Scientific Journal of Gdynia Maritime University

No. 136/2025, 74–88
ISSN 2657-6988 (online)
ISSN 2657-5841 (printed)
DOI: 10.26408/136.06

Submitted: 15.04.2025
Accepted: 22.10.2025
Published: 29.12.2025

SUSTAINABLE COSMETIC PRODUCTS BASED ON NATURAL PLANT OILS

Paulina Malinowska
Poznań University of Economics and Business, Institute of Quality Science, Department of Technology and Instrumental Analysis, ORCID: 0000-0002-4791-1130, e-mail: paulina.malinowska@ue.poznan.pl

Abstract: An analysis was carried out of the market choice of leave-on cosmetic care oils available on the Polish market. The study aimed to analyze market trends and evaluate the chemical composition of cosmetic oils in terms of sustainability aspects. The analysis revealed a clear trend towards the use of more sustainable plant oil-based raw materials, the development of waterless formulas, multifunctionality, and minimalism formulations. The largest group in the market offer consists of cosmetic universal (multipurpose) oils as well as hair care oils. A total of 98 natural plant oils and fats were identified in the analyzed products' composition, often used as substitutes for mineral or silicone oils, with the most popular being sunflower oil, almond oil, jojoba oil, argan oil, and soybean oil.

Keywords: sustainable ingredients, market trends, cosmetic care oils, Polish cosmetics market.

1. INTRODUCTION

1.1. Sustainable cosmetics industry

The cosmetics industry has seen significant changes in recent years, with a growing focus on sustainability, transparency, and environmental responsibility [Hazra et al. 2024].

Following the COVID-19 pandemic, the beauty and personal care sectors have been increasingly driven by several key priorities: enhancing the skin barrier, boosting immunity and anti-inflammatory benefits, implementing responsible and sustainable manufacturing practices, favoring local supply chains, promoting upcycled solutions between the cosmetics and food industries, and choosing ingredients that support sustainability and biodiversity. In addition, there is a strong emphasis on social and cultural inclusivity, digital commerce, and products linked to overall health and well-being [Goyal and Jerold 2021; Jaswal 2022; Jiang 2023].

Sustainable development presents a complex challenge, requiring continuous and coordinated changes in political, economic, and technological approaches to address environmental, economic, and social issues [Cosmetics Europe 2017; Sukiennik, Dokurno and Fiedor 2017; Ejdys and Szpilko 2022]. In this context, Cosmetics Europe, through its *Commit for Our Planet* initiative, encourages all industry players – from small businesses to large corporations – to collaborate in reducing greenhouse gas emissions, enhancing packaging solutions, and protecting nature [https://commitforourplanet.cosmeticseurope.eu/].

The European cosmetics industry is adopting various sustainability strategies to tackle environmental challenges, including the use of biodegradable ingredients, integration of thermal renewable energy, emission reporting, and sustainable procurement guidelines for non-renewable resources [Sahota 2014; European Chemicals Agency 2022].

In the modern beauty industry, consumer demand is driving manufacturers to adopt sustainable production practices, promoting a more holistic approach that aligns with the life cycle principles of cosmetic products. This shift in perspective has fostered the growth of environmentally friendly, sustainable cosmetics [Hazra et al. 2024].

Consumers are increasingly aware of ecological issues, influencing their preference for a diverse selection of eco-friendly beauty products [Witek, Kędzia and Staniec 2024]. Haller, Lee and Cheung [2020] report that 57% of consumers are open to modifying their purchasing habits to help to reduce the negative environmental impact of their choices. Additionally, 80% stated that sustainability is a key factor for them and that they are prepared to spend more on eco-friendly and sustainable brands. Furthermore, consumers prioritize buying high-quality, safe products that positively affect the environment, as well as human and animal well-being [Witek, Kędzia and Staniec 2024].

To meet these expectations, the industry is shifting towards more sustainable practices. Green cosmetics are carefully developed using natural and environmentally safe ingredients. Sustainable production emphasizes ethical sourcing, cruelty-free processes, and eco-conscious packaging and distribution. The sustainable strategies used in cosmetics industry are [Sasounian et al. 2024]:

- natural ingredients (extracted from plants, animals, microorganism or minerals);
- organic ingredients (obtained from organic agriculture);
- vegan ingredients (not derived or tested on animals);
- clean beauty (awareness of sustainable safety of ingredients);
- green beauty (balance among body beauty, well-being and sustainable practices);
- minimalist formulations;
- multifunctional formulations.

1.2. Sustainable raw materials in leave-on cosmetic care oils

The entire cosmetics supply chain, from the initial sourcing of raw materials through to consumer use and disposal can have an impact on sustainability. A raw material is deemed sustainable only if it possesses environmentally favorable characteristics while also fulfilling ethical, social, and economic responsibilities. To ensure sustainability, five key aspects should be evaluated when selecting raw materials [Bom et al. 2019; Bom, Ribeiro and Marto 2020b]:

- the ingredient's biodegradability and bio-based composition;
- the material's origin and sourcing, along with the methods used for its synthesis, extraction, or purification;
- the fact that a natural, green, or organic ingredient is not inherently sustainable;
- the possibility of a synthetic raw material being considered sustainable when compared to alternatives on the market.

Growing environmental concerns regarding cosmetic ingredients are fueling an increasing demand for sustainable alternatives. Certain ingredients can have harmful effects on the environment, especially on aquatic ecosystems, prompting a worldwide shift toward eco-friendly products. This trend has led to a preference for renewable formulations, ideally composed entirely of naturally derived ingredients [Sasounian et al. 2024].

The ingredients fulfil several functions in a cosmetic formulation and how they affect the safety, efficiency, sensorial attributes, functional properties and physicochemical stability of the finished products. Combining all these features in the development of a sustainable cosmetic is not easy. Synthetic ingredients are developed to overcome the specific limitations of natural ingredients, which often involve numerous chemical processes, such as synthesis, extraction, and purification. Moreover, incorporating natural ingredients – those obtained directly from nature and used in their unaltered state – into formulations can present challenges, including instability and aesthetic drawbacks [Bom et al. 2020].

One of the categories of cosmetic products that require replacing conventional, but often unsustainable ingredients, is care oils. The essential raw materials in this category are emollients. They prevent water loss, give the formulations their sensorial properties, such as feeling and visual characteristics, and determine their consistency. Emollients provide excellent spreadability and contribute to a soft and pleasant after-feel. Emollients come from various petrochemical and bio-based sources, with silicone oils, hydrocarbons, and esters being the most common. While silicones offer outstanding physicochemical and sensory properties, their high chemical stability leads to poor biodegradability and a significant risk of bioaccumulation. With growing consumer awareness of environmental concerns, there is an increasing demand for more eco-friendly alternatives, pushing the cosmetics industry to develop bio-based substitutes for silicone oils [Goussard, Aubry and Nardello-Rataj 2022]. The most common emollients are classified in

4 different groups, according to their molecular structure: hydrocarbons, fat alcohols, esters, and silicone oils.

Sustainability challenges concerning these raw materials and their possible sustainable alternatives are presented in Table 1.

Table 1. Emollients – sustainability challenges and possible sustainable alternatives

Type	Example	Source	Sustainability concerns	Possible sustainable alternatives
Hydrocarbon-based	Petrolatum, mineral oil	Synthetic, naturally derived (mineral)	Petrochemical origin	Vegetable oils; squalanes obtained from byproducts of the olive oil industry or produced by microbial fermentation of renewable materials
	Squalane	Naturally derived from squalene (animal or plant-based)	Animal exploitation or deforestation	
Fatty alcohols	Cetyl alcohol, octyldodecanol	Natural (animal or plant-based) or synthetic	Animal exploitation, deforestation, use of heavy metals catalysts in chemical reactions	Fatty alcohols derived from sustainably sourced plants. Use of clay instead of heavy metals as a catalyst in chemical reactions to produce fatty alcohols
Ester-based	Isopropyl myristate (monoester), caprylic/capric triglyceride	Synthetic or naturally derived from animal or plant sources	Animal exploitation, deforestation	Use of biocatalytic processes instead of chemical production
	Olive oil	Natural (plant based)	Decreased production for food industry	Use of microbial cell factories to produce esters by fermentation of sustainable sources of sugars
Silicones and derivatives	Linear and cyclic silicones and derivatives	Synthetic, naturally derived from mineral (silicon)	Bioaccumulative, harmful to ecosystems and to human health	Polysaccharides of animal, plant or microbial origin; plant-derived nonpolar alkanes; products derived from green chemistry

Source: [Bom et. al 2019].

The most widely used emollients in the cosmetics industry are hydrocarbon-based and ester-based compounds, fatty alcohols, and silicones. Hydrocarbon-based emollients have occlusive properties, hydration power, resistance to oxidation and long shelf-life. Ester-based compounds are also used as emollients, actives, and emulsifiers, and they are very important for the stability, sensory properties and other

aspects of formulated cosmetics. Fatty alcohols stabilize the formulations, provide consistency, may interact with emulsifiers and provide both emolliency and moisturization. Silicones and their derivatives are chemically inert, resistant to oxidation and humidity, and are easily spreadable, forming water-resistant but permeable films [Douguet et al. 2017; Chao et al. 2018; Duprat-de-Paule et al. 2018; Martins and Marto 2023].

The sustainability problems of the above-mentioned emollients concern mainly petrochemical origin, animal exploitation, deforestation, use of heavy metal catalysts in chemical reactions, decreased production for the food industry, bioaccumulative, and harmful to ecosystems and to human health [Martins and Marto 2023].

Various studies have outlined diverse strategies for achieving sustainability, including the utilization of locally sourced, low-cost natural ingredients, the development of new or enhanced raw materials through green chemistry, and the repurposing of industry by-products and waste [Carriço, Ribeiro and Marto 2018; Costa, de Alves and Maia Campos 2019; Fresneda et al. 2019]. A key challenge in substituting synthetic ingredients with sustainable alternatives in topical formulations is maintaining the high-quality standards typically linked to conventional products, as consumers expect the same level of performance and effectiveness.

From a technical perspective, replacing high-performing synthetic raw materials with natural, sustainable ingredients can be difficult due to issues, such as instability and aesthetic limitations commonly associated with their use [Saraf 2012; Sahota 2014]. In cosmetic care oils, natural oils, butters, fats, or waxes, are ingredients to be considered for the replacement of synthetic emollients [Bom et al. 2019]. The use of this type of ingredient may have several disadvantages, such as the occurrence of crystallization when using natural triglycerides, oxidation with unsaturated compounds, the development of undesirable colors or odors, and incompatibilities between natural and synthetic ingredients that can affect the stability of the formulations [Garrison and Dayan 2011].

The study aimed to analyze market trends and evaluate the chemical composition of leave-on cosmetic care oils available on the Polish market in terms of sustainability aspects.

2. MATERIAL AND METHODS

The analysis of market offer of leave-on cosmetic care oils available on the Polish market in the first quarter of 2025 was conducted. A total of 514 leave-on cosmetic products were reviewed, sold in online drugstores Rossmann and Hebe, including face care, lip care, hand and nail care, hair care oils, as well as universal (multipurpose) and beauty (firming, anticellulite, anti-stretch marks) oils, and baby care oils. The products available in Rossmann and Hebe drugstores were chosen

for analysis, as Rossmann is the leading player in the Polish cosmetics market, and, together with Hebe, they represent the two largest and most popular drugstore chains in Poland [https://fashionbiznes.pl/najpopularniejsze-drogerie-w-polsce-2024-ranking/].

The analysis proceeded in four stages:

Stage 1: Reviewing the market offer of cosmetic care oils available on the Polish market.

Two criteria were used for selecting products for analysis. The first criterion was the product name – all cosmetics containing the word "oil" in their name and belonging to the aforementioned categories were analyzed. The second criterion was the chemical composition – cosmetics that used emollient, hydrophobic, and oily ingredients as a base were analyzed. Therefore, products with the words "serum", "elixir" and "concentrate" in their commercial names were also included in the analysis.

Stage 2: Division of all cosmetic care oils into 7 categories: face care oils, lip care oils, hand and nail care oils, hair care oils, universal (multipurpose) oils, beauty (firming, anticellulite, anti-stretch marks) oils, and baby care oils.

Stage 3: Carrying out a detailed analysis of the trends and the chemical composition of the products.

The most important active ingredients (natural oils) were identified based on their Latin and English names present in the INCI (International Nomenclature of Cosmetic Ingredients) composition indicated on the labels. The data collected from the INCI compositions of products is a kind of qualitative analysis without numerical measure, such as concentration or dose of the ingredient.

Stage 4: Analysis of the pricing strategy of cosmetic care oils in relation to their packaging volume on the Polish market: the packaging volume range, the average packaging volume, the most common volume, the oil price range, the average oil price, the cheapest oil (brand) and the most expensive oil (brand).

The collected data were processed using Microsoft Excel.

3. RESULTS AND DISSCUSION

3.1. The categories of cosmetic care oils available on the Polish market

The analysed leave-on cosmetic care oils were classified into 7 categories, according to their purpose (Fig. 1):

- face care oils (85 products);
- lip care oils (99 products);
- universal (multipurpose) oils (116 products);
- beauty (firming, anti-stretch marks and anti-cellulite care oils) oils (37 products);
- hair care oils (109 products);

- hand and nail care oils (44 products);
- baby care oils (24 products);

and into 4 categories according to their commercial names (Fig. 2):

- oils (476 products);
- serums (34 products);
- elixirs (3 products);
- concentrates (1 product).

The largest category of cosmetic care oils are universal (multipurpose) oils (22.6%), intended for face, body and hair care. They occur always with "oil" as a commercial name. The second largest category is hair care oils (21.2%), occurring with "oil", "serum" and "elixir" as commercial names. Only in the face care category do all commercial names appear: "oil", "serum", "elixir" and "concentrate", then in the lip care category were "oil" and "serum". In other categories, producers use the commercial name "oil".

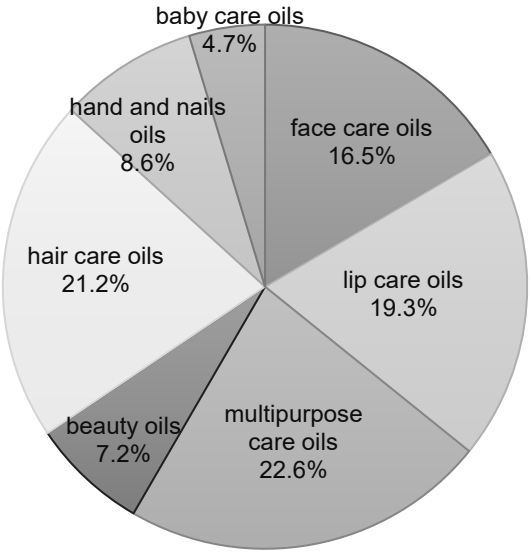

Fig. 1. Division of cosmetic care oils according to their purpose

Source: own study.

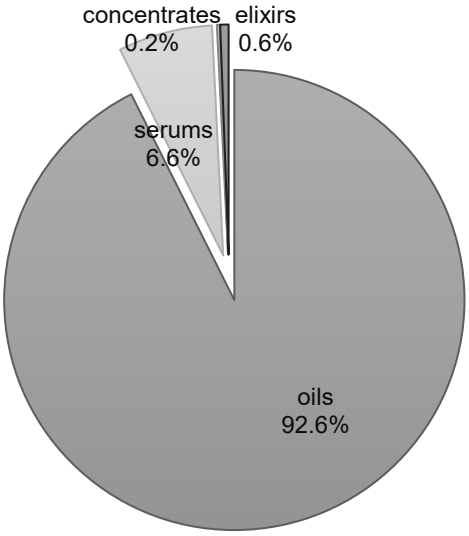

Fig. 2. Division of cosmetic care oils according to their commercial names

Source: own study.

3.2. The market trends in terms of sustainability on category of cosmetic care oils

The analysis revealed a clear trend towards:

1) the replacement of non-biodegradable ingredients, like silicones, paraffin oil, hydrogenated polydecene, polyisobutene or polybutene, with more sustainable plant oil-based raw materials:
   - usage mainly of plant oils and fats as well as the ingredients of natural origin like caprylic/capric triglyceride, squalene, squalane, coco-caprylate/caprate, ethylhexyl palmitate, dicaprylyl ether,
   - usage of biodegradable ingredients of natural origin mainly in formulas of face care oils, multipurpose care oils, beauty oils and baby care oils,
   - still usage of non-biodegradable ingredients in the vast majority of products for lip car oils, hair care oils and hand and nails care oils,
   - the usage in formulations of natural oils with varying degrees of sustainability;
2) the development of waterless formulas:
   - most skincare oils do not contain water or contain only trace amounts of it;
3) multifunctionality:
   - formulations based on natural oils can be intended for the care of the face, body, and hair, as well as for different skin types and skin concerns;

4) minimalism formulations:
   – short list of ingredients in many care oil formulations,
   – only essential ingredients included in care oil formulations.

3.3. The natural plant oils and their sustainability aspects in terms of cosmetic care oils

In the analysis of the chemical composition of cosmetic care oils, particular attention was paid to natural plant oils and fat (with varying degrees of sustainability) that are the most common active ingredients and have a fundamental influence on the caring properties of the cosmetic care oils. A total of 98 plant oils and fats were identified in the products, with the content of plant oils in the analyzed products ranging from one to several. The analysis focused on the ten plant oils with the highest usage frequency in the analyzed products. The usage frequency for each plant oil was determined by the sum of the number of products containing that specific oil, ranked in descending order. The most popular plant oils turned out to be sunflower oil, almond oil (both present mainly in multipurpose care oils), jojoba oil (present mainly in lip care oils) and argan oil (present mainly in hair care oils) (Tab. 2). Less popular plant oils, present in at least 4% of the analyzed products, were coconut oil, olive oil, sesame oil, hemp oil, rosehip oil, rice oil, safflower oil, wheat oil, linseed oil and raspberry oil.

Table 2. Top 10 natural oils included in the composition of leave-on cosmetic care oils[1]

Natural oil	Face care oils (n = 85)	Lip care oils (n = 99)	Multi-purpose care oils[2] (n = 116)	Beauty oils[3] (n = 37)	Hair care oils (n = 109)	Hand and nail care oils (n = 44)	Baby care oils (n = 24)	Total (n = 514)
Helianthus annuus (sunflower) seed oil	35 (41.2%)	29 (29.3%)	59 (50.9%)	21 (56.8%)	37 (33.9%)	15 (34.%)	13 (54.2%)	209 (40.7%)
Prunus amygdalus (almond) dulcis oil	18 (21.2%)	16 (16.2%)	61 (52.6%)	18 (48.6%)	19 (17.4%)	22 (50.0%)	13 (54.2%)	167 (32.5%)
Simmondsia chinensis (jojoba) seed oil	29 (34.1%)	39 (39.4%)	28 (24.1%)	11 (29.7%)	17 (15.6%)	8 (18.2%)	6 (25.0%)	138 (26.8%)
Argania spinosa (argan) kernel oil	23 (27.1%)	16 (16.2%)	26 (22.4%)	5 (13.5%)	41 (37.6%)	11 (25.0%)	1 (4.2%)	123 (23.9%)
Glycine soja (soybean) oil	10 (11.8%)	11 (11.1%)	13 (11.2%)	10 (27.0%)	12 (11.0%)	11 (25.0%)	5 (20.8%)	72 (14.0%)
Vitis vinifera (grape) seed oil	15 (17.6%)	12 (12.1%)	23 (19.8%)	4 (10.8%)	8 (7.3%)	2 (4.5%)	1 4.2%)	65 (12.6%)
Ricinus communis (castor) seed oil	3 (3.5%)	26 (26.3%)	6 (5.2%)	1 (2.7%)	9 (8.3%)	16 (36.4%)	1 (4.2%)	62 (12.1%)

cont. Table 2

Persea gratissima (avocado) oil	11 (12.9%)	3 (3.0%)	17 (14.7%)	10 (27.0%)	11 (10.1%)	7 (15.9%)	2 (8.3%)	61 (11.9%)
Macadamia ternifolia (macadamia) seed oil	8 (9.4%)	11 (11.1%)	12 (10.3%)	5 (13.5%)	17 (15.6%)	4 (9.1%)	0 (0%)	57 (11.1%)
Prunus armeniaca (apricot) kernel oil	17 (20.0%)	6 (6.1%)	8 (6.9%)	2 (5.4%)	8 (7.3%)	2 (4.5%)	4 (16.7%)	47 (9.1%)

[1] number of products (percentage of the products) containing (according to producers' declarations) in the plant oil per total 514 analysed and per category of product,
[2] body, face and hair care oils; [3]firming, anti-stretch marks and anti-cellulite care oils.

Source: own study.

There are also many natural, exotic oils which are used only in one or two analyzed products as: vaccinium vitis-idea (lingonberry) seed oil, trigonella foenum-graecum (fenugreek) seed oil, silybum marianum (milk thistle) seed oil, psoralea corylifolie (babchi) seed oil, pongamia glabra (karanja) seed oil, pistacia vera (pistachio) seed oil, phyllanthus emblica (amla) oil, perilla frutescens (perilla) seed oil, pentaclethra macrolaba (pracaxi) seed oil, papava orientala (oriental poppy) oil, melia azachrachta (chinaberry) seed oil, magnifera indica (mango) seed oil, lycium barbarum (goji berry) seed oil, luffa cylindrica (luffa/sponge gourd) seed oil, gevuina avellana (Chilean hazel) seed oil, canola oil, brassica napus (rapeseed) seed oil, brassica juncea (mustard) seed oil and bertholletia excelsa (Brazil nut) seed oil. It was found that in most cases used in care oils active ingredients are precisely selected and correspond to the actual needs of the target group of users for whom these products are designed.

Table 3 presents the advantages and disadvantages related to the sustainability aspects of the 10 most popular plant oils. It is important to emphasize that natural plant oils are not always 100% sustainable raw materials, and their assessment is not always straightforward. The degree of sustainability of plant oils depends on:

- origin of the raw material;
- method of production;
- evaluation of their environmental and social impact.

It can vary depending on agricultural practices, local regulations, and innovations in production. Attention is drawn to certifications and standards, which can influence the sustainability assessment of a particular oil. Sustainable oils are derived from raw materials grown organically, without excessive use of pesticides and chemical fertilizers, and without contributing to deforestation, peatland drainage, or habitat destruction. Ideally, they come from local production, perennial crops, or low-emission sources, which reduces their carbon footprint. Such plant oils often carry certifications for sustainable agriculture (RSPO), organic (BIO), or Fair Trade. Vegetable oils are not considered sustainable if their production contributes to environmental degradation, biodiversity loss, excessive water use, or a significant increase in carbon footprint. Cosmetic manufacturers rarely include information

about the sustainability of vegetable oils on product labels. Considering the listed advantages and disadvantages of plant oils, it can be concluded that the most sustainable oils seems to be grapeseed oil and jojoba oil, while the least sustainable are almond, soybean and avocado oils. An average degree of sustainability is observed for sunflower oil, argan oil, castor oil, macadamia oil, and apricot oil.

Table 3. Sustainability aspects of the 10 most common natural oils

Natural oil	Advantages	Disadvantages
Helianthus annuus (sunflower) seed oil	Grown in Europe, moderate water use in favorable conditions	Often cultivated as a monoculture, water footprint varies by region
Prunus amygdalus (almond) dulcis oil	High quality, rich in nutrients	Very high water use
Simmondsia chinensis (jojoba) seed oil	Drought-tolerant plant, low water demand, long shelf life	Limited availability, often imported
Argania spinosa (argan) kernel oil	Traditional cultivation in Morocco, supports local communities	Limited supply, sensitive to market demand and overharvesting
Glycine soja (soybean) oil	Widely available, inexpensive, high production efficiency	Linked to deforestation (especially in South America), often genetically modified (GMO), pesticide-intensive
Vitis vinifera (grape) seed oil	Derived from wine industry waste (grape seeds), minimizes waste	May require long-distance transport, the extraction process can be energy intensive, depending on local wine production
Ricinus communis (castor) seed oil	Low water requirements, beneficial properties	Mainly grown in India – long transport, sometimes poor environmental regulation
Persea gratissima (avocado) oil	Nutrient-rich	Very high water demand, deforestation (e.g. in Mexico), pressure on local communities
Macadamia ternifolia (macadamia) seed oil	High quality, long-living trees	Long-distance transport (e.g. Australia, Africa), fertilizer use
Prunus armeniaca (apricot) kernel oil	Made from pits – a byproduct of fruit processing	Limited local availability, region-dependent production

Source: own study based on: [https://www.fao.org/publications/en, https://www.undp.org/, https://www.worldwildlife.org/, https://hassavocadoboard.com/, https://australianmacadamias.org/industry].

3.4. The market prices and packaging volumes of cosmetic care oils

Pricing strategies play a crucial role in determining profitability. Even small adjustments in pricing can significantly influence both the gross margins and sales volumes. Setting the price too low for a premium product may lead customers to question its quality. On the other hand, pricing value-oriented products too high can drive consumers toward more affordable alternatives offered by the competitors.

The prices and packaging volume of the analyzed cosmetic care oils were taken under consideration during analysis. The results are presented in Table 4.

With the aim of conducting of pricing analysis, the unit of measurement was average price (in PLN) per 100 ml. The market prices of the most popular raw materials – natural oils – are varied. The cheapest oils, such as sunflower or soybean oil, can be several times less expensive than almond, argan, grapeseed, or apricot oil. Despite these differences, no correlation was found between the market prices of the analyzed products and the presence of specific oils in their formulations. Both cheaper and more expensive products may contain either low-cost or high-cost raw materials. No correlation also was found between the market prices of the analyzed products and the degrees of sustainability of used plant oils in their formulations. Both cheaper and more expensive cosmetic care oils may contain more sustainable and less sustainable plant oils.

The average market prices of cosmetic care oils are highest in the category of face care oils, while the lowest prices are observed in the category of hand and nail care oils. The average prices for multipurpose oils, beauty oils, and hair care oils are at a similar level.

Table 4. Market prices and volumes of cosmetic care oils

Feature	Face care oils (n = 85)	Lip care oils (n = 99)	Multi-purpose care oils[1] (n = 116)	Beauty oils[2] (n = 37)	Hair care oils (n = 109)	Hand and nails care oils (n = 44)	Baby care Oils (n = 24)
Packaging volume range (ml)	7.5–100.0	1.0–168.0	10.0–5000.0	30.0–250.0	7.0–250.0	2.0–15.0	30.0–300.0
Average packaging volume (ml)	32	11	254	128	76	10	158
Most common volume	30 ml (63.5%)	5 ml (13.1%)	100 ml (41.4%)	100 ml (40.5%)	100 ml (36.8%)	15 ml 10 ml (45.5%)	200 ml (25.0%)
Oil price range (PLN/100 ml)	30.0–2666.7	17.26–4499.0	4.53–609.7	6.4–255.0	15.33–699.9	53.3–2545.0	4.01–220.0
Average oil price (PLN) regardless of volume	82.5	30.3	65.2	61.8	65.0	22.2	39.2
Cheapest oil (brand)	Arganove Castor Oil	Alterra Lip Oil	Isana Body Oil	Babydream Mamas Anti-stretch mark Oil	Bioelixire Hair Oil	Nacomi Cuticle Oil	Ziajka Baby Oil
Most expensive oil (brand)	Elemis Pro-Collagen Marine Oil	Affect Divine Lip Oil	Beautiona Massage Oil	Elemis Cellutox Anti-cellulite Oil	Kérastase Chronologiste Hair Oil	Londontown Cuticle and Nail Oil	Little Butterfly London Baby Oil

[1] body, face and hair care oils,
[2] firming, anti-stretch marks and anti-cellulite care oils.

Source: own study.

A similar variation applies to the packaging volumes of cosmetic oils. The smallest packaging volumes are found in lip care oils, hand and nail care oils, and face care oils. Multipurpose oils are available in the largest packaging volumes, and this category also shows the widest range of available sizes. The most commonly available packaging volume of oils on the market is 100 ml.

4. CONCLUSIONS

No raw materials, packaging components, or production methods can be deemed as entirely sustainable. Nevertheless, with well-thought-out strategies, it is possible to significantly minimize the environmental footprint of cosmetic products. As awareness around sustainability grows, it becomes increasingly important to carefully evaluate raw materials through several key factors: how biodegradable they are, whether they are bio-based, their origin, and the processes used to extract, synthesize, or purify them. A common misconception persists that all synthetic ingredients are inherently harmful to the environment while all naturally derived substances are sustainable – which is not always the case. Moreover, sustainability should be viewed holistically. It extends beyond environmental concerns to also include economic and social dimensions [Bom at el. 2020b]. The example of plant oils, discussed in this context, illustrates this broader perspective. While there have been notable improvements toward more sustainable production practices, selecting ingredients that fully meet sustainability criteria remains a complex task during formulation development.

The analysis revealed that the manufacturers are aiming to replace non-biodegradable ingredients into the ingredients of natural origin and biodegradable ones with varying degrees of sustainability. They develop waterless, multifunctional formulas with a short list, of only essential ingredients. It is evident that implementing all changes at once is unfeasible, and the continuous regulatory developments regarding ingredients and packaging only add to the complexity. For this reason, conducting a similar analysis in several years is warranted, as it will allow for an evaluation of how manufacturers are responding to all changes and whether they are able to keep up with them.

REFERENCES

Bom, S., Fitas, M., Martins, A.M, Pinto, P., Ribeiro, H.M., Marto, J., 2020, *Replacing Synthetic Ingredients by Sustainable Natural Alternatives: A Case Study Using Topical O/W Emulsions*, Molecules, vol. 25.

Bom, S., Jorge, J., Ribeiro, H.M., Marto, J., 2019, *A Step Forward on Sustainability in the Cosmetics Industry: A Review*, Journal of Cleaner Production, vol. 225, pp. 270–290.

Bom, S., Ribeiro, H.M., Marto, J., 2020, *Sustainability Calculator: A Tool to Assess Sustainability in Cosmetic Products*, Sustainability, vol. 12.

Carriço, C., Ribeiro, H.M., Marto, J., 2018, *Converting Cork By-Products to Ecofriendly Cork Bioactive Ingredients: Novel Pharmaceutical and Cosmetics Applications*, Industrial Crops and Products, vol. 125, pp. 72–84.

Chao, C., Génot, C., Rodriguez, C., Magniez, H., Lacourt, S., Fievez, A., Len, Ch., Pezron, I., Luart, D., van Hecke, E., 2018, *Emollients for Cosmetic Formulations: Towards Relationships between Physicochemical Properties and Sensory Perceptions*, Colloids and Surfaces A: Physical and Engineering Aspects, vol. 536, pp. 156–164.

Cosmetics Europe, 2017, *Socio-economic Development and Environmental Sustainability: the European Cosmetics Industry's Contribution*, https://cosmeticseurope.eu/files/-8614/9738/2777/CE_Socio-_development_and_environmental_sustainability_report_2017.pdf (access: 01.03.2025).

Costa, G.M.D., de Alves, G.A.D., Maia Campos, P.M.B.G., 2019, *Application of Design of Experiments in the Development of Cosmetic Formulation Based on Natural Ingredients,* International Journal of Phytocosmetics and Natural Ingredients, vol. 6, no. 4.

Douguet, M., Picard, C., Savary, G., Merlaud, F., Loubat-Bouleuc, N., Grisel, M., 2017, *Spreading Properties of Cosmetic Emollients: Use of Synthetic Skin Surface to Elucidate Structural Effect*, Colloids and Surfaces. B Biointerfaces, vol. 154, pp. 307–314.

Duprat-de-Paule, S., Guilbot, J., Roso, A., Cambos, S., Pierre, A., 2018, *Augmented Bio-Based Lipids for Cosmetics*, OCL, vol. 25, no. 5.

Ejdys, J., Szpilko, D., 2022, *European Green Deal – Research Directions. A Systematic Literature Review*, Economics and Environment, vol. 81, no. 2, pp. 8–38.

European Chemicals Agency (ECHA), 2022, *Microplastics*, https://echa.europa.eu/hot-topics/microplastics (access: 01.03.2025).

Fresneda, M., Trujillo-Cayado, L.A., García, M.C., Alfaro-Rodriguez, M.C., Muñoz, J., 2019, *Production of More Sustainable Emulsions Formulated with Eco-Friendly Materials*, Journal of Cleaner Production, vol. 243, no. 6.

Garrison, M., Dayan, N., 2011, *Formulating Cosmetics with Natural Oils, Fats, Butters, and Waxes*, [in:] Dayan, N., Kromidas, L. (eds.) *Formulating, Packaging, and Marketing of Natural Cosmetic Products*, John Wiley & Sons, Inc., Hoboken, NJ, USA, pp. 213–238.

Goyal, N., Jerold, F., 2021, *Biocosmetics: Technological Advances and Future Outlook*, Environmental Science and Pollution Research, vol. 30, pp. 25 148–25 169.

Goussard, V., Aubry, J.-M., Nardello-Rataj, V., 2022, *Bio-Based Alternatives to Volatile Silicones: Relationships between Chemical Structure, Physicochemical Properties and Functional Performances*, Advanced in Colloid and Interface Science, vol. 304.

Haller, K., Lee, J., Cheung, J., 2020, *Meet the 2020 Consumers Driving Change,* https://nrf.com/research/meet-2020-consumers-driving-change (access: 08.04.2025).

Hazra, S., Chatterjee, S., Majumdar, R., Banerjee, K., 2024, *The Role of Social Media in Promoting Sustainable Green Cosmetics*, International Journal of Research Management, vol. 6, no. 1, pp. 126–130.

https://australianmacadamias.org/industry (access: 12.04.2025).

https://commitforourplanet.cosmeticseurope.eu/ (access: 30.03.2025).

https://fashionbiznes.pl/najpopularniejsze-drogerie-w-polsce-2024-ranking/.

https://hassavocadoboard.com/ (access: 12.04.2025).

https://www.fao.org/publications/en (access: 12.04.2025).

https://www.undp.org/ (access: 12.04.2025).

https://www.worldwildlife.org/ (access: 12.04.2025).

Jaswal, A., 2022, *Effect of Augmented Reality on Online Beauty Accessory Purchase during Covid-19 Pandemic: A Study of L'oréal Paris Makeup Genius*, Academy of Marketing Studies Journal, vol. 26(S2), pp. 1–10.

Jiang, Y., 2023, *The Impact of Covid-19 on the Cosmetics Industry*, Advances in Economics, Management and Political Sciences, vol. 11, no. 1, pp. 277–283.

Martins, A.M, Marto, J.M., 2023, *A Sustainable Life Cycle for Cosmetics: From Design and Development to Post-Use Phase*, Sustainable Chemistry and Pharmacy, vol. 35, pp. 1–28.

Sahota, A., 2014, *Sustainability: How the Cosmetics Industry is Greening up*, John Wiley & Sons, http:// onlinelibrary.wiley.com/book/10.1002/9781118676516 (access: 06.04.2025).

Saraf, S., 2012, *Formulating Moisturizers Using Natural Raw Materials*, [in:] Lodén, M., Maibach, H.I. (eds.) *Treatment of Dry Skin Syndrome: The Art and Science of Moisturizers*, Springer, Berlin/Heidelberg, Germany, pp. 379–397.

Sasounian, R., Martinez, R.M., Lopes, A.M., Giarolla, J., Rosado, C., Magalhães, W.V., Velasco, M.V.R., Baby, A.R., 2024, *Innovative Approaches to an Eco-Friendly Cosmetic Industry: A Review of Sustainable Ingredients*, Clean Technology, vol. 6, no.1, pp. 176–198.

Sukiennik, J., Dokurno, Z., Fiedor, B., 2017, *System instytucjonalnej równowagi a proces zmian instytucjonalnych z perspektywy zrównoważonego rozwoju*, Ekonomista, no. 2, pp. 121–143.

Witek, L., Kędzia, G., Staniec, I., 2024, *Towards Sustainable Purchase: The Effect of Social Responsibility, Innovativeness and Knowledge of Natural Cosmetics Purchasing Consumers' Intentions*, Economics and Environment, vol. 87, no. 4, pp. 1–28.