



DEVELOPMENT OF SUSTAINABLE BIO-BASED PAINTS FROM BREADFRUIT, AVOCADO AND CASTOR SEED OILS: PRODUCTION, CHARACTERIZATION AND PERFORMANCE EVALUATION

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ABSTRACT: Paints are complex mixtures that provide both decorative and protective functions for a wide range of surfaces including wood, metal, and masonry. This study focused on the production and characterization of alkyd resin-based paint from locally sourced seed oils: breadfruit (*Artocarpus altilis*), avocado pear (*Persea americana*), and castor (*Ricinus communis*). The seeds were subjected to three drying methods (sun-drying, air-drying, and oven-drying) to evaluate the effect of drying on oil yield and quality. Oil extraction was carried out using n-hexane in a Soxhlet apparatus. Physicochemical properties of the extracted oils, including pH, acid value, viscosity, iodine value, peroxide value, refractive index, saponification value, and free fatty acid content, were determined. Alkyd resins were synthesized through a two-stage process involving alcoholysis (monoglyceride formation) using glycerol and sodium hydroxide as catalyst, followed by esterification using maleic anhydride and xylene. Paints were formulated from the alkyd resins using titanium dioxide as pigment, cobalt naphthenate as drier, texanol as coalescing agent, and petrol as solvent. The formulated paints were characterized for drying time, adhesion strength, gloss, water resistance, and hardness. Results showed that castor oil had the highest oil yield, while oven-drying consistently produced the highest yields across all seed types. Breadfruit oil exhibited the highest iodine value (119.29 gI₂/100g), indicating superior drying properties, while avocado oil showed the highest adhesion strength (1.7 MPa) and gloss (50). Breadfruit oil paint dried fastest (68.7 hrs), while avocado oil paint took longer (72.3 hrs). All paints demonstrated good water resistance and moderate hardness. The findings demonstrate that breadfruit, avocado, and castor seed oils are viable raw materials for sustainable alkyd resin and paint production, offering potential for reducing dependence on imported petroleum-based binders in Nigeria's paint industry.

Keywords: Alkyd resin, breadfruit seed oil, avocado pear seed oil, castor seed oil, paint formulation, vegetable oil polymers

1.0 1.0

1.0 INTRODUCTION

Paints and coatings are essential materials widely used for the protection and decoration of surfaces such as metals, wood, concrete, plastics, and masonry structures. They perform important functions by forming a protective film that prevents corrosion, moisture penetration, chemical attack, and surface deterioration, while also enhancing aesthetic appearance (Lawal *et al.*, 2021; Hassan *et al.*, 2023).

The quality and durability of paint products therefore play a significant role in infrastructure development, industrial growth, and environmental protection.

A conventional paint formulation consists of four major components: binder (resin), pigments, solvents, and additives. Among these components, the binder is the most critical because it holds the pigment particles together and ensures adhesion of the paint film to the substrate. The nature of the binder largely determines the drying time, hardness, flexibility, gloss retention, and resistance properties of the paint (Lawal *et al.*, 2021; Romanus *et al.*, 2023).

Consequently, the selection of an appropriate binder is fundamental to the overall performance of any paint system. Alkyd resins are one of the most widely used binders in the paint and coatings industry, especially for decorative and protective applications. Alkyd resins are oil-modified polyester resins produced through esterification and polycondensation reactions involving vegetable oils or fatty acids, polyhydric alcohols, and polybasic acids or anhydrides (Jafari, Farzaneh, & Tavakoli, 2022). They are favored due to their excellent film-forming ability, good adhesion, gloss, flexibility, and ease of application under ambient conditions (Lawal *et al.*, 2021; Romanus *et al.*, 2023).

Traditionally, alkyd resins are produced using petroleum-based raw materials or edible vegetable oils such as soybean and linseed oils. However, the increasing cost of petroleum products, volatility of crude oil prices, and growing environmental concerns have reduced the sustainability of petroleum-derived raw materials (Aliyu, Bello, & Isa, 2022; Hassan *et al.*, 2023). In addition, the industrial use of edible oils creates competition between food and non-food applications, which is undesirable in developing countries where food security remains a challenge (FAO, 2019).

In response to these challenges, research has increasingly focused on the use of renewable, biodegradable, and underutilized vegetable oils for industrial applications. Agricultural by-products and waste seeds have gained attention as alternative raw materials for oil extraction due to their availability and low cost (Okolie *et al.*, 2016). The utilization of these wastes not only reduces environmental pollution but also promotes waste valorization and sustainable resource management (Udeozor *et al.*, 2022).

Breadfruit seeds and avocado pear seeds are examples of agricultural wastes that are often discarded after consumption of the edible portions of the fruits. Studies have shown that these seeds contain appreciable quantities of oil with physicochemical properties suitable for industrial applications (Okolie *et al.*, 2016). Despite their oil potential, breadfruit seed oil and avocado pear seed oil remain largely underutilized in paint and coating applications (González-Torres *et al.*, 2023).

Several studies have reported that oils extracted from underutilized seeds possess suitable physicochemical properties such as iodine value, saponification value, and acid value, which are important parameters for alkyd resin synthesis (Ezeokonkwo & Ojmelukwe, 2018; Lawal *et al.*, 2021). These properties influence the drying behavior, hardness, and durability of alkyd-based paints (Gbadamosi & Odukoya, 2020).

Avocado pear seed oil has been reported to possess good oxidative stability and antioxidant properties, which are beneficial for industrial applications, including coatings (Nwachukwu & Egbuonu, 2017; Ozolua *et al.*, 2020; Olagunju & Afolayan, 2020). Its utilization also contributes to reducing waste generated from avocado processing industries (González-Torres *et al.*, 2023).

Castor seed oil is a well-established industrial oil known for its high oil yield and unique fatty acid composition, particularly its high ricinoleic acid content. This gives castor oil high viscosity, good film-forming ability, and chemical stability, making it suitable for alkyd resin synthesis and paint formulation (Ibrahim & Ogundola, 2024). When blended with other vegetable oils, castor oil can enhance the flexibility and performance characteristics of alkyd resins (Abayeh, Aina, & Okounghae, 2013).

Research has shown that blending different vegetable oils can improve the overall performance of alkyd resins by combining the beneficial properties of each oil (Adegbaaju *et al.*, 2020). Therefore, the combined use of breadfruit seed oil, avocado pear seed oil, and castor seed oil presents a promising approach for producing alkyd resins suitable for paint formulation (Gbadamosi & Odukoya, 2020).

The use of locally available vegetable oils for alkyd resin and paint production offers several advantages, including reduction in production cost, decreased dependence on imported raw materials, environmental sustainability, and promotion of local industrial development (Aliyu *et al.*, 2022). Consequently, the production and characterization of paint from vegetable oils using breadfruit seed oil, avocado pear seed oil, and castor seed oil is of significant scientific, economic, and environmental importance (Hassan *et al.*, 2023).

Beyond availability, the chemical composition of vegetable oils plays a crucial role in determining their suitability for alkyd resin production. Fatty acid structure, degree of unsaturation, and functional groups such as hydroxyl moieties directly influence resin reactivity, film formation, and curing behavior (Gbadamosi & Odukoya, 2020). Oils with appropriate iodine and saponification values tend to form alkyd resins with improved drying characteristics and mechanical strength, making physicochemical evaluation a necessary step in binder development (Jafari *et al.*, 2022).

The iodine value of oil is particularly important in paint technology because it indicates the level of unsaturation, which governs oxidative drying behavior. Oils with higher iodine values generally produce faster-drying alkyd resins through autoxidation, while oils with lower iodine values yield non-drying or semi-drying films (Ezeokonkwo & Ojimelukwe, 2018; Lawal *et al.*, 2021). Understanding the iodine value of breadfruit, avocado, and castor seed oils therefore provides insight into their potential drying performance in formulated paints.

Similarly, the saponification value gives an indication of the average molecular weight of fatty acids present in oils and influences resin chain length and hardness of the final paint film. Oils with higher saponification values tend to form resins with shorter fatty acid chains, which may enhance hardness but reduce flexibility (Gbadamosi & Odukoya, 2020). Conversely, oils with moderate saponification values often produce balanced alkyd resins suitable for decorative and protective coatings (Romanus *et al.*, 2023).

Another critical parameter is the acid value, which reflects the level of free fatty acids present in the oil. High acid values may interfere with esterification reactions during alkyd synthesis and negatively affect film durability (Aliyu *et al.*, 2022). Oils with low acid values are therefore preferred, as they enhance resin stability and reduce the risk of premature degradation during storage and application (Hassan *et al.*, 2023).

The use of blended vegetable oils has emerged as a practical strategy to overcome the limitations of single-oil systems. Blending allows the complementary properties of different oils to be combined, resulting in alkyd resins with improved balance between drying time, flexibility, hardness, and gloss (Adegbaaju *et al.*, 2020). In this context, blending breadfruit and avocado seed oils with castor oil can potentially offset low drying tendencies while enhancing film elasticity and adhesion (Hassan *et al.*, 2023).

In addition to resin synthesis, the performance properties of the resulting paints are critical indicators of industrial applicability. Properties such as drying time, adhesion, hardness, gloss, and water resistance determine the suitability of a paint for specific applications and service environments (Lawal *et al.*, 2021). Systematic evaluation of these properties provides a basis for comparing vegetable oil-based paints with conventional petroleum-based products (Hassan *et al.*, 2023).

Finally, the local production of alkyd resins and paints from indigenous agricultural **resources** aligns with national goals of industrialization, waste reduction, and sustainable development. By converting underutilized seeds into functional industrial materials, this approach supports circular economy principles and reduces environmental burden (Okolie *et al.*, 2016). Consequently, expanding research on alternative vegetable oils for paint production is both timely and essential for advancing sustainable materials development in Nigeria (Udeozor *et al.*, 2022).

Nigeria relies heavily on imported paints and petroleum-based raw materials, making local paint products expensive and vulnerable to supply fluctuations. Meanwhile, seeds from breadfruit, avocado, and castor are often discarded, creating environmental waste and wasting potential industrial resources. Although these oils have potential for paint production, their use—individually or in blends for alkyd resin synthesis is limited. This gap calls for research on utilizing these locally available oils to produce cost-effective and sustainable paints.

This study is significant as it promotes the use of renewable and environmentally friendly raw materials in paint production. Utilizing vegetable oils from breadfruit, avocado, and castor seeds can reduce reliance on imported petroleum-based resins, lowering production costs and enhancing local industrial self-sufficiency.

Moreover, converting these commonly discarded seeds into value-added products helps minimize environmental pollution and demonstrates the industrial potential of Nigeria's agricultural resources, contributing to sustainable development. Successful formulation of paint from these oils could provide a cost-effective and eco-friendly alternative for the local paint industry. The aim of this study is to produce and characterize alkyd resin-based paint from breadfruit, avocado, and castor seed oils.

2.0 METHODOLOGY

2.1 Materials

2.1.1 Samples

The seeds used in this study includes: Avocado pear (*Persea americana*) Breadfruit (*Artocarpus altilis*) and Castor (*Ricinus communis*). These seeds were selected due to their local availability, high oil content, and suitability for alkyd resin and paint formulation and they were obtained by market survey.

2.1.2 Apparatus

The equipment used for extraction, alkyd resin synthesis, and paint formulation included: Analytical weighing balance, Soxhlet extraction apparatus, Rotary evaporator, Round-bottom flasks, Beakers, conical flasks, and standard laboratory glassware, Separating funnels, Blender or grinder, Glass rods and stirring rods, pH meter, Refractometer, Oven (for drying seeds), Viscometer, Plastic beakers and Mesh sieve

2.1.3 Reagents Used

The chemicals and reagents used in this study were:

n-Hexane – extraction solvent, Glycerol – polyol for alkyd resin synthesis, Maleic anhydride – acid component for esterification, Xylene – reaction medium and viscosity regulator, Potassium

hydroxide (KOH) – for titration and acid value determination, Ethanol – for solubility tests, Phenolphthalein – indicator for titration, Distilled water – for all solution preparations, Sodium hydroxide (NaOH) – catalyst for alcoholysis, Titanium dioxide (TiO₂) – pigment for paint, Cobalt Naphthenate – drier for paint, Texanol – coalescing agent and Petrol – solvent for paint formulation

2.1.4 Sample Preparation

The seeds of avocado pear, breadfruit, and castor were obtained by market survey from Osogbo and Ibadan. Each seed was carefully cleaned to remove dirt, debris, and damaged seeds to ensure high-quality oil extraction.

- Avocado seeds were grated into smaller pieces to facilitate faster drying and improve oil extraction.
- Castor seeds were dehulled before drying.
- Each sample was weighed prior to drying to determine initial moisture content.

2.1.5 Sample Treatment

To investigate the effect of different drying conditions on oil yield and quality, seeds of each type were subjected to three drying methods:

- Sun-drying: Seeds were exposed to direct sunlight for 5 days.
- Air-drying: Seeds were shade-dried at room temperature for 5 days.
- Oven-drying: Seeds were dried in an oven at 60 °C until constant weight was achieved.

After drying, seeds were weighed again to determine final moisture content and assess the effectiveness of each method.

2.1.6 Paint Production

2.1.6. 1 Oil Extraction

Dried seeds were grinded into fine powder using a mechanical blender to enhance solvent penetration during extraction. Each batch was labeled according to seed type and drying method. Oil extraction was carried out using a Soxhlet apparatus with n-hexane: 250 g of powdered seed was placed in a Soxhlet thimble. The thimble was inserted into the Soxhlet apparatus containing 1.5 L of n-hexane. Extraction continued until no further oil was observed in the solvent. The solvent was evaporated under controlled conditions using a rotary evaporator to obtain the crude oil.

Oil yield (%) was calculated as:

$$\text{oil yield} = \frac{\text{weight of oil extracted (g)}}{\text{weight of seed or sample (g)}} \times 100$$

Oils obtained from all three drying methods for each seed type were collected in labeled containers for subsequent alkyd resin synthesis and physicochemical analysis.

2.1.6.2 Production of Alkyd Resins and Paint Formulation

Oils obtained from the three drying methods for each seed type were blended in equal proportions to form composite oil samples. These composite oils were used for alkyd resin synthesis, carried out in two stages: alcoholysis (monoglyceride formation) and esterification. Each oil was processed separately.

2.1.6. 2.1 Castor Seed Oil

Stage 1: Alcoholysis (Monoglyceride Formation)

30 g of heated castor oil was transferred into a beaker. 8.5 g of glycerol and 5 mL of 0.5% NaOH were added. The mixture was heated at 240 °C and stirred continuously for 45 minutes and 1 mL

of the mixture was dissolved in 3 mL methanol; complete dissolution confirmed monoglyceride formation.

Stage 2: Esterification

10 g of maleic anhydride and 2 mL of xylene were added.

The mixture was heated at 240 °C and stirred until maleic anhydride dissolved completely.

Note: Excess maleic anhydride caused a rapid increase in viscosity, leading to premature gel formation, limiting proper polymer chain growth.

2.1.6.2 Breadfruit Seed Oil

Stage 1: Alcoholysis (Monoglyceride Formation)

20 g of heated breadfruit oil was placed in a beaker. 8 g of glycerol and 5 mL of 0.5% NaOH were added. Heated at 240 °C and stirred for 45 minutes. 1 mL of the mixture dissolved in 3 mL methanol to confirm monoglyceride formation.

Stage 2: Esterification

2.5 g of maleic anhydride and 2 mL of xylene were added. Heated at 240 °C and stirred continuously for 2 hours. Acid value was monitored until 5.6 and the alkyd resin was allowed to cool.

Stage 3: Paint Formulation

20 g of breadfruit alkyd resin was mixed with 30 mL of petrol. 5 g of titanium dioxide dissolved in distilled water was added. 2 g of cobalt Naphthenate drier was added and mixed for 30 minutes. 2 mL of Texanol was added while stirring for 10 minutes. The paint was filtered through a mesh sieve for smooth texture and uniform film formation.

2.1.6.3 Avocado Pear Seed Oil

Stage 1: Alcoholysis (Monoglyceride Formation)

10 g of heated avocado oil was placed in a beaker. 3.5 g of glycerol and 5 mL of 0.5% NaOH were added. Heated at 240 °C and stirred for 45 minutes. 1 mL dissolved in 3 mL methanol confirmed monoglyceride formation.

Stage 2: Esterification

1 g of maleic anhydride and 2 mL of xylene were added.

Heated at 240 °C and stirred continuously for 2 hours.

Acid value monitored until reaching 5.0.

The alkyd resin was allowed to cool.

Stage 3: Paint Formulation

5 g of avocado alkyd resin was mixed with 10 mL of petrol. 5 g of titanium dioxide dissolved in distilled water was added. 1 g of cobalt Naphthenate drier was added and stirred for 30 minutes. 0.5 mL of Texanol was added while stirring for 10 minutes. The paint was filtered through a mesh sieve for a smoother, uniform film.

2.2 Methodology

2.2.3 Characterization Methods

Below was the parametric analysis carried out on the products: **Drying Time; Adhesion Test; Water Resistance Test; Hardness; Glossary of the Paint**



Fig 1: Seed Samples in different drying methods

3.0 RESULTS AND DISCUSSION

3.1 Physicochemical Properties of Oils

3.1.1 Weight of the Samples

Table 3.1: Weight of Seed Samples Used for Oil Extraction

Oil Type	Drying Method	Weight of Seed Sample (g)
Breadfruit	Sun-dried	250
Breadfruit	Air-dried	250
Breadfruit	Oven-dried	250
Avocado	Sun-dried	250
Avocado	Air-dried	250
Avocado	Oven-dried	250
Castor	Sun-dried	250
Castor	Air-dried	250
Castor	Oven-dried	250

Key: Breadfruit 250g, Avocado 250g, and Castor 250g

A constant seed weight of 250 g was used for all samples to ensure uniformity and allow accurate comparison of oil yield and physicochemical properties across oil types and drying methods. This standardization eliminates mass-related bias in oil recovery and quality assessment.

Table 3.2: Physicochemical Properties of Oils

Oil Type	Drying Method	pH	Oil Yield (%)	Acid Value (mgKOH/g)	Viscosity (mPa·s)	Iodine Value (gI ₂ /100g)	Peroxide Value (meq/kg)	Refractive Index	Saponification Value (mgKOH/g)	FFA (% Oleic Acid)
Breadfruit	Sun-dried	6.9	12.4	3.93	29.8	112.94	4.8	1.463	137.45	1.94
Breadfruit	Air-dried	6.9	13.2	3.37	29.7	119.29	4.9	1.461	134.64	2.49
Breadfruit	Oven-dried	6.9	16.4	3.37	29.8	115.48	4.7	1.462	137.45	2.22
Avocado	Sun-dried	6.3	16.4	2.24	32.2	68.53	2.7	1.460	106.59	1.11
Avocado	Air-dried	6.5	19.2	2.81	32.2	69.79	2.9	1.461	106.59	0.83
Avocado	Oven-dried	6.3	22.4	2.24	32.2	73.60	2.5	1.461	109.39	1.11
Castor	Sun-dried	6.6	35.6	3.37	33.7	76.14	2.6	1.471	129.03	1.39
Castor	Air-dried	6.7	38.1	2.81	33.2	79.95	2.7	1.469	117.81	1.11
Castor	Oven-dried	6.6	39.2	3.37	33.6	81.22	2.6	1.471	115.01	1.39

All oils exhibited slightly acidic to near-neutral pH values, indicating minimal hydrolytic degradation during processing. Breadfruit oil showed the most stable pH across drying methods, while avocado oil exhibited slightly lower pH values, suggesting mild organic acid presence.

Oil yield increased consistently from sun-dried < air-dried < oven-dried samples across all oil types. Castor seed oil recorded the highest yield, confirming its oil-rich nature. Oven drying enhanced oil recovery due to effective moisture removal and cellular breakdown.

All oils showed low acid values, indicating limited free fatty acid formation. Avocado oil exhibited the lowest acid values, suggesting better resistance to hydrolysis. The results confirm the suitability of all oils for alkyd resin synthesis.

Castor oil showed the highest viscosity due to hydroxylated fatty acids, while breadfruit oil showed the lowest. Drying method had minimal effect on viscosity, indicating stable flow behavior.

Breadfruit oil exhibited the highest iodine values (119.29), indicating higher unsaturation and better drying characteristics. Avocado oil showed the lowest values, classifying it as non-drying, while castor oil showed intermediate behavior.

Peroxide values were generally low, indicating minimal oxidation. Oven-dried samples showed slightly lower peroxide values, reflecting improved oxidative stability.

The refractive index values of all oils fell within narrow ranges, indicating purity and absence of major impurities. Castor oil exhibited the highest refractive index, reflecting its higher degree of hydroxylation and unsaturation compared to breadfruit and avocado oils.

Breadfruit oil showed the highest saponification values, suggesting the presence of shorter-chain fatty acids. Avocado oil recorded the lowest values, indicating longer fatty acid chains. Castor oil exhibited intermediate values, confirming its suitability for alkyd resin production.

FFA values were generally low for all oils, indicating limited hydrolytic rancidity. Avocado oil showed the lowest FFA content, suggesting better storage stability, while breadfruit oil exhibited slightly higher values.

3.2 Physicochemical Characterization of Oils and Paint Analysis

This section presents the physicochemical properties of avocado, breadfruit, and castor oils, as well as the properties of alkyd paints produced from these oils. All measurements were done in triplicate, and mean values were taken. Below were results of analyses of paint produced from Alkyd resin obtained from avocado, breadfruits and castor seeds.

3.2.1 Drying Time

Table 3.3: Drying Time of Alkyd Paint Samples at 40 °C

Sample	Trial 1	Trial 2	Trial 3	Mean (hrs)
X (Avocado oil)	72	73	72	72.3
Y (Breadfruit oil)	68	70	68	68.7

Key: X = Avocado and Y = Breadfruits

Breadfruit oil paint dried the fastest (68.7 hrs), while avocado oil paint took the longest (72.3 hrs) which is consistent with its high viscosity. Faster drying improves practicality in paint application.

3.2.2 Adhesion on Wood

Table 3.4: Adhesion of Alkyd Paint on Wood

Sample	Trial 1	Trial 2	Trial 3	Mean (MPa)
X (Avocado oil)	1.8	1.5	1.8	1.7
Y (Breadfruit oil)	1.4	1.2	1.5	1.37

Key: X = Avocado and Y = Breadfruits

Adhesion strength was highest for avocado oil paint (1.7 MPa) and lowest for breadfruit oil paint (1.37 MPa). Showing it can form strong and durable films on wood surfaces.

3.2.3 Gloss of the Paint

Table 3.5: Gloss of Alkyd Paint at 60 °C

Sample	Trial 1	Trial 2	Trial 3	Mean
X (Avocado oil)	50	50	50	50
Y (Breadfruit oil)	49	49	48	48.7

Key: X = Avocado and Y = Breadfruits

Gloss values indicate smooth, reflective surfaces for all two paints. Avocado oil paint had the highest gloss (50), while breadfruit oil was slightly lower (48.7).

3.2.4 Water Resistant

Table 3.6: Water Resistance of Alkyd Paint Samples

Sample	Trial 1	Trial 2	Trial 3	Mean (%)
(Avocado oil)	1.2	1.1	1.2	1.17
(Breadfruit oil)	1.1	1.1	1.1	1.10

Key: X = Avocado and Y = Breadfruits

All paints showed good water resistance, with avocado oil paint slightly better (1.17%) than breadfruit (1.10%) suitable for protective coatings.

3.2.5 Hardness

Table 3.15: Hardness of Alkyd Paint Samples

Sample	Hardness
X (Avocado oil)	Soft
Y (Breadfruit oil)	Moderate

Key: X = Avocado and Y = Breadfruits

Avocado oil paint formed a soft film and breadfruit oil paint was moderate showed moderate-soft hardness, balancing flexibility with mechanical strength.



Fig 2: Heating Process of Alcoholysis and esterification



Fig 3: Paint being tested on a Plank



Fig 4: Paint made from Breadfruit seed



Fig 5: Paint Made from Avocado Pear Seed

3.2 Discussion of Findings

The physicochemical analysis of breadfruit, avocado, and castor oils revealed distinctive characteristics that are influenced by both the type of oil and the drying method employed. The pH values of all oils were slightly acidic to near-neutral, ranging from 6.3 to 6.9. Breadfruit oil exhibited the most stable pH (oven-dried, air-dried and sun-dried) across all drying methods, indicating minimal chemical changes during extraction. In contrast, avocado oil showed slightly lower pH values, suggesting the presence of mild organic acids, which may influence its stability and suitability for certain applications such as paint formulation.

Oil yield varied significantly across the three seed types and drying methods. Castor oil consistently demonstrated the highest yield, followed by avocado and breadfruit oils. The results indicated that oven drying enhanced oil recovery for all seed types, likely due to more effective moisture removal and disruption of seed cell structure. This finding underscores the importance of drying techniques in maximizing oil extraction efficiency, particularly for oils intended for industrial applications like alkyd resin production.

Acid values were generally low for all oils, with avocado oil showing the lowest values. This suggests limited hydrolysis of triglycerides and minimal free fatty acid formation, which is desirable for oil stability. Breadfruit oil, while slightly higher in acid value, still falls within an acceptable range for alkyd resin synthesis. Castor oil exhibited intermediate acid values,

confirming its moderate susceptibility to hydrolytic reactions, likely due to its hydroxylated fatty acids.

Viscosity measurements at 38 °C revealed that castor oil had the highest viscosity (33.7) among the three oils, while breadfruit oil had the lowest (29.7). The high viscosity of castor oil can be attributed to the presence of ricinoleic acid, a hydroxylated fatty acid that increases intermolecular interactions. Avocado oil showed moderate viscosity, and all oils demonstrated minimal changes in viscosity across drying methods, indicating stable flow properties that are favorable for paint formulations requiring controlled film thickness and spreadability.

The iodine values highlighted differences in unsaturation levels among the oils. Breadfruit oil had the highest iodine values (119.29), indicating greater unsaturation and better drying potential. Avocado oil had the lowest values, classifying it as a non-drying oil, whereas castor oil exhibited intermediate iodine values. These differences are critical in determining the curing behavior of alkyd paints, as more unsaturated oils typically polymerize faster when exposed to air.

Peroxide values were uniformly low, suggesting minimal oxidative degradation during oil extraction and storage. Oven-dried samples tended to have slightly lower peroxide values, indicating improved oxidative stability due to the more complete removal of moisture, which reduces hydroperoxide formation. The low peroxide content confirms that the oils are suitable for paint production and other industrial applications without significant risk of rancidity.

Refractive index measurements supported the purity and quality of the oils. Castor oil displayed the highest refractive index (1.471), reflecting its higher hydroxylation and moderate unsaturation. Breadfruit and avocado oils had lower refractive indices (1.460), consistent with their fatty acid composition. These optical properties are relevant in monitoring oil quality and can affect the clarity and appearance of the resulting alkyd paint films, which is in accordance with the work of Umunakwe (2012).

The saponification values revealed that breadfruit oil contains shorter-chain fatty acids (1.94), while avocado oil is composed of longer-chain fatty acids (0.83). Castor oil showed intermediate values, suggesting a balance of chain lengths suitable for alkyd resin synthesis. These findings indicate that breadfruit oil could contribute to harder paint films, whereas avocado oil may enhance flexibility, and castor oil provides a combination of mechanical strength and pliability.

Paint analysis further reflected the influence of oil properties on performance. Breadfruit oil paint dried the fastest (68.), consistent with its high iodine value, while avocado oil paint took longer to dry due to its low unsaturation (72.3). Adhesion tests showed that avocado oil paint had the highest adhesion strength (1.7), suggesting strong film formation on wood surfaces, whereas breadfruit oil paint had the lowest (1.37). This is in accordance with the work of Sanyaolu *et al.*, 2019.

Gloss, water resistance, and hardness results indicated that all two paints were suitable for decorative and protective applications. Avocado oil paint displayed the highest gloss and a soft film (50), which favors aesthetic finishes. Breadfruit oil paint had moderate hardness and slightly lower gloss (48.7) but dried quickly, making it suitable for fast application. Overall, the findings suggest that the physicochemical properties of the oils directly influenced the performance characteristics of the resulting alkyd paints, which is in accordance with the work of Romanus *et al.*, 2023.

4.0 CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

The study concluded that seed type and drying method significantly influence oil yield and physicochemical properties, which in turn affect the performance of alkyd paints. Oven drying

maximized oil extraction efficiency across all seeds, while sun-drying and air-drying produced slightly lower yields. Castor oil emerged as the most oil-rich and versatile seed oil, suitable for alkyd resin production due to its moderate unsaturation, high viscosity, and balanced mechanical properties. Breadfruit oil, with high iodine values and fast drying time, is ideal for applications requiring rapid paint curing, whereas avocado oil, with low acid values and high adhesion, is suitable for aesthetic and flexible coatings.

The properties of the oils were closely linked to the functional performance of the alkyd paints. Paints made from these oils demonstrated varying drying times, adhesion strengths, gloss levels, hardness, and water resistance, reflecting the physicochemical characteristics of the base oils. The findings support the feasibility of using locally sourced seed oils for sustainable paint production, reducing reliance on conventional petrochemical oils.

4.2 Recommendations

- Avocado and breadfruit oils should be explored further for commercial alkyd paint production, given their unique physicochemical properties and performance characteristics.
- Oven drying is recommended for oil extraction from seeds to maximize yield and ensure consistent physicochemical quality, particularly for industrial applications.
- Further studies should investigate blending these oils in various ratios to optimize alkyd paint performance, potentially combining fast drying, high adhesion, and flexibility in a single formulation.
- Storage and shelf-life studies are advised to evaluate the long-term stability of oils and their derived paints, particularly focusing on oxidative and hydrolytic degradation under different environmental conditions.
- Exploration of other locally available oil seeds for alkyd resin and paint production is recommended to promote sustainable and environmentally friendly alternatives to conventional petroleum-based products.

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