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**SHORT COMMUNICATION**

# DEHYDRATION OF CHEESE BY HOT AIR, MICROWAVE AND FREEZE-DRYING

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**Abstract:** The objective of this work was to study the dehydration of skim cheese through different methods, in particular by hot air, microwave and freeze-drying, in order to assess which of these methods would be more suitable for the development of a new product (cheese snack). For the three processes of dehydration, several temperatures, powers and times were used, respectively. The drying time was optimized to allow the water activity of the final product to be between 0.3 and 0.4. The color and texture of the product obtained by the three processes were evaluated, and the nutritional analysis (protein, lipids, ash) of the product dried by hot air at 52 ºC and by microwave at 750 W and 850 W was performed. The sensory analysis of the microwave dehydrated products was also carried out.
The results obtained revealed that the temperature played a relevant role in the drying time and the hardness of the product. In the dehydration by microwave, the power of 850 W resulted in a lower drying time and a better color preservation, but in a high hardness of the samples.
Among the three processes studied, the microwave drying was the fastest for the water removal from the cheese.

**Keywords:** *air temperature, ash, drying time, lipids, microwave power, protein, water activity*

## INTRODUCTION

The drying of food products may be carried out by various dehydration technologies, individually or in combination, accordingly to the efficiency of the process and the quality of the final product intended. Due to the characteristics of the product to be dehydrated it is not possible to indiscriminately use any dehydration technique [1]. However, the dehydration methods used on a large scale are those based on the exposure of the food product to a hot air flow [2]. Freeze-drying is used to preserve perishable products. The water is removed from the product by a process of sublimation, passing directly from the solid to the gaseous state without passing through the liquid state [3]. One of the most recent processes of drying is performed by microwaves. The product is subjected to microwave radiation by heating only the part of the product where the water is [4].

## MATERIALS AND METHODS

### Samples

The cheese samples were supplied by Fromageries Bel Portugal. The samples were 2 mm thick slices with 10 to 15 mm diameter.

### Hot air drying

The cheese slices were dehydrated in a tray dryer (Armfield, UK) at 43 and 52 °C and with an air speed of 1.2 $m \cdot s^{-1}$. The drying process was ended when the water activity ($a_w$) of the product was between 0.3 and 0.4. Each drying experiment was repeated.

### Freeze-drying

Ten replicates of around 10 g of cheese were frozen in a cold chamber at -20 ºC. These frozen samples were dried in a freeze-dryer (SB4, Armfield, UK) during 6, 12 and 24 h.

### Microwave dehydration

Five experiments were performed at different power levels - 350 W, 500 W, 650 W, 750 W e 850 W - in a microwave (MT-243, Whirlpool, USA). The samples were conditioned in triangular cooking vessels. The mass was registered every 15 s until a constant value was reached.

### Quality evaluation

Different quality parameters were evaluated - water activity, $a_w$ (AQUA LAB Cx-2, Decagon Devices Inc., USA), color (Minolta CR-300, Minolta Corporation, USA) and texture (TA.XT.PLUS, Stable Micro Systems, UK). Protein [5], lipids [6] and ash [7] were also analyzed.

The sensory analysis of the final products was also carried out by a trained panel of 11 judges. Each judge performed a hedonic appreciation of each of the attributes - color intensity, odor intensity, cheese aroma, hardness and crunchiness - in a scale with 5 levels, 1 being the lowest level and 5 the highest. A scale from 1 to 9 was also used for the global appreciation of the samples.

**Statistical analysis**

One-way analysis of variance (ANOVA) (using SPSS 10.0 statistics software, SPSS Inc., Chicago, IL) was used for the determination of differences between determinations. Tukey's test was additionally then formed with the purpose of means paired comparison. The results were considered significantly different when $P < 0.05$.

## RESULTS AND DISCUSSION

There was a decrease in the water content along the hot air drying time, and the lowest value of final water content (0.09 kg $H_2O$·kg $DM^{-1}$) was observed at 52 ºC. It should be noted that the drying time increased with the decreasing temperature. Thus, for a temperature increase from 43 °C to 52 °C (9 °C difference), a reduction of about 27 % of the water content in the sample was observed for 5 hours of drying. A rapid water loss is also observed at the beginning of the drying process due to the rapid evaporation of the free water of the product, which is in agreement with Ozgen [8].

Considering only the falling-rate period, the Fick's 2$^{nd}$ law series solution was applied with one term to the water loss kinetics. A diffusivity of $4.24 \times 10^{-11}$ $m^2 \cdot s^{-1}$ at 43 °C and $4.71 \times 10^{-11}$ $m^2 \cdot s^{-1}$ at 52 °C was obtained for similar final $a_w$ values, 0.372 and 0.384, respectively. According to Castell-Palou and Simal [9], the constant-rate drying period was not observed in the hot air drying process of cheese.

The $a_w$ values of the lyophilized dehydrated cheese were much lower than the target value. For a dehydration period of 6 h, the value obtained was $0.131 \pm 0.004$, this value being even lower for higher dehydration times. Since the final sample was still frozen for a dehydration time of 3 h, probably the recommended time to reach an $a_w$ of about 0.3 should be between 3 and 6 h.

The drying time decreased with the increase of the microwave power used in this type of drying. The power of 850 W reduced 3 times the drying time at the power of 350 W, to reach the desired $a_w$ value, between 0.3 and 0.4 (Figure 1).

The microwave drying process presented the highest hardness (33.05 N for 500 W) and fracturability (45.99 N for 350 W). A relation of the hardness with the water content of the samples dehydrated by the different methods was observed. Regarding the color of the samples, the microwave drying presented the highest values of saturation [$C^* = (a^{*2} + b^{*2})^{1/2}$]. The higher this value, the greater the perceived color intensity [10].

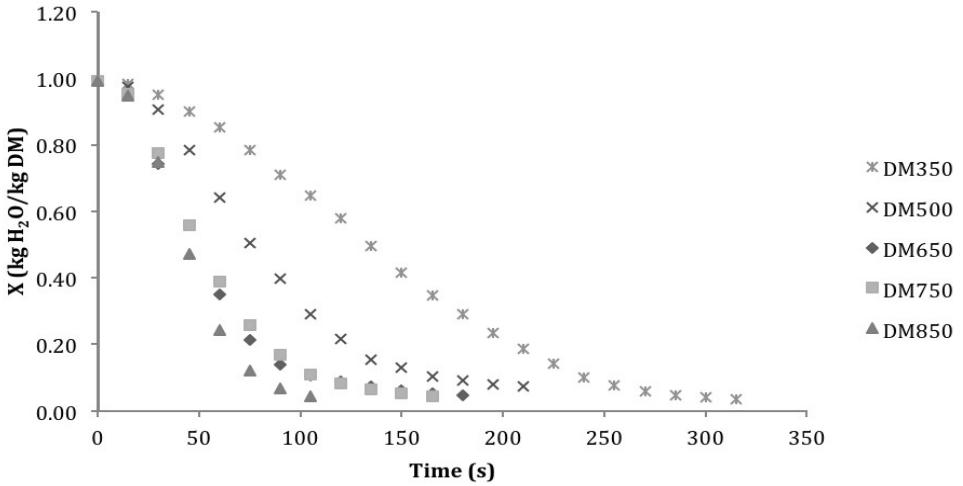


***Figure 1.*** *Water content of sliced cheese during the microwave drying process (DM350 – at 350 W, DM500 - at 500 W, DM650 - at 650 W, DM850 - at 850 W)*

With respect to the nutritional analysis of the dehydrated cheese, in particular the lipid content, its values varied between 24.5 % and 26.5 %, and the lowest value was obtained for the microwave drying at 750 W. With respect to proteins, their values presented slight variations, between 52 % and 55 %. The process of hot air dehydration resulted in a higher average value of protein content in relation to the microwave process at 850 W (Figure 2).

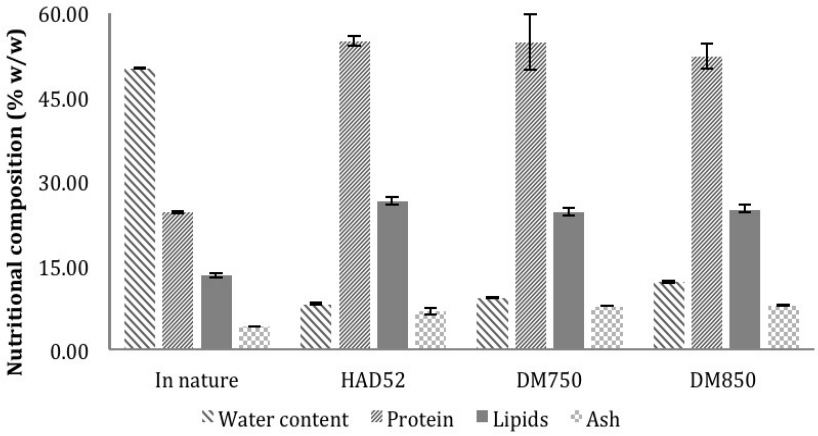


***Figure 2.*** *Nutritional composition of the cheese slices in nature and dehydrated by hot air and microwave (HAD52 - hot air at 52 °C, DM750 - microwave at 750 W, DM850 – microwave at 850 W)*

Concerning the sensory analysis of the dehydrated cheese, the overall assessment was more favorable to the microwave dehydrated samples at 750 and 850 W - 4.9 and 5.3, respectively - than at 650 W. This may suggest that the samples pleased the judges, but without great enthusiasm. These samples presented a similar perception of crunchiness and, from the point of view of the judges, these products had a medium crunchiness. However, the judges consider the samples harder than crunchy (Figure 3).

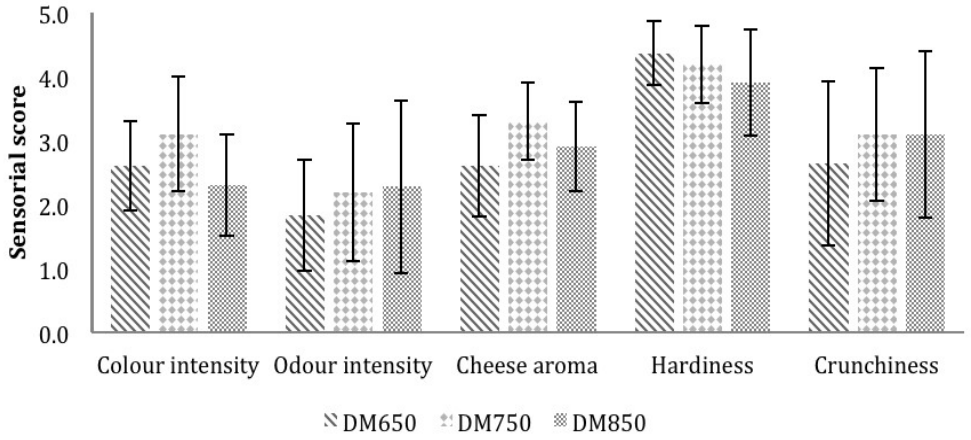


***Figure 3.*** *Sensory analysis results of cheese dehydrated by microwave (DM650 - 650 W, DM850 - 850 W)*

## CONCLUSIONS

Among the three drying processes studied, the microwave dehydration is the most effective and fastest process for reducing water of sliced cheese in order to achieve water activity levels of 0.3 - 0.4. However, the hardness of the product surpasses its crunchiness, in the level of sensorial acceptance. Microwave power of 850 W resulted in a shorter drying time and better color preservation of the cheese.

## ACKNOWLEDGMENT

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