STM JOURNALS

Journal of
Modern Chemistry &
Chemical Technology

ISSN: 2229-6999 (Online)
ISSN: 2321-5208 (Print)
Volume 16, Issue 1, 2025
January–April
DOI (Journal): 10.37591/JoMCCT

https://journals.stmjournals.com/jomcct

Research JoMCCT

A Comparative Study of Oven, Spouted Bed, and Convective Tunnel Drying Methods of Mango for Oil Production

Uku Eruni Philip[1,*], Ozioko Fabian Chidiebere[2]

Abstract

Mango seeds, with a high moisture content exceeding 70% (wet basis) require effective drying methods to ensure their preservation and to enhance the quality of derivative products like mango seed oil. Proper drying is essential to inhibit enzymatic activity and microbial growth, which extends the shelf life of these seeds. This study investigates multiple drying techniques, including conventional oven drying, spouted bed drying, and convective tunnel drying, to determine their effectiveness in moisture reduction, oil quality improvement, and microstructural transformation. Oven drying, a commonly used method, is simple but often leads to uneven drying and potential overheating, which can degrade oil quality. Advanced methods like spouted bed drying and convective tunnel drying show promise in addressing these challenges. Spouted bed drying facilitates uniform heat and mass transfer due to seed suspension, while convective tunnel drying offers controlled airflow and temperature conditions, enhancing moisture removal efficiency. The study uses scanning electron microscopy to examine the structural changes in mango seeds post-drying. The micrographs reveal that spouted bed drying and tunnel drying produce significant alterations in seed microstructure, creating pathways that improve oil diffusion. This structural optimization results in higher oil yield and quality, as indicated by key parameters such as free fatty acid content, peroxide value, and color stability. The findings emphasize the comparative advantages of advanced drying techniques over conventional methods. Spouted bed drying, in particular, emerges as a highly efficient technique for balancing moisture removal with preservation of oil quality. These insights contribute to the development of optimized drying protocols that maximize oil extraction potential while maintaining the nutritional and physicochemical properties of mango seed oil. By identifying optimal drying conditions, this research aids in advancing sustainable processing techniques for mango seeds, aligning with the goals of value addition and waste minimization in agro-industrial sectors.

Keywords: Oven, spouted bed, drying methods, mango, oil production

***Author for Correspondence**
Uku Eruni Philip
E-mail: bookings.bestino@gmail.com

[1]Lecturer, Chemical Engineering Department, Federal University Otuoke, Bayelsa State, Nigeria
[2]Lecturer, Chemical Engineering Department, Delta State University, Ozoro, Delta State, Nigeria

Received Date: December 27, 2024
Accepted Date: January 03, 2025
Published Date: January 20, 2025

Citation: Uku Eruni Philip, Ozioko Fabian Chidiebere. A Comparative Study of Oven, Spouted Bed, and Convective Tunnel Drying Methods of Mango for Oil Production. Journal of Modern Chemistry & Chemical Technology. 2025; 16(1): 15–19p.

INTRODUCTION

Mango (*Mangifera indica*) seeds, a byproduct of mango processing, are often discarded despite their potential as a valuable source of oil and other bioactive compounds. Mango seed oil has several applications in cosmetics, pharmaceuticals, and food industries. However, the high moisture content (>70% wet basis) of mango seeds poses significant challenges for storage, preservation, and oil extraction. Drying is an essential pre-treatment step in mango seed processing, as it reduces moisture, preventing microbial growth and enzymatic spoilage, while also enhancing the yield and quality of the extracted oil [1–5].

Traditional drying methods, such as oven drying, have been commonly employed to reduce the moisture content of mango seeds. However, alternative drying techniques, such as spouted bed drying and convective tunnel drying, have been proposed as potentially more efficient methods. These modern techniques may offer advantages in terms of drying time, energy consumption, and oil quality. This paper reviews the different drying methods applied to mango seeds, compares their effects on oil extraction, and investigates the structural changes in the seed as a result of these drying techniques [6–10].

METHODOLOGY

The study examines three drying methods: conventional oven drying, spouted bed drying, and convective tunnel drying.

1. *Oven drying*: Mango seeds were dried at low temperatures (<50°C) for 1 to 2 days. The drying process was monitored by recording the change in seed mass and moisture content over time.
2. *Spouted bed drying*: Mango seeds were pre-dried using a spouted bed dryer under the following conditions: air temperature of 70°C, air velocity of 10.5 m/s, and drying time of 4 hours, based on findings from Chielle et al. [1]. Moisture reduction was observed, and the oil extraction potential was evaluated by extracting oil from the dried seeds.
3. *Convective tunnel drying*: Mango seeds were dried in a convective tunnel dryer at an atmospheric temperature of 70°C and air velocity of 2 m/s, also as per the methodology suggested by Chielle et al. [1]. The moisture content and oil yield were recorded and compared with those from spouted bed drying and oven drying.

The dried mango seeds were subjected to oil extraction using a solvent-based method, and the yield was measured. Scanning electron microscopy (SEM) was used to observe the microstructure of the mango seeds before and after drying, providing insights into the structural changes that could influence oil extraction efficiency.

Determination of Crude Fiber of Agro Seed Oil

Crude fiber refers to the insoluble and combustible organic residue that remains after a sample undergoes successive treatments with light petroleum spirit, boiling dilute sulfuric acid, boiling dilute sodium hydroxide, and alcohol. It mainly consists of cellulose, lignin, and hemicellulose.

Principle

Starch and protein are dissolved when the sample is boiled with sulfuric acid followed by sodium hydroxide. The remaining residue, which is the fiber, is washed, dried, and weighed. After ashing the residue, the weight of the ash is subtracted from the fiber weight. This method is empirical, so it is essential to follow the procedure carefully.

Procedure

Alkaline Hydrolysis

1. Add 25 mL of 1.25 NaOH solution to the residue in a beaker containing 100 mL of acid.
2. Boil the mixture for 2 to 3 minutes, then allow it to cool for filtration.
3. Filter the mixture using filter paper and wash the residue with distilled water.
4. Dry the filtered residue in an oven at 105°C for 1 hour, then record the weight of the residue.
5. Ash the filter paper and combine it with the residual material in one container.
6. Heat the mixture at 550°C for 3 hours to obtain the ash, and record the results.

Calculate the crude fiber using the following formula:

Crude fiber (g) = Weight of residue – Actual ash

The percentage of crude fiber can be determined by dividing the weight of the residue by the original sample weight.

Calculation

Weight of residue (g) = (Weight of filter paper + residue) – (Weight. of filter paper)
= 1.056 – 0.994 = 0.062 g

Weight of ash (g) = (Weight of crucible + ash) – (Weight of crucible)
= 25.698 – 25.675 = 0.023 g

Actual ash (g) = Weight of ash – Blank (ash weight of empty filter paper)
Actual ash (g) = 0.023g – 0.002g = 0.021 g

Crude fiber (g) = Weight of residue – Actual ash
=0.062 – 0.021 = 0.041 g

$$\% \text{ Crude fiber} = \frac{Crude\ fiber}{Sample\ weight} \times \frac{100}{1}$$

RESULTS AND DISCUSSION

Figure 1 shows the theoretical evaluation of the extract recovered from native pear seed oil of 400 g initial mass (Eludicote species) upon the effect of time. The result demonstrate decrease in the initial feed mass of 350 g of the native pear seed oil with increase in the oil extracted from the process with respect to times. However, the theoretical regression equation of each behavior is shown in Figure 1 as $Y_{IC} = -0.0043x^2 - 0.5202x + 149.97$ (initial concentration by mass g), $Y_{RC} = 0.0043x^2 + 0.5202x + 0.0308$ (recovered volume in mL), and $Y = -0.0024x^2 + 0.2041x + 0.0271$ (final concentration) in terms of polynomial expression of quadratic equation and the best fit of the square root of the polynomial expression in terms of its reliability are $R_{IC}^2 = 0.9988$ (99.98%), $R_{RC}^2 = 0.9988$ (99.98%), and $R_{FC}^2 = 0.9729$ (96.36%). The above polynomial expression of the quadratic equation defines the rate of initial native pear seed mesh conversion with extracted oil. This has further revealed the significance of the extraction model adopted to monitor the initial concentration, volume of oil recovered and the final concentration using the mechanothermal approach in oil production for domestic application, pharmaceutical, chemical, and industrial utilization.

Figure 2 shows the theoretical evaluation of the extract recovered from native pear seed oil of initial mass (Eludicote species) upon the effect of time. The result demonstrate decrease in the initial concentration of the native pear seed oil with increase in the oil extracted from the process with respect

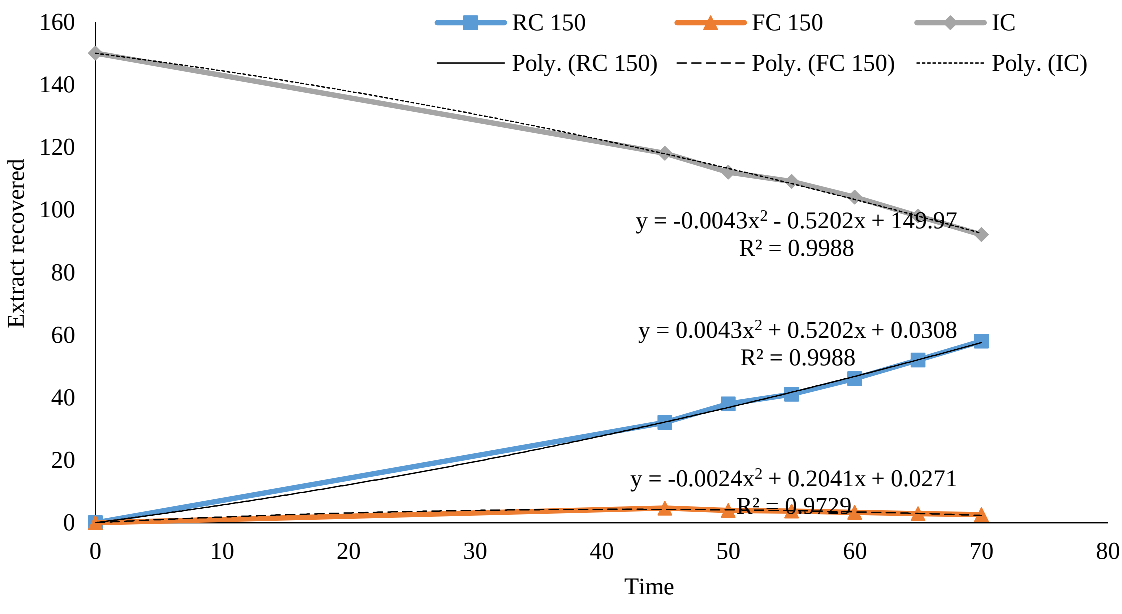

Figure 1. Functional parameters of extract recovered from local pear seed oil.

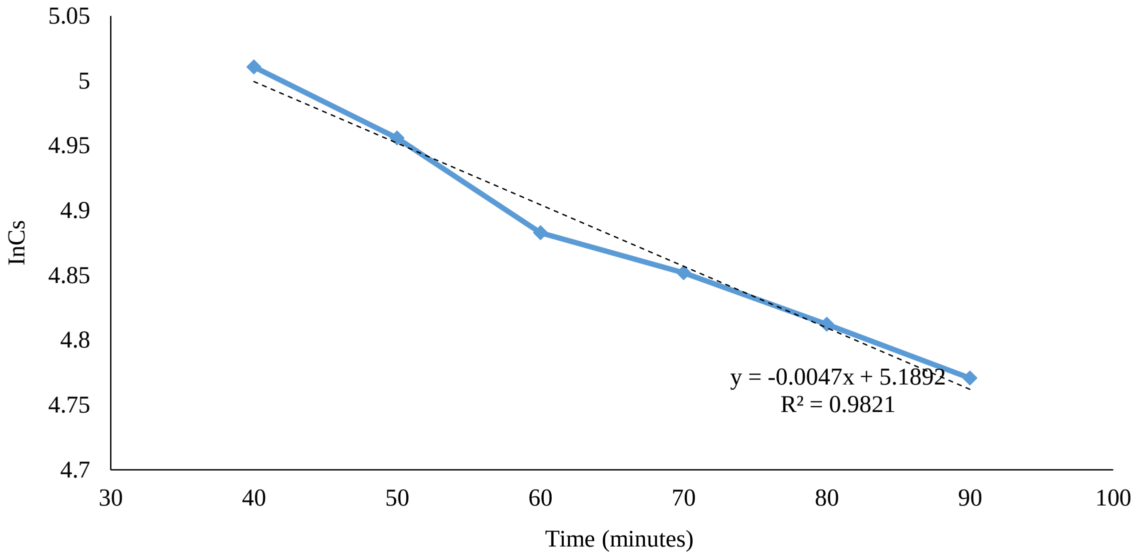

Figure 2. Concentration of oil recovered against time.

to times. However, the theoretical regression equation of each behavior is shown in Figure 2 as Y = 0.004*x* + 5.1892 (initial concentration by mass g), (Recovered volume in mL) and (final concentration g) and the best fit of the square root of the polynomial expression in terms of its reliability is $R^2 = 0.9821$ (99.21%) .The above polynomial expression of the quadratic equation define the rate of initial native pear seed mesh conversion with extracted oil. This has further revealed the significance of the extraction model adopted to monitor the initial concentration, volume of oil recovered and the final concentration using the mechanothermal approach in oil production for domestic application, pharmaceutical, chemical, and industrial utilization.

The results indicate that all three drying methods significantly reduced the moisture content of mango seeds, with the spouted bed and convective tunnel drying methods showing faster drying times compared to oven drying. Oven drying took 1 to 2 days, while the spouted bed and convective tunnel methods completed the drying process within 4 hours. The faster drying time in the alternative methods may be due to the enhanced heat and mass transfer facilitated by high air velocity and the turbulent flow in the drying chambers. Oil yield from mango seeds was the highest when the seeds were dried using the spouted bed method, followed by the convective tunnel dryer. The oven-dried seeds had the lowest oil yield, which could be attributed to prolonged drying times that might have led to oil degradation or loss. The SEM images of the dried mango seeds revealed significant structural changes. After drying, the seeds' surface became more porous and brittle, which is ideal for oil extraction. This porosity is essential because it increases the surface area and enhances the diffusion of oil from the seed into the extraction medium, as observed by Tan et al. [2].

In terms of oil quality, the spouted bed and convective tunnel drying methods produced higher-quality oil compared to the oven drying method. The oil extracted from seeds dried using modern techniques had lower acidity and peroxide values, suggesting better preservation of oil quality during the drying process.

CONCLUSION

The study demonstrates that spouted bed and convective tunnel drying methods are more effective than traditional oven drying in terms of reducing drying time, enhancing oil yield, and preserving oil quality. the faster drying times, coupled with improved structural changes in the seeds, make these methods particularly advantageous for industrial-scale mango seed oil production. SEM analysis revealed that drying significantly alters the seed structure, enhancing oil diffusion and extraction efficiency. future research should focus on optimizing drying parameters to further improve energy efficiency and product quality.

REFERENCES

1. Ekorong FJA, Zomegni G, Desobgo SC, Ndjouenkeu R. Optimization of drying parameters for mango seed kernels using central composite design. Bioresour Bioprocess. 2015;2:8. DOI:10.1186/s40643-015-0036-x.
2. Tacias-Pascacio VG, Castañeda-Valbuena D, Fernandez-Lafuente R, Berenguer-Murcia Á, Meza-Gordillo R, Gutiérrez LF, et al. Phenolic compounds in mango fruit: A review. J Food Meas Charact. 2022;16:619–36. DOI:10.1007/s11694-021-01192-2.
3. Singh S, Sharma RK. Mango seed: a potential source of oil and other bioactive compounds. J Food Sci Technol. 55 (11): 4214–4221.
4. López LC, Hincapié-Llanos GA. Comparison of mango (Mangifera indica) dehydration technologies: A systematic review. AgriEngineering. 2024;6:2694–717. DOI:10.3390/agriengineering6030157.
5. Ahmed M, Akter MS, Lee JC, Eun JB. Encapsulation by spray drying of bioactive components, physicochemical and morphological properties from purple sweet potato. LWT Food Sci Technol. 2010;43:1307–12. DOI:10.1016/j.lwt.2010.05.014.
6. Teira E, Lekunberri I, Gasol JM, Nieto-cid M, Alvrez-Salgado XA, Figueiras FG. Dynamics of the hydrocarbon degrading cycloclastic bacteria during mesocosm simulated oil spills. Environ Microbiol. 2007; 9 (10): 2551–2562.
7. Teranoto M, Suzuki M, Hatmanti A, Harrayama S. The potential of cycloclasticus and altererythrobacter strains for use in bioremediation of petroleum aromatic contaminated tropical marine oil spills. Environ J Biosci Bioeng. 2010; 110 (1): 48–52.
8. Torstensson L, Fell M, Stenberg B. Need of a strategy for evaluation of arable soil quality. AMBIO. 1998; 27 (1): 4–7.
9. Ukpaka CP. Studying the depuration time on changes in biomarkers profile on Nigeria crude oil. Appl Sci Rep. 2016; 13 (2): 69–74.
10. Ukpaka CP. The effect of functional parameters on microbial characteristics in crude oil degradation. J Res Environ Sci Technol. 2012; 1 (4): 66–90.

