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The Role of Flexibility in the Development and Adoption of Green Cosmetics: A Systematic Review and Future Research Agenda

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Abstract
The potential to revolutionize the beauty industry is increasingly acknowledged in the burgeoning field of green cosmetics, emphasizing environmental sustainability and natural ingredients. This paper investigates the idea of flexibility in green cosmetics, emphasizing how flexible formulations and practices may improve sustainability. After conducting a thorough literature search from 2003 to 2023 and analyzing current trends, many domains were identified in which flexibility was crucial. These consist of flexible formulating techniques, flexible procurement of ingredients, and creative packaging ideas. The study emphasizes that flexible methods in consumer behavior, green chemistry, and regulatory frameworks are necessary to overcome the difficulties associated with integrating sustainable practices. We also examine how adaptive impact evaluations and collaborative research methods promote innovation and enhance product performance. By examining the relationship between sustainability and flexibility, this study offers a path forward for advancing eco-friendly cosmetics, highlighting the significance of flexibility in fulfilling changing consumer needs and environmental objectives.

Keywords: Green cosmetics, flexibility, sustainability, systematic literature review, bibliometric analysis.
JEL Code: H51, H52, and H53, and H75

INTRODUCTION

Recently, the organization's success has depended on how quickly, efficiently, and effectively it adapts to changes in the business environment. To establish new competitive advantages, organizations must shift their emphasis towards flexibility. Flexibility allows an organization to introduce new products effortlessly, provide a wide range of products, or respond to consumer orders more rapidly (Kodali & Anand, 2010). The growing consumer demand for sustainable and eco-friendly goods is causing significant changes in the cosmetics sector (Agyeman, 2014). Green cosmetics are a substantial step in reducing the environmental impact of cosmetics since they emphasize natural components and sustainable production methods. Over the past 20 years, this developing sector has gained traction, reflecting a more significant cultural movement towards sustainability and eco-consciousness. One increasingly important component in the development of green cosmetics is flexibility. Green cosmetics demand a dynamic approach to formulation, ingredient sourcing, and production, in contrast to traditional formulations, which frequently rely on strict ingredient lists and standardized methods (Bom et al., 2019). Achieving sustainability in cosmetic goods requires innovation and adaptation to changing customer demands and environmental conditions. This study examines the function of flexibility in the green cosmetics sector and how flexible emphasis and approaches support the expansion and flexible effectiveness of the industry. This research clarifies the connection between flexible practices and the more general goals of such cosmetics, such as lessening environmental effects and enhancing product performance, by examining research from 2003 to 2023. We determine how creative packaging ideas, flexible formulation strategies, and flexible ingredient procurement might improve sustainability and solve industrial problems. The study of flexibility in eco-friendly cosmetics sheds light on recent developments. It suggests avenues for future investment that how flexibility and sustainability goals are connected will help people develop better and more flexible solutions, which will ultimately help green cosmetics keep getting better. The study's objective is detailed; this paper mainly follows this research objective: (1) To define flexibility in the green cosmetic industry; (2) To develop a research profile of the author, journal, and country of publication (3) to identify the most commonly most used theories and research methodology (4) To find out the gap and discuss the future direction. The rest of the organization Section 2 is the literature review of green cosmetics & flexibility in green cosmetics. Section 3 includes the research

methodology. 4 shows the bibliometric analysis of the papers. Network analysis is shown in Section 5. Section 6, discussion, and 7, conclusion. 8 shows the future scope.

LITERATURE REVIEW

The United States Food and Drug Administration (USFDA) defines cosmetics as artificially intended to be poured, rubbed, sprayed, sprinkled, or applied to the human body to maintain skin, cleaning, beautifying, and attractive appearances (USFDA, 2002). According to European Regulation No. 1223/2009, a cosmetic product is defined as any substance or mixture that is meant to come into contact with the external parts of the human body (such as the skin, hair, nails, lips, and external genital organs), or with the teeth and mucous membranes of the mouth. The purpose of these products is primarily to clean, perfume, alter their appearance, protect, maintain their condition, or correct body odors. To preserve competitiveness, flexibility should be integrated into the industry culture even though the term has been interpreted differently in various contexts (Singh et al., 2021). The term “flexibility” in green cosmetics applies to different considerations such as “adaptability,” “workability,” or “expandability.” Indeed, such terms refer to ingredient sourcing, technology, product development, packaging, marketing, regulatory compliance, and consumer engagement (Alğin Yapar, 2017; Bozza et al., 2022; Tilikidou & Delistavrou, 2023). Regarding the cosmetics industry, flexibility is essential because numerous categories of chemicals are used in cosmetics manufacturing. The cosmetics industry contains various chemically based products that should be replaced with organically produced raw materials. There are different types of chemicals that are used in cosmetics; the manufacturer should adapt the flexibility in their raw materials at production time, which can easily replace such chemicals as TPP, petroleum, PPB, phthalates, avobenzone, mercury, tretinoin, and hydroquinone, enzymes, "gentle" acids like salicylic acid, and beta-hydroxy acid, and lactic and glycolic acids exfoliate, which are harmful cosmetic ingredients (Tilikidou & Delistavrou, 2023; Patak et al., 2021). These substances eliminate microbeads but are acidic, and the extraction method may not be sustainable (Z. H. Cheng et al., 2020).

Flexibility in various aspects of the cosmetic industry

The cosmetics sector is evolving rapidly due to legislative changes, shifting customer tastes, and technological improvements. Raw materials, technology, product development, packaging, marketing, regulatory compliance, and consumer involvement are areas where businesses must be flexible to remain competitive and satisfy a wide range of market expectations. Here's an in-depth look at some places where flexibility may be used (Mishra et al., 2014). The cosmetic industry relies heavily on flexibility in raw materials to adapt to changing consumer preferences, regulatory requirements, and supply chain disruptions (Pérez-Pérez et al., 2019). This flexibility allows companies to source and use diverse ingredients, reduce dependency on a single source, and quickly substitute or reformulate products in response to shortages, price fluctuations, or regulatory changes. It also enables companies to adapt their product offerings to meet changing consumer preferences, ensure compliance with evolving regulatory requirements, and drive innovation and product development. Overall, flexibility in raw materials is crucial for the industry's success.

Reflection of flexibility in raw materials

When discussing the ingredient's flexibility, two concepts are essential to sustainability: their environmental fate and their sources. Organic-sourced meaning and definition were already shown in the next section, but organic must have a stricter definition; natural & organic aren’t enough to be considered flexible ingredients. Additionally, the percentage of carbon particles that originate from renewable sources is known as the bio-based content of an ingredient or formulation. Destiny and degradability: an ingredient or product is considered biodegradable if it is briefly eliminated into simple, non-toxic environmental components (Bom et al., 2019). An ingredient's synthesis, extraction, and purification processes determine its sustainability. The idea that all-natural products are beneficial, and all synthetics are harmful can frequently result from misleading data. Although natural components are desirable, sustainability issues may exist in cosmetic products. Synthetic additives must be considered when making ethical decisions because they can also help maintain the flexibility of raw materials.

- **Flexibility in product formulation**
  Plant-based, biodegradable, and eco-friendly components increase product versatility. Businesses are testing lesser-known yet natural solid ingredients as an alternative to synthetic chemicals. Flexible brands quickly change their

formulas to remove harmful ingredients and include safer alternatives as new knowledge about compound impacts on the environment or human health becomes available.

- **Addressing Triphenyl Phosphate (TPP) in green cosmetics: A focus on flexibility**
  Ensuring flexibility in dealing with triphenyl phosphate (TPP) in cosmetics is crucial for maintaining the safety of products for consumers and the environment while achieving optimal performance. Here is how adaptability might be utilized in this particular situation. Natural substitutes for flame prevention in cosmetics are uncommon. This is frequently used as a plasticizer and flame retardant in various items, including cosmetics (Mendelsohn et al., 2016). TPP can be used as a flame retardant or plasticizer in cosmetics; however, because of concerns about possible adverse effects on health and the environment. Natural substances are used in formulating organic cosmetics, while synthetic compounds like TPP aren't included. Emollients and moisturizers in organic cosmetics include flexible ingredients such as coconut oil, jojoba oil, shea butter, and cocoa butter. In addition, beeswax, carnauba wax, and candelilla wax provide texture, emollience, and stability to green cosmetics. Green tea and jasmine extracts enhance skin without any flame retardants. Natural mineral pigments create colour and coverage without dyes. Natural emulsifiers and thickeners mix oil and water (World Health Organisation & International Programme on Chemical Safety, 1991).

- **Flexibility in cosmetics petroleum-based ingredient reduction**
  Petroleum-based compounds have been used in cosmetics for their affordability and efficacy. However, demand for sustainable, green cosmetics and healthy alternatives is rising (Jaini et al., 2020). Innovative and flexible methods are needed to reduce petroleum-based cosmetic components to fulfill consumer and environmental criteria. Typical petroleum-based components in cosmetics include (Mori, 2023). Mineral oil, petrolatum, and paraffin are avoided in organic cosmetics for health and ecological reasons. Natural alternatives to petroleum-derived components are common in organic cosmetics, and ingredients in organic cosmetics provide great skincare without petroleum-derived chemicals. Certified organic cosmetics from trusted companies offer high-quality natural ingredients and sustainable production. Mineral oil, petrolatum, and paraffin are petroleum-based emollients and occlusives in skincare and cosmetics—these oils moisturize like petroleum-based compounds (Mori, 2023). Shea butter, cocoa butter, beeswax, plant-based waxes, vegetable glycerine, and botanical extracts are essential to organic cosmetics. Products with vitamin- and fatty acid-rich shea butter moisturize the skin—organic skincare benefits from rich cocoa butter. Plant waxes provide texture and stability without chemicals (Mcintosh et al., 2018).

- **Flexible phasing out cosmetics Polypropylene Beads (PPB)**
  Due to their cost and efficacy, polypropylene beads (PPB) are utilized in cosmetics, especially exfoliating applications. They cause microplastic contamination, which is a major environmental issue. Phasing out PPB flexibly requires sustainable and creative methods to preserve product performance and reduce environmental impact (Tilikidou & Delistavrou, 2023). Cosmetics and personal care products use microbeads and tiny plastic particles for exfoliation and texture enhancement. Facial scrubs, body washes, toothpaste, and exfoliating cleansers include them (Mori, 2023). However, many nations have prohibited or restricted PPBs in cosmetics due to their environmental impact. Cosmetics can provide excellent exfoliation by substituting natural alternatives for PPBs without harming ecological degradation. When choosing cosmetics, consumers may search for items branded as "microbead-free" or "plastic-free" to be sure they are making environmentally friendly decisions (Mori, 2023). Supporting companies that place a high priority on sustainability and environmental responsibility can also help the cosmetics business adopt more eco-friendly practices. PPBs can be replaced with natural, biodegradable exfoliants, fruit enzymes, and clays. Apricot kernel, walnut shell, and rice powder exfoliate gently without harming the environment. Papaya and pineapple enzymes turnover cells, whereas kaolin and bentonite absorb oil (Beerling, 2013).

- **Flexibility in Cosmetic Phthalate Elimination**
  Cosmetics employ phthalates as plasticizers and solvents, which may damage the hormonal system and remain in the environment. Flexibility in removing phthalates requires inventive and sustainable methods to assure product safety, regulatory compliance, and consumer pleasure (Juhász & Marmur, 2014). Many sectors, including cosmetics,

use phthalates to improve flexibility, transparency, and durability. Fragrances, nail polishes, hair sprays, and other skincare products sometimes include them (Bickers et al., 2003). Declining synthetic chemicals like phthalates and selecting organic cosmetics made from natural substances will help the environment and health. Certified organic products are transparent and meet stringent natural and organic ingredient standards. Essential oils, plant-based emollients, natural preservatives, botanical extracts, natural humectants, mineral pigments, fruit and flower extracts provide aroma, moisturizers, antimicrobials, and color without phthalates in organic cosmetics. Essential oils, plant-based emollients, natural preservatives, botanical extracts, and natural colors improve organic cosmetics' fragrance, moisture, and nutrition. Vanilla oils, coconut, shea, cocoa, jojoba, almond oils, aloe vera, honey, and glycerine hydrate skin (Beerling, 2013).

- **Flexibility in addressing Avobenzone in cosmetic formulations**
  Avobenzone is an everyday broad-spectrum UVA organic sunscreen. Although successful, it poses stability and environmental issues, notably regarding reef health (Jaini, 2019). Flexible avobenzone management requires creative, sustainable, and adaptable formulation solutions to fulfill consumer requirements and regulatory norms. Avobenzone, a chemical ingredient in sunscreens, provides UVA protection; sunscreen ingredients like zinc oxide and titanium dioxide form a barrier on the skin to prevent UV rays (Bom et al., 2019). Cosmetics and skincare products often contain UVA-blocking avobenzone, which absorbs and dissipates UVA radiation to prevent skin damage. However, some people may be allergic to avobenzone, and its efficacy may be limited. Mineral sunscreen contains zinc oxide for UVA and UVB protection, while titanium dioxide reflects and absorbs UV radiation. Red raspberry and carrot seed oils also offer antioxidant and fatty acid supplements. Organic cosmetics can use coconut oil's hydrating and emollient properties.

- **Flexibility in formulating with Salicylic Acid in cosmetics**
  When using salicylic acid in a solution, formulators can be flexible in using its advantages while considering stability, skin sensitivity, and customer preferences for sustainable and natural components (Alğin Yapar, 2017). Here's how salicylic acid-based cosmetic compositions might incorporate flexibility: Salicylic acid, a gentle and efficient cosmetic and skincare ingredient, exfoliates, treats acne, and improves skin texture. It removes dead skin cells, unclogs pores, and avoids acne. Salicylic acid is utilized in acne cleansers, toners, spot treatments, and creams for sensitive skin. It also reduces acne redness and irritation by reducing inflammation (Bom et al., 2019). Sebum production is regulated to prevent shine and oiliness, and it prevents blackheads and whiteheads. Start with a low dose and increase as tolerated to minimize irritation. Willow Bark Extract, White Willow Bark Powder, Lactic Acid, Glycolic Acid, Citric Acid, and Malic Acid can replace salicylic acid in organic cosmetics, and Willow Bark Extract exfoliates and clarifies gently with natural salicylates (Przybylska-Balcerek & Stuper-Szablewska, 2019). Powder made from white willow bark offers mild exfoliating and anti-inflammatory effects. Lactic acid in dairy and fermented foods dissolves dead skin cells for smoother, brighter skin. Glycolic acid from sugar cane improves skin texture and cell turnover (Beerling, 2013). Citrus fruits produce citric acid, which eliminates dead skin and renews cells. Apple malic acid enhances skin texture and tone.

Flexibility in Technology

New substances that offer unique advantages and address specific consumer demands, such as sun protection, hydration, and anti-aging, are introduced with the help of fresh scientific findings. Advanced Formulation Techniques: Improving the distribution and effectiveness of active chemicals using technologies such as encapsulation, nanotechnology, and biocompatible polymers (Bom et al., 2019). Smart Manufacturing: streamlining manufacturing, cutting waste, and enhancing product consistency via automation and AI-driven processes (Y. Cheng & Jiang, 2022). Platforms for customization: creating software and digital technologies that enable customized cosmetics and skin care products based on particular customer information.

Flexibility in Product Development

Adopting agile methodologies to prototype, test, and iterate new products based on real-time consumer feedback and market trends. Trend Adaptation: Staying ahead of emerging trends, such as clean beauty, vegan formulations, and sustainable sourcing, to continuously innovate product offerings (Amberg & Fogarassy, 2019). Scalable Solutions: Creating

scalable formulations that can be easily adapted for different markets and demographics, allowing for global expansion without compromising product integrity.

Packaging flexibility and sustainability

Use recyclable plastics, biodegradable paper, and glass to minimize the environmental effects. It creates circular, economy-friendly packaging that can be reused or refilled and designing packaging that can be easily adjusted for seasonal themes, special editions, or regulatory changes (Papista & Dimitriadis, 2019). Innovative Packaging using QR codes to provide consumers with more information, interactive experiences, and authentication.

Flexible marketing

Mix conventional and digital channels, such as social media, influencer partnerships, email marketing, and in-store promotions, to reach a wider audience. Personalized Campaigns in using consumer data to build targeted, customized marketing campaigns that match individual tastes and behaviours. Real-Time Engagement in responding to consumer queries, issues, and feedback on social media and other digital channels (Bozza et al., 2022).

Flexible regulatory compliance

Monitor worldwide regulatory changes and alter formulations, labeling, and marketing to guarantee compliance. Consumers want openness and trust. Therefore, transparency initiatives include thorough information on ingredient origin, product safety, and environmental effects. To comply with environmental and corporate social responsibility rules, adopt sustainability reporting techniques (Bozza et al., 2022).

Flexible consumer engagement interactive platforms

Enhance satisfaction with virtual try-on tools, skincare tests, and personalized consultation services. Actively solicit and implement consumer input into product development and marketing tactics to meet expectations. Community Building: Brand-led social efforts, user-generated content campaigns, and loyalty programs help loyal consumers build community (Chakraborty et al., 2024).

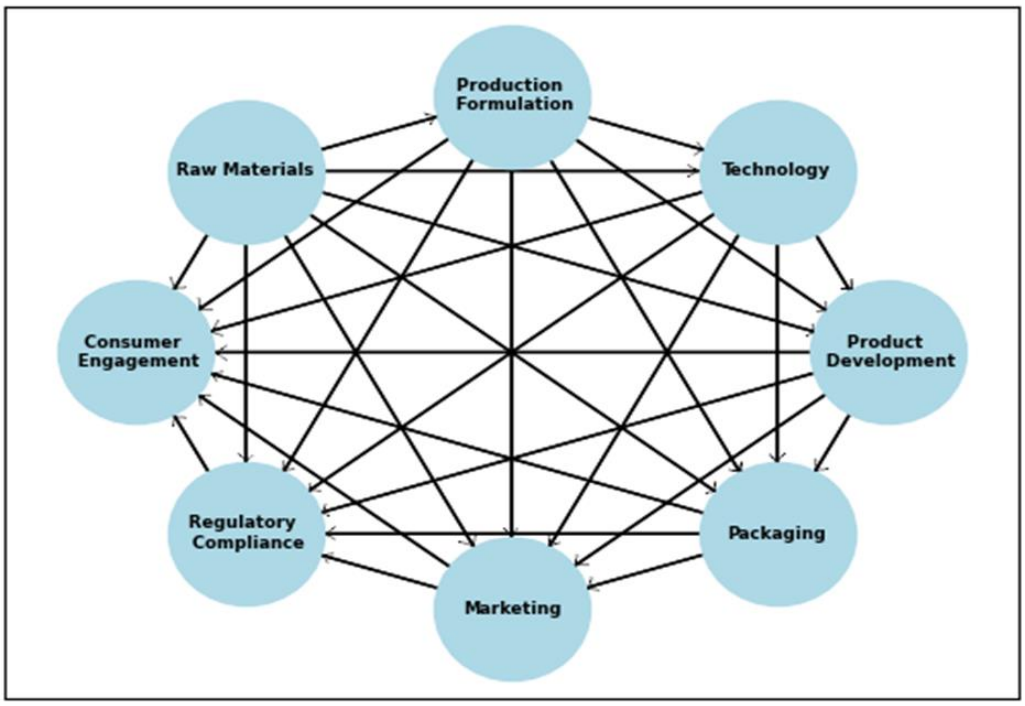

Fig. 1 Proposition model

This diagram, Fig. 1., is made with the help of Python and Visual Studio codes, illustrating the interconnectedness of various aspects of a business or production process. It highlights the importance of flexibility in raw materials, production

formulation, technology, product development, packaging, marketing, regulatory compliance, and consumer engagement. Changes in raw materials can affect all other areas, leading to adjustments in different places. Technology, product development, packaging, marketing, regulatory compliance, and consumer engagement are interconnected. Flexibility in these areas can drive innovation, improve regulatory compliance, and enhance consumer engagement. Regulatory compliance ensures that all areas adapt to meet legal and safety standards, while consumer engagement strategies help adapt to product development, packaging, and marketing changes.

Table 1 Theoretical framework

Theory	Product	Variable	Authors
Theory of planned behavior	Green cosmetics	Behavioral belief, normative belief, control belief, attitude, subjective norm, perceived behavioral control, green purchase intention, green behaviors	(Askadilla & Krisjanti, 2017)
Theory of Consumption value	Green cosmetics	Brand awareness, brand loyalty, perceived quality, and purchase intention	(Shafig AL-Haddad, 2018)
Theory of planned behavior	Organic cosmetics	Attitude, health consciousness, environmental consciousness, price consciousness, brand, availability	(Prakash et al., 2019)
Stimulus Response Organism	Organic personal care products	Knowledge, natural content, welfare, sensory appeal, quality, price, practical value, hedonic value, and purchase intention.	(Tania Vergura - Cristina Zerbini - Beatrice Luceri, 2020)
Theory of planned behaviors	Natural cosmetics	Product knowledge, attitude towards environmental and natural cosmetics, subjective norms, perceived behavioral control, purchase intention, and purchase behaviors.	(Tengli & Srinivasan, 2022)
Theory of planned behaviors	Green cosmetics	Health consciousness, ecological motive, environmental knowledge, subjective norm, perceived behavioral control, attitude, purchase intention, and consumer involvement	(Shimul et al., 2022)
Perceived value theory	Green cosmetics	Ethical concern, perceived functional value, perceived emotional value, perceived social value, behavioral intention	(Suphasomboon & Vassanadumrongdee, 2022)
Brand equity theory	Green cosmetics	Endorses credibility, brand/products, attitude, and intention to purchase	(Liang et al., 2022)
Information–Motivation–Behavioral Skills Model	Green cosmetics	Information, motivation, green cosmetic efficiency, and green cosmetics purchase intention	(Limbu et al., 2022)
Dual factor theory	Organic beauty products	Green advertisements, green brand image, LOHAS consumption tendency, perceived consumer effectiveness, trust, green attitude, and purchase intention	(Lavuri et al., 2022)

Innovation resistance theory	Sustainable cosmetics	Economic sustainability, social sustainability, environmental sustainability, social prestige, brand attractiveness, brand attachment, purchase intention, word of mouth, and intention to join the online brand community.	(Gr & Dabija, 2022)
Value belief norm theory	Cosmetics and detergents	Egoistic values, altruistic values, biosphere values, risk perception, ascription of responsibility, personal norms, consumption country	(Tilikidou & Delistavrou, 2023)
Theory of planned behaviors	Climate change risk perception	Attitude, subjective norms, perceived behavioral control, risk perception, consumption intention, country	(Delistavrou et al., 2023)

Summary of the studies reviewed

For green cosmetics research, Table 2 is handy and detailed. It lists the most popular tools, theories, and countries contributing to this field of study. It also contains sample sizes and significant research findings to identify literature gaps. However, many highly cited works are theoretical research on green cosmetics' conception and progress. Table 3 summarizes the relevant literature well.

Table 2 Summary of the Study Review

Author	Title	Country	Study type	RM sample size	Theory	Major finding
(Tilikidou & Delistavrou, 2023)	Cosmetics and Detergents with Recycled CO2: A Cross-Country Study with a Modified by Risk Perception Values-Beliefs-Norms Model	Germany, France, and Spain	Empirical	SEM (Sample=1538) (Female>Male)	VBN Theory	The VBN-focused study examines how recognition affects accountability, individual standards, and consumption intentions. A study found that VBN affects French, German, and Spanish CPG variations. In France and Germany, modulation analysis suggests a stronger correlation between personal norms and consumption intentions.
(Shimul et al., 2022)	Investigating Female Shoppers' Attitude and Purchase Intention towards Green Cosmetics in South Africa	South Africa	Empirical	SEM (sample = 408) (Female)	TPB	The results indicate that professionals should strive to augment customers' awareness and engagement with eco-friendly cosmetics. Consumers should be informed and educated through an integrated marketing communication strategy utilizing

						campaigns, commercials, and public relations.
(Kumar et al., 2021)	Young working women's purchase intention towards organic cosmetic products	India	Empirical	PLS-SEM (Sample=166) (Female)	TPB	Environmental consciousness and health concerns substantially impact young female customers' attitudes towards green cosmetics. Consumers ' psychological variables and attitudes are the primary components on which to focus and capture the market.
(Al-Samydai et al., 2020)	The impact of social media on consumers and health behaviors towards choosing herbal cosmetics.	Jordan	Descriptive	In-depth interview (sample = 497) (Female>Male)	None	Social media platforms facilitate the promotion of cosmetic items to diverse demographics, encompassing various age groups and genders. The marketer uses multiple social media platforms to advertise items and implements pull methods to entice youthful clients.
(Kapoor & Singh, 2019)	Towards environmental awareness: A review on the upgrowing edge of green cosmetics	India	Literature Review	PRISMA	None	The marketer must comprehend the desires and requirements of the consumer and categorize the product based on its functions or characteristics.
(Feng et al., 2018)	Promoting the Diffusion of Sustainable Innovations in the Cosmetic Industry	Taiwan	Literature Review	None	None	Companies should adhere to sustainability principles in their business plans and managerial operations.
(Liobikienė & Bernatonienė, 2017)	Why determinants of green purchase cannot be treated equally? The case of green cosmetics: Literature review	Kaunas	Literature Review	PRISMA	None	The author proposed a health-conscious, eco-friendly cosmetics model. Environmentally friendly beauty products are growing, but they can be better. Marketers and companies should prioritize health over color. Brands should offer affordable, high-quality products.

(Ayob et al., 2016)	The Enlightenment from Malaysian Consumers' Perspective Towards Cosmetic Products	Malaysia	Descriptive	In-depth interview (sample = 30) (Female>Male)	None	The behavior Suggests that the price of cosmetics should be affordable, and the price factor directly affects consumers' purchasing behavior.
(Pudaruth et al., 2015)	Gender-based differences in understanding the purchasing patterns of eco-friendly cosmetics and beauty care products in Mauritius: a study of female customers Sharmila	Mauritius	Empirical	Multiple regression (sample = 150) (Female)	None	A study found that eight factors influence the purchase of eco-friendly cosmetics: women's lifestyles, ethical consumerism, the pharmacological essence of green beauty products, visual appeal, price, moral claims, brand image, and social influences.
(Cervellon & Carey, 2014)	Sustainable, hedonic, and efficient Interaction effects between product properties and consumer reviews on post-experience Responses	United Kingdom	Empirical	Interview (Sample=186)	None	The paper found that hedonic value understanding affects consumers less than practical value. Reviews help people evaluate ambiguous utilitarian features like anti-aging, which they can't assess independently. Customers are more resilient to reviews when the product emphasizes sustainability.
(Shivanand et al., 2010)	Herbs Play an Important Role in the Field of Cosmetic	India	Review	None	None	Herbal cosmetics and formulations are covered. These cosmetics use specific formulation methods to combine oils, waxes, natural colorants, fragrances, or botanical components like leaves and flowers. Herbal cosmetics need quality control for efficacy and safety.
(Dimitrova et al., 2009)	Customer knowledge management in the natural	Bulgaria	Empirical	Multiple regression (Sample=450)	None	The author suggests using a logit model to increase customer-company knowledge sharing. Customers can understand

	cosmetics industry					promotional messaging, which facilitates knowledge sharing. They should promote Bulgarian rose products using a cohesive advertising mix that includes print, web, and television.
(Rajagopal, 2007)	Buying decisions towards Organic Products: an analysis of Customer Value and Brand Drivers	Mexico	Empirical	Linear equation (Sample=369)	None	The study found that strategic positioning and effective retailing improve consumer perceptions and create lasting customer value for unfamiliar brands' non-conventional products. Empirical evidence suggests business advertising and promotions influence synthetic cosmetics purchases.

Abbreviations: VBN Theory -Value-belief norm theory, TPB- Theory of planned behavior, PV Theory-Perceived value theory, IMB Model-, Stimulus-organism-response (SOR) theory, TCV Theory- Theory of consumption value.

RESEARCH METHODOLOGY

This study comprehensively analyzes existing research examining implementing flexibility in green cosmetics practices. According to earlier studies in the field, the study employs a systematic review approach (Ould & Ellili, 2023) It is an essential and effective way to visualize, summarize, and analyze the existing published literature in the field. Bibliometric analysis can deeply explore the quantifiable & statistical data & correlation between publications and provide researchers with reliable information (Rao & Shukla, 2023). Therefore, we quantitatively analyzed the literature review using the green cosmetic method in this article.

Database, keywords, and inclusion criteria

Several indexing and abstracting databases exist. Databases like Web of Science and Scopus can be interdisciplinary or subject-based, such as PubMed, Medline, AGRICOLA, and ERIC. We utilized Scopus, which summarizes scientific datasets, gives reliable indexes, and contains high-quality publications (Pranckut, 2021) According to Bhardwaj et al. (2023), Google Scholar searches conference papers, theses, reviews, book chapters, correspondence, data works, and unpublished materials more broadly than Scopus. Unlike Google Scholar, Scopus does not alter these citations because it does not hold this content. Synonyms may have yielded comparable entries in Scopus (Bhardwaj et al., 2023).

Inclusion and exclusion criteria

According to PRISMA, publications must be consecutive but treated equally after the first screening steps (Rao & Shukla, 2023). We used keywords to evaluate 406 Scopus-extracted scientific articles from (2003–2023) Fig. 2. Find, eliminate, and address identical paper records using keywords—an analysis of research by inclusion/exclusion criteria. Refine articles using the abstract, title, and keywords. From 2003 to 2023, pharmacology, toxicology, pharmaceuticals, environmental science, business management and accounting, social science, economics, econometrics, finance, multidisciplinary, humanities, and psychology were included in the basics of the subject area. Review papers, conference papers, and final publications were included.

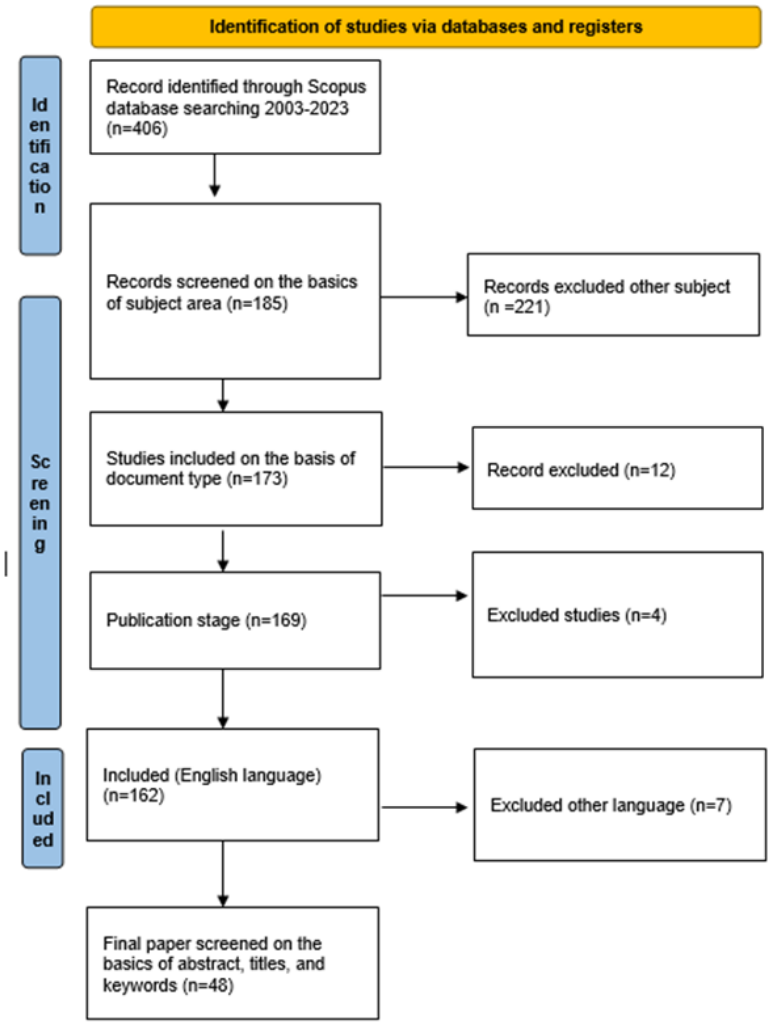

Fig. 2 PRISMA Model

DESCRIPTIVE ANALYSIS AND RESULTS

This section presents a bibliometric analysis of green cosmetic literature from 2003 to 2023. Bibliometric analysis software includes Cite Space, R Studio, Bib Excel, VOS Viewer, Gephi, and His Cite (van Eck & Waltman, 2010). Our study used VOS viewer and R studio for quantitative and visual literature analysis. This study used VOS to explain the network visualization and R Studio to explain the co-word analysis and top authors over time co-word analysis. Cluster analysis also simplifies sample classification for analysis.

Results: systematic analysis of the research field

To assess the advancement of a particular field of study, it is necessary to consider the number of scholarly publications published on the subject (Bhardwaj et al., 2023). Fig. 3. indicates the trend of publication from 2003 to 2023. The publication growth was stable until 2014. Two waves are observed in Fig. 3. The first wave is in the year 2015 with 10 publications and the second wave is achieved in the year 2022 with 35 publications.

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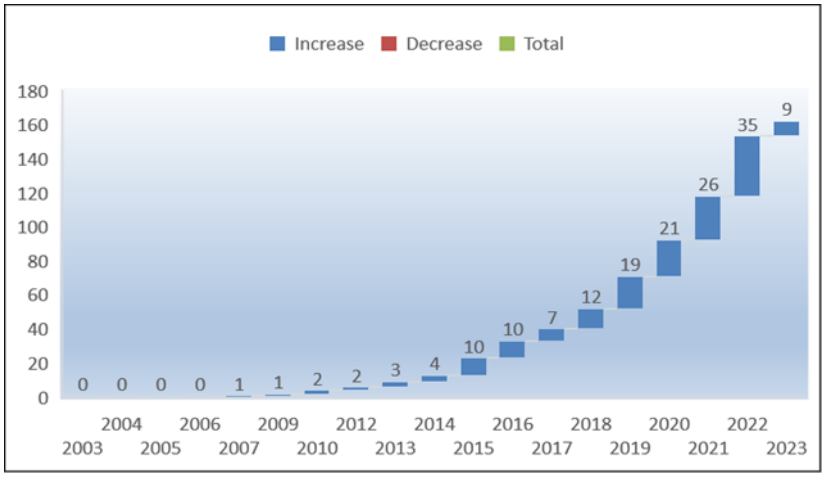

Fig. 3 Green cosmetics publication growth

Prolific authors and their affiliated institutions and countries

Assess an author's prominence by production and citation. Fig. 4. shows both indices' top 20 most productive authors over 20 years. Table 3 lists the top 10 publishing basics writers throughout time. Over time, author publishing shows productivity. Circle size indicates the author's article count. Dark circles indicate annual citations. Fig. 3 shows no 2003–2023 green or organic cosmetics trend. Green cosmetics were fashionable in 2013. The first cosmetics author, Baby AR, wrote three 2013 field papers by Azoulay S and Baby AR (2018): 4 and 3. Bujak published most about eco-cosmetics. Initially used by scientists and intellectuals, the h-index assesses publication output and citation effect.3: Table 3 illustrates an author's publications and citations.

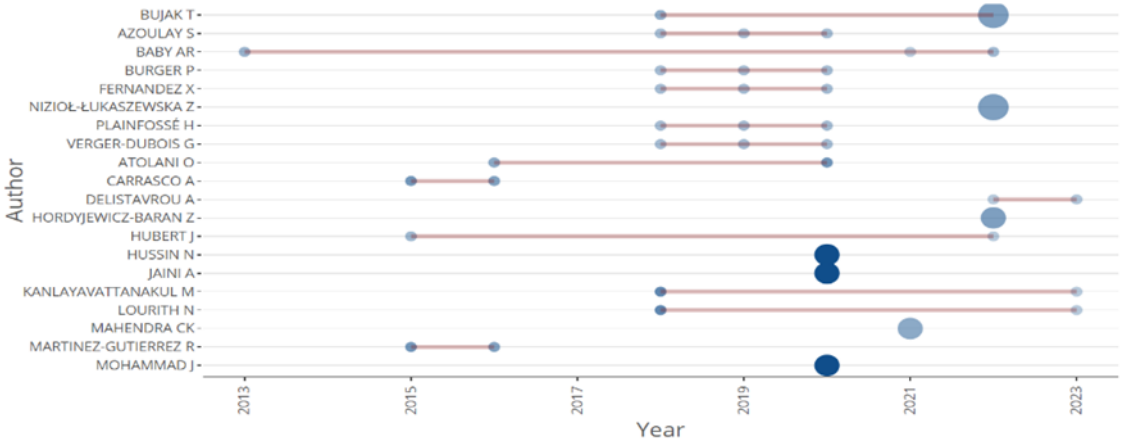

Fig. 4 Top authors over time

Table 3 Most cited authors and their affiliations and countries

	Author	Article	Institute	Country	Total citation	H Index
1	BUJAK T	4	University of Information Technology and Management based in Rzeszów	Poland	919	19
2	AZOULAY S	3	University of Côte d'Azur	France	996	15
3	BABY AR	3	University of Sao Paulo	Brazil	5520	38
	BURGER P	3	Johns Hopkins School of Medicine	Maryland	90611	141

4						
5	FERNANDEZ X	3	University of Côte d'Azur	France	3680	32
6	NIZIOŁ-ŁUKASZEWSKA Z	3	University of Information Technology and Management based in Rzeszów	Poland	964	18
7	PLAINFOSSÉ H	3	University of Côte d'Azur	France	139	6
8	VERGER-DUBOIS G	3	Axlepios Biomedical, Carros	France	95	5
9	ATOLANI O	2	University of Iiorin	Nigeria	1739	24
10	CARRASCO A	2	University of Seville	Spain	1407	12

Sources Analysis

Vos Viewer retrieves publications from the literature database. Table 4 shows the top 15 green cosmetics journals by ABDC category, indexing, and publisher. The most significant value of h for which an author/journal has produced at least h papers that have been referenced at least h times is the h-index. Resources, International Journal of Cosmetic Science, and Social Journal Responsibility cover sustainability, cosmetics, and molecules. The International Journal of Cosmetic Science publishes 247 research papers in 162 linked articles. Journals of Applied Toxicology ranks second with 189 citations and 1 document. Molecules is the third most generated journal, with 189 citations and 13 publications, with cosmetic journals citing 119 and 1. Cosmetics Journal contains 117 citations and 20 documents. The percentage distribution of the most produced green cosmetics journals is shown in Fig. 5.

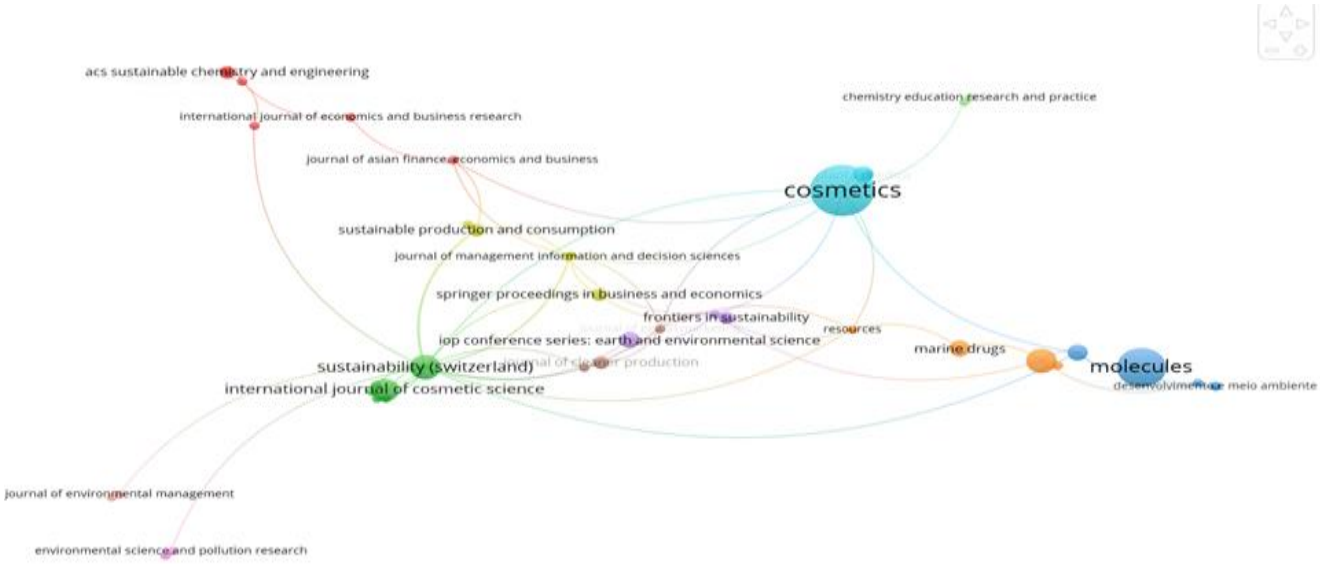

Fig. 5 Network visualization of journals

Table 4 Leading journal publishing on green cosmetics

Source	TP	TC	Green Cosmetic	ABDC category and Indexing	Publisher
International Journal of Cosmetic Science	5	247	X	X (H index 72)	Blackwell Publishing Ltd

Journal of Applied Toxicology	1	189	X	X (H index 91)	John Wiley & Sons Ltd
Molecules	13	131	X	X (H index 199)	MDPI AG
Resources	1	119	X	X (H index 46)	MDPI
Cosmetics	20	117	✓	X (H index 35)	MDPI
Journal of Cleaner Production	2	114	✓	A (H index 268)	Elsevier
Planta medica	3	105	X	X (H index 129)	Georg Thieme Verlag
Sustainability (Switzerland)	6	93	✓	X (H index 136)	MDPI
Sustainable chemistry and pharmacy	6	90	X	X (H index 38)	Elsevier BV
Brazilian journal of pharmaceutical sciences	3	84	X	X (H index 48)	Faculdade de Ciencias Pharmaceuticals (Biblioteca)
Marine drugs	3	69	X	X (H index 144)	MDPI
ACS sustainable chemistry and engineering	2	68	X	X (H index 155)	American Chemical Society
International journal of biological macromolecules	1	46	X	X (H index 166)	Elsevier
Journal of Product and Brand Management	1	45	✓	X (H index 97)	Emerald Group Holdings Ltd.
Social responsibility journal	1	42	✓	B (H index 45)	Emerald Group Publishing

Most productive Country

Studying research country-by-country provides valuable insights into the strengths and weaknesses of different regions, identifies potential areas for improvement, and informs international policies. This approach helps understand research trends, patterns, and impact, leading to a more practical approach toward research (Mishra et al., 2014). A published study, Fig. 7, shows a highly productive country from 2003 to 2023. The top 15 countries for green cosmetics research productivity were examined until June. Citation is an essential impact indicator. Numerous citations make an author or country significant in the field. References and articles from the 15 most referenced nations are shown in Fig. 6. Portugal has 304 references and eight publications, making it the first most mentioned country. Poland: 242 citations, 15 documents. Italy has 189 citations and 14 papers. The fast-growing India has 122 citations and 16 papers.

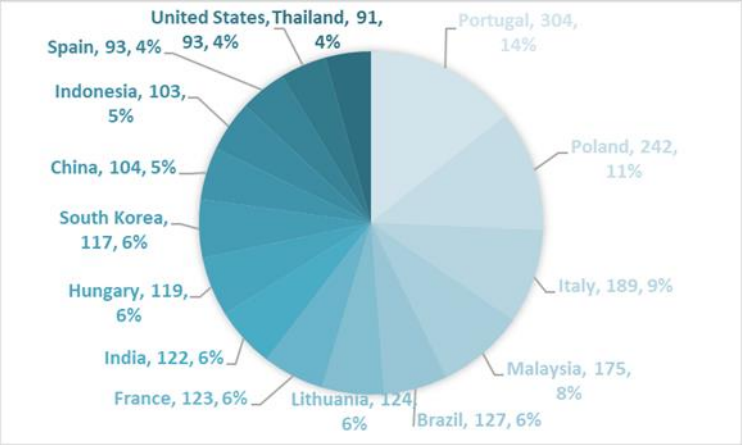

Fig. 6 Most productive country

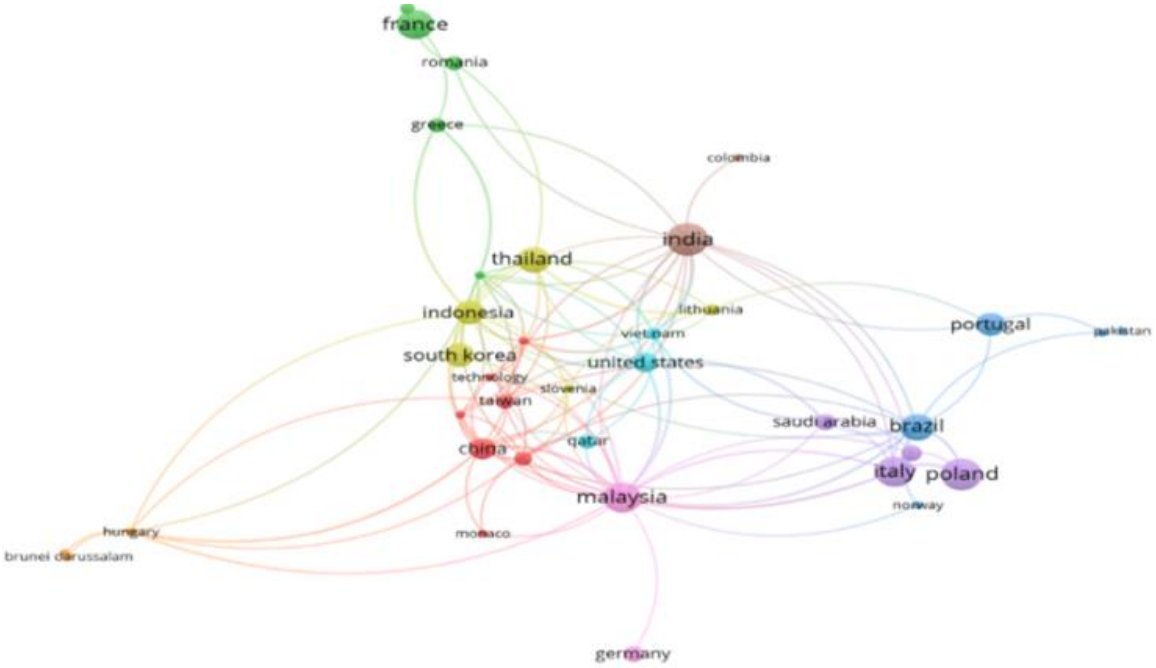

Fig. 7 Network visualisation of the country

NETWORK ANALYSIS

Network analysis is now a scientific method for studying complex relationships in various research fields (Ould & Ellili, 2023). In network analysis, all participants are systems, not independent individuals. Some software like VOS Viewer and CitNet Explorer can perform network analysis. To create and view bibliographic maps, van Eck & Waltman (2013) developed the existing computer program, VOS Viewer. This research uses this software because it lends itself to intuitive manipulation and establishing relationships between data.

The co-occurrence analysis

To determine the relationship between the articles' principal themes and detect patterns, we recommend utilizing co-words, which estimate the frequency of thematic terms and keywords in the text. Vos creates 690 author keywords from preliminary data. Next, this paper retrieved 82 terms with at least two occurrences. Fig. 8. shows the author's keyword network map. Natural cosmetics in sustainability and the green cosmetic business are clusters 1 (green) and 2 (brown). Tengli & Srinivasan (2022) examined gender-based natural cosmetics purchases. Amberg & Fogarassy (2019) and Dimitrova et al. (2009) explore natural cosmetics consumer knowledge management in green consumer behaviors in the cosmetic market. Green cosmetics are in blue Cluster 2. Khan & Salim (2021) analyze Saudi female cosmetics buying motivations. Singhal & Malik, (2018) studied female cosmetic customers' green marketing purchases. Certification is examined in green cosmetics regulatory and commercial framework (Bozza et al., 2022). The three red clusters are cosmetic. Malaysian consumers know more about cosmetics (Ayob et al., 2016). Suphasomboon & Vassanadumrongdee, (2022) explain cosmetic industry sustainability transitions from multi-stakeholder perspectives Feng et al., (2018) explore cosmetics and sustainable innovation dissemination. Yellow Group 4: Cosmetics Sustainability and Green Usage. In small and medium industries with system dynamics, the author explore model-based sustainable cosmetics development. Suphasomboon & Vassanadumrongdee, (2022) Sustainable cosmetics and personal care: ethics and value. In 2022, Gr & Dabija (2022) will apply the SOR model and triple bottom line to increase sustainable cosmetic brand purchasing. Natural and organic cosmetic sustainability: consumer, product, effectiveness, toxicity, and regulation, by (Fonseca-santos et al., 2015). Cluster 5 (purple) talks about antioxidant activities, how antioxidant plants change the oil-in-water emulsion, and ways to get Eryngium maritimum out of its plant form to learn more about its chemicals, antibacterial properties, and antioxidant activities. Pink Cluster 6 signifies green cosmetics. Jaini (2019) found that eWoM moderates Malaysian cosmetics buyers' green purchasing behavior. Climate change and beauty product purchases are discussed (Pitaloka & Widiatami, 2022). Cluster 7 (orange) defines green cosmetics' antioxidants. Using a simple lattice design, develop face cosmetics with microbial levan and plant-derived (Helenas et al., 2023). Cluster 8 (light blue) theory of planned conduct, which explains

consumer behavior, is the most prevalent green cosmetics theory. Tengli & Srinivasan (2022) study natural cosmetics customers' gender-based buying behavior using the TPB theory—green cosmetics buying intentions and attitudes among South African women (Shimul et al., 2022). Gender-based natural cosmetics purchase behavior experimentation is widespread in sustainability. Industries are studying and keeping green cosmetics using herbal extract, brand equity, circular economy, stability, cosmeceuticals, fermentation, anti-age, and other ways. To be sustainable, green cosmetics must address flexibility, climate change, hazardous substances, and risk perception. Due to climate change, cosmetic companies must limit their carbon footprint and use of non-renewable resources. Safety and environmental protection require addressing hazardous substances and risk perception. Green cosmetics' flexibility requires more research.

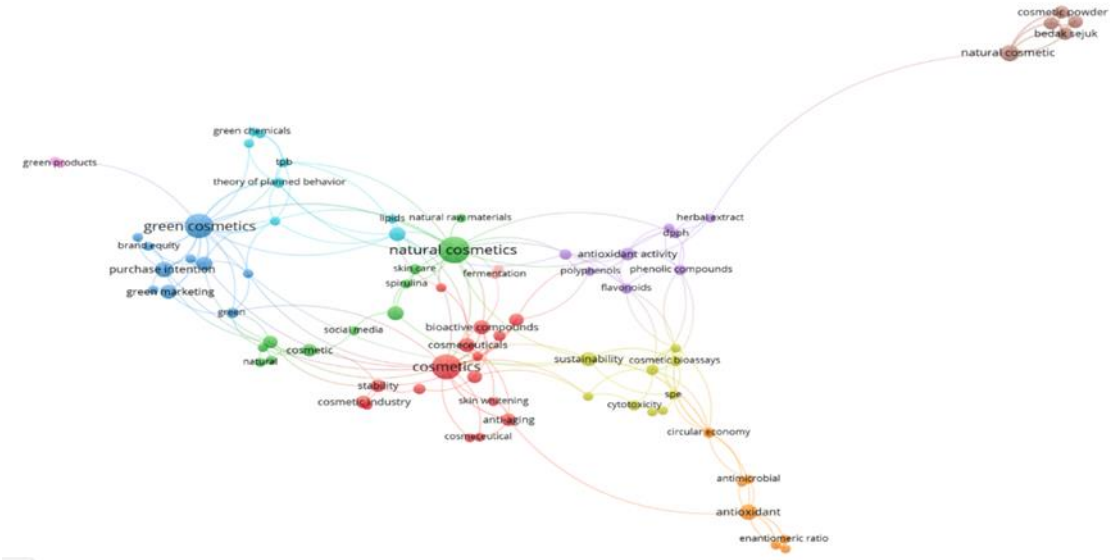

Fig. 8 Network visualization of authors' keywords

Co-word cloud analysis

A co-word analysis is a bibliometric method that examines the connections between terms or keywords in a body of literature. This technique examines how often words occur together in papers to help uncover the structure and development of study subjects, themes, and trends (Chakraborty et al., 2024). R Studio's Biblioshiny package was used to analyze keywords. Word cloud analysis is used to identify the most popular topics and keywords in publications. This analysis shows how frequently keywords and research domain concepts occur together. Fig. 9. shows co-occurrence words will be used to construct this word cloud analysis. The frequency of "cosmetics" is 50, then articles are 38, cosmetics are 35, humans are 31, and so on.

Fig. 9 Co-word analysis

- **Plant extract**
  Plant extracts are crucial in cosmetics because they benefit the skin. In anti-aging skincare, antioxidant-rich green tea extract promotes youthful skin. Chamomile extract soothes and reduces inflammation, while aloe vera hydrates the skin. Anti-inflammatory and antibacterial calendula extract helps wounds heal and treat skin disorders. Popular options include licorice root extract (Barbulova et al., 2015).

- **Drug effect**
  Active pharmaceutical ingredients (APIs) have unique potential and issues when used in cosmetics (Przybylska-Balcerek & Stuper-Szablewska, 2019). An in-depth examination of how these pharmacological effects affect human health, the degree of flexibility required to control them, and the relationship between safety and efficacy is provided below. These include anti-inflammatory, antioxidant, moisturizing, exfoliating, UV protection, anti-acne, and wound healing for the skin. In addition, some organic alternatives are available, such as rosemary, green tea, and aloe vera, which heal irritated skin (Swami et al., 2010). Antioxidants reduce free radicals, protect skin from external stresses, and improve texture (Helenas et al., 2023). Remove dead skin cells, enhance texture, and diminish fine lines and wrinkles using exfoliating agents. Sun protection chemicals block UV rays, while anti-acne compounds heal acne and wounds. To ensure safety and efficacy, use these components as advised and visit a dermatologist or healthcare expert.

- **Enzymes**
  Cosmetics often use proteolytic enzymes to exfoliate and regenerate the skin. These enzymes break down skin proteins, helping to remove dead skin cells and promote new cell growth (Przybylska-Balcerek & Stuper-Szablewska, 2019). Papain, a proteolytic enzyme derived from papaya fruit, gently exfoliates and brightens the skin. Similarly, the pineapple fruit proteolytic enzyme, bromelain, also exfoliates and renews the skin by breaking protein connections between dead skin cells (Dini & Laneri, 2021). The pumpkin fruit enzyme is also commonly used to help remove dead skin cells and pollutants, leaving the skin looking clean and beautiful. Both papain and bromelain can be found in papaya seed and pineapple extract.

- **Chemistry**
  The cosmetic industry requires flexibility in its formulation, stability, efficacy, safety, and chemistry. Surfactants, emollients, preservatives, humectants, UV filters, antioxidants, and pH adjusters are important (Bom et al., 2019). Emollients moisturize and soften skin by providing a protective barrier, while surfactants lift oils and debris from skin and hair. Preservatives inhibit microbiological development and improve shelf life, while humectants keep skin moist. Sunburn and premature aging are prevented with UV filters. Antioxidants destroy free radicals and cause skin problems. pH adjusters keep cosmetics acidic or alkaline for skin compatibility.

- **Un classified drugs**
  Unclassified cosmetic drugs have potential pharmacological effects on the skin but are not classified as pharmaceuticals by regulatory agencies. Examples include peptides, plant extracts, hyaluronic acid, alpha and beta acids. Peptides increase collagen formation, minimize wrinkles, and improve skin smoothness, while plant extracts offer antioxidant and anti-inflammatory bioactive ingredients (Draelos, 2009)

- **Phenol derivatives**
  Chemical compounds developed from phenol, an aromatic component, are employed in cosmetics and other industries. Cosmetics can use phenol derivatives as preservatives and skin conditioners (Przybylska-Balcerek & Stuper-Szablewska, 2019). Some phenol derivatives may be hazardous and should be used in cosmetics in moderation: Common cosmetic phenol derivatives and their functions. Organic cosmetics use natural antioxidants like vitamin E, rosemary extract, and grapefruit seed extract to prolong shelf life and prevent microbiological growth. Organic essential oils like tea tree and lavender oil also serve as antimicrobial alternatives. Natural chelating agents, like citric acid, can also prevent cosmetic oxidation.

- **Antioxidant**
  Antioxidants are necessary in cosmetics to safeguard the formula, especially from the rancidity of fatty ingredients (natural oils, fats, and fragrances) (Bickers et al., 2003). Antioxidants function as skin care actives in addition to aiding in formulation stabilization. They scavenge free radicals to protect the skin from oxidative stressors and delay the onset of age indications on the skin (Bom et al., 2019). If it involves protecting products, natural antioxidants can substitute synthetic ones, with vitamins being the most widely used. Among them are plant-based forms of vitamins E (tocopherol), A (retinyl palmitate), and C (ascorbic acid) (Beerling, 2013).

DISCUSSION

This section represents the overall understanding of the green cosmetic topic under discussion, including past research and future scope. In recent years, the term green cosmetics has gained popularity and interest (Kumar et al., 2021). The study focuses on the development of green cosmetics in the years 2003-2023. We employed bibliometric analysis to integrate the fragmented information base and investigate knowledge pathways, meaningful clusters, and the potential for more productive future research. The bibliometric portion of this study provides the scientific approach via different network visualizations, charts, diagrams, and graph datasets. The descriptive part of this study explains that the cosmetics sector requires flexibility in various aspects, such as raw materials, product formulation, technology, packaging, marketing, regulatory compliance (Delistavrou et al., 2023), and consumer involvement. The industry's shift towards organic and eco-friendly materials necessitates adaptability to regulatory changes and customer preferences. Technology flexibility, such as encapsulation and intelligent manufacturing, enhances product performance and efficiency (Bom et al., 2019). Eco-friendly packaging, marketing, and regulatory compliance also require flexibility. By being open to ingredient sources and environmental effects, brands can maintain sustainability and consumer satisfaction. Modern markets are complicated; therefore, the cosmetics industry must be flexible. Innovation and adaptation help brands adjust to changing customer preferences, regulatory requirements, and trends. This strategy assures long-term success and helps build a consumer base that values the brand's quality, flexibility, and innovation. A primary obstacle is substituting non-sustainable artificial components for environmentally friendly substitutes. Much research has been done on the possible uses of sustainable ingredients. But before natural, organic, or green chemistry-derived ingredients are added to cosmetics, more research and analysis must be done to find out what the ingredient does, how safe it is, how stable it is in the formulation, and how well it meets the aesthetic needs of the end user (Bom et al., 2019). Additionally, as the current EU regulation does not mandate the origin of components to be made explicit, consumers cannot be sure of the source of ingredients because numerous ingredients marketed under one name may be of animal, vegetable, or synthetic origin. Reducing energy consumption, choosing eco-friendly products, reducing waste, and using sustainable transportation can help mitigate climate change and create a healthier planet for future generations (Indra et al., 2020). As organizations grow more environmentally conscious, they incorporate green initiatives into their strategies to attain their goals. A wide range of chemicals that can harm human health and the skin's health are frequently found in cosmetic products (Jaini et al., 2020). This study has explored the world of green cosmetic ingredients as an alternative to these possibly hazardous substances to address this problem. Finding cosmetics that meet their strict environmental and sustainability standards may be challenging. Consumer demand has prompted cosmetics companies to make and promote eco-friendly products. Includes flexible ingredients, flexible manufacturing, and sustainable packaging. To satisfy environmentally conscious consumers, "green cosmetics" emphasize innovation and growth (Haleem et al., 2018). Flexibility in cosmetics for effective and affordable green cosmetics is difficult. This allows innovation and distinction in the crowded cosmetics industry. Eco-conscious consumers increase brand loyalty and their customer base. All business levels must be creative, adaptable, and willing to change for green cosmetics. This meets ethical product demand and helps the environment. The study gives consumers healthier and safer options by shedding light on the advantages of substituting natural, environmentally friendly components for conventional cosmetic ones.

CONCLUSION

The first part of this research explains the flexibility of the green cosmetic industry. A green cosmetics research review emphasizes ingredient availability, formulation, and research methodology adaptability. Flexibility helps solve field problems, promotes sustainability, and encourages collaboration. Using flexible approaches, green cosmetics may change to fulfil the demand for sustainable and creative products. This study discussed the flexibility in the cosmetics industry and the requirements for alternative of chemicals. Still, a more detailed analysis of the minimum and maximum percentages of

organic & natural portions is required. There is an opportunity for improvement and more research. Flexible, sustainable ingredients play a significant role in how sustainable cosmetics are. The cosmetic industry's main challenge is replacing synthetic ingredients with sustainable alternatives. Some studies showed that the entire life cycle of a cosmetic product, from making it to throwing it away, needs to be looked into in detail (Bom et al., 2019). This includes using flexible ingredients, green chemistry, formulation, certification, and the minimum or maximum requirements for the stability of natural and organic ingredients (Beerling, 2013). The second part of this research discussed the most commonly used theory, methodology, sample size, and targeted audience. It helps future researchers determine what is widely used in green cosmetics and the research methodology. Most importantly, the tables show an imbalance among male consumers, requiring more investigation into the purchasing behavior of green cosmetics. Secondly, this study discussed the co-word analysis of green cosmetics—plant extract, enzymes, antioxidants, phthalates, phenols, and unclassified drugs. It is essential to analyze the past and present and predict the likelihood of future advancements in this field. We have examined 48 published articles from the Scopus database to provide new perspectives on green cosmetics. Additionally, as it has become an emerging flavor with enormous potential, it is essential to consider how awareness of it may affect communities, businesses (such as manufacturing and services), universities, and local governments. The study aims to help upcoming researchers easily grasp the conceptual framework of this topic so that even more research may be done to further develop the presently developing body of knowledge.

FUTURE RESEARCH

Flexibility research in green cosmetics may include technical breakthroughs, consumer behavior, regulatory frameworks, and environmental impact assessments. This research will explore cosmetic flexibility, effectiveness, environmental sustainability, social responsibility, and product lifecycles to meet growing sustainable practice standards. (1) Biodegradable/biobased materials: new research on packaging and product materials (Cinelli et al., 2019). (2) Green Chemistry Formulas: Innovation: Using innovative green chemistry to create eco-friendly cosmetics. Sustainability of Ingredient Sourcing: Examining how ingredient farming impacts biodiversity and ecosystems and how synthetic biology may deplete natural ingredients. In addition, a comparative study between synthetic and green cosmetics is required (3) Regulation and Certification Advance: Global Standards Harmonisation: Studies on the feasibility and impact of harmonizing global green cosmetics standards to improve international trade while meeting high environmental and consumer safety standards (Bozza et al., 2022). (4) Examine green cosmetics trends and how research and development flexibility may help the sector adapt. Develop predictive models that identify green cosmetics demands and issues, emphasizing flexibility may boost resilience and creativity. (5) Tech innovations: AI and Machine Learning in Product Development: Optimising formulations for performance and environmental impact using AI and machine learning, potentially reducing physical testing (G. Kumar et al., 2024).

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