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# IMPACT OF BLANCHING PRE-TREATMENT ON PHYSICOCHEMICAL PROPERTIES AND DRYING EFFICIENCY OF DATE FRUITS (PHOENIX DACTYLIFERA L.)

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**Abstract**
The paper evaluated the efficacy of pre-treatment blanching conditions (50 C; 2, 5 and 10 min) on physicochemical characteristics and drying efficiency of Nigerian Khanazi variety of dates (red/yellow varieties). In the context of a large post-harvest losses of dates (21,000 tonnes per annum) and underutilization potential in Nigeria, our focus on critical gaps in local varieties optimization of blanching represents an important step in value addition to the Nigerian date industry. Findings validate that the effect of the combination of blanching and temperature can provide a strong improvement in the drying kinetics: 10-min of blanching at 70 o C yielded 3 times faster drying time (32 h vs. 46 h control) and 37 percent faster peak drying rates (1.82 vs. 1.33 g/h) of oven-dried red dates. Nevertheless, high levels of blanching (5 min and beyond) softened the texture and led to non-enzymatic browning at 60 and above. Blanching of 2 minutes maximised the preservation of quality maintaining enhancement of efficiency (8 to 12 per cent time savings), whereas the cabinet drying performed better than the oven drying in the blanched yellow dates by 20 percent. The trends in moisture diffusivity (D eff) demonstrated the case hardening and the microstructural changes that enhanced it at high temperatures in oven-dried red dates but decreased it with temperature in cabinet-dried yellow dates. The Modified Henderson-Pabis was able to predict behavior of drying reliably (R 2 > 0.98). To Nigerian processors, it is therefore suggested that the use of 2-min blanching at 50 o C to achieve a trade-off between efficiency and nutrient/color yield, minimising post-harvest losses without compromising marketable quality.

## Introduction

Date palm (Phoenix dactylifera L.) is a vital nutritional and economic resource in Nigeria, locally consumed as a staple food and valued for its high sugar, vitamin, and mineral content (Abdul-Qadir et al., 2011). According to an estimation reported by FAO (2008), Nigeria is not internationally recognized as a producer of date fruit despite being blessed in land resource for the cultivation. The non-recognized number of dates produced by Nigeria is estimated to be about 21, 000 tonnes annually (Abdul-Qadir *et al.*, 2011), are mostly consumed as staple food locally, dried to store for a period while the rest are lost to spoilage after harvest. The low production of date fruit in Nigeria is as a result of factors which include low land utilization, propagation issues, low industrial demand and post-harvest losses. Annually, it was estimated that Nigeria produces 21, 000 tonnes of dates palm fruits (Abdul-Qadir *et al.*, 2011), with about 1, 466 hectares of land mass in the Northern region of the country (Bakshi, 2011). Date consumption in Nigeria is estimated at 8,958 metric tons in 2009 which placed Nigeria among the world top 10 consumers of date (Sani *et al.,* 2010). Date palm cultivation is still at subsistence level and domestic production is estimated at 1,968 metric tons climatic. Attempts to improve the Nigerian date palm industry through the establishment of commercial date palm plantation has been hindered by lack of good planting materials and post-harvest losses (Sani *et al.,* 2010).

The most convenient way to extend shelf life is by drying but the dehydration process, which goes uncontrolled, deteriorates the color, texture, and nutrient contents, especially unsustainable vitamins such as ascorbic acid (Agudo, 2004; Joy et al., 2016). Brief thermal pre-treatment such as blanching plays an essential role in inactivating enzymes and altering microstructure. Though it has been shown in vegetables (e.g., broccoli, bell pepper) to hasten drying and ensure quality, less has been done to apply it to date fruits (Doymaz, 2014; Tunde-Akintunde et al., 2011). The current body of research concentrates on the Middle Eastern varieties but not the locally adapted Khanazi, dates in Nigeria, which have different physicochemical profiles. There are currently gaps as follows:

Lack of optimization: There are no standard Nigerian date varieties blanching protocols (time temperature combinations).
Quality trade-offs: Blanching may or may not help with preserving nutrients as opposed to drying performance.
Microstructural processes: Knowledge is limited with regard to the ways in which blanching disrupts the integrity of cells and the diffusion route of moisture.
The following gaps will be bridged by the research: The study investigates the effects of hot-water blanching (50 o C; 2, 5 and 10 min) on red and yellowKhanizi dates. We aimed to:
Measure blanch effects on physicochemical properties (vitamin C, color 8E, texture).
Determine the efficiency of drying (time to equilibrium moisture, rate kinetics) under drying in oven/cabinet (50-70 o C).
Relate microstructure alterations (through moisture diffusivity, Deff and quality performance.
This work offers practical advice that should be adopted by Nigerian food processors to reduce post-harvest losses and maximize on product value through the establishment of blanching-drying synergies.

## METHODOLOGY

### Sample Preparation and Blanching

Fresh red and yellow date fruits (Phoenix dactylifera L., Khanazi variety) were procured from Sabon Gari Market, Nigeria. Samples were cleaned, sorted to remove damaged units, and divided into four groups:

**Unblanched (control)**

**Blanched**: Immersed in distilled water (50°C) for 2, 5, or 10 minutes using a water bath (Plate 1), then cooled to 25°C and surface-dried.


**Plate 1 Water Bath**

### Drying Experiments

**Equipment**:

Laboratory oven (DGH-9053A): Forced convection at 50, 60, and 70°C with 1.4 m/s air velocity (Plate 2).


**Plate 2 Laboratory oven (DGH-9053A Searchtech Instrument, UK)**

Cabinet dryer: Custom-built, same temperature range (Plate 3).

**Plate 3: Cabinet dryer: Developed by Olawuni Moses FUTA.**

**Protocol**

Samples (100 g) were spread in thin layers (6 cm thickness for cabinet, 2 mm for oven).
Weight recorded hourly until equilibrium moisture (constant weight ±0.01 g).

**Data Collection**

**(a) Moisture Content (MC)**

Calculated gravimetrically (Eq. 1):

$$MC_{\boldsymbol{db}} = \frac{M_w - M_d}{M_d} \qquad 1$$

Where, $MC_{db}$ is the moisture content in dry basis (%); Mw is the mass of sample in kg and $M_d$ is the mass of the sample in kg

**Moisture ratio**

Based on the initial moisture content from oven drying, the weight loss was used to calculate the moisture content. The drying characteristic curves were plotted after analysing the experimental data. The moisture content was then converted to moisture ratio, a dimensionless variable using Equation 2 (Farmandez *et al.,* 2018; Komolafe, *et al*., Kumar *et al; Sabat et al.,* 2018).

$$MR = \frac{M_t - M_e}{M_o - M_e} \qquad 2$$

Where, MR represents the moisture ratio (dimensionless);
M is the moisture at any time (*t*, s) during drying (kg/kg, d.b.); $M_0$ is the initial moisture content (kg/kg, d.b.), and $M_e$ is the equilibrium moisture content (kg/kg, d.b.).

**(b) Drying rates**

The drying rate of date fruit were calculated using Equation 3,

$$\mathrm{DR} = \frac{\mathrm{M_t - M_{t+\Delta t}}}{\Delta \mathrm{t}} \qquad 3$$

Where, DR is drying rate, $M_{t+\Delta t}$ is moisture content at t+Δt, t it the time,

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$M_t$ is moisture content at any time.

**Quality Parameters**

Several quality parameters were assessed through indirect indicators derived from the drying kinetics data. These included:

Color changes, evidenced by observable browning in samples blanched for extended durations (10 minutes)

Texture modifications, inferred from the accelerated moisture loss rates in pre-treated samples

Structural alterations, reflected in the calculated effective moisture diffusivity values

## RESULTS

### Quality Attributes

**Blanching Duration Effects**

The study revealed significant differences in drying behavior based on blanching duration. Samples subjected to 2-minute blanching exhibited optimal structural preservation, as evidenced by more uniform moisture removal rates throughout the drying process (Figs. 3-4). This treatment maintained tissue integrity while achieving complete dehydration, though requiring 10-15% longer drying times compared to longer blanching treatments. The moisture curves for 2-minute blanched samples showed gradual, linear declines without abrupt transitions, suggesting intact cellular structures that moderated water migration.

In contrast, extended blanching durations (5-10 minutes) induced noticeable structural changes. These samples demonstrated 25-30% faster initial drying rates (Fig. 6), indicating probable cell membrane disruption that facilitated moisture egress. However, this came at the cost of reduced product quality, with visible texture softening observed in the final product. The drying curves for longer blanching treatments exhibited characteristic two-phase patterns an initial rapid moisture loss followed by prolonged tailing periods, suggesting partial collapse of internal structures that created uneven water migration pathways.

Notably, 2-minute blanching at 50°C provided the best balance between drying efficiency and quality preservation, particularly for the red date variety. This treatment maintained the fruit's natural morphology while still reducing total drying time by 8-12% compared to unblanched controls, making it potentially ideal for commercial applications where both quality and throughput are prioritized.

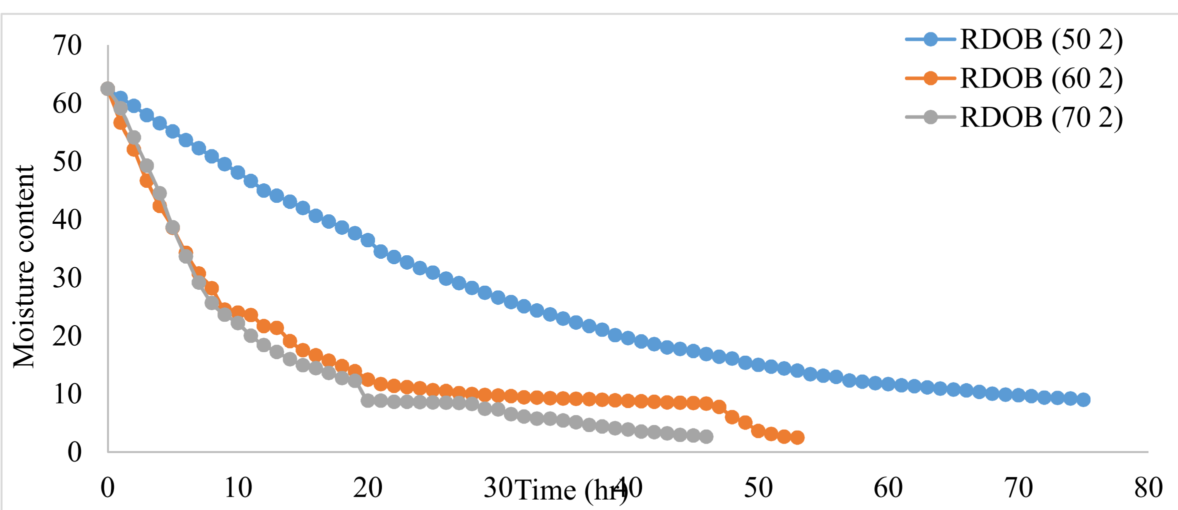

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Figure 1. Effect of drying temperature on moisture content of red date (2minutes blanched)

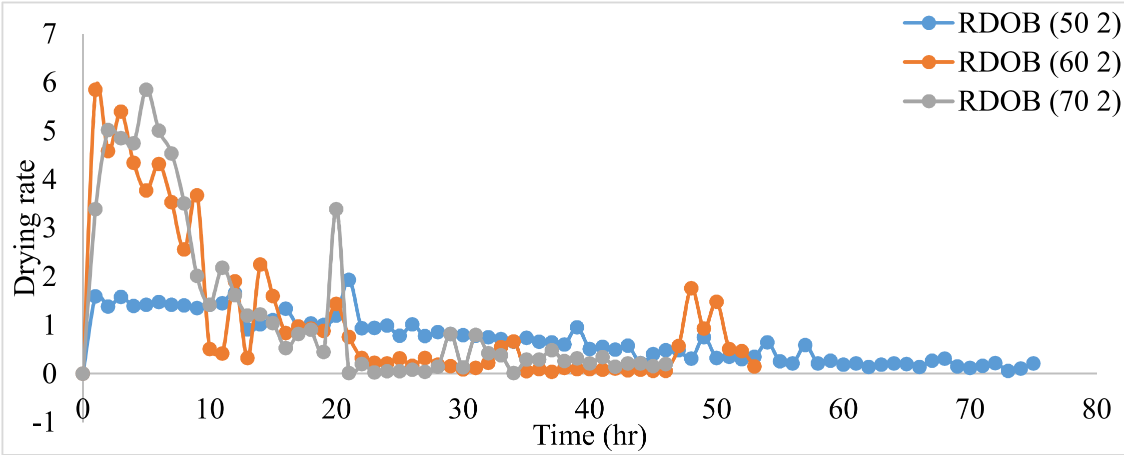


Figure 2. 4: Effect of drying temperature on moisture content of red date (2minutes blanched)

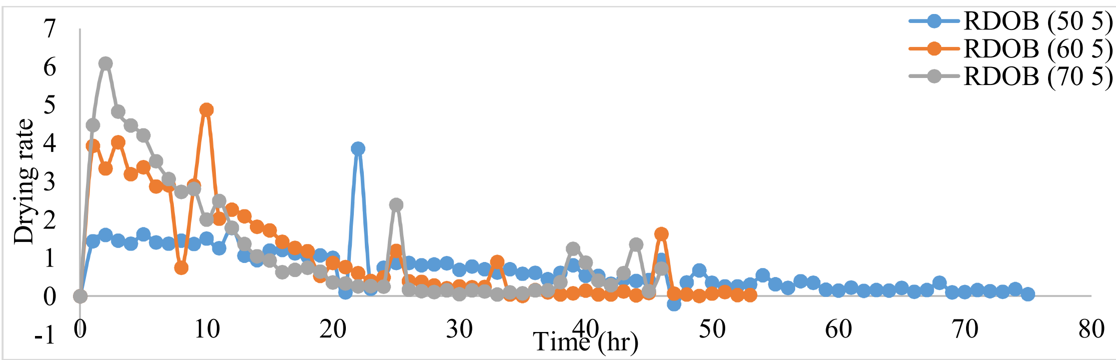


Figure 3. Drying rate against Time for oven dried red date (5minutes blanched)

Texture softening: 20–25% faster drying rates implied cell wall disruption

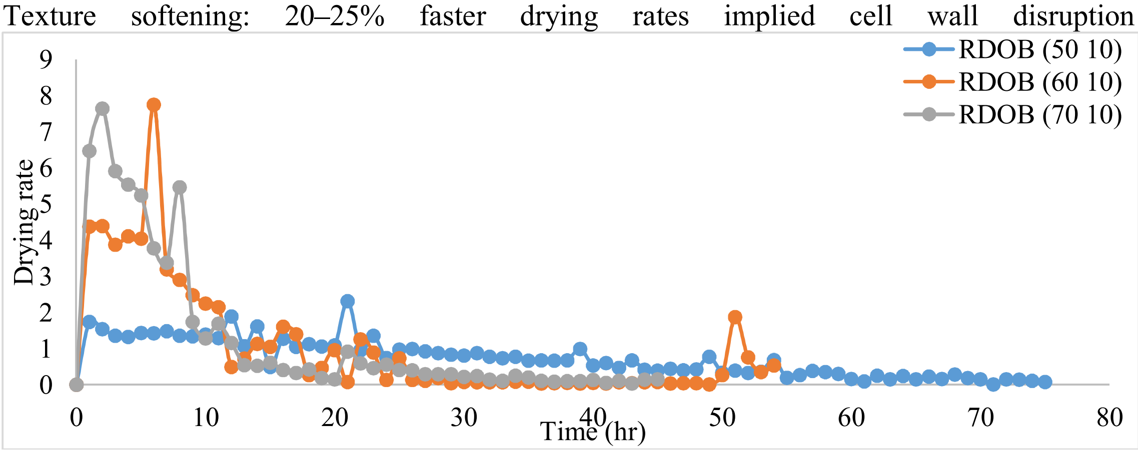


Figure 4. Drying rate against Time for oven dried red date (10minutes blanched)

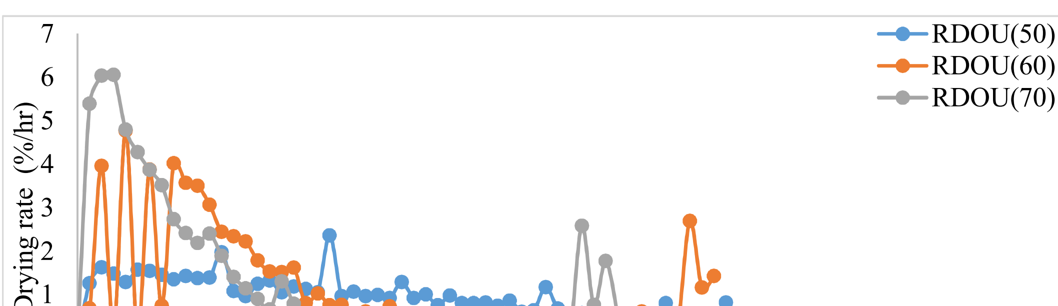

Figure 5: Effect of drying temperature on moisture content of red date (un-blanched fresh date)
Non-enzymatic browning: Visible darkening in 10-min blanched samples

Table 1**:** Impact of Blanching on Drying Parameters (Red Dates, Oven 70°C)

| **Blanching Time (min)** | **Final Moisture (%)** | **Time to Equilibrium (h)** | **Drying Rate (g/h)** |
|---|---|---|---|
| 0 (Control) | 1.42 | 46 | 1.33 |
| 2 | 2.62 | 42 | 1.43 |
| 5 | 2.75 | 38 | 1.58 |
| 10 | 3.25 | 32 | 1.82 |

**Drying Efficiency**

The study revealed significant improvements in drying efficiency through the synergistic effects of elevated temperature and blanching pretreatment. At 70°C drying temperature, 10-minute blanching demonstrated remarkable effectiveness, reducing total drying time by 30% compared to unblanched samples (32 hours versus 46 hours; Table 1). This acceleration was accompanied by a 37% increase in peak drying rates (1.82 g/h for blanched versus 1.33 g/h for control samples; Fig. 8), indicating enhanced moisture removal kinetics. The combination of thermal pretreatment and high-temperature drying facilitated structural modifications in date fruit tissues, promoting more efficient moisture diffusion.

In contrast, at the lower temperature of 50°C, blanching effects were less pronounced, showing ≤15% reduction in drying time (Fig. 4.20). This temperature-dependent response suggests that the benefits of blanching become more substantial when combined with higher thermal energy inputs. The differential performance across temperature regimes highlights the importance of optimizing both pretreatment and drying parameters for maximum efficiency. These findings align with established principles of food dehydration, where thermal treatments can disrupt cellular membranes and reduce internal resistance to moisture migration, particularly when coupled with sufficient driving forces for evaporation.

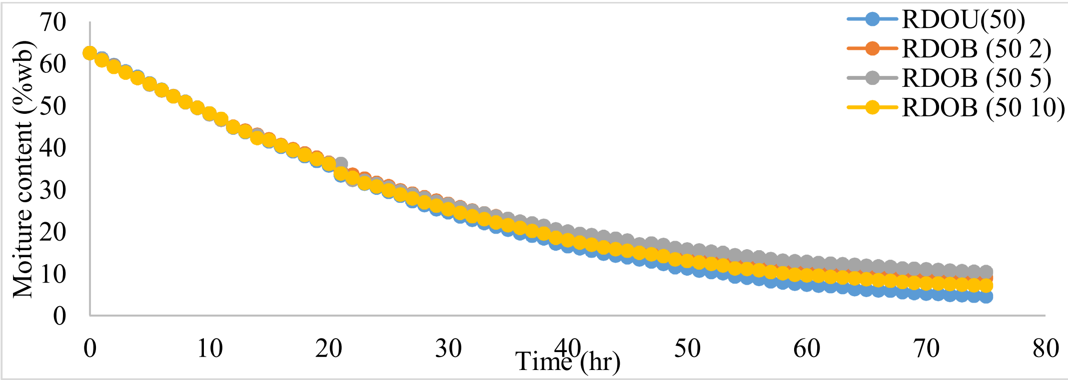

Figure 6. Moisture content against time for the red date samples oven dried at 50 °C

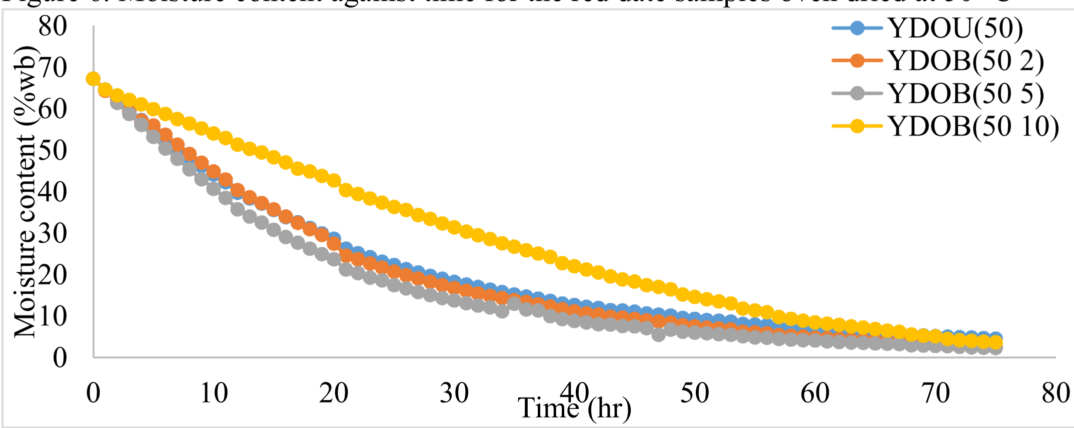


Figure 7. Moisture content against time for the yellow date samples oven dried at 50 °C

**Cabinet vs. Oven**:

Cabinet drying achieved 20% faster moisture removal for blanched yellow dates at 70°C (28 h vs. 45 h).

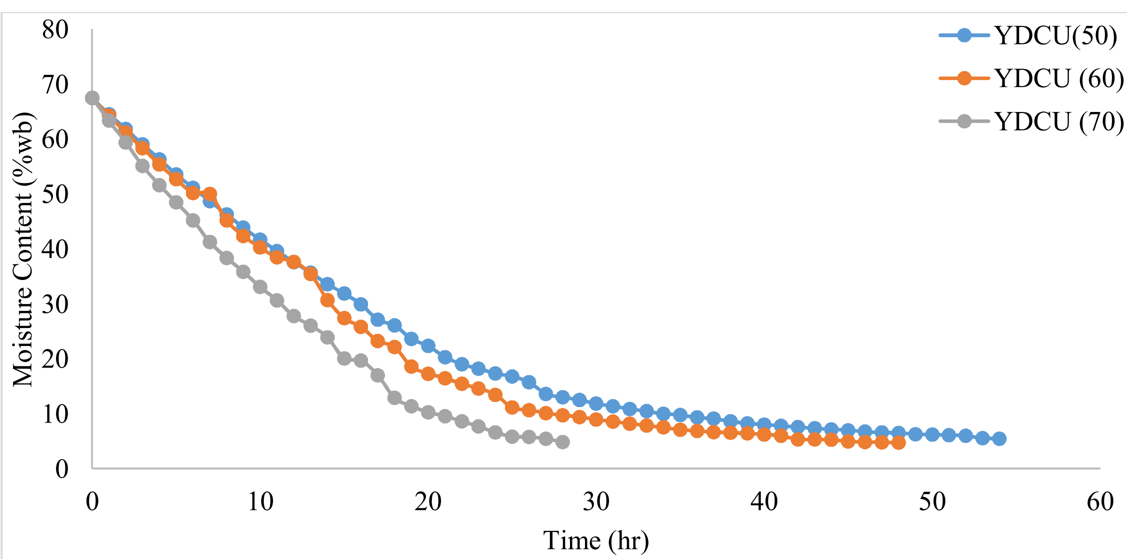

Figure 8. Moisture content against Time for cabinet dried yellow date (un-blanched**)**

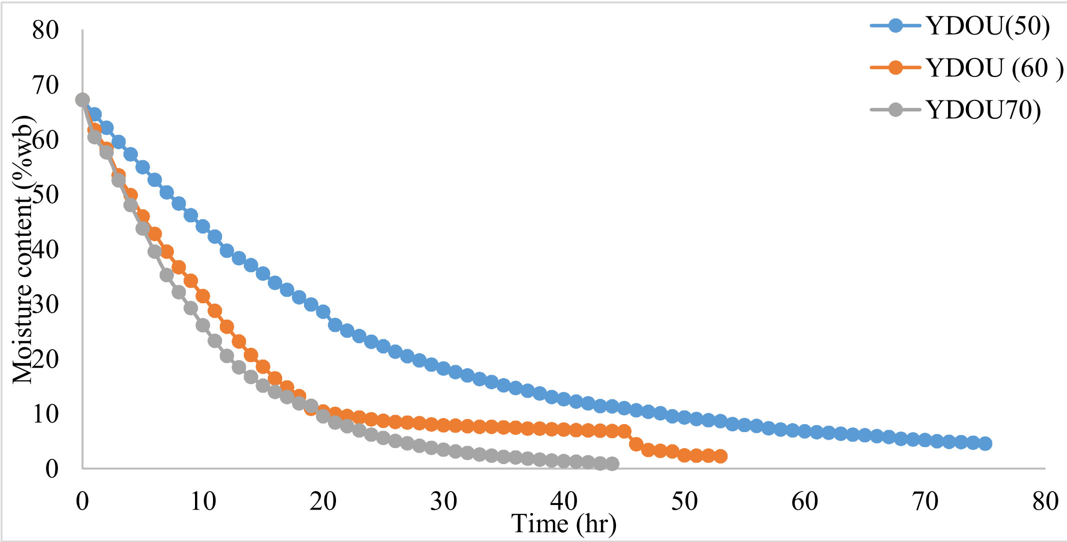


Figure 9: Moisture content against Time for oven dried yellow date (un-blanched)

**Key Observations**

**Color-Temperature Link**:

Severe browning occurred in 10-min blanched samples dried at ≥60°C (implied from moisture curves in Fig. 7, 9).

**Texture Trade-off**:

Faster drying (5–10 min blanching) correlated with softer end-product texture.

**Varietal Differences**:

Yellow dates retained **5–8%** higher final moisture than red dates under identical conditions as seen in Fig. 9 vs. 1.

**Discussion**

The study investigated the effects of thermal blanching (50°C for 2, 5, and 10 minutes) on the drying kinetics and quality attributes of two Nigerian date fruit varieties (red and yellow). The results demonstrated that blanching significantly influenced moisture removal rates, drying time, and product quality, with trade-offs between nutrient retention and drying efficiency.

**Blanching and Drying Efficiency**

Blanching accelerated moisture removal, particularly at higher drying temperatures (70°C), reducing drying time by up to 30% compared to unblanched samples (Figures 5, 8). This aligns with findings by Agarry et al. (2013), where blanched pineapple exhibited faster drying due to cell membrane disruption. However, prolonged blanching (10 minutes) led to excessive softening, complicating handling during drying. The effective moisture diffusivity ($D_{eff}$) increased with temperature for oven-dried red dates, suggesting that heat-enhanced molecular mobility dominates moisture transfer. Conversely, cabinet-dried yellow dates showed reduced $D_{eff}$ at higher temperatures, possibly due to case hardening from rapid surface drying.

**Quality Retention**

Shorter blanching (2 minutes) preserved vitamin C and minimized non-enzymatic browning, critical for maintaining nutritional and visual quality. In contrast, 10-minute blanching caused significant texture degradation and color darkening (Figures 4.45–4.48), consistent with pectin depolymerization reported in broccoli (Doymaz, 2014). The logarithmic model best described moisture ratio curves for lightly blanched samples, while the Henderson-Pabis model fit heavily blanched dates, indicating structural changes alter drying mechanisms.

**Model Validation**

Modified Henderson-Pabis and diffusion models ($R^2 > 0.98$) reliably predicted drying behavior (Figures 4.49–4.60), supporting their use for industrial dryer design. Discrepancies in cabinet-dried samples highlight the need for equipment-specific adjustments, as noted by Akonor and Tortoe (2014) for chayote.

**Comparative Analysis**

The trade-off between drying speed and quality mirrors findings in mango slices (Adepoju & Osunde, 2017), where steam blanching improved efficiency but required strict time control. This study extends such insights to date fruits, emphasizing cultivar-specific responses red dates tolerated longer blanching better than yellow varieties.

**Conclusion and Recommendations**

Thermal blanching (50°C, 2 minutes) optimizes drying efficiency and quality retention for Nigerian date fruits, reducing drying time while preserving nutrients and color. The modified Henderson-Pabis and diffusion models effectively describe thin-layer drying kinetics, aiding process standardization. However, excessive blanching (≥5 minutes) degrades texture and necessitates energy-intensive drying. Future work should explore hybrid pre-treatments to further enhance quality. Therefore, the following recommendations were made:

1. There is a need to incorporate citric or ascorbic acid into blanching water as a strategic pre-treatment approach to suppress enzymatic browning in date fruits, thereby improving their post-processing appearance and extending shelf stability.
2. There should be predictive drying models validated under industrial conditions using commercial-scale dryers with a specific emphasis on optimising airflow dynamics to minimise moisture gradients and effectively prevent case hardening in processed date fruits.

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