

Review of Natural Oils Used in the Production of Anti-Corrosive Soaps

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Abstract

Natural-oil based soaps are highly recommended over the commercial soaps in maintaining skin health and preventing it from corrosion as they are rich in skin-loving bio-compounds that moisturize the skin, helping fight against bacterial diseases and strengthen skin as first line of defense against corrosive environment. About 60-70% of soap mass contains fat. The natural oils utilized for soap production include coconut oil, olive oil, palm oil, avocado and almond oil etc. all offering unique characteristics to soaps including fluffy stable lather, moisturizing capability, firmness and moisture. The commercial industries are synthesizing highly alkaline soaps with low quality raw materials. The review aims to compare physical and chemical properties of natural-oil based soaps with commercially synthesized soap formulations by comparing the total fatty matter TFM, total alkali content, pH, hygiene efficiency and preservative chemicals added to the soaps. All these parameters have been compared with the standard guidelines provided by International Standard Organization ISO for the soap manufacture. The literature strongly evidence preferring natural-oil based soaps over the commercial soaps owing to their mildness on skin and promoting skin health.

Keywords: Bio-compounds, Skin corrosion, Natural oils, alkaline

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1. Introduction

Soaps are one of the major representatives of the cosmetic industry utilized for personal hygiene. The cleansing provided by the soap is because of its ability to disperse the water-insoluble material from the skin and holding it in water [1]. Utilizing soap for cleaning purposes becomes the demand of every person and becomes an unavoidable demand of every person. Thus cosmetic industry is doing business in billion dollar each year [2]. Soaps are basically salts of fatty acids which are soluble in water [3]. Adding suitable and quality ingredients is the first step in making good quality soaps. Unfortunately, commercial soap processing industries compromise quality of soap over the economic benefits and utilize animal fat over plant oils and claim these soaps more long-lasting which is against ethical considerations. The commercial soaps also contain large volume of unreacted alkali content which hardens them but poses harmful impact on the skin causing dryness, burning, rashes and itching on skin. Soaps also contain harmful ingredients like sulphates and parabens which are added in commercial soaps to enhance their shelf life and soaps can be stored and preserved for longer period of time. Commercial soaps also contain chemicals which pollute waterbodies and impose eutrophication in them.

On account of the skin related complexities arising in people after utilizing commercial soaps, the population is shifting toward using skin friendly soap formulations which

repair the natural skin barrier and maintain pH of skin thereby moisturizing it [4]. Studies are focused on the development of soaps from raw materials which are mild on skin. The skin moisturizing ability of soap is currently restored and increased via adding plant-based oils as alternative to animal fat. The natural oils are derived from plant sources and are tremendously researched for their topical benefits in curing skin related disorders like skin burns, fight inflammation, hydrate the skin, enhancing skin barrier and boost moisture of skin thereby preventing it from corrosion [5]. Appropriate selection of fats and oils is the key to soap production as it brings unique attributes to the final soap formulation. The fats and oils are raw materials of soaps having great importance in a way that they determine quality attribute of soap from their lather to the degree of moisturization they provide. About 60-70% of soap formulation solely contains base oils content. The natural oils are categorized on basis of the properties they impart on final product. The base oils are the first category which include coconut oil, palm oil and olive oil, all these are responsible for production of stable bars with heathy leathers and quality moisturizing ability.

The second category of natural oils for production of soap is luxury oils including jojoba oil, avocado oil, sweet almond oil and shea butter all these are the secondary oils with utilized in blends and they impart-loving characteristics in soap making them rich in vitamins [6]. The strong points behind any soap formulation are minimum ingredients added

in them, and these ingredients do not pose any environmental and health concerns. The raw material exploited in production should be biodegradable and degraded products do not pose any toxicity to the environment. The soap production should not require any kind of catalysts, if so then they do not create any harmful effect on the benefit of soaps [7]. Based on keen research, no such review is available, yet which provide clear and vivid demarcations between physiochemical properties. The review focus on the natural plant-based oils which are utilized in the production of soaps good for skin and investigate the quality attributes they impart to the soaps which are missing in the commercial soaps and also compare the natural oil-based soap formulation with the commercial soaps in terms of saponification index, free alkali content, preservatives being added and pH and moisture levels along with future advancements of developing skin friendly soaps.

2. Comparison of Natural-Oil Based Soap with Commercial Soaps

On basis of the data available in research articles, a fine quality and well-formulated soap is the one which has striking balance of all the physiochemical parameters and their values fall within guidelines of international Standard Organization ISO. These parameters include Free Alkali content (unreacted caustic alkali), Total amount of fatty acids TFM, pH of soap formulation. The characteristics include preservatives addition and hygienic effectiveness of soaps.

2.1. Total Fatty Matter (TFM)

The overall fatty matter component of soap is crucial in determining the quality facets of soap formulations. The total fatty matter addresses the amount of fats present in the soaps. The total fatty matter of soap determine the soap hardness and is always mentioned by soap manufacture[8]. Soaps having higher levels of total fatty matter are considered high quality soaps performing smoother skin cleansing, higher lather production and are gentle and mild with skin. Good quality soaps come under grade one soaps that have 76% TFM in them. The percentage of TFM is lower than the required result in soap formulation which creates dryness on the skin specifically and soap is considered inferior in quality (Table 1). In one investigation, the total fatty matter of soaps produced from the plant-based oils has been calculated. The oils include olive oil, argan oil, daphne oil and menengic oil, all these utilized for production of soap bar. The results proved these oils as effective anti-dryness agents in soaps with TFM content between 63% to 81% enlisting the prepared soap products among grade1 and grade2 soap categories [9]. Similarly the olive oil based bar also prevents the skin from drying and prevent issues like itching and appearance of rashes on skin as is evident from the study where the calculated TFM of soap bar is above 76% which indicates high moisturizing ability of the olive oil based soaps and hence they are ranked grade 1 soaps [10].

The soap formulation prepared using sunflower oil as base oil also showed the fatty matter content of about 75% which indicated the skin-moisturizing effect defending against the drying [11]. Similar result for TFM 75% using *Z. mauritiana* seed kernel oil-based soap have also been observed thus categorizing them as good quality moisturizing skin healing soaps [12]. The commercial soaps contain fatty acids like steric acid and palmitic acid contributing to

increment of soap TFM up to 92%. The reduction in the commercial soap TFM is because of the addition of fillers which are the dried chemicals added in commercial soaps in order to enhance the soap hardness as result the marketed soap bars create dryness on the skin. Because of these, the TFM percentage even drops to 50% making soaps causing burns on the skin while corroding the skin barrier [13]. A study investigated the TFM of the most widely utilized commercial brands of soaps and results had shown lower concentration of fatty acids in them, according to international standards soap formulation of commercially utilized soap brands like Lux and Lifebuoy etc. are categorized as grade2 soaps causing dryness on the skin and the study declared the presence of fillers as the main cause of TFM percentage reduction[14]. Another study also witnessed similar results for lifebuoy soap and claimed it as grade3 soap due to lower percentage of TFM observed [15].

2.2. Total Alkali Content

Another important parameter for estimating the quality of soap is the alkali content it contains. The total amount of alkali content present in any sap formulation is related directly to the unreacted alkali content including sodium and potassium hydroxides left in the soaps. According to international standards the content of free alkali should not exceed 2% in good quality soap. The unreactive alkali is corrosive to the skin causing burning sensation and formation of dry patches on skin. The high alkali content upon application, strip off natural oils of skin. In case of commercial soap formulations, an additional amount of alkali is added which enhances the bar hardness and foaming potential. This unreacted alkali content solubilize the natural oils and fats secreted by skin glands to protect from the environment thereby causing scaling and increased risk of fungal and bacterial infections [16]. One study investigated the total alkali content of washing bars and found out higher alkali content in the selected commercial washing and bathing bars with alkali content between 2-3% which exceeds the ISO limit of 2% alkali content [13]. The free alkali in the plant oil-based soap formulations is in very minute amount making them suitable for application on skin. The study showed zero presence of free alkali content in medicated soap bars containing olive, dephne and argon oil [9]. The similar findings have been gathered in the soap utilizing avocado oil as source of fat [17]. Free alkali content in coconut-oil base soaps also fall below threshold value provided by International Standard Organization ISO. The alkali content of soap bar came out to be less than 0.1% (Figure 1) [18].

2.3. pH of Soap and Skin Compatibility

pH measurement involves estimating the acidic and basic nature of soap. The skin is an important organ having its own pH so anything that comes in contact with skin layer will perform specific action ultimately affecting skin health. According to ISO standards standard pH of soap formulation should be between the 7.0–10.5. The pH of human skin is 5.5 indicating it to be slightly acidic. So, the soap formulation that is highly basic (due to containing higher alkali content and additives like sulphonates) will harm the skin by leaching essential biochemicals from skin which contribute to skin corrosion. Soapy cleansers which have pH ranging from 8 to 9 are considered suitable for skin.



Figure 1: Harmful impacts of Commercial Soaps

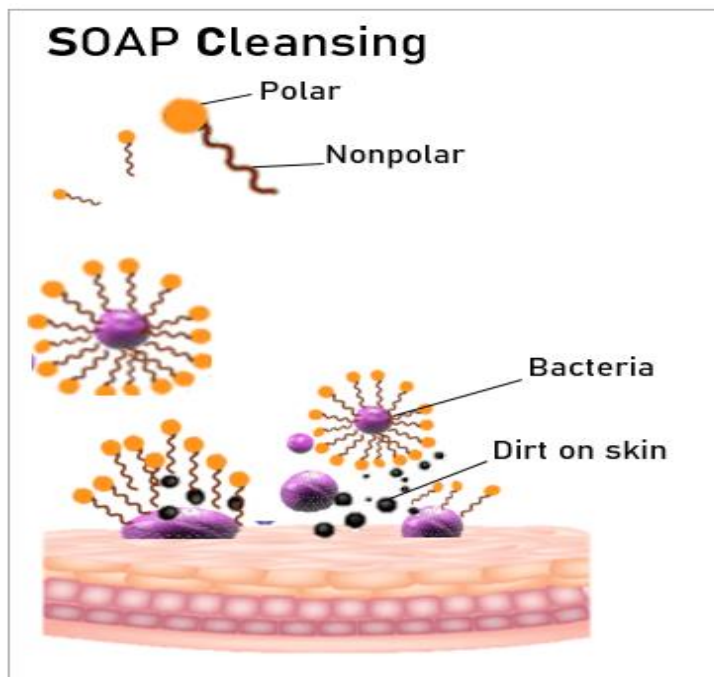


Figure 2: Soap Removing Adsorbed Dirt & Bacteria

Table 1: ISO Provided TFM grading of soaps

Grading	TFM%	Soap Quality	Moisturizing Ability
Grade 1	≥76%	Superior Quality	Fine Moisturizing
Grade 2	70%-75%	Moderate Quality	Medium
Grade 3	60%-70%	Harsh Soap	Drying

Table 2: Standard pH Ranges of Soaps

pH range	Soap Bar	Characteristic
4.5-6.5	Gentle	For Sensitive skin
7-8	Balanced	For Normal skin
8-10	Basic	For Nonsensitive skin
10-11	Harsh	For Industrial Usage

Table 3: Chemical composition of Commercial Soaps

Ingredients	Utilization	Range
Tallow, Steric Acid	Saponification Process	75-80%
Glycerol stearate, glycerine, silicone fluids	For Emolliating purpose	1-3%
beta-carotene, carbazole violet	For coloring bars	0.1%
Titanium dioxide	For Bleaching	2%
Sodium lauryl ether sulphate	For Bacterial attack prevention	5%
vanillin	For fragrance	1%
Benzoyl Peroxide	Anti-acne	10%

Table 4: Chemical composition of Natural Oil-based Soaps

Ingredients	Utilization	Range
Plant Fat	Saponification Process	75-80%
Palm oil, Coconut Oil, Olive Oil	For Emolliating purpose	-
Plant Based Powders	For coloring bars	5%
Kojic acid, Lemon juice	For Bleaching	1-4%
Essential Oils	For Bacterial attack prevention	5%
Fragrance oils	For fragrance	1%
Alovera extract, honey	Anti-acne	10%

Moderate alkalinity of soap helps prevent skin from attack of harmful microbes (Table 2) [16]. Commercial soap production sector often compromises with pH standards due to leaving excess potassium and sodium hydroxide in solid and liquid soap bars which increase alkalinity of final soap product. Studies conducted on physiochemical properties of commercial soap cosmetic sector products. One study has examined quality of quality attributes of 18 soap products of different brands utilized in Pakistan with a pH disturbance in fewer brands [19]. Likewise another study conducted on the 33 handwashing commercial products of Saudi Arabia out of them the 16 products have high alkalinity of greater than 10 [20]. Another study also found the higher pH level between 9-10 for the commonly available in skincare products which is generally not mentioned in product description of soaps [21]. The soap formulations prepared using natural oils are very hydrating due to lower free alkali content in them and also the alkalinity related skin irritation in soap is treated by adding oils during saponification stage. The oils have varying concentrations of saturated and unsaturated contents resulting in varying pH of final soaps. The neem oil based soap formulation has pH of 9.5 with total fatty matter percentage making it appropriate for topical application on skin [22]. Other studies also witnessed the stable skin compatible pH of the soaps from natural oil of coconut [23], olive oil [24] and almond oil [25].

2.4. Preservatives

The preservatives are the compound added to soap formulations to enhance their shelf life allowing long-term storage of soaps. The synthetic preservatives added to commercial soaps which inhibit the microbial degradation of soap and prevent from adverse environmental conditions. The common preservatives added to commercial soap formulations include triclocarban, Chloroxylenol, parabens and Isothiazolinones etc. Studies have reported their presence in the waste water bodies and polluting the aquatic bodies that receive them harming the untargeted aquatic life (Table 3) [26-27]. The plant fat-based soap formulations are not added with synthetic preservatives, yet they receive some preservation techniques for shelf-life increment. One study

showed the utilization of the berry extract as natural preservative to enhance the shelf life of soaps having origin from nature. The berry extract contain antioxidants which present the oxidative damage of soap formulation [28]. Another study showed the preservation of the natural soap formulation form the utilizing a blend of essential oil added to soap formulation and the blend include clove oil, neem oil thyme and tea tree oil for active protection against bacterial and fungal invasions [29]. Another study utilized antioxidants to prevent active microbial attacks on soap there by preventing it from oxidative damage. Natural soap formulation prepared from using blend of oils containing olive, coconut and palm oil & during soap production extract of *Paris polyphylla* has been gradually allowing to incorporate in soap matrix [30]. There are other natural preservatives added to base oils which utilized for soap production as per study utilized antioxidant potential of evening promise oil to protect sunflower oil which is widely utilized as cosmetic oil (Table 4) [31].

2.5. Hygiene Efficiency

Personal hygiene involves the removal of dirt and excess oils from skin and also the protection of skin from various bacterial infections. The good quality soap formulations contain ingredients that provide effective cleansing and have antibacterial properties. Various oils provide the protection against the bacterial infections and are added in soap formulations one such example include Citrus sinensis seed oil added in commercial soap to raise the antimicrobial protection [32]. Natural antiseptic soap formulations are produced for utilizing natural oils as base oils and added with other antibacterial oils. One study has investigated the soap formulation prepared from blend of various tropical seed oils and added with Moringa seed oil. The antibacterial assays revealed the suitability of soap (Figure 2) [24].

3. Current Advancements & Future of Natural-oil Based soaps

The studies are now carried out to employ the natural-oil based soaps on commercial level due to the

minimal toxicity being forced by nature-oil based chemical compound as compared to synthetic surfactant compounds [33]. The natural-oil based soap production is being actively researched in terms of raw materials derived from agro-industrial wastes, wasted cooking oil and exploiting the skin friendly properties of non-edible oils to use them as base oils or antibacterial oils [34]. Sufficient literature reports on experimenting with blends of different oils to improve properties of soaps and curing skin complications [35].

4. Conclusions

The public demand is shifting toward the usage of cosmetics which are synthetic chemical free and highly maintain skin health using nature-based raw materials. The soaps are the slats of fatty acids and major representative of cosmetic market which provide hygiene and protection of skin from fungal and bacterial infections. Global community is shifted toward the usage of soap formulations having origin from nature and contain less hazardous chemicals. The soaps are produced on commercial scale, and this market generates significant revenue each year. The commercial soap production sector although meeting an immense demand compromise on the quality of soaps. The parameters like total fatty matter, pH, total amount of alkali content in soaps determine the quality of soaps. The total amount of fatty acids and alkaline contents of soaps is dependent on saponification index of soaps and these two are the major variables which determine the appropriate grade and status of soaps.

The dry and patchy skin requires such soaps which have high TFM and moderate alkalinity, these two factors control the moisturizing ability of soaps. Lower amount of unsaponifiable content (TFM) and higher total alkali contents of soap indicate lower grade soap which impose skin concerns like burning sensation, itching, lower resistance to bacterial and fungal infections, impaired skin natural oil barrier and aging of skin. The commercial sector leaves large amounts of unreacted alkali content in soaps to aid in bar hardness and most commonly utilize the animal fat instead of plant-based oils and non-degradable preservatives like parabens for gaining commercial benefits while settling over quality of soap and its influence on skin and environment. The utilization of natural oils from plants for soap production, avoiding the addition of synthetic preservatives and superfatting of the soap formulation for efficient moisturization to skin and providing hydration etc. are the best green chemistry practices opted for natural soap production. Natural-oil based soaps have lower alkaline matter, higher TFM and skin compatible pH as compared to commercial soaps and highly recommended for cleansing of skin with no side effects.

References

- [1] D. Mijaljica, F. Spada, I.P. Harrison. (2022). Skin cleansing without or with compromise: soaps and syndets. *Molecules*. 27(6): 2010.
- [2] A. Thirunavukkarasu, R. Nithya, R. Sivashankar, A.B. Sathya, S. Rangabhashiyam, S.A. Pasupathi, M. Prakash, M. Nishanth. (2023). Green soap formulation: an insight into the optimization of preparations and antifungal action. *Biomass Conversion and Biorefinery*. 13(1): 299-310.
- [3] N. Cavalheiro, J.P. Stadler, E.D. Giusti, L.T. Chendynski, S.I.A.A. Gomes. (2024). Ecological soap production using green chemistry principles. *Acta Scientiarum. Technology*. 46(1).
- [4] A. Das, L. Deb, L. Behara, S. Bose, I. Baral, R. Basak. Making of Organic Cosmetic (Soap) using Fruit Waste.
- [5] A.R. Vaughn, A.K. Clark, R.K. Sivamani, V.Y. Shi. (2018). Natural oils for skin-barrier repair: Ancient compounds now backed by modern science. *American journal of clinical dermatology*. 19(1): 103-117.
- [6] O. Parker. (2025). Soap How. Publifye AS: pp.
- [7] N. Prieto Vidal, O. Adeseun Adigun, T.H. Pham, A. Mumtaz, C. Manful, G. Callahan, P. Stewart, D. Keough, R.H. Thomas. (2018). The effects of cold saponification on the unsaponified fatty acid composition and sensory perception of commercial natural herbal soaps. *Molecules*. 23(9): 2356.
- [8] (1995). For a recent bibliography, see: Parr, R. G.; Yang, W. *Annu. Rev. Phys. Chem.* 46: 701.
- [9] T. Sabudak, E. Ozcan. (2025). Determination of fatty acids in plant oils by gas chromatography, production and analysis of solid soap from these oils. *Bulgarian Chemical Communications*. 166.
- [10] S. Arasaretnam, K. Venujah. (2019). Preparation of soaps by using different oil and analyze their properties. *Nat Prod Chem Res*. 7(357): 2-4.
- [11] E. Kurniawati, I. Kristianingsih, A.I.H. Purwani. (2024). Comparative effect of sunflower seed oil (*helianthus annus l.*) On the characteristics and quality of liquid soap formulations. *Jurnal EduHealth*. 15(01): 267-273.
- [12] J. Pandey, S. Gaire, K. Sharma, D. Pun, A. Gyawali, G. Lamichhane, D. Budean, H.P. Devkota. (2023). Exploring the potentials of *Ziziphus mauritiana* Lam. seed kernel oil as pharmaceutical oil base: Physicochemical characterization and ketoconazole soap formulation. *Heliyon*. 9(11).
- [13] K. Betsy, M. Jilu, R. Fathima, J.T. Varkey. (2013). Determination of alkali content & total fatty matter in cleansing agents. *Asian Journal of Science and Applied Technology*. 2(1): 8-12.
- [14] C. Mwanza, K. Zombe. (2020). Comparative evaluation of some physicochemical properties on selected commercially available soaps on the Zambian market. *Open Access Library Journal*. 7(3): 1-13.
- [15] M. Gautam, P. Acharya. (2023). Physico-chemical parameterization of some commercially available toilets and laundry soaps in Tansen, Palpa. *Tribhuvan J*. 2(1): 29-40.
- [16] J.F. Nova, S.Z. Smrity, M. Hasan, M. Tariquzzaman, M.A.A. Hossain, M.T. Islam, M.R. Islam, S. Akter, M.S. Rahi, M.T.R. Joy. (2025). Comprehensive evaluation of physico-chemical, antioxidant, and antimicrobial properties in commercial soaps: A study on bar soaps and liquid hand wash. *Heliyon*. 11(4).
- [17] O.I. Oloruntele, S.O. Adeoye, B.A. Jaji, M.M. Ibrahim, M.I. Hamza. (2025). Assessment of the Physico-Chemical Characteristics, Phytochemicals, Biological Activities, and Soap-Making Process Using the Pulp and Seed Oils of Avocados (*Persea americana*). *UMYU Scientifica*. 4(1): 452-460.

- [18] L. Sukeksi, V. Diana In *Preparation and characterization of coconut oil based soap with kaolin as filler*, Journal of Physics: Conference Series, 2020; IOP Publishing: 2020; p 012046.
- [19] S.A. Mahesar, R. Chohan, S.T.H. Sherazi. (2019). Evaluation of physico-chemical properties in selected branded soaps. Pakistan Journal of Analytical & Environmental Chemistry. 20(2): 177-183.
- [20] A. Alsalhi, L. Alzamil, K. Alekrish, R. Alhaqbani, R. AlKanaan, A.M. Al-Mohaimed, N. Almohawis, H. Alsalhi, A. Al-Salhy, A. Alsalhi. (2024). Exploring pH levels and environmental impacts on handwash products in Riyadh, Saudi Arabia: A cross-sectional study. Journal of Family Medicine and Primary Care. 13(1): 230-234.
- [21] J. Tarun, J. Susan, J. Suria, V.J. Susan, S. Criton. (2014). Evaluation of pH of bathing soaps and shampoos for skin and hair care. Indian journal of dermatology. 59(5): 442-444.
- [22] M. Shaibu, F.O. Orivri. Formulation and Assessment of the Antimicrobial Properties of Herbal Soap Made with Bioactive Neem Plant *Azadirachta Indica*.
- [23] R. Kirdi, A. Sarrai, B. Said, Z. Hadri. (2024). Physicochemical and microbiological characteristics of natural antiseptic solid soaps formulated from coconut oil, palm oil, and olive oil incorporating tea tree essential oil as antibacterial agent. Journal of Applied Sciences and Environmental Management. 28(10B Supplementary): 3399-3405.
- [24] O. Atolani, E.T. Olabiyi, A.A. Issa, H.T. Azeez, E.G. Onoja, S.O. Ibrahim, M.F. Zubair, O.S. Oguntoye, G.A. Olatunji. (2016). Green synthesis and characterisation of natural antiseptic soaps from the oils of underutilised tropical seed. Sustainable Chemistry and Pharmacy. 4: 32-39.
- [25] K.V. Kumar, B.G. Angel, D. Jeevani, G. Pavithra, K.S. Kumar, K. Sowmya, M. Yashaswini, V.G. Srivalli. (2024). PREPARATION AND EVALUATION OF POLYHERBAL SOAP.
- [26] M. Nowak-Lange, K. Niedziałkowska, K. Lisowska. (2022). Cosmetic preservatives: hazardous micropollutants in need of greater attention? International Journal of Molecular Sciences. 23(22): 14495.
- [27] C.G. Daughton, T.A. Ternes. (1999). Pharmaceuticals and personal care products in the environment: agents of subtle change? Environmental health perspectives. 107(Suppl 6): 907.
- [28] O. Adigun, C. Manful, N. Prieto Vidal, A. Mumtaz, T.H. Pham, P. Stewart, M. Nadeem, D. Keough, R. Thomas. (2019). Use of natural antioxidants from newfoundland wild berries to improve the shelf life of natural herbal soaps. Antioxidants. 8(11): 536.
- [29] V.-G. Stănescu, V. Popescu, V. Vasilache, G. Popescu, C.M. Rîmbu, A. Popescu. (2025). Cleaner Processes for Making Laundry Soap from Vegetable Oils and an Essential Oil. Applied Sciences. 15(7): 3821.
- [30] Y. Fu, Q. Fu, L. Yang, Y. Bao, Q. Tian, Y. Gao, X. Liu, Q. Huang. (2024). Utilizing the above-ground extract of *Paris polyphylla* as a natural antioxidant and antimicrobial additive in soap formulation. Biomass Conversion and Biorefinery. 14(8): 9821-9838.
- [31] R. Fecker, Ş. Avram, I. Cocan, E. Alexa, L. Bora, D. Minda, I.Z. Magyari-Pavel, C.A. Dehelean, C. Danciu. (2025). In Vitro and In Ovo Evaluation of *Oenothera biennis* L. Oil as an Alternative Preservative for Oil-Based Products. Foods. 14(2): 332.
- [32] O. Atolani, N. Adamu, O. Oguntoye, M. Zubair, O. Fabiyi, R. Oyegoke, O. Adeyemi, E. Areh, D. Tarigha, L. Kambizi. (2020). Chemical characterization, antioxidant, cytotoxicity, Anti-Toxoplasma gondii and antimicrobial potentials of the Citrus sinensis seed oil for sustainable cosmeceutical production. Heliyon. 6(2).
- [33] M.R. Chirani, E. Kowsari, T. Teymourian, S. Ramakrishna. (2021). Environmental impact of increased soap consumption during COVID-19 pandemic: Biodegradable soap production and sustainable packaging. Science of the Total Environment. 796: 149013.
- [34] H. Soni, M. Kaur, M. Verma In *Recent advances in the production of soap from used cooking oil for environment remediation*, E3S Web of Conferences, 2024; EDP Sciences: 2024; p 03014.
- [35] M. Zunita, Y. Bindar, E. Restiawaty, S. Pramesti, M. Hayati. (2025). Advancing the Production of Transparent Solid Soaps with Indonesian Natural Oils. QUIMICA: Jurnal Kimia Sains dan Terapan. 7(1): 6-12.