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Research Paper

The Effect of Resting Time and Mixing Duration on the Physicochemical and Functional Properties of Paprika Foam and Powder

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Extended Abstract

Introduction In the food industry, increasing consumer demand for natural additives and functional ingredients has raised the importance of paprika (*Capsicum annuum*), known for its richness in bioactive compounds such as antioxidants, carotenoids, and vitamins. However, due to its sensitivity to heat and moisture, conventional drying methods often compromise paprika's color, aroma, and nutritional quality. Foam-mat drying a novel technique addresses these limitations by transforming liquid matrices into stable foams, enabling efficient drying at lower temperatures. This approach is especially beneficial for sticky and thermolabile substances that are difficult to dry using traditional methods. Microwave-assisted drying further improves efficiency by providing uniform internal heating, reduced drying time, and energy savings. While the general efficacy of foam-mat drying has been documented for various food matrices, there remains a lack of detailed optimization studies specific to paprika, particularly involving the interplay of key processing parameters such as foam resting time and mixing duration. This study aimed to investigate and optimize the effects of two primary process variables resting time (0 to 20 minutes) and mixing duration (1 to 10 minutes) on the quality attributes of foam and paprika powder prepared by foam-mat drying using microwave energy.

Methods In this study, red bell peppers were purchased from the local market in Jiroft, Iran pulped, and stored at -18°C to prevent physiological changes. The foaming agents included milk protein concentrate and maltodextrin, mixed at a 1:1 ratio. Before processing, samples

were thawed naturally and equilibrated to room temperature. The effect of rest time (0–20 min) and mixing time (1–10 min) on the properties of the resulting foam and powder was investigated using Response Surface Methodology, designed via Design Expert v11 software. Foam was prepared using a laboratory mixer, then spread in uniform 5-mm layers and dried using a microwave at 400W. The resulting dry samples were ground and sieved to obtain paprika powder. Foam density, physical stability, bulk and tapped density, true particle density, product yield, and hygroscopicity were measured using standard procedures. Foam density was calculated as weight-to-volume ratio; stability was assessed via drainage over 120 minutes. Powder densities were measured before and after tapping, and true density was determined using toluene displacement. Yield was calculated based on final powder weight, and hygroscopicity was assessed by moisture uptake in a 75% RH desiccator over one week.
Results and Discussion Foam density ranged from 0.956 to 0.990 g/cm³. It increased with longer resting times and shorter mixing durations. The optimal foam density was achieved at approximately 5.5 minutes of mixing and 10 minutes of rest. The model fitted with $R^2 = 0.97$ showed high predictive accuracy. Foam stability varied between 58–69%. Excessive mixing (>5.5 min) led to structural collapse due to over-aeration, while shorter mixing improved stability. Optimal stability was found with short rest and mixing times. The regression model ($R^2 = 0.91$) confirmed significant interactions between mixing and resting durations. Yield was inversely related to mixing duration. Excessive aeration reduced mass retention. The yield ranged between 14.02% and 26.66%, with the highest values recorded at 20 min rest and 1 min mixing. However, the model ($R^2 = 0.63$) had limited predictive power, suggesting other unmeasured factors may also influence yield. Hygroscopic index ranged from 83.5% to 84.5%. It increased with longer rest and decreased with extended mixing. This behavior reflects changes in particle structure and surface chemistry affecting moisture affinity. The regression model showed excellent fit with $R^2 = 0.99$. All three density measurements increased with longer mixing durations and shorter resting times, suggesting more compact particle packing and reduced porosity. The observed ranges were as follows: bulk density from 0.31 to 0.43 g/cm³, tapped density from 0.31 to 0.43 g/cm³, and particle density from 0.32 to 0.49 g/cm³.These changes were attributed to smaller, more compact particles formed under intense mixing. The R^2 values for these models exceeded 0.97, confirming strong model validity. Using desirability analysis, the optimal condition was determined to be 0 minutes of rest and 5.5 minutes of mixing, achieving a balance between high yield, foam stability, moderate density, and low hygroscopicity. This condition yielded the most desirable product with acceptable energy use and process time (desirability = 0.55).
Conclusion This study demonstrates the importance of balancing foam resting time and mixing duration in the microwave-assisted foam-mat drying of paprika. Moderate mixing and minimal resting produced the most stable foam and highest-quality powder in terms of structural integrity, yield, and moisture resistance. The application of RSM modeling allowed precise optimization, supporting its utility in industrial-scale drying process design. These findings provide valuable insights for the food industry in developing natural, functional, and shelf-stable paprika powder products using sustainable and efficient processing methods.

Keywords: Paprika powder, Microwave, Flooring, Drying

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