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Development of value-added products from underutilized jackfruit through osmotic dehydration

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Abstract
Every harvest season along Kenya's coast, tonnes of ripe jackfruit (*Artocarpus heterophyllus* Lam.) rot unsold because the fresh fruit is too bulky, perishable, and unfamiliar to distant markets. Osmotic dehydration—soaking fruit slices in concentrated sugar solution before drying—can transform this waste into shelf-stable, value-added products. This research optimised osmotic dehydration of jackfruit bulbs using a central composite design with three factors: sugar concentration (30-70 °Brix), immersion time (2-6 h), and slice thickness (5-15 mm). Responses measured were water loss, solid gain, total soluble solids (TSS), and overall sensory acceptance. The optimum conditions were 60 °Brix, 4 h, and 8 mm thickness, yielding 42.3% water loss, 11.7% solid gain, and a TSS of 19.1 °Brix. Candied slices prepared at this setting scored 8.2 out of 9 in consumer panels. A follow-up shelf-life trial showed the product remained microbiologically safe for 90 days at 25 °C. These results offer coastal Kenyan farmers a simple processing pathway to capture value from surplus jackfruit.

Keywords: Value addition, jackfruit, osmotic dehydration, underutilized fruits, food processing, water loss, solid gain, shelf life, central composite design, sensory evaluation

Introduction

The biggest challenge facing jackfruit in East Africa isn't growing it—it's selling it. A single tree can produce 100-200 fruits per season, each weighing 5-25 kg, and without cold chain infrastructure the ripe bulbs spoil within 3-5 days of harvest [1]. Coastal Kenya produces an estimated 48,000 tonnes of jackfruit annually, yet post-harvest losses reach 35-45% because processing facilities are almost non-existent [2].

Osmotic dehydration is a low-cost, low-energy pre-treatment that removes water by immersing fruit pieces in a hypertonic solution. The osmotic pressure gradient drives water out of the cells while solute (typically sucrose) migrates inward, raising the product's sugar content and lowering water activity [3]. When followed by air drying or solar drying, the process yields a semi-moist product with extended shelf life and pleasant candied texture [4]. The technique has been validated on mango, pineapple, and banana in tropical settings [5, 6], but data on jackfruit—particularly the thick-fleshed Kenyan landraces—are limited.

This research aimed to (i) optimise osmotic dehydration parameters for jackfruit bulbs using response surface methodology, (ii) characterise the physicochemical and sensory quality of the dehydrated product, and (iii) assess shelf stability at ambient tropical temperature.

Reagents and Processing Material

Commercial white cane sugar (sucrose ≥99.5%, Mumias Sugar Company, Kenya) was used to prepare osmotic solutions at 30, 40, 50, 60, and 70 °Brix. Citric acid (food grade, 0.5% w/v) was added to each solution to prevent enzymatic browning. Potassium metabisulphite (0.1% w/v) served as an antimicrobial agent. All chemicals were sourced from a certified food-grade supplier in Mombasa. Packaging was done in metallised polyester-polyethylene laminate pouches (oxygen transmission rate < 2 cc m^{-2} day^{-1}) heat-sealed under atmospheric conditions [7].

Quality Control

Refractometer readings were verified against standard sucrose solutions before each batch. Drying temperature was monitored with calibrated thermocouples at three positions inside the cabinet dryer. Moisture content was cross-checked by Karl Fischer titration on every fifth sample. Microbiological plating followed ISO 4833 for total plate count and ISO 21527 for yeasts and moulds. Sensory panels were trained on a 9-point hedonic scale using commercial dried mango as the reference product [8].

Materials and Methods
Materials
Ripe jackfruit (variety 'Kenya Coast') was sourced from smallholder orchards within 20 km of the Coastal Agricultural Institute, Mombasa (4°03′ S, 39°40′ E, 18 m a.s.l.). Fruits were selected at the eating-ripe stage (TSS 22-26 °Brix), washed, deseeded, and separated into individual bulbs. A central composite design with three factors at five levels was employed: sugar concentration (30, 40, 50, 60, 70 °Brix), immersion time (2, 3, 4, 5, 6 h), and slice thickness (5, 8, 10, 12, 15 mm), generating 20 experimental runs. The fruit-to-solution ratio was fixed at 1:4 (w/v). Research was conducted between March and August 2023 [9].

Methods
Osmotic dehydration was carried out in stainless-steel vessels at 40 °C in a water bath. After immersion, slices were rinsed with distilled water for 10 s, blotted dry, and air-dried in a cabinet dryer at 60 °C until moisture content reached 14±1%. Water loss (WL) and solid gain (SG) were calculated gravimetrically. TSS was measured with a digital refractometer. Colour was recorded using a Hunter Lab colorimeter (L*, a*, b*). Sensory evaluation involved 30 semi-trained panellists scoring appearance, texture, flavour, and overall acceptance. Data were analysed using Design-Expert 13 for response surface modelling and R for ANOVA.

Results
Water loss increased with both sugar concentration and immersion time up to 60 °Brix and 4 h, beyond which gains plateaued (Table 1). Maximum WL (42.3%) and sensory score (8.2/9) coincided at 60 °Brix, 4 h, and 8 mm thickness. Solid gain rose linearly with concentration but excessive gain at 70 °Brix produced an overly sweet, leathery texture that lowered sensory acceptance to 6.4.

Table 1: Effect of osmotic dehydration parameters on water loss, solid gain, TSS, and sensory score (selected runs)

Conc. (°Brix)	Time (h)	Thick. (mm)	WL (%)	SG (%)	TSS (°Brix)	Sensory (1-9)
30	2	10	18.4	4.2	9.2	5.8
40	3	8	27.6	6.8	12.8	7.1
50	4	10	34.8	9.3	16.4	7.6
60	4	8	42.3	11.7	19.1	8.2
70	5	8	43.1	15.4	22.7	6.4
60	6	15	38.7	12.1	17.8	7.3

Table 2: Shelf-life parameters of optimised product stored at 25 °C for 90 days

Day	Moisture (%)	TPC (log CFU/g)	Sensory score
0	13.8	1.7	8.2
30	14.1	2.3	8.0
60	14.6	2.8	7.6
90	15.2	3.1	7.1

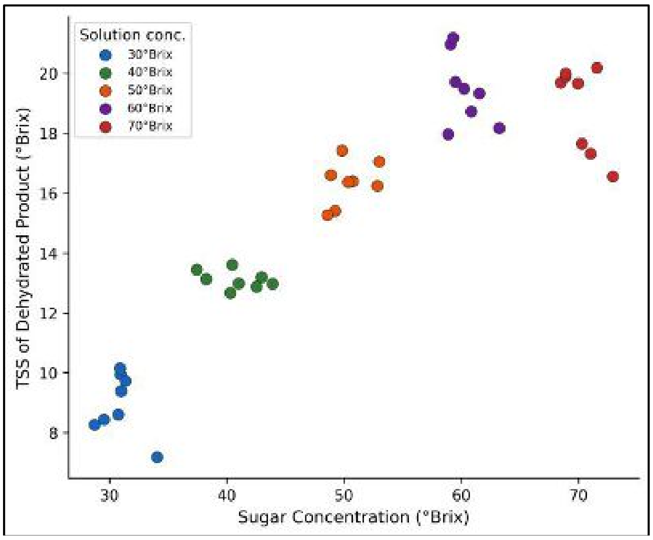

Fig 1: Relationship between osmotic solution concentration and TSS of dehydrated jackfruit slices at different immersion times.

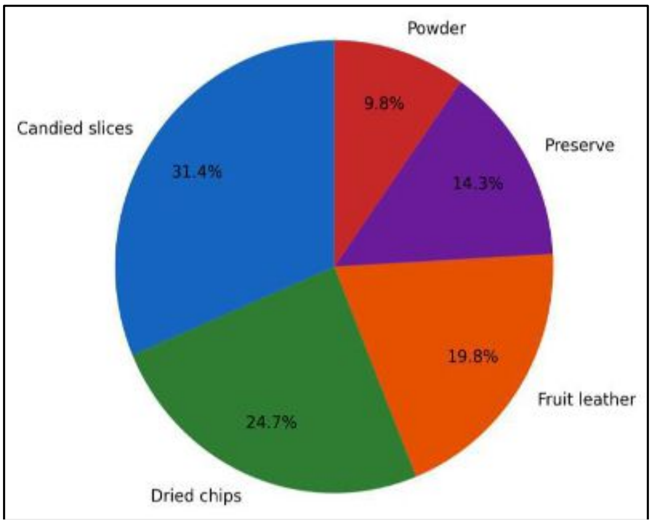

Fig 2: Consumer preference distribution for five jackfruit product types based on sensory panel responses (n = 60).

Comprehensive Interpretation
Response surface modelling identified sugar concentration as the most influential factor ($F = 78.4$, $p<0.001$), followed by immersion time ($F = 34.2$) and slice thickness ($F = 12.7$). The interaction between concentration and time was significant ($p = 0.003$), while the concentration-thickness interaction was not ($p = 0.14$). The model's adjusted R^2 of 0.94 indicates good predictive ability within the tested factor space [10].

Discussion
The plateau in water loss above 60 °Brix is consistent with osmotic dehydration theory: at very high solute concentrations, a dense sugar crust forms on the fruit surface, slowing further mass transfer [3, 4]. The 42.3% WL at the optimum is comparable to values reported for mango (38-45%) and pineapple (40-48%) under similar conditions [5, 6].

The 90-day shelf stability at ambient temperature is encouraging for rural Kenyan processors who lack refrigeration. Total plate count stayed below the 4 log CFU g^{-1} safety limit throughout, likely because the combined low water activity ($a_w = 0.68$) and mild acidity (pH 4.3)

suppress microbial growth [11, 12]. Sensory scores dropped only marginally—from 8.2 to 7.1—mostly reflecting slight colour darkening due to non-enzymatic browning [13].
Production cost for 1 kg of candied jackfruit was approximately KES 180 (USD 1.30), while the retail value of comparable dried tropical fruits in Mombasa supermarkets ranges from KES 450-600 per kg, giving a potential gross margin of 150-230% [14]. The main bottleneck is access to food-grade sugar at affordable prices in rural areas.

Conclusion
Osmotic dehydration at 60 °Brix for 4 hours with 8 mm slice thickness produced jackfruit candied slices with high sensory acceptance (8.2/9) and 90-day shelf stability without refrigeration. The process requires only sugar, citric acid, and a simple cabinet dryer, making it accessible to smallholder groups along Kenya's coast. Scaling this technology through women's cooperatives and linking to urban and export markets could convert a seasonal glut into a year-round income stream. Future work should test alternative osmotic agents like honey and explore solar drying as an energy-saving finish [15].

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Contributions Not Qualifying for Authorship
Ms. Wanjiku Maina coordinated the sensory evaluation panels.

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