

# Design and Fabrication of Process Air-Flow and Control Systems of a Food Dehydrator for Powdered Akamu Production

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*Abstract - This research details the design and testing of a specialized system for producing dry powdered akamu, a traditional Nigerian fermented cereal porridge. While akamu is a major dietary staple, its high moisture content (approx. 51%) limits its shelf life to roughly seven days under normal conditions. This project addresses this by developing a dehydrator that utilizes a vapor compression refrigeration cycle for air dehumidification combined with electric heating. The system is managed by an Arduino-based smart control system that monitors temperature and humidity levels. Experimental results showed the system successfully reduced akamu moisture content to 26% within three hours, removing 3% more wet mass than traditional heat-only dehydrators.*

*Index Terms - Akamu Preservation, Arduino Control, Dehumidification, Food Dehydration, Vapor Compression Cycle.*

## I. INTRODUCTION

With a population exceeding 200 million, food security is a critical priority for Nigeria. Maize is one of the nation's most cultivated crops, frequently processed into a fermented form known as Akamu (or Ogi and Koko). While nutritionally dense and highly digestible, akamu in its wet paste form is highly susceptible to microbial contamination due to its high moisture content. Traditional preservation, such as air drying, is often weather-dependent and can take up to a week. This study aims to develop a mechanical process to convert akamu into a stable powder, extending its shelf life for domestic and international markets.

## II. LITERATURE REVIEW

Akamu production involves steeping grains like maize or millet for 2-3 days, followed by wet milling and sieving. The resulting slurry is fermented by microorganisms before being pressed into wet cakes. Drying is the most effective way to inhibit spoilage

by reducing water activity. Standard dehumidification methods include:

- Cooling: Using coils below the air's dew point to condense moisture.
- Desiccants: Using liquid or solid agents like silica gel to absorb water.
- Compression: Sating air until it loses moisture-holding capacity. This project utilizes the Vapor Compression Cycle, consisting of a compressor, condenser, expansion valve, and evaporator, to remove moisture from the air before it reaches the heating element.

## III. MATERIALS AND METHODOLOGY

The system was designed using a multi-phase approach involving conceptual ideation, evaluation, and detailed design.

### A. Drying Chamber Design

A box-style chamber with equidistant shelves was adopted. The design utilizes alternate clearances (left and right) on each shelf to force air in a zigzag pattern across the product, maximizing moisture pickup. Two process fans serve as the primary air movers.

### B. Control System and Algorithm

The control system utilizes an Arduino microcontroller to manage two primary modes:

1. Simultaneous Operation: Running the compressor (moisture removal) and the heater together to optimize the drying rate.
2. Time-Based Cycling: Turning the compressor off periodically (e.g., every 15 minutes) to prevent evaporator frosting and manage energy consumption. The system operates until a set relative humidity (RH) of 20% is reached within the chamber.

### C. Hardware Specifications

- Temperature Control: Designed to maintain a constant range with a maximum limit of 60°C to prevent product discoloration.
- Moisture Removal: A refrigeration loop integrated with the air stream to lower humidity rapidly.
- Safety: Includes grounded components and insulated wiring for operator safety.

## IV. RESULTS AND CONCLUSION

### A. System Performance without Load

Initial test runs (without akamu) showed that the moisture removal system could lower humidity to approximately 40% RH very quickly. Periodic "spikes" in humidity were observed when the moisture removal system cycled off, likely due to residual moisture on the evaporator coils.

### B. Drying Results with Akamu

When loaded with 4kg of sample, the system achieved the following:

- Moisture Reduction: Final moisture content of 26.47% was reached in 3 hours.
- Layer Thickness: A negative correlation was found between layer thickness and drying speed; thinner layers dried significantly faster.
- Shelf Variation: The lower shelves lost approximately 8% more mass than the upper shelves, suggesting higher heat or lower humidity at the point of air entry.

### C. Comparative Performance

The prototype's "normal mode" (heating + dehumidification) was compared against a "heat-driven only" mode (simulating standard dehydrators):

- Normal Mode: Removed 7.17% of mass in the test period.
- Heat-Only Mode: Removed only 4.31% of mass in the same timeframe. This proves that the integrated dehumidification system removes roughly 3% more moisture than heat alone, enhancing efficiency.

## V. CONCLUSION

The project successfully demonstrated a practical mechanical solution for converting high-moisture akamu into a stable powder. By regulating

temperature and humidity through a smart control system, the dehydrator produced a product suitable for long-term storage, potentially reducing food waste and enhancing economic opportunities in the Nigerian agricultural sector. Future work should explore heat recovery systems to capture waste heat from the refrigeration cycle to further improve energy efficiency.

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