OSMOTIC DEHYDRATION OF BUTTON MUSHROOM: FICKIAN DIFFUSION IN SLAB CONFIGURATION

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Abstract — Osmotic dehydration is a method to partially remove moisture from vegetables and fruits. Three sucrose concentrations (20, 30 and 40% w/w) in four temperatures (30, 40, 50 and 60°C) were used in this study. Effective diffusion coefficient was determined for examined temperatures and concentrations using Fick’s second law of diffusion adapted to slab geometry. The calculated effective diffusion coefficients of water were of the order of 10^{-9} m^2/s. Activation energy was calculated and found to be 17.533, 4.861 and 5.446kJ/mol for 20, 30 and 40% w/w solutions, respectively.

Keywords — Osmotic dehydration, Button mushroom, Effective diffusion coefficient, Activation energy.

I. INTRODUCTION

Mushrooms are edible fungi of commercial importance and their cultivation has emerged as a promising agrobased land-independent enterprise (Shivhare et al., 2004). Consumption of mushrooms has increased substantially due to their nutritional value, delicacy and flavor. Button mushroom (Agaricus bisporus) is the most widely cultivated and consumed mushroom throughout the world and it contributes about 40% of the total world production of mushroom (Giri and Prasad, 2007) but due to very short shelf life of fresh mushroom using preservation methods to extend the shelf life is recommended. Drying is the easiest means to increase the longevity of high moisture products (Shukla and Singh, 2007). On the other hand mushrooms are very sensitive to temperature, therefore choosing a proper method of drying is a very important decision.

Osmotic dehydration is widely used for partial removal of water from product by immersion of mushroom in a hypertonic solution. The deriving force for the diffusion of water from the tissue into the solution is provided by the higher osmotic pressure of the hypertonic solution (Rastogi and Raghavarao, 2004). Simultaneously some of the solute diffuses into the tissue. The rate of diffusion of water depends on temperature, concentration of osmotic solution, material to solution mass ratio, size and geometry of the material.

Knowledge of drying kinetics of biological materials is essential to design, optimization and control of the drying process. Several studies have been carried out to determine osmotic drying behavior of plants (Ade-Omowaye et al., 2002; Azuara and Beristain, 2002; Corzo and Bracho, 2006; El-Aouar et al., 2003; Rahimzade Khoyi and Hasari, 2007; Rastogi and Raghavarao, 2004; Sutar and Gupta, 2007) and some on drying behavior of mushrooms (Bhuiyan et al., 2003; Giri and Prasad, 2007; Sahbaz et al., 2000; Walde et al., 2006), but there is a lack of studies on osmotic dehydration of button mushrooms. Therefore, the present study wishes to determine the effect of osmotic solution concentration and temperature on drying kinetics during osmotic dehydration of button mushrooms and to calculate the effective diffusion coefficient and activation energy of the samples in different situations of osmotic dehydration.

II. MATERIALS AND METHODS

A. Materials

Fresh button mushrooms were obtained daily from local market and before each test the mushrooms were sorted according to their size and maturity, washed to remove dirt and sliced with a sharp knife. Slices of 5mm thickness were then blanched in boiling water for 1 minute to inactive enzymes responsible for enzymatic browning. Initial moisture content was measured at 103±2°C. Commercial sucrose was used as the osmotic agent.

B. Osmotic dehydration

Prior to starting osmotic dehydration of mushroom in osmotic solution, the slices were blotted with tissue paper to remove excess moisture from the surface. Osmotic solution was prepared (20, 30 and 40%w/w concentrations). A hot water bath was used to keep osmotic dehydration at desired temperatures (30, 40, 50 and 60°C). The mass ratio of slices to osmotic solution was maintained at 1:25 in order to ensure that the concentration of the osmotic solution did not change significantly during the experiment (Rastogi and Raghavarao, 2004).

Observations were taken at intervals of 15 minutes for the first hour, followed by intervals of 30 minutes for the next 2 hours and two final measurements with intervals of 60 minutes. Therefore, total process time for osmotic dehydration was 5 hours.

C. Calculations

Solution of Fick’s second law of diffusion assuming mushroom slices to be a flat plate results the following equation for diffusion of moisture through the material to the surface (Azoubel et al., 2002):