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Article

Studying The Effect of Red Onion Peel Extract on The Quality of Transparent Soap

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Abstract: This study was conducted to determine the industrial benefit of red onion peel extract on the most important physical and chemical properties of manufactured transparent soap. Three vegetable oils were selected for manufacturing: castor oil, olive oil, and coconut oil. Different ratios of materials were used to improve the transparency of the soap, and the best ratio was selected for the study. The results of soap with added onion peel extract were not significantly different from soap without the extract. Its pH was 9.48, while the one without the extract was 9.52. As for the results of moisture, solubility and permeability, they were 12.7%, 8.2%, and 92.6% respectively for soap with added extract. As for the extract without added water, the moisture content was 12.6%, while the solubility was 8.1% and the permeability was 94.2%. The foam height was 11.5 cm for soap with added extract, and its stability rate was better than that of soap without extract, reaching 95% compared to 94.2%. The soap with added red onion extract had a biological benefit, as its inhibition zones for Staphylococcus aureus were 28.7 mm, while its inhibition zones for Escherichia coli were 17.45 mm. Furthermore, the prepared transparent soap retained its properties over a period of 90 days. Therefore, we conclude that the ratios of the improved ingredients, selected oils, and added extract were successfully studied.

Keywords: Extract, Enriched Soap, Detergents, Castor Oil

Introduction

Soap manufacturing is a long established chemical industry that remains highly significant to this today, and it is directly linked to hygiene and personal care products [1]. It has undergone significant evolution over time, driven by advancements in industrial chemistry, which has led to increased market demand for high quality visually appealing products [2]. Transparent soap is a prime example, it commands high market value due to its desirable clarity and moisturizing ingredients, which provide superior sensory qualities compared to traditional soap [3]. Furthermore, the transparency of the soap is not determined solely by the saponification reaction between fats or oils and sodium hydroxide, it also depends on its overall chemical composition and manufacturing conditions [4]. Transparency is influenced by the fatty acid composition of the oils used, as well as the type and concentration of transparency enhancing agents, such as glycerin, propylene glycol, sorbitol, sucrose, and ethanol [5]. The primary function of these additives is to reduce light scattering within the soap structure by inhibiting the crystallization of soap salts [6]. This leads to increased light transmission, resulting in a transparent and homogeneous soap [7]. From the perspective of industrial chemistry, the soap making process is on characterized by precision and balance, taking into account even the most subtle interrelated properties [8]. For example, increasing the amount of moisturizing agents improves the soap is transparency but reduces its hardness, thereby increasing its melting point [9]. Therefore, the manufacturing process requires studying the effect of ingredient proportions on the chemical and physical properties of the soap [10]. pH is considered one of the most important chemical properties, alongside moisture content, transparency, hardness, foam stability, and storage stability, all these indicators are of critical importance in evaluating soap quality [11]. Furthermore, the growing interest in green chemistry in recent years has made it essential to utilize agricultural waste in modern industries while simultaneously to minimize its negative environmental impact [12]. This approach is central to employing natural compounds to further improve the properties of chemical products in general, and cosmetic in particular [13]. Red onion (Allium cepa L.) skins are widely available agricultural by product rich in phenolic compounds and flavonoids, most notably quercetin [14]. These compounds possess antioxidant and antimicrobial properties. Although plant extracts are used in various industrial sectors, their application in the personal care and detergent industries remains limited [15].

Accordingly, this study aims to further enhance the quality of transparent soap formulations by investigating the effect of varying proportions of glycerin, propylene glycol, and sorbitol on the soap is physicochemical properties. It also seeks to determine the optimal formulation and subsequently evaluate the impact of adding red onion peel extract on these properties. Finally, a comparative analysis is conducted between the improved soap and commercially available transparent soaps to assess the effectiveness of the enhanced product.

Materials and Methods

Olive oil, coconut oil, and castor oil were all used in this study. As for the chemicals, they were of high purity and supplied by Sigma-Aldrich. In general, it was prepared with glycerin, sorbentol and propylene glycol as enhancing materials. Sodium hydroxide, pure sucrose, 95% ethanol, and distilled water were among the basic materials used in manufacturing and preparation.

The red onion peels were simply collected from local markets by peeling the onions. The peels were thoroughly cleaned of any clinging dirt, washed, and then dried at room temperature. The red onion peels were ground, then 20 grams were weighed and placed in a beaker. About 200 ml of ethanol was added and it was left for 24 hours at room temperature, stirring continuously using a magnetic stirrer to ensure the greatest possible decomposition of the active ingredients. After a full day, the mixture was filtered using Wattman filter paper No. 1, the filtrate was separated from the sediment, and it was evaporated using a heater with a temperature not exceeding 40 degrees Celsius. Then we stored the extract in a refrigerator at 4°C until use.

The hot method was adopted in preparing the soap with the following proportions of oils: 16% castor oil, 35% coconut oil, and 49% olive oil. The total weight of the mixture was 500 g. The mixture was heated to 70°C and maintained at this temperature for 10 minutes. The container was then removed from the heat, and when the mixture cooled to 45°C, sodium hydroxide solution (prepared beforehand by dissolving 140 g of sodium hydroxide in 175 ml of distilled water) was gradually added while stirring continuously until the trace stage was reached. Next, 50 g of sucrose dissolved in 75 ml of distilled water was added to the mixture, followed immediately by 75 g of 95% ethanol. The final product was divided into 8 portions, and transparency enhancers were added according to the formulations shown in Table (1).

Table 1. Proportions of transparent soap compositions

Sample	Glycerin (g)	Sorbitol (g)	propylene glycol (g)
F1	150	0	0
F2	100	50	0
F3	50	100	0
F4	75	75	0
F5	100	0	50
F6	75	50	25
F7	50	50	50

F8	50	75	25

The pH was measured using a BIOBASE/pH-T10 pH meter after dissolving 1 gram of soap in 10 ml of distilled water. Moisture content was measured by drying 2 grams of soap in a drying oven at 105°C, and the percentage moisture content was calculated using the following formula [16]:

$$\%Moisture = \frac{W1 - W2}{W1} \times 100$$

Where: W1 = weight before drying , W2 = weight after drying.

The foam was tested using a graduated cylinder by dissolving 1 gram of soap in 100 ml of distilled water, shaking it thoroughly for 30 seconds, and recording the foam height inside the cylinder in centimeters [17]. To calculate the foam stability ratio, the foam height was remeasured after 5 minutes, and the ratio of the second height to the first was calculated [18]. The solubility rate of the prepared soap was measured by placing 10 grams of the sample in a beaker and immersing it in 100 ml of distilled water for a full day (24 hours), and then recalculating its weight. The percentage loss was calculated using the following formula [19]:

$$\%Solubility = \frac{W1 - W2}{W1} \times 100$$

To measure transparency, pieces of soap were cut to a constant thickness of about 5 millimeters, then the small pieces were placed in a cell of an APEL PD-303U UV spectrophotometer, and the light transmittance was recorded at a wavelength of 500 nm using air as a blank spectrometer [20].

After testing all the prepared formulations, the best one was selected, and red onion peel extract was added at a concentration of 1% (w/w) of the selected formulation. This was then tested and compared with commercial soap.

The antibacterial activity test was performed using the Agar Well Diffusion method, where bacteria were cultured on Müller's medium, wells with a diameter of 6 mm were drilled, 100 µl of the dissolved soap sample (10 mg/mL) was added to each well, and the plates were placed in an incubator set to 37°C for 24 hours. The diameter of the inhibition zone was then measured in mm.

To determine the storage stability of the soap, the samples were kept at room temperature 25 for 90 days and the pH, foaming and transparency were remeasured every 30 days.

GraphPad Prism9 software was used to find the average of three repeated readings for the tests.

Results and Discussion

Table (2) shows the chemical and physical properties of the prepared transparent soap samples. The pH results showed a range between 9.48 and 9.8, which is considered acceptable, indicating that the amount of sodium hydroxide used in the preparation was appropriate and that no unreacted sodium hydroxide was present. Maintaining the acidity of the formula is important, and the acidity of the soap affects its cleaning properties in addition to its effect on the skin when it comes into contact with it, so the soap should be kept at a moderate acidity[21]. The pH of the prepared formulation F6 was 9.52, and this value decreased to 9.48 when onion peel extract (formula F9) was added. One of the most important reasons that led to the decrease in acidity is the presence of phenolic compounds in onion peel extract, and these compounds work to reduce alkalinity[22].

The results in Table (2) show that the moisture content ranged from 11.7% to 13.3%. It is worth noting that moisture plays a significant role in the smoothness of the soap. However, increased soap moisture leads to a negative consequence: faster soap consumption [23]. Conversely, a low humidity level negatively affects the appearance of the soap, causing it to crack[24]. The moisture content of the prepared sample F6 was 12.6%, but this percentage increased significantly when the extract was added to the soap, reaching 12.7% in the F9 formulation.

Despite this slight increase, it is not considered a negative effect on the quality of the soap, but rather confirms the preservation of the water balance in the soap formula when the extract is added.

On the other hand, solubility is one of the characteristics that assesses the resistance of soap to consumption in our daily lives. The lowest percentage of solubility for all prepared samples was 8.1%, and this percentage was for sample F6. If this indicates anything, it indicates the balanced structure of this model. This means that the proportions used for transparency-enhancing materials not only improved the appearance of the soap but also significantly contributed to preserving the soap's internal structure. Although the soap's solubility increased to 8.2% when the extract was added, this increase did not negatively affect its quality.

Table (2) shows the results of the tests for all the prepared soap formulations, showing the effect of the proportions of transparency-enhancing materials on the tests in each sample, in addition to showing the results of adding the extract to the soap, as it did not affect the general results of the tests.

Table 2. The chemical and physical properties of the prepared transparent soap

Sample	pH	%Moisture	%Solubility
F1	9.8±0.02	11.7±0.15	8.4±0.13
F2	9.73±0.06	12.1±0.17	8.5±0.16
F3	9.68±0.04	12.7±0.18	9.1±0.12
F4	9.64±0.03	13±0.14	9.5±0.14
F5	9.57±0.02	12.8±0.20	8.8±0.15
F6	9.52±0.03	12.6±0.25	8.1±0.18
F7	9.5±0.07	13.3±0.14	9.9±0.23
F8	9.49±0.04	12.9±0.19	9.0±0.18
F9	9.48±0.09	12.7±0.28	8.2±0.21
Commercial	9.62±0.08	12.4±0.17	8.7±0.17

Transparency was expressed by measuring the light transmittance of the samples. Table (3) shows the transparency results for the prepared formulations. Transparency is considered one of the most important criteria for evaluating the quality of transparent soap [25]. It reflects the homogeneity of the formulation structure and the success of the preparation methods. The results showed clear differences between the various formulations, ranging from 77.4% to 94.2%. Form F6 recorded the highest light transmittance, which is one of the reasons for its selection from among the other formulations in this study. The high transparency is attributed to the balanced proportions of glycerin, propylene glycol, and sorbitol, which are crystal-modifying agents [26]. The results shown in Table (3) indicate that model F1 has the lowest permeability and is therefore considered the least transparent model. This ratio may be due to an imbalance in the proportions of the added improving materials. The penetration rate of formulation F6 was 94.2%, but it decreased significantly when onion peel extract was added to the formulation, reaching 92.6% for formulation F9.

Despite this decrease, it did not negatively affect the quality of the soap. The presence of natural pigments in the extract is considered a definite cause of reduced permeability, as pigment compounds affect light transmission and thus reduce transparency[27]. It is worth noting that the commercial soap chosen in this study for comparison purposes recorded a lower permeability than the soap fortified with the extract, as its permeability reached 91.3%. Therefore, this enhances the success of the transparent soap preparation process and the selection of transparency-enhancing materials in proportions, in addition to the product maintaining its transparency properties when onion peel extract is added to it. The difference in transparency between the soap produced in this study and the commercial soap selected for comparison may be due to the quality and proportions of the oils used in the industry, or to the manufacturing conditions or the type of improving materials. Table (3) shows the permeability results for all the samples that were manufactured in addition to the commercial soap.

Table 3. Results of Transparency for prepared formulations and commercial soaps

Sample	Light transmittance %
F1	77.4±1.1
F2	83.6±0.9
F3	87.7±0.9
F4	89.8±1.0
F5	91.4±0.7
F6	94.2±0.8
F7	88.5±0.8
F8	89.2±1.2
F9	92.6±0.7
Commercial	91.3±0.8

As for the foam properties, Table (4) shows the foam height results in addition to its stability in relation to the manufactured soap formulations. The foaming property is one of the characteristics that assesses product quality in addition to its suitability for consumers[28]. Since the models contain different proportions of enhanced materials, they must differ from each other in terms of foam formation. The foam height in the samples ranged from a minimum of 9.6 cm for sample F1 to a maximum of 11 cm for sample F6. After adding the extract, the foam height increased to 11.5 cm for sample F9. The stability or consistency percentages of the foam were 89.9%, 94.2% and 95% respectively. This means that the proportions used for oils and improving materials have added another advantage to the non-transparent soap, which is its foaming property and stability. It is worth noting that castor oil, which is used in soap making, improves the foaming property, as it is known for its ability to form foam because it contains ricinoleic acid [29]. In addition to the role of castor oil in improving foam, we do not overlook the role of olive oil in improving the softness and moisture of the soap [30]. In terms of foam properties, we select the F6 model as the best manufactured formula among the other models. Table (4) shows indicates that the amount of extract used did not negatively affect the saponification process, the soap's composition, or its properties. When comparing the F9 formula modified with extract to commercial soap, it was found that the commercial soap had a lower foam height (10.8 cm) and a lower stability (93%) than formula F9. This suggests that the formula prepared and modified with extract has a greater ability to produce foam and maintain its stability than commercial soap. This may be due to some commercial products prioritizing the selection of inexpensive ingredients, regardless of the impact on quality. From the results of Table (4), we conclude that balancing the proportions of the oils used, as well as balancing the proportions of the improving materials, helped to obtain a formula with excellent foam and stability compared to the commercial soap model. Also, strengthening the prepared formula with red onion peel extract did not negatively affect the quality of the formula, and this indicates the possibility of preparing a high-quality transparent soap by strengthening it with the plant extract.

Table 4. Foaming results for prepared formulations and commercial soaps

Sample	Foam height (cm)	Foam stability (%)
F1	9.6±.32	89.9±0.89
F2	9.8±0.25	90.8±1.14
F3	10±0.28	91.7±1.45
F4	10.3±0.40	92.5±1.98
F5	10.5±0.22	93.3±2.05
F6	11±0.18	94.2±0.96
F7	10.2±0.65	92.2±1.78
F8	10.6±0.54	93.5±1.43
F9	11.5±0.46	95±2.11
Commercial	10.8±0.60	93±1.98

Table (5) shows the results of the biological activity of the prepared formulation F6, the formulation after its supplementation with red onion peel extract F9, and a commercial soap sample. The Agar Well Diffusion method was used, measuring the diameters of the inhibition zones against Gram-positive Staphylococcus aureus and Gram-negative Escherichia coli.

The results showed that formulation F6 had a lower effect compared to the commercial soap, with inhibition diameters of 12.85 mm for E. coli and 19.5 mm for S. aureus, while the commercial soap diameters were 13.85 mm and 20.4 mm, respectively. The formulation supplemented with red onion peel extract (F9) showed the highest activity compared to both formulation F6 and the commercial soap sample, with inhibition diameters of 17.45 mm for E. coli and 28.7 mm for S. aureus.

The results confirm that the extract has given additional functional value to the soap while maintaining its main properties. Therefore, the results confirm the possibility of using red onion peel extract as an antibacterial enhancer for transparent soap.

Table 5. Antibacterial activity

Sample	E. coli (mm)	S. aureus (mm)
F6	12.85±0.66	19.5±0.45
F9	17.45±48	28.7±0.38
Commercial	13.85±39	20.4±0.25

Table (6) shows the stability of the physical and chemical properties of the formulation treated with red onion peel extract (F9) during a 90-day storage period at room temperature not exceeding 25°C. Changes in pH, foaming, and transparency were monitored. Testing the effect of storage on the formulation is an important indicator in evaluating the shelf life of various industrial products.

The pH results in Table (6) show a decrease from 9.48 to 9.27 after 90 days of storage. This decrease is not considered significant for the product formulation and is attributed to the continuation of certain reactions occurring within the soap, in addition to the potential reaction of some base with carbon dioxide in the atmosphere. Nevertheless, this slight decrease suggests the stability of the prepared soap formulation. As shown in Table (6), there was a slight, almost imperceptible decrease in transparency, with light transmittance dropping from 92.6% to 91.3% during the storage period. It can be said that this decrease is due to the loss of some moisture, and thus the product's composition has been affected. It is very important to focus on the transparency feature, which is the identity of the prepared product, as its permeability still exceeds 90% throughout the 90-day storage period. This means that the soap produced, to which onion peel extract was added, maintained its transparency during the storage period. As for the foam characteristic, we note in Table (6) that the height of the foam decreased slightly and gradually from 11.5 cm at time zero to 11 cm on day 90. This slight decrease is not considered a structural defect and may be due to a reduction in the product's moisture content over time, which slightly affected its solubility at the start of use. Nevertheless, the foam remained stable until the end of the storage period.

These results indicate that the extract used from red onion peels did not negatively affect the composition of the prepared soap. This enhances the possibility of adopting and marketing it as a stable, high-quality product.

Table 6. Storage stability of the F9 formulation

Storage period (day)	pH	Light transmittance %	Foam height (cm)
0	9.48±0.09	92.6±0.7	11.5±0.46
30	9.32±0.08	91.8±0.5	11.4±0.35
60	9.29±0.11	91.4±0.7	11.2±0.57
90	9.27±0.08	91.3±0.4	11.0±0.42

Conclusion

This study concludes that it is possible to manufacture transparent soap using various vegetable oils and fortifying them with different improving agents, resulting in good physicochemical properties. Adjusting the proportions of the improving agents enhances the quality of the produced soap. Furthermore, fortifying the prepared product with red onion peel extract gave the soap improved lathering and stability, in addition to other properties. The fortification with the extract had a positive, rather than negative, effect. Moreover, the biological effect was enhanced, as the soap fortified with red onion peel extract exhibited greater biological activity against bacteria than the unfortified soap. Finally, regarding storage stability, this study concluded that storage conditions did not affect the properties of the prepared soap, which supports the use of the method described for preparing soap fortified with red onion peel extract.

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