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Research Article:

Physicochemical Comparison of Soaps Produced from Fresh, Cooked, and Naturally Treated Oils

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Abstract

Background and Objectives: Green chemistry plays a vital role in the pharmaceutical industry. Utilizing herbs to reduce rancidity and oxidation in various cooked oils is a cost-effective and environmentally friendly approach. Cooked oil significantly impacts environmental pollution, affecting aquatic life and soil quality. This research aims to create high-quality soap using herb-infused oils to treat waste oils exhausted from restaurants, offering a practical solution to sustainable waste management. In addition, it provides various skin benefits, such as moisturizing, and cleaning. **Method:** A simple small-scale cold process method was used to formulate three types of soaps with different oils within. One formulation uses cooking oil from a fast food restaurant; named as soap (W), another uses fresh oil; named as Soap (F), and the third Soap (T) uses greenly treated oils with turmeric powder, peppermint, and rosemary powder in a certain concentration. Different physicochemical tests assessed the physicochemical quality of soap through various tests, including organoleptic evaluation, hardness, pH measurement, moisture content, matter insoluble in alcohol, foam stability, cleaning ability, free fatty acid or alkali content, and total fatty matter. **Results:** Soap (T) exhibited a refined yellow color, smooth texture, and met ASTM and ISO standards across all parameters. Notably, Soap (T) showed the longest foam stability (9 minutes, Kd=0.077) and the lowest free fatty acid content (0.751%), indicating superior quality and skin safety. Soap (W) and Soap (F) also met the standards but with lower performance metrics. Soap (T) is identified as the optimal formulation, balancing quality, sustainability, and practical performance. **Conclusion:** Soap (T) met all ASTM and ISO standards, showing superior quality and performance. Its green, eco-friendly components help balance skin moisture, Soap (T) stands out as the best option for practical use and sustainability. Further studies on reducing wrinkles, and preventing acne are recommended.

1. Introduction

Around 3000 BC, the Sumerians employed a mixture of ashes and water to degrease raw wool and fabric, preparing them for dyeing. They called the ashes "al-qualy," a term from which the contemporary word "alkali" in chemistry is derived (1). The use of soap in ancient civilizations, notably in Babylon and Egypt, underscores the pervasive significance of sanitation and individual hygiene. The Babylonians pioneered soap-manufacturing methodologies circa 2800 BCE, employing a combination of animal fat and botanical ashes, thereby establishing the foundations for contemporary soap fabrication. Conversely, the ancient Egyptians incorporated soap-like materials into their cleansing practices, which were crucial for preserving spiritual cleanliness before religious ceremonies (2).

The composition of soap primarily involves alkali and oils, which undergo a saponification process to create the final

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product. The alkali, typically sodium hydroxide, reacts with various oils, including vegetable fats, to produce soap and glycerin. The specific ratios and types of oils can significantly influence the soap's properties, such as moisturizing effects and cleansing ability. Additionally, soap calculators are valuable tools in soapmaking, allowing artisans to accurately measure and adjust ingredient ratios for desired outcomes (3,4). The properties of soap are critical for determining their quality and effectiveness. Various studies have evaluated the physicochemical properties of soaps, revealing significant variations across different brands and formulations (5–7). Key properties include moisture content, pH, total fatty matter, foaming stability, and free alkali, which collectively influence the soap's performance and user experience (8,9).

Vegetable oils are triglycerides, i.e. three fatty acid chains connected via the carboxyl group to a glycerol backbone, as shown in **Figure 1**. The molecular structure of vegetable oils, such as sunflower oil, olive oil, and coconut oil, consists primarily of triglycerides, which are molecules formed by three fatty acid chains attached to a single glycerol molecule. Sunflower oil is high in polyunsaturated fats, particularly linoleic acid, whereas olive oil is rich in monounsaturated fats, mainly oleic acid1. Coconut oil, on the other hand, contains a high percentage of saturated fats, predominantly lauric acid. These differences in fatty acid composition influence their physical properties and uses. Furthermore, all three oils have double bonds in the cis-configuration, impacting their stability and behavior in various applications (10).

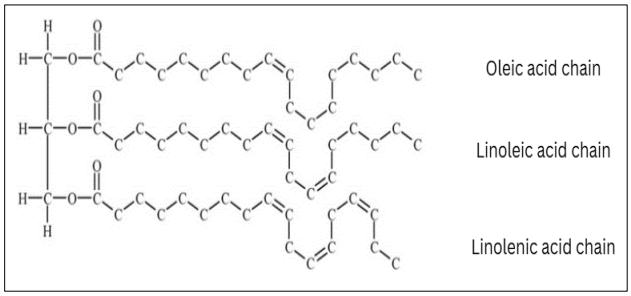

Figure 1. Molecular structure of vegetable oil (11)

2. Materials and Methods

2.1. Chemicals/Materials

Coconut oil, beeswax, sunflower oil, olive oil, peppermint oil, castor oil, turmeric powder, peppermint, and rosemary powders were purchased from the local market. Waste sunflower oil was taken from a local restaurant in Mosul city. Absolute ethanol and methanol were obtained from (Medox, U.K.). Caustic Soda or sodium hydroxide (NaOH) for industrial use from (KOUT of industry, Kuwait). For titration: NaOH and sodium carbonate Na_2CO_3 (Lab Tech Chemicals, China). Concentrated HCl and concentrated H_2SO_4(Qualigens, India), diethyl ether (Lab-Scan, Ireland), phenolphthalein indicator, and methyl orange indicators (Qualikems, India).

2.2. Methods

2.2.1. Production of soap by cold process

In modern soapmaking, soap formulations usually include a mix of 3-6 oils, though this can vary. Different oils contribute unique qualities, such as hardness, lather, creaminess, and conditioning. Sodium Hydroxide (lye) is utilized in combination with fats and oils to initiate the saponification process, thereby producing soap. Sodium Cocoate, derived from coconut oil, is renowned for generating a rich lather and excellent cleansing properties. Sodium Olivate, obtained from olive oil, contributes to a mild and moisturizing soap. Sodium Castorate, sourced from castor oil, enhances lather and provides conditioning properties.

This study utilized a combination of oils with a higher percentage of sunflower oil. An online soap calculator (SoapCalc) was utilized to determine the exact amounts of oils and alkali required for the production of three formulae of soaps; soap (F, W, and T). The precise quantities of coconut oil, sunflower oil, olive oil, and castor oil were measured and combined in a large pot. These oils were then gently heated until fully melted. Separately, sodium hydroxide was carefully mixed with water and allowed to cool (4). The oil mixture was combined with sodium hydroxide solution till forming a trace (light pudding-like consistency). Peppermint oil, as a superfat (SP), was added in the quantity calculated by SoapCalc. Finally, the mixture was poured into molds and allowed to set for 12-24 hours before being cut and left to cure for 2-4 weeks. The values expressed in SI units are to be considered as the definitive standard. No alternative units of measurement are incorporated within this standard. All formulations were produced on a small scale.

2.2.1.1. Production of Fresh (F) and Cooked or Waste (W) soap formulation

For the production of soap (F), fresh sunflower oil was used, while for soap (W), wasted sunflower oil was employed, both in the amounts and costs specified in **Table 1.**

Table1. Composition of soap (F and W) formulations to make a 500 g batch

Composition	Soap (F)	Soap (W)
Coconut oil	100	100
Fresh Sunflower oil	250	-
Wasted Sunflower oil	-	250
Olive oil	125	125
Castor oil	25	25
Peppermint oil (SF)	25	25
Industrial NaOH	70	70
Distilled water	140	140
Cost (ID)	3,479	3,327.5

F: Soap made from fresh oil, W: Soap made from waste oil, all oils were weighed in grams. SF: Super fat. ID: Iraqi Dinar.

2.2.1.2. Production of Treated soap (T) formulation

The mixture was prepared by combining 5% rosemary powder with olive oil and allowing it to sit for one month. All oils, including waste sunflower oil and rosemary-infused olive oil, were mixed, with turmeric and peppermint powder added at 5% of the total oil mass. The composition and costs are demonstrated in **Table 2**. This mixture was heated to 35-37°C for about 12 hours with continuous stirring, then sieved using disposable coffee filters. The mixture was combined with sodium hydroxide solution, trace was formed, and peppermint oil was added with continuous mixing. Finally, the mixture was poured, set, cut, and cured as mentioned above.

Table 2. Composition of soap treated (T) to make a 500 g batch

Composition	Soap (T)
Coconut oil	100
Wasted Sunflower oil	250
Olive oil	125
Castor oil	25
Peppermint oil (SF)	25
Industrial NaOH	70
Distilled water	140
Turmeric (%)	5
Peppermint (%)	5
Rosemary (%)	5
Cost (ID)	3,477.5

T: Soap made from Treated oil. All oils were weighed in grams. SF: Super fat, Herbs (w/w%) were added to the wasted sunflower and olive oils. ID: Iraqi Dinar.

2.2.2. Preparation of titration solutions

2.2.2.1. NaOH and HCl solutions

A 0.1 N was prepared for NaOH by weighing 4 g of NaOH pellets dissolving in distilled water (D.W) and completing the volumetric flask to 1000 mL. For HCl, a volume of 8.3 mL concentrated HCl was taken carefully and added to an amount of D.W., and an additional amount of D.W. was added to complete the volume of 1000 mL in a volumetric flask.

2.2.2.2. Indicator Solutions

The solution of Methyl orange indicator which is an acid-base indicator was prepared by weighing 0.1g and dissolving in 100 mL D.W. sonicated for 6 minutes using a sonicator bath (PowerSonic 410, Korea).

The solution of Phenolphthalein indicator which is also an acid-base indicator was prepared by weighing 1 g and dissolving in 100 mL of 80% methanol solution. This indicator changes color at a specific pH range (8.2 to 9.6), signaling the endpoint of the titration when the solution transitions from pink (alkaline) to colorless (neutral).

2.2.2.3. Standardization of HCl and NaOH solutions

The exact concentration of HCl was determined by titration against standard sodium carbonate Na_2CO_3, 0.2 g of Na_2CO_3 was weighed and put in a conical flask, and then 75 mL of D.W. and 2-3 drops of methyl orange indicator were added. After titration, the normality of HCl was found to be 0.075.
The exact concentration of NaOH was determined by titration against the standardized HCl as a secondary standard using a phenolphthalein indicator. After titration, the normality of NaOH was found to be 0.076.

2.2.3. Physicochemical quality tests

2.2.3.1. Organoleptic parameters

The soap's sensory characteristics were assessed visually to observe their appearance, color, texture, odor, and clarity. Taking photographs for further inspection.

2.2.3.2. Hardness test

To measure the hardness of soap, a tablet hardness tester (Laboao YD-1, China) was used. A 1-cm piece of the prepared soap formula was placed in the device in place of a tablet. The digital number displayed by the tester was then inspected and recorded. The test was repeated three times to ensure the accuracy and consistency of the results.

2.2.3.3. pH measurement

Two grams of soap were incorporated into 20 milliliters of D.W. and subjected to agitation, after which the resulting soap suspensions were permitted to remain undisturbed in a beaker for a minimum duration of 12 hours before the insertion of a pH meter (pH20 Tester, APERA® Instruments, China), with the subsequent three measurements being documented (6).

2.2.3.4. Moisture percentage (21,22)

For the determination of moisture content, 5 grams of samples were accurately weighed using analytical balance of sensitivity 0.001 mg into dried butter paper in an oven for 3 hrs and temperature of 101˚C and repeated until a constant weight was reached. The moisture content was found from the weight difference. The % moisture was calculated using the equation:

$$\text{Moisture}(\%) = \frac{\text{Weight of Wet Sample} - \text{Weight of Dry Sample}}{\text{Weight of Wet Sample}} \times 100 \quad \ldots. (1)$$

2.2.3.5. Matter insoluble in alcohol

A 1-gram sample of soap was weighed and dissolved in 50 milliliters of hot ethanol. After complete dissolution using a water bath (KOTTERMANN LABORTECNIK, Germany) at 50°C, the solution was cooled, filtered using filter paper and washed with ethanol. The wetted filter paper was allowed to dry overnight. Next day, the residue remaining on the filter paper was further dried in an oven at a temperature of 50°C for 1 hr, allowed to cool, and

subsequently weighed. The measurement of matter insoluble in alcohol was determined using equation (2):(5,6)

$$\text{Matter Insoluble in Alcohol}(\%) = \frac{\text{Weight of Filter Paper (after)} - \text{Weight of Filter Paper (before)}}{\text{Weight of Soap Sample}} \times 100 \ldots. \ (2)$$

2.2.3.6. Foam stability

A 30 mL of 5% water dilution of soap samples was prepared, and this amount was placed into 100-mL transparent graduated cylinders. The solution was shaken vigorously for 20 shakes and allowed to stand. The initial foam height (after shaking), and the time taken (t 0.5) for the foam to reduce to half of its initial value were recorded (6,23). One common equation used is the foam half-life equation, which can be expressed as:

$$t\ 0.5 = \frac{ln2}{Kd} \quad \ldots. \ (3)$$

Where K_d= rate constant for foam decay.

2.2.3.7. Cleaning ability

A drop of peppermint oil was placed on each strip of filter paper. The strips were placed into large test tubes containing 10 mL of 1% soap solutions. The soap solutions were then shaken vigorously for 2 minutes. The filter paper was removed rinsed with water, and placed into a hot air oven (Binder oven, USA) at 40°C for 30 minutes for drying. The cleansing power was observed and recorded (6).

2.2.3.8. Free fatty acid or free alkali (FFA or FAK%)

The soap samples were prepared for testing by adding a previously weighed soap formula (2 g) into a conical flask then 100 mL of hot neutral ethanol was added. The flasks were put on hot plate until the soap was completely dissolved. After cooling, three drops of phenolphthalein indicator were added. If the solution turns to pink then titrated with HCL until the color disappears and calculate the alkalinity, but if not titrate the solution with NaOH until a pink color appears and calculate the percent of free acid (24,25).

$$\text{FFA}\ \% = \frac{\text{N(NaOH)} \times \text{V(NaOH)} \times 28.25}{\text{Sample weight}} \quad \ldots. \ (4)$$

The value (28.25) is a conversion factor used to calculate the percentage of free fatty acids in a soap sample. This factor is derived based on the molecular weights of common fatty acids in soap and the stoichiometry of the titration process. It simplifies the calculation by incorporating these elements into a single number.

$$\text{FAK}\ \% = \frac{\text{V (HCl)} \times \text{N(HCl)} \times 36.45}{10 \times \text{Sample weight}} \ \ldots. \ (5)$$

The value (36.45) in the formula (5) is derived from the molecular weight of hydrochloric acid (HCl), which is approximately 36.45 g/mol. The value 10 is a conversion factor used to standardize the calculation to a percentage. Together, these values are used to accurately determine the alkalinity percentage in a sample (24,26).

2.2.3.9. Total fatty matter (TFM %)

An applicable procedure involves weighing 10 grams of the soap sample and mixing it with 150 milliliters of distilled water, then dissolving it using a water bath and allowing it to cool. A blend of concentrated hydrochloric acid (HCl) and water in a 1:1 ratio is then added to separate the oils from the soap solution, resulting in foam production after a 15-minute settling period. To solidify the superficial oil layer, 7 grams of beeswax are added to each sample, followed by heating using a water bath, after cooling the upper layer is separated., the % of fatty matter in the prepared soap samples was calculated using the relation (1).

$$\text{TFM}\ [\%] = \frac{(weight\ of\ upper\ layer - weight\ of\ beeswax)}{weight\ of\ sample} \times 100 \quad \ldots. \ (6)$$

2.2.3.10. Economic feasibility

To determine the economic feasibility of soapmaking, one must analyze production costs, including raw materials, utilities, and packaging, and compare these costs against the selling price and projected revenue. Considering market demand and environmental impact, such as using waste oil for sustainability, is also essential for making an informed decision (27,28).

2.2.3.11. Statistics

Pairwise comparisons were performed using t-tests to identify which specific samples differ. The results were given as mean ± standard deviation and statistically analyzed using a t-test, $p<0.05$ was considered as significant.

3. Results and Discussion

3.1. Production of soap by cold process

The small-scale cold process of soap production is a time-honored technique that combines oils and lye in the absence of thermal application, thereby facilitating a natural saponification reaction. This technique is esteemed for its capacity to yield superior-quality soaps with beneficial characteristics, as substantiated by numerous investigations examining diverse formulations and components.

Figure 2. Waste (W) Soap bar (left), Fresh (F) Soap bar (middle) and Treated (T) soap bar (right)

Single-oil soaps like Castile (made from olive oil) are rare because most single oils do not produce good soap, while collection of oils is used nowadays to produce a soap that is not only effective in cleansing but also offers various skin benefits and to attain the desired balance of cleansing, moisturizing, and lathering properties. Additionally, modern soap recipes are super-fatted with excess oils that do not react with the lye, enhancing the moisturizing properties of the soap compared to those that are solely cleansing (1). In this study, all soap formulations demonstrated successful saponification. During the mixing of lye with oils, the temperature reached up to 50°C. The process of pouring into molds was straightforward, and the soap was ready for cutting approximately 12 hours later. However, the treated soap (T) exhibited greater ease of manipulation during subsequent handling.

3.2. Physicochemical quality tests

3.2.1. Organoleptic parameter

The visual properties are depicted in **Figure 2**. Soap (T) exhibited a refined yellow color and a notably smooth texture, devoid of any bubbles or ash. In contrast, the alternative formulations (W and F) showed the presence of soda ash, a white, powdery substance primarily composed of sodium carbonate, formed when sodium hydroxide in the soap reacts with carbon dioxide during curing. The absence of soda ash in Soap (T) indicates the effectiveness of the natural treatment and the balanced formulation, ensuring a smooth and aesthetically pleasing surface. All formulations have a pleasant peppermint odor. This highlights the successful integration of natural ingredients in soap production.

3.2.2. Hardness test

There was a noticeable difference in hardness when handling. Although this variation was within acceptable limits, it was better quantified using a digital device, as expressed in Table 3. The comparison was also done utilizing ASTM Standard Test Methods for Chemical Analysis of Soaps (29), this specifies a 20-40 Newtons (N) hardness range.

Table 3. The hardness and matter insoluble in alcohol for the soap formulations

Sample	Hardness (N)	ASTM Standard (N)	pH	ISO Standard
Soap (F)	15.9	20-40	9.7	9.0-10.5
Soap (W)	11.4	20-40	9.5	9.0-10.5
Soap (T)	10.0	20-40	8.8	9.0-10.5

F: Soap made from fresh oil, W: Soap made from waste oil, T: Soap made from Treated oil, N: Newton, ASTM: American Society for Testing & Materials, ISO: International Organization for Standardization.

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3.2.3. pH measurement

This measures the acidity or alkalinity of the soap. A balance is necessary to ensure the soap is not too harsh on the skin. Human adult skin typically exhibits an average pH slightly below 5, indicating a mildly acidic nature. It is believed that prolonged use of cleaning agents, such as soap, may alter the skin's pH. The pH of the soap formulations prepared in this study ranged from 8.8 to 9.7 (see Table 3), which falls within the ISO standard range of 9.0 to 10.5. This suggests that the treated soap (T) is not corrosive to human skin (30).

3.2.4. Moisture percentage

Determines the amount of water in the soap. Lower moisture content generally indicates a longer-lasting bar. Soap (F) exhibits an exceptionally low moisture content of 0.2%, which could result in brittleness and susceptibility to cracking, but during handling there were no signs of cracking or brittleness. Soap (W) has a moisture content of 8%, falling short of the ISO standard range of 10.5% to 12.5%, potentially affecting its longevity and user experience. In contrast, Soap (T) demonstrates a moisture content of 10.2%, aligning closely with the lower threshold of the ISO standard range. This indicates that Soap (T) is more likely to offer an optimal balance between hardness and usability, minimizing the risk of brittleness and ensuring satisfactory performance. Overall, Soap (T) meets the criteria most closely, suggesting it will deliver the best practical results among the three samples (31). See Table 4.

Table 4. The moisture and matter insoluble in alcohol percentages

Sample	Moisture %	ISO Standard (%)	Matter insoluble in Alcohol (%)	ASTM Standard (%)
Soap (F)	0.2	10.5-12.5	8.5	(70-80)
Soap (W)	8	10.5-12.5	11.6	(70-80)
Soap (T)	10.2	10.5-12.5	14.7	(70-80)

F: Soap from fresh oil, W: Soap from waste oil, T: Soap from Treated oil

3.2.5. Matter insoluble in alcohol (%)

Determining the purity of soaps involves this parameter. By this, soap was dissolved in ethanol, followed by filtration using filter paper. The undissolved matter was then weighed. Typically, additives do not dissolve in alcohol, and foreign matter persists because soap itself generally dissolves in alcohol (24). This process quantifies the presence of non-soap materials, often referred to as builders or fillers. These materials include sodium silicate, sodium carbonate, and sodium phosphate, along with other constituents such as bleaching agents, whitening

agents, and fluorescing agents. Table 4 indicates that the lower percentage for (F) is 8.5%, while the higher percentage for (T) may be attributed to the presence of herbal materials. The percentage for (W) is 11.6%. All these values are within acceptable limits and are significantly lower than the maximum standard specification of (70-80)% (29) and this is in agreement with Idoko Owoicho et al (6).

3.2.6. Foam stability

The foam test is a crucial criterion for determining the acceptability of soap (8). The ability of soap to produce and sustain foam, also referred to as lather, is predominantly determined by the surfactants it contains (32). When soap is combined with water and agitated, these surfactants lower the surface tension of the water, facilitating the entrapment of air in small bubbles and resulting in foam formation. Time was recorded in minutes. Soap (T) exhibited a longer duration of 9 minutes (Kd=0.077), as shown in **Table 5**, indicating greater foam stability for this formulation. However, there was no significant difference ($p>0.05$) between all formulations which is in agreement with Stoyan I. Karakashev et. al (23)

Table 5. The foam's stability, cleaning ability, and free alkali

Sample	Foam stability (Kd)	Cleaning ability	FFA (%)	ISO specification
Soap (F)	0.081	Very good	0.854	< 2%
Soap (W)	0.086	Very good	1.60	< 2%
Soap (T)	0.077	Very good	0.751	< 2%

F: Soap made from fresh oil, W: Soap made from waste oil, T: Soap made from Treated oil, Kd: rate constant for foam decay, FFA (%): percentage of free fatty acid.

3.2.7. Cleaning ability

The other physical parameter is cleaning or washing ability in **Table 5** showed that the cleaning of all soap formulations was very good, and their washing property is normal.

3.2.8. Free fatty acid or free alkali (FFA or FAK%)

The presence of free caustic alkali in soap is essential to prevent the soap from becoming oily; however, an excess of free caustic alkali can cause skin irritation. Titration results provide a measure of the levels of free alkali in each soap sample. In this study, none of the tested samples turned pink upon the addition of two drops of phenolphthalein indicator, necessitating the continuation of titration with NaOH until a pink color was observed. Burette volumes were recorded, and the FFA% was calculated using the relevant equation. All recorded values were significantly below the maximum permissible limit of 7-8%, as specified by ASTM standards (29).

Among the samples, Soap (W) exhibited the highest FFA content at 1.60%. This could be attributed to the properties of the cooked sunflower oil used, which influence the rate of saponification and, consequently, the overall quality of the soap. Soap (T), on the other hand, demonstrated the lowest FFA content, suggesting superior quality. This could be due to the herbal treatment of the oils, which may enhance saponification, resulting in purer and higher-quality soap that is safer for human skin (30,33). No significant differences between the three formulations were observed **Table 5**.

3.2.9. Total fatty matter (TFM %)

Given that the minimum standard for Total Fatty Matter (TFM%) according to ASTM is 40%, all the formulations for Soap (F), Soap (W), and Soap (T) are well within the acceptable range (29). The total fatty matter determination was 78%, 74%, and 73% for soaps: F, W, and T respectively (**Table 6**). The quality of the soap is represented by the total fatty matter. If the total fatty matter is lower, then it is not optimum for dry skin. The greater the fatty matter more it helps moisturize the skin. However; all exceed the minimum requirement (40%), indicating that each formulation meets the ASTM standards for TFM%, ensuring quality and compliance, however; samples differ significantly from the standard value . **Figure 3** illustrates the foam formation before the addition of acid and wax (left), and the subsequent formation of the upper fatty layer after the addition of acid and beeswax for solidification (right).

Table 6. The total fatty matter (TFM%)

Sample	TFM%	ASTM Standard (%)
Soap (F)	78	40
Soap (W)	74	40
Soap (T)	73	40

F: Soap made from fresh oil, W: Soap made from waste oil, T: Soap made from Treated oil

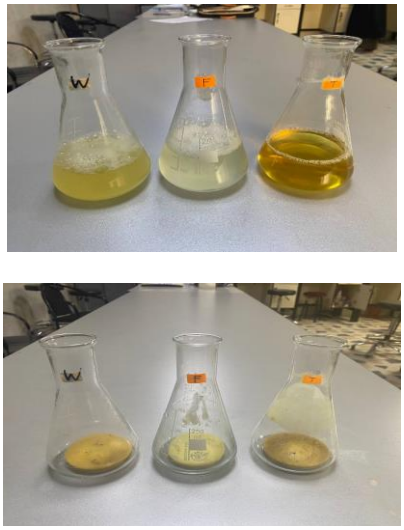

Figure 3. Total fatty matter formation

3.2.10. Economic feasibility

From the initial comparison of the mean differences, it appears that the costs of Soap (T) and Soap (F) are very close, while the cost difference between Soap (W) and the other two is more pronounced. Based on the provided data, Soap (T) is the most economically feasible option considering both quality and cost. Soap (T) demonstrates superior quality across all evaluated parameters, such as visual properties, hardness, pH, moisture content, foam stability, cleaning ability, and free fatty acids, while maintaining a competitive cost of 3,477.5 ID. Although Soap (W) has a slightly lower cost (3,327.5 ID), its performance metrics are not as strong as Soap (T). Soap (F) has a similar cost (3,479 ID) to Soap (T), but again, does not match the same level of quality. Thus, Soap (T) strikes the best balance between cost-effectiveness and high quality.

4. Conclusion

Based on the comprehensive analysis of visual properties, hardness, pH, moisture content, foam stability, cleaning ability, and free fatty acids, Soap (T) consistently demonstrates superior quality among the three formulations. Soap (T) exhibited a refined yellow color, smooth texture without bubbles or ash, and met all ASTM and ISO standards, including hardness, pH, and moisture content. The absence of soda ash in Soap (T) highlights the effectiveness of the natural treatment and balanced formulation. Moreover, Soap (T) displayed the longest foam stability duration and the lowest free fatty acid content, indicating better performance and skin safety. These results suggest that Soap (T) offers the best practical results, balancing economic viability and sustainability while integrating natural ingredients effectively. Consequently, Soap (T) is recommended as the most optimal formulation for achieving high-quality soap production.

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Conflict of Interest:

There are no financial or non-financial interests to disclose.

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Ethics statements:

This study does not require ethical approval from an ethics committee.

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المقارنة الفيزيوكيميائية للصابون المنتج من زيوت طازجة، مطهية، ومعالجة طبيعياً

الخلاصة:

الخلفية والأهداف: تلعب الكيمياء الخضراء دورًا حيويًا في صناعة الأدوية. استخدام الأعشاب لتقليل التزنخ والأكسدة في زيوت الطبخ المختلفة يعد نهجًا اقتصاديًا وصديقًا للبيئة. يؤثر زيت الطبخ المستهلك بشكل كبير على التلوث البيئي، مما يؤثر على الحياة المائية وجودة التربة. يهدف هذا البحث إلى إنتاج صابون عالي الجودة باستخدام زيوت مشبعة بالأعشاب لمعالجة الزيوت المستهلكة من المطاعم، مما يوفر حلاً عمليًا لإدارة النفايات المستدامة. بالإضافة إلى ذلك، يوفر فوائد مختلفة للبشرة، مثل الترطيب والتنظيف. **الطريقة:** تم استخدام طريقة بسيطة على نطاق صغير لتبريد الزيوت لتشكيل ثلاثة أنواع من الصابون باستخدام زيوت مختلفة. يحتوي تكوين واحد على زيت الطبخ من مطعم للوجبات السريعة، ويحتوي الآخر على زيت طازج، والثالث يحتوي على زيوت معالجة بالطريقة الخضراء باستخدام مسحوق الكركم والنعناع ومسحوق إكليل الجبل بتركيز معين. تم تقييم جودة الصابون الفيزيوكيميائية من خلال اختبارات مختلفة، بما في ذلك التقييم العضوي، والصلابة، وقياس الرقم الهيدروجيني، ومحتوى الرطوبة، والمادة غير القابلة للذوبان في الكحول، وثبات الرغوة، وقدرة التنظيف، ومحتوى الحمض الدهني الحر أو القلوي، والمادة الدهنية الكلية. تم تقييم الجدوى الاقتصادية من خلال تحليل تكاليف الإنتاج والأثر البيئي، مع التركيز على فوائد استخدام الزيوت المستهلكة لإنتاج الصابون المستدام وبتكلفة فعالة. **النتائج:** أظهر الصابون (T) لونًا أصفر نقيًا، ونسيجًا ناعمًا، وامتثالًا لمعايير ASTM وISO في جميع المعايير. من الجدير بالذكر أن الصابون (T) أظهر أطول ثبات للرغوة 9) دقائق، (Kd=0.077وأدنى محتوى من الأحماض الدهنية الحرة (0.751%)، مما يدل على جودة عالية وأمان للبشرة. كما أن الصابون (W) والصابون (F) امتثلا للمعايير ولكن بمؤشرات أداء أقل. تم التعرف على الصابون (T) كتركيبة مثالية، تحقيق التوازن بين الجودة والاستدامة والأداء العملي. **الخاتمة:** استوفى الصابون (T) جميع معايير ASTM وISO، مما يدل على جودة عالية وأداء متميز. توازن مكوناته الصديقة للبيئة رطوبة البشرة، ويبرز الصابون (T) كأفضل خيار للاستخدام العملي والاستدامة. يوصى بمزيد من الدراسات حول تقليل التجاعيد ومنع حب الشباب.