

## Variation of physical properties of banana along drying for cvs. *Musa nana* and *Musa cavendishii*

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### Resumo

O presente trabalho teve como objectivo proceder à secagem de duas variedades de banana (*Musa nana* e *Musa cavendishii*) à temperatura de 50 °C e 70 °C e comparar as propriedades dos frutos secados com as do fruto em fresco.

Com os resultados obtidos concluiu-se que a densidade aparente aumenta com a perda de água durante a secagem e que os produtos secados têm menos luminosidade e são mais acastanhados, independentemente da variedade da banana.

Em relação à textura, verificou-se uma redução da dureza superior a 60 % com a secagem a 70 °C para ambas as variedades, quando comparado com o fruto fresco. Por outro lado, não se observou uma alteração significativa na coesividade e elasticidade da banana com a secagem, independentemente da temperatura de secagem e da variedade.

Palavras chave: banana, secagem, densidade, cor, textura

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### Abstract

Bananas from two different cultivars, *Musa nana* and *Musa cavendishii*, were dried by hot air at two different temperatures (50 °C and 70 °C) with the purpose of comparing their properties with the corresponding fresh products.

Along the drying process, it was possible to conclude that bulk density of both types of banana increased as the water content was diminishing. The results also indicate that drying originated darker products when compared to the fresh ones, with lower L\* (luminosity) and b\* (yellowness) and with higher a\* (intensification of reddish color). These results were obtained for both cultivars under study and the two hot air temperatures (50 °C and 70 °C).

With respect to texture, it was observed a reduction of hardness, with drying at 70 °C, higher than 60 % for the two banana varieties, when compared with the fresh fruits. In addition, the values of cohesiveness and springiness are similar among the fresh and dried state, independently of the banana variety and the temperature of drying.

Keywords: banana, dried, density, color, texture.

### Introduction

Banana (genus *Musa*) is one of the oldest cultivated plants. It is native from tropical South and Southeast Asia, but, at present, it is cultivated all over the tropics. Bananas are grown at least in 107

countries, primarily for their fruit, and, to a lesser extent, to produce fiber from banana. They present a variety of sizes and colors when ripe, including yellow, purple, and red.

The banana, which is an excellent tropical fruit, has an agreeable flavor and a high nutritional value. The characteristic aroma of bananas arises from a complex mixture of compounds, esters of short-chain fatty acids such as acetates, butanoates, and 3-methylbutyl esters (Macku and Jennings, 1987; Perez et al., 1993). It is a calorific food, rich in carbohydrates, sugar, fiber, minerals and vitamins, and with a very low contribution of fat (Arvanitoyannis and Mavromatis, 2009). However, the chemical composition, the nutritional value and the sensory properties of the bananas can be influenced by several factors, such as cultivar, climatic conditions of the growing area, soil composition or arable land of the region, agricultural practices, storage and the commercialization conditions (Galan and Cabrera, 1999).

Fresh banana changes rapidly after harvesting and the color, firmness, and flavor of the fruit are always damaged during storage (Collin and Dalnic, 1991). Drying stabilizes the product by decreasing its water activity and moisture content, but the quality of the fruit and particularly its color and flavor are sensitive to thermal treatment. Bananas are dried by several methods, including convective drying, vacuum drying, microwave drying, and microwave freeze drying with or without pretreatments (Corrêa et al., 2012). Yet, air-drying is the most common drying method employed for foodstuffs, including banana (Demirel and Turhan, 2003; Hofsetz et al., 2007).

The main objective of this work was to study the effect of a convective air drying at temperature of 50 °C and 70 °C on the physical properties such as bulk density, color and texture of two banana varieties.

## Material and Methods

Banana fruits from Madeira island - Portugal (*M. nana*) and Costa Rica (*M. cavendishii*) were obtained from a local supermarket. Before starting the experiments, each banana was peeled, both ends were discarded, and then the fruit was sliced by a knife to disks with a thickness of 5 mm.

The convective drying was made in an electrical FD 155 Binder drying chamber with air flow of 0.5 m/s and in perforated tray. The samples were dried until reaching a final moisture content lower than 10% (wet basis) in order to ensure good preservation characteristics as well as good final physical and chemical properties.

Moisture content was determined by a halogen moisture analyser (Mettler Toledo HG 53) set to 130 °C and velocity 3 (medium). Each experimental point was the mean value of four samples. Bulk density was evaluated by liquid displacement using water at 4 °C in a picnometer. Color was measured according to the CIELAB color scale relative to the standard illuminant D65 over a white tile. The coordinates L\* a\* b\* were measured using a colorimeter chroma meter CR-400 and it was used the average of 10 measurements taken in five slices for each experimental point. The texture profile analyses (TPAs) were assessed using a texture analyser (Stable Microsystems TA.XT.Plus,) and were obtained by compression of the sample in two consecutive cycles between parallel plates using a probe of 75 mm diameter with a 5 second interval between cycles. The load used cell was 5 kg and the test speed was 0.5 mm/s. The textural properties were then calculated.

## Results and Discussion

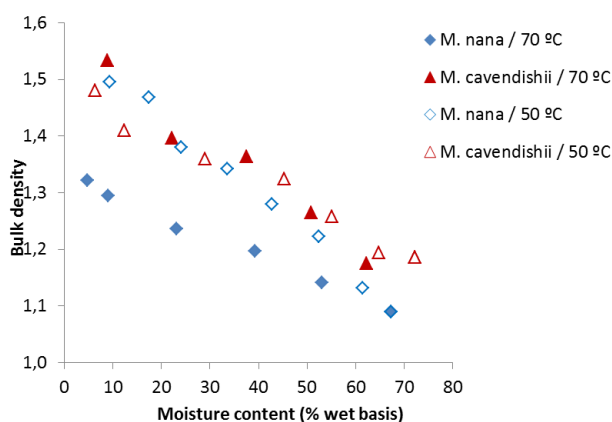
The initial moisture content of fresh banana was, respectively, 2.06 g/g (d.b.) and 2.61g/g (d.b.) to *Musa nana* and *Musa cavendishii* varieties. Corrêa et al. (2012) refer values of moisture content ranged between 2.38 g/g (d.b.) and 2.99 g/g (d.b.) to fresh bananas (*M. acuminata* var. *nanica*), depending on the ripe degree (unripe and overripe).

Table 1 presents the drying time and the corresponding moisture content of *M. nana* and *M. cavendishii* at the end of the drying process at 50 °C and 70 °C.

**Table 1.** Final drying conditions at 50 °C and 70 °C to *M. nana* and *M. cavendishii*

| Final conditions            | <i>M. nana</i> |       | <i>M. cavendishii</i> |       |
|-----------------------------|----------------|-------|-----------------------|-------|
|                             | 50 °C          | 70 °C | 50 °C                 | 70 °C |
| Drying time (h)             | 8.75           | 4.50  | 7.50                  | 5.00  |
| Moisture content (g/g w.b.) | 9.36           | 4.71  | 6.37                  | 8.83  |
| Moisture content (g/g d.b.) | 0.10           | 0.05  | 0.07                  | 0.10  |

The bulk density of fresh *M. nana* and *M. cavendishii* is, respectively, 1.09 g/cm<sup>3</sup> and 1.19 g/cm<sup>3</sup>. Figure 1 illustrates the variation of this property along drying at 50 °C and 70 °C of both banana varieties. During the drying process it was observed an increase of the bulk density, independently of the banana variety. The extent of change in density at 50 °C to slices of Cavendishii banana and *M. nana* is, respectively, 27.1 % and 17.5 %. However, with the increase in temperature it was observed a different behavior on the extent of change in bulk density with the variety. In fact, the change of bulk density with the increase of temperature is much more pronounced in *M. nana* than in *M. cavendishii*. The obtained results for the *M. cavendishii* variety are consistent with the ones highlighted by Demirel and Turhan (2003), who refer that, for the Cavendishii and Gros Michel banana slices, the extent in diameter, thickness, volume area and density of the slices was not affected neither by temperature of air drying in the range of 40 °C to 70 °C nor the pretreatments (sodium bisulphite and ascorbic/citric acid). These authors refer also that, excluding the thickness, all the remaining parameters were affected by the banana variety. The change of bulk density with temperature to *M. nana* can be explained by a major effect of temperature on changes on banana physical structure and phenomena such as shrinkage, that determine the structural and physical properties of the dried product.



**Figure 1.** Bulk density along the drying at 50 °C and 70 °C of *M. nana* and *M. cavendishii*.

The values for the color parameters of the *Musa nana* and *Musa cavendishii* obtained from fresh and dried fruits at 50 °C and 70 °C are presented in Figures 2 and 3. The coordinate L\* refers to lightness, the a\* coordinate refers to green (-)/red (+) chromaticity and the coordinate b\* indicates blue (-)/yellow (+) chromaticity. L\* values closer to 100 represent greater brightness, while values near 0 indicate less brightness. The L\*, a\*, and b\* parameters of fresh *Musa nana* and *Musa cavendishii* are approximately 72.7, 2.5 and 32.7, and 70.5, 0.6 and 31.5, respectively. Even considering the slight differences observed in the color according to the variety Corrêa et al. (2012) identified similar values for ripe fresh bananas (*M. acuminata* var. *nanica*) 65.09, 3.49 and 25.63, respectively, for L\*, a\* and b\* color parameter.

In general, the slices of the two banana varieties were white-yellowish at the fresh state and developed a yellow-brownish color along drying. Furthermore, it is possible to conclude that an increase in temperature from 50 °C to 70 °C originated a small effect on the color parameters.

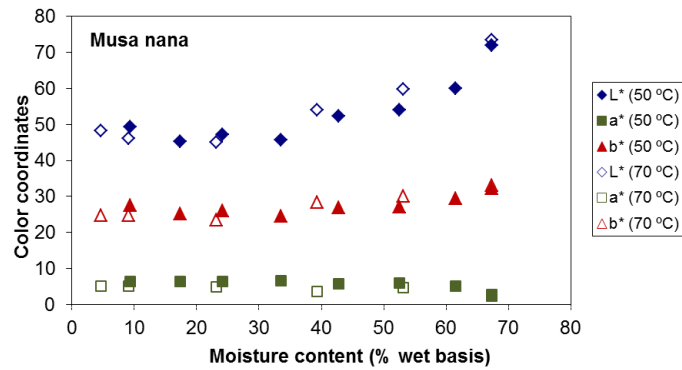


Figure 2. Color coordinates versus moisture content along the drying at 50 °C and 70 °C of *M. nana*.

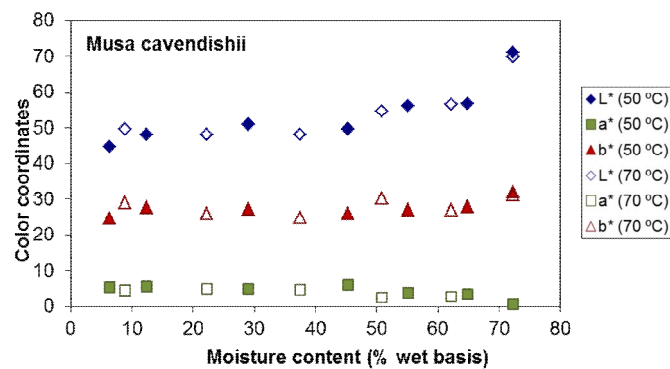


Figure 3. Color coordinates versus moisture content along the drying at 50 °C and 70 °C of *M. cavendishii*.

The total colour difference ( $\Delta E$ ) along the drying of the two banana varieties at 50 °C and 70 °C is illustrated, respectively, in Figure 4.

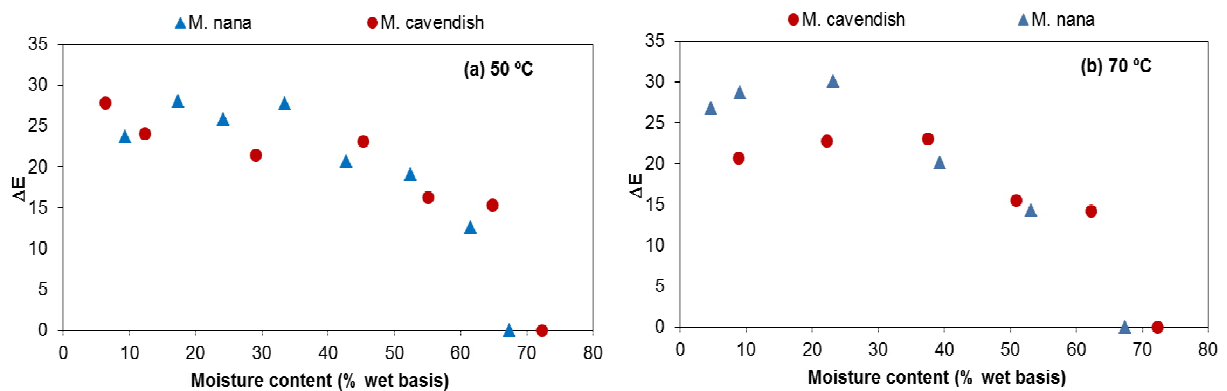


Figure 4. Total colour difference for dried *M. nana* and *M. cavendishii* at 50 °C (a) and 70 °C (b).

The total color difference for the two banana varieties along the drying at 50 °C and 70 °C reveals a similar color deviation in relation to the fresh fruit. However, the increase in temperature tends to

decrease the discoloration, particularly in *M. cavendishii*, implying an enzymatic character of the browning as shown by Demirel and Turhan (2003).

The hardness of the samples taken from the fresh and dried bananas at 50 °C and 70 °C is presented in Figure 5. The results show that the two varieties of banana in the fresh state possess a similar hardness. With drying the *M. cavendishii* variety shows a decrease of firmness with the increase of temperature from 50 °C to 70 °C, while *M. nana* presents itself harder at 50 °C when compared with the fresh state. However, for the drying of 70 °C, both varieties show a reduction in hardness higher than 60 %.

Adhesiveness in the fresh banana is 4.48 N.s to *M. nana* and 4.30 N.s to *M. cavendishii*. The dried banana has very low values of adhesiveness, independently of the drying temperature and variety.

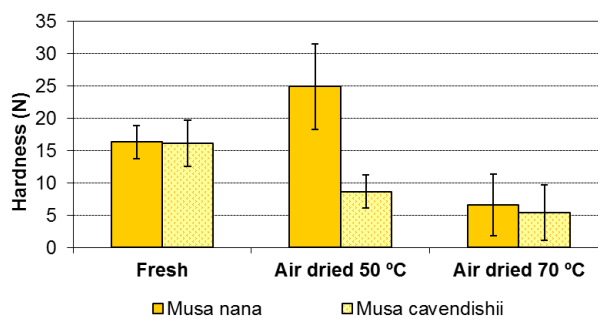


Figure 5. Hardness of fresh and air convective dried *M. nana* and *M. cavendishii*.

Figure 6(a) shows the values found for cohesiveness of the fresh and dried banana varieties. Cohesiveness refers to the strength of the internal bonds that keep the sample cohesive. It is possible to observe that the values are similar among the fresh and dried state, independently of both the variety and the temperature of drying. Figure 6(b) reveals the springiness found for the different samples analysed in the fresh and air dried bananas. Springiness, which expresses the percentage of recovery of the sample, is similar for the two fresh banana varieties. The results also reveal that the drying temperature does not alter springiness in a visible way.

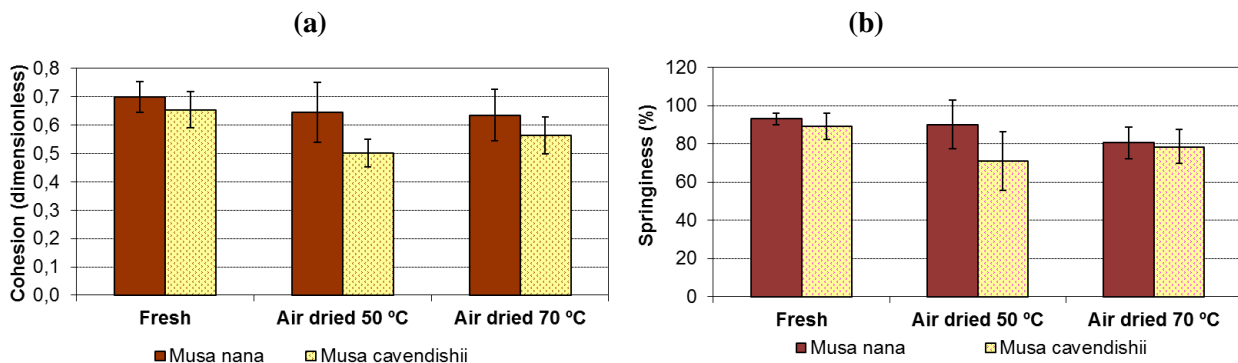


Figure 6. Cohesiveness (a) and Springiness (b) of fresh and dried *M. nana* and *M. cavendishii*.

## Conclusions

Bananas from two different cultivars, *Musa nana* and *Musa cavendishii*, were dried by hot air at two different temperatures (50 °C and 70 °C) with the purpose of comparing their properties with the corresponding fresh products.

Along the drying process, it was possible to conclude that bulk density of both types of banana increased as the water content was diminishing. The results also indicate that drying originated darker products when compared to the fresh ones, with lower L\* (luminosity) and b\* (yellowness) and with higher a\* (intensification of reddish color). These results were obtained for both cultivars under study and the two hot air temperatures (50 °C and 70 °C).

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## Acknowledgments

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