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Influence of temperature on textural properties of Rocha pear (*Pyrus communis* L.) from different sources

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Abstract

'Rocha' pear is the main pear cultivar produced in Portugal and is important in other countries. It is a traditional product, classified as PDO (protected designation of origin). Most pears are consumed directly providing sugars, vitamins, organic acids, polyphenols, minerals and other nutrients. Some are also used for the preparation of fresh juice, canned beverages, alcoholic beverages, jellies and jams. Drying is an efficient way of preserving foods due to the significant reduction in water activity, thus inhibiting microbial growth and undesirable enzymatic modifications. Furthermore, it facilitates handling, storage and transportation, and avoids the use of expensive cooling systems. In this work, pears of the variety Rocha harvested at different orchards (four of the Western region and one of the "Beira Baixa") were studied, fresh and dehydrated at two temperatures, 40 and 60 ºC, to determine and compare their texture attributes. The texture properties were evaluated by the method of texture profile analysis (TPA), using a texturometer, TE.XT.Plus Stable Micro Systems. The texture parameters evaluated were: hardness, adhesiveness, cohesiveness, elasticity and chewiness. The TPAs were obtained for samples of pears from the different origins analyzed in different orientations, and with or without the skin. In order to characterize each set of pears in relation to their maturation state, their acidity and soluble solids contents were determined, and the maturation index was then calculated.

Keywords: Pear, Rocha pear, drying, acidity, soluble solids contents, texture.

Introduction

Rocha Pear (*Pyrus communis* L.) is the main cultivar produced in Portugal, and is classified as Protected Designation of Origin (PDO). As it has a good storage potential, its distribution is possible for the market almost throughout the whole year, differentiating it competitively against other varieties (1). Pear production represents a significant economic activity in Portugal (c.a. 190.000 tonnes per year), and the cultivar Rocha represents 95% of the National Product (2).

Pear fruits are highly appreciated by consumers due to their sweetness, crispness and aroma. Most pears are eaten fresh when ripe. However, the increase in the supply of processed products, particularly subjected to drying (3, 4), may provide an opportunity for development and enable the provision of alternative products to consumers. The drying of fruits is a very ancient practice for food preservation still in use nowadays, once the process significantly reduces water activity, thus inhibiting microbial growth and undesirable enzymatic modifications. Furthermore, it facilitates handling, storage and transportation, and avoids the use of expensive cooling systems (5).

During maturation there is a decrease in acidity and an increase in soluble solids. The state of ripeness greatly influences both the acidity and soluble solids content of pears, and so does drying (6). The drying influences acidity, and in particular at higher drying temperatures, since part of the acidity present in pears is due to volatile acids, which are eliminated by vaporization (7).

Texture is also one of the most important quality parameters that influence the consumer's acceptability. The changes occurring in the cell wall's structure and composition greatly influence fruit firmness (8). In a sensory point of view, texture is generally defined as the overall feeling that a food gives in the mouth and is therefore comprised of properties that can be evaluated by touch (9). However, in a more specific way, texture is composed of several textural properties which involve different types of characteristics: mechanical (hardness, chewiness, and viscosity), geometrical (particle size and shape) and chemical (moisture and fat content) (10). Instrumental measurements of fruit texture have become fundamental for the assessment of fruit quality (11), being instrumental texture profile analysis (TPA) one of the most used methods for determining food texture, by simulating or imitating the repeated biting or chewing of a food.

Materials and Methods

The Rocha pears used in this study were from five different locations: Torres Vedras (TV), Azueira (AZ), Bombarral (BO), Cadaval (CD) and Caria (CA). The first four are from the area of Protected Designation of Origin ("Região do Oeste") whereas the last is from a different region ("Beira Baixa"). For the convective drying, an electrical stove WTB Binder with an air flow of 300 m^3/h was used, setting the air temperatures to 40 ºC and 60 ºC. The pears were peeled and the peels were dried separately from the pulp, although under the same conditions. The pulp was cut into slices of about 3mm thickness prior to drying.

The acidity determination was made by the method described in the Portuguese standard NP-1421, which evaluates the volume of normal alkaline solution, in milliliters, necessary to neutralize 100 cm^3 of the product in liquid solution. The sample preparation followed the Portuguese Standard NP-783. This determination was made separately to the pulp and peel of three pears from each location, in the fresh state and after drying at 40 °C and at 60 °C. The total soluble solids were determined by refractometry. This measurement was made using a portable refractometer Atago 9207 (00-90%). The sampling for this determination was exactly the same as described earlier for acidity.

Texture profile analysis (TPA) to all the samples was performed using a Texture Analyser (model TA.XT.Plus from Stable Micro Systems). The textural properties: hardness, springiness, cohesiveness, and chewiness were calculated after standard equations (Mayor, 2007). Three pears were used from each location and eight measurements were performed in each pear, being the samples obtained in two directions: axial and tangential.

Results and Discussion

The determinations of total soluble solids and acidity were made to the pears in the fresh state and after drying, separating the peel from the pulp. These results are presented in Table 1 and also include the maturation index for the case of the fresh pears, giving an indication of the state of ripeness in which the pears were harvested. The evaluation of total soluble solids is related to the quantity of sugars present in the fruit, which is supposed to increase along maturation, while acidity diminishes, giving place to a sweeter ripe fruit. The peel, which is the part of the fruit that is directly exposed to the sun, showed on average lower acidity (4.31 mL NaOH/100g dry solids) and higher maturation index (0.31) compared to pulp, which had 9.32 mL/100g d.s. and 0.16, respectively. When comparing the pulp of the pears from the different origins, one can see that the pears from Bombarral (BO) were the less sweet (1.20 ºBrix); however they did not present the lowest maturation index (1.14). In fact, the pears from Torres Vedras (TV), although having a higher value for TSS (1.47 ºBrix) presented the lowest maturation index (1.12), which is due to the strong contribution of the acidity present (12.15 mL/100g d.s.).

As to the effect of drying on these chemical properties, from the results in Table 1 it can be seen that drying caused the same decrease in acidity, regardless of temperature and part of the pear: for the pulp, the decrease was 98.6% and 98.5% for 40 °C and 60 °C, respectively, and in the peel acidity fell by 99.8% at both temperatures. Comparing the values obtained for acidity in the peel and pulp, one realizes that acidity decreases very considerably with drying. The decrease in acidity that has occurred during drying is related to the fact that the heat causes evaporation of most of the volatile compounds that are responsible for acidity (6). On the other hand, the increase of soluble solids that occurs during drying in the pulp is due to the water evaporation, resulting in an increase in the concentration of the solids present (6). In this case, the pears had an average moisture content of 85% in the fresh state, which was reduced to around 1.5% after drying. In fact, the soluble solids content of the pulp increased 81.5% when dried at 40 °C and 81.9% when the drying was done at 60 °C. However, the soluble solids content of the peel did not change with drying, because the evaporation of water happens essentially on the pulp and not in the peel. Finally, it was observed that the difference in drying temperature (40 or 60 ºC) did not influence total soluble solids or acidity contents, resulting in similar products regardless of the temperature used.

Table 1. Total soluble solids, acidity and maturation index (when applicable) for the pulp and peel of pears in the fresh state and after drying (value ± standard deviation).

Location [*]	Pulp Fresh			Pulp Dried at 40ºC		Pulp Dried at 60ºC	
	TSS[1]	Acidity[2]	MI[3]	TSS[1]	Acidity[2]	TSS[1]	Acidity[2]
TV	1.47±0.12	12.15±2.14	0.12±0.02	7.93±0.21	0.16±0.02	7.73±0.38	0.10±0.03
AZ	1.53±0.12	9.46±0.57	0.16±0.02	7.93±0.21	0.16±0.02	8.50±0.10	0.06±0.02
BO	1.20±0.17	8.42±0.30	0.14±0.02	8.13±0.15	0.07±0.01	7.50±0.50	0.26±0.05
CD	1.33±0.15	7.67±0.61	0.17±0.01	6.77±0.55	0.23±0.05	7.40±0.10	0.09±0.04
CA	1.57±0.12	8.89±1.09	0.18±0.02	7.57±0.15	0.07±0.01	8.07±0.32	0.15±0.01
Location [*]	**Peel Fresh**			**Peel Dried at 40ºC**		**Peel Dried at 60ºC**	
	TSS[1]	**Acidity[2]**	**MI[3]**	**TSS[1]**	**Acidity[2]**	**TSS[1]**	**Acidity[2]**
TV	1.30±0.10	4.26±1.17	0.33±0.09	1.30±0.10	0.03±0.00	1.03±0.06	0.01±0.00
AZ	1.50±0.10	4.29± 0.39	0.35±0.05	1.83±0.15	0.01±0.00	1.77±0.12	0.01±0.00
BO	1.07±0.12	4.95 ± 0.41	0.22±0.03	1.33±0.29	0.01±0.00	1.17±0.31	0.04±0.01
CD	1.10±0.10	3.47± 0.39	0.32±0.05	1.23±0.25	0.04±0.02	1.10±0.10	0.01±0.01
CA	1.50±0.10	4.58 ± 0.60	0.33±0.05	0.90±0.10	0.01±0.00	1.40±0.10	0.02±0.00

[*] TV- Torres Vedras, AZ- Azueira, BO- Bombarral, CD- Cadaval, CA- Caria.
[1] Total Soluble Solids expressed in ºBrix.
[2] Acidity expressed in mL NaOH/100g dry solids.
[3] Maturation Index of the fresh pears calculated as MI = TSS/Acidity.

Figure 1 shows the results for the textural properties of the fresh pears, measured in three different ways. The textural properties evaluated were hardness, springiness, cohesiveness, adhesiveness and chewiness, but the results for adhesiveness are not presented because the values were approximately zero (below 0.2), meaning that adhesiveness is not relevant for the Rocha pear. Figure 1(a) presents the results for hardness, which is the force required to originate a deformation, and represents the energy required to compress a food between the teeth or between the tong and the mouth. From the graph in figure 1(a) is possible to see that the pears from different locations present relevant differences in firmness: the pears from Bombarral (BO) are the softer whereas the ones from Azueira (AZ) and Cadaval (CD) are harder. With respect to the part of the pear, if the peel is compared with the pulp (both radial) one sees that the pulp is harder, as a consequence of the ripeness state, since, as seen before, the pulp was less ripe than the peel. On the other hand, comparing the values obtained for hardness of the pulp in the two directions (radial and tangential), is possible to see that in some cases there is practically no difference, like it happens with the pears from Bombarral (BO), Cadaval (CD) and Caria (CA), whereas in other cases the differences are appreciable, Torres Vedras (TV) and Azueira (AZ). Figure 1(b) shows the results obtained for chewiness, which represents the energy needed to disintegrate a solid food in order to swallow it. This property is strongly related to hardness, as expressed by equation (5), therefore it would be expected that this property would show a similar trend as hardness, as in fact can be observed comparing the two graphs in Figure 1(a) and 1(b).

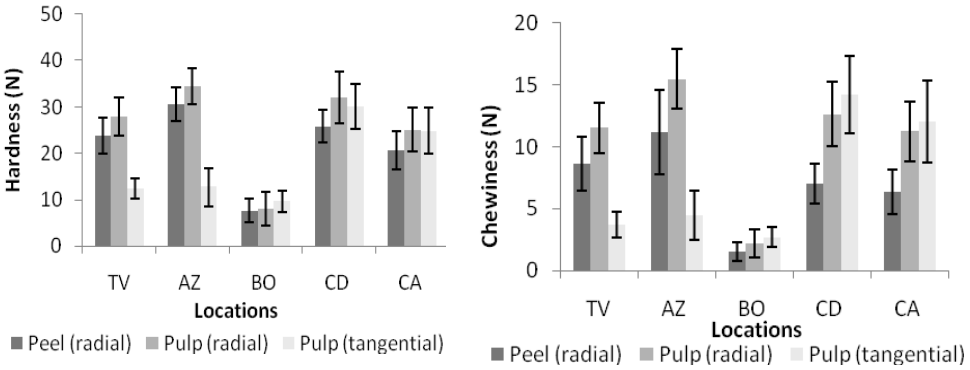


Figure 1. Textural properties of fresh pears: (a) Hardness; (b) Chewiness; (TV- Torres Vedras, AZ- Azueira, BO- Bombarral, CD- Cadaval, CA- Caria).

Figure 2(a) shows the results for cohesiveness, which is the force of the internal bonds in the food that keep the sample cohesive. The results reveal that, like it was observed for hardness and chewiness, the Bombarral (BO) is the less cohesive of the pears analyzed, and that the peel is less cohesive than the pulp, for all locations. With respect to the orientation, once again the major differences were observed in the Torres Vedras (TV) and Azueira (AZ) pears. In the graph of Figure 2(b) the springiness of the pears at study is presented. This textural property represents the capacity of recovering shape after compression, i.e., the speed of return to the original state after removal of the force which caused the deformation. With respect to springiness, it was still possible to see that the pears analyzed were quite homogeneous, showing no relevant differences either between the different locations, or the part of the pear (pulp or peel) or even the cutting direction (radial or tangential).

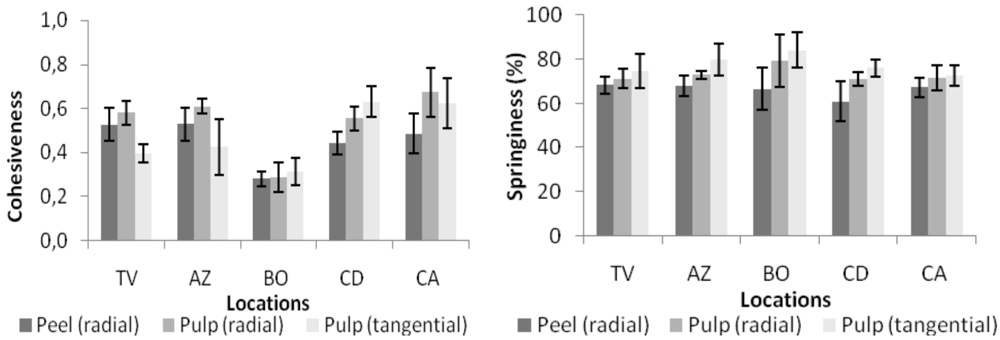
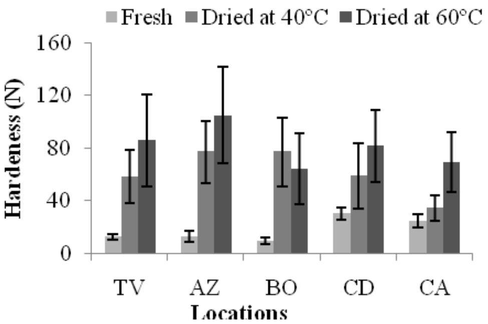


Figure 2. Textural properties of fresh pears: (a) Cohesiveness; (b) Springiness. (TV- Torres Vedras, AZ- Azueira, BO- Bombarral, CD- Cadaval, CA- Caria).

In the graphs of Figure 3 and 4, one can see how the drying influences the texture of the pears at study. Since in the dried pears the texture was evaluated only in the tangential direction, a comparison is made between the properties of the pulp in fresh and after drying in this direction. Figure 3(a) gives evidence that drying causes a considerable increase in hardness for the pears from all locations. Furthermore, in general it is observed that increasing temperature increases hardness, with the only exception being Bombarral (BO). For the drying at 40 °C hardness increases in average 65 % relatively to the fresh pears, while for the drying at 60 ºC the increase is around 73 % in average, also in relation to the fresh state. The increase in hardness with drying is due to the loss of a considerable amount of water, in fact practically all the water present in the fresh pears, reducing considerably the volume of the product and therefore turning it denser, as a consequence of the high concentration of solids after drying. Furthermore, at higher temperatures some caramelization processes may also occur, giving place to harder products, depending on the temperature used, and the type and concentration of sugars present. It can bee seen in Figure 3(b) that, as a direct consequence of the increase in hardness, cohesiveness also increases with drying, meaning that the work necessary to chew the dried pears is substantially higher when compared to the fresh pears. Also chewiness increases with drying temperature, as a consequence of the harder fruits obtained at higher temperatures.



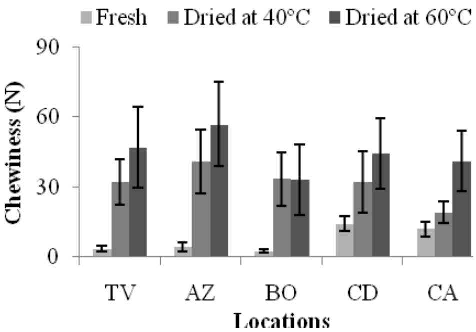
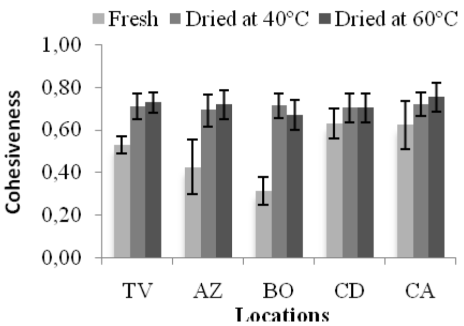


Figure 3. Textural properties of fresh and dried pears, for the pulp and on the tangential direction: (a) Hardness; (b) Chewiness; (TV- Torres Vedras, AZ- Azueira, BO- Bombarral, CD- Cadaval, CA- Caria).

Figure 4(a) shows how drying increases cohesiveness, particularly in the pears from Torres Vedras (TV), Azueira (AZ) and Bombarral (BO), since for Cadaval (CD) and Caria (CA) the changes are quite negligible. On the other hand, the drying temperature practically does not influence cohesiveness, being the results for 40 ºC similar to those for 60 ºC. In fact, the structural changes that occur due to the loss of practically all the water present in the pears are the ones that are responsible for the increase in cohesiveness, and the drying at the higher temperature (60 ºC) produces the same dehydration extent, although this happens faster than at 40 ºC. Finally, in Figure 4(b) the values of Springiness are presented and they reveal that this textural property is not so affected by drying or even by the temperature used as the other properties seen before.



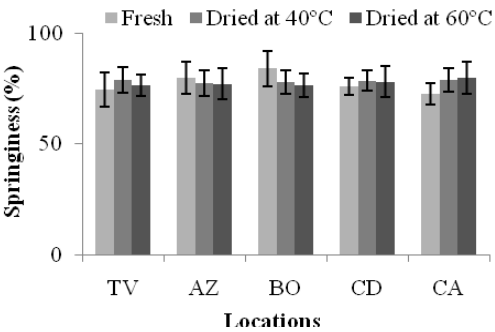


Figure 4. Textural properties of fresh and dried pears, for the pulp and on the tangential direction: (a) Cohesiveness; (b) Springiness. (TV- Torres Vedras, AZ- Azueira, BO- Bombarral, CD- Cadaval, CA- Caria).

Conclusions

From the results obtained in this study it was possible to conclude that the peel of the pears studied had lower acidity and higher maturation index, when compared to the pulp. The results also showed that the drying process, both at 40 °C and 60 ºC, greatly reduced the acidity, either in the pulp or the peel, whereas for the drying of the pulp an increase in soluble solids was observed. Besides, it was also concluded that the changes induced by drying were not influenced by the drying temperature.

Through the results obtained for the texture was possible to conclude that for the fresh pears analyzed, the textural attributes hardness, chewiness and cohesiveness were higher in the pulp than in the peel. Furthermore, with drying the hardness of the pulp increased considerably, and this was also reflected in the increase of chewiness. Unlike what happened with hardness and chewiness, cohesiveness did not change with increasing drying temperature. Regarding springiness it was concluded that this property did not undergo important changes, neither with the cutting direction nor with the drying temperature.

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