# INFLUENCE OF ULTRASOUND PRETREATMENT ON CONVECTIVE DRYING OF PINEAPPLE

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ABSTRACT – The convective drying is a slow operation. Several techniques has been studied to increase the kinetics of process such as the pretreatments in liquids or the application of high intensity ultrasound during both, pretreatment or convective drying. In this work, the influence of the pretreatment (with distilled water (20 and 40 min at 25 °C) on convective drying (40 °C, 1 m s$^{-1}$) of pineapple slices (2.0 cm diameter, 0.5 cm thickness) was studied. The application of ultrasound during pretreatment (55.5 W/L, 40 kHz) or during convective drying (31 kW m$^{-3}$; 21.8 kHz) was also addressed. The results showed that the application of ultrasound during the pretreatment and during drying increased water transport and reduced the drying time. The use of ultrasound in the pretreatment or in the convective drying could improve drying processes.

## 1. INTRODUCTION

Drying is one of the oldest ways for food preservation being the convective drying one of the most extended techniques (MUJUMDAR, 2006). It is based on the moisture removal by the contact of the wet food with a heated air current. It is widely used for drying fruits like pineapple (SANTOS & SILVA, 2009; CORRÊA et al., 2011, 2012; RAMALHO & MASCHERONI, 2012). However, convective drying involves the exposure of the food to high temperature for a long time with consequent degradation of quality characteristics as nutrient contents, color and mechanical properties (CORRÊA et al., 2012; KUROZAWA et al., 2014).

In order to minimize these undesirable effects, some alternatives have been explored. Among them, it can be highlighted the use of pretreatments in liquids as distilled water, assisted or not by high intensity ultrasound (AZOUBEL et al., 2010; FERNANDES et al., 2008; FERNANDES and RODRIGUES, 2007) or the use of convective drying assisted by power ultrasound (OZUNA et al., 2011; CÁRCEL et al., 2012; GAMBOA-SANTOS et al., 2014).

The goal of this work was the study of the influence of the ultrasonically pretreatment with distilled water of pineapple in the later convective drying kinetics, carried out also with and without the ultrasound application.

# 2 MATERIAL AND METHODS

## 2.1 Sample preparation

The pineapple (Ananas comosus) used in this work was the new hybrid 73-114, known as Golden Pineapple or MD2, produced in Costa Rica and bought in Valencia, Spain. To minimize the influence of natural variability of the raw material, the fruits were selected with a similar ripening grade (12 -14 ºBrix), moisture content (5.49±0.59 d.b.) and color.

The fruits were cut in three parts in the transversal way and only the central part was considered neglecting the upper and the bottom parts. This is due to the different sugar content from one extreme to another (RAMALLO & MASCHERONI, 2012). Disks shaped samples of 2.0 cm diameter and 0.5 cm thickness were obtained from the pulp, with the aid of a cork-borer and wrapped until drying experiments.

## 2.2 Pretreatments

After the preparation, a set of samples was immersed in a bath of distilled water at 25 ºC assisted by ultrasound (55.5 W/L, 40kHz) for 20 (PUS-20) and 40(PUS-40) min. The relation fruit/solution was about 1/300 (w/w). The temperature was maintained by recirculation of a cooling fluid in the jacket of the bath. Another set of samples was not pretreated (PUS-0).

## 2.4 Drying experiments

The experiments were carried out in the drying system presented in Figure 1, previously described (CÁRCEL et al., 2007, 2011; GARCÍA-PÉREZ et al., 2011; OZUNA et al., 2011).

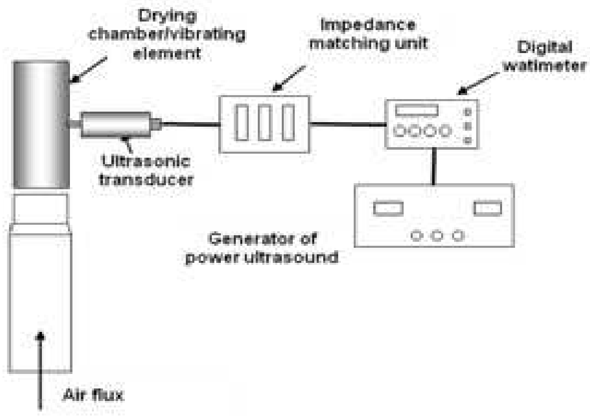


Figure 1 - Scheme of the ultrasonically assisted drier

For each run, forty samples were put in fixed positions in a sample holder allowing the free flow of air around them. This support was then introduced in the system. The drying chamber was an aluminum cylindrical vibrating element (internal diameter 100 mm, height 310 mm and thickness 10 mm) that works as an air-borne ultrasonically activated drying chamber. The cylinder is driven by a piezoelectric composite transducer (21.8 kHz); thus, the ultrasonic system was able to generate a high-intensity ultrasonic field with an average sound pressure of 154.3 dB (measured using an ultrasonic power of 31 $kWm^{-3}$ and air stagnant conditions) The drier operates automatically and a PC supervises the whole process; the air velocity and temperature were controlled using a PID algorithm. A scale allowed the samples to be weighed at preset times by using two pneumatic moving arms and obtaining the drying kinetics for each case.

Drying experiments were carried out using an air velocity of 1.0 m $s^{-1}$ and a temperature of 40 ºC, with (PUS-0-DUS; PUS-20-DUS and PUS-40-DUS) and without (PUS-0-D; PUS-20-D and PUS-40-D) application. In the case of ultrasonic assisted (21.8 kHz) drying experiments, an ultrasonic power density of 31 kW $m^{-3}$ (electrical power applied to transducer divided by the drying chamber volume) was used. The drying was stopped when samples lost the 80 % of the initial weight. Each drying condition tested was carried out by triplicate.

## 3. RESULTS AND DISCUSSION

The immersion in distilled water assisted by ultrasound increased the moisture content of the samples from 5.26 to 9.00 (d.b.) due to the fact that the fruit present higher osmotic pressure. On the other hand, it improved the further drying process with and without ultrasound assistance (**Figures 2 and 3**). Regarding the convective drying without ultrasound assistance (PUS-0-D, PUS-20-D and PUS-40-D), it could be observed (**Figure 2**) that the pretreatment increased the dehydration with consequent shorter drying time. Similar results were observed in previous works. (AZOUBEL et al., 2010; FERNANDES et al, 2008; FERNANDES and RODRIGUES, 2007). Among the periods of treatment, that performed at 20 min presented shorter drying time. As a result, it is considered the best condition. It can be assumed that the ultrasound pretreatment causes structural changes in the food (LEE; FENG, 2011) like the micro channels formation (CÁRCEL et al. 2012). The changes within 20 min of treatment aids the further drying. However, a longer time treatment could have therefore greater structure damage that does not favor the drying process.

The experiments performed with ultrasound assistance, with or without pretreatment (PUS-0-DUS, PUS-20-DUS and PUS-40-DUS), presented shorter drying time with respect to the drying without assistance. Drying time for a conventional convective drying at 40 ºC was about 8 to 12 hours and the convective drying assisted by ultrasound was about 5.8 to 6.3 hours, i.e, the use of ultrasound in drying reduced until 50% of the drying time. The cavitation and the sponge effect, characteristics of drying assisted by ultrasound (CÁRCEL et al., 2007, 2011; GARCÍA-PÉREZ et al., 2011; OZUNA et al., 2011) reduces the external and the internal resistance to drying. The use of the pretreatment shows a trend to decrease drying time.

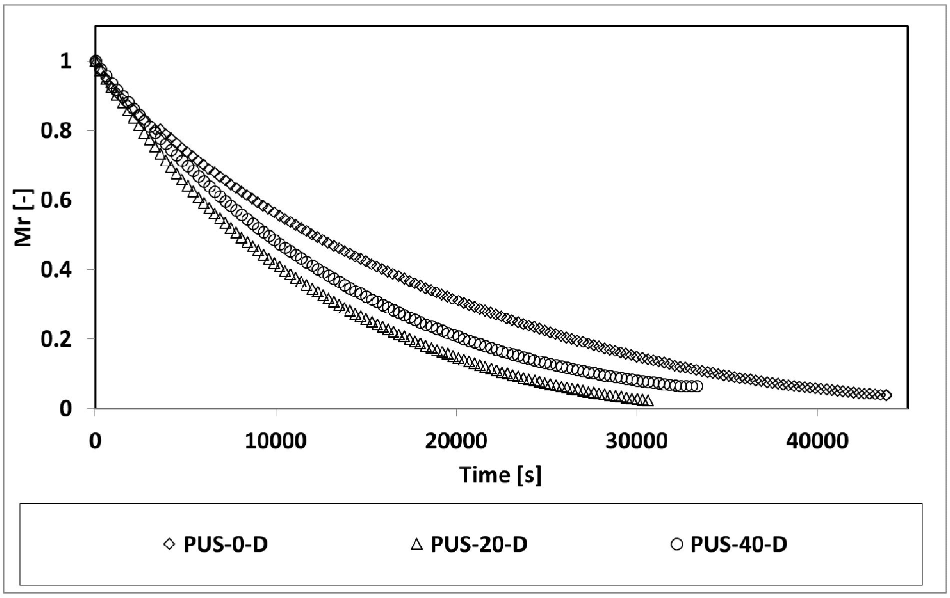


Figure 2 – Drying kinetics of pineapple slices at 40 ºC. Conv means convective drying, USDW means immersion in distilled water assisted by ultrasound

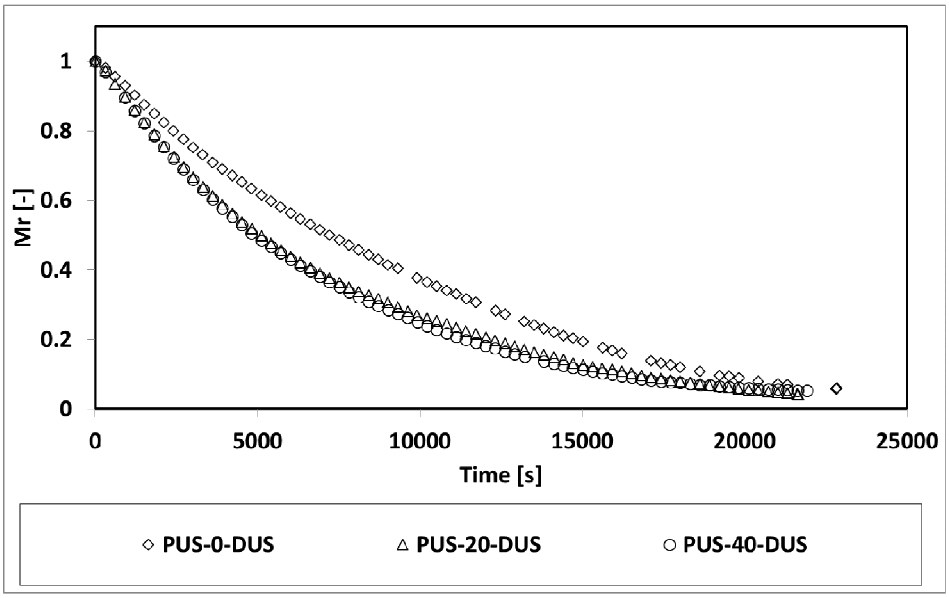


Figure 3 – Drying kinetics of pineapple slices at 40 ºC, assisted by ultrasound. Conv means convective drying, USDW means immersion in distilled water assisted by ultrasound

## 4. CONCLUSION

The pretreatment of pineapple with ultrasound in distilled water affected the later drying increasing the drying rate probably by affecting the internal structure of fruit. Moreover, the ultrasonically assisted drying improved also the drying kinetics. The combination of pretreatment with ultrasound and drying also with ultrasound application provided the fastest process. More research is needed to determine how ultrasound affects internal structure of pineapple.

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