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# EFFECT OF DRYING ON THE TEXTURAL ATTRIBUTES OF GREEN PEPPER AND PUMPKIN

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*Abstract*: The present work evaluates the effect of different drying treatments on the textural attributes of green bell peppers and pumpkin, which were dried using two different methods: air drying and freeze-drying. From the results it is possible to conclude that the increase in drying temperature reduces drastically the hardness of green peppers and the freeze drying has an intermediate effect between vegetables dried at 30ºC and 70ºC. Moreover, the springiness is higher in dried green peppers but an opposite effect was observed on chewiness. With respect to pumpkin, it was not found any dependence between the fiber orientation and the hardness of the fresh vegetable. In addition, increasing temperature from 30ºC to 70ºC particularly reduces the hardness and the chewiness of dried product and maintains cohesiveness and springiness approximately constant.

*Keywords*: Green pepper, pumpkin, hardness, texture, drying

## INTRODUCTION

Pumpkin and bell pepper are very popular in Portuguese cuisine. However, their processed form is scarce in the market. Therefore, the drying, which is one of the oldest methods for food preservation, may represent a possible method to commercialize these vegetables.

The most popular drying process uses convection through hot air, but high temperatures can change the composition and the nutritional value as well as physical properties, density, porosity, mechanical properties and organoleptic quality of the products. Despite the high costs and time consuming of freeze drying, this process generates minor changes in colour, flavor, chemical composition and texture (Nawirska, 2009).

Texture is the result of complex interactions among food components at a microstrutural level and at higher structural levels as, for instance, the structure of the tissue (cellular orientation, porosity) and the different types of tissues or organs that constitute food materials (Aguilera and Stanley, 1999; Mayor et al., 2007).

Apart from the perceived primary characteristics, texture and flavor play also an important role on the acceptability of foods by the consumers.

Hence, it is crucial to determine and control the texture of the processed foods. However, this implies knowledge about changes in the mechanical properties because they are related with the textural and sensorial characteristics of the food. Several authors have studied the changes of the mechanical properties of food during convective drying and, in general, they found that a soft product (fresh) is transformed into a rigid product (dried). Alternatively it changed from a predominantly plastic behavior to a more elastic behavior (Telis et al., 2005).

The fresh pumpkin has values ranging from 0.96 to 2.53 for apparent modulus of elasticity, 250-630 kPa for failure stress, 0.42-0.71 for failure strain and 85-285 kJ/m$^3$ for toughness and their failure mode is fiber debonding (Mayor et al., 2007).

The present work aims to study the effect of freeze-drying and air drying at different temperatures on the texture of pumpkin and green pepper. Texture attributes (hardness, adhesiveness, springiness, cohesiveness, and chewiness) were estimated after measurements made with a texturometer.

## MATERIALS AND METHODS

Pumpkin and green bell pepper were purchased in a local market, washed and cut into samples of approximately 2x2 cm and dried in a ventilated oven and in a freeze drier.

For the convective drying, an electrical stove WTB Binder with ventilation was used. The stove was operated at constant temperatures of 30ºC, 50ºC and 70ºC, and the air flow was 300 $m^3$/h.

For the freeze drying, the samples were frozen in a conventional kitchen freezer, and then left in the freeze-drier (model Table Top TFD5505) for 38 hours at a temperature between - 47 ºC and - 50 ºC, and a pressure of 5 mTorr (0.666 Pa).

For the drying of pumpkin only the pulp was used, whereas the bell pepper was dried with skin.

The fresh pumpkin was peeled and texture profile analysis was carried out on cylindrical samples removed at 1, 3 and 4 cm of the skin and on axial and radial directions as illustrated in Figure 1.

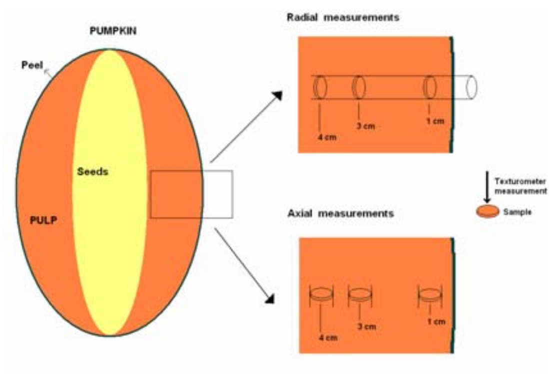


Fig. 1. Sample preparation in pumpkin

Measurements to the fresh green pepper were done on both sides of the pepper tissue, that is to say, from the skin (external) and the flesh (internal) sides (fig. 2 (a) and (b) respectively).

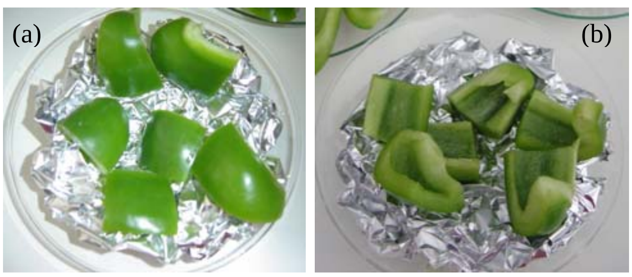


Fig. 2. External (a) and internal (b) sides of green bell pepper

Texture profile analysis (TPA) to all the samples was performed using a Texture Analyser (model TA.XT.Plus). The texture profile analysis was carried out by two compression cycles between parallel plates performed on cylindrical samples (diameter 10 mm, height 3 mm) using a flat 75 mm diameter plunger, with a 5 seconds interval of time between cycles. The parameters that have been used were the following: 5 kg force load cell and 0.5 mm $s^{-1}$ test speed.

The textural properties: hardness, springiness, cohesiveness, and chewiness were calculated after equations (1) to (4) (see fig. 3):

$$\text{Hardness} = H = F_1 \quad (1)$$

$$\text{Springiness} = S = \frac{\Delta T_2}{\Delta T_1} \quad (2)$$

$$\text{Cohesiveness} = C = \frac{A_2}{A_1} \quad (3)$$

$$\text{Chewiness} = H \text{ x } S \text{ x } C \quad (4)$$

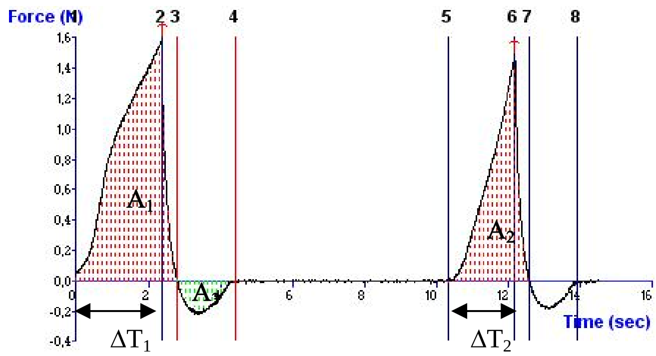


Fig. 3. Illustration of a texture profile analysis, and variable definition

## DISCUSSION OF RESULTS

The results of firmness (hardness) for the green bell pepper are illustrated in fig. 4. This parameter can be related to the force performed by mastication that takes part during eating.

Rupture of the skin from the flesh side required a lower force (10.9 N) when compared with the same action from the skin side (13.8 N).

In the first bite the fresh green pepper requires a much higher energy than the dried vegetable, which means that drying makes the product softer. For example, comparing the fresh (external) pepper with the pepper dried at 30ºC, the firmness decreases from 10.9 N to 0.7 N, which is a very extreme change.

Moreover, the increase in temperature for the air drying of the bell pepper, also produces a pronounced effect on firmness with a decrease from 0.7 N at 30ºC to 0.3 N at 50ºC, corresponding to 60 % reduction over a 20ºC interval.

Finally, the freeze drying treatment also induces a pronounced softening of the pepper, although not so intense as the air drying does. In fact, the freeze dried pepper shows a hardness of 1.4 N, representing a decrease of 90 % relative to the fresh product, but higher than the samples dried by convection, either at 30ºC or at 50ºC.

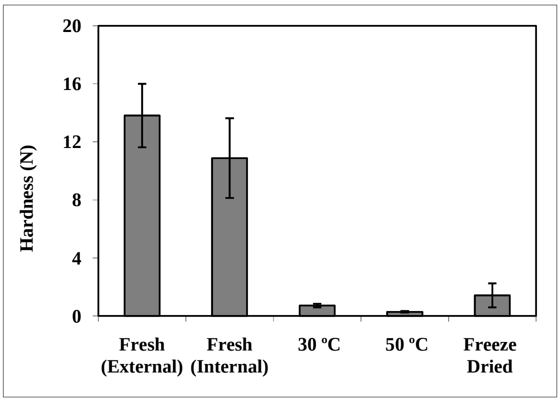


Fig. 4. Hardness of green pepper in the fresh form and dried with convective and freeze drying (the lines in each bar stand for standard deviation)

Table 1 shows the results obtained for the texture parameters calculated from the compression TPA curves for the green bell pepper (through equations (1) to (4)) In every case 6 analysis were performed and 6 TPA's were obtained. The values of fresh green pepper were measured from the skin side (external) side, and all the dried samples also from the external side. The values for adhesiveness were not included, because they were less than 0.005, thus indicating that the peppers do not have measurable adhesiveness.

Table 1. Texture attributes obtained for fresh and dried green peppers

| | Fresh product | Air drying 30ºC | Air drying 50ºC | Freeze drying |
|---|---|---|---|---|
| Cohesiveness (± standard deviation) | 0.62 (±0.03) | 0.64 (±0.05) | 0.75 (±0.06) | 0.70 (±0.04) |
| Springiness (%) (± standard deviation) | 73.79 (±6.73) | 70.03 (±14.53) | 87.38 (±15.25) | 80.40 (±6.51) |
| Chewiness (N) (± standard deviation) | 4.87 (±0.95) | 0.32 (±0.01) | 0.18 (±0.03) | 0.80 (±0.34) |

From the results presented in table 1, it can be observed that in general, the air convection of green pepper at 30ºC and 50ºC has a small effect on cohesiveness and springiness as compared with the fresh vegetable. However, springiness, which is a measure of the recovery in height after the compression during the mastication, is higher for the green peppers dried at higher temperature.

As to cohesiveness, it also increases from the fresh state to the dried one as well as it increases with drying temperature. As to chewiness, it diminishes greatly with drying and drying temperature, as a result of the variation observed previously in hardness.

As to the comparison between the two drying methods tested, the results show a trend for texture of green peppers to be more sensitive to air convective drying, and particularly at the highest temperature, than the freeze drying.

Regarding the other vegetable analysed in the present study, fig. 5 shows the hardness of the fresh pumpkin on the axial and radial directions, and at different locations. In every case 4 analysis were performed and 4 TPA's were obtained.

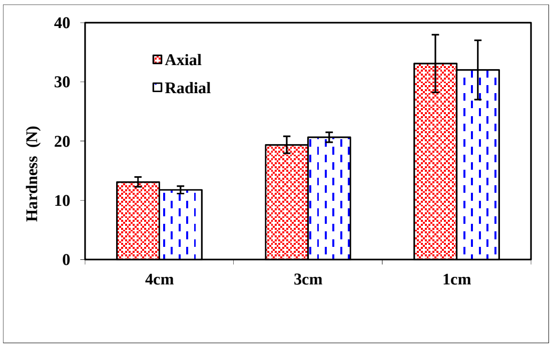


Fig. 5. Hardness of fresh pumpkin samples taken at 1, 3 and 4 cm of the skin and on axial and radial directions (the lines in each bar stand for standard deviation)

At each position analyzed, 1, 3 and 4 cm of the skin, the results show small differences between both directions. This means that there is no dependence of hardness on the fiber orientation, that is to say that the maximum force needed for the first bite is approximately the same independently of the orientation of the bite. The medium values of hardness for the fresh pumpkin were 12.4, 20.0 and 32.6 at 4, 3 and 1 cm of the skin, respectively.

However the results also show that hardness is very dependent of the distance from the skin. This can be attributed to the heterogeneous composition of the flesh of the pumpkin from skin to seeds. In fact, the flesh of the pumpkin is considerably harder than the pulp near the centre.

Fig. 6 illustrates the hardness of pumpkin in the fresh form and dried with convective and freeze drying. The compression was performed on axial direction and at 3 cm of the skin during all the tests.

The results show that the fresh pumpkin has a much higher hardness (19.4 N) when compared to the dried samples (varying from 6.6 N at 30ºC and 0.3 N at 70ºC). For example, the reduction in hardness from the fresh pumpkin to that dried at 30ºC is 66 %, which is the same reduction from 30ºC to 50ºC (2.2 N). As to the reduction from 50ºC to 70ºC it is greater, 86 %, thus indication that higher temperatures have a more pronounced effect on the softening of the pumpkin pulp. Furthermore, the freeze drying treatment produces pumpkin with firmness equal to 1.6 N, higher than the sample dried at 70 ºC, but smaller than the sample dried at 50 ºC. Finally, the freeze drying treatment also induces a pronounced softening of the pumpkin, representing a decrease of over 90 % relative to the fresh product.

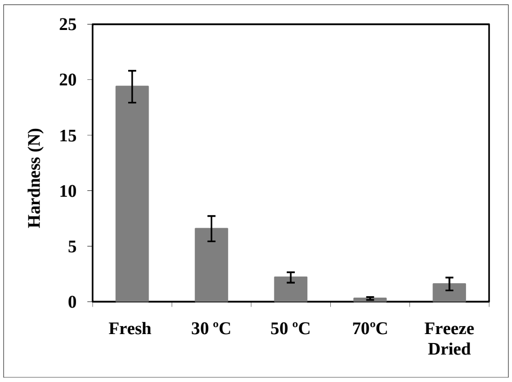


Fig. 6. Hardness of pumpkin in the fresh form and dried with convective and freeze drying (the lines in each bar stand for standard deviation)

The textural attributes of fresh and dried pumpkin are presented in Table 2. Again the values found for adhesiveness were too close to zero, thus indicating that the pumpkin does not show adhesiveness.

Table 2. Texture attributes obtained for fresh and dried pumpkin

| | Fresh product | Air drying 30ºC | Air drying 70ºC | Freeze drying |
|---|---|---|---|---|
| Cohesiveness (± standard deviation) | 0.49 (±0.01) | 0.53 (±0.07) | 0.56 (±0.07) | 0.55 (±0.03) |
| Springiness (%) (± standard deviation) | 66.83 (±3.81) | 47.89 (±3.32) | 65.11 (±21.65) | 64.93 (±6.01) |
| Chewiness (N) (± standard deviation) | 6.39 (±0.45) | 1.63 (±0.45) | 0.10 (±0.03) | 0.56 (±0.18) |

The results show that the cohesiveness of pumpkin remains approximately constant after drying, with just a slight increase, which means that fresh and dried pumpkins have similar strengths of internal bonding.

Based on the values found for springiness, it is also possible to conclude that drying (convective air drying and freeze drying) do not alter significantly the capacity of the pumpkin to return to its original shape after deformation. An exception was observed for the product dried at 30ºC, which showed a lower value for springiness than those of all other cases.

Furthermore, the drying of pumpkin reduces significantly the chewiness of the pumpkin, once again due to the intense diminishing in the hardness, as observed earlier.

Finally, comparing the freeze dried pumpkin with that dried by convection it is possible to see that the values encountered for the different texture parameters are situated between those of the samples dried at 30ºc and those dried at 70ºC.

## CONCLUSIONS

From the results it is possible to conclude that drying temperature reduces drastically the hardness of green peppers and the freeze drying has an intermediate effect between vegetables dried at 30ºC and 70ºC.

In addition, the springiness is higher in dried green peppers though an opposite effect was observed on chewiness.

With respect to pumpkin, it was not observed dependence between fiber orientation and the hardness of the fresh vegetable.

Furthermore, the drying of pumpkin reduces particularly the hardness and the chewiness of dried product but cohesiveness and springiness remain approximately constant.

## ACKNOWLEDGEMENTS

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## REFERENCES

Aguilera, J.M. and D.W. Stanley (1999), Microstructural principles of food processing and engineering, Aspen Publishers, Gaithersburg.

Mayor, L., R.L. Cunha and A.M. Sereno (2007), Relation between mechanical properties and structural changes during osmotic dehydration of pumpkin, Food research International, Vol. 40, pp. 448-460.

Nawirska, A., A. Figiel, A.Z. Kucharska, A. Sokol-Letowska, and A. Biesiada (2009), Drying kinetics and quality parameters of pumpkin slices dehydrated using different methods, Journal of Food Engineering, Vol. 94, pp. 14-20.

Telis, V.R.N., J. Telis-Romero and A.L. Gabas (2005), Solids rheology for dehydrated food and biological materials, Drying Technology, Vol. 23, pp. 759-780.