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Predictive Mass and Volume Models for African Star Apple Based on the Geometrical Attributes

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Physical properties of crops provide a vivid description of their sizes, shapes and behavioural characteristics which can be the basis for classification during handling and processing. Accurate prediction of mass and volume, among other important physical characteristics of crops, is crucial in the design of postharvest handling systems, particularly for sorting, grading and packaging of fruits and vegetables. This study therefore, focused on determining some physical attributes of African star apple and developing mathematical models to estimate the mass and volume of the fruits based on selected geometrical attributes. A total of 150 fresh African star apples were purchased from Oje Market in Ibadan, Oyo State, Nigeria, and classified into two groups for model development: prediction models (100 samples) and validation models (50 samples). The procedure involved gravimetric properties measurement which included the mass and volume measurement, geometrical attributes measurement of the axial dimensions (length, width, thickness) along the three mutually-perpendicular axes, from which their mean diameters [arithmetic mean diameter (AMD), geometric mean diameter (GMD), and equivalent mean diameter (EMD)] and projected areas were calculated. Regression analysis was carried out to develop the predictive mathematical models based on three classifications: axial dimensions, projected areas, and mass models based on volume. The accuracy of evaluation of the models developed was determined by the coefficient of determination (R2). The length, width, thickness of African star apple fruits were 45.01±2.28, 43.88±2.52, and 44.22±2.30 mm, while the projected areas ranged from 1094.33 to 1951.187 mm^2. The gravimetric analysis showed average mass and volume of 57.36±7.46 g, and 54.75±7.34 cm^3, respectively. Among the developed models, those based on individual axial dimensions showed moderate correlation coefficients (R^2 = 0.514-0.632), with length-based models being the best among single-variable models. The longitudinal projected area models demonstrated a more predictive capability amongst all projected area models (R^2 = 0.607). The most accurate prediction was achieved by the mass model based on volume (R^2 = 0.9902), establishing a more highly reliable relationship between these parameters for African star apple fruits. The study established that mass can be accurately predicted using volume measurements, confirming findings from similar studies on other agricultural products. The developed models provide essential data for designing postharvest handling and processing systems for African star apples, contributing to the mechanization of unit operations currently performed manually. These predictive mathematical models will facilitate the development of automated sorting and grading equipment, ultimately reducing processing costs and improving efficiency in African star apple value chain operations.
Keywords: African star apple, physical properties; mass/volume modelling, geometrical attribute; size and shape indicators

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