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Influence of Dehydration in the Physical-Chemical Quality of Commercial Sunflower Almonds

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Abstract

Sunflower almonds are widely marketed and have numerous technological applications. Through the drying process occurs the reduction of the water content of the product, a factor that contributes to increase its useful life. However, nutritional losses and physical damage can also occur. In this context, the objective of this study was to evaluate the effect of different temperatures applied in the drying process on the physical-chemical characteristics of commercial sunflower almonds. Convective drying was performed using temperatures of 40, 50, 60 and 80 °C. Afterwards, the samples before and after the drying process were analyzed with respect to the following parameters: moisture, water activity, ash, lipids, proteins, carbohydrates and energetic value to observe the influence of different drying temperatures on these attributes. It was verified that the increase of the temperature of the drying air causes an increase in the ash content, total solids, lipids, carbohydrates and energetic value. However, the reduction of moisture content, water activity and proteins was observed. There was no significant difference between the samples in relation to pH.

Keywords: drying, *Helianthus annuus* L, sunflower endosperm, temperature

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1. Introduction

The sunflower (Helianthus annuus L.) is a plant native to North America and belongs to the Asteraceae family. It is resistant to adverse climatic conditions and is composed of mesocarp, pericarp (fruit wall) and endosperm (almonds and seeds). (Carvalho *et al*., 2018). In addition, it can be used in human and animal feeding (Carvalho *et al*., 2018). In addition to being considered as a major oilseed crop and source of vegetable oils, and to date, traditional sunflower varieties are the main commercially grown varieties, but sunflower varieties with high oleic capacity are of economic importance (Muder *et al*., 2017).

It stands out for having great economic importance, as it is widely used in the production of edible oil and biodiesel. The internal consumption of sunflower seeds has grown exponentially, due to its high nutritional value, standing out from the other oilseeds because it has a high content of protein, potassium, magnesium and polyunsaturated fatty acids (approximately 31.0%), (13.1%), cottonseed (18.1%), flaxseed (22.4%), soybean oil (3.5%), peanut (25.5%), and safflower seeds (28.2%) (Sˇkrbic and FIlipcˇev, 2008; Amorim *et al*., 2017; Scharlack, 2017).

The quality of the sunflower seeds is influenced by the inherited genetic characteristics of their lineages, germination and vigor, but also by post-harvest processing and storage conditions (Gvozdenac *et al*., 2018). Its harvesting is carried out when the product has reached the appropriate physiological maturity, where the best yields, higher dry matter content and high moisture content are verified. However, for adequate processing and storage to occur, it is essential to reduce the moisture content through the application of unitary operations such as convective drying, which is the process most used in agricultural products and which provides the reduction of activity chemical and biological properties, guaranteeing the quality and stability of the final product (Smaniotto *et al*., 2017).

Drying is one of the most important stages of post-harvesting, involving both the transfer of heat and mass through the application of high temperatures that cause evaporation of water in the product. Multiple physical and biochemical processes are also associated with the drying process, such as shrinkage, cracking and loss of thermosensitive compounds. The mathematical modeling applied to the drying process aims to predict the behavior of the raw material in relation to the loss of moisture over time, to size equipment and perform the optimization of the process, providing a reduction in the drying time and consequently the reduction of costs and greater nutritional preservation of the product (Defraeye and Radu, 2018; Keneni *et al*., 2019).

Considering the importance of the study of the drying process in agricultural products, the present work had the objective of evaluating the effect of different drying temperatures on the physical-chemical characteristics of commercial sunflower almonds.

2. Material and Methods

The study was conducted in the Food Engineering Laboratory (LEA), located in the Natural Resources and Technology Center (CTRN) of the Federal University of Campina Grande, Campina Grande - Paraíba.

The sunflower's (*Helianthus annuus* L.) almonds were purchased at the fair of the city of Campina Grande - PB and taken to the laboratory (LEA), where they were submitted to the drying process in an oven with air circulation at a temperature of 40, 50, 60, 70 and 80 ºC, in which the samples were evenly distributed in trays (Figure 1), forming a thin layer. After dehydration, the samples were crushed in a knife mill where they were left with flour textures with irregular granulometry. Then packed and stored in laminated and vacuum sealed packages.

Figure 1. Commercial sunflower almonds

2.1 Physical-Chemical Characterization

The commercial sunflower kernels before and after the drying process were characterized according to the following physicochemical parameters: moisture, total solids, pH, ash and protein followed the methodologies described by the Instituto Adolf Luttz (Brazil, 2008). Water activity (Aw) was determined using the Decagon® Aqualab CX-2T device at 25 °C; The total carbohydrate content was calculated by difference to obtain 100% of the total composition (FAO, 2003). The lipid content was determined according to the methodology described by Bligh and Dyer (1959). The energy value was calculated according to the methodology proposed by Rocha Júnior *et al*. (2003).

2.2 Statistical Analysis

The data obtained in relation to the physico-chemical characterization of the dehydrated samples were statistically evaluated by means of a completely randomized design and the means compared by the Tukey test at 5% probability, with the aid of the statistical program ASSISTAT version 7.7 beta (Silva and Azevedo, 2016).

3. Results and Discussion

Table 1 shows the results obtained for the physico-chemical characterizations performed on commercial sunflower kernels before the drying process.

Table 1. Physical-chemical characterization of commercial sunflower kernels before the drying process

Parameters	Commercial almonds
Moisture (%)	14.60 ±0.05
Total solids (%)	85.40 ±0.05
Water activity (Aw)	0.534 ±0.01
pH	6.81 ±0.02
Titratable Acidity (%)	1.7 ±0.1
Ashes (%)	3.04 ±0.04
Lipids (%)	8.16 ±0.47
Proteins (%)	17.09 ±0.64
Carbohydrates (%)	57.11 ±0.28
Energetic value (Kacal/100g)	370.24 ±0.32

Commercial almonds before the drying process had a moisture content of 14.60% and total solids content inversely proportional to their moisture content. Silva et al. (2019) determined in lentil seeds moisture content (10.5%) and total solids of (89.5%). Fellow (2006) classified as intermediate moisture products those with aw between 0.6 and 0.85 and products with low humidity are those with aw values up to 0.6. We can classify sunflower almonds as intermediate moisture products (0.534). Brito *et al*. (2015) when analyzing for 90 days urucun seeds obtained water activity ranging from 0.630 to 0.673.

Before the drying process, they obtained pH close to neutrality. Close values were also obtained by Silva *et al*. (2017) for chickpeas (6.37 - 6.57). The value of titratable acidity (1.7%) was higher than the values found by Silva *et al*. (2017) for whole sunflower seeds with bark (0.774 - 0.830%).

The ash content was higher than those obtained by Silva *et al*. (2017) for gyrosol seeds with bark (1.75-2.06%), evidencing that the almonds have a significant amount of this parameter. However, it presents lower lipid content when compared to studies by Santos *et al.* (2017) for favela seeds (35.20%).

High values were also obtained for protein content (17.09%) and for carbohydrate content (57.11%). Feitosa *et al*. (2017) quantified 4.75% protein in jackfruit almonds. These high levels show that the almonds have a considerably elevated energy value (370.24 kcal/100g).

Table 2 shows the physical-chemical characterization and energetic value of commercial sunflower almonds after the drying process at temperatures of 40, 50, 60, 70 and 80 ℃.

Table 2. Physical-chemical characterization of dehydrated sunflower almonds

Parameters	Convective drying (℃)				
	40	50	60	70	80
Moisture (%)	10.04^{a}	9.07^{b}	7.58^{c}	5.78^{d}	2.91^{e}
Total solids (%)	89.96^{e}	90.93^{d}	92.42^{c}	94.22^{b}	97.09^{a}
Water activity (Aw)	0.416^{a}	0.406^{b}	0.365^{c}	0.360^{cd}	0.356^{d}
pH	6.82^{a}	6.83^{a}	6.85^{a}	6.83^{a}	6.82^{a}
Titratable Acidity (%)	1.44^{a}	1.33^{a}	1.30^{a}	1.03^{b}	1.46^{a}
Ashes (%)	3.15^{e}	3.64^{d}	3.96^{c}	4.26^{b}	4.83^{a}
Lipids (%)	7.01^{b}	7.69^{ab}	7.84^{ab}	8.15^{a}	8.22^{a}
Proteins (%)	19.14^{b}	20.28^{a}	16.04^{c}	13.55^{d}	12.1^{e}
Carbohydrates (%)	60.3^{d}	59.32^{e}	64.58^{c}	68.26^{b}	71.94^{a}
Energetic value (Kacal/100g)	380.85^{e}	387.61^{d}	393.04^{c}	400.59^{b}	410.14^{a}

Note: Letter superscripts equal in the same line do not present significant difference at the 5% probability level.

The final moisture content obtained for all temperatures were relatively low, differing statistically from each other. There was a reduction of this parameter of 7.13% between the almonds submitted to 40 and 80 ℃. According to Santos *et al*. (2019) the moisture content is inversely proportional to the applied temperature, ie, the higher the drying temperature the lower the moisture content of the product. It was also verified that the amount of total solids was higher when using higher temperatures (80 ℃), presenting 97.06%, this increase of the total solids content is justified by the reduction of the water content of the almonds. As well as the moisture content the total solids content also presented statistical differences at the 5% probability level.

The values obtained for the water activity corroborate with the data obtained for the moisture content, since they also reduced with the increase of the temperature of the drying air, varying from 0.416 to 0.356 when the temperature ranged from 40 to 80 ℃. Statistically, only the almonds submitted to a temperature of 70 ℃ did not present a significant difference between those submitted to 60 and 80 ℃, but presented differences of those submitted to 40 and 50 ℃. According to Silva *et al*. (2019) water activity is one of the main properties when considering the processing, storage and storage stages of agricultural products.

The pH values obtained at all drying temperatures were close to neutrality (pH = 7.00), ranging from 6.82 to 6.85, however, they did not present significant statistical differences. Bouvie *et al*. (2016) obtained pH of 5.23 and 6.23 for mesocarp and exocarp of Brazil nut tree (Bertholletia excelsa), respectively. When analyzing the titrable total acidity, only the almonds submitted to temperature of 70 ℃ presented differences when compared to the others according to the Tukey test at 5% of probability. This same parameter had values lower than 1.5%. According to Aroucha *et al*. (2010) the acidity has great utility in the food industry as a preservative, index for quality evaluation, sensorial indicator among other functions.

The ash quantification showed statistical differences between all the applied temperatures, with a gain with the increase of temperature, in relation to the almonds before the drying process (Table 1) there was a gain of up to 1.79% when the temperature ranged from 40 to 80 ℃. Values close to the present study were quantified Kato *et al*. (2016), which obtained 5.44% for brazil nut cake after the cold pressing process.

In relation to the lipid content, the almonds obtained similar behavior to the ash content, that is, there was also a gain with increase of the drying temperature, being the highest content obtained for the temperature of 80 ℃ (8.22%) and the lowest temperature for 40 ℃ (7.01%). Statistically, the seeds submitted at 50 and 60 ℃ did not show any differences between them, as well as those submitted at 70 and 80 ℃. Lower values were observed by Lemos et al. (2015) when analyzing noni seeds (6.34%).

There was a gain of 1.14% in the protein content between the temperatures of 40 and 50 ℃, however, from the temperature of 60 ℃, it was noticed degradation of this content being the seeds submitted to 80 ℃ with lower content protein (12.1%). All applied temperatures presented statistical difference. Ortolan *et al*. (2016) obtained 21.17% of proteins for baru seeds dehydrated at 140 ℃, being close to that obtained for almonds submitted to 50 ℃ in the present study. Malacrida *et al*. (2007) obtained 20.1% protein for dried yellow melon seeds at 40 ℃.

The results obtained in this work for the total carbohydrates content, presented a variation of 60.3 to 71.94%, being these respectively for the almonds submitted to the temperatures of 40 and 80 ℃, evidencing, that the sunflower almonds are rich in fibers. When compared to each other, they presented statistical difference at the 5% probability level. Lower carbohydrate values were obtained by Amaral *et al*. (2019) when they obtained flours of the fruit bocaiuva in the temperature between 40 and 50 ℃ (46,36%).

This high carbohydrate content contributes considerably to its high energy value, and can contribute significantly to raise the food standard of the population. As the drying temperature increased, an increase in the energetic value of the almonds was observed, ranging from 380.85 to 410.14 Kcal/100g, presenting a statistical difference between the applied temperatures.

4. Conclusion

Through the evaluation of the physicochemical parameters in the different treatments applied, it was verified that the increase of the temperature provided the reduction of moisture content, water activity and proteins. In contrast, there was an increase in ash content, total solids, lipids, carbohydrates and energetic value. No statistically significant difference was observed between the samples with respect to pH, however, for the acid parameter only the sample submitted to a temperature of 70 ℃ differed from the others. And the almonds submitted to 50 ℃ obtained the highest protein content and lipid content, so it is considered to be the ideal temperature for the drying process of sunflower almonds.

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