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ANALYSIS OF THE DRYING KINETICS AND THE ENERGY EFFICIENCY OF THE ELECTROHYDRODYNAMIC (EHD) DRYING OF MUSHROOM SLICES

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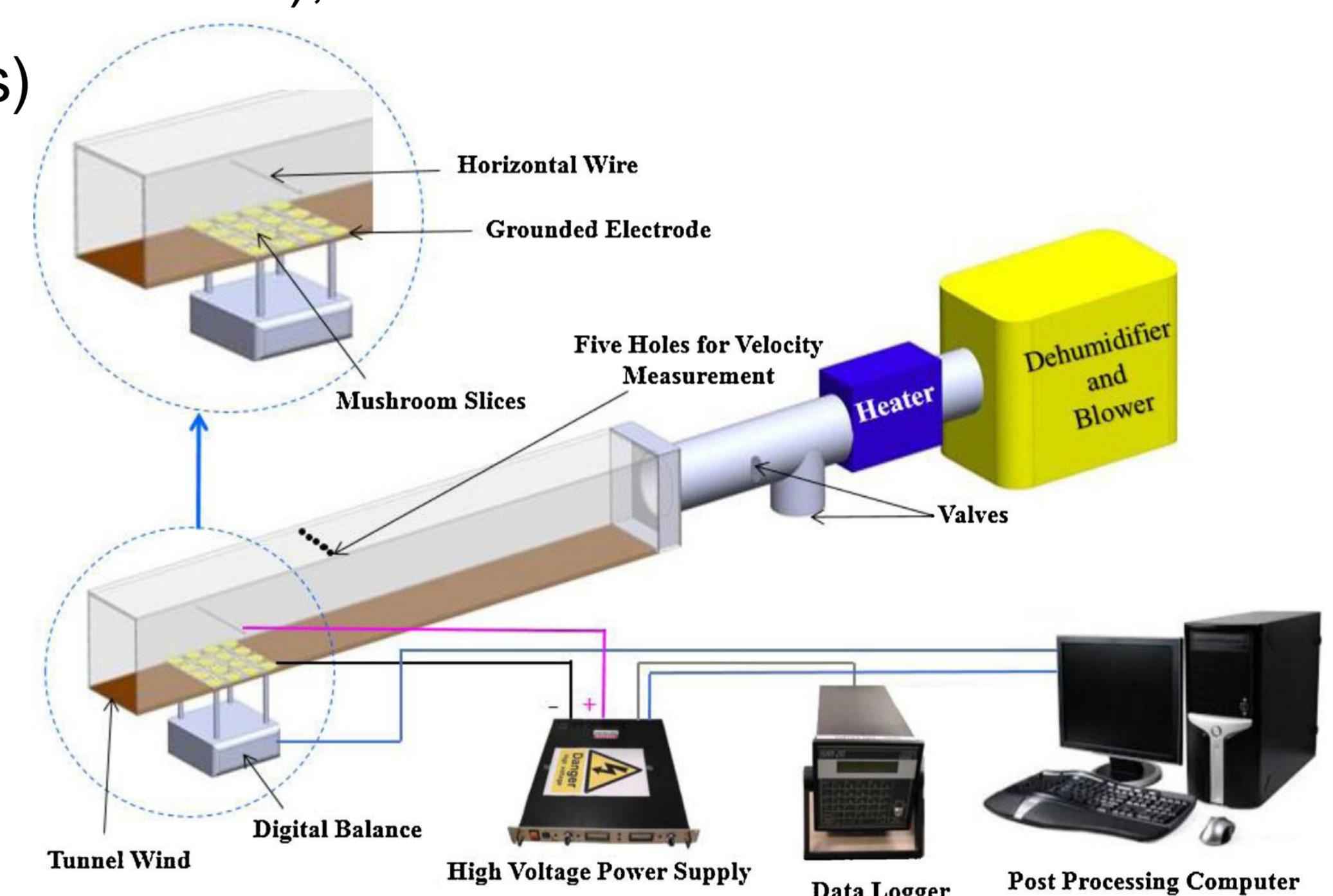
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Introduction

- 60% of all the energy used by food industry is used for the drying of products ! An efficient drying technique has become an important issue.
- EHD drying is a promising method that can be carried out using AC or DC high voltage between 2 electrodes. The primary mechanism for EHD drying is the electric wind generated by a corona discharge.
- The objective of this work was to explore how some process parameters (voltage and primary air velocity) affect the drying kinetics and energy consumption. EHD Drying experiments were performed on the button mushroom, the most widely cultivated mushroom throughout the world.

Experimental Set-up, Procedures

- The convective system is equipped with a wind tunnel (190 cm long and 15 × 15 cm² internal dimensions), a dehumidifier and a blower.
- Air (45°C 10% RH) was blown in the tunnel at 2 different primary air velocities (0.4 and 2.2 m/s)
- The corona wind was generated by application of a positive high voltage V_0 (0-30 kV) at a wire electrode (0.15 mm diameter) located 6 cm above a grounded perforated plate.
- Drying experiments were conducted at $V_0 = 0, 20, 25$ and 30 kV.
- Fresh mushroom slices (65 g) were blanched and laid on the perforated plate.
- The weight changes of mushroom slices over time were recorded with a sampling rate of 10 s. The drying was continued for 5 h.
- Drying rates (DR) and Energy consumption (E) of wind tunnel and EHD system were derived from measurements.



Results and Discussion

- For a low primary air velocity (0.4 m/s), DR values were significantly influenced by the voltage until 90 min of drying (Fig.1). The higher the applied voltage, the faster the drying rate. Electric field intensity was effective at the first stage of drying (i.e. constant-rate period). For a high primary air velocity (2.2 m/s), the drying rate values were not significantly influenced by the voltage. A considerable drying rate can result from a combination of a small cross-flow velocity and a large applied voltage. It implies that the electric body force is dominant over the flow inertia. This was confirmed by PIV measurements (Fig. 2). The electric force generated a secondary air flow that increased mass transfer.
- The enhancement in the moisture removal using 2.2 m/s air velocity remained fairly constant regardless of the different intensity of corona wind application (Fig. 3). For the experiments conducted at the cross-flow of 0.4 m/s, the final moisture content decreased with the applied voltage, that is consistent with the increase of drying rate response of drying treatments at 0.4 m/s.
- The energy consumption for blowing air in the tunnel (E_{tunnel}) was close to the total energy (E_{total}) of the drying treatments (Fig. 4). It is because the energy consumption due to the EHD system was very low.

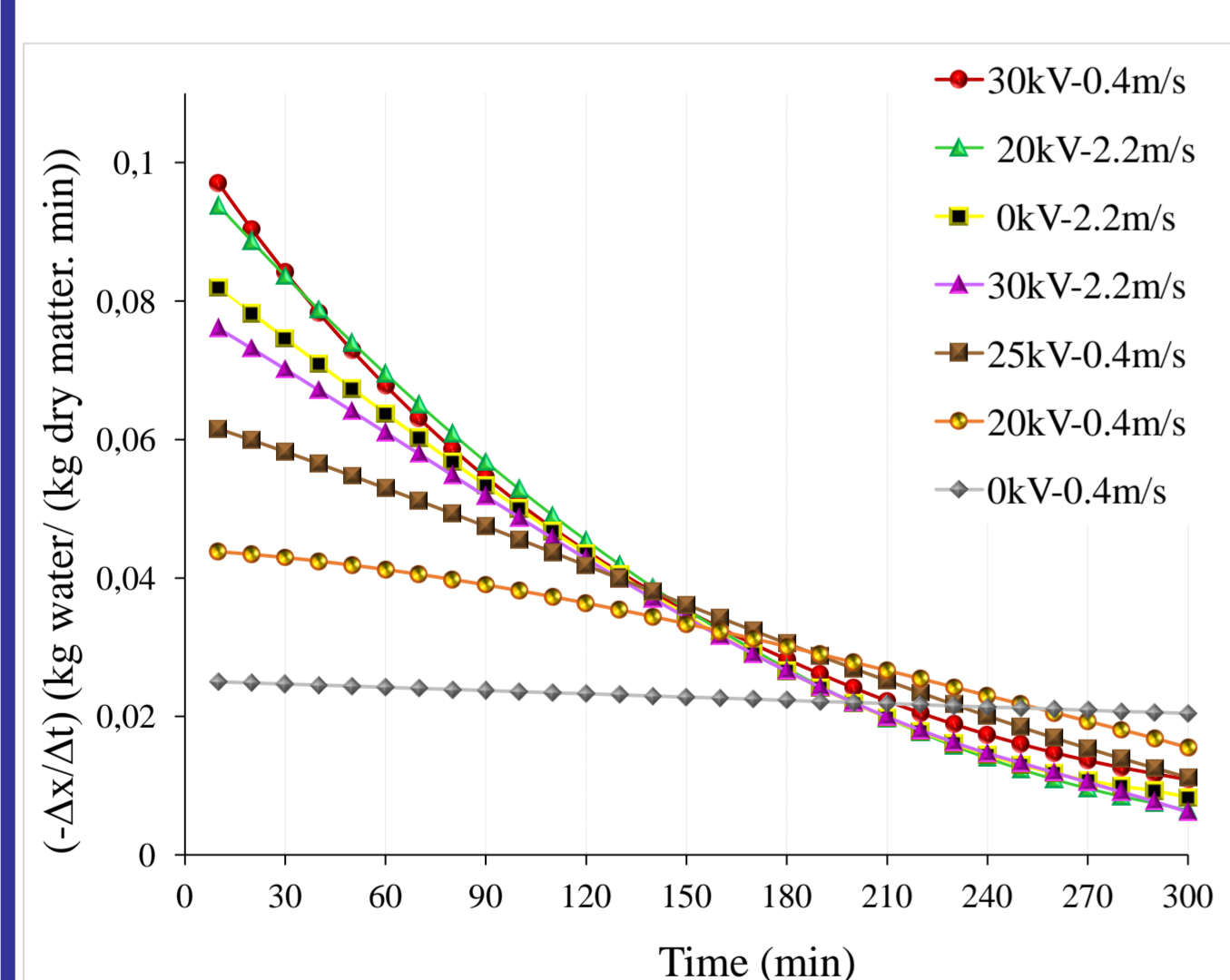


Fig. 1: Drying kinetics according to voltage and primary air velocity

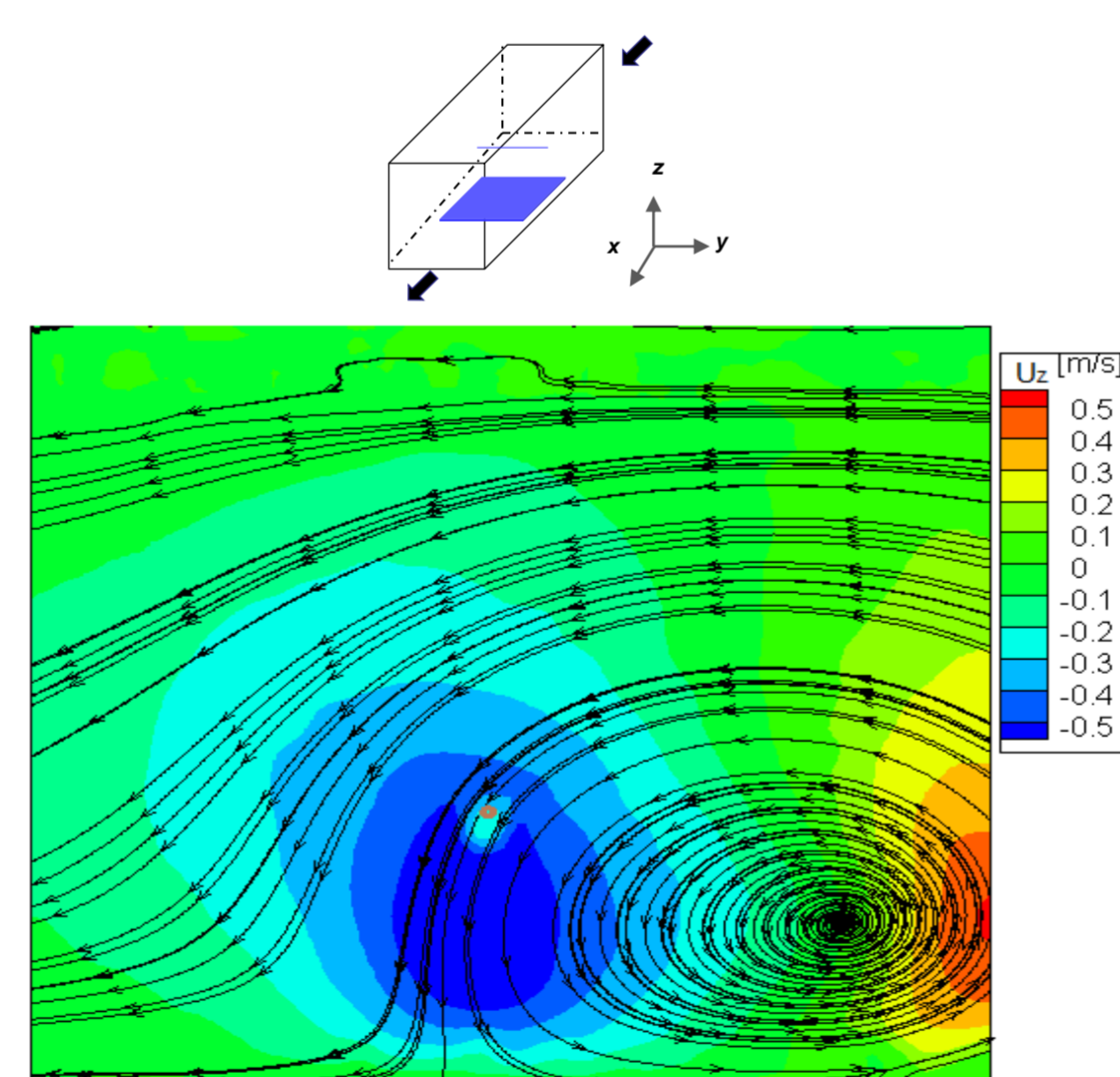


Fig. 2: Streamlines and vertical velocity component For a low primary air velocity (PIV measurements at the center of the tunnel)

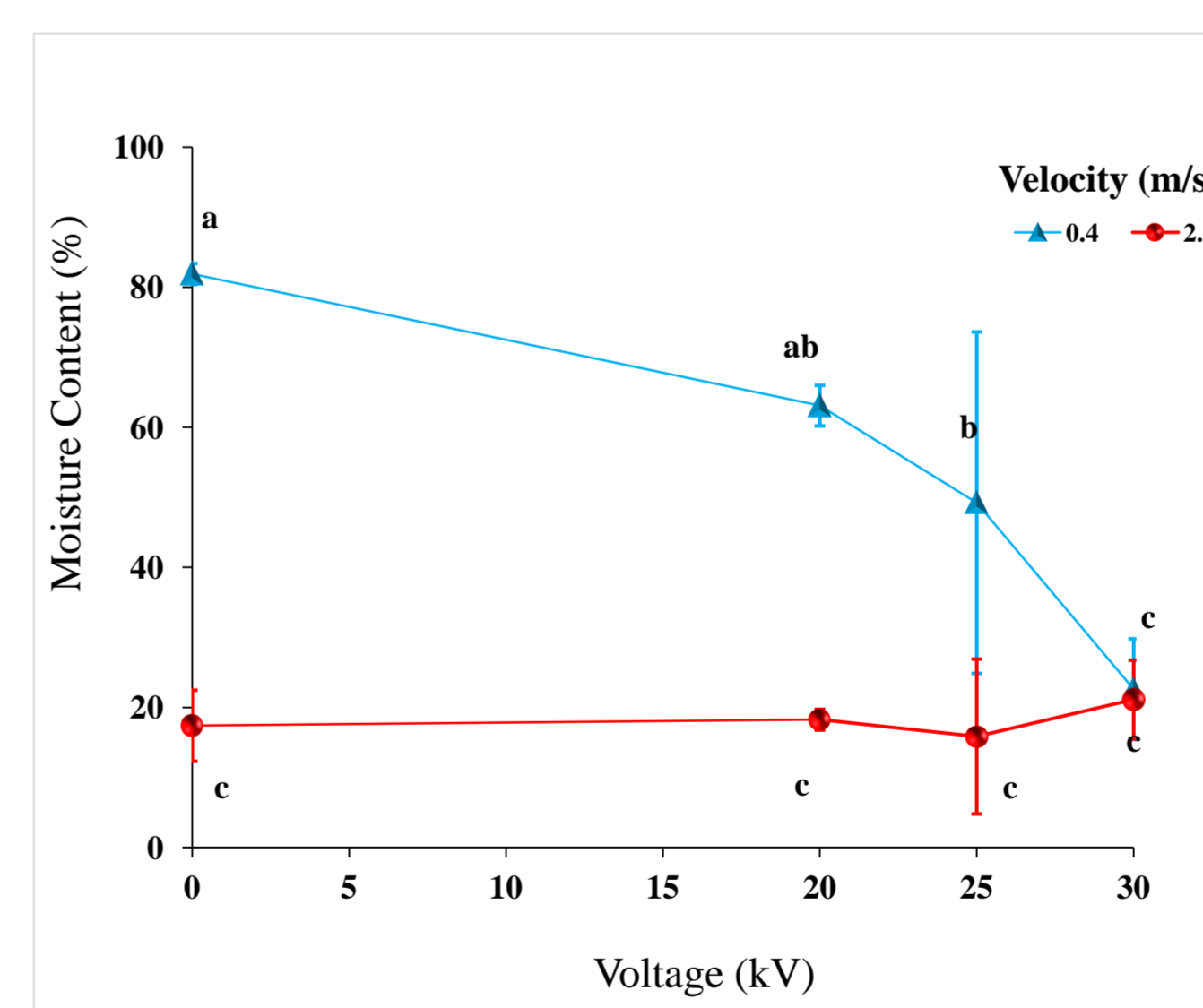


Fig. 3: Final moisture content (%) of mushroom slices after 5 h (means with different lower case letters are significantly different ($p < 0.05$))

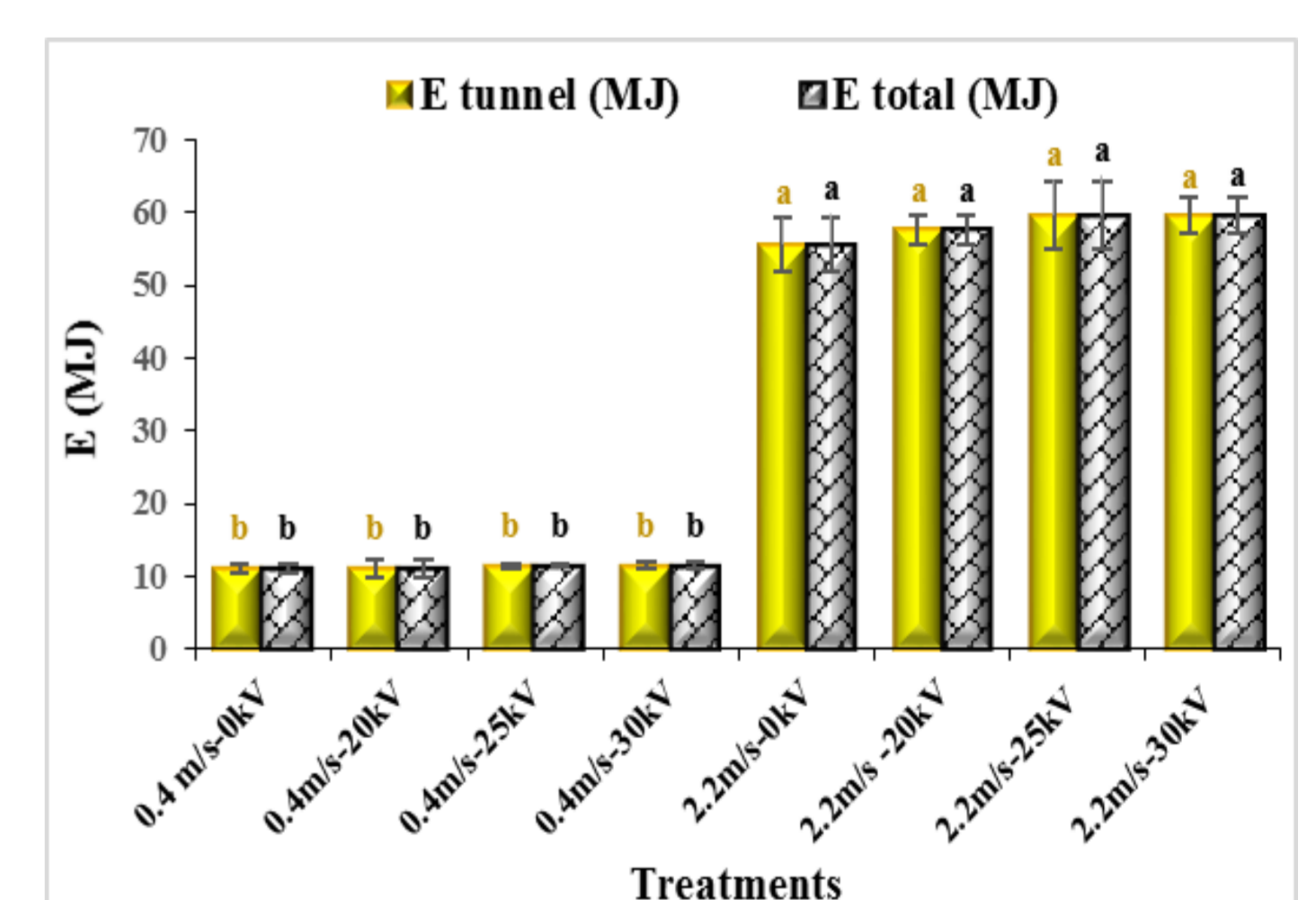


Fig. 4: Effect of treatments on energy consumptions (E_{tunnel} and E_{total}) (means with different lower case letters are significantly different ($p < 0.05$))

Conclusions

- EHD drying with a low primary air velocity :
 - Allows to obtain similar drying rates and final moisture content than by pure forced convection at high velocity.
 - Induces very low energy consumption compared to pure forced convection.
- This performance is due to the electric body force that is able to :
 - Generate secondary airflows which enhance convective heat and mass transfer.
- The analysis of the influence of the EHD drying on the quality attributes of dried mushrooms will be the further step.
- A demonstrator will be designed using a CFD model to optimize the geometry and the process parameters.

