Extraction and Storage Stability of Terminalia Catappa Seed Oil

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Abstract

Background:
Terminalia catappa, commonly referred to as tropical or Indian almond, is a nutrient-rich but underutilized oilseed widely distributed in tropical regions. Its kernel oil, rich in unsaturated fatty acids and antioxidants, has potential as an alternative to conventional edible and industrial oils. However, data on its long-term storage stability under varying environmental conditions remain limited. This study investigated the oxidative stability and storage behaviour of *T. catappa* kernel oil as influenced by processing method and light exposure over 22 weeks.

Methods:
Oil was extracted from oven-dried and roasted kernels using Soxhlet extraction with n-hexane. Samples were stored at ambient temperature (27.5 ± 1 °C)s under two conditions: light exposure and dark storage. Oxidative stability was assessed over 22 weeks through periodic evaluation using established indicators of lipid deterioration.

Results:
Both the processing method and storage condition significantly affected oil stability. Oil from roasted kernels exhibited greater resistance to oxidative degradation than oil from oven-dried kernels. Samples stored in the dark showed slower oxidation rates than those exposed to light. Oxidative deterioration increased with storage time and became more pronounced after approximately 11 weeks, particularly under light exposure.

Conclusions:
Roasting and protection from light significantly enhance the oxidative stability of *T. catappa* kernel oil. The results revealed a clear influence of both storage condition and pre-processing technique on oil stability. These findings provide a basis for optimizing storage conditions and support the potential industrial application of the oil as a stable, sustainable, locally sourced alternative to conventional vegetable oils.

Background

Terminalia catappa, commonly referred to as tropical or Indian almond, is a nutrient-rich, underutilized oilseed found predominantly in tropical regions. Its seed oil, characterized by high unsaturated lipid content and antioxidant potential, presents a promising alternative to conventional edible and industrial oils. Despite growing interest in its nutritional and functional benefits, limited empirical research has explored the long-term storage stability of *T. catappa* kernel oil, particularly under varied environmental conditions.

Oil extraction is a fundamental process that involves the separation of lipids from plant matrices such as seeds, nuts, or fruits. The production of oil from oilseeds is a lucrative and significant industry, with numerous studies conducted to enhance oil yield and regulate its composition [1]. Various methods

exist for extracting oil from oilseeds, each playing a crucial role in determining oil quality and yield [2]. The intended application and cost considerations often determine the choice of extraction method, as it affects oil yield, quality, and stability [3].

Common extraction methods for plant oils include distillation, solvent extraction, cold pressing, and maceration [4]. Extraction techniques can further be categorised into traditional methods, mechanical methods, solvent-based extractions, supercritical fluid extraction [5], distillation [6], hot water flotation [7], cold percolation [8], and gas-assisted mechanical methods.

The selection of an extraction method depends on both the plant species and the desired oil quality [9].

Processing methods used in the production of plant oils present both benefits and drawbacks [10]. While these methods are essential for oil extraction, they can compromise the quality and health benefits of the final product. A notable drawback is the use of chemical solvents in some extraction processes. Solvents such as hexane are sometimes used, raising concerns about residual traces in the final oil. Although strict standards aim to minimize residues, even trace amounts may concern consumers seeking organic or minimally processed oils.

Additionally, plant oil refining often includes bleaching and deodorization steps [11]. While these steps enhance oil stability and shelf life, they may also eliminate beneficial compounds such as antioxidants and phytochemicals found in unrefined oils [12]. This modification of the oil's composition may limit its health-promoting properties.

High-temperature processing methods used during refining can also be detrimental [13]. Elevated temperatures may degrade sensitive fatty acids, such as omega-3s, and promote the formation of trans fats or other undesirable by-products. Such degradation compromises nutritional integrity and may introduce compounds detrimental to cardiovascular health.

Furthermore, processing methods, especially in large-scale production, can result in homogenised plant oils [14]. Such uniformity may reduce the diversity of nutrients and bioactive compounds, potentially diminishing the health benefits of a varied, unprocessed diet. Reduced diversity in processed oils may limit their health benefits compared to less refined, traditional extraction methods. Choosing minimally processed or cold-pressed oils may balance nutritional benefits with reduced processing-related drawbacks.

Nuts and seeds constitute a significant part of the human diet in many countries [15]. Seeds may be pressed for oil, although some are also widely consumed as snacks or used in baked goods. Generally, heat pre-treatment improves microbiological safety, digestibility, sensory quality, and shelf life [16].

Pre-treatment of oilseeds is a crucial step to facilitate oil extraction and enhance process efficiency. Oilseeds vary in oil content and physical characteristics. Therefore, the pre-treatment process differs slightly among seed types. These methods facilitate impurity removal, moisture reduction, and improved

oil yield [17]. Common pre-processing methods include cleaning, dehulling, crushing, flaking, cooking, drying, roasting, pre-pressing, enzymatic treatment, and solvent treatment.

Seed drying, shelling, and storage conditions significantly influence oil yield and quality. Improper drying or prolonged exposure to moisture and heat can lead to lipid oxidation and enzymatic hydrolysis, thereby increasing free fatty acid levels and compromising oil stability [18]. Roasting and oven-drying, as investigated in this study, are pre-processing treatments that can enhance oil extractability and preserve antioxidant content, but they require optimization to minimize degradation.

Proper storage conditions are critical for preserving the quality, flavour, and nutritional value of oils over time [19]. Multiple studies highlight key factors affecting oil stability, such as exposure to light, temperature fluctuations, oxygen, packaging materials, and potential cross-contamination.

Light protection is a primary consideration in oil storage. Light exposure, especially to sunlight, can trigger photochemical reactions that accelerate oil oxidation [20]. Shielding oils from light helps preserve essential fatty acids and prevents off-flavours caused by photo-oxidation.

Oxygen is a well-known catalyst of oil degradation. Oxygen initiates lipid oxidation, forming volatile compounds and off-flavours [21, 22]. Rancidity can be prevented by reducing the water content through refining and dehydration. Oxygen plays an important role in rancidity because the higher the oxygen content, the faster the occurrence of ketone rancidity and oxidation rancidity. Oxygen can be removed by adding nitrogen to filled bottles and vacuum packaging or adding antioxidants to reduce the oxygen content of edible oils.

Furthermore, preventing cross-contamination is crucial to the distinct characteristics of stored oils [23]. Studies recommend using separate containers for each oil type to prevent flavour and quality transfer. This practice maintains the integrity of individual oils, preserving their unique flavour and nutritional value.

Effective oil storage involves multiple strategies: shielding from light, controlling temperature, limiting oxygen exposure, choosing proper containers, and avoiding contamination [24]. Following these storage practices is vital to extending oil shelf life while preserving its freshness, taste, and nutritional value.

Thus, storage temperature is a pivotal factor in determining oil quality and shelf life [25]. Proper temperature control is vital for safeguarding the sensory qualities, nutrient profile, and overall stability of oils, both at domestic and industrial scales [26].

Humidity also plays a critical role in preserving oil quality and stability [27]. Humidity levels in the storage environment affect oils by increasing their vulnerability to oxidation, moisture absorption, and reduced shelf life. High humidity poses a significant risk to oils by accelerating oxidation [28]. Therefore, oils should be stored under controlled humidity conditions to reduce the risk of moisture-related degradation [29].

Moisture absorption is especially concerning as it alters the physical and chemical characteristics of oils [30]. Hygroscopic oils, due to their water affinity, are more susceptible to environmental moisture uptake. Such moisture absorption may result in emulsification, the formation of water droplets within the oil, which encourages microbial growth and further degrades oil quality. To prevent such issues, oils should be stored in low-humidity environments to limit moisture absorption and preserve oil integrity [31].

In industrial settings, where large quantities of oils are stored, humidity control becomes even more critical [32]. Climate-controlled storage facilities are used to maintain optimal humidity levels for preserving oil quality. Controlled environments are particularly essential for food-grade oils, where consistency and quality are critical.

Research emphasizes the need to control humidity to prevent degradation resulting in rancidity, off-flavours, and reduced nutritional content. Through appropriate storage and packaging, households and industries can effectively manage humidity-related risks and preserve oil stability [33].

Materials and Methods

Fruit Collection and Pre-Processing: Fresh ripe *T. catappa* fruits were collected from various locations within Lagos metropolis- within Lagos State University, Ojo campus, Iba town, and LASU Badagry campus. The fruits were identified and authenticated by the Botany Department of Lagos State University, Ojo, Lagos State, Nigeria. A voucher of the plant (**Voucher No: LSH 001172**) was deposited in the Lagos State University herbarium. The fruit's outer flesh was manually removed with a scalpel, and the hard-shelled nuts were sun-dried for 14 days. The kernels (nuts) were extracted by manually breaking the dried shells with the aid of a vice. The total seeds were weighed and then portioned into two equal parts. A portion of kernels was oven-dried in an oven at 125 °C for 25 min, allowed to cool, then milled in a power blender and weighed. The second portion of seeds was transferred in batches into a stainless-steel frying pan and roasted over an electric hotplate (electric stove) for 20 min. After cooling, the roasted samples were likewise milled with a blender and weighed.

Extraction and Purification of Oil: The oil was extracted with the aid of a Soxhlet extractor, using n-hexane as the solvent. 100 g of milled kernels were packed in the thimble of the Soxhlet extractor, and the extractor was filled with 400 mL of n-hexane. Oil extraction was performed at a temperature of 50 °C for 6 hours in two batches for both dried and roasted samples. The solute-to-solvent ratio, used for the entire extraction, was 1:4 (100 g:400 ml). The oil yield obtained at the end of every extraction time for every extraction condition was calculated and recorded. After each extraction process, the solvents were removed in each case at a temperature of 60 °C using a rotary evaporator. The entire extraction process was carried out under every set of conditions in triplicate, and the average values were reported.

The oil yield of *T. catappa* was calculated using

$$\%\text{Oil yield} = \frac{\text{Weight of oil extracted (g)}}{\text{Weight of } T.\ catappa \text{ seed (g)}} \times 100$$

The extracted crude oil samples were purified using Ogunsua and Badifu's (1989) approach throughout the purification phase [34]. Two millilitres (2ml) of distilled water were added to the crude Indian almond oil and heated at 70 ºC in a water bath for 30 minutes. 0.07 mL of acetic anhydride ($C_4H_6O_3$) was added, and the mixture was stirred for 30 min at 70 °C, then cooled. The sample was then centrifuged at 2000 rpm for 30 min, and the supernatant was decanted to obtain the degummed oil. To the degummed oil, 7.55g of 1M KOH were added, and the mixture was stirred for 10 min at 25 °C with a Stuart magnetic stirrer (model 8186), after which it was heated for 45 min at 80 °C to coagulate the soap. This was further centrifuged at 2000 rpm for 20 min in a Heraeus Sepatech centrifuge. The oil was then washed with 80 mL of distilled water by shaking the mixture vigorously in a separating funnel and allowing it to stand for 15 min. The lower aqueous layer was then separated and discarded. The oils obtained from the dried and roasted samples were labelled "**degummed**" [12].

The degummed oil received 0.56g of fuller's earth, and the combination was heated for 10 min at 100 ° Celsius. Thereafter, the mixture was filtered while being vacuumed using Whatman No. 1 filter paper. Following an hour of bleaching with steam, the oil was dried in an oven (Gallenkamp oven 300 Plus).

Determination of the Storage Stability of *T. catappa* Kernel Oil

Oil samples were transferred to transparent, opaque, and glass containers. The containers were closed and subjected to two different storage conditions: (i) the oven-dried and roasted *T.catappa* kernel oil was subjected to daylight exposure at room temperature, and another set of the two oil samples was kept at room temperature in darkness [35, 36].

The stability of the oven-dried and roasted *T. catappa* kernel oil extracted and purified was evaluated. Tests were conducted according to the AOAC method No. 940.28 [37] for chemical property analyses, including acidity, peroxide value, iodine value, and free fatty acid, every week for the first two months and then bi-weekly until 22 weeks.

Statistical Analysis

The IBM-SPSS Statistical package (version 25) was utilised to analyse the results. One-way analysis of variance [38] was used to compare means, and Turkey's Honestly Significant Difference (HSD) test was used for post hoc analysis. Triplicates of each experiment were carried out, and results were presented as mean ± standard error of the mean. Values with $p<0.05$ were considered significant.

Results

Table 1: Percentage yield of Oven-dried and Roasted *T. catappa* kernel Oils

Parameter	Oven-Dried *T. catappa* seeds	Roasted *T. catappa* seeds
Initial Weight of Seeds (g)	3,499	3,499
Weight of Seeds After Processing (g)	3,265	3,202
Quantity of crude Oil Extracted (g)	1,704	1,471
% Oil yield (crude)	52.19	45.94
% Oil yield (Purified)	42.69	34.74

Table 1 shows the percentage oil yield from Oven-dried and Roasted *Terminalia catappa* kernels. The extracted oil from the pre-treated *T. catappa* seed had a higher crude oil yield from the oven-dried seed (52.19%) than the roasted seed (45.94%). After purification, there was a loss of about 9%; the oil yield was 34.75 (35%) for roasted and 42.69% for oven-dried *T. catappa* kernel. Previous studies have reported a higher oil yield from roasted, compared to oven-dried *T. catappa* kernels [39].

The Peroxide value, as shown in Figure 1 above, increased more rapidly in the kernel oil exposed to light than in that kept in the dark from the first week of storage.

Effect of Storage Period: There was a significant increase in peroxide value from week 1 to week 22 compared to week zero.

Effect of Storage Type: At week zero, roasted dark and roasted exposed oils had no significant difference. There was also no difference between oven-dried dark and oven-dried exposed samples. But from week 1 to week 22, the roasted exposed oil had significantly higher ($p<0.05$) PV compared to the roasted dark. Similarly, the oven-dried exposed was significantly higher than the oven-dried dark from week 1.

Effect of Treatment: At week zero, the Peroxide value of oven-dried was significantly lower than that of roasted. But at week 1, the oven-dried sample kept in the dark became significantly higher compared to the roasted dark. Also, roasted exposed was higher compared to oven-dried exposed. At week zero, oven-dried was lower than roasted. But from week 1, oven-dried became higher than roasted throughout week 22 of storage.

For both roasted and oven-dried, the PV for the exposed was significantly higher ($p<0.05$) compared to the roasted, all through to week 22.

Effect of Storage Period: Figure 2 shows a progressive increase in the AV from week 0 to week 22. But there was no difference between week 1 and week 0; the increase became significant from week to week.

Roasted Dark: There was a sharp decrease in AV by week 1, after which there was a steady increase until week 22. Compared to week zero, the acid value was significantly lower from week 1 to week 12. But from week 14, there was an increase which became significant from week 18 to week 22.

Roasted Exposed: There was a steady reduction in AV until week 3, after which there was a steady increase until week 22. The acid value was significantly lower than the baseline value until week 6; there was no significant difference from the baseline from week 6 until week 14, but from week 16, the increase became significant.

Oven-dried Dark: Right from week 1 to week 22, there was a significant increase in AV.

Oven-dried Exposed: Similarly, there was also an increase from week 1 until week 22.

Effect of Storage Type: At week 0, there was no difference between the AV of roasted dark and roasted exposed oils, and also between oven-dried dark and oven-dried exposed oils. But from week 1 to week 22, subsequently, there was a significant increase in the AV of both oven-dried exposed and roasted exposed oils compared to their respective counterparts kept in the dark.

Effect of Treatment: At week zero, the AV of oven-dried dark oil was significantly lower compared to the roasted dark sample. But from week 1, the AV of oven-dried dark significantly increases compared to the roasted dark. A similar result occurred in the roasted and oven-dried exposed samples.

The % free fatty acid value of oleic acid (Figure 3) for both oven-dried kernel oils was the same (0.21). However, the value increased gradually in the kernel oil kept in the dark when compared to that exposed to light on a weekly and biweekly basis until week 10-14, where they had the same value (0.56).

Effect of Storage Period: On the whole, there was no difference in FFA values from week 0 to week 3. But there was a significant increase from week 4 to week 22 within each storage group.

Effect of Storage Type: from week 0 to week 22, there was no significant difference between the FFA value of the roasted dark and roasted exposed oils. Also, there was no difference between the oven-dried dark and oven-dried exposed oils. The storage did not have any effect on the FFA value of the *T. catappa* kernel oil.

Effect of Treatment: At week zero, the FFA value of roasted dark was significantly higher than that of oven-dried dark. But from week 1, there was a significant increase in oven-dried dark compared to roasted dark until week 22. Similarly, the FFA value of roasted exposed was significantly higher than that of oven-dried exposed at week zero, but from week 1, there was a significant increase in the oven-dried exposed oil compared to roasted exposed oil until week 22. As the week went by, the oven-dried dark was more unstable compared to the roasted dark.

At week zero (Figure 4a), there were significant differences between roasted and oven-dried *T. catappa* seed oil. Oven-dried exposed iodine value showed a significant increase in all (between week zero and

week 22). At week 22 (Figure 4b), the treatments (oil type) differed in all cases, while roasted dark and roasted exposed showed a reduction; roasted dark had a higher iodine value than roasted exposed. But in the case of oven-dried dark, the exposed sample was higher, suggesting exposure had a more significant effect than darkness for the dried treatment. Roasted exposed was higher than the oven-dried dark.

Discussion

In this study, the storage stability of oven-dried and roasted *Terminalia catappa* seed oils was monitored under controlled conditions for a period of 22 weeks to assess changes in key physicochemical parameters.

The findings indicated that oil stored in the presence of light degraded more rapidly than oil stored in the dark. Specifically, oxidative indicators such as peroxide value increased more significantly under light exposure, corroborating the established role of photo-oxidation in accelerating lipid deterioration. This pattern was more pronounced in oven-dried samples, which exhibited greater instability compared to roasted oil across all storage conditions. This suggests that thermal pre-treatment via roasting may contribute to the preservation of natural antioxidants (e.g., tocopherols), which confer enhanced oxidative resistance during storage.

Moreover, although storage time led to progressive changes in the physicochemical attributes of both oils, such as increases in peroxide value, acid value, and moisture content, the roasted oil consistently maintained better compositional integrity. Importantly, colour retention was noted across both oil samples, which suggests minimal pigment degradation and acceptable visual quality throughout the storage duration.

The rancidity indices remained within acceptable limits for both oil types, with neither sample exhibiting significant off-odours or discolouration. This indicates that the oxidative degradation products remained below the sensory detection threshold. These findings underscore the importance of optimised storage conditions, specifically limiting light exposure and using airtight, non-reactive containers to maximize oil stability and prolong shelf life.

Additionally, the study's results showed that the method of seed processing (roasting vs. oven drying) had a more pronounced effect on stability than the storage conditions alone. This suggests that improving pre-extraction treatments could be an effective strategy to enhance oil quality during post-extraction storage.

In conclusion, *Terminalia catappa* seed oil demonstrated good oxidative stability over 22 weeks under controlled storage conditions, particularly when derived from roasted seeds and stored away from light. These results support the feasibility of storing the oil under ambient conditions ($27.5 \pm 1\ ^{\circ}C$), provided it is protected from light and air, and suggest its potential for use in long-shelf-life food and cosmetic products.

Conclusion and Recommendation

Optimized processing and light-protective storage enhance the oxidative stability of *Terminalia catappa* kernel oil, supporting its viability as a sustainable, locally sourced alternative for culinary and industrial applications. Its wider adoption could contribute to food security and economic development.

Abbreviations

Abbreviations

FFA Free fatty acid

AV Acid value

PV Peroxide value

AOAC Association of official Analytical chemists

T. catappa Terminalia catappa

Declarations

Ethical Approval and Consent to Participate

The research proposal was submitted to the Institutional Review Board of Lagos State University, and ethical approval was obtained (Approval No: LASU/23/REC/07/001) from the LASU Research Ethics Committee, Ojo, Lagos State, Nigeria, before the commencement of this research. Kindly note that Consent to participate was not applicable for this study.

Consent for Publication

The research authors hereby give consent for the publication of this manuscript titled “Extraction and Storage Stability of *Terminalia catappa* Seed oil in the journal. All authors have read and approved the final version of the manuscript and agreed to its submission and publication.

The authors confirm that the content of this manuscript has not been published previously, and is not under consideration for publication elsewhere. The authors also understand that the manuscript will be made publicly available and agree to its dissemination in accordance with the journal’s policies.

Availability of data and materials

The datasets generated and analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interest.

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Authors Contributions

A. O. I drafted the proposal, designed the study, conducted the data analysis, and drafted the initial manuscript. O.B.A conceptualised the research, co-designed the study, supervised the research, and reviewed the manuscript. B. O. E., G. M. S., and O. O. O were involved in the project design and reviewed the manuscript. K. R. I, J. O. A, S. O. A, G. C. E, M. O. A, O. O. I, and P. B. O carried out the oil extraction and storage stability evaluation. T. E was involved in the experimental design, and K. A. A was involved in proposal development and designed the nut-cracking machine.

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References

1. Akubude, V.C., J. Maduako, C. Egwuonwu, E.O. Ajala, A.M. Olaniyan, I.C. Ozumba, and C. Nwosu, *Almond oil: powerhouse of nutrients.* Agricultural Engineering International: CIGR Journal, 2020. **22**(3): p. 190-201.
2. Savoire, R., J.-L. Lanoisellé, and E. Vorobiev, *Mechanical continuous oil expression from oilseeds: a review.* Food and Bioprocess Technology, 2013. **6**(1): p. 1-16.
3. Tasan, M., U. Gecgel, and M. Demirci, *Effects of storage and industrial oilseed extraction methods on the quality and stability characteristics of crude sunflower oil (Helianthus annuus L.).* Grasas y aceites, 2011. **62**(4): p. 389-398.
4. Shikov, A.N., I.Y. Mikhailovskaya, I.A. Narkevich, E.V. Flisyuk, and O.N. Pozharitskaya, *Methods of extraction of medicinal plants*, in *Evidence-Based Validation of Herbal Medicine*. 2022, Elsevier. p. 771-796.
5. Aremu, M., H. Ibrahim, and T. Bamidele, *Physicochemical characteristics of the oils extracted from some Nigerian plant foods–a review.* Chemical and Process Engineering Research, 2015. **32**: p. 36-52.

6. Sorin-Stefan, B., M. Ionescu, G. Voicu, N. Ungureanu, and V. Vladut, *Calculus elements for mechanical presses in oil industry.* Food Industry, 2013. **1**(8).
7. Fellows, P. and B. Axtell, *Setting up and running a small-scale cooking oil business.* Wageningen, Netherlands: CTA, 2012.
8. Kalia, V. and S. Lal, *Modified cold percolation method for extracting oil from oil seeds.* 2002.
9. El Asbahani, A., K. Miladi, W. Badri, M. Sala, E.A. Addi, H. Casabianca, A. El Mousadik, D. Hartmann, A. Jilale, and F. Renaud, *Essential oils: From extraction to encapsulation.* International Journal Of Pharmaceutics, 2015. **483**(1-2): p. 220-243.
10. Yap, P.S.X., K. Yusoff, S.-H.E. Lim, C.-M. Chong, and K.-S. Lai, *Membrane disruption properties of essential oils—A double-edged sword?* Processes, 2021. **9**(4): p. 595.
11. Gharby, S., *Refining vegetable oils: Chemical and physical refining.* The Scientific World Journal, 2022. **2022**.
12. Adu, O.B., M. Omojufehinsi, M. Esanboro, D. Abe, A. Shofolahan, E. Uzodinma, K. Badmus, and O. Martins, *Effect of processing on the quality, composition and antioxidant properties of Terminalia catappa (indian almond) seed oil.* African Journal of Food, Agriculture, Nutrition and Development, 2013. **13**(3): p. 7662-7678. .
13. Vaisali, C., S. Charanyaa, P.D. Belur, and I. Regupathi, *Refining of edible oils: a critical appraisal of current and potential technologies.* International Journal of Food Science & Technology, 2015. **50**(1): p. 13-23.
14. Show, K.-Y., D.-J. Lee, J.-H. Tay, T.-M. Lee, and J.-S. Chang, *Microalgal drying and cell disruption–recent advances.* Bioresource technology, 2015. **184**: p. 258-266.
15. Albuquerque, T.G., M.A. Nunes, S.M. Bessada, H.S. Costa, and M.B.P. Oliveira, *Biologically active and health promoting food components of nuts, oilseeds, fruits, vegetables, cereals, and legumes*, in *Chemical analysis of food*. 2020, Elsevier. p. 609-656.
16. Barba, F.J., N.S. Terefe, R. Buckow, D. Knorr, and V. Orlien, *New opportunities and perspectives of high pressure treatment to improve health and safety attributes of foods. A review.* Food Research International, 2015. **77**: p. 725-742.
17. He, K., H. Cheng, D.J. McClements, Z. Xu, M. Meng, Y. Zou, G. Chen, and L. Chen, *Utilization of diverse probiotics to create human health promoting fatty acids: A review.* Food Chemistry, 2024: p. 140180.
18. Mele, M.A., M.Z. Islam, H.-M. Kang, and A.M. Giuffrè, *Pre-and post-harvest factors and their impact on oil composition and quality of olive fruit.* Emirates Journal of Food and Agriculture, 2018. **30**(7): p. 592-603.
19. Rotondi, A., L. Morrone, G. Bertazza, and L. Neri, *Effect of duration of olive storage on chemical and sensory quality of extra virgin olive oils.* Foods, 2021. **10**(10): p. 2296.
20. Ebuzoeme, C.N., *The Photochemical Effects of LED Lights on Various Cooking Oils*. 2016, Texas Southern University.

21. Morales, M.T. and R. Przybylski, *Olive oil oxidation.* Handbook of olive oil: analysis and properties, 2013: p. 479-522.
22. Ahmed, M., J. Pickova, T. Ahmad, M. Liaquat, A. Farid, and M. Jahangir, *Oxidation of lipids in foods.* Sarhad Journal of Agriculture, 2016. **32**(3): p. 230-238.
23. Osimani, A., C. Garofalo, J. Harasym, and L. Aquilanti, *Use of essential oils against foodborne spoilage yeasts: Advantages and drawbacks.* Current Opinion in Food Science, 2022. **45**: p. 100821.
24. Mortensen, G., G. Bertelsen, and P.V. Nielsen, *Packaging of cheeses*, in *Handbook of food and beverage fermentation technology*. 2004, CRC Press. p. 402-419.
25. Manzocco, L., S. Calligaris, M. Anese, and M.C. Nicoli, *Determination and prediction of shelf life of oils/fats and oil/fat–based foods*, in *Oxidative stability and shelf life of foods containing oils and fats*. 2016, Elsevier. p. 133-156.
26. Benkhoud, H., Y. M'Rabet, M. Gara Ali, M. Mezni, and K. Hosni, *Essential oils as flavoring and preservative agents: Impact on volatile profile, sensory attributes, and the oxidative stability of flavored extra virgin olive oil.* Journal of Food Processing and Preservation, 2022. **46**(5): p. e15379.
27. Juvvi, P., M.K. Selvi, and S. Debnath, *Effect of vacuum frying on quality attributes of pear (Pyrus communis L) chips and blended oil.* Journal of Food Processing and Preservation, 2020. **44**(6): p. e14488.
28. Azwa, Z., B. Yousif, A. Manalo, and W. Karunasena, *A review on the degradability of polymeric composites based on natural fibres.* Materials & Design, 2013. **47**: p. 424-442.
29. Barden, L. and E.A. Decker, *Lipid oxidation in low-moisture food: A review.* Critical reviews in food science and nutrition, 2016. **56**(15): p. 2467-2482.
30. Nayak, P.K., U. Dash, K. Rayaguru, and K.R. Krishnan, *Physio-chemical changes during repeated frying of cooked oil: A Review.* Journal of Food Biochemistry, 2016. **40**(3): p. 371-390.
31. Karnwal, A., *Prospects of Microbial Bio-surfactants To Endorse Prolonged Conservation in the Pharmaceutical and Agriculture Industries.* ChemistrySelect, 2023. **8**(26): p. e202300401.
32. Firouz, M.S., K. Mohi-Alden, and M. Omid, *A critical review on intelligent and active packaging in the food industry: Research and development.* Food Research International, 2021. **141**: p. 110113.
33. Marsh, K. and B. Bugusu, *Food packaging—roles, materials, and environmental issues.* Journal of food science, 2007. **72**(3): p. R39-R55.
34. Ogunsua, A. and G. Badifu, *Stability of purified melon seed oil obtained by solvent extraction.* Journal of Food Science, 1989. **54**(1): p. 71-73.
35. Lin, C.-C., Y.-L. Chen, J.M. Lin, and T. Ujiie, *Evaluation of the antioxidant and hepatoprotective activity of Terminalia catappa.* The American journal of Chinese medicine, 1997. **25**(02): p. 153-161.
36. Hemery, Y.M., L. Fontan, R. Moench-Pfanner, A. Laillou, J. Berger, C. Renaud, and S. Avallone, *Influence of light exposure and oxidative status on the stability of vitamins A and D3 during the storage of fortified soybean oil.* Food chemistry, 2015. **184**: p. 90-98.
37. AOAC, *Official methods of analysis.* 1990.

38. Dicenta, F., P. Martínez-Gómez, N. Grané, M. Martín, A. León, J. Cánovas, and V. Berenguer, *Relationship between cyanogenic compounds in kernels, leaves, and roots of sweet and bitter kernelled almonds.* Journal of Agricultural and Food Chemistry, 2002. **50**(7): p. 2149-2152.
39. Adu, O., M. Omojufehinsi, M. Esanboro, D. Abe, A. Shofolahan, E. Uzodinma, K. Badmus, and O. Martins, *Effect of processing on the quality, composition and antioxidant properties of Terminalia catappa (indian almond) seed oil.* African Journal of Food, Agriculture, Nutrition and Development, 2013. **13**(3).

Figures

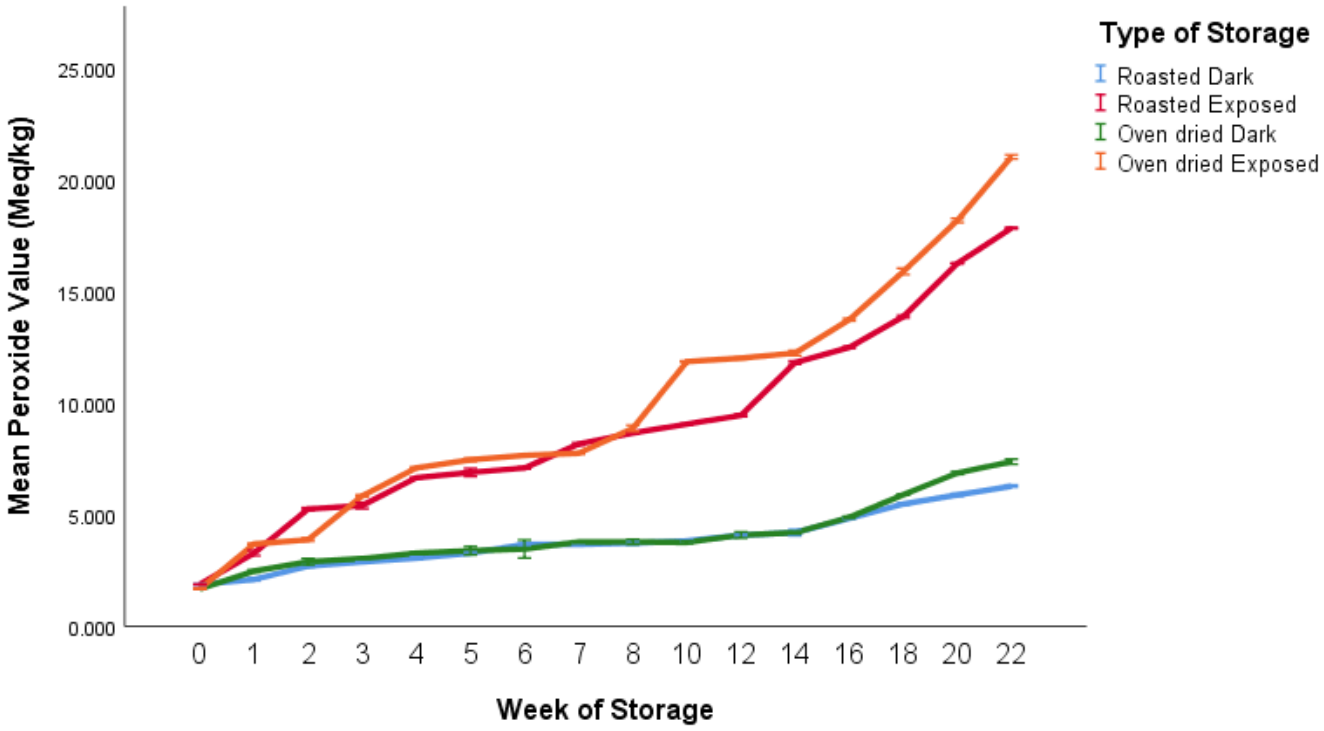


Figure 1

Peroxide value of 22 weeks storage stability analysis of roasted and oven-dried *T. catappa* kernel oil.

Values are means of triplicate determinations ± standard deviation. Values considered significantly different at $p<0.05$.

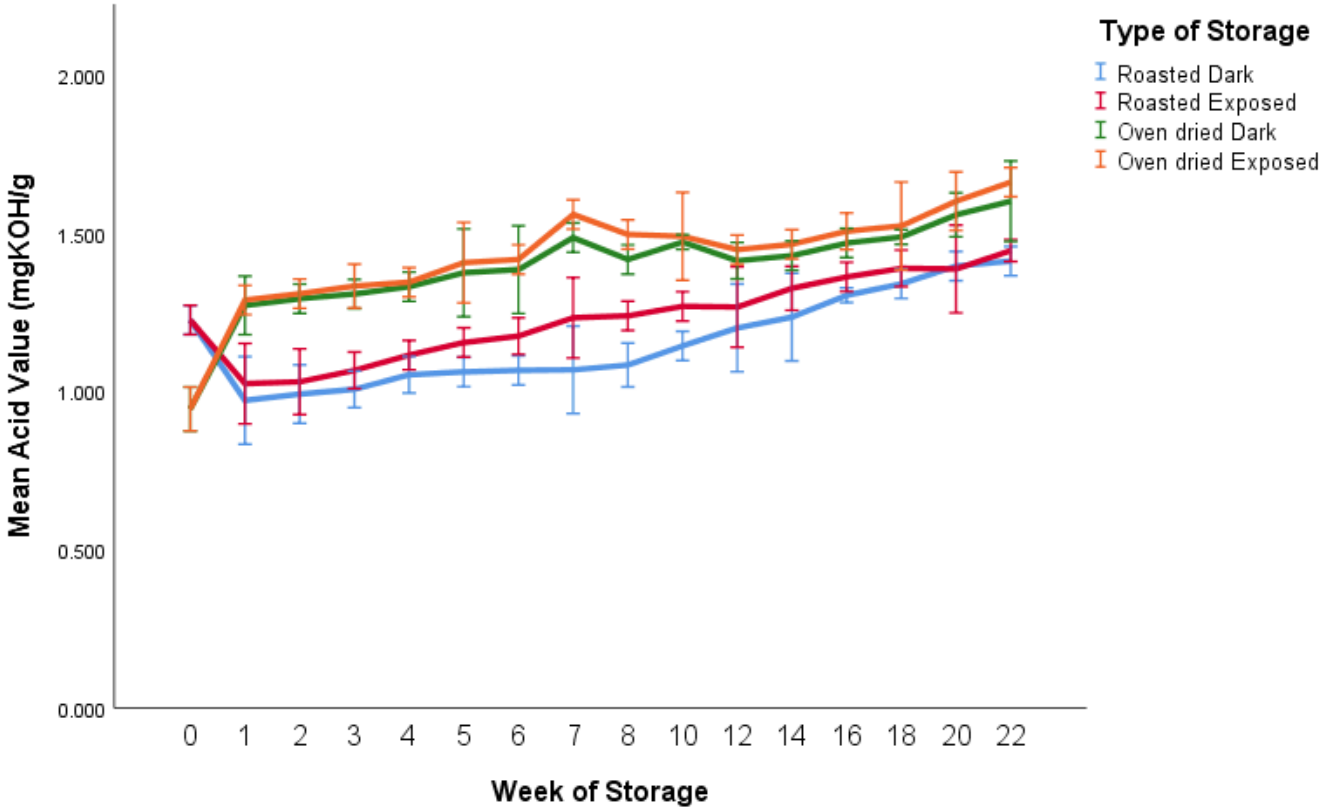


Figure 2

Effect of storage on acid value of 22 weeks storage stability analysis of oven-dried and roasted *T. catappa*kernel oil.

Values are means of triplicate determinations ± standard errors of means. Values considered significantly different at $p<0.05$.

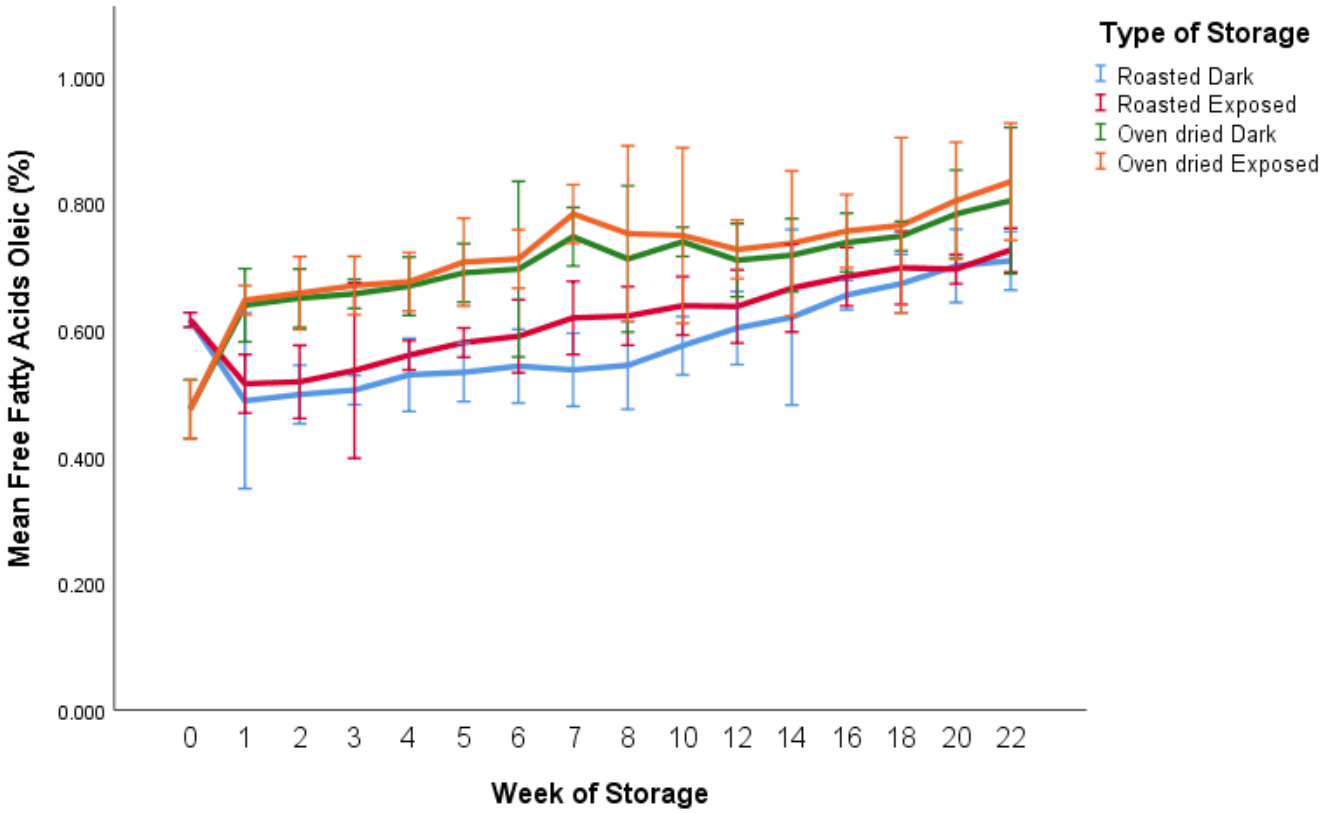
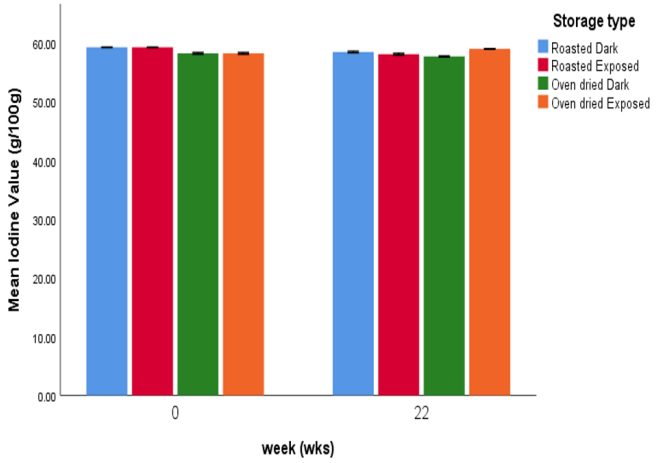


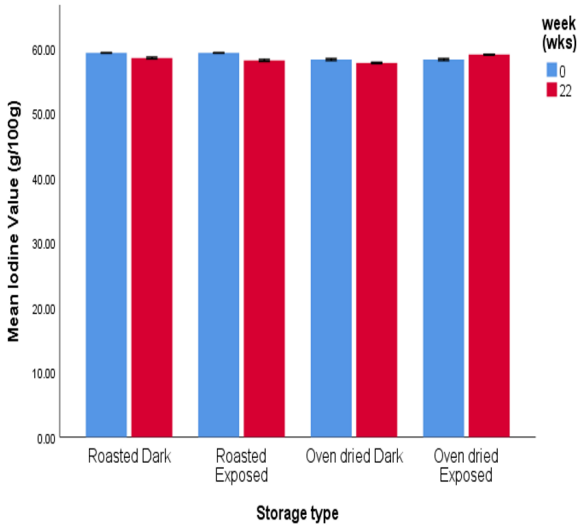
Figure 3

Effect of storage on free fatty acid value (oleic acid) of oven-dried and roasted *T. catappa* oil in dark and exposed conditions.

Values are means of triplicate determinations ± standard errors of means. Values considered significantly different at $p<0.05$.



a



b

Figure 4

a: Iodine value of 22 weeks storage stability analysis of roasted and oven-dried *T. catappa* kernel oil.

Values are means of triplicate determinations ± standard error of means. Values considered significantly different at $p<0.05$.

b: Iodine value of 22 weeks storage types analysis of roasted and oven-dried *T. catappa* kernel oil.

Values are means of triplicate determinations ± standard error of means. Values considered significantly different at $p<0.05$.