in metallic cans has significantly varied, the product complying with the requirements set by the Order of Health Ministry no. 975/1998. As regards the content in tin, a light increase was registered after 12 month-storage.

- Tomato paste belongs to very aggressive media when it comes to the corrosion risk of metallic containers, due to high titratable acidity 7,58 - 7,60 g citric acid /100g d.s., in the case of the product under study). Therefore, when tomato
paste is packed in metallic containers, the surface of these containers should be protected by applying acid-proof lacquers.

- After 6 month-storage, the organoleptic properties of the product “Tomato Paste” packed in metallic cans do not undergo significant changes, the product complying with the requirements set by the Order of Health Ministry no. 975/1998 and those of the Order 362/670/107/2002, regarding the approval norms for content, manufacturing, quality, packaging, labeling, marking and storage of tomato sauce and tomato paste.

- After 12 month-storage, the organoleptic properties of the product “Tomato Paste” packed in metallic cans are differentiated:
  - some metallic cans show delaminations of the protective lacquer in points and areas of 1 cm²; the product has also a dead red colour, whereas the taste and smell are specific to tomato concentrates;
  - the product shows delaminations of protective lacquer in rare points and areas of 0.5 cm²; the product has also a dead red colour, whereas the taste and smell are specific to tomato concentrates;

- After 6 and 12-month storage, the content in sodium chlorine of the product “Tomato Paste” preserved in metallic cans does not undergo modifications as against the initial value.

- After 6 and 12 month-storage, titratable acidity of the product ”Tomato Paste” packed in metallic cans does not undergo modifications as against the initial value.

- Modifications can be seen in all cans as regards the content in iron and tin, progressive increases being registered after 6 and 12 month-storage.

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