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Quality assessment of mushroom slices dried by hot air combined with an electrohydrodynamic (EHD) drying system

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ABSTRACT

In this study, hot air combined with an electrohydrodynamic (EHD) drying system was designed and examined for drying button mushroom (*Agaricus bisporus*) slices. The effects of three levels of voltage (17, 19 and 21 kV) and electrode gap (5, 6 and 7 cm) on solid and bulk density, porosity, shear strength, water absorption capacity (WAC) and total color difference (ΔE) of dried mushroom slices in comparison to oven dried mushroom slices were investigated. ANOVA showed that the hot air combined with EHD drying method had significant effects on bulk density and shear strength ($p \le 0.01$) reduction as well as on porosity ($p \le 0.001$) and WAC increase ($p \le 0.01$), but this system had no significant effects ($p \ge 0.05$) on the solid density and ΔE parameters in comparison to the oven drying system. In addition, results indicated that increasing the voltage or decreasing the electrode gap resulted in some advantages such as bulk density and shear strength reduction or porosity and WAC increase that introduced this combined drying method as an improved method for drying mushroom slices.

Keywords: Electric field strength; Voltage; Porosity; Water absorption capacity

1. Introduction

Drying is one of the oldest methods of food preservation and it represents a very important aspect of food processing (Bajgai and Hashinaga, 2001a). Food drying continues to be an interesting preserving operation, because not only it leads to shelf life prolongation and volume reduction, but also it is a technique for products diversification and new products design. In fact, drying can be further expanded if improvements in food quality and process applications are achieved (Seguí et al., 2013). Therefore, there is now a growing interest in using of new processing of food and similar materials (Bai and Sun, 2011). For instance, a novel and promising drying process, Electrohydrodynamic (EHD) drying has been developed only recently (Bai et al., 2013) that complies well with high product quality and low energy consumption issues (Singh et al., 2012).

EHD drying is a drying method that uses a high electric field (HEF) to promote the drying rate. HEF system used for drying consists of one or multiple point electrode (needle or wire) and a plate electrode (Li et al., 2006). EHD drying can be carried out using either alternating (AC) or direct current (DC) mode (Bai et al., 2010) and the primary mechanism for this drying method is the corona or ionic wind produced by applying a sufficiently high voltage to an electrode with a small radius of curvature (Ould Ahmedou et al., 2009). In fact, this drying method depends on the strength of the ionic wind, which impinges on the material to be dried, produces turbulent, vortex like motions in it and enhances the mass

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transfer rates of the liquid and volatile components inside the biological medium. Thus, EHD drying results from a conversion of electrical to mechanical energy (Hashinaga et al., 1999). Most importantly, the EHD process can be employed on a commercial scale. As a first step toward the realization of this technology for industrial applications, a prototype has been designed and constructed to demonstrate its potential by Lai (2010) who confirmed that this technology can be successfully scaled up for industrial applications. However, studies have shown that EHD drying technique is highly effective at the first stage of drying i.e., surface evaporation stage, and like most drying techniques its effectiveness reduces, as the drying process advances in time. It seems to be helpful to provide auxiliary heating to the material to assist moving of moisture to the surface to expedite the removal of moisture by corona wind (Wong and Lai, 2004). In this paper a combination of EHD drying to a fixed high temperature (60 °C) as a new drying method was investigated to merge the advantages of two drying methods to avoid or minimize the limitations of them for drying mushroom slices (Taghian Dinani et al., 2014a). Mushrooms have been used throughout the world for many centuries not only for their delicacy, flavor and nutritional value but also for their functionality. The button mushroom (*Agaricus bisporus*) is the most widely cultivated and consumed mushroom throughout the world, but it has a short shelf life compared to most vegetables at ambient temperatures and requires special attention to preserve it. Among various methods of mushroom processing, drying is one of the most important preservation methods employed for its storage (Taghian Dinani et al., 2014b). The quality of dried mushrooms is determined by a combination of factors, but most properties or characteristics depend on consumer preferences. For instance, the rehydration ability, density and porosity of the dried product are important physical properties characterizing the quality of dried materials. Furthermore, color and texture are two important quality parameters that influence consumer acceptance (Argyropoulos et al., 2011).

EHD is not a well-explored method of drying and various factors can influence the drying process (Bai et al., 2010). Thus the objective of this study was to investigate the influence of technical parameters of hot air combined with an EHD drying system such as voltage and electrode gap on solid and bulk density, porosity, shear strength, water absorption capacity (WAC) and total color difference (ΔE) of dried mushroom slices in comparison with oven drying.

2. Material and method

2.1. *Experimental set-up*

The experimental set-up of hot air combined with an EHD drying system is shown in Fig. 1. The EHD system consisted of a Teflon frame (internal dimensions of 26 × 36 cm and external dimensions of 36.7 × 42.5 cm) with multiple T1-thermocouple alloy (Ni90/Cr10) wires (Chromel®, Hoskins Manufacturing Company, Nebraska, United States) having a diameter of 0.254 mm and a length of 26 cm projected to a fixed horizontal grounded metallic plate (32.8 × 23.1 cm rectangle stainless steel plate). The perforated plate (23.1 × 32.8 cm) and blanched mushroom slices (placed on the perforated plate) were put on the horizontal grounded plate. In this investigation, 6 wires were used, and the electrode spacing between the two neighboring wires was 5 cm. The discharge gap between the Teflon frame and the grounded electrode was set by four tubes with desired heights. The wire electrodes were connected to a DC high-voltage power supply (Model Sefelec, Ottersweier, Germany), which supplied electricity with a positive voltage range of 0–60 kV. The described EHD system was placed in a chamber (VC 7018 Vötsch Industrietechnik, Germany) to provide constant temperature (60 °C) and relative humidity (10%) control during drying in order to obtain more reliable results. A data logger (Model AOIP, Evry, France) was used during drying to record the weight changes of mushroom slices.

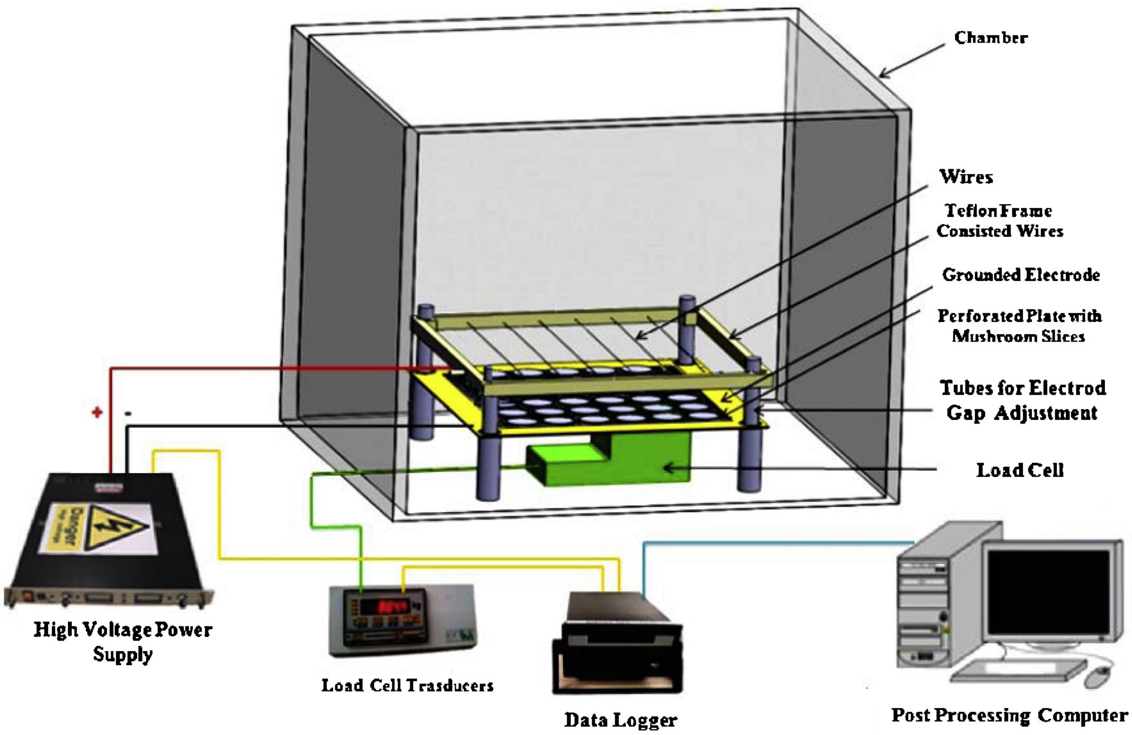

Fig. 1 – Scheme of the experimental set-up.