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NATURAL AND ARTIFICIAL DEHYDRATATION OF APPLES AND BANANAS. COMPARATIVE STUDIES

BY

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Abstract. In this study, the natural and artificial dehydration of apples and bananas was performed. The products were dehydrated naturally, at room temperature, and artificially in the oven, radiator and microwave. The resulting dehydrated products were analysed for the vitamin C and carbohydrates content, total acidity and dry substance (in this case sugar content). Experimental results showed that after dehydration, all products still contain small amounts of vitamin C, and the sugar values for dried apple samples are higher than for dry bananas. Furthermore, for all dehydrated products, the total acidity is low and the pH is high, making dried products, compared to fresh ones, more tolerable for consumers with digestive problems, as detailed below.

Keywords: natural dehydration; artificial dehydration; apples; bananas.

1. Introduction

According to the literature, the dehydration is the main method for product preservation for a long period of time, by reducing the water activity in

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their composition (Sobukola *et al*., 2007). In order to ensure the fruit preservation, it is sufficient to reduce the humidity to 18-24%. The reduction of moisture level has the advantage that the water contained in the fruit is not available to the microorganisms and is physico-chemically bound to sugars (Nour, 2014). Besides the transformations of structure, color, aroma and flavor, dehydration process reduces the nutritional value of the vegetal products because there are sensitive transformations in the chemical composition of the products due the thermal regime applied. Although the protein degradation and depletion of vitamins occur during dehydration, it has been found that the carbohydrate and organic acid content is preserved (Beceanu and Chira, 2002). Dehydration of plant products can take place both naturally and artificially, there being differences between the two dehydration methods in process duration and cost price.

The most well-known fruits in Romania are apples, the apple culture being constantly growing. Due to the technological features, they are a raw material with a high weight in the food industry. The chemical composition of apples vary greatly depending on the variety and environmental conditions, but generally they contain: water (83-93%), sucrose (7.4 to 16.2%), vitamin C, B1, B2, PP (5-18 mg/100g), fatty acids (0.16-1.24 mg/100g) and other minor compounds. Due to the varied composition, apples can be consumed both fresh and dehydrated or preserved (Beceanu, 2001). Instead, banana tree is the most important tree species in the tropical area, being particularly appreciated worldwide. Moreover, bananas grow rapidly and can be harvested throughout the year, constituting a real source of energy and health. The chemical composition of bananas consists of: water (72-75%); carbohydrate (11.4-27%); vitamins, organic acids, etc. Bananas can be dried and eaten as a type of chip.

Compared to an apple, banana has four times more protein, twice as many carbohydrates, three times more phosphorus, five times more vitamin A and iron and twice as many other vitamins and minerals (Drobota and Drobota, 1993).

Taking into account the above-mentioned aspects, the natural and artificial dehydration of apples and bananas was carried out in this study and some comparisons were provided based on experimental data. The products were naturally dehydrated at room temperature and artificially using three different heating sources: oven, radiator and microwave. The resulting dehydrated products were analyzed for carbohydrates, vitamin C, organic acids, and dry substances content (in this case sugar content).

2. Experimental

2.1. Preparing Fruits for Dehydration

The fruits for dehydration were collected from local producers from Iași area in the case of apples and from the supermarket in the case of bananas.

In order to perform the dehydration, the fruits were subjected to a different preliminary preparation. In the case of apples, they were washed with distilled water, dried and then sliced with a thickness of 5 and 10 mm, having an approximate weight of 2 and 35 g. In the case of bananas, they were peeled and then sliced with the same dimensions and weighed.

It should be noted that although all the slices were well-established at the beginning, their weight was not the same. Therefore, for a better understanding of the experimental data, in Table 1 the characteristics and encodings of the samples taken in the analysis are presented.

Table 1

Characteristics of the Samples and their Encoding

Product	Characteristics		Sample encodings
	thickness, [mm]	weight, [g]	
Banana	10	10	B1
	10	11	B2
	5	7	B3
	5	8	B4
Apple	10	35	M1
	10	25	M2
	5	20	M3
	5	19	M4

The natural dehydration was performed at room temperature (20-22°C) for 90 h. The artificial dehydration was performed using a heater (for 35 h, at a temperature about 25°C), on the laboratory oven (for about 5 h at 100°C) and on the microwave oven (for 5 min, at a power of 800 W). The all obtained samples were encoding and these are presented in Table 2.

Table 2

Encoding of all Obtained Samples

Sample	Encoding
Banana sample dried in the oven	BO
Banana sample dried at room temperature	BRT
Banana sample dried on the radiator	BR
Banana sample dried using microwave	BM
Apple sample dried in the oven	MO
Apple sample dried at room temperature	MRT
Apple sample dried on the radiator	MR
Apple sample dried using microwave	MM

All reagents used for analytical investigations (total acidity, vitamin C and carbohydrate contents and dry substance) were from Merck.

2.2. Preparing the Extract Samples for Analysis

In order to analyse the vitamin C and carbohydrates content, total acidity and dry substance, the dried apple and banana samples were subjected to extraction process according to literature (Cobzaru, 2017). Thus, the 15 g of grounded sample with 100 mL distilled water were placed in a glass bottle. The mixture was stirring periodical at room temperature for 60 min. Finally, the mixture was filtered. The obtained extract was transferred in a 250 mL flask and then filled with distilled water to the mark. The obtained extract was used for analysis.

2.3. Analytical Procedures

2.3.1. Analysis of Total Acidity

The procedure for determination of the total acidity was same for each dried banana and apple extract according to literature (Cobzaru, 2017). Thus, 20 mL of extract was placed in a glass bottle, then were added the distilled water (with the purpose to reducing the colour of the extract) and phenolphthalein 1% solution. The mixture was titrated with NaOH sol. 0.1 N until the colour of the solution has become persistent for a few seconds. The total acidity (TA) is calculated by relation:

$$TA, \% = \frac{a \cdot F \cdot c \cdot x \cdot 100}{m}$$

where: a – volume of the NaOH 0.1 N consumed at titration, [mL]; F – factor of the NaOH 0.1 N solution; c – dilution factor; m – amount of the sample, [g]; x = 0.0067 (corresponding to malic acid - the predominant acid in the products).

2.3.2. Analysis of Vitamin C Content

The vitamin C content of the both dried banana and apple extracts was determinate through iodometric method described in the literature (Cobzaru and Horoba, 2011). Thus, a 10 mL of extract was introduced into a 100 mL volumetric flask and then filled with starch/HCl solution to mark. From this solution was taken 50 mL and titrated with a 0.01 N iodine solution until the blue colour that had occurred persisted for a few seconds. The titration was repeated two more times and at the end of it the arithmetic mean was performed. The vitamin C content (mg) in 100 gram of product is calculated by relation:

$$C_{vit\,C} = 1.321 \cdot 10^4 \left(\frac{V_T}{M_P} \right), \text{ mg/100 g vegetal material}$$

where: V_T – volume of iodine 0.01 N used for titration of the sample, [mL]; M_P – the amount of vegetal material for extraction, [g].

2.3.3. Analysis of Carbohydrates Content

Content of the carbohydrates from dried banana and apple extracts was determined according method described in the literature (Cobzaru and Horoba, 2011). Thus, in a 300 mL conical flask were placed a 10 mL extract with 25 mL of distilled water, 50 mL of $CuSO_4$ 1% and 0.1 g of talc powder. The mixture was subjected to heating moderately for 5 min. After cooling under a stream of water, to avoid agitation of the contents, in mixture are introduced 15 mL of HCl 5% and 20 mL iodine 1%. This operation have to make very quickly because the copper oxide passing in solution can be oxidized by oxygen from the air. After, shaken and rest for 2 min, the mixture was titrated with $Na_2S_2O_3$ 0.1 N in the presence of starch as indicator. A blank sample was make in the same time. The amount of the carbohydrates expressed in grams of glucose per 100 g of extract was calculated by relation:

$$X = \frac{(n_1 - n_2) \times F \times 20}{a \times v}$$

where: n_1 – amount of the $Na_2S_2O_3$ 0.1 N consumed for blank sample titration, [mL]; n_2 – amount of the $Na_2S_2O_3$ 0.1 N consumed for titration of the extract, [mL]; F – the factor of the $Na_2S_2O_3$ 0.1 N; v – amount of the extract, [mL]; a – amount of the vegetal material used in extraction process, [g].

2.3.4. Analysis of Content of the Dry Substance (the Sugar Content)

The content of dry substance (in this case the sugar content) was determined according to the literature (Cernătescu and Cobzaru, 2014). Thus, a single drop of the extract is placed on the prism of a refractometer (ABBE, Brix range from 0-32% at 20^{o}C) that is finally pointed towards a light source and the procentage of dry substance is obtained by relation:

$$\%\text{ dry substance} = \frac{I - m_1}{m} \text{x}100$$

where: I – value of refractive index; m_1 – amount of the analysed sample, [g]; m – total amount of the sample for analysis, [g].

2.3.5. pH

The pH of the all extracts were measured using a glass electrode laboratory pH-meter (Model HI 9124, Hanna Instrument Inc.,). Readings were taken in triplicate and averaged.

3. Results and Discussions

3.1. Drying Apples and Bananas

3.1.1. Natural Drying at Room Temperature

In Fig. 1 are presented the values obtained for the apple and banana samples dried at room temperature.

From the experimental data shown in Fig. 1, it can be noticed that regardless of size, the banana samples corresponding to the lower weight are dried after 50-60 h at room temperature. Instead, for higher-weight banana samples, the water removal is more difficult (about 60-70 h). In the case of apples, it can be noticed that regardless of weight and size, all samples are drying out much more difficult, requiring 60-70 h. In the case of apples, it can be noticed that the all samples are drying much more difficult, nearly 60-70 h.

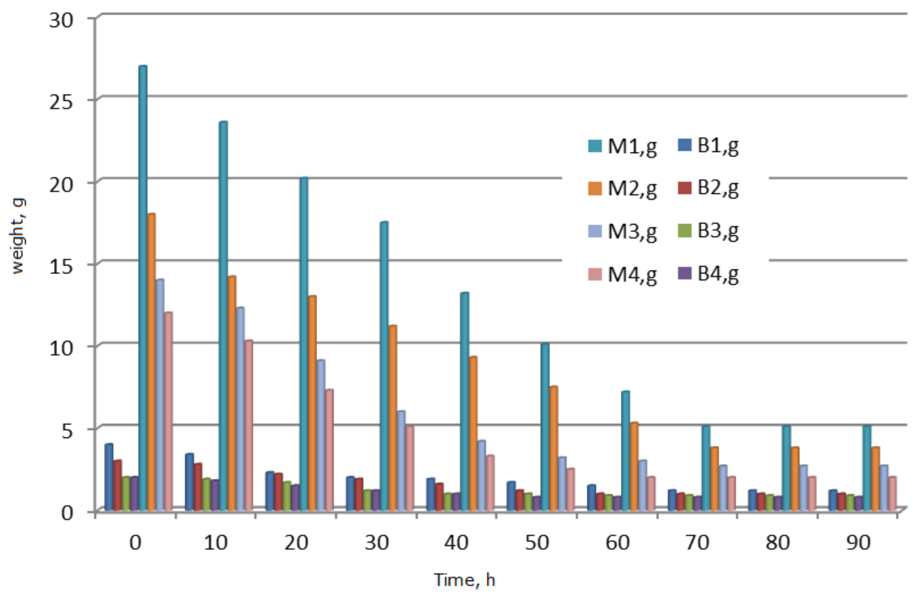

Fig. 1 – Graphical representation of the drying of apples and bananas at room temperature.

3.1.2. Artificial Drying of Apples and Bananas Using a Radiator

Fig. 2 shows the artificial drying of apples and bananas using a radiator.

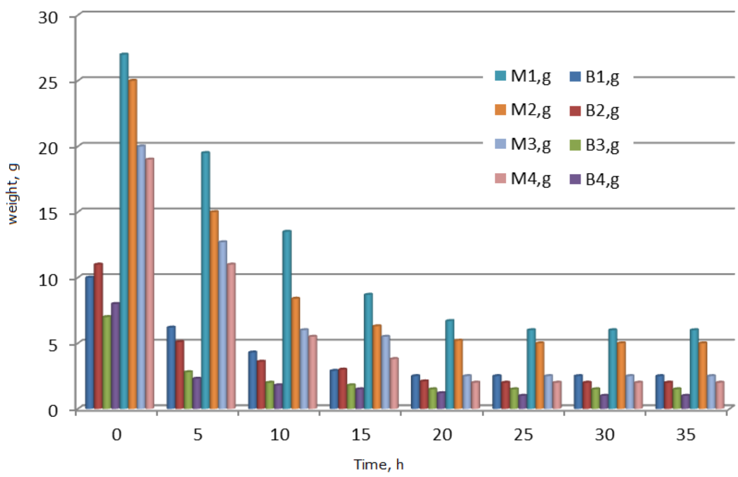

Fig. 2 – Graphical representation of the drying of apples and bananas using an radiator.

From Fig. 2 it can be seen that using the radiator (where the temperature at its level is much higher than that of the room), the time required to dry the bananas with the larger weight is approximately the same as that for drying the lower weight samples. This is also observed in the case of apple samples.

3.1.3. Artificial Drying of Apples and Bananas at the Oven

Fig. 3 shows the drying of banana and apple samples at the oven.

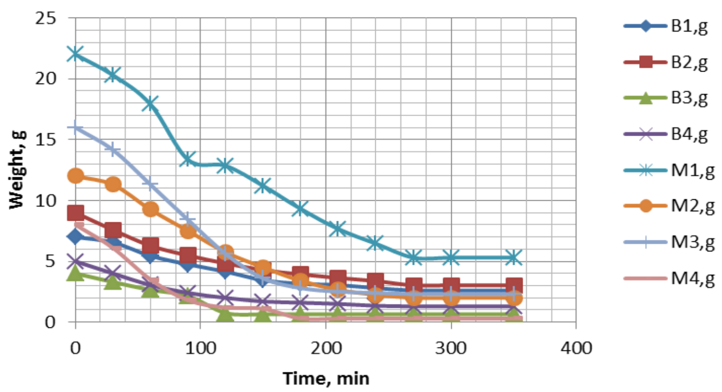

Fig. 3 – Graphical representation of the drying of bananas and apples in the oven.

It can be seen from Fig. 3 that all banana samples were dried in about 250 min. Exception makes the B3 sample dried in a shorter time (about 150 min). In the case of apples the same thing could be noticed, except for M4 sample where only 180 min were necessary.

3.1.4. Artificial Drying of Apples and Bananas in the Microwave Oven

Fig. 4 shows the values obtained for the apple and banana.

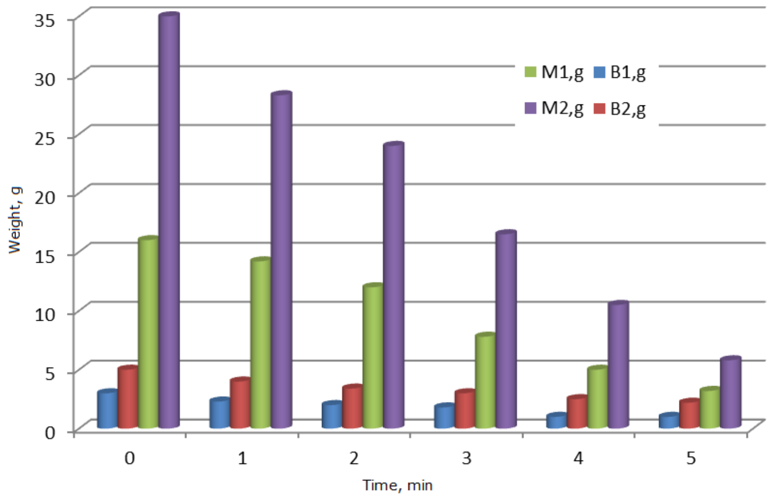

Fig. 4 – Graphical representation of the drying of apples and bananas in the microwave.

From the data presented, it can be noticed that the apple and banana samples were dried much faster (about 5 min), and after this time they got a caramel look.

3.2. Analysing Dried Samples of Apples and Bananas

3.2.1. Determination of Total Acidity

Table 3 presents the experimental data obtained for total acidity and pH.

Table 3
Experimental Data Obtained in the Determination of Total Acidity and pH

Samples	BO	BRT	BR	BM	MO	MRT	MR	MM
T_A, [%]	0.028	0.053	0.022	0.036	0.024	0.009	0.025	0.104
pH	2.97	2.33	3.21	2.71	3.12	4.10	3.08	3.96

Table 3 shows that the total acidity for all samples is small, ranging 0.009-0.104. This fact is in accordance with Kowalska and Jadczak (2007) who noticed a decrease of acidity in dehydrated apples. Also, the pH for all dried products is acidic, making them more tolerable by the consumers with digestive problems.

3.2.2. Determination of Vitamin C Content

Although it is considered to be a quantitative analysis method, it is not possible to accurately assess the amount of vitamin C in the analysed products because it can be rapidly oxidized during sample preparation (in this case, drying at high temperatures) or in samples may still exist and other oxidizable substances. Therefore, we have to mention that the experimental results presented in Table 4 are estimative.

Table 4
Estimated Values for the Amounts of Vitamin C in the Studied Samples

Sample	BO	BRT	BR	BM	MO	MRT	MR	MM
Vitamin C, mg/100 g product	2.83	12.32	5.13	12	3.44	1.84	1.23	3.9

From the data presented in Table 4, it can be seen that the products analysed still contain small amounts of vitamin C. This may be possible because, according to statistics, fresh apples have vitamin C content between 5-18 mg/100 g of product and bananas of about 8.7 mg/100 g product (Beceanu, 2001).

An interesting result was obtained with samples of bananas that have been dried at room temperature and microwaves, respectively. In this case, the amount of vitamin C is much higher than the apple samples analyzed. This fact can be attributed to other active substances present in bananas and which can be highlighted by iodine titration.

3.2.3. Determination of Carbohydrate Content

Table 5
The Carbohydrate Content of the Analysed Products

Sample	BO	BRT	BR	BM	MO	MRT	MR	MM
Total sugar, [%]	30.87	7.12	23.75	7.12	14.24	23.75	21.36	59.37
Reducing sugar, [%]	26.00	6.00	20.00	6.00	12.00	20.00	18.00	50.00
Sucrose, [%]	4.00	1.12	3.75	1.12	2.24	3.75	3.36	9.37

As can be seen from Table 5, the sucrose values for dried apple samples are higher than for dry bananas. This can be explained by the amount of sucrose present in fresh produce, which for apples is about 7.4-16.2%.

Generally, by drying, the dry matter concentration increases, however, in this case, a small value is recorded for all samples subjected to drying. This can be done on the basis of the high dehydration temperatures leading to the caramelization of existing carbohydrates in the products.

3.2.4. Determination of the Dry Substance Content (Sugar Content) by the Refractometric Method

Table 6 presents the experimental results obtained for the dry substance content (sugar content), analysed by the refractometric method.

Table 6
Experimental Results for the Dry Substance Content (Sugar Content), by the Refractometric Method

Sample	BO	BRT	BR	BM	MO	MRT	MR	MM
Dry substance, [%]	0.972	1.78	0.735	2.405	1.153	0.308	0.14	0.49

From the Table 6 it can be seen that in the case of banana samples, the concentration in the dry substance is much higher than in the case of apple samples. Even between samples of the same product, the concentration values in the dry substance are different, due to the temperatures at which the dehydration processes occurs. Compared to the results obtained in the previous analysis, it can be noticed that values of the analysed samples are very small, these can be attributed to several factors which influences the analysis namely: the temperature of the apparatus, light natural or artificial, the degree of wear of the appliance etc.

4. Conclusions

In this study the natural and artificial dehydration of apples and bananas was performed and some comparatives were provided. Experimental results showed that after dehydration, all products still contain small amounts of vitamin C, and the sugar values for dried apple samples are higher than for dry bananas. Furthermore, for all dehydrated products, the total acidity is low and the pH is high, making dried products more tolerable for consumers with digestive problems, compared to fresh ones.

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DESHIDRATAREA NATURALĂ ŞI ARTIFICIALĂ A MERELOR ŞI BANANELOR. STUDII COMPARATIVE

(Rezumat)

În acest studiu s-a realizat deshidratarea naturală și artificială a merelor şi bananelor, iar pe baza datelor experimentale s-au făcut câteva comparații. Produsele au fost deshidratate natural, la temperatura camerei, şi artificial, la etuvă, calorifer şi cuptor cu microunde. Produsele deshidratate rezultate au fost analizate din punct de vedere al glucidelor, vitaminei C, acizilor organici și a substanței uscate. Rezultatele experimentale au arătat că, după deshidratare, toate produsele încă mai conțin mici cantități de vitamina C, iar valorile zaharozei în cazul probelor de mere uscate sunt mai mari decât în cazul bananelor uscate. Mai mult, pentru toate produsele deshidratate, valoarea acidității totale este mică, iar cele de pH sunt mari, ceea ce face ca produsele uscate, comparativ cu cele proaspete, să fie tolerate mai ușor de consumatorii cu afecțiuni digestive.