**Characterization of a bioreactor of trays for solid state fermentation under abiotic conditions: Hydrodynamics and heat transfer**

Gerardo Gómez-Ramos1,2\*, Carlos Castillo-Araiza1, Sergio Huerta-Ochoa2, Moíses Couder-García1, Lilia Prado-Barragan2

*1 Laboratory of Reactor Engineering Applied to Chemical and Biological Systems. Chemical Engineering Area. Dept. of IPH. Autonomous Metropolitan University-Iztapalapa, Av. San Rafael Atlixco 186 Vicentina, C.P. 09340, Mexico City; 2 Department of Biotechnology, Autonomous Metropolitan University-Iztapalapa, San Rafael Atlixco 186, Vicentina, C.P. 09340, Mexico City.*

*\*Corresponding author: gagr@xanum.uam.mx*

**Highlights**

* Solid State Fermentation
* Two-zones model approach.
* Hidrodynamics.
* Heat transfer.

**1. Introduction**

Solid state fermentation in recent years is booming in the biotechnology industry, due to the potential to produce value-added metabolites in different industries, for example; enzymes, biofuels, food additives, precursor molecules for chemical and pharmaceutical industries, among others [1].But nevertheless; in this type of systems, one of the biggest problems for scaling systems is the heat transfer, Due to the temperature gradients that are generated in the bioreactor, some reports mention gradients of up to 10 ºC [2], this is due to the exotherm of the biological reactions in the fermenter. Several authors have made characterizations of heat transfer; however, we still do not have a reliable methodology to scale the process. This could be due to not considering the effect of hydrodynamics when characterizing the heat transport parameters.

Due to the above, the objective of this work was to characterize the hydrodynamics and the effect it presents in the transport of heat in a tray bioreactor to produce proteases (SSF) under abiotic conditions.

**2. Methods**

The characterization of the system was carried out in a bioreactor of trays packed with agroindustrial waste (fruit, vegetable and soybean paste).

*2.1 Hydrodynamic characterization.*

 *2.1.1 Pressure Drop*

To characterize hydrodynamics, pressure drops were determined in the system by varying the aeration flow (VkgM) using two high precision manometers at the inlet and at the bioreactor outlet.

 *2.1.2 Profile Velocity*

To determine the velocity profiles, two hydrodynamic models were used, which are based on the system pressure drop, vacuum fraction, air properties (density, viscosity). The hydrodynamic user models were Navier-Stokes-Darcy-Forchheimer (NSDF) and Two-zones model (developed in the research group). The NSDF model has been proven in previous works that adequately reproduces the velocity profiles obtained through experimental data, therefore it was used as a basis to compare with the Two-zones model.

*2.1 Characterization of heat transfer.*

 2.1.1. Temperature gradients

The temperature was determined in transient state in different sampling ports along the bioreactor generating wide gradients that allow greater certainty when determining the parameters of heat transport (effective conductivity and the coefficient of heat transfer in the wall). said parameters were estimated by coupling hydrodynamics using Two-zones model.

**3. Results and discussion**

Figure 1a shows the experimental pressure drops in the system at different aeration flows (VkgM), in figure 1b the velocity profiles (cm s-1) are shown using both hydrodynamic models and figure 1c shows the temperature profile in the bioreactor, this was with constant aeration flow and bath temperature.



**c)**

**b)**

**a)**

**Figure 1.** Experimental and theorical results in the system

As shown in Figure 1b, the velocity profiles obtained in the Two-zones model are practically identical to those obtained by means of NSDF (difference less than 3%), which gives us certainty about the results, together with the advantage that under the same computing conditions the processing time is reduced by 3000 times. The hydrodynamics was coupled to the estimation of the heat transfer parameters with the abiotic experimental data. The effective thermal conductivity and wall heat transfer coefficient present a value of ca. 9.49\*10-3 W m-1 K-1 and 3.68\*10-1 W m-2 K-1

**4. Conclusions**

The Two-zones model allows reliable speed profiles to be obtained, greatly reducing the computation time, on the other hand the coupling of hydrodynamics to the heat transfer model allows to have a greater certainty of the heat transfer parameters and realizes all these analyzes under biotic conditions allow us to determine the effect of the bioreactor in the fermentation.

**References**

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