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Energy-efficient drying of african walnut (Tetracarpidium conophorum): implications for the water–energy–food nexus and climate-resilient agro-processing

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Abstract

African walnut (Tetracarpidium conophorum) is a perennial, oil-rich indigenous nut widely distributed in the humid forest zones of West and Central Africa, particularly in Nigeria, where it grows naturally in wild and semi-managed forest systems. It is commonly consumed boiled as a snack and used in traditional diets due to its high nutritional and functional value and its role as a locally consumed food. The nut contains approximately 30–35 % lipid content, 20–25 % crude protein, and is rich in essential minerals such as potassium, magnesium, and iron, making it an important contributor to household nutrition and emerging local agro-processing value chains. Despite its nutritional importance, commercialisation remains limited due to its high moisture content, rapid spoilage, and lack of optimised postharvest processing systems.

Drying is a key preservation method, but it is energy-intensive and often inefficient in smallholder processing systems. Within the Water–Energy–Food (WEF) Nexus, improving drying efficiency offers a pathway to reduce postharvest losses, lower energy demand, and enhance food availability while maintaining resource sustainability.

This study evaluates the drying kinetics, effective moisture diffusivity, and energy efficiency of African walnut using cabinet and oven drying systems at 50, 65, and 80 °C, with and without shells. Energy efficiency refers to the amount of electrical energy required per kilogram of water removed, while effective moisture diffusivity describes the internal moisture migration rate within the nut structure under thermal gradients. Results showed that increasing temperature significantly reduced drying time and increased diffusivity from 6.23×10 to 4.72×10 m^2/s, with oven drying at 80 °C achieving the lowest specific energy consumption (0.11 kWh/kg water removed). While higher temperatures improved drying efficiency, they may also accelerate degradation of heat-sensitive nutrients such as vitamins and unsaturated fatty acids, highlighting a trade-off between process efficiency and nutritional quality.

From a WEF Nexus perspective, improved drying technologies can extend shelf life, enable storage, and support value addition such as kernel processing and small-scale oil

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extraction. This improvement in efficiency will strengthen emerging local market opportunities and enhance livelihood opportunities in rural West Africa.

Keywords: African walnut, agro-processing, drying kinetics, energy efficiency, moisture diffusivity, nigeria, water–energy–food nexus