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Original Research Article

EXPLORING THE PHYSICOCHEMICAL AND ANTIMICROBIAL PROPERTIES OF AVOCADO PEAR OIL IN TOPICAL PHARMACEUTICAL FORMULATIONS

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ABSTRACT

Avocado pear (Persea Americana mill) is a nutrient-rich, creamy textured, distinctive flavoured fruit with a high oil content, making it a valuable source of lipid-soluble bioactive compounds with diverse technological applications. In this study, we extracted oil from the mesocarp (flesh) of edible avocado pear using the mechanical extraction method and evaluated its physicochemical properties in comparison to commercial olive oil (OL). Parameters assessed included oil yield, pH, refractive index, specific gravity, relative viscosity, density, iodine value, saponification value, acid value, and free fatty acid composition. The extracted avocado oil (AV) was utilized in the formulation of benzoic acid and benzoic acid-ciprofloxacin hydrochloride ointments, which were assessed for antifungal efficacy. The extracted AV exhibited significant resemblance ($p<0.05$) to olive oil in terms of oil yield (27.5%), pH (AV:7.40; OL:7.8), iodine value (AV:0.04; OL:0.005 mg/KOH/g), acid value (AV:0.75; OL:0.65 mg KOH/g), and density (AV:1.21122; OL:1.00526 g/cm^3), with no statistically significant differences ($p>0.05$). However, relative viscosity (AV:88.82; OL:57.53 cSt), saponification value (AV:106.17; OL:187.08 mg/KOH/g), and free fatty acid composition, particularly oleic (AV:0.28%; OL:0.62%) and linoleic acids (AV:0.41%; OL:0.27%), exhibited significant variation ($p<0.05$). All the benzoic acid formulations prepared with avocado oil demonstrated greater inhibitory activity against Aspergillus niger (An) compared to Candida albicans (Ca). The benzoic acid–ciprofloxacin formulation containing avocado oil, also demonstrated enhanced inhibitory activity against Aspergillus niger (33.10 mm) and Candida albicans (21.00 mm) compared to the olive oil-based formulation (An:27.57mm; Ca:22.50mm) and the control (An:25.75 mm, Ca:18.00 mm). Overall findings indicate that avocado oil exhibits physicochemical and antimicrobial properties comparable to those of olive oil, reinforcing its potential as a natural excipient in topical antimicrobial formulations as well as in other pharmaceutical, cosmetic, and industrial applications.

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INTRODUCTION

Avocado (*Persea americana*), a member of the Lauraceae family, and commonly known as avocado pear or alligator pear due to its distinctive shape and textured skin, is a nutritionally rich fruit with significant economic and industrial value, that has gained considerable attention for its high lipid content and diverse bioactive compounds. Avocados are of dozens of

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varieties and differ in their size, appearance, quality and susceptibility to cold based on the type of specie [1]. Native to Central America, it is now cultivated extensively in warm temperate and subtropical regions worldwide, with leading producers including Mexico, the United States, South Africa, and Chile [2]. Three species are largely cultivated and produced to varying degrees in the tropical rainforest and savannah belts of Nigeria [3]. The fruit comprises approximately 65% mesocarp (flesh), 20% seed, and 15% pericarp (peel) [4]. The edible flesh which is yellow-greenish, with a luscious, creamy, buttery consistency and subtle nutty flavour [5] is particularly valued for its high content of monounsaturated fatty acids, vitamins, and phytochemicals with anti-oxidative and anti-inflammatory properties [3, 6].

Nutritionally, avocado is a rich source of essential vitamins and minerals, including vitamin K, vitamin E, vitamin B6, vitamin C, folate, and copper. It also contains a high concentration of potassium, exceeding that found in bananas, along with carbohydrates, dietary fibre, and beneficial lipids [7]. Approximately 75% of an avocado's caloric content is derived from fat, primarily monounsaturated lipids, which have been shown to have favourable impact on serum cholesterol levels and cardiovascular health, weight management [6, 7]. The fruit's pericarp contains bioactive compounds with reported antiviral, antibiotic, and insecticidal properties, traditionally utilized in ethnomedicine for the treatment of dysentery and parasitic infections [8]. Additionally, the fruit contains a unique fatty alcohol, avocadene (16-heptadecene-1,2,4-triol), which has been identified as a potential bioactive compound with dermatological applications [9]. Oil yield from avocado can vary from 6.0 – 97 % depending on its varieties, part of the avocado used, extraction method used and period of extraction [10]. Avocado oil, primarily derived from the mesocarp, is considered a high-quality vegetable oil with a composition similar to that of olive oil, albeit with higher concentrations of β-sitosterol and lower levels of squalene and polyphenols [11]. It is widely incorporated into cosmetic products due to its moisturizing and emollient properties, which contribute to skin hydration and repair [12]. Additionally, it is also being widely utilized in the food, nutraceutical, and pharmaceutical due to its beneficial health attributes and technological applications. The growing global demand for avocado oil has driven interest in optimizing its extraction and refining processes to enhance yield and preserve bioactive components.

Several extraction methods are employed to obtain avocado oil, including mechanical (cold pressing), solvent-based, and advanced techniques such as supercritical CO_2 and ultrasound-assisted extraction [2]. Cold pressing is favoured for culinary applications as it minimizes heat-induced degradation of bioactive compounds [13]. However, solvent extraction, particularly using hexane, remains the most common method for industrial-scale production due to its higher yield, despite concerns regarding residual solvents and environmental impact [3]. Recent studies have explored enzymatic extraction and ultrasound-assisted aqueous extraction to improve oil recovery while maintaining quality [2].

Despite the extensive characterization of avocado oil's physicochemical and nutritional properties, limited research has investigated its pharmaceutical potential. While avocado oil has been incorporated into cosmetics and dermatological formulations, its application in drug delivery systems remains underexplored [13]. This study aims to bridge this gap by evaluating the potential of avocado oil as a pharmaceutical excipient. Specifically, the physicochemical properties of mechanically extracted avocado oil were compared with commercial olive oil to assess its suitability for medicinal formulations. Furthermore, the extracted oil was employed in the development of benzoic acid and ciprofloxacin hydrochloride ointments, with subsequent antimicrobial evaluation against *Aspergillus niger* and *Candida albicans*. The findings from this study contribute to the growing body of knowledge on the pharmaceutical applications of avocado oil and its potential as a sustainable alternative to conventional excipients.

MATERIALS AND METHODS

Carbon tetrachloride, Iodine monochloride solution, potassium iodine solution (Sigma-Aldrich, USA), N/10 solution of thiosulphate, 95% ethanol, Solvent ether (Merck, US), phenolphtalein, N/10 aqueous potassium hydroxide, sodium hydroxide, Sabouraud dextrose agar (Sigma-Aldrich, USA), benzoic acid powder (A.M food Chemical Co. Ltd, China), salicylic acid powder, liquid paraffin, white soft paraffin (Unicorn Petroleum Indust. PVT. Ltd., India), Premulgin D (Lubrizol, Ohio), distilled water (Lion water, Nsukka, Nigeria). All other chemicals used were of analytical grade and water was double distilled.

The test organisms used for assessing antifungal activity were clinical strains of *Aspergillus niger* and *Candida albican* obtained from Bishop Shanahan hospital, Nsukka, Enugu state, Nigeria.

Avocado pear fruits were harvested at full maturity from a local farm in Nsukka, Enugu state, Nigeria. They were visually inspected for defects and stored at room temperature for two days before processing, and extracting the oil in our laboratory.

Determination of physical properties of avocado pear

The physical properties of the avocado pear fruit such as the shape, size, weight, color and sphericity were determined using the methods described by Mohsenin and Orhevba *et al* [14, 15].

Extraction of Avocado Pear Oil

Avocado pear oil was extracted using a method reported by Costagli [16] and Nwaokobia [17] with slight modifications. Simply, the avocado fruit was thoroughly washed, the pericarp was peeled off (deskinned) and the fruit was destoned (i.e. the inner seed in the middle of the fruit was removed) with a stainless steel knife. The pulp (mesocarp) was scraped into an electric blender, and then blended with a little water until a smooth homogenous mix was obtained. This process also facilitates the release of oil from the vacuoles. The blended

pulp was transferred into a stainless steel vessel where malaxation occurred by heating the pulp-paste (with constant stirring, every 5 min) over a water bath set at a temperature of 50 – 60 ^{O}C until most of the water content had evaporated. This step allows the rupture of cell walls allowing the release of small oil droplets to aggregate and form larger droplets thus, increasing the oil yield. The avocado paste was then transferred to a muslin cloth with a pore size of about 2 mm, manually squeezed hard to extract the and then stored in a clean dry bottle for further analysis.

Physicochemical Properties of the Extracted Avocado Pear Oil

Some physical properties (moisture content, viscosity, specific gravity, refractive index, density and pH) of the extracted avocado oil were evaluated for using standard methods [16-19]. Other chemical properties (like refractive index, specific gravity, density, iodine value, peroxide value, acid value, saponification value, free fatty acid value) evaluated were all determined by AOAC methods [20].

All determinations were done in triplicates and values in the result are presented as mean and standard deviations.

Iodine value

Iodine value expresses the quantity in grams of iodine absorbed per 100 g of lipid and it is indicative of the measure of the average degree of unsaturation of a lipid. Here, a 10 ml volume of the avocado pear oil was poured into 250 mL iodine flask and the oil was dissolved in 10 mL of carbon tetrachloride solution. A 25 mL volume of iodine monochloride solution was added to the mixture and the flask was closed with a stopper that had been previously moistened with potassium iodide solution. The mixture was allowed to stand for 30 min in a dark place, at a temperature of between 15 – 25^{o}C with occasional shaking. After 30 min, the stopper was carefully removed and 15 mL of potassium iodide solution was added to the mixture followed by 100 mL of water. The liberated iodine was titrated with 0.1N sodium thiosulphate solution with thorough shaking after each addition. When the iodine color became pale, 3 drops of starch mucilage was added as the indicator and the titration was continued until the color was discharged. A blank titration without the oil but with the same volume of reagents was also similarly performed. The iodine value of the oil was calculated using the formula:

$$Iodine\ value = {[126.9(V_B - V_T)N]}/{10W} \quad \ldots\ldots\ldots\ldots\ldots \quad Eq.1$$

where, 126.9 is the atomic weight of iodine, V_B and V_T are the volumes in mL of the 0.1N sodium thiosulphate consumed by the blank and test oil (avocado) respectively, N, is the exact normality of the sodium thiosulphate and W, is the weight of the avocado oil. The same procedure was also repeated using olive oil as a control.

Acid value

The acid value measures the quantity of potassium hydroxide in milligrams required to neutralize the free acids present in 1 g of a substance. It is indicative of hydrolytic rancidity and the edibility of the lipid. Here, a 10g quantity of the avocado pear oil was accurately weighed and dissolved in 50 mL of a mixture of equal volume of 95% alcohol and ether (which has been neutralized with the addition of 1 mL phenolphthalein solution) in a 250 mL conical flask. Two (2) drops of phenolphthalein TS was added to the mixture and it was titrated with 0.1N potassium hydroxide VS with constant shaking until the color of the solution remained pink after shaking for 30 seconds. The acid value of the avocado pear oil was then calculated using the formula:

$$\boldsymbol{Acid\ value} = \frac{V_a \times 56.1 \times 100}{Wt\ (g)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad Eq.2$$

where, a, is the volume in mL of 0.1N potassium hydroxide, 56.1 is the molecular weight of potassium hydroxide and Wt is the weight of the avocado oil. The same procedure was also repeated using olive oil as a control.

Saponification value

Saponification value expresses the quantity of potassium hydroxide in mg required to neutralize the free acids, and saponify the esters present in 1g of the substance. It is indicative of the average molecular weight of the triacylglycerol in a sample. Here, a 2g quantity of oil was weighed out into a 250 mL flask and 25 mL of 0.5N alcoholic potassium hydroxide solution was added to it. The flask was attached to a reflux condenser and heated on a steam bath for 1 h, frequently rotating the contents. One milliliter (1 mL) of phenolphthalein was added to the solution and the excess potassium hydroxide was titrated with 0.2N hydrochloric acid VS. A blank (without the oil) was similarly titrated following the same procedure and the saponification value (S.V) of the oil was calculated using the formula:

$$S.V = \frac{(V_B - V_T) \times N \times 56.1}{Wt\ (g)} \ldots\ldots\ldots\ldots \quad Eq.3$$

Where, 56.1 is the molecular weight of potassium hydroxide, V_B and V_T are the volumes in mL of the 0.2N hydrochloric acid consumed by the blank and test oil (avocado) respectively, N, is the exact normality of the hydrochloric acid and W, is the weight in g of the avocado oil. The same procedure was also repeated using olive oil as a control.

Preparation of ointment

Six batches of ointments (B-1 to B-3 and C-4 to C-6) containing either benzoic acid (BA), or a combination of benzoic acid and ciprofloxacin hydrochloride (BAC), were prepared using the fusion method according to the composition presented in Table 1. The emulsifying ointments (white soft paraffin, Premulgin D® and liquid paraffin) were melted according to their melting points over a water bath. Weighed quantities of either BA or BAC and salicylic acid were triturated with a portion of the melted emulsifying ointment until a smooth homogenous mix was obtained. The remaining emulsifying ointment was

gradually added and the resultant ointment was filled into collapsible tubes and stored for further analysis. Batches B-1 and C-4 were prepared with liquid paraffin and served as control. B-2 and C-5 ointment formulations were prepared with avocado pear oil in place of liquid paraffin, while B-3 and C-6 were prepared with olive oil.

Evaluation of the Ointments

The agar-well diffusion method with slight modifications was used in determining the antimicrobial activity and inhibition zone diameters (IZDs) of the prepared ointments. The sabouraud dextrose agar (SDA) plate method was employed and the test microorganisms used were turbidimetrically standardized *Candida albican and Aspergillus niger*. A 200 mL of distilled water was measured using a 500 mL measuring cylinder and poured into a beaker containing 20 g of SDA. The mixture was heated over a flame until a homogenous suspension was formed and then 250 mg of chloramphenicol was added to the suspension in order to inhibit bacterial growth. The suspension was transferred into bijou bottles and sterilized in an autoclave at 21^{o}C for 15 min. A 20 mL of sterile SDA was poured into petri dishes and allowed to solidify. The plates were then seeded with a loop full of the standardized test microorganisms (3 plates for each microorganism). The culture plates were divided into two equal segments using a wax pencil and using a standard cork borer, two holes (10 mm in diameter) were bored into each segment. A 0.2g quantity of each formulated ointment was introduced into each hole under sterile conditions, allowed to stand for 15 min and incubated at 37 ^{0}C for 24 h. The inhibition zone diameter, IZDs of the formulated ointments were then measured from the plates.

Statistical Analysis

All data obtained were analysed using Microsoft Excel and SPSS version 20 (SPSS Inc. Chicago, IL, US). All values are expressed as mean ± standard deviation (mean ± SD). Means were compared using the one-way Analysis of variance (ANOVA) and difference between experimental means were assessed by Duncan Post-Hoc test, where ($p < 0.05$) was considered statistically significant.

Table 1: Formula for preparing Benzoic acid and Benzoic acid-ciprofloxacin hydrochloride ointments

Ingredients (g)	Batches					
	B1	B2	B3	C4	C5	C6
Benzoic acid	6.0	6.0	6.0	6.0	6.0	6.0
Ciprofloxacin hydrochloride	-	-	-	0.1	0.1	0.1
Salicylic acid	3	3	3	-	-	-
White soft paraffin (petroleum jelly)	45.5	45.5	45.5	45.5	45.5	45.5
Emulsifying wax (Premulgin D®)	27.3	27.3	27.3	27.3	27.3	27.3
Liquid paraffin	18.2	-	-	18.2	-	-
Avocado pear oil	-	18.2	-	-	18.2	-
Olive oil	-	-	18.2	-	-	18.2

*Batches B1-B3 are the benzoic acid ointments containing either liquid paraffin, avocado pear oil or olive oil while batches C4-C6 are the benzoic acid-ciprofloxacin ointments also containing either liquid paraffin, avocado pear oil or olive oil.

RESULTS

The physicochemical properties of the extracted avocado oil as presented in Tables 2 and 3 were evaluated and compared with a commercial grade sample of olive oil to assess its suitability for pharmaceutical and industrial applications.

Physical Characteristics of Avocado Pear Fruit

The physical characteristics of the avocado pear fruit is presented in Table 2. The avocado pear fruit displayed an oblong shape, with vertical axis dimensions greater than the horizontal axis. The fruit dimensions were 10.081 mm (major diameter), 9.258 mm (intermediate diameter), and 8.326 mm (minor diameter). The sphericity was calculated as 0.039, indicative of the fruit's elongated nature. The average weight of the fruit was 299.5 g, aligning with values reported for the Hass variety [21]. The fruit's skin colour was purplish-black at maturity, typical of certain avocado cultivars [13].

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Physicochemical Properties of Extracted Oil

The physical properties of the avocado pear oil are presented in Table 3. The oil yield from the mesocarp of avocado was 27.5%, which is significantly higher than 11.1% and 6.3% yield previously reported in similar studies [3, 17] using other extraction methods but consistent with values reported in recent studies using mechanical extraction [22- 23]. The moisture content was 0.50%, and the pH was measured at 7.4 (31.1 ± 0.5 °C). The density (1.01122 g/cm^3), specific gravity

(0.9120 g/mL), and refractive index (1.464) were all within accepted ranges for pharmaceutical oils. The oil's relative viscosity was 88.82 cSt, higher than that of olive oil (57.53 cSt). The iodine value was 150.45 mg KOH/g, while the acid value, peroxide value, and saponification value were 0.76 mg KOH/g, 0.048 g/g, and 176.17 mg KOH/g respectively. The oil was found to contain 0.28% oleic acid and 0.41% linoleic acid.

Antimicrobial Activity of Avocado Oil-Based Ointments

Ointments formulated with avocado pear oil showed pronounced antifungal activity. The benzoic acid–avocado oil formulation demonstrated the highest inhibition zone diameter (IZD) against *Aspergillus niger* (33.10 mm) and *Candida albicans* (25.00 mm), exceeding the activity of the olive oil-based counterpart. The benzoic acid–ciprofloxacin–avocado oil combination exhibited IZDs of 30.50 mm and 21.00 mm against *A. niger* and *C. albicans*, respectively. The olive oil-based formulations showed comparatively lower IZDs (Table 4, Figures 1A–H).

Table 2: Physical Characteristics of Avocado Pear Fruit

Physical characteristics evaluated	Observation
Shape of the fruit	Oblong
Color of the avocado pear fruit	Purple-black
Average weight (g)	299.5
Sphericity	0.039
Size:	
a) Major diameter (length)	10.08 mm
b) Intermediate diameter (width)	9.25 mm
c) Minor diameter (thickness)	8.32 mm

Table 3: Some physicochemical properties of Avocado oil compared to commercial grade sample of olive oil

Physicochemical properties	Avocado Pear oil	Olive oil
Oil yield (%)	27.5	-*
pH	7.4± 0.01	7.8± 0.00
Moisture content	0.50 ± 0.02	0.48 ± 0.01
Density (g/cm^3)	1.01122 ± 0.18	1.00526± 0.00
Specific gravity at 25^{o}C (g/mL)	0.9120± 0.01	0.8980± 0.22
Relative viscosity (Cst)	88.82 ± 0.05	57.53± 0.06
Refractive index at 25^{o}C	1.464± 0.41	1.450± 0.32
Iodine value (mg KOH/g)	150.45 ± 1.10	184.80 ± 1.30
Peroxide value (g/g)	0.048± 0.01	0.040± 0.00
Acid value (mg KOH/g)	0.76± 0.00	0.65± 0.01
Saponification value (mg KOH/g)	176.17± 1.25	187.08± 1.46
Free fatty acid (%): Oleic acid	0.28	0.62
Linoleic acid	0.41	0.27

*A commercial grade sample of olive oil was used for the evaluation.

Table 4: Sensitivity test of the formulated ointments showing inhibitory zone diameter (IZD)

Formulation	Inhibition zone diameter (mm)	
	Candida albicans	***Aspergillius niger***
Benzoic acid ointment with avocado oil	25.00	33.10
Benzoic acid ointment with olive oil	22.50	28.25
Benzoic acid + Ciprofloxacin with avocado oil	21.00	30.50
Benzoic acid ointment + liquid paraffin	18.50	26.75

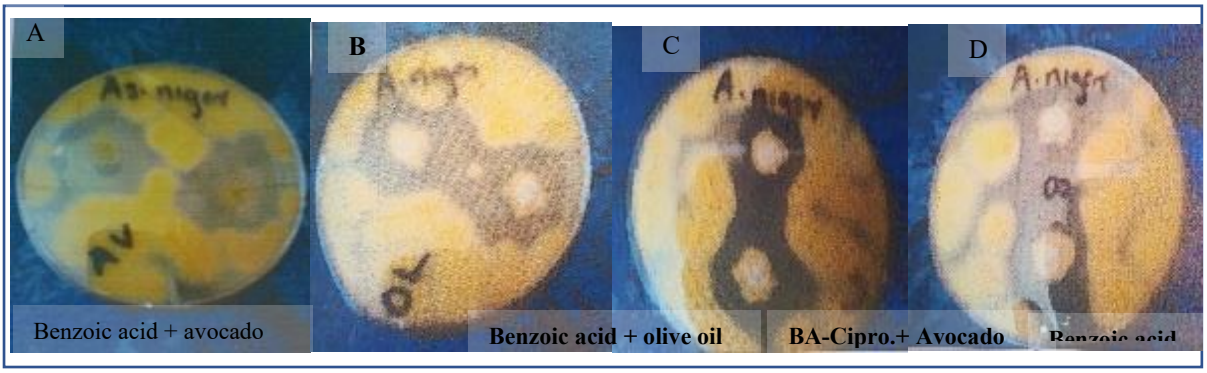

Fig. 1A-D: Antibiogram of Aspergillus niger isolates

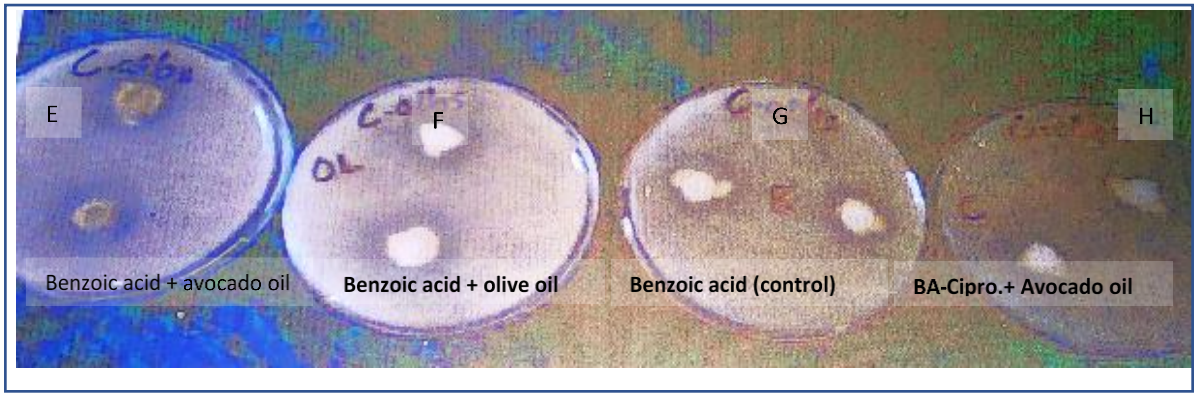

Fig. 1E-H: Antibiogram of *Candida albicans* isolates

DISCUSSION

The high oil yield obtained (27.5%) is consistent with reports that variability in oil yield and quality can vary depending on fruit variety, maturity/ripening stage, fruit tissue type, pre-extraction handling, extraction technique and extraction conditions (temperature, pH, added enzymes or malaxing time) employed [23, 24]. A previous study in Australia reported that prolonged malaxation time and mechanical pressing significantly enhances oil liberation. This was attributed to improved enzymatic activity and mechanical breakdown, which help reduce interference from lipophilic and lipoproteic particles that otherwise retain oil within the paste [25-27]. Other studies have also indicated that oil content in avocado mesocarp varies between 16–17% in September and 25–30% in April, with later-season fruits producing higher yields due to increased lipid accumulation in idioblast cells [2, 28]. The high oil yield supports the feasibility of avocado oil as a viable extract for pharmaceutical applications.

The physicochemical parameters evaluated with reference to pH, density, and refractive index show close resemblance to olive oil (Table 3) and were in line with established standards for edible and topical-grade oils [11]. The refractive index value (1.464) indicates a high degree of purity and acceptable unsaturation, similar to that of refined vegetable oils [29]. The low acid and peroxide values confirm the oil's oxidative stability and low level of hydrolytic degradation, qualities important for storage and shelf life [30].

Avocado oil exhibited higher viscosity than olive oil, a property attributed to a lower degree of unsaturation. A higher level of unsaturation is known to reduce viscosity, making oils more fluid [2]. Oils with higher viscosity are advantageous in topical formulations as they enhance skin adherence and act as

occlusive agents, aiding moisture retention [2, 13]. Avocado oil also exhibited higher linoleic acid content than olive oil, a property attributed to enhanced skin penetration and hydration, thus, reinforcing its utility in dermatological applications [13]. The iodine, acid, and saponification values suggest that the oil contains long-chain fatty acids suitable for emollient and soap applications. This could also contribute to increased oxidative stability and shelf life [2].

The antimicrobial result demonstrated the ability of avocado oil to enhance the efficacy of benzoic acid and ciprofloxacin in the treatment of fungal infections. The large inhibition zones recorded against *Aspergillus niger* and *Candida albicans* can be attributed to bioactive compounds present in avocado oil and align with earlier studies reporting antimicrobial activity of phytochemicals such as polyphenols, flavonoids, alkaloid, tannins and saponins found in avocado oil [8, 31]. The activity of these phytochemicals have been reported to cause inhibitory effects on microbial growth by disrupting bacterial and fungal cell membranes, leading to leakage of intracellular contents [31-33]. The pronounced inhibitory effect observed against *Aspergillus niger* is particularly significant, as this fungal species, ubiquitously found worldwide in decaying matter is a known causative agent of skin infections, particularly in individuals exposed to organic matter in occupational settings [2]. Reports of mould-related injection abscesses are also prevalent in developing countries, highlighting the need for effective antifungal formulations [34]. Therefore, topical preparations containing either benzoic acid or a combination of benzoic acid and ciprofloxacin using avocado pear oil would be particularly useful in the treatment of skin infections caused by *Aspergillus niger.*

Additionally, similar studies on avocado seed extracts demonstrated strong inhibitory effects against *Streptococcus agalactiae*, a pathogen associated with soft tissue infections, meningitis, and pneumonia, further supporting the therapeutic potential of avocado-based formulations [35].

Our findings reinforce the dual function of avocado oil as both an active antimicrobial agent and an effective natural pharmaceutical excipient. Its favourable physicochemical properties, combined with biological activity, support its potential use in dermatological formulations targeting fungal skin infections, particularly in cases of drug resistance or sensitivity to synthetic antifungal agents.

CONCLUSION

This study demonstrates that avocado oil possesses physicochemical properties comparable to olive oil, with notable differences in viscosity, iodine value, and fatty acid composition. Its higher linoleic acid content, high stability, emollient and moisturizing properties, support its potential benefits in dermatological formulations, while observed antimicrobial efficacy of the avocado oil-based ointments demonstrated strong antifungal activity against *Aspergillus niger* and *Candida albicans*, surpassing the efficacy of conventional olive oil-based formulations. The incorporation of avocado oil into **topical pharmaceutical products** could provide **a natural, effective alternative** for managing **skin infections and fungal dermatological conditions**, supporting the broader utilization of avocado oil for cosmetic, nutraceutical, pharmaceutical and industrial applications. Further research is recommended to explore **synergistic effects** with conventional antimicrobials and to optimize formulation stability for **commercial applications** as well as and explore broader therapeutic applications of avocado oil in other drug delivery systems.

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AUTHORS' CONTRIBUTION

U.O.N.C. did the conceptualization, methodology, investigation, and data curation. U.U.J did the sample collection and writing initial original draft of the manuscript. U.C.N was involved in the microbiological studies and data analysis. O.S.I. designed and supervised the work, manuscript reviews and editing.

CONFLICT OF INTEREST

The authors have no conflict of interest to declare.

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