Crispy air-dried pineapple rings: optimization of processing parameters

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Abstract

Great changes in the structure of vegetal tissue could be produced by both osmotic dehydration and air drying. Texture of material moves from elastic-visco-plastic to rigid, becoming fragile and brittle. These changes are welcomed when the final product is a crispy and crunchy snack food. The aim of this work is to define the combined process, involving the osmodehydration and air-drying techniques, in order to obtain dried and crispy pineapple rings, having high qualitative characteristics. Six mm thick pineapple rings were osmodehydrated for 30 minutes in pineapple juice and sucrose solution, both at 50°Bx. Not pre-treated and pre-osmodehydrated rings were air dried at 70-75-80 °C till constant weight. Dry matter, soluble refractometric residue, pH and titratable acidity of raw and osmodehydrated samples were measured. Solid gain and water loss of the osmotic process were assessed. Dry matter and water activity of dried product were also measured. Changes of colour and surface area due to processing were evaluated by image analysis technique. Final product crispness was determined by bending snapping test. The sensorial characteristics were judged by a panel test. From both instrumental and sensorial aspects air-dehydrated samples resulted crispier than the respective osmo-airdehydrated ones regardless of solution type and temperature. This behaviour could be linked to the higher residual water content of the osmo-airdehydrated pineapple rings. The higher the drying temperature the better the results for instrumental and sensorial crispness. As expected the colour was negatively influenced with the increase in drying temperature. The osmotic pre-treatment in sucrose solution protected the colour during drying but the osmo-dehydration with pineapple juice hadn’t the same positive influence. The best result was obtained with not pre-treated pineapple rings dried at 75°C: the product was slightly amber-coloured, crispy and not hard and consequently appreciated by the tasters.

Keywords: pineapple; osmodehydration; air-drying; crispness.

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1. Introduction

There is an increasing demand for healthy, natural and tasty foods, in this context, dried crispy fruits represent an innovative and nutritional product. Costa Rica is the world’s leading exporter of fresh pineapple mainly to Europe and North America. A minimum of 20% of fruits are discarded in the fields and by packing houses because of visual defects due to the high quality standards of retailers and consumers, even though these pineapples have good internal properties. Most of the wasted fruits are processed by the juice industry, but the final product has a relatively low added value due to the high competitiveness of the juice market [1]. The introduction of crispy dried pineapple rings to the market represents an alternative processing technology which could add value to this type of raw material.

Traditionally, fruits in developing countries are sun dried and the quality of these products is often poor as it is difficult to control the rate of drying and the extent of cell damage in the fruit tissue. In order to obtain high quality dried pineapple products for the local as well as export market, osmotic dehydration was considered as a valid pre-treatment [2]. The technique consists of soaking the foods in a hypertonic salt or sugar or combined solution to reduce water content while increasing soluble solid content. The driving force for water removal is the difference in osmotic pressure between the fruit and the hypertonic solution. Osmotic dehydration, commonly used to remove part of the water content of fruit before further drying, could improve sensory and functional properties [3]. In particular application of osmotic dehydration led to a better fruit texture and increased the stability of the colour pigment during storage. Great changes in the structure of vegetal tissue could be produced by both osmotic dehydration and air drying, as widely reviewed by Lewicki [4-5]. In particular, texture of material moves from elastic-visco-plastic to rigid, becoming fragile and brittle. These changes are welcomed when the final product is a snack food such as pineapple rings, in which “crispy” and “crunchy” are sensory attributes greatly influencing quality evaluation by the consumers [6]. The aim of this work is to define the combined process, involving the osmodehydration and air-drying techniques, in order to obtain dried and crispy pineapple rings, having elevated qualitative characteristics. The tested osmotic solutions were sucrose solution and pineapple juice, the latter being chosen to minimize the alteration of the original sensorial characteristics of raw fruit.

2. Materials & Methods

2.1 Process: osmotic dehydration and air drying

Pineapple of cv Extra Sweet (Costa Rica), peeled and cored by a spoon soil auger (d = 25mm), was mechanically cut into 6.0 mm thick rings. Pineapple rings were either soaked in pineapple juice or sucrose solution (both at 50% w/w) for 30 minutes at 20°C and at atmospheric pressure. The ratio fruit/solution was 1/3. Not pre-treated and pre-osmodehydrated rings were air dehydrated at 70-75-80 °C (dry bulb) up to a constant weight. Air dehydration was performed using an alternate upward-downward air-circulated pilot drier (Thermo-Lab. Codogno, LO) operating at an air velocity of 1.5 m/s. Each trial was repeated twice. The samples that were not immediately analysed were sealed in a high barrier film bag and stored at room temperature in glass jars containing anhydrous calcium chloride.

2.2 Chemical and physical analysis

Dry matter, pH and total titratable acidity of raw and osmodehydrated samples were determined according to AOAC methods [7] and refractive index (°Bx) using a multiscale automatic refractometer (mod. RFM91, BS, UK). Solid gain (SG) and water loss (WL) of the osmotic process were assessed and expressed as g / 100 g of initial fresh pineapple [8].
Dried pineapple rings water activity (aw) was measured by an electronic hygrometer (Aqua Lab. CX-2-Decagon Devices, Pullman, USA), based on the determination of the dew point. Dried pineapple rings moisture content was determined according to Karl Fischer method after extraction in anhydrous methanol (ASTM D 6304-2004 a, 1-procedure A). A Mettler Toledo DL53 Titrator equipped with an electrode Mettler Toledo DM142, was used. Changes of colour (CIE-Lab system) and surface area due to processing were evaluated by Image Analysis technique. To this aim full colour images of 3 pineapple slices (raw and air dehydrated) were acquired by digitalisation with a CanonScan N650U flat-bed scanner (Canon Inc., Tokio, Japan) at 300 dpi resolution and were stored as JPG files. The acquisition was made imposing a black box over the product to guarantee constant light conditions. Thirteen colour tests of a reference chromatic scale were put on the scan flat in order to standardize the colour analysis. The acquired images were analyzed, for colour and surface area, by a specific software (Software Image Pro Plus 5.0 Media Cybernetics, Silver Spring MD, USA).

2.3 Mechanical analysis

Final product crispiness was determined by bending snapping test. This test was carried out using a Zwick Machine (mod. Z005, Zwick Roell, Germany) fitted with a 100 N load cell. One pineapple disc at a time was placed on two supports separated by a distance of 45.0 mm, each one equipped with a 8.0 mm diameter horizontal rod at the tip. A third compressing bar, with the same dimensions, was driven down between the two supports at a speed of 10 mm/min, bending each specimen until it snapped. The slope (Emod) before the first fracturability peak of highest magnitude was calculated from the force-displacement curves as the index of crispness of the dried pineapple rings [9].

2.4 Sensorial analysis

Sensory analysis was performed on dried pineapple rings by means of a descriptive test [10]. The 10 trained panellists expressed a judgement on colour, firmness, crispness and flavour characteristics concerning both intensity and pleasantness. The panellist used a free scale from 0 (low) to 10 (very high). Each session was repeated on two subsequent days. Results were elaborated with FIZZ, Software Solutions for Sensory Analysis and Consumer Test, Biosystems, France.

2.5 Statistic analysis

Analysis of variance (ANOVA) and Tukey multiple range test were used to determine statistically significant difference (P ≤ 0.05). Different letters corresponded to a significant difference.

3. Results & Discussion

Preliminary osmosis tests, carried out for 30 - 60 - 120 minutes, indicated that the length of process didn’t influence significantly the solid-liquid exchange of pineapple rings. Consequently a brief time (30 minutes) was chosen as it was considered more sustainable in terms of energy saving and reducing process time. During the osmotic process the initial dry matter and refractive index of pineapple rings increased as a consequence of both water loss (WL) and solid gain (SG) regardless of osmotic solution used (Table1). The osmodehydration in sucrose solution decreased significantly the pH of pineapple rings. The same treatment in juice, characterized by a pH value of 3.59 and a total titratable acidity of 33.78 meq/100g, did not modify the pH while caused a consistent increase of the total acidity.
Table 1. Solid gain (SG) and water loss (WL) due to osmosis. Dry matter (%), refractive index (°Bx), pH and total titratable acidity of pineapple rings: raw (RAW), osmodehydrated in pineapple juice (PJ) and in sucrose solution (SU).

<table>
<thead>
<tr>
<th>Sample</th>
<th>SG</th>
<th>WL</th>
<th>Dry matter (%)</th>
<th>°Bx</th>
<th>pH</th>
<th>Acidity (meq/100g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RAW</td>
<td>-</td>
<td>-</td>
<td>13.35 a</td>
<td>12.30 a</td>
<td>3.71 b</td>
<td>9.44 a</td>
</tr>
<tr>
<td>PJ</td>
<td>2.05 b</td>
<td>3.76 b</td>
<td>16.90 b</td>
<td>15.97 b</td>
<td>3.72 b</td>
<td>12.27 b</td>
</tr>
<tr>
<td>SU</td>
<td>1.10 a</td>
<td>2.22 a</td>
<td>16.78 b</td>
<td>15.84 b</td>
<td>3.50 a</td>
<td>8.98 a</td>
</tr>
</tbody>
</table>

Air drying caused a considerable shrinkage of pineapple rings with a reduction of about 35% of the initial surface area, but no significant differences due to the use of the two osmotic solutions and three drying temperatures were highlighted (data not reported).

The air dehydration process led to an evident browning of samples. This was confirmed by higher a* values and lower L* and b* values of dried samples compared to the raw ones (Figure 1). As expected increasing drying temperature colour was negatively influenced. In fact, comparing the samples prepared with the same pre-treatment the maximum a* values and the minimum L* values were found in rings dried at 80°C. On the contrary the minimum a* values and the maximum L* values were found at 70°C. The osmotic pre-treatment in sucrose solution protected the colour during drying as confirmed especially by a* values. On the other hand the osmo-dehydration with pineapple juice hadn’t the same positive influence and even drying at 70°C and 80°C the browning phenomenon was incremented, as demonstrated by lower L* and higher a* values (Figure 1).

The Emod values, reported in Figure 2, showed a progressive trend with the drying temperature: pineapple rings dried at 80°C had the highest crispness coefficient and those dried at 70°C had the lowest. This positive influence of drying temperature is in accordance with the results obtained for osmo-air-dried apple rings [9]. The osmodehydration also influenced significantly the Emod values, which were lower in both pre-treated samples except for those dried at 80°C, which had similar values.
The sensorial tests confirmed partially the results of image analysis (Figure 3): in fact the colour of samples dried at the lowest temperature was judged the lightest and at the same time the most pleasant. By increasing the drying temperature the rings acquired a colour tending towards orange/brown due to the browning phenomenon, resulting less pleasant. But the protective effect of osmosis in sucrose solution wasn’t supported by the scores of intensity and pleasantness of colour obtained by the sugar osmo-air-dried rings.

Most samples obtained quite a high score (> 5) for both the intensity and the pleasantness of flavour parameter (Figure 3). In particular the flavour of the samples dried at 75°C was judged more intense and pleasant if compared to those dried at the other temperatures. The samples dried at 80°C obtained the lowest judgements, this phenomenon may be due to the developing of “cooked” flavour. Both osmosis treatments tended to improve the flavour and its pleasantness.

The texture sensorial analysis (Figure 4) completed the information supplied by bending snapping test. Among the samples dried at the same temperature the not pre-treated ones were judged the crispiest, less firm and so more pleasant than the respective treated ones. These products were crispy at the first bite but firm during mastication, this phenomenon may be due to the absence of porosity inside tissutal structure of rings. According to bending-snapping results the crispness, valuated by tasters, was positively
influenced by the increasing drying temperature. Overall the highest score for both crispness and pleasantness was given to the not-treated samples dried at 75°C and 80°C.

![Graph showing intensity (firmness and crispness) and pleasantness of texture of pineapple rings](image)

Fig. 4. Intensity (firmness and crispness) and pleasantness of texture of pineapple rings: dried at 70°C, 75°C, 80°C without pre-treatment (NT70, NT75, NT80), after osmodehydration in pineapple juice (PJ70, PJ75, PJ80) and in sucrose solution (SU70, SU75, SU80)

Moisture content of dried pineapple rings decreased as the drying temperature increased, regardless of the pre-treatment applied (Table 2), as verified for a similar apple product [9]. The lower the dry matter the higher the water activity, which increased with diminishing of drying temperature. At all the tested temperatures the dried rings had a significantly lower moisture content and water activity than the respective osmo-air-dried ones.

<table>
<thead>
<tr>
<th>T (°C)</th>
<th>Activity water</th>
<th>Dry matter (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NT</td>
<td>PJ</td>
</tr>
<tr>
<td>70</td>
<td>0.21 b A</td>
<td>0.27 b B</td>
</tr>
<tr>
<td>75</td>
<td>0.17 a A</td>
<td>0.22 a B</td>
</tr>
<tr>
<td>80</td>
<td>0.16 a A</td>
<td>0.20 a B</td>
</tr>
</tbody>
</table>

From both instrumental and sensorial aspects air-dehydrated samples resulted crispier than the respective osmo-airdehydrated ones independently of the solution type and temperature, confirming the inversely proportional relationship between water activity and moisture content and crispness [9-11-12]. The osmotic pre-treatments didn’t contribute to the formation of the porous and crumbly structure of pineapple rings during the drying process, whereas it contributed to the increase of the residual water content, which affected the texture of final products.

4. Conclusion

Contrarily to what was expected and reported by literature [9] the osmotic pre-treatment didn’t contribute towards creating a structure with cavities and voids that could lead to brittleness and fragility of pineapple rings during drying. This fact supports the relevance of tissue characteristics which influence
osmotic exchanges and rheological behaviour. Nevertheless the osmotic treatment in sucrose solution protected the colour during drying, confirming that the solid gain limited the not enzymatic browning through air dehydration, as observed for other fruits [3]. The best result was obtained drying pineapple rings not pre-treated at 75°C: the product was slightly amber-coloured, crispy and not too firm and consequently appreciated by the tasters. The not pre-treated rings dried at 70°C presented a very light colour but a chewy and firm texture while the same rings dried at 80°C, despite being crispy, were brownish yellow with a slightly unpleasant taste.

References


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