EXPLANATORY TEXT

This study investigated the drying of umbu seeds (Spondias tuberosa) at temperatures of 50, 60, 70, and 80 °C using an air circulation and renewal oven. This fruit is native to certain Brazilian biomes, such as the Caatinga. While previous research has highlighted the nutritional properties of its pulp, few studies have addressed the potential uses of its residues.

Fruit processing by the food industry generates residues that are typically discarded. However, repurposing these materials for human consumption may provide health benefits and reduce environmental impact by minimizing waste disposal.

Drying is an important step in the process of extracting some by-products from fruit residues, since a considerable part of these by-products is extracted from the fruit flour. Therefore, an adequate description of this step is necessary. Therefore, the objective of this work is to apply two solutions for the diffusion equation (analytical and numerical) and evaluate the effects of the drying process on parameters provided by these two solutions.

The diffusion equation was considered for the geometry of a finite cylinder (two-dimensional case), assuming boundary conditions of the third kind. For the analytical solution, three parameters were considered: the effective constant mass diffusivity (D), the convective mass transfer coefficient for the north and south interfaces of the cylinder (h_1), and the convective mass transfer coefficient for the east and west interfaces of the cylinder (h_2). For the numerical solution, the effective diffusivity was considered as a function of the local moisture content ($D(M)$), the convective mass transfer coefficient was assumed to be equal for all interfaces (h), and shrinkage was incorporated into the model.

The optimizations of the thermophysical parameters using analytical solution showed the influence of temperature on the effective mass diffusivity and on the convective mass transfer coefficient. These coefficients increased with increasing temperature. Furthermore, the values obtained for h_1 were greater than those obtained for h_2. This result must be related to the fact that the air flow in the oven used was parallel to the radius of the cylinder and, therefore, the convective effect tends to be greater.

Since the proposed numerical solution considers diffusivity as a function of local moisture content, about 10 expressions were tested (including exponential, hyperbolic cosine and linear functions). The best fit, based on chi-square analysis, was obtained with an exponential model of the form $D(M) = be^{aM}$.

Statistical indicators showed that the numerical solution provided a better fit to experimental data compared to the analytical approach. However, contour plots of moisture distribution generated from the numerical model revealed a significant moisture gradient only at the beginning of the drying process.

Internally, the umbu seed presents a heterogeneous structure with a thick outer shell and an inner kernel. These heterogeneities observed may imply different behaviors of the thermo-physical parameters from those already observed for fruits. The behavior of these parameters can be attributed to a number of reasons, including internal porosity. Therefore, when considering the morphology of the umbu seed, it is observed that there are spaces between the nucleus and the outer shell that tend to be influenced by shrinkage. Therefore, shrinkage may not be a function of moisture content alone.

Overall, the findings of this study represent a preliminary step toward evaluating the viability of using umbu seeds in the food industry, where drying is one of the first and most essential stages in processing.