# STUDY ON THE PARAMETERS' VARIATION IN FRUITS DRYING PROCESS

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**Abstract.** *The aim of the study was the pursuing of the parameters' variation of fruits drying process.As materials we use fruits with hard texture (apple, pear, quince) and as methods we used the conventional drying (with air convection) and unconventional drying (with microwave and infrared radiation).*
*We determined the variation of the following parameters : mass, product's core temperature, humidity, drying time. We used hydration as an estimation method of the drying products' texture modification.*
*The conventional drying one was done at 100°C for 120 minute. The microwave treatment was performed at 30% from oven maximum power – 900 W, in this case the drying period depending on each kind of fruit, so the thermic treatment lasted different intervals (30 minutes - apple, 36 minutes - pear and 20 minutes - quince). The IR drying depends also on fruit type, as at 70°C the drying time for fruits was variable (apple - 49 minutes, quince - 25 minutes and 73 minutes for pear).*
*The experimental determinations pointed out that the drying duration is sensitivly decreasing as compared to the conventional drying process (~1/3) for the same content of moisture.*
*Also, we found out that the quince texture is the hardest one leading to an easier drying and hydration process. The pear had very high water content and is a very rich source of carbohydrates, which are the principal responsible for the changes happened during the drying treatment, resulting in some colour transformation.*

**Keywords**: *air convection, microwave, infrared radiations, fruit drying, texture.*

## 1.Introduction

Drying is one of the oldest and most cost-effective means of preservation of grains, crops and foods in all varieties. From both the energy and environmental point of view and in order to feed the growing population, it is important that drying technology is improved to reduce spoilage and enhance quality of the products. Much has been accomplished over the past decades as far as understanding and development of drying technologies are concerned for food and agro-products (Mujumdar, 2000; Askari *et. al.*, 2004).

Dried vegetables and fruits are an important sector in the ingredient market. Most vegetables and fruits are generally dried convectively with heated air. Hot-air dried vegetables are often difficult to rehydrate because of case-hardening and shrinkage occurring during the drying process. The consumer demand has increased for processed products that keep more of their original characteristics.

Major disadvantage of hot air drying of food is low energy efficiency and lengthy drying time during the falling rate period. Prolonged exposure to elevated drying temperature may result in substantial degradation in quality attributes, such as colour, nutrients and flavour, severe shrinkage also reduces bulk density and rehydration capacity (Feng *et al.,* 1998; Askari *et. al*., 2004).

The fact that fruits and vegetables collapse during dehydration has been established before (Lozano *et al.,* 1980; Askari *et. al*., 2004). These researchers concluded that the slow and difficult rehydration of dehydrated apples is explained by the development of locked–in pores caused by cellular collapse during dehydration.

Cellular shrinkage during air drying was faster than the bulk shrinkage from full moisture to a moisture content of 1.5% (w/w). After this point, the shrinkage coefficient was converged. The result of the uneven shrinkage was an increased cellular porosity.

This can be explained by a three–dimensional rearrangement of tissue due to the cellular collapse (Askari *et. al*., 2004). The use of microwave energy and infrared radiation has been of growing interest over the years (Askari *et. al*., 2004; Swasdisevi *et al.,* 2007).

Microwave heating is an important technique in industrial drying and food processing because it has several advantages over convective heating, for example, fast heating, high energy efficiency, and uniform moisture distribution in products.

Microwaves are electromagnetic waves in the frequency range 300 MHz to 300 GHz (equivalent to a wavelength of 1-0.01 m) generated by a magnetron type vacuum tube. Electromagnetic energy at 915 and 2450 MHz can be absorbed by water containing materials or other substances, such as carbon and some organics, and converted to heat.

Because waves can penetrate directly into the material, heating is volumetric (from inside out) and provides fast and uniform heating throughout the entire product. The quick energy absorption by water molecules causes rapid water evaporation (resulting in higher drying rates of food), creating an outward flux of rapidly escaping vapour.

In addition to improving the drying rate, this outward flux can help to prevent the shrinkage of tissue structure, which prevails in most conventional air drying techniques. Hence better rehydration characteristics may be expected in microwave dried products (Khraisheh *et al*., 1997; Prabhanjan, 1995; Quezada & Bórquez, 2005).

Some researchers reported that using microwave reduces drying time (25-90%) and applying energy at lower level improves quality of final products, such as color, rehydration capacity, density and porosity (Prabhanjan *et al.*, 1994; Funebo *et al*., 2000; Askari *et. al*., 2004).

The use of infrared radiation technology in dehydrating foods has several advantages as follows: decreased drying time, high energy efficiency, high quality product, uniform temperature in the product and reduced necessity for air flow across the product (Swasdisevi *et al.,* 2007). Infrared (IR) radiation is the part of the electromagnetic spectrum that is predominantly responsible for the heating effect of the sun. Infrared radiation is found between the visible light and radio waves (figure 1), and can be divided into three different categories, namely, near-infrared radiation (NIR), mid-infrared radiation (MIR), and far-infrared radiation (FIR) (Ranjan *et al.,* 2002; Seyhun *et al.,* 2009) .Several researchers have applied far infrared radiation (FIR) drying technique successfully to many food products, e.g., potato (Afzal & Abe, 1998), barley (Afzal & Abe, 2000), and rice (Abe & Afzal, 1997). Mongpraneet *et al.* (2002) examined the drying behavior of the leaf parts of welsh onion undergoing combined far infrared and vacuum drying. The results showed that the radiation intensity levels dramatically influenced the drying rate and the dried product qualities.

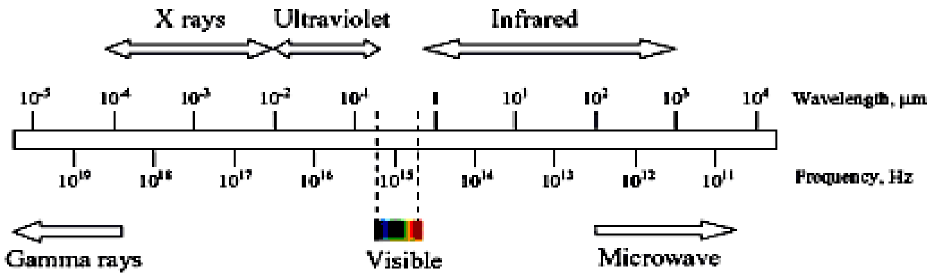


**Figure 1. Electromagnetic wave spectrum (**Krishnamurthy *et al.,* 2008**)**

Mongpraneet *at al.* (2004) later determined the energy consumption in far infrared drying of onion. From their experiments, less than half of the energy input was utilized for evaporating water from the onion. Approximately 73-99% of the energy input, depending on the dryer configulation, was converted into radiant energy. The efficiency decreased with increasing distance between the heater source and drying materials (Swasdisevi *et al.,* 2007).

The objective of this investigation was to observe the effect of drying method on the structural changes of some fruits (pears, apples and quinces).

## 2. Materials and methods

### 2.1 Materials

Pears, apples and quinces purchased from a supermarket were washed under running cold water, and then the excess was removed from pears surface using paper towels. Fruits were then peeled, portioned and sized in the cube-shaped samples of 10 mm side.

### 2.2. Methods

The following parameters were analyzed:

- internal temperature of product with an AMPROBE TPP1-C1 Pocket Thermometer Immersion Probe;
- product mass using a digital balance PARTNER AS110/C/2, with an accuracy of ± 0.001 g;
- heat treatment using warm air convection in a MEMMERT UNB 400 oven;
- heat treatment using a SAMSUNG microwave, 900 W power;
- heat treatment using infrared radiations in a AND 4714 balance.

The hydration method was used in order to determine the modification of the dried fruits texture. Hydration of dried fruits is used to bring back the initial state of the fruits. Hydration of fruits strictly depends on water content, air humidity and storage duration.

## 3. Results and Discussion

### *3.1. Heat treatment using warm air convection*

The internal temperature of fruits (figure 2) increases rapidly in the first 30 minutes (the highest values for this parameter were registered in pears at 50.5 ºC and in apples at 48.1 ºC), followed by a stabilisation of internal temperature and, in the end of the process, by a decrease of internal temperature, probably due to the accelerated rate of water evaporation at the fruits surface. At the end of the heat treatment with warm air convection the maximum internal temperature was reached by pears at (38 ºC) as against quinces at (37.2 ºC).

In figure 3 one can observe that the weight of the fruits treated by warm air convection decreases. After 30 minutes of heat treatment the weight of pears was 5.8 g and the weight of quinces was 5.3 g.

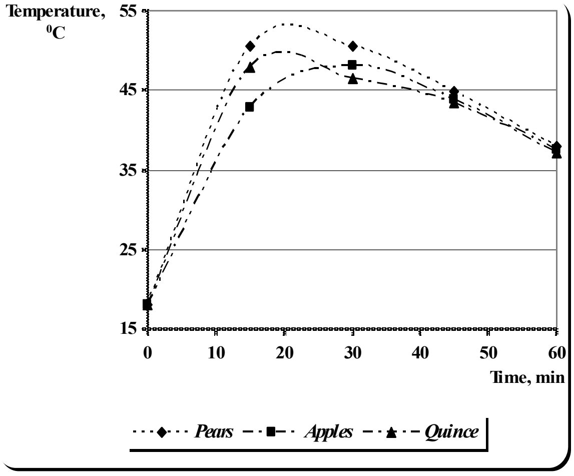


**Figure 2. Variation of internal temperature function of time during heat treatment using warm air convection**

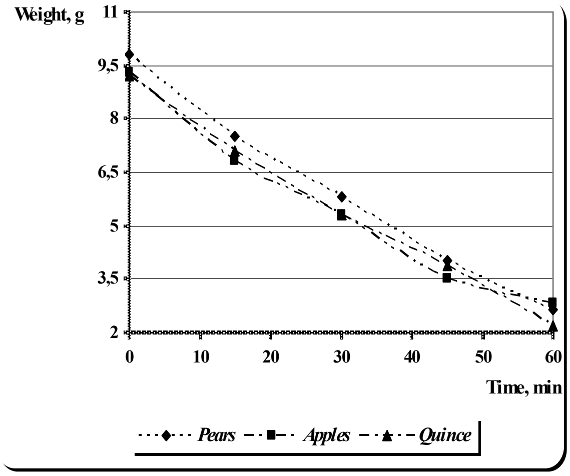


**Figure 3. The evolution of fruits weight during heat treatment with warm air convection**

After 60 minutes of heat treatment with warm air convection the lower value of weight was registrated for quince (2.17g), and the highest for apples (2.81g).
This means that thermic treatmentby warm air convection leads to the elimination of a high quantity of water from the product.
At hydratation of fruits dried by warm air convection (figure 4) one can observe that pears and apples require the longest hydratation time and this means that this type of treatment affected the cappilary structure of these fruits. This fenomenon was not observed in quinces.

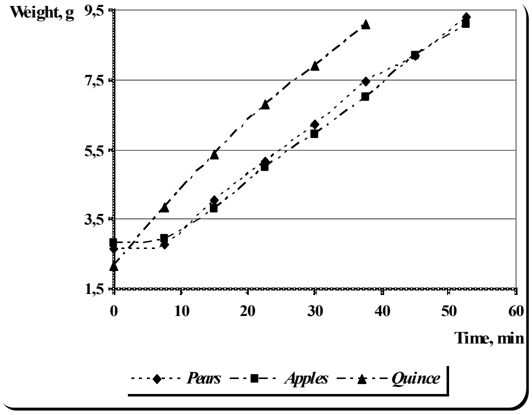


**Figure 4. Evolution of warm air convectin dried fruits weight during hydratation**

### *3.2. Heat treatment using microwaves*

In the case of microwaves drying process (figure 5), using 30% of power, one can observe that the internal temperature increases in 2-10 minutes for all the fruits. After 10 minutes treatment the highest value of internal temperature was registred in pears (76.2 ºC) and the lowest one was registred in quinces (60.8ºC). These values for internal temperature are not desirable because they produce the degradation of vitamins.
In the first part of microwave heat treatment an increase of water evaporation rate is noticed and may be explained by the temperature increase.

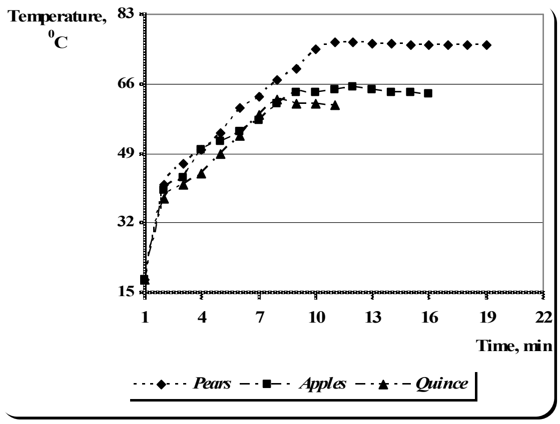


**Figure 5. Variation of internal temperature function of time during heat treatment using microwaves**

After 15 minutes of microwaves treatment the internal temperature begings to stabilize, the highest value of this parameter being registered in pears (75.4 ºC).

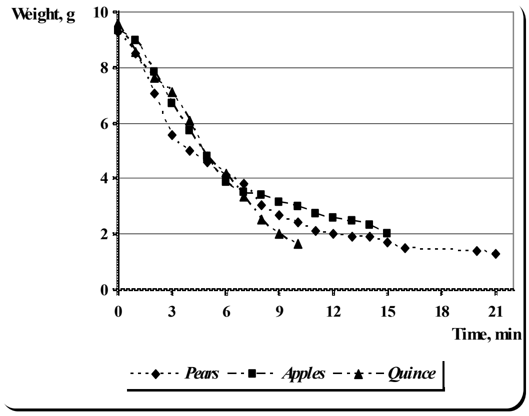


**Figure 6. Evolution of fruits weight during heat treatment using microwaves**

In figure 6 one can observe that the weight of microwaves dried fruits decreases. After 10 minutes of treatment the following values were registered: 2.41g for pears, 3g for apples and 1,63 grams for quince.

In the case of microwaves heat treatment, fruits hydratation (figure 7) requires a shorter time, as compared to the warm air convection treatment.

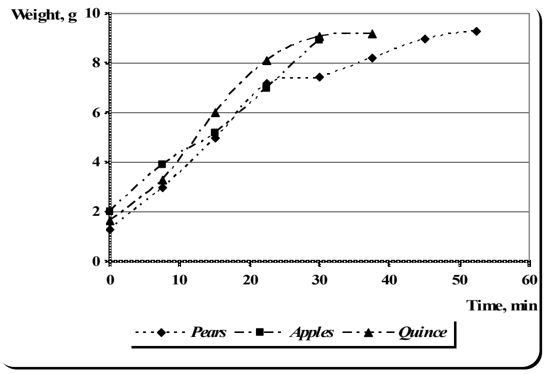


**Figure 7. Evolution of microwaves dried fruits weight during hydratation**

Of the three analysed ranges of fruits, apples required a shorter hydratation time (30 minutes) as compared to pears (52.5 minutes). This can be explained by a negatttive influence of microwaves on fruits texture.

### 3.3. *Heat treatment with infrared radiations*

The highest content of evaporated water was registered in apples (after 9.5 minutes humidity was 27.9%). For pears and quince the loss humidity was 19% and 18.6% respectively.

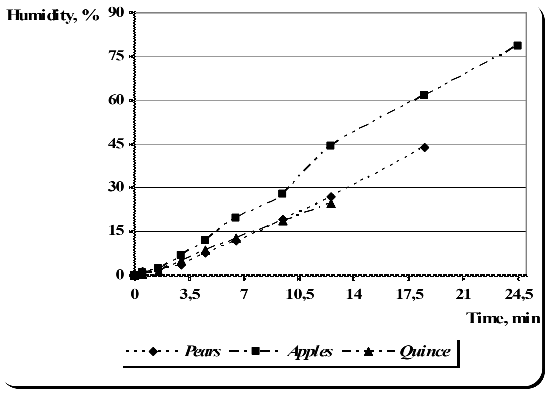


**Figure 8. Variation of humidity loss function of time during infrared radiations heat treatment**

Variation of evaporated water quantity function of time is liniar for all the fruits ($R^2$ values varying between 0.9866 for pears and 0.997 for quinces).

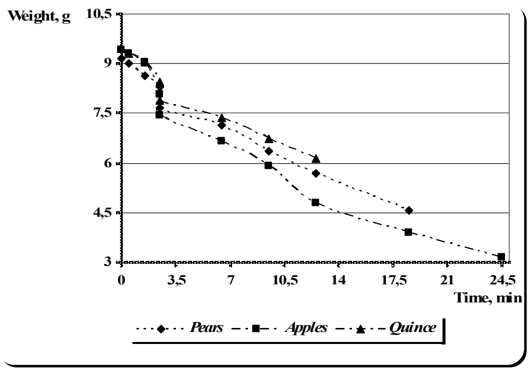


**Figure 9. Evolution of fruits weight during heat treatment using infrared radiations**

Evolution of fruits weight during infrared radiation treatment is the same as during warm air convection treatment and microwaves treatment. After 9.5 minutes of treatment the weight of pears was 6.37g, the weight of apples was 5.92g and the weight of quince was 6.72g.

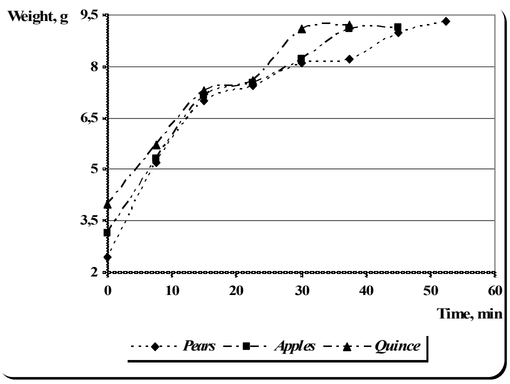


**Figure 10. Evolution of infrared radiation dried fruits weight during hydratation**

In the case of infrared radiations treated fruits (figure 10) one can observe that the shortest hydratation time was required by quinces (37.5 min) while pears required 52.5 min for hydratation.

## 4. Conclusions

We appreciated that unconventional heat treatment (microwaves and infrared radiations) assures constant water elimination as compared to warm air convection treatment, fact that does not determine major textural modifications in the analyzed fruits.

Accelerated drying interval of the first period in conventional drying, which affects the quality of dried product is replaced in unconventional drying by gentle moisture elimination. Fruits that are most suitable for drying using both conventional and unconventional heat treatment are quinces, while pears were the most difficult ones to get dried.

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