



## Exploring The Efficacy Of Black Soaps Derived From Palm Oil And Palm Kernel Oil With Caustic Potash (KOH) Extracted From Plantain Peel

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### ABSTRACT

This study explores the potential of utilizing agricultural by-products, specifically plantain peels, as a source of caustic potash for producing high-quality black soaps from palm oil and palm kernel oil. The objectives were to evaluate the physicochemical properties and efficacy of these soaps in addressing various skin conditions. Plantain peels were sun-dried, burned, and processed to extract potassium hydroxide, which was then used in soap production. The results show that both soaps exhibited beneficial properties, with the palm kernel oil soap displaying a softer texture. The study highlights the potential of these black soaps in providing effective skincare solutions for common dermatological concerns, while also promoting sustainable utilization of agricultural by-products.

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## INTRODUCTION

Black soap, also known as African soap, has been a staple in traditional skincare routines for centuries. Typically made from a combination of palm oil, palm kernel oil, and plant ash, black soap is renowned for its cleansing and moisturizing properties. Palm oil and palm kernel oil, rich in fatty acids, are commonly used in black soap production due to their beneficial properties.

However, the production process often relies on harsh chemicals like sodium hydroxide (NaOH), which can be detrimental to both human skin and the environment. The accumulation of plant by-products in the environment also poses significant environmental hazards, highlighting the need for sustainable and innovative approaches to utilize these agro-based materials.

Research has shown that caustic potash (KOH), extracted from plantain peel, offers a sustainable alternative to NaOH. Studies have demonstrated the potential of KOH-based black soaps, but further investigation is needed to fully explore their efficacy and benefits. Previous studies have highlighted the importance of natural ingredients and sustainable practices in skincare product development, but there remains a knowledge gap in the specific application of palm oil and palm kernel oil with KOH extracted from plantain peel.

This study aims to investigate the efficacy of black soaps derived from palm oil and palm kernel oil, utilizing KOH extracted from plantain peel. The primary objectives are: To determine the physicochemical properties of the fats and oils extracted from palm oil and palm kernel oil. To produce soaps from the individual blends of palm oil and palm kernel oil using caustic potash (KOH) extracted from plantain peels and assess their quality parameters. By exploring the unique properties of these ingredients and their effects on skin health, this research aims to provide valuable insights into the formulation and effectiveness of black soaps for skincare applications.

## METHOD

### Materials

#### Collection of Raw Materials

Palm oil and palm kernel oil were sourced from Ori-Akabo Market in Ikeduru Local Government Area of Imo State. These oils were transported to the laboratory of the Chemical Engineering Department, Federal University of Technology, Owerri, for analysis and processing. All solvents used in this study were of analytical grade and purchased from the university's chemical stores.

#### Equipment and Instruments

- a. Reactor vessel
- b. Thermometer
- c. Heating mantle
- d. Stirrer
- e. Filter paper
- f. Evaporating dish
- g. Weighing balance
- h. pH meter
- i. Spectrophotometer

#### Reagents

- a. Caustic potash (KOH)
- b. Distilled water
- c. Ethanol
- d. Ether
- e. Phenolphthalein indicator

#### Here's An Explanation Of Each Apparatus And Equipment Used In The Study:

Apparatus/Equipment Used:

1. Weighing Balance: Used to measure the mass of ingredients and materials with precision.
2. Autoclave: A pressure chamber used to sterilize equipment and materials.
3. Incubator: A temperature-controlled environment used to promote microbial growth or chemical reactions.
4. Thermometer: Measures temperature, ensuring accurate control and monitoring.
5. Soap Moulds: Shapes the soap into desired forms.
6. Refrigerator: Stores materials and samples at a controlled temperature.
7. Gas Burner: Provides a heat source for various processes.
8. Beakers: Glass containers for measuring and mixing liquids.
9. Siever: A tool for separating particles of different sizes.
10. Conical Flask: A glass vessel for mixing and heating materials.
11. Nylon (waterproof): Used for covering and protecting equipment or materials.
12. Digital Weighing Balance: Provides precise measurements of mass.
13. Screpper: A tool for scraping and transferring materials.
14. Petri Dishes: Shallow containers for culturing microorganisms or chemical reactions.
15. Measuring Cylinder (1 liter, 100mls): Accurately measures liquid volumes.
16. Stirrer:

#### Mixes and blends materials.

#### Chemicals/Reagents Used:

1. Palm Oil (red oil): A vegetable oil used as a soap-making ingredient.

2. Palm Kernel Oil (from frying): Another vegetable oil used in soap production.
3. Caustic Potash (KOH): A strong alkaline substance used for saponification.
4. Isopropanol Solvent: A chemical used for dissolving and extracting materials.
5. Phenolphthalein Indicator: A pH indicator used to detect acidic or basic conditions.
6. Ethanolic Potassium Hydroxide: A solution used for titration and analysis.
7. Water (H<sub>2</sub>O): Used as a solvent and in various chemical reactions.
8. Hydrochloric Acid (HCl): A strong acid used for neutralization and analysis.

These apparatus and chemicals/reagents were used in the soap-making process, analysis, and quality control of the produced soaps.

### **Research Methodology**

#### **Preparation of Caustic Potash (KOH)**

The unripe plantain peels were sun-dried for seven days to remove excess moisture. The dried peels were then weighed using an analogue weighing balance, which showed a mass of 2 kg. The peels were subsequently burnt in a controlled environment to produce a caustic potash (KOH) extract. The burnt plantain peels were collected and weighed using a digital weighing balance, which showed a mass of 233.4 g.

To prepare the caustic potash solution, 233.4 g of the burnt plantain peels were soaked in 500 ml of water for 12 hours to allow for complete dissolution of the caustic contents. The resulting solution was then filtered using a net sieve to separate the raffinate (solid residue) from the extract (liquid solution). To maximize caustic extraction, the raffinate was soaked again in an additional 500 ml of water for another 12 hours. The combined solution weighed 1,300 g.

To concentrate the caustic potash solution, it was heated using a gas burner while continuously stirring. This process ensured the removal of excess water and increased the solution's potency. After heating, the solution was weighed to be 700 g, indicating a concentrated caustic potash solution.

This prepared caustic potash solution was then used in the soap-making process, as described in the subsequent sections.

#### **Preparation Of Black Soap With Palm Kernel Oil**

A batch of black soap was prepared using palm kernel oil and caustic potash. Initially, 410 g of palm kernel oil (obtained from frying) was measured into a reactor, followed by the addition of 205 g of caustic potash. The mixture was then placed on a gas burner and heated under continuous stirring until homogeneity was achieved.

The temperature of the mixture was monitored, and at 170°C, the water in the soap mixture had fully evaporated, indicating the formation of the soap base. The soap mixture was then poured into a plastic mould and allowed to solidify for three days. After solidification, the black soap was removed from the mould and was ready for use. The physical and chemical properties of this soap were later analyzed and compared with those of the soap produced using palm oil.

Note: The temperature of 170°C is quite high and may affect the quality of the soap. Typically, soap making temperatures range from 100°C to 140°C. Also, the use of a plastic mould may not be ideal, as it may affect the soap's texture and quality. A metal or wooden mould would be a better option.

#### **Preparation Of Black Soap With Palm Oil**

A batch of black soap was prepared using palm oil and caustic potash (KOH). Initially, 152 g of caustic potash (KOH) was measured into a reactor, followed by the addition of 313 g of palm oil. The mixture was then placed on a gas burner and heated under continuous stirring until a homogenous mixture formed. The temperature of the mixture was monitored using a thermometer, and at 175°C, the water in the soap had fully evaporated. The soap mixture was then poured into a plastic mould and allowed to solidify for three days.

#### **Quality Control**

To ensure the reliability and accuracy of the results, all determinations were carried out in triplicates. All glassware used was thoroughly washed and rinsed with distilled water. Additionally, all reagents used were of analytical grade and sourced from British Drug House, Poole, England.

#### **Preparation Of Black Soap Samples**

Two samples of black soap, labeled BS1 and BS2, were prepared according to the method. Equal quantities of palm oil and palm kernel oil were added to separate containers containing equal portions of caustic potash derived from plantain peels. The mixtures were then manually kneaded using a pestle and mortar. The soap samples were allowed to cure for at least two weeks before they were ready for use. These samples were subsequently analyzed using pH determinations, infrared spectroscopic analyses, and phytochemical screenings. help determine the optimal conditions for soap production and ensure the final product meets the desired standards.

**Free Fatty Acids (Acid Number or Acid Value)**The chemical analysis of the oil was conducted to determine its quality and properties. The following chemical parameters were determined using standard procedures outlined by the Association of Official Analytical Chemists (AOAC):

1. pH: This measures the acidity or basicity of the oil.
2. Acid Value (AV): This represents the amount of free fatty acids present in the oil.
3. Free-Fatty Acids (FFA): This measures the amount of unbound fatty acids in the oil.
4. Iodine Value (IV): This indicates the degree of unsaturation in the oil, which affects its stability and shelf life.
5. Saponification Value (SV): This measures the amount of fatty acids present in the oil, which is essential for soap production.
6. Peroxide Value (PV): This indicates the level of oxidation in the oil, which can affect its quality and stability.

These chemical parameters provide valuable information about the oil's quality, stability, and suitability for soap production. The results of these analyses can One gram (1 g) of the oil was dissolved in 50 ml of isopropanol solvent in a 250 ml conical flask. 3-4 drops of phenolphthalein indicator were added to the mixture, and the content was titrated against 0.1M KOH until a pink color that persisted for 15 seconds was obtained. The acid value (mgKOH/g) was calculated using the following formula:

$$\text{Acid Value (mgKOH/g)} = (\text{Volume of KOH used (ml)} \times \text{Molarity of KOH (0.1M)} \times 56.1) / \text{Weight of oil sample (g)}$$

Where 56.1 is the molecular weight of KOH. The free fatty acid (FFA) content was alculated as a percentage using the following formula:

$$\text{Free Fatty Acid (FFA) (\%)} = (\text{Acid Value (mgKOH/g)} \times 100) / 1.99$$

Where 1.99 is the factor used to convert acid value to FFA percentage. Note: The factor 1.99 is specific to oleic acid, which is the most common fatty acid in oils. If the oil contains other fatty acids, a different factor may be required.

#### **Determination of Iodine Value**

The iodine value (IV) of the oil sample was determined using the Wijs' iodine method. The procedure involved the following steps:

1. Weighing: 0.4 g of the oil sample was accurately weighed into a conical flask.
2. Addition of carbon tetrachloride: 20 ml of carbon tetrachloride was added to the flask.
3. Addition of Dam's reagent (Wijs' iodine): 25 ml of Dam's reagent was added to the flask using a safety pipette in a fume chamber.
4. Mixing and waiting: The content of the flask was vigorously swirled and then placed in the dark for 150 minutes (2.5 hours).
5. Addition of potassium iodide and water: 20 ml of 10% aqueous potassium iodide and 125 ml of distilled water were added to the flask using a measuring cylinder.
6. Titration: The content was then titrated with 0.1 M sodium thiosulfate solution until the yellow color almost disappeared.
7. Addition of starch indicator: A few drops of 15% starch indicator were added, and the titration was resumed until the color disappeared after vigorously shaking.
8. Blank test: The same procedure was repeated for the blank test.

The iodine value (IV) was calculated using the following expression:

$$\text{IV} = (\text{Volume of sodium thiosulfate used (ml)} \times \text{Molarity of sodium thiosulfate (0.1M)} \times 12.69) / \text{Weight of oil sample (g)}$$

Where 12.69 is the factor used to convert the titration result to iodine value. Note: The iodine value represents the amount of iodine (in grams) that reacts with 100 grams of oil. It is an indicator of the oil's unsaturation level and its tendency to oxidize.

### Iodine Value (IV)

$$IV = (C \times (V1 - V2)) / M$$

Where:

- C = Concentration of Sodium thiosulfate solution  
 V1 = Volume of Sodium thiosulfate solution used for blank titration  
 V2 = Volume of Sodium thiosulfate solution used for sample titration  
 M = Mass of the sample

### Saponification Value (SV)

$$SV = (N \times (V1 - V2)) / W$$

Formulas

Acid Value (AV)

$$AV = (N \times (V1 - V2)) / W$$

Where:

- N = Normality of hydrochloric acid used  
 V1 = Volume of hydrochloric acid used to titrate sample  
 V2 = Volume of hydrochloric acid used to titrate blank  
 W = Weight of oil in grams

Peroxide Value (PV)

$$PV = (S - B) / M$$

Where:

- S = Volume of sodium thiosulfate solution used to titrate sample  
 B = Volume of sodium thiosulfate solution used to titrate blank  
 M = Mass of the sample

The units for the Iodine Value, Saponification Value, and Peroxide Value are typically expressed in terms of grams per 100 grams of oil (g/100g).

$$PV = (S - B) \times N \times 200 / W$$

Peroxide Value (PV) Formula

Where:

- PV = Peroxide Value  
 S = Titre value for the sample  
 B = Titre value for the blank  
 N = Normality of the acid (0.1N)  
 W = Weight of the sample

This formula calculates the Peroxide Value, which is a measure of the amount of peroxides present in the oil sample. The units of Peroxide Value are typically expressed in terms of milliequivalents per kilogram of oil (meq/kg).

### Physical Characterization of Soap:

Hardness Test:

1. The hardness of the soap was determined using a modified penetrometer method.
2. A needle (6.4 cm in length; 1 mm in diameter) with a lead fishing weight (130g) attached was lowered into the soap.
3. The distance the needle penetrates the soap after 30 seconds was recorded as a measure of its hardness.
4. This was repeated three times for each soap sample, and the mean and standard deviation were computed.

Determination of pH:

1. 5 g of the oil sample was poured into a clean, dry 25 ml beaker.
2. 13 ml of distilled water was added to the sample and mixed for 5 minutes.
3. The mixture was then cooled to 25°C in a cold water bath.

4. A pH meter was standardized with a buffer solution, and the electrode was immersed into the sample.
5. The pH value was read and recorded..
6. The pH meter was likely standardized with a buffer solution of known pH, such as pH 4 or pH 7, to ensure accuracy and reliability of the pH readings.

#### Plantain Peel Extract

1. Mass of dried plantain peel: 2000g
2. This indicates the initial amount of plantain peel used for extraction.
3. Mass of burnt plantain peel: 233.4g
4. This suggests that some of the plantain peel was burnt or degraded during the extraction process, resulting in a loss of mass.
5. Initial and final mass of H<sub>2</sub>O: 1000ml (1 liter)
6. This indicates that 1 liter of water was used for extraction, and the initial and final masses are the same, suggesting no significant water loss or gain.

#### **Black Soap with Palm Kernel Oil and Caustic Potash (KOH)**

1. Weight of KOH: 205g
2. This is the amount of caustic potash (KOH) used in the soap production.
3. Weight of palm kernel oil (P.K.O4): 410g
4. This is the amount of palm kernel oil used in the soap production.
5. Temperature at which H<sub>2</sub>O evaporated: 170°C
6. This is the temperature at which water evaporated during the soap production process.
7. Specific gravity of water: 0.93g/cm<sup>3</sup>
8. This is the density of water used in the soap production.
9. Density of water: 0.93g/cm<sup>3</sup>
10. This is the same as the specific gravity of water, indicating the density of water.
11. Weight of water: 93g (144g - 51g)
12. This is the weight of water used in the soap production, calculated by subtracting the weight of the empty beaker (51g) from the weight of the beaker with water (144g).
13. Weight of sample (KOH): 127g (178g - 51g)
14. This is the weight of the KOH sample, calculated by subtracting the weight of the empty beaker (51g) from the weight of the beaker with the KOH sample (178g).
15. Density of sample: 1.27g/cm<sup>3</sup>
16. 16 This is the density of the KOH sample, calculated by dividing the weight of the sample (127g) by its volume (100cm<sup>3</sup>).
17. Specific gravity of sample: 1.366 (1.27/0.93)
18. This is the specific gravity of the KOH sample, calculated by dividing the density of the sample (1.27g/cm<sup>3</sup>) by the density of water (0.93g/cm<sup>3</sup>).
19. Weight of whole sample (KOH): 700g
20. 20 This is the total weight of the KOH sample used in the soap production.
21. Concentration of sample (KOH): not explicitly stated, but can be calculated based on the weight of KOH and the volume of water used.

#### **Black Soap with Palm Oil and Caustic Potash (KOH)**

##### Soap Production Parameters

1. Mass of caustic potash: 152g
2. This is the amount of caustic potash (KOH) used in the soap production.
3. Mass of oil used: 304g (152g x 2)
4. This is the amount of palm oil used in the soap production, calculated by multiplying the mass of caustic potash (152g) by 2.
5. Temperature at which H<sub>2</sub>O evaporated: 170°C
6. This is the temperature at which water evaporated during the soap production process.

### **RESULTS AND DISCUSSION**

1. Total Fatty Matter (60.2%)

This indicates the percentage of fatty acids present in the soap. A higher value indicates a milder soap, while a lower value indicates a harsher soap. In this case, the total fatty matter is 60.2%, which suggests a relatively mild soap.

2. Free Caustic Alkali (0.02%)

This measures the amount of unreacted alkali (in this case, caustic potash) present in the soap. A lower value indicates a safer soap, as excessive alkali can cause skin irritation. The result of 0.02% is very low, indicating a safe and gentle soap.

3. Moisture (28.0%)

This measures the amount of water present in the soap. A higher value can indicate a softer soap, while a lower value can indicate a harder soap. In this case, the moisture content is 28.0%, which suggests a relatively soft soap.

4. Glycerine in Soap (3.86%)

Glycerine is a humectant that helps retain moisture in the skin. A higher value indicates a more moisturizing soap. The result of 3.86% indicates a moderate amount of glycerine in the soap.

5. Unsaponified Matter (2.52%)

This measures the amount of impurities present in the soap. A lower value indicates a purer soap. In this case, the unsaponified matter is 2.52%, which suggests a relatively pure soap.

**Table 4.1** Analysis result of Soap Prepared from Plantain Peel extract And Palm Kernel Oil extracted By Frying.

S/N <sub>o</sub>	Test carried out	Result obtained (%)
1.	Total fatty matter	60.2
2.	Free caustic alkali	0.02
3.	Moisture	28.0
4.	Glycerine in soap	3.86
5.	Unsaponified matter	2.52
6.	Matter insoluble in ethanol	3.20
7.	Free Caustic Alkali as K <sub>2</sub> O	2.20

**Matter Insoluble in Ethanol (3.20%)**

This measures the amount of substances present in the soap that are insoluble in ethanol. A higher value can indicate a more exfoliating soap. The result of 3.20% suggests a moderate amount of insoluble matter.

**Free Caustic Alkali as K<sub>2</sub>O (2.20%)**

This measures the amount of unreacted alkali present in the soap, expressed as potassium oxide (K<sub>2</sub>O). A lower value indicates a safer soap. The result of 2.20% is relatively low, indicating a safe and gentle soap. Overall, these results suggest that the soap prepared from plantain peel extract and palm kernel oil extracted by frying has a relatively mild and gentle composition, with a moderate amount of moisturizing properties and a low amount of impurities.

**Table 4.2** Analysis result of Soap Prepared From From Plantain Peel extract and Palm Oil

S/N <sub>o</sub>	Test carried out	Result obtained (%)
1.	Total fatty matter	54.20
2.	Free caustic alkali	0.02
3.	Moisture	31.50
4.	Glycerine in soap	3.58
5.	Unsaponified matter	3.6
6.	Matter insoluble in ethanol	3.00
7.	Free Caustic Alkali as K <sub>2</sub> O	4.10

1. Total Fatty Matter (54.20%):

This indicates the percentage of fatty acids present in the soap. A higher value indicates a milder soap, while a lower value indicates a harsher soap. In this case, the total fatty matter is 54.20%, which suggests a relatively mild soap, but slightly harsher than the soap prepared with palm kernel oil (60.2%).

2. Free Caustic Alkali (0.02%):

This measures the amount of unreacted alkali (in this case, caustic potash) present in the soap. A lower value indicates a safer soap, as excessive alkali can cause skin irritation. The result of 0.02% is very low, indicating a safe and gentle soap, similar to the soap prepared with palm kernel oil.

3. Moisture (31.50%):

This measures the amount of water present in the soap. A higher value can indicate a softer soap, while a lower value can indicate a harder soap. In this case, the moisture content is 31.50%, which suggests a relatively soft soap, but slightly harder than the soap prepared with palm kernel oil (28.0%).

4. Glycerine in Soap (3.58%):

Glycerine is a humectant that helps retain moisture in the skin. A higher value indicates a more moisturizing soap. The result of 3.58% indicates a moderate amount of glycerine in the soap, slightly lower than the soap prepared with palm kernel oil (3.86%).

5. Unsaponified Matter (3.6%):

This measures the amount of impurities present in the soap. A lower value indicates a purer soap. In this case, the unsaponified matter is 3.6%, which suggests a relatively pure soap, but slightly less pure than the soap prepared with palm kernel oil (2.52%).

6. Matter Insoluble in Ethanol (3.00%):

This measures the amount of substances present in the soap that are insoluble in ethanol. A higher value can indicate a more exfoliating soap. The result of 3.00% suggests a moderate amount of insoluble matter, slightly lower than the soap prepared with palm kernel oil (3.20%).

7. Free Caustic Alkali as K<sub>2</sub>O (4.10%):

This measures the amount of unreacted alkali present in the soap, expressed as potassium oxide (K<sub>2</sub>O). A lower value indicates a safer soap. The result of 4.10% is slightly higher than the soap prepared with palm kernel oil (2.20%), indicating a slightly less safe soap.

Overall, these results suggest that the soap prepared from plantain peel extract and palm oil has a relatively mild and gentle composition, with a moderate amount of moisturizing properties and a low amount of impurities. However, it has a slightly higher amount of unreacted alkali and a slightly lower amount of glycerine compared to the soap prepared with palm kernel oil.

### Discussion

The results obtained from the analysis of the two black soaps made from palm kernel oil and palm oil reveal significant differences in their physical and chemical properties. The total fatty matter (TFM) content of the black soap made from palm kernel oil extracted by frying was higher (60.2%) compared to that of palm oil (54.20%). This indicates a higher quality black soap product from palm kernel oil, with a greater amount of fatty acids that contribute to its moisturizing and nourishing properties.

The caustic alkali content in both soaps was very low (0.02% and 0.02%), indicating a mild nature of the soaps, which is suitable for skin use. The moisture content in the black soap made from potassium hydroxide and palm kernel oil produced by frying was higher (31.50%) compared to that of palm oil (28.0%), indicating a softer soap. This is consistent with the observation that the black soap made from palm kernel oil was softer than that of palm oil.

The glycerine content of the black soap made from palm kernel oil was higher (3.86%) compared to that of palm oil (3.58%), indicating a more moisturizing soap. The lower glycerine content in the palm oil soap suggests a lower moisturizing characteristic compared to the palm kernel oil soap.

The physical appearance of the two soaps also differed, with the black soap made from palm kernel oil having a darker color and being softer, while the palm oil soap appeared harder and lighter in color. Although both soaps are dark-brown in color, the palm kernel oil soap has a more intense color, which may be due to the higher mineral content in the palm kernel oil. According to literature, both black soaps have medicinal characteristics due to the mineral content in the palm kernel oil, palm oil, and plantain peel. The concentration of the caustic was calculated using the specific gravity method, which ensures a safe and gentle soap product.

The results of this study highlight the potential of palm kernel oil as a viable alternative to palm oil in the production of black soap. The higher TFM, glycerine content, and softer texture of the palm kernel oil soap make it a more desirable product for skin care. Additionally, the use of palm kernel oil and plantain peel in black soap production offers a sustainable and eco-friendly option for the cosmetics industry.

Overall, this study demonstrates the importance of understanding the physical and chemical properties of black soap products and their ingredients, to ensure the production of high-quality and effective soap products for skin care. The results of this study can be used to inform the development of new soap products and formulations, and to promote the use of sustainable and eco-friendly ingredients in the cosmetics industry.

## CONCLUSION

This study demonstrates the potential of palm kernel oil as a sustainable and effective alternative to palm oil in black soap production, with benefits for skin health and sustainability. The findings show that palm kernel oil soap has a softer texture, making it suitable for sensitive skin and skin conditions like eczema and acne. The use of palm kernel oil and unripe plantain peel as a source of caustic potash offers a natural and eco-friendly approach to black soap production. Based on the research findings, recommendations include promoting the use of natural ingredients, exploring the potential of palm kernel oil in cosmetics, and conducting further research on cost-effectiveness and scalability. Future studies should focus on developing new products using palm kernel oil and unripe plantain peel, and promoting sustainable practices in the cosmetics industry.

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