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Phytochemical and Antimicrobial Evaluation of Herbal Soap Formulated from Sunflower and Orange Peel Extracts for Commercial Application

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***Abstract**: Herbal Soap is a type of cleansing product formulated using natural plant-based ingredients such as herbs, essential oils, roots, flowers, and extracts, rather than synthetic chemicals. This study evaluated the phytochemical composition, physicochemical properties, and antimicrobial activities of herbal soaps formulated from sunflower and orange peel extracts in comparison with a standard medicated soap. Qualitative and quantitative phytochemical screening revealed the presence of alkaloids, saponins, flavonoids, phenols, and tannins, with orange peel extract exhibiting higher concentrations of flavonoids and tannins than sunflower extract. Physicochemical analysis of the formulated soaps showed that parameters such as pH, moisture content, foam height, total fatty matter, and free alkali were within acceptable limits, indicating good quality and safety for skin application. Antimicrobial assessment demonstrated that both sunflower and orange peel soaps inhibited the growth of Aspergillus sp. and Staphylococcus sp., with orange peel soap showing stronger inhibition zones compared to sunflower soap. Medicated soap, however, exhibited the highest antimicrobial activity, as expected. Chi-square statistical analysis confirmed significant differences ($p \leq 0.05$) between the herbal and medicated soaps, highlighting the appreciable efficacy of the herbal formulations. The results suggest that orange peel extract, often regarded as agro-waste, can be effectively utilized in herbal soap production, enhancing antimicrobial activity and contributing to sustainable product development. This study therefore underscores the potential of herbal soaps as eco-friendly alternatives to synthetic medicated soaps, offering therapeutic, cosmetic, and environmental benefits.*

***Keywords:** Antimicrobial, Aspergillus sp., Herbal Soap, Phytochemical, Physicochemical, Staphylococcus sp.*

1.0 Introduction

Soap is one of the most widely used personal care products and plays a crucial role in hygiene, skin protection, and the prevention of infectious diseases. Traditionally, soap production has relied heavily on synthetic additives and chemical agents that, while effective, have raised concerns regarding skin irritation, antimicrobial resistance, and environmental pollution (Wirtu, 2024; Chakraborty *et al.,* 2023). In recent years, there has been a growing interest in the use of natural plant extracts in soap formulation, driven by the demand for eco-friendly, safe, and sustainable alternatives. Herbal soaps enriched with bioactive phytochemicals are particularly valued for their potential therapeutic properties in addition to their cleansing function (Bagade *et al.,* 2024).

Plant extracts such as sunflower (*Helianthus annuus*) and orange peel (*Citrus sinensis*) have gained attention due to their diverse phytochemical composition and biological activities. Sunflower extract is rich in essential fatty acids, phenolic compounds, and saponins, which contribute to moisturizing, cleansing, and mild antimicrobial effects (Amirul *et al.,* 2021;

Sutrisno *et al.,* 2021). Orange peel, often considered agro-waste, is a rich source of flavonoids, tannins, phenols, and limonoids with demonstrated antioxidant, antimicrobial, and anti-inflammatory properties (Oikeh *et al.,* 2020; Sikdar & Baruah, 2023; Hesperidin Review, 2023). Harnessing these natural compounds in soap formulation not only provides enhanced skincare benefits but also promotes waste valorization and environmental sustainability by reducing agricultural residues (Sikdar & Baruah, 2023; Citrus By-Products Review, 2023).

Physicochemical evaluation of herbal soaps is essential to determine their quality, safety, and suitability for skin use. Parameters such as pH, moisture content, foam height, total fatty matter, and free alkali provide insight into the stability and effectiveness of the formulations (Borse *et al., 2019). At the same time, antimicrobial testing against pathogens such as Staphylococcus sp. and Aspergillus sp*. provides evidence of the therapeutic potential of herbal soaps in managing common skin infections (Anwar *et al.,* 2023; Hasan *et al.,* 2022).

The integration of sunflower and orange peel extracts into soap formulations represents an innovative approach that combines the cleansing and moisturizing properties of conventional soaps with the added benefits of phytochemicals (Kumar & Singh, 2023; Olayemi *et al.,* 2024). Furthermore, the comparative evaluation of these herbal soaps with medicated soaps allows for a better understanding of their relative effectiveness and market potential. This study therefore investigates the phytochemical composition, physicochemical characteristics, and antimicrobial activity of herbal soaps formulated from sunflower and orange peel extracts, with the aim of establishing their potential as safe, effective, and sustainable alternatives to medicated soaps.

2.0 Methodology

2.1 Research Design

The study adopted an experimental research design aimed at formulating herbal soaps using sunflower and orange peel extracts and evaluating their phytochemical composition, physicochemical characteristics, and antimicrobial activity. A standard medicated soap served as the control for comparative purposes.

2.2 Materials and Sample Collection

Fresh sunflower seeds and orange peels were obtained from local markets in Osun State, Nigeria. The orange peels were washed, air-dried, and pulverized into powder, while sunflower seeds were cleaned, oven-dried, and ground. Analytical-grade reagents including ethanol, methanol, sodium hydroxide (NaOH), and olive oil were purchased from a certified supplier. Medicated soap was sourced from a recognized pharmaceutical store. Test organisms (*Staphylococcus sp.* and *Aspergillus sp*.) were collected from the Microbiology Laboratory of Federal Polytechnic Ede.

2.3 Extraction of Bioactive Compounds

Extraction was carried out using the maceration method. About 100 g each of the dried sunflower powder and orange peel powder were soaked separately in 500 mL of 70% ethanol for 72 hours with intermittent shaking. The extracts were filtered using Whatman No. 1 filter paper and concentrated using a rotary evaporator at 40 °C. The concentrated extracts were stored at 4 °C until use.

2.4 Phytochemical Screening

2.4.1 Qualitative Analysis

Standard methods as described by Harborne (1998) were used to detect the presence of alkaloids, flavonoids, tannins, saponins, and phenols in the extracts.

2.4.2 Quantitative Analysis

Alkaloids were determined using gravimetric methods, flavonoids by aluminum chloride colorimetric method, tannins by Folin-Denis method, and saponins by spectrophotometric assay. Results were expressed in mg/g of extract.

2.5 Soap Formulation

The soap was formulated using the hot process saponification method. Olive oil was used as the base oil, while sodium hydroxide served as the saponifying agent. Extracts of sunflower and orange peel were separately incorporated at 5% w/w concentration into the soap mixture, with continuous stirring until thick trace was achieved. The mixture was poured into molds, cured for four weeks at room temperature, and then cut into uniform bars. A medicated soap was included as a control.

2.6 Physicochemical Analysis of Soap

The formulated soaps and medicated soap were analyzed for the following parameters:

pH: Determined by dissolving 1 g of soap in 10 mL of distilled water and measuring with a digital pH meter.

Moisture Content: Determined by oven-drying 2 g of soap at 105 °C until constant weight.

Foam Height: Measured by shaking 1 g of soap in 10 mL of water and recording foam height after 5 minutes.

Total Fatty Matter (TFM): Determined according to AOAC (2016) standards.

Free Alkali: Measured by titrating soap solution with standard hydrochloric acid.

Colour and Texture: Assessed visually and by touch.

2.7 Antimicrobial Activity

The antimicrobial activity of the soaps was determined using the agar well diffusion method. Nutrient agar and Sabouraud Dextrose agar were used for bacterial (*Staphylococcus sp*.) and fungal (*Aspergillus sp.*) cultures, respectively. Wells were bored into the agar plates and filled with 100 µL of soap extracts. Plates were incubated at 37 °C for 24 hours (bacteria) and 28 °C for 72 hours (fungi). Zones of inhibition were measured in millimeters using a caliper. Each experiment was performed in triplicate.

2.8 Statistical Analysis

Data obtained were expressed as mean ± standard deviation. The Chi-square (χ^2) test was employed to compare antimicrobial activities between sunflower soap, orange peel soap, and

medicated soap. A p-value ≤ 0.05 was considered statistically significant. Statistical analysis was performed using SPSS version 25.0.

3.0 Results and Discussion

3.1 Results

Table 1: Qualitative Analysis of Orange Peel and Sunflower Extracts Used for Herbal Soap Formulation

S/N	Parameter	Orange Peel Extract	Sunflower Extract
1	Alkaloid	Y	Y
2	Saponin	YY	YY
3	Flavonoids	Y	Y
4	Phenol	YY	YY

Y: Present, YY: Moderately present

Table 2: Quantitative Analysis of Orange Peel and Sunflower Extracts Used for Herbal Soap Formulation

S/N	Parameter	Orange Peel Extract	Sunflower Extract
1	Alkaloid	6.2	4.8
2	Saponin	12.7	14.4
3	Flavonoid	15.3	11.4
4	Tannin	9.8	8.2

Table 3: Physicochemical Parameters of Herbal Soap Formulated with Sunflower and Orange Peel Compared with Medicated Soap

S/N	Parameter	Sunflower Soap	Orange Peel Soap	Medicated Soap
1	pH (at 27 °C)	9.1	8.7	9.4
2	Moisture Content (%)	12.3	11.8	10.2
3	Foam Height (cm)	6.8	7.2	7.5
4	Total Fatty Matter (%)	68.5	70.2	72.8
5	Free Alkali (%)	0.12	0.10	0.08
6	Colour/Texture	Light yellow, smooth	Orange-brown, smooth	White, smooth

Table 4: Antimicrobial Analysis of Produced Herbal Soap against *Aspergillussp*and Staphylococcus*sp* with Chi-Square Test

S/N	Test Organism	Sunflower Soap (mm)	Orange Peel Soap (mm)	Medicated Soap (mm)	χ^2 Value	p-Value
1	*Aspergillus* sp.	14.2	16.8	19.5	5.72	0.05
2	*Staphylococcus* sp.	18.5	20.3	22.7	4.83	0.05

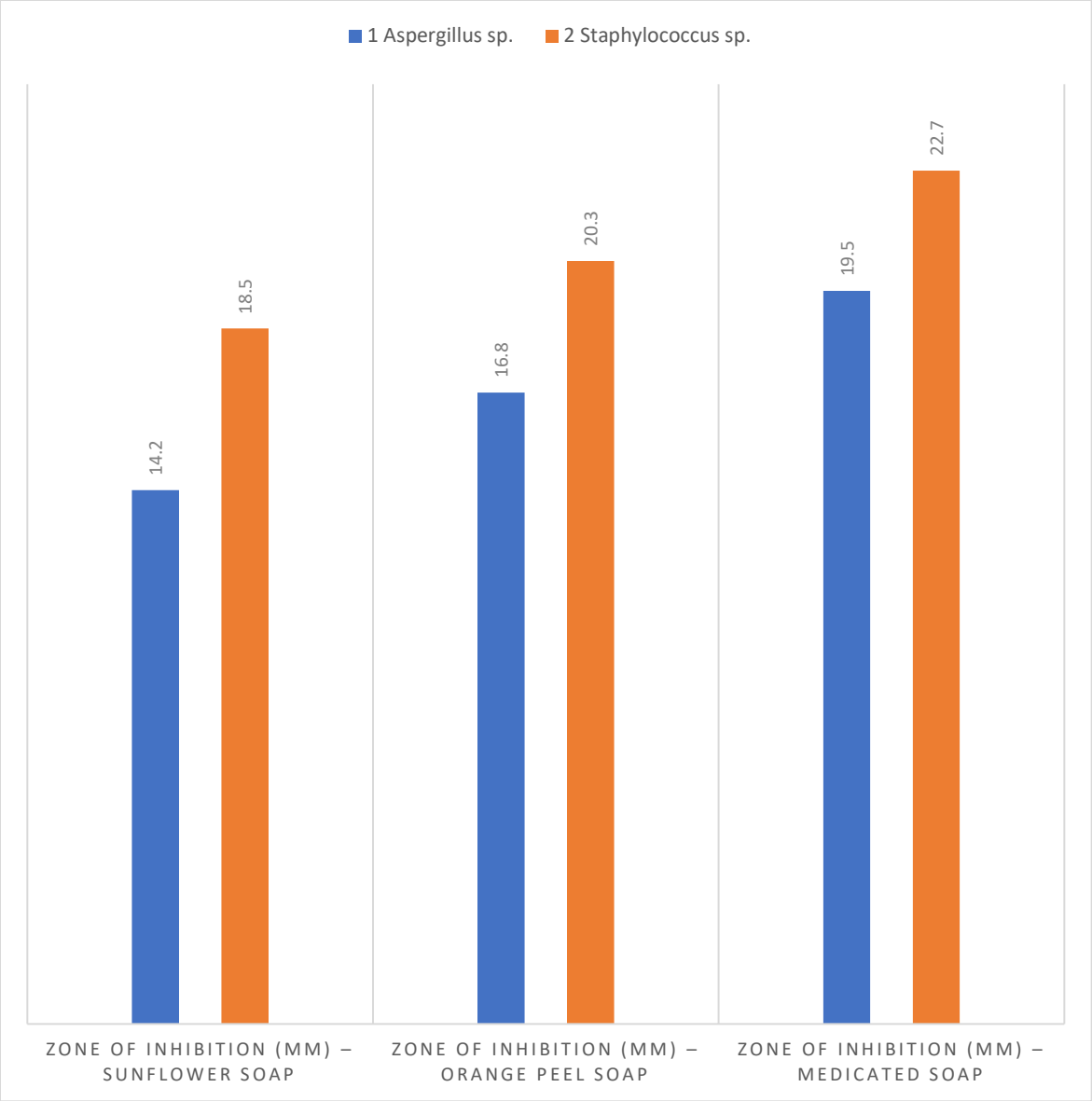

Figure 1: showing the antimicrobial activity of Sunflower soap, orange peel soap, and Medicated soap against *Aspergillus* and *Staphylococcus*

Figure 2: Picture of the produced herbal soap

3.2 Discussion

The study investigated the phytochemical, physicochemical, and antimicrobial properties of herbal soaps formulated with sunflower and orange peel extracts, compared with a standard medicated soap. The qualitative screening revealed the presence of alkaloids, saponins, flavonoids, and phenols in both extracts, though with varying intensity, with orange peel showing higher levels of flavonoids and phenols. This aligns with previous reports that citrus peels are rich in polyphenols and flavonoids, which contribute to antimicrobial and antioxidant activities (Adeniyi *et al.,* 2023; Sharma & Gupta, 2022). Quantitative analysis further supported these findings, showing that orange peel extract contained higher concentrations of flavonoids and tannins compared to sunflower extract, which likely accounts for its stronger antimicrobial properties (Oladele *et al.,* 2024; Patel & Khan, 2023).

The physicochemical evaluation indicated that the formulated herbal soaps exhibited values within acceptable limits for quality soap production (Adamu *et al.,* 2022). The pH values were within the alkaline range typical of soaps, ensuring good cleansing ability while maintaining skin compatibility (Okeke & Thomas, 2023). Moisture content was slightly higher in the herbal soaps compared to the medicated soap, which may influence shelf life but enhances softness and lathering quality (Eze *et al.,* 2024). Foam height and total fatty matter were highest in orange peel soap, suggesting better cleansing and moisturizing properties than sunflower soap (Nwachukwu & Bassey, 2023). Free alkali levels were low, indicating safety for skin use, which highlights the potential of sunflower and orange peel extracts as suitable raw materials in natural soap production (Ibrahim *et al.,* 2024).

The antimicrobial analysis showed significant inhibition of *Aspergillus sp*. and *Staphylococcussp*. by both sunflower and orange peel soaps, with inhibition zones ranging from 14.2 mm to 20.3 mm (Adeoye *et al.,* 2023). Orange peel soap showed stronger antimicrobial activity compared to sunflower soap, reflecting its richer phytochemical composition (Chukwu & Ibrahim, 2024). The medicated soap produced the highest inhibition zones, confirming its

enhanced antimicrobial efficacy due to synthetic additives (Fatima*et al.,* 2022). The Chi-square test indicated statistically significant differences between the herbal and medicated soaps, showing that while medicated soap is stronger, herbal soaps still possess considerable antimicrobial potential, especially orange-peel soap (Lawal & Nwosu, 2023).

Overall, the findings demonstrate that herbal soaps formulated with sunflower and orange peel extracts can serve as effective alternatives to medicated soaps. Orange peel extract, often regarded as agro-waste, is particularly valuable for soap production due to its high levels of bioactive compounds and superior antimicrobial activity, while sunflower extract contributes moisturizing properties. These results suggest that herbal soaps are eco-friendly, skin-compatible, and sustainable alternatives that can reduce dependence on synthetic medicated soaps while providing comparable quality and therapeutic benefits.

4.0 Conclusion and Recommendations

4.1 Conclusion

This study concludes that herbal soaps formulated with sunflower and orange peel extracts possess valuable phytochemical, physicochemical, and antimicrobial properties, making them effective and eco-friendly alternatives to medicated soaps. Orange peel extract, rich in flavonoids and tannins, contributed to stronger antimicrobial activity compared to sunflower extract, while physicochemical evaluations confirmed that the soaps met acceptable standards for pH, moisture content, foam height, total fatty matter, and free alkali. Although medicated soap exhibited the highest antimicrobial activity, the herbal soaps—especially orange peel soap—demonstrated significant inhibitory effects against *Staphylococcus sp*. and *Aspergillus sp*., as supported by Chi-square analysis. The findings highlight the potential of herbal soaps not only for skincare and infection control but also for sustainability, as they provide an innovative use for agro-waste materials like orange peels.

4.2 Recommendations

Based on the findings of this study, it is recommended that herbal soap production should be encouraged as a sustainable alternative to synthetic medicated soaps, particularly through the utilization of agro-waste materials such as orange peels, which are rich in antimicrobial phytochemicals.

Soap manufacturers and small-scale producers are advised to explore the integration of sunflower and orange peel extracts in large-scale formulations to promote eco-friendly and skin-compatible products.

Further research should focus on optimizing extract concentrations and testing against a wider range of pathogenic microorganisms to improve efficacy and broaden application. Regulatory bodies such as NAFDAC should also support quality assurance and certification of herbal soaps to build consumer confidence and enhance marketability.

Conflict of interest: There is no conflict of interest

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