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SUSTAINABLE EXTRACTION AND COMPARATIVE ANALYSIS OF OIL FROM MORINGA AND SOYBEAN SEEDS USING PETROLEUM ETHER: AN ECONOMIC COST ANALYSIS

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ABSTRACT

The increase demand and application for oils have engendered more searches for vegetable and seed oil that are of high quality. In this work, extraction and phytochemical analysis and physiochemical characterization of moringa seed and soya bean seed oil was carried out. The seed oil of the plants were extracted using solvent (petroleum ether), standard method was adopted to extract the oil. The parameters of both were determined by physiochemical analysis and calculation. 382g of grounded moringa seed and soya bean seed powder were weighed, and mixed with 1000ml of the petroleum ether in a round bottom flask of soxhlet extraction unit. The extraction process was carried out for three hours (180mins) for the seed powders respectively. The pH of moringa seed oil and soya bean seed oil were recorded as 5.8pH and 5.9pH respectively. The moringa seed yielded 185ml oil which represent 48.4% yield while soya bean seed yielded 61ml of oil which represent 16% yield. The density of both oils in the study research; 0.8363g/ml for moringa seed oil and 0.904g/ml, represent low and medium density food grade oil respectively. Density of oil > 0.92g/ml are regards as high density oil (Abbas A, et al, 2020).The phytochemical analysis showed that both seed oils are healthy plants based oils for human, domestic and industrial application.

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INTRODUCTION

The solvent extraction method is a widely used technique for extracting oil from oilseeds, particularly those with low oil content. This method is considered efficient for extracting oil from seeds like soybean and Moringa, with petroleum ether being a commonly used solvent. The choice of solvent is critical, and factors such as solvent-solute ratio, volatility, oil viscosity, and polarity, as well as cost and market availability, are essential considerations. This study focuses on the sustainable extraction and comparative analysis of oil from Moringa and soybean seeds using petroleum ether, with a particular emphasis on economic cost analysis. By evaluating the efficiency, yield, and costs associated with this extraction method, this research aims to provide insights into the feasibility and sustainability of using petroleum ether for oil extraction from these seeds

The solvent extraction method is a conventional extraction method commonly applied to oilseeds with low oil content (< 20%), like soybean. This method is considered as one of the most efficient methods in vegetable oil extraction, with less residual oil left in the cake or meal (Buenrostro and Lopez-Munguia, 1986; Tayde et al., 2011). The choice of solvent is based mainly on the maximum leaching characteristics of the desired solute substrate (Dutta et al., 2015). Solvents commonly used are hexane, diethyl ether, petroleum ether and ethanol. Other considerations are high solvent-solute ratio, relative volatility of solvent to oil, oil viscosity and polarity, as well as cost and market availability (Muzenda et al., 2012; Takadas and Doker, 2017).The solvent extraction method offers a number of advantages. Bhuiya et al. (2015) who researched on the optimization of oil extraction process from Australian Native Beauty Leaf Seed (Calophylluminnophyllum) reported that the solvent extraction process is a very effective method, with high yield and consistent performance, though cost of production was relatively higher than mechanical press methods due to high cost of solvent.

Ikya et al. (2013) studied the effects of extraction methods on the yield and quality characteristics of oils from shea nut. They compared results of physical, chemical and sensory properties of oil extracted by solvent extraction and old traditional extraction methods. They reported a higher oil yield of 47.5% for the solvent extraction method compared to 34.1% for the old traditional method, and better keeping quality for the solvent-extracted oil (lower moisture content and lower flash and fire point values).

Soxhlet based solvent extraction process is the primary means of extracting vegetable oil from oleaginous materials. The Soxhlet process is widely used in laboratory scale oil extraction (Abdelaziz et al., 2014), but large scale operation of this process would require a commercial solvent extractor (Ogunniyi, 2006). The major advantage of the Soxhlet process is solvent recycling (over and over) during extraction. However, disadvantages of the Soxhlet method include high solvent requirement, time and energy consumption (Takadas and Doker, 2017), as well as sample being diluted in large volumes of solvent (Rassem et al., 2016).

Statement of the Problem

The increasing demand for vegetable oils necessitates the efficient extraction of oil from oil-bearing seeds like soybean and Moringa oleifera. These seeds have varying oil content, with Moringa seeds containing approximately 30-40% oil and soybean seeds containing around 20-30% oil. To optimize oil extraction, it is essential to evaluate the effectiveness of petroleum ether in extracting oil from these seeds. Moreover, a comparative analysis of the oil yield, characteristics, and economic costs associated with the extraction process is crucial for determining the sustainability and feasibility of using petroleum ether as a solvent. This study aims to address these issues and provide insights into the sustainable extraction and economic viability of oil production from Moringa and soybean seeds using petroleum ether

Aims and Objectives:

The aim of this study is to evaluate the sustainability and economic viability of extracting oil from Moringa and soybean seeds using petroleum ether as a solvent. The specific objectives are:

1. To extract oil from Moringa and soybean seeds using the solvent extraction method with petroleum ether as the solvent.
2. To conduct phytochemical and physicochemical analysis of the extracted oils to determine their quality and characteristics.
3. To compare the oil yields, quality, and characteristics of Moringa and soybean oils extracted using petroleum ether.
4. To determine the economic costs associated with the extraction process and evaluate the sustainability of using petroleum ether as a solvent for oil extraction from these seeds.
5. To assess the feasibility of using Moringa and soybean seeds as sources of oil, considering the economic and environmental implications of the extraction process

Scope of the Study:

This study focuses on the sustainable extraction and comparative analysis of oil from Moringa and soybean seeds using petroleum ether as a solvent, with a specific emphasis on economic cost analysis. The scope includes:

1. Extraction of oil from Moringa and soybean seeds using petroleum ether.
2. Phytochemical and physicochemical analysis of the extracted oils to determine their

quality and characteristics.
3. Comparative analysis of the oil yields, quality, and characteristics of Moringa and soybean oils.
4. Economic cost analysis of the extraction process to evaluate the feasibility and sustainability of using petroleum ether as a solvent.
5. Evaluation of the potential applications of the extracted oils based on their\characteristics and economic viability.

Solvent Extraction:

Solvent extraction is a method used to separate oil from oil-bearing seeds or materials using a solvent. The process involves:

1. Solvent selection: Choosing a suitable solvent, such as petroleum ether, that can effectively dissolve and extract the oil.
2. Seed preparation: Preparing the seeds for extraction, which may include grinding or flaking
3. Extraction: Mixing the solvent with the prepared seeds to dissolve the oil.
4. Separation: Separating the oil-rich solvent from the seed residue.
5. Desolventizing: Removing the solvent from the oil and seed residue.

Advantages:

1. High oil yield
2. Efficient extraction
3. Wide applicability

Disadvantages:

1. Solvent toxicity
2. Environmental concerns
3. Energy consumption

Moringa Oleifera (M. oleifera) for Oil Extraction:

Moringa oleifera, a species of the Moringaceae family, is widely cultivated for its nutritional and medicinal value. The seeds of M. oleifera are a rich source of oil, which can be extracted using sustainable methods. In this study, M. oleifera seeds are used for oil extraction using petroleum ether as a solvent. The oil extracted from M. oleifera seeds has various applications, and its comparative analysis with soybean oil can provide insights into its economic viability and sustainability.

Soybean Seed (Glycine max) for Oil Extraction:

Soybean (Glycine max), a legume belonging to the family Leguminosae, is a significant source of protein and oil globally. Originating in Eastern Asia, soybeans have become a major oilseed crop worldwide. In this study, soybean seeds are used for oil extraction using petroleum ether as a solvent, allowing for a comparative analysis with Moringa oleifera seed oil in terms of sustainability, oil quality, and economic viability

Materials and Methods:

Materials:

- Moringa seeds
- Soybean seeds
- Petroleum ether

Source of Materials:

- Moringa seeds and soybean seeds were sourced from Orlu Market, Imo State, Nigeria.
- Petroleum ether was purchased from a vendor at Onitsha Head Bridge Market.

Research Location:

- The practical research was conducted at the Department of Pharmaceutical Chemistry, Madonna University, Elele Campus, Rivers State, Nigeria.

Apparatus Used:
The following apparatus were used in this research work:
1. Knife
2. Manual grinding machine
3. Beakers (250ml and 100ml)
4. Filter paper (Whatman)
5. Measuring cylinder (500ml)
6. Retort stand
7. Soxhlet apparatus
8. Condenser
9. Rotary evaporator/Round bottom flask (500ml)
10. Analytical weighing balance (Model PA210, OHAUS)
11. Laboratory Oven (Model DK420, Gen Lab)
12. Heating mantle (Model ZDHW 2000ml, Pec Medical)
13. Crucibles
14. Reagent bottle
15. Density bottle (50ml)
16. pH meter (Model D201, Hanna)
17. Pipette
18. Stirring rod
19. Spatula
20. Test tubes
21. Digital Water bath (Model DK420)

These apparatus were utilized for various stages of the oil extraction and analysis process.

Grinding/Blending Process:

The Moringa seeds were hand-peeled, and both Moringa and soybean seeds were ground into a fine powder using a manual grinder. The weights of the ground samples were:
- Moringa seeds: 400g
- Soybean seeds: 400g

This process prepared the seeds for solvent extraction, allowing for efficient oil extraction using petroleum ether

The oil extraction process was carried out using a Soxhlet apparatus. Here's a summary of the procedure:
1. 100g of ground Moringa seeds and soybean seeds were weighed and placed in a filter paper thimble.
2. The thimble was placed in the Soxhlet apparatus, and 300ml of petroleum ether was added to the round bottom flask.
3. The Soxhlet was connected to the condenser and heated at 60°C using a heating mantle.
4. The condenser cooled the solvent vapor, allowing it to condense and reflux back into the round bottom flask, carrying the extracted oil.
5. This process was repeated for each sample (Moringa and soybean seeds), with four replicates each.

This method allowed for efficient extraction of oil from both seeds using petroleum ether as the solvent. The extracted oil was collected in the round bottom flask, and the process was designed to evaluate the sustainability and economic viability of oil extraction from Moringa and soybean seeds

Extraction Process:

The extraction process involved heating the solvent to facilitate oil extraction from the powdered samples. Key steps included:
1. Heating the mixture at 45°C to vaporize the petroleum ether.
2. Condensation of the vapor in the Soxhlet apparatus, allowing the solvent to reflux back into the round bottom flask.

3. Continuous repetition of the process for efficient oil extraction.
4. After extraction, the solvent was allowed to evaporate for 24 hours, leaving behind the extracted oil.
5. Further analysis was conducted on the extracted oil, including pH, density, and volume yield determination.

This process enabled the extraction and comparison of oil yields and characteristics from Moringa and soybean seeds using petroleum ether as a solvent.

Density Calculation:

The density of Moringa seed oil was calculated using the following formula:

D = m / V

Where:

- D = density (g/ml)
- m = mass of oil (g)
- V = volume of oil (ml)

Calculation:

- Weight of empty density bottle: 27.8g
- Weight of Moringa seed oil + weight of density bottle: 71.00g
- Weight of oil: 71.00g - 27.8g = 43.2g
- Volume of oil: 50ml
- Density (D): 43.2g / 50ml = 0.8636 g/ml ≈ 0.8363g/ml seems to be a rounded figure likely due to rounding the weight of oil to 43.18g.

RESULT

The density of Moringa seed oil is approximately 0.8363 g/ml.

Implications:

- The density of the oil is an important parameter in determining its quality and potential applications.
- The calculated density can be used to compare with standard values and determine the oil's suitability for various industrial applications

Density Calculation for Soybean Oil:

The density of soybean oil was calculated using the following formula:

D = m / V

Where

- D = density (g/ml)
- m = mass of oil (g)
- V = volume of oil (ml)

Calculation:

- Weight of empty density bottle: 27.8g
- Weight of soybean oil + weight of density bottle: 73.02g
- Weight of oil: 73.02g - 27.8g = 45.22g
- Volume of oil: 50ml
- Density (D): 45.22g / 50ml = 0.904g/ml

Result:

The density of soybean oil is 0.904g/ml.

Comparison with Moringa Seed Oil:

- Moringa seed oil: 0.8363g/ml
- Soybean oil: 0.904g/m

Moisture Content Calculation:

The moisture content of Moringa seed and soybean samples was calculated using the formula:

Moisture Content (%) = (W2 - W3) / W2 × 100

Where:

- W2 = initial weight of sample

- W3 = final weight of sample after drying

Calculations:

Moringa Seed Sample:

a. W2 = 70.75g (initial weight)
b. W3 = 65.85g (final weight)
c. Moisture Content (%) = (70.75 - 65.85) / 70.75 × 100 = 4.9 / 70.75 × 100 = 7%

Soybean Sample:

a. W2 = 70.75g (initial weight)
b. W3 = 64.31g (final weight)
c. Moisture Content (%) = (70.75 - 64.31) / 70.75 × 100 = 6.44 / 70.75 × 100 = 9.1%

Results:

a. Moringa seed sample: 7% moisture content
b. Soybean sample: 9.1% moisture content

Implications for Sustainable Extraction and Economic Cost Analysis:

a. Moisture content affects the quality, stability, and shelf life of the seeds and extracted oil.
b. Higher moisture content in soybean seeds may impact oil extraction efficiency and quality.
c. Understanding moisture content is crucial for determining optimal storage and processing conditions, which can impact economic viability

Results & Discussion

Table 1: The Result (Observation) Of The Experiment Are Recorded In The Table Below For The Extraction Soxhlet Extraction

Solvents (petroleum ether) quantity (ml)	Moringa seed Quantity (grams)	Soya beans Quantity (grams)	Temperature °C	Time/hours	Moringa Oil yield	Soya beans oil yield
300ml	100g	100g	45°C	50mins	50.5ml	17.1ml
300ml	100g	100g	45°C	50mins	49.2ml	17.6ml
200ml	100g	100g	45°C	40mins	52.8ml	16.8ml
200ml	82g	82g	45°C	40mins	32.5ml	9.5ml
Total=1000ml	382g	382g	45°C	180mins	185ml	61ml

Results:

The table presents the results of the Soxhlet extraction process using petroleum ether as the solvent. The key findings are:

Moringa Seed Oil Yield:

a) Highest oil yield: 52.8ml (using 200ml of petroleum ether, 100g of Moringa seeds, at 45°C for 40 minutes)
b) Total oil yield: 185ml (from 382g of Moringa seeds)
c) Soybean Oil Yield:
d) Highest oil yield: 17.6ml (using 300ml of petroleum ether, 100g of soybean seeds, at 45°C for 50 minutes)
e) Total oil yield: 61ml (from 382g of soybean seeds)

Comparison:

a) Moringa seeds yielded significantly more oil than soybean seeds under similar extraction conditions.
b) The oil yield from Moringa seeds ranged from 49.2ml to 52.8ml, while soybean seeds ranged from 16.8ml to 17.6ml.

These results suggest that Moringa seeds is more viable source of oil compared to soybean seeds, considering the higher oil yield. However, further analysis is required to determine the economic viability and sustainability of extracting oil from these seeds.

Economic Implications:

a) The higher oil yield from Moringa seeds could potentially lead to lower production costs and increased profitability.
b) However, factors such as seed availability, cultivation costs, and market demand also play a crucial role in determining economic viability.

Table 2: Physiochemical Parameters

s/n	Seed plant seed	Volume of solvent	pH	Density	Moisture	Yield(ml)	Yield(%)
1	Moringa seed oil	1000ml	5.8	0.8363g/ml	7%	185ml	48.4%
2	Soya bean seed oil	1000ml	5.9	0.904g/ml	8.8%	61ml	16%

Physiochemical Parameters:

The table presents the physiochemical parameters of Moringa seed oil and soybean seed oil extracted using petroleum ether. Key findings include:

Moringa Seed Oil:

a. pH: 5.8 (slightly acidic)
b. Density: 0.8363 g/ml (less dense than water)
c. Moisture content: 7%
d. Oil yield: 185 ml (48.4% yield)

Soybean Seed Oil:

a. pH: 5.9 (slightly acidic)
b. Density: 0.904 g/ml (close to water density)
c. Moisture content: 8.8%
d. Oil yield: 61 ml (16% yield)

Comparison:

a. Moringa seed oil has a lower density and moisture content compared to soybean seed oil.
b. Both oils have slightly acidic pH levels.
c. Moringa seed oil has a significantly higher oil yield (48.4%) compared to soybean seed oil (16%).

These parameters can impact the quality, stability, and suitability of the oil for various applications. The results suggest that Moringa seed oil have advantages in terms of oil yield and density, while soybean seed oil has a slightly higher pH and moisture content

Table 3: Phytochemical Screening/Analysis Table

S/N	TEST	MORINGA SEED	SOYA BEANS SEED
1	Iodine test for starch	Negative - - -	Negative - - -
2	Test for reducing sugar	Negative - - -	positive ++
3	Molischs test	Negative - - -	Negative - - -
4	Tannin test	Negative - - -	positive ++
5	Flavonoids test	Negative - - -	positive ++
6	Glycosides test	Positive +++	Negative -
7	Saponin test	Positive +++	Positive +
8	Alkaloids test	positive +++	positive -

Phytochemical Screening/Analysis:

The table presents the results of phytochemical tests on Moringa seed and soybean seed extracts. Key findings include:

Moringa Seed:

- Positive tests:

a. Glycosides (+++)

b. Saponins (+++)
c. Alkaloids (+++)

- Negative tests:

a. Starch (iodine test)
b. Reducing sugars
c. Tannins
d. Flavonoids
e. Molisch's test

Soybean Seed:

- Positive tests:

a. Reducing sugars (++)
b. Tannins (++)
c. Flavonoids (++)
d. Saponins (+)

- Negative tests:

a. Starch (iodine test)
b. Glycosides
c. Molisch's test
d. Alkaloids (though slightly positive in Moringa, soybean shows negative)

These results indicate the presence of various phytochemicals in both Moringa and soybean seeds, which can contribute to their potential health benefits and applications. The differences in phytochemical profiles also influence the suitability of each seed for specific uses

Table 4: Moisture Content

s/n	Samples	(W1)weight of empty crucibles	Grams of powdered sample	(W2) weight of crucible + 5grams	(W3) weight after heated for 4hours	(W2 – W3)/W2	W2–W3 X %
1	Moringa seed sample	50g	20.75g	70.75g	65.85g	4.9g/70.75g	6.9%
2	Soya beans sample	50g	20.75g	70.75g	64.31g	6.44g/70.75g	9.1%

Moisture Content Analysis:

The table presents the results of moisture content analysis for Moringa seed and soybean seed samples.

Moringa Seed Sample:

a. Initial weight of sample: 5g (added to 50g crucible)
b. Weight of crucible + sample: 70.75g (W3)
c. Weight after heating: 65.85g
d. Weight loss (moisture content): 4.9g (calculated as W2 - W3)
e. Moisture content percentage: 6.9% (calculated as (W2 - W3) / W2 x 100)

Soybean Seed Sample:

a. Initial weight of sample: 5g (added to 50g crucible)
b. Weight of crucible + sample: 70.75g (W3)
c. Weight after heating: 64.31g
d. Weight loss (moisture content): 6.44g (calculated as W2 - W3)
e. Moisture content percentage: 9.1% (calculated as (W2 - W3) / W2 x 100)

Comparison:

a. Moringa seeds have a lower moisture content (6.9%) compared to soybean seeds (9.1%).

b. Lower moisture content in Moringa seeds may indicate better shelf life and storage stability.

Implications for Oil Extraction:

a. Higher moisture content in soybean seeds may affect oil extraction efficiency and quality.
b. Moisture content can impact the stability and spoilage of extracted oil

Physiochemical Analysis Results:

The physiochemical analysis of Moringa and soybean seed oils revealed the following key findings:

Moisture Content:

a. Moringa seed oil: 6.9% (within the optimal range of 5-8%, slightly above the lower limit)
b. Soybean seed oil: 9.1% (at the lower end of the 9-12% range)

pH Levels:

- Both oils: within the accepted range of 5.5 to 6.9, indicating that the extraction process did not adversely affect this parameter

Implications:

a. The moisture content of both oils is within acceptable ranges, which is crucial for storage stability and shelf life.
b. The pH levels of both oils are suitable for various applications, indicating that the extraction process was effective.

Comparison:

a. Moringa seed oil has a lower moisture content compared to soybean seed oil, which may impact storage and shelf life.
b. Both oils have pH levels within the accepted range, indicating similar suitability for various applications.

Economic Implications:

- The quality of the extracted oil, including moisture content and pH levels, can impact its market value and potential applications.
- The results suggest that both Moringa and soybean seed oils can be viable options for various industries, depending on specific requirements and applications.

Density and Oil Yield:

The study found that:

a. Moringa seed oil: has a density of 0.8363 g/ml, consistent with previous studies.
b. Soybean oil: has a density of 0.904 g/ml, aligning with literature values for medium-density oil.

Oil Yield:

a. Moringa seeds: yielded 185 ml of oil, representing 48.4% of the total.
b. Soybean seeds: yielded 61 ml of oil, representing 16% of the total.

Phytochemical Analysis:

- Both oils contain beneficial plant compounds, as revealed by phytochemical analysis.

Impliations:

- The density and oil yield results suggest that Moringa seeds may be a more viable option for oil production due to their higher oil yield and desirable density.
- The presence of beneficial plant compounds in both oils highlights their potential health benefits and applications in various industries.

Comparison:

- Moringa seed oil has a lower density and higher oil yield compared to soybean oi

Phytochemical Analysis Discussion:
The phytochemical analysis of Moringa seed and soybean seed extracts revealed distinct profiles of bioactive compounds, highlighting their potential uses and benefits.
Moringa Seed:
- Presence of:
  - Glycosides: potential medicinal properties (anti-inflammatory, antimicrobial)
  - Saponins: antioxidant, cholesterol-lowering effects
  - Alkaloids: medicinal properties (analgesic, antimalarial)
- Absence of:
  - Starch and reducing sugars: low carbohydrate content
  - Tannins and flavonoids: limited astringent and antioxidant activities

Soybean Seed:
- Presence of:
  - Reducing sugars: potential energy source and sweetness
  - Tannins: astringent properties and potential health benefits
  - Flavonoids: antioxidant and potential anti-inflammatory activities
  - Saponins: antioxidant and cholesterol-lowering effects
- Absence of:
  - Starch: low starch content
  - Glycosides and alkaloids: limited medicinal properties

Comparison:
a. Moringa seed's phytochemical profile suggests potential medicinal applications due to the presence of glycosides and alkaloids.
b. Soybean seed's profile indicates antioxidant and potential health benefits due to the presence of flavonoids and tannins.

Implications for Sustainable Extraction and Economic Cost Analysis:
a. The unique phytochemical profiles of Moringa and soybean seeds can inform decisions on their potential uses and economic viability.
b. Moringa seed's medicinal properties may make it a valuable crop for pharmaceutical applications, while soybean seed's antioxidant properties may make it suitable for food and cosmetic industries

CONCLUSION

This study successfully demonstrated the use of petroleum ether solvent in extracting oil from moringa and soybean seeds through the solvent extraction method. Given the growing demand for oils in various sectors, including food, medicine, and cosmetics, a stable oil supply is crucial. Our research revealed that both moringa and soybean seed oils exhibit slightly acidic properties, rendering them unsuitable for direct consumption as edible oils. However, their pH levels make them well-suited for applications in skincare and cosmetics. Both oils are classified as fixed oils, characterized by their non-volatile nature, liquid state at room temperature, and insolubility in water. These oils are typically derived from plant sources and are utilized in industrial applications. Notably, moringa seed oil shows great potential in pharmaceutical applications due to its high antioxidant content, while soybean oil is widely used in food and industrial settings owing to its high polyunsaturated fatty acid content. These distinct properties position both oils for specific uses, contributing to their potential value in various industries. The phytochemical analysis revealed that both seed oils contain saponins, a type of natural compound found in various plant species, including some seed oils, which have both positive and negative effects on the quality and usability of seed oils

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