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OSMOTIC DEHYDRATION OF KIWI FRUIT: DETERMINATION OF MACRO AND MICRONUTRIENTS

DESIDRATAÇÃO OSMÓTICA DE KIWI: DETERMINAÇÃO DE MACRO E MICRONUTRIENTES

DESHIDRATACIÓN OSMÓTICA DE KIWI: DETERMINACIÓN DE MACRO Y MICRONUTRIENTES

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ABSTRACT

Currently, the interest in study of drying has facilitated the entry of certain food that previously was almost impossible to be commercialized, i.e. due to advanced technologies during its storage which enable the maintenance of nutrients, vitamins and other bioactive compounds, among them, the osmotic dehydration and convective drying. This study aims to determine the macro and micronutrients of kiwi fruit var. Hayward, marketed by CEAGESP - São José do Rio Preto - SP, in natura, after osmotic pretreatment and convective drying. Analyses were performed according to AOAC and spectrophotometric technique of atomic absorption. The results demonstrated that the macro nutrients are similar to those found in the classic literature. The values for micronutrients showed an increase in the concentration of potassium, phosphorus and magnesium, and with osmotic dehydration at temperatures of 60°C and 70°C.

Keywords: Kiwi Fruit. Osmotic Dehydration. Nutrients.

RESUMO

Atualmente, o interesse pelo estudo da secagem tem facilitado a entrada de certos alimentos que anteriormente eram quase impossíveis de serem comercializados, devido às tecnologias avançadas de armazenamento que permitem a manutenção de nutrientes, vitaminas e outros compostos bioativos, entre eles a desidratação osmótica e a secagem convectiva. Este estudo tem como objetivo determinar os macro e micronutrientes do fruto do kiwi var. Hayward, comercializado pela CEAGESP – São José do Rio Preto – SP, in natura, após pré-tratamento osmótico e secagem convectiva. As análises foram realizadas de acordo com a AOAC e técnica espectrofotométrica de absorção atômica. Os resultados demonstraram que os macronutrientes são semelhantes aos encontrados na literatura clássica. Os valores de

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micronutrientes apresentaram um aumento na concentração de potássio, fósforo e magnésio, com a desidratação osmótica nas temperaturas de 60 °C e 70 °C.

Palavras-chave: Kiwi. Desidratação Osmótica. Nutrientes.

RESUMEN

Actualmente, el interés en el estudio del secado ha facilitado la incorporación de ciertos alimentos que anteriormente eran casi imposibles de comercializar, debido a las tecnologías avanzadas de almacenamiento que permiten mantener nutrientes, vitaminas y otros compuestos bioactivos, entre ellos la deshidratación osmótica y el secado convectivo. Este estudio tiene como objetivo determinar los macro y micronutrientes del kiwi var. Hayward, comercializado por CEAGESP – São José do Rio Preto – SP, en estado fresco, después del pretratamiento osmótico y del secado convectivo. Los análisis se realizaron según la AOAC y mediante técnica espectrofotométrica de absorción atómica. Los resultados demostraron que los macronutrientes son similares a los encontrados en la literatura clásica. Los valores de micronutrientes mostraron un aumento en la concentración de potasio, fósforo y magnesio, con la deshidratación osmótica a temperaturas de 60 °C y 70 °C.

Palabras clave: Kiwi. Deshidratación Osmótica. Nutrientes.

1 INTRODUCTION

The kiwi fruit has its origin at the Asian mountains, exactly in southeast, at the Chinese mountains, in altitudes that range from 400 to 800 m. The plants grow in the river border and they can get height upper to 9 m. The name was given in reference to a New Zealand bird in China which is known as Chinese gooseberry or “gooseberry”. New Zealand became the great producer in the decade of 1950 and after the fruit was imported to the USA, England and Italy, where this last country has the major world production, followed by New Zealand and Chile (PORTUGAL JOURNAL, 2007).

The kiwi fruit is newly placed in the Brazilian Market, considering that only in the decade of 1971, its seeds and rooted tents of New Zealand, came from France, arrived in our country and, from 1985 its cultivation in commercial scale. Here, it appears as an alternative of grape cultivation, where presented with good market prices, low cost of production and harvest realized in different seasons of the other fruit cultivation. The fruit comes from the kiwi tree, Actinidia gender, Actinidiaceae family, Theales order, creeper plant similar to the grapevines which grow in the shadows of other trees, about 100 g of crude weight, green-brown coloring with big content of water, acid flavor, juicy and green pulp, plant with black seeds in rays format (cause this, the origin of the name, in Greek idiom: Aktis means ray).

The varieties of the kiwi fruit cultivation more known are: Green (the sweeter and less acid), Golden King, Bruno, Monty, Elmwood and Hayword (PAZ, 2007). The last one will be approached in this study. The ideal climate for its cultivation is the temperate climate, supporting severe and constant winters. Its flowering occurs from October to November and the harvest from March to May. The irrigation must be controlled in order to avoid water excess and to impede its sprouting, beyond to avoid strong winds.

Nowadays, the Brazilian consumption of this variety is represented for about 70% of the importation arising from Chile and the United States.

The drying of fruits has becoming a globalized alternative to the actual demanding and practical market. Some of the advantages of the dehydrate food is that it can conserve its nutritional features, its food value stays concentrated, because of few loss of water, there is facility on the logistics storage, packaging and transportation, besides that, the process is economics and the manpower can be ordinary or non-specialized. Ally to the drying, the osmosis has been an economically viable alternative in order to maintain or concentrate some nutrients, among them the majority minerals as calcium, sodium, potassium and magnesium.

On the determination of the food unity, two definitions must be considered: relative humidity and absolute humidity. The first one represents the mass of water vapor presented in 1 kilo of dry air and the second one, is the quantity of water contained in the air in relation to what could be contained if it was saturated (CELESTINO, 2010). This humidity regulates the humidity of final balance reached by a biological material when submitted for a period of minimum time necessary on these conditions.

The osmotic dehydration is a kind of a simple pre-treatment and with easy manipulation, it acts on the acceleration of the drying of food, conserving and concentrating many nutrients.

The osmosis in food consists on the immersion, usually fruits and vegetables, in solution below the point of saturation of the solute. The solute remove water of the food, making it dehydrated. This procedure can ensure the preservation of nutrients, favoring its shelf life and palatability. On the osmotic dehydration occurs the removal of water of the food by the effect of the osmotic pressure.

The osmotic dehydration can be used as pre-treatment in process which involve the drying both natural and artificial, ensuring a reducing of water content in the food, resulting on the decrease of time and energy waste, occurring water loss and solid gain (AZEREDO, 2004). Some osmotic solutions are saline and others sugared (glucose, saccharose, etc.) used to increase the solid concentrations.

The osmosis followed by the drying on temperatures of 40°C, 50°C, 60°C and 70°C was used as basis to verify the behavior of the physics-chemistry features in the kiwi fruit before and after the treatment.

The analysis of macro nutrients in fruits matches to the determination of proteins, carbohydrate, fixed mineral residue (ash), humidity, lipids, besides the energetic value.

The micronutrients have great importance to prevent and combat diseases, among them are the calcium (fortify bones), iron (avoid and combat many anemia mode), sodium and potassium (help to balance the organisms ions and on the blood pump to the heart), magnesium (after potassium, the magnesium is the intracellular mineral more abundant in human organism).

Recent studies indicate the potassium with action anticancerigenous. Its recommended daily ingestion is for adults (16 years old or more) < 2g/day (<5g/day of salt) and increase of potassium consumption for, at least, 3,51g/day. For children (2 to 15 years old, including), the maximum level of ingestion of 2g/day of sodium and the minimum ingestion of 3,51g/day of potassium must be adjusted based on the needs of energy in relation to the adults, according to World Health Organization - WHO (GIRASSOLINSTITUTO, 2015)

The objective of this study was determine the concentrations of minerals (micronutrients) and macronutrients (humidity, carbohydrate, ashes, fats, proteins and caloric value) of kiwi fruit commercialized at CEAGESP, in São José do Rio Preto City - SP before and after the osmotic dehydration with solution of 10% of commercial saccharose and drying in fixed bed dryer in the laboratory of the drying plant at Department of Food Engineering and Technology of UNESP-São José do Rio Preto Field-SP.

2 MATERIALS AND METHODS

The kiwi fruits of species Hayward, acquired from CEAGESP-São José do Rio Preto-SP, were exported by FRUSAN, FRUTERA FERNANDO S.A, from Las Condes City-Chile and imported by GUEPARDO IMPORTATION AND EXPORTATION LTDA, from Pato Branco City-PR/Brazil, harvest 2015, the fruits were manually peeled and sliced with the support of a stainless steel slicer. The dimensions, thickness and diameter, were measured using a caliper ruler (STARRETT mod. 125MEA). On the analysis of drying, the fruits were selected, washed and packed for the experiment, in cold chamber at 4ºC and after vacuum packed for posterior analysis. The fruits presented average height of 65,11mm and middle diameter of 54,89 mm (Figure 1).

Figure 1

Dimension of the kiwi fruit in nature

The fruits arising from CEAGESP-São José do Rio Preto-SP, were selected, washed and cut in slices around 7mm, immersed in solution of commercial saccharose at 10% per 1h and after this period, taken to trays which were weighted and put in the fixed bed dryer. The weighing of trays with slices of the fruits were weight in breaks of 5 minutes at the first half hour of drying, in breaks of 10 minutes during the next one hour and a half, in breaks of

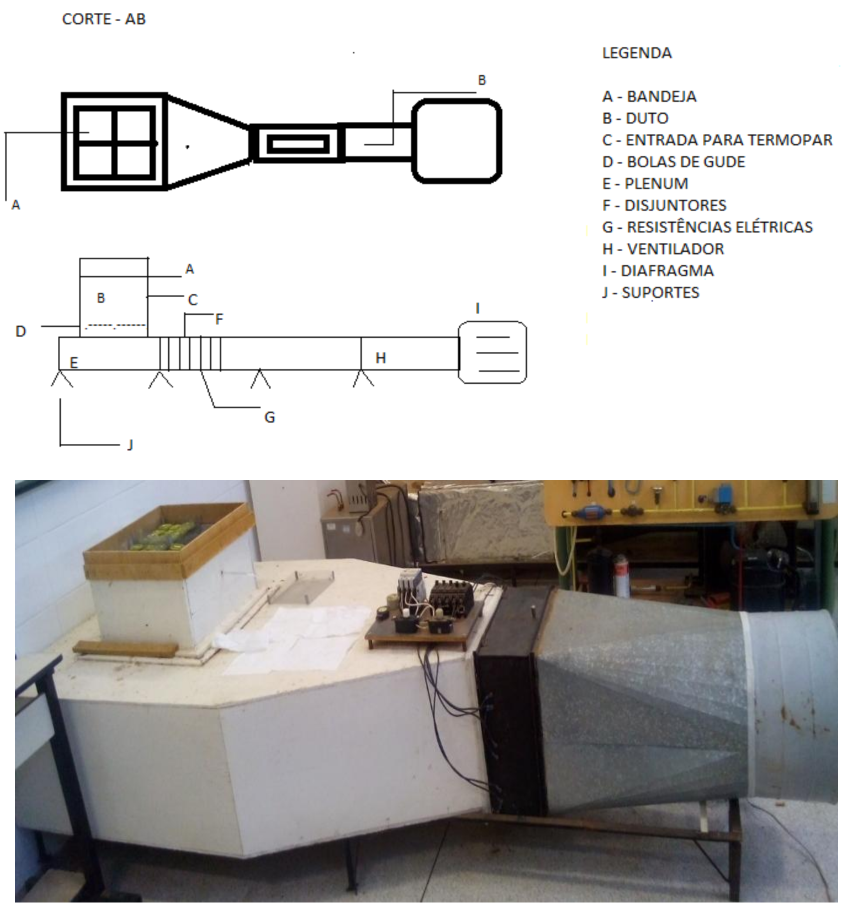
30 minutes in the next three hours and a half and from one and one hour until the weight of each tray was constant.

The kinetics of drying was realized in hot air forced convection dryer, drawn and produced by student, teachers and technician on the area of Food Engineering at (Figure 2). The equipment is situated in the drying plant of the Department of Food Engineering and Technology, UNESP/São José do Rio Preto Field.

The fixed bed dryer is compound by a diaphragm which regulates the air speed, put at the entrance of the ventilator, measured by a portable anemometer in different times of drying. The heating of the air was realized by six electric resistances linked in parallel with individual actuation and an additional resistance linked to a variation of voltage for the manual regulation of temperature. A portable thermocouple, for the reading of temperature, was put in an entrance in the duct, above glass sphere, for the homogenization of the air flow. The figure 1 represents the scheme of the bed dryer.

Figure 2

Fixed Bed Dryer– Scheme



Source: the author, 2015.

The used temperatures of drying were: 40°C, 50°C, 60°C and 70ºC with variation of ±3°C with air flow at 2,1 ± 0,3 $m.s^{-1}$. Three trays were used in the dryer (triplicates), measuring 19 cm x 19 cm each one.

With the periodic weighing of the trays containing the product, humidity curves versus time were determined.

The analysis of the macronutrients were made according to the AOAC (2000) and with the micronutrients, it was used the spectrometry technique of atomic absorption, solubilizing the fruit ashes with HCl and HNO_3 concentrated and distilled water, and after with HCl and HNO_3 diluted (10%). After this stage, melting pots and flasks of Erlenmeyer were put in electric plates for evaporation of the material until the half. The solutions of the melting pots were transferred to flasks of Erlenmeyer and stayed in the plate until the volume decrease in 2 or 3 mL and after, removed from the plate and refrigerated, were added in each melting pot 20 mL of distilled water, filtrating in volumetric balloons of 100 mL and the volume completed. These solutions were taken to analysis of mineral micronutrients.

3 RESULTS AND DISCUSSIONS

In Table 1 below, it was observed the values of the nutritional composition (macronutrients) in relation to those found in literature where it is confirmed that they are really close to those found in this study.

For a better visualization of the behavior of dehydration, the rates of drying of the kiwi fruit pre-treated with solution of saccharose at 10% were calculated due to the content of humidity (Figure 3), of the kiwi fruit pre-treated with solution of saccharose at 10%, observing a decreasing rate as the humidity decreases. The kinetics of the drying demonstrated that it occurs in decreasing rate. The behavior of drying can present constant and/or decreasing rates of drying. For biological products, the behavior of drying is, usually, decreasing. This behavior is determined by internal migration of humidity (PARK; BIN; BROD, 2002; BENDLIN, 2003). This demonstrates that the diffusion is probably the physical mechanism that rules the movement of water in the fruit. The water evaporation inside the food is influenced by many phenomena, as: capillarity, physics-chemistry link of water to solid substances inside food, migration of solutes, deformation of the product, and others; these phenomena offer great resistance (BENDLIN, 2003). Pena et al (2008), on the drying of residual fiber of passion fruit, and Azoubel et al (2009), on the drying of cashew with and without osmotic pre-treatment, also observed decreasing rates of drying.

On Table 1, it was observed the values of nutritional composition (macronutrients) in relation to those found in literature where confirms that they are really close to those found in this study (BEEVER & HOPKIRK, 1990; UNIFESP, 2015).

Table 1

Values of macro and micronutrients of kiwi fruit in comparison with data of literature

PARAMETERS	RESULTS					
	Kiwi in nature	Kiwi with osmosis	Kiwi dried to 40°C	Kiwi dried to 50°C	Kiwi dried to 60°C	Kiwi dried to 70°C
HUMIDITY (d.b %)	5,02	5,4	6,4	5,7	6,04	5,4
LIPIDS (%)	0,2	0,0	0,4	3,2	2,9	3,5
PROTEINS (%)	0,2	0,0	4,02	6,3	6,6	6,67
ASH (%)	0,8	0,6	0,6	3,2	2,7	3,2
CARBOHYDRATES (%)*	93,8	94	88,6	81,6	81,8	81,2
ENERGETIC VALUE (Kcal/100g)**	377,8	376,0	374,1	380,4	379,7	382,9

*obtained by difference
** obtained by addition
Source: the author, 2015

Every fruit has significant content of all majority minerals (Na, K, Ca, Mg and P) in mg/100g (MENDES-FILHO et al, 2014).

The results of analysis of micronutrients (minerals) are in table 2, where it was observed that the contents of calcium, potassium and magnesium present increasing content after the pre-treatment with osmosis and the drying in temperatures of 40°C, 50°C, 60°C and 70°C.

Figure 3

Rate of drying of the kiwi fruit pre-treated with solution of commercial saccharose at 10%

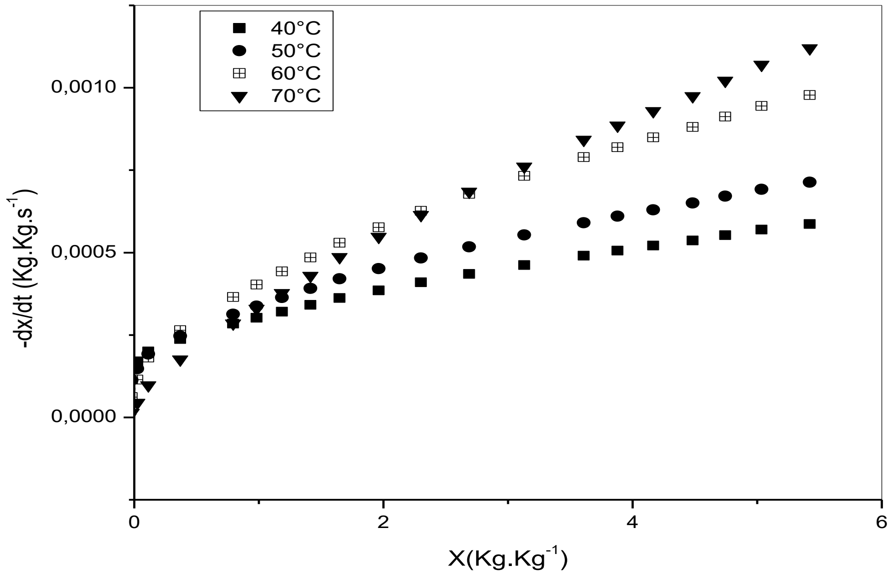


Table 2

Results of the analysis of minerals (micronutrients) by spectrophotometry of atomic absorption

Concentrations of metals (mg.100g^{-1})	Sample results (mean and standard deviation)					
	Kiwi in nature	Kiwi with osmosis	Kiwi 40°C	Kiwi 50°C	Kiwi 60°C	Kiwi 70°C
Ca	3,49±0,03^{d}	3,43±0,01^{d}	0,38±0,03^{c}	4,11±0,013^{b}	4,04±0,01^{b}	3,56±0,02^{a}
K	6,46±16,9^{e}	4,93±1,41^{f}	11,61±1,41^{d}	15,50±2,12^{b}	14,28±21,21^{c}	16,12±2,82^{a}
Mg	0,67±0,01^{e}	0,62±0,01^{e}	0,95±0,00^{d}	1,44±0,02^{b}	1,24±0,02^{c}	1,62±0,03^{a}
Na	2,07±2,82^{c}	1,8±1,41^{d}	1,44±3,53^{e}	2,34±1,41^{f}	1,21±2,12^{d}	3,98±2,12^{a}
P	0,90±0,00^{f}	1,21±0,00^{e}	4,27±0,00^{d}	5,71±6,36^{c}	6,39±1,41^{b}	7,80±1,41^{a}

*Averages followed by the same line do not differ significantly among them at the level of 5% of probability by Tukey test.

The calcium had discreet variation before and after the osmotic dehydration, meaning that this procedure can decrease its concentration. The daily ingestion of this mineral is of 0,8 g/100g and must always come accompanied by the vitamins C and D and by the Magnesium; the phosphorus also helps its absorption, but in limited quantity; excess of proteins, soft drinks, coffee and alcohol can block this absorption (BRAZIL, 1998). The table of composition of food indicates a content of 0,024 g/100g of comestible part of this mineral in the raw kiwi fruit (TACO, 2011).

The expressive concentration of potassium in relation to other mineral nutrients in the kiwi fruit pre-treated osmotically and dry at temperature of 70°C, can characterize a benefit for the manufacture of food products as that found in current market, for example, the dehydrate apples, besides this, the nutrient is much useful to the balance of the liquids in human organism. According to the table of composition of food, the content of potassium in raw kiwi fruit is of 0,269 g/100g of comestible part (TACO, 2011).

The daily ingestion recommended (DIR) of magnesium is of 0,28 g/day for women and of 0,35 g/day for men (MAFRA & COZZOLINO, 2007). The content of this mineral in the samples before and after the osmotic dehydration demonstrated itself increasing what indicates that the treatment benefits its concentration. According to the table of composition of food, in raw kiwi fruit, the content of magnesium is of 0,011g/100g of comestible part (TACO, 2011).

The sodium presented accentuated concentration, also at 70°C, and the element favors nervous stimuli to neurons (CORSINO, 2009). The daily ingestion recommended by the National Agency of Health Vigilance (1998) is of 2,4 g. According to the table of composition of food, in raw kiwi fruit, the content of sodium is of traces by 100g of comestible part (TACO, 2011). This result denotes that the osmotic dehydration concentrates the mineral in the kiwi fruit according to the increase of the temperature of drying, with some peaks of decline in intermediate temperatures on the zone stablished by this study.

The phosphorus with accented values in this same temperature gets in the composition of the muscles, blood, bones, teeth and hormones. According to the National Agency of Health Vigilance (BRAZIL, 1998), the content of phosphorus, for adult individual is of 0,7 g/day (MILLER-IHLI, 1996) or of 0,8 g/day. Even if the contents found of this mineral in the samples are below to the Indicated, the results indicates that the osmotic dehydration does not influence in its decline, unlike, the same can be even more concentrated with this kind of treatment.

4 CONCLUSIONS

In the drying process of kiwi fruit pre-treated with solution of saccharose at 10%, it was verified that in the temperature of 70°C with speed of 2,1 $m.s^{-1}$, the humidity of balance was achieved quickly, around 4h, comparing with other temperatures at the same speed.

In the analysis of the macronutrients, the values found were on the zone found in literature.

The analysis of micronutrients demonstrated that the osmotic pre-treatment provided larger concentration of some minerals, as the potassium, the phosphorus and magnesium.

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