EVALUATION OF PRESERVATION CONDITIONS ON NUTS PROPERTIES

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Abstract

Dried fruits like nuts are very much appreciated, but because of their hygroscopicity may be susceptible to undesirable changes during storage. Therefore, this work was undertaken to study the effect of different storage conditions on three types of nuts commonly consumed in Portugal (almond, hazelnut and walnut). The samples were originated from different countries and while most had the internal skin on, one sample had it off. The storage conditions tested were: ambient temperature, high temperatures (30 and 50 °C) and low temperatures (refrigeration at + 2 °C and freezing at – 15 °C). The characteristics evaluated were water activity, moisture content, colour and texture.

The results obtained in the present work allowed concluding that the storage conditions that best preserve the characteristics of nuts are those at low temperatures, because, while the treatments at high temperatures induced in general more changes, the refrigeration and freezing systems had a lower effect on the products characteristics, particularly moisture, water activity, hardness and friability. Also the results indicate that the nuts stored under all conditions tested had values of water activity lower than 0.6, thus guaranteeing stability at the microbial and enzymatic levels. It was further concluded that the internal skin had a great influence on the characteristics of the nuts, particularly texture and colour, for all treatments tested.

Keywords: almond, colour, hazelnut, walnut, texture.

Introduction

Tree types of nuts are used worldwide in confectionary, culinary and bakery food applications due to their desirable flavour attributes and high energy density.

Almonds (*Prunus dulcis*, syn *Prunus amygdalus*, *Amygdalus communis* L. and *Amygdalus dulcis* Mill) are one of the most important commercial tree nut crops worldwide (Xiao et al., 2014). Almonds provide important nutrients such as vitamin E, monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA), arginine, and magnesium. Almonds also contain considerable amounts of potential prebiotic indigestible carbohydrates (Bolling et al., 2010; Liu et al.).

The common hazel plant (*Corylus avellana* L.) is a shrub native to Europe and Asia that grows in temperate climates. Hazelnut plays a major role in human nutrition and health because of its special composition of fat (around 60%), most of which are highly rich in MUFA (mainly oleic), protein, carbohydrate, dietary fiber, vitamins (vitamin E), minerals, phytosterols (mainly β-sitosterol), squalene and antioxidant phenols (Oliveira et al., 2008; Yada et al., 2013).

Walnut tree (*Juglans regia* L.) was originated from Southeast Asia and east Mediterranean areas and was introduced in Europe by the Romans. Walnuts, despite the pleasant taste, were considered for long, inconvenient for human consumption because they are very rich in fat. However they bring a great benefit to health because they help control bad cholesterol and therefore help to protect the heart. They are particularly rich in minerals like copper and zinc, required for formation of haemoglobin in the blood (Almeida, 2013; Tapia et al., 2013).

The storage conditions are of major importance so as to maintain the integrity and quality of nuts, and thus prevent spoilage (Freitas-Silva, Venâncio, 2011; Ma et al., 2013). Post-harvest handling and storage might deteriorate both nut nutritional value and taste. It is well known that many factors, such as a high drying temperature or prolonged storage under air and / or at a relatively high temperature and humidity have negative effects on various nut quality attributes (Tsantili et al., 2011).

The aim of this work was to study the effect of different storage conditions on nuts (almond, hazelnut and walnut), namely ambient temperature, high temperatures and low temperatures. The characteristics evaluated were water activity, moisture content, colour and texture.

Materials and Methods

Sampling

The fruits evaluated in this study were almond, hazelnut and nut. The fruits were all without the outer shell, but in some cases they had the inner skin (seed coat) and in other cases not.

The almond samples were: from Spain with skin (A-SP-s), Portugal with skin (A-PT-s) and from United States with and without skin (A-US-s and A-US-n). The hazelnut samples were: from Spain with skin (H-SP-s), Portugal with skin (H-PT-s) and from Turkey without skin (H-TR-n). The walnut samples were: from Chile with skin (W-CH-s), Portugal with skin (W-PT-s), Romania with skin (W-RO-s) and USA with skin (W-US-s).

Determination of water activity and moisture content

The water activity was measured at 25 °C by a hygrometer (Rotronic Hygroskop BT-RS1) connected to a thermal bath. In all cases four determinations were made to calculate the medium value and standard deviation. Moisture content was evaluated by drying in a stove (WTB-Binder) at 105 °C until reaching constant weight. In all cases three determinations were made.

Evaluation of colour

The colour of all samples was measured using a handheld tristimulus colorimeter (Chroma Meter-CR-400). The parameters measured were the lightness L*, which varies between 0 and 100 (from black to white, respectively), and the coordinates of opposed colour: a* and b*, which vary from – 60 to + 60, where the a* assumes negative values for green and positive values for red, while b* assumes negative values for blue and positive for yellow. The total colour change (ΔE), was the parameter considered for the overall colour difference evaluation, between a sample and the reference fruit (without storage, designated with an index 0:

$$\Delta E = \sqrt{(L_0* - L*)^2 + (a_0* - a*)^2 + (b_0* - b*)^2} \qquad (1)$$

Evaluation of texture

The texture profile analysis (TPA) for all samples was made by a texturometer (TA.XT.Plus from Stable Micro Systems). The text performed was measure force in compression and the probe used was a Blade Set HDP/BS (Warner- Bratzler). Twenty measurements were carried for each fruit and each storage condition. The curve force (N) versus distance (mm) allows to calculate the hardness (the force at first peak) and friability (the distance of first peak).

Storage conditions

The fruits were stored without package for 90 days at ambient conditions, in a stove at two temperatures with controlled temperature but no control over relative humidity, under refrigeration and frozen (Table 1). The use of high temperatures (50 °C) aimed at verifying the effect of these storage conditions on the water absorption and therefore the conservation.

Table 1

Storage conditions for the fruits studied

Description	Temperature, °C	Relative humidity, %
B: Just acquired (base)	–	–
AT: Ambient temperature	23.4±2.5	50.5±6.7
S30: Stove (T controlled but RH not)	30.0±0.0	36.0±3.6
S50: Stove (T controlled but RH not)	50.0±0.0	13.2±1.5
R: Refrigerated	2.3±3.7	48.1±23.3
F: Frozen	-15.4±2.6	61.7±6.2

Results and Discussion

Figure 1 shows that the moisture content of the almond samples was always higher before storage, regardless of the conditions. Comparing the different origins, the almond from Spain had the highest moisture content.

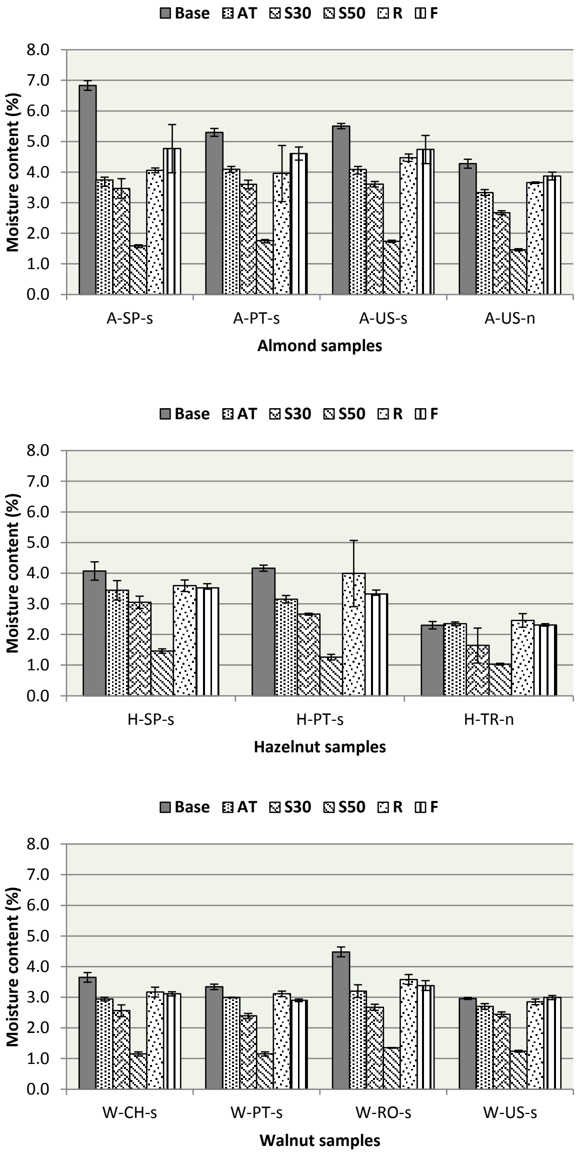


Figure 1. Moisture content of nuts

AT – Ambient temperature; S30, S50 – storage at high temperature (30 and 50 °C); R – refrigerated; F – frozen; Origin: SP – Spain, PT – Portugal, US – United States, RO – Romania, CH – Chile, TR – Turkey

As to the almonds from the United States, the absence of the skin contributed to a further dehydration, because the moisture content of the almond with skin was 1.74% while for the sample without skin was 1.46%.The results also reveal that for all almonds the frozen samples were those that had the moisture content more similar to the base ones. The trend observed for almonds was also observed for hazelnuts and walnuts. However, the relative contents are different, where almonds have higher moisture contents when compared to the other two nuts studied. The values of the water activity for all samples and all storage conditions are presented in Figure 2. The results show that, like what was observed for moisture, the storage of 50 °C produces the almonds with lower water activity, while the frozen almonds showed the higher water activity among the stored samples. The results for the other two nuts studied, hazelnuts and walnuts, are very similar, but once again the magnitude of the values is different, so that the almonds present much higher water activity. One important issue concerning stability and that may influence is lipid quality oxidation, but that was not studied in this work.

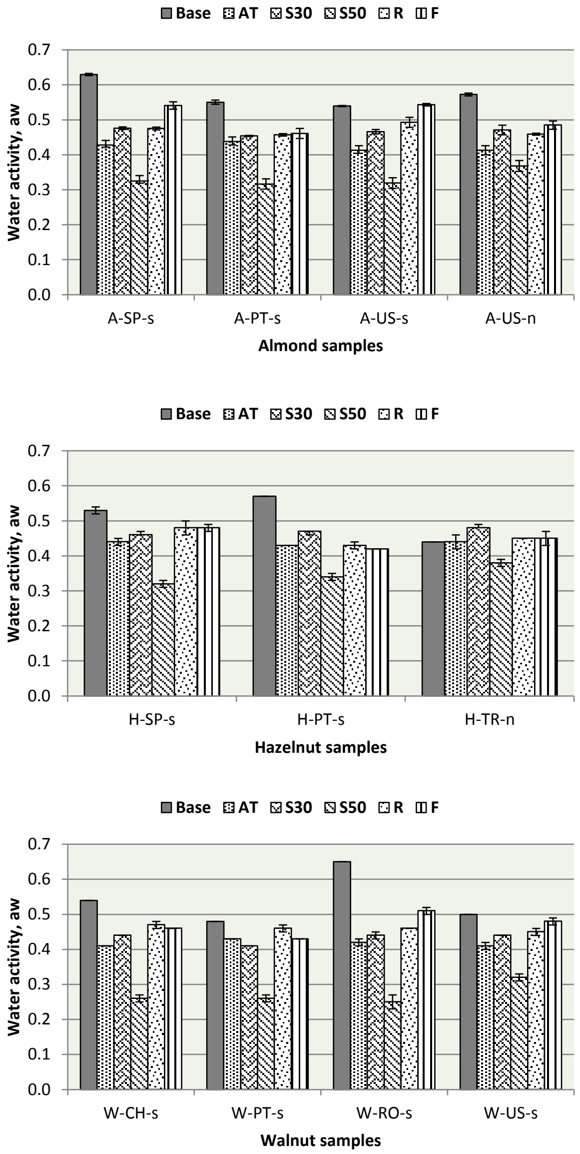


Figure 2. Water activity of nuts

AT – Ambient temperature; S30, S50 – storage at high temperature (30 and 50 °C); R – refrigerated; F – frozen; Origin: SP – Spain, PT – Portugal, US – United States, RO – Romania, CH – Chile, TR – Turkey.

However, and despite the slight changes observed, these findings allow to conclude that in general the samples are stable and not susceptible to spoilage, since for all storage conditions the values of aw are lower than 0.6, thus preventing the development of any bacteria, fungi or yeasts.

Table 2 shows the values of the colour parameters for all the nut the samples before storage.

The values of L*, a* and b*are very similar for the three almond with the skin, but differ much of that of the sample without skin, as naturally expected. The almond samples with the skin present values of L* (brightness) under 50, thus indicating that they are very dark, contrasting with the value of the sample without skin (L*=78.1), which stand in the region approaching white. The values of a* are positive in all cases, thus indicating that the samples have a more or less (depending on the presence of the skin) reddish colouration. In the case of the A-US-n sample, the value is very close to zero, indicating that the predominance of red is very weak. Regarding the values of b*, they are all strongly positive, and so the intensity of the yellow colour is high.

As to the colour parameters for hazelnut, the results are very similar to those of the almonds and the trends observed are the same as discussed above. Also the influence of the internal skin is well evidenced.

Regarding the walnut samples, and because they were in this case all with the internal skin, the results are very close among each other. However, it is worth mentioning that the values of a* and b* are smaller in the skin of the walnuts as compared to the skin of the other two nuts studied.

Table 2

Colour parameters of the nuts

Sample	L^*_0	a^*_0	b^*_0
Almond			
A-SP-s	47.8±3.3	16.5±1.7	32.7±3.3
A-PT-s	43.4±2.9	16.8±1.5	30.5±2.7
A-US-s	47.3±2.6	17.2±1.1	33.9±2.2
A-US-n	78.1±2.2	1.6±1.2	28.1±2.1
Hazelnut			
H-SP-s	42.6±4.1	17.8±1.9	24.5±3.3
H-PT-s	47.2±4.4	18.6±2.0	26.2±2.6
H-TR-n	75.2±3.1	4.8±1.5	31.6±3.1
Walnut			
W-CH-s	40.6±6.4	11.5±1.9	24.2±2.4
W-PT-s	48.2±6.3	9.4±2.4	28.4±3.7
W-RO-s	49.3±6.0	10.3±1.8	31.1±2.8
W-US-s	47.0±6.4	8.9±1.9	26.7±4.1

Figure 3 shows the total colour difference between each sample and the reference, which consisted of the nuts before storage. The values were calculated by equation (1) from the mean values for each case, and therefore no standard deviation is included. The results show that the highest differences were observed for those almonds stored at 50 °C, and that is particularly visible for the almonds with skin. These results indicate that the skin is affected by heat, becoming darker due to the browning processes occurring during storage.

Hence, the results seem to indicate that maybe refrigeration and freezing could be an alternative to preserve the colour of the almonds with skin.

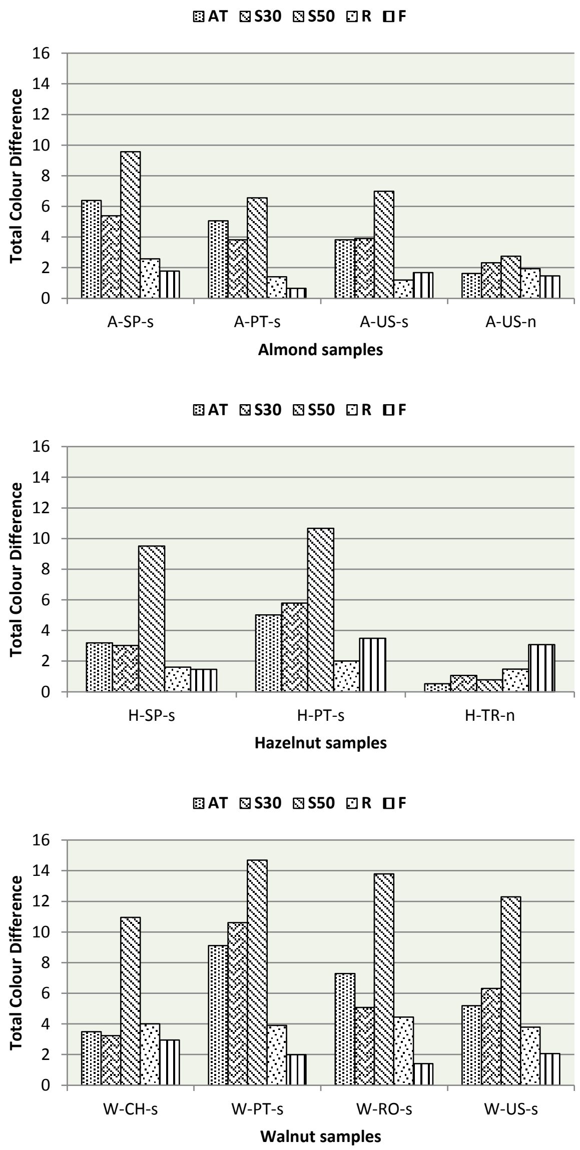


Figure 3. Total colour difference of nuts

AT – Ambient temperature; S30, S50 – storage at high temperature (30 and 50 °C); R – refrigerated; F – frozen; Origin: SP – Spain, PT – Portugal, US – United States, RO – Romania, CH – Chile, TR – Turkey

In relation to the other two nuts, it was also observed that the storage at 50 °C originated the highest colour differences. As to the best method of storage for these two nuts, although in majority of the cases it is freezing like in the case of almonds, there are however some exceptions, in the case of hazelnuts from Portugal and from Turkey.

Hardness is the mechanical strength to crush. It is important as it ensures the physical integrity of the product, allowing it to support the mechanical stress in the process of packing and transportation. The hardness limits are specified according to the diameter and weight of the sample and refers to the minimum resistance to be removed from the container without breaking. The textural attribute hardness was evaluated for almonds and hazelnuts and the results are shown in Figure 4.

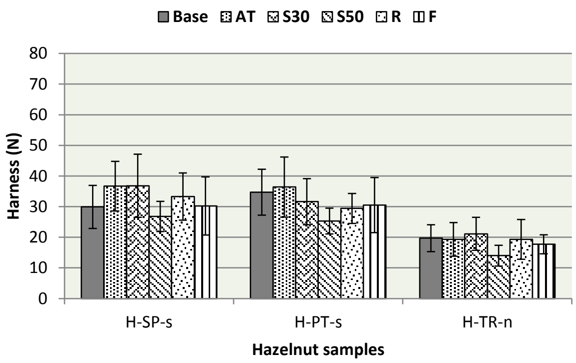


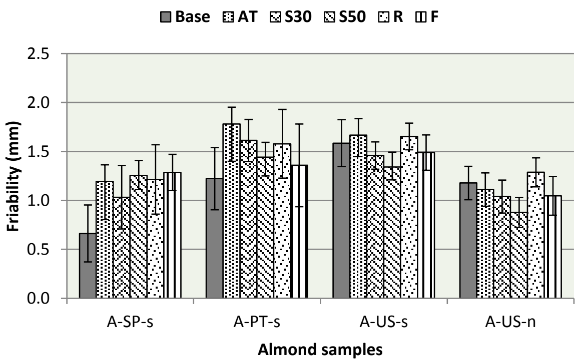
Figure 4. Hardness of almonds and hazelnuts

AT – Ambient temperature; S30, S50 – storage at high temperature (30 and 50 °C); R – refrigerated; F – frozen; Origin: SP – Spain, PT – Portugal, US – United States, TR – Turkey

The almonds from different origins show important differences in terms of this characteristic, being the almonds from Spain the softer among the samples with skin. Naturally that by removing the skin, the hardness decreases, as the results of the two sample from US (with and without skin) indicate. As to the effect of storage conditions, the results are not consistent among the different almonds, because the same treatment produces contradictory effects on different almonds. However, in general, the refrigeration and freezing conditions allow obtaining values closer to the reference samples of almonds.

As to the hazelnuts, it can be observed from Figure 4 that the variability is lower when compared to the almonds, and so are also the values of hardness. In fact, the hardness of the almond samples is almost double of the hazelnut samples. In the case of hazelnuts, all the storage conditions allow obtaining products with a similar hardness to the unstored samples.

The friability respects to the ease with which the fracture occurs in the products, and assumes a particular importance to avoid product loss. Figure 5 presents the results obtained for friability of almonds and hazelnuts, and these are quite consistent with what was previously observed for hardness. Once again the almond without skin shows to be less affected by storage, while the almond from Spain in that which suffers higher changes along storage, regardless of the conditions. Figure 5 also reveals that hazelnuts have lower friability when compared to almonds.



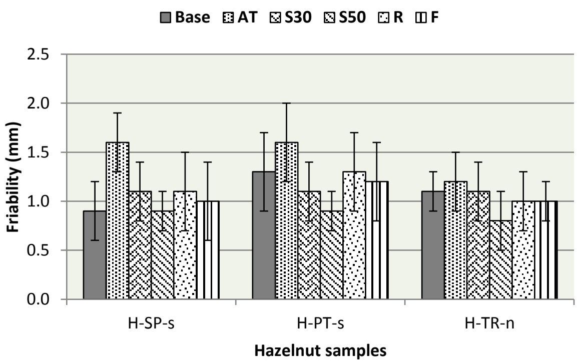


Figure 5. Friability of almonds and hazelnuts

AT – Ambient temperature; S30, S50 – storage at high temperature (30 and 50 °C); R – refrigerated; F – frozen; Origin: SP – Spain, PT – Portugal, US – United States, TR – Turkey

Conclusions

The findings of the present work allowed to draw some general conclusions as to the best storage conditions to preserve the characteristics of nuts. In fact, while the treatments at high temperatures induce in general more changes, the refrigeration and freezing systems are recommended for their lower effect on the products characteristics.

Furthermore, it was also concluded that the nuts stored under all conditions tested were safe from the point of view of the microbiological stability, given the very low water activity observed in all cases. Finally, it is important to note that the presence or absence of the internal skin greatly influences the product properties.

Acknowledgment

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