DRIED BROCCOLI (*BRASSICA OLERACEA* L. VAR. *ITALICA*) STALK THROUGH APPLICATION OF OSMOTIC DEHYDRATION AND MICROWAVE-ASSISTED HOT AIR DRYING

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ABSTRACT

This thesis focuses on the valorization of broccoli stalk as dried food product rather being discarded in the field. Drying can increase the shelf life of food products by removing the water content to a point where the product is shelf-stable. There are various drying technologies in food processing and recent advent of hybrid system such as microwave-assisted hot air drying is very promising. A study was conducted to compare the drying performance of broccoli stalk slices dried under hot air drying and microwave-assisted hot air drying. The results indicated that the microwave-assisted hot air drying was more efficient since it allowed faster moisture removal. Different treatments of preconditioning drying are suggested to improve the quality of dried product.

Osmotic dehydration is a method of removing water from a product with minimum input of thermal energy. This method is generally used as a pre-treatment before the drying process. It helps improve the product quality and reduce the energy requirements for drying. In this part of the study, we sought to optimize the conditions of osmotic dehydration process on broccoli stalk slices to maximize the water loss while minimizing the solute (sugar) gain. The first series of tests were conducted in a water bath without agitation. The best results were obtained with a solution containing 56% sucrose (w/v) maintained at 42 °C and immersion time of four hours. Under these conditions, broccoli stalk slices showed nearly 61.5% of water loss with a solute gain of 6.7%.

Thereafter, drying characteristics of osmotically dehydrated broccoli stalk slices under microwave-assisted hot air drying were investigated. The results demonstrated that the osmotic dehydration pre-treatment remarkábly reduced the drying time while maintaining the dried product's color and shape as that of the untreated dried broccoli samples. Among the different mathematical models studied, Page model was the best to describe the thin layer drying kinetics of osmotically dehydrated broccoli stalk slices.

During the osmotic dehydration with no agitation, the mass transfers were low resulting in long processing times. Therefore, a dewatering apparatus equipped with a pump for controlling the speed of the solution was designed and constructed. The device was used to study the effects of the flow velocity on the performance of osmotic dehydration process. The results showed that the flow velocity helps in faster rate of water removal while reducing the amount of sucrose gain. The optimum operating conditions were found to be at a temperature of 30 °C with a sucrose concentration of 54 °Brix and it was moving at a speed of 3.5 mm/s. Under these conditions, it only took 120 minutes to remove 65% of the water from the broccoli stalk slices, and sucrose gain was 3.9%.

Osmotic dehydration results in loss of water and sucrose gain in the broccoli stalk slices. These compositional changes alter the dielectric properties (ε' and ε'') of the product and its ability to convert the electromagnetic energy of the microwaves into heat. In this study, it was found that ε' and ε'' of broccoli stalk were dependent on the osmotic dehydration processing parameters. Compared to fresh sample, the ε' decreases and ε'' increases when broccoli stalk is subjected to the osmotic dehydration pre-treatment, resulting in better conversion of microwave energy into heat.

Further study was conducted to evaluate the effects of osmotic dehydration and microwave-assisted hot air drying on the quality of the dried broccoli stalk slices. The parameters used for the evaluation were: vitamin C content, chlorophyll content, total phenolic content, color and texture. It has been demonstrated that when compared to that of the fresh sample, osmotic dehydration pre-treatment resulted in a significant decrease ($p < 0.05$) in vitamin C content, chlorophyll content, and total phenolic content. In addition, the osmotically dehydrated product has led to minimal color change and softer texture. When compared to varying drying temperatures, a drying temperature of 40 °C resulted in arriving at the best quality of the finished product.

The last part of the study focused on the economic aspects of the production process of dried broccoli stalk slices. The parameters selected were raw material availability, process design, energy input, capital inputs, operation costs and environmental benefits. The economic analysis indicated that the proposed production process had a return on investment of 34.3% with a two-year payback period. Considering the positive results of the analysis and environmental benefits, the production of dried broccoli stalk slices seems to be viable on a commercial scale. Furthermore, this concept of osmotic dehydration followed by microwave-assisted hot air drying could eventually be used to process other biological materials that have the potential at the marketplace.