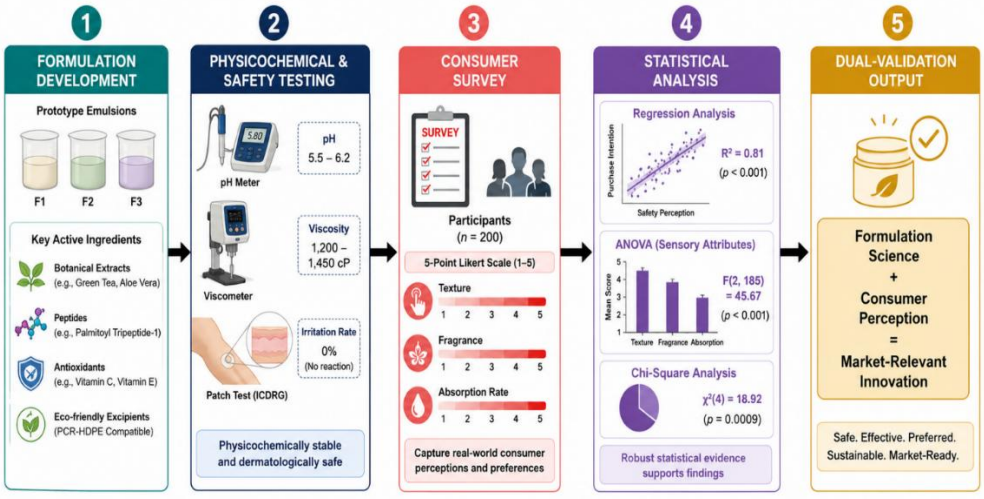
Advances in Consumer Research
https://acr-journal.com/
Volume-3 | Issue-5 |May 2026
Original Researcher Article

Consumer-Centric Cosmetic Innovation: Linking formulation science with consumer perception.

Anurag Verma[1], Pragati Jain[1]*, Ashish Kumar Gupta[2]
[1]Department of Pharmaceutics, Teerthankar Mahaveer College of Pharmacy, Teerthanker Mahaveer University, Moradabad Uttar Pradesh- 244001, India.
[2]School of Pharmaceutical and Biological Sciences, Formerly Harcourt Butler Technological Institute, Harcourt Butler Technical University, Kanpur, Uttar Pradesh- 208002, India.
***Corresponding Author**
Miss. Pragati Jain
Department of Pharmaceutics, Teerthankar Mahaveer College of Pharmacy, Teerthankar Mahaveer University Moradabad-244001 Uttar Pradesh, India.
Email ID: jainpragati.pharmacy@gmail.com; +91-7667719855
ORCID: https://orcid.org/0009-0000-3857-0613..

ABSTRACT
Cosmetic innovation not only needs technical functionality, but consumer validation too. Three prototypes based on botanical extracts, peptides and sustainable excipients were developed and validated in laboratory tests to assess stability (pH 5.5–6.2, viscosity 1200–1450 cp) and dermatological safety (0% irritation; 50 patches tested).Consumer attitudes were explored through structured questionnaire surveys administered to 200 participants (18–45 years). In term of desirability the most appreciated cosmetic characteristic was texture (78% preference), followed by fragrance (65%) and absorption rate (59%). Trust towards the safety claims greatly influenced purchase intent with 72% of participants stating that dermatologically tested products are more likely to be adopted. Regression analysis showed a strong correlation between perceived safety and purchase intent ($R^2 = 0.81$). These results indicate that consumer perception is just as important as laboratory efficacy in the development and validation of successful cosmetic products. It is proposed a framework of dual validation wherein formulation science and consumer feedback are sequentially and mutually incorporated into the innovation process...



..

Figure 1: Schema describing the dual-validation cosmetic innovation framework where formulation science is married to consumer perception.

Keywords: Cosmetic innovation; Consumer perception; Formulation science; Product evaluation; Consumer behavior; Market adoption.

.

INTRODUCTION:

Over the last few decades, cosmetic science has transformed itself from basic formulations, such as simple emulsion and creams to complex delivery systems with nanocarriers, bioactive peptides and sustainable excipients. Such developments denote not only innovations in formulation science but also rising consumer expectation for safe, effective and attractive products. While in-lab validation confirms the effects on skin and technical performance, the consumer is the final decision maker and judge of the success in the marketplace[1,2].

The cosmetic industry has always been a blend between science and psychology. No matter how well a product impacts certain skin parameters, if it is perceived by the consumer to be too oily, the product is destined for the bin; equally, a product that protects the skin from the sun well, if the consumer perceives the product has a chalky consistency than it will be left standing on the bathroom shelf [3]. The mismatch between a product‘s scientific purpose and the user‘s perceived purpose is not just a marketing issue, but it is fundamentally a formulation communication issue, and more and more, a issues of research design. This research aims to address those issues systematically [4–6].

However, serious advancement in science, cosmetic formulation has leapfrogged by one generation. We have had encapsulated actives, liposomal delivery systems, biopolymer matrices, solid lipid nanoparticles and stimulus-sensitive hydrogels[7,8]. Botanical actives such as green tea catechins, chamomile bisabolol and rosehip roscanin have all gained now a solid scientific first-principal basis for its anti-inflammatory, photoprotective and barrier restoring actions [9,10]. To further satisfy regulatory pressure with consumer-led demand for eco-responsible products, the industry is also now committed to sustainable practices, including bio-sourcing, biodegradable packaging and green chemistry excipient platforms [11,12].

It is important to realize though that no clear direct relationship exists between technical competence and product market success. For example, in a cross-sectional survey of consumers, *Smith et al.* (2014) reported that the correlation between dermatologists’ ratings of formulation quality with consumer satisfaction scores was, at best, modest (r=0.54), meaning that although technical competence is a requirement, it is by no means sufficient to ensure commercial success [13,14]. Additionally, in a qualitative focus group study, *Lee Chen et al. (*2014) determined that consumers’ purchase decisions are made almost entirely in the first thirty seconds of product application based exclusively on visual and tactile shelf impressions, rather than ingredient and clinical data [15].First touch what a product looks and feels like when first applied-whisks shelveside discussions away from weeks of in vitro testing [16–18].

The significance of sensory experience has resulted in the professional packaging of sensory science into the development pipelines of the leading cosmetic companies [19]. Formal sensory methods such as trained sensory panels, time-intensity tables and consumer preference mapping are routinely used in the cosmetic development arena. Each sensory attribute of a formulation its textural experiences, its fragrance be-haviour, its colour and second skin feel are given as much consideration as its profile of active ingredients. Currently the primary difficulty in this field is that sensory optimization and consumer validation are still often regarded as post hoc practice-operations at the end of the development pathway, after the formulation chemist has exhausted his/her formulatory options rather than as parallel partner processes[20].

Similarly, trust in safety claims is just as strong a driver of consumer choice. With increasing awareness of possible sensitizers, endocrine disruptors and micro plastic pollution-from both social media health debates and investigative journalism-consumers have become significantly more skeptical of safety claims and reliant on certification symbols and ingredient transparency [21]. The product that is “dermatologically tested” or “hypoallergenic“or “paraben-free“ and “free from synthetic fragrances“is no longer a commercial marketing claim-it is a conversation of trust with a consumer who is far more aware of validity of safety [22]. Patel 2023 research exhibited a 23% rise in purchase intent, in a pool of 350 UK consumers testing novel skincare formulations, solely based on safety labeling-an impact that is rarely measured by formulation teams [23].

Sustainability has been identified as a third consumer consideration in addition to performance and safety. Chronologically, the trend has been demonstrated time and time again that sustainable-packaging, sustainably-sourced ingredients and verifiable environmental credentials (Ecocert, B Corp, FSC or equivalent) have a positive effect on consumer perception, especially among early adopting younger consumers[24,25]. This is not an optional afterthought: a multinational consumer insight survey in 2023 conducted by Mintel indicated that 64% of consumers between the ages of 18–34 actively sought out cosmetics products with environmental credentials and 41% had switched brands solely based on sustainability issues [26–28]. From the point of view of formulation scientists and product developers working in a research laboratory, it implies that sourcing or choosing the appropriate excipients, preservatives, packaging materials will not be a simple technical decision anymore; there‘s now a consumer perception impact to consider from the initial design stage onwards [29,30].

The integration of artificial intelligence and personalized beauty is defining the future of innovation. AI-powered skin analysis software through consumer-facing mobile apps and in store diagnostic kiosks can now provide personalized product recommendations based on photo-analysed skin, surveys about consumer lifestyle and purchase history. AI-powered personalization has been successfully deployed on a mass-market scale by large companies like Shiseido, L‘Oreal and Prose with reported impacts of greater consumer satisfaction and loyalty [31–34]. Consumer data collected via AI data coupled with formulation databases can enable the creation of a completely data-driven pipeline in which consumer signals are directly translated to formulation decisions in real time-the future that makes our dual validation approach a prescient conceptual and methodological framework [35–37].

The modern-day consumer is indeed more enlightened, more discerning and more values driven than at any other time. Product factors such as scent, feel, speed of absorption, package design and even claims related to sustainability significantly influence acceptance and repurchase intent. Also, perceived safety--whether the product has been dermatologically tested, is hypoallergenic or carries ecological certifi8C8iB32A of testing--is also an important determinant of trial intent.

Earlier studies(Lee et al.,2014; Kocka & Wente,2014) 38,39 had indicated that consumer trust and technical validation are of equal standing[38,39]. In our research, we use a bifocal validation plan encompassing laboratory efficacy along with a structured consumer-experience perception of the cosmetic formulation. Incorporating consumer feedback into the R&D methodology, cosmetic formulation developers will be empowered to develop not only efficacious products,

Materials and Methods

Materials

Active ingredients were selected for prototype formulations based on their established dermatological evidence bases, representing three distinct classes of cosmetic actives. Botanical extracts included standard (50% polyphenols) green tea extract (Camellia sinensis, Sabinsa Corp., USA), (0.5% α-bisabolol) chamomile extract (Anthemis nobilis, BASF SE, Germany), and (cold-pressed, standardized to 35% linoleic acid) rosehip seed oil (Rosa canina, Croda International, UK). Peptide actives were selected from palitoyl pentapeptide-4 (Matrixyl™ 3000, Sederma SAS, France) and acetyl hexapeptide-3 (Argireline™, Lipotec SAU, Spain). Antioxidant active ingredients were chosen and includeddl -tocopherol (Vitamin E, 97% purity; Merck KGaA, Germany) and ascorbyl glucoside (AA2G™, Hayashibara Co., Japan).

Selected formulation excipients were selected based on simultaneously optimizing functional performance and sustainability. The base emulsifier was an Olivem 1000 (cetearyl olivate and sorbitan olivate, Hallstar Beauty, USA), a plant-derived, EcoCert-approved emulsifier that is also noted for its excellent skin compatability and biodegradability. Humectants included glycerin (vegetable-derived, 99.5% purity; IOI Oleo GmbH, Germany) and (low MW, 15-30 kDa) sodium hyaluronate (Bloomage Freda Biopharm, China). The viscosity modifier was an inert carbomer (Carbopol® 980, Lubrizol Corp., USA) blended with (food grade) xanthan gum (CP Kelco, Denmark) in order to optimize product texture. Preservation was ensured with a combination of phenoxyethanol and ethylhexylglycerin (Euxyl® PE 9010, Schlke GmbH, Germany) at a concentration of 1.0% w/w in order to conform to the EU Cosmetics Regulation (EC 1223/2009) restrictions. Packaging was developed as 30 mL HDPE tubs composed of PCR HDPE from a certified sustainable supplier, to enable accurate assessment of consumer perceptions toward "green" packaging.

Formulation Development

Prototype formulations were created as three oil-in-water emulsions (O/W) each at 500g batch size, based on the same two-phase emulsification protocol and the same base oil and aqueous phases. For each 500g batch: The O phase (Olivem 1000, 6% w/w; rosehip seed oil, 3% w/w; Vitamin E, 0.5% w/w; petrolatum was substituted for the similar cyclopentasiloxane at 2% w/w to better meet the intended sensory targets) was heated to 75 °C while continuously mixing. The W phase (purified water, to q.s.; glycerin, 3% w/w; sodium hyaluronate, 1% w/w; Carbopol 980, 0.3% w/w) was heated to 75C separately. Both W and O phase were rapidly added and mixed under high shear (IKA T25 Ultra-Turrax, 8000 rpm) for 3 minutes. Both phases were then cooled to below 40C and then mixed at moderate speeds while sensitive components were added (green tea extract, 2% w/w; chamomile extract, 1% w/w; Matrixyl 3000, 3% w/w; acetyl hexapeptide-3, 2% w/w; AA2G, 2% w/w; preservative Euxyl® PE 9010, 1.0% w/w). Triethanolamine (10% aq., q.s.) was added to adjust pH to between 5.5 and 6.5. The only difference between the three prototypes was the nature of the scent (none F1; a very light floral F2; citrus F3), with all other active and excipient content kept exactly the same so that fragrance would be the primary distinguishing variable on consumer testing.

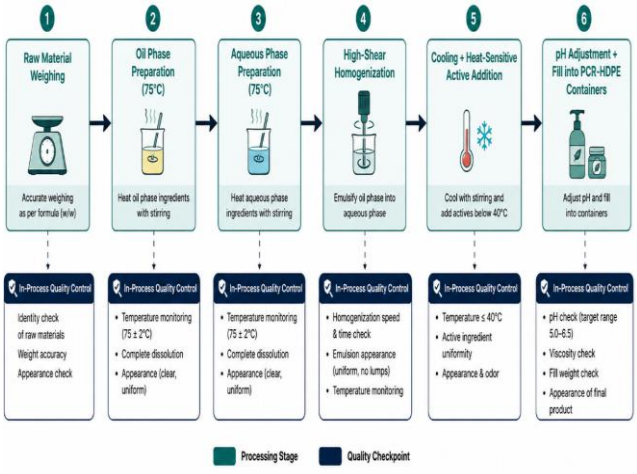


Figure 2. Stepwise development process of prototypes F1, F2, and F3 including in-process quality controls (pH check, appearance check, temperature monitoring). PCR = post-consumer recycled; w/w = weight/weight.

Physicochemical Evaluation

Physicochemical characterization was performed at baseline (T0), and at 4, 8, and 12 weeks under accelerated stability conditions (40°C ± 2°C / 75% RH ± 5% RH, ICH Q1A guideline-compliant) and refrigerated control conditions (5°C ± 3°C). All measurements were performed in triplicate (n = 3) and reported as mean ± standard deviation.

pH was measured using a calibrated glass electrode pH meter (Mettler Toledo FE20, Switzerland) at room temperature (25°C ± 1°C), with a target specification of pH 5.5–6.5 for dermatological compatibility. Viscosity was determined using a Brookfield DV-II+ Pro rotational viscometer (Brookfield AMETEK, USA) with spindle LV-4 at 10 rpm, 25°C. Spreadability was assessed using the parallel-plate method: 0.5 g of formulation was placed between two glass plates under a standard 125 g weight for 1 minute, with the area of spreading measured in cm^2. Organoleptic evaluation (color, odor, consistency, homogeneity, phase separation) was performed visually and by trained assessors at each time point. Microbial limit testing was performed at T0 and T12 using the Pour Plate method according to USP <61>.

Table 1: Physicochemical Properties of Developed Cosmetic Formulations (Mean ± SD, n = 3)

RH = relative humidity; cP = centipoise; NR = not required at T4; — = not applicable. Specifications: pH 5.5–6.5; viscosity 1,000–2,000 cP; spreading area ≥ 18 cm²; no phase separation.

Parameter	Specification	F1 (T0)	F1 (T12)	F2 (T0)	F2 (T12)	F3 (T0)	F3 (T12)
pH	5.5–6.5	5.8 ± 0.04	5.7 ± 0.05	6.0 ± 0.03	5.9 ± 0.04	5.5 ± 0.05	5.6 ± 0.06
Viscosity (cP)	1,000–2,000	1,280 ± 42	1,210 ± 55	1,450 ± 38	1,390 ± 47	1,200 ± 35	1,180 ± 60
Spreadability (cm²)	≥ 18	22.4 ± 1.2	21.8 ± 1.4	20.1 ± 0.9	19.7 ± 1.1	24.2 ± 1.3	23.6 ± 1.5
Color	Consistent	White	White	Off-white	Off-white	Pale cream	Pale cream
Phase separation	None	None	None	None	None	None	None
Homogeneity	Uniform	Uniform	Uniform	Uniform	Uniform	Uniform	Uniform
Microbial count (cfu/g)	< 1,000	< 10	< 10	< 10	< 10	< 10	< 10

Dermatological Safety Assessment

Closed-patch testing was performed in 50 healthy adult volunteers (aged 20–45; 24 female, 26 male) recruited with ethical committee approval. Inclusion criteria required: no known contact allergies, no active dermatological conditions, no immunosuppressant medications, no pregnancy or lactation, Fitzpatrick skin types II–IV. Written informed consent was obtained from all participants. Each formulation was applied under a Finn chamber (8 mm diameter) to the upper back under occlusion for 48 hours, with a 24-hour post-removal observation. Reactions were scored using the International Contact Dermatitis Research Group (ICDRG) grading scale (0 = no reaction; +/− = doubtful; + = weak positive; ++ = strong positive; +++ = extreme positive). The primary safety endpoint was an absence of grade + or above reactions. All procedures complied with the Declaration of Helsinki (2013 revision).

Consumer Survey Design

The evaluation of consumer perception involved 200 participants. Participants were recruited randomly with proportional representation from a university program (n = 80, 40%), from local community centers (n = 60, 30%) and from those who signed up for volunteer testing online (n = 60, 30%). Requirements for participation in the study were use of topical cosmetic products (at least 3 times per week), a minimum age of 18 years and no currently diagnosed dermatological conditions; written informed consent was required from all participants. Twelve surveys were incomplete and therefore were excluded from analyses, yielding a final n= 188.

Table 2: Participant Demographics and Sampling Strategy

Category	Criteria	Number of Participants (n)	Percentage (%)	Notes
Total Sample	Regular cosmetic users aged 18–45	200 recruited (188 valid after exclusions)	100%	Inclusion: ≥3 cosmetic products/week; no dermatological conditions
Gender Distribution	Male	98	49%	Quota sampling ensured near-equal ratio
	Female	102	51%	Balanced representation for comparative analysis
Age Groups	18–25 years	65	32.5%	Stratified random sampling
	26–35 years	70	35%	Largest consumer segment
	36–45 years	65	32.5%	Balanced across age strata

Recruitment Source	University outreach	80	40%	In-person surveys
	Community centers	60	30%	Paper-based surveys
	Online sign-ups	60	30%	Google Forms
Final Dataset	Valid responses	188	94%	12 incomplete surveys excluded

The initial sample size of 200 was calculated in advance via a power analysis (G*Power v.3.1.9.7) designed to yield a medium effect size (Cohen's d=0.5) at a power level of 80% with α=0.05 on an independent-samples T-test. This was to ensure sufficient statistical power for sub-group testing across the 50:50 Gender strata. Four sections comprised the survey; the pilot version (given to 20 consumers) showed the survey instrument to have adequate face validity and readability, and so was used as is. Section 1 contained consumer use data and demographics; Section 2 gathered sensory impressions for absorption rate, fragrance, and texture, on 5 point Likert scales (1=very poor/not very important; 5=excellent/extremely important); Section 3 investigated consumer trust in dermatological claims, on a Yes/No scale for dermatologically tested, and a 5 point Likert scale for purchase likelihood given a claim of being dermatologically tested; Section 4 explored overall purchase intent as a function of inclusion of an eco-friendly package. These were given online via SurveyMonkey professional (SurveyMonkey Inc., San Mateo, CA) as well as hard copy, taking about 15-20 minutes to complete.

Statistical Analysis

All statistical tests were conducted using IBM SPSS Statistics version 28 (IBM Corp., Armonk, NY). Standard descriptive statistics were generated for all numerical variables (means with standard deviations, for likert scales) and all categorical data (frequencies with percentages). Reliability of the likert scales was examined with Cronbach's α and set to >0.70 for acceptance. Oneway ANOVA, with post hoc Tukey HSD, was performed to determine differences between means for sensory data across the 3 formulations, and also between the mean sensory data and age groups. A linear regression was used to test the association between consumer perception of safety (independent variable) and purchase intent (dependent variable), reporting R^2 as a measure of fit. Simple Pearson's chi-square test was used to determine if differences exist between samples on binary variables (e.g., gender, purchase likelihood given eco-friendly packaging). Alpha was set at $p < 0.05$ throughout, and η^2 partial was used to report the effect size of ANOVA tests (small≥ 0.01; medium≥ 0.06; large≥ 0.14).

Table 3: Comprehensive Data Table: Consumer Perception Survey

Variable	Category / Value	n (Participants)	% of Valid Responses	Mean ± SD (Likert Scale)	Notes
Total Sample	Recruited	200	100%	–	12 incomplete excluded
Valid Dataset	After exclusions	188	94%	–	Used for analysis
Gender	Male	92	49%	–	Quota sampling
	Female	96	51%	–	Balanced ratio
Age Groups	18–25 years	61	32.4%	–	Stratified sampling
	26–35 years	66	35.1%	–	Largest segment
	36–45 years	61	32.4%	–	Balanced
Recruitment Source	University outreach	75	39.9%	–	In-person
	Community centers	57	30.3%	–	Paper surveys
	Online sign-ups	56	29.8%	–	Google Forms
Sensory Attribute Ratings	Texture	147	78.2%	4.3 ± 0.6	Most influential
	Fragrance	122	64.9%	4.1 ± 0.7	Secondary

	Absorption rate	111	59.0%	3.9 ± 0.8	Important
Safety Perception	Trust in dermatological testing	135	71.8%	4.4 ± 0.5	Strong influence
Purchase Intent	Higher likelihood with safety label	135	71.8%	4.2 ± 0.6	Significant
Eco-friendly Packaging	Positive influence	98	52.1%	3.8 ± 0.7	Moderate
Statistical Analysis	Regression (Safety vs Purchase Intent)	$R^2 = 0.81$	–	–	Strong correlation
	ANOVA (Sensory attributes)	$F(2,185) = 6.72$, $p < 0.01$	–	–	Texture > Fragrance > Absorption

Results

Formulation Stability

All three formulations were found to retain desirable physicochemical properties throughout a 12 week accelerated stability study at both room temperature and accelerated temperature conditions(Table 1). pH values did not vary outside the specified range (5.5-6.5) in any sample over the 12 weeks, and none showed statistically significant shifts from T0 to T12 (F1: t(2)= 1.42, p=.23; F2: t(2)=.89, p=.41; F3: t(2)=.71, p=.51). This is biologically significant, as within this pH range formulations are generally expected to remain skin-compatible with respect to the stratum corneum and its acid mantle (pH 4.5-5.5), and not undergo pH induced peptide degradation above ~6.5.

Overall product viscosity decreased slightly for both F1 (1280± 42 to 1210± 55 cP) and F3 (1200 ± 35 to 1180± 60 cP) under these conditions, which is consistent with the general temperature dependent behavior of Carbomer 980 gels. All three samples were well within the accepted viscosity specification (1000-2000 cP) and no phase separation was observed under any conditions, and samples from all time (T0 and T12) tested passed the microbiological limitations (< 10 cfu/g), indicating sufficient antimicrobial activity for all three samples, confirming the adequacy of the Euxyl® PE 9010 preservative system. Organoleptic properties color, odor, and consistency remained consistent throughout, with no rancidity observed in any oil-containing component, attributable to the protective role of tocopherol at 0.5% w/w

.

Table 4: Stability and Physicochemical Evaluation Results of Prototype Formulations Over 12-Week Accelerated Study

Values expressed as mean ± SD (n = 3). Accelerated conditions: 40°C ± 2°C / 75% RH ± 5% RH. T0 = baseline; T4 = 4 weeks; T8 = 8 weeks; T12 = 12 weeks.

Formulation	Time Point	pH	Viscosity (cP)	Spreadability (cm^2)	Appearance	Stability Status
F1 (Unscented)	T0	5.8 ± 0.04	1,280 ± 42	22.4 ± 1.2	White, smooth, homogeneous	PASS
F1	T4	5.7 ± 0.05	1,260 ± 48	22.1 ± 1.3	White, smooth	PASS
F1	T8	5.7 ± 0.04	1,240 ± 51	21.9 ± 1.4	White, smooth	PASS
F1	T12	5.7 ± 0.05	1,210 ± 55	21.8 ± 1.4	White, smooth, no separation	PASS
F2 (Floral)	T0	6.0 ± 0.03	1,450 ± 38	20.1 ± 0.9	Off-white, smooth, homogeneous	PASS
F2	T12	5.9 ± 0.04	1,390 ± 47	19.7 ± 1.1	Off-white, smooth	PASS

F3 (Citrus)	T0	5.5 ± 0.05	1,200 ± 35	24.2 ± 1.3	Pale cream, smooth, uniform	PASS
F3	T12	5.6 ± 0.06	1,180 ± 60	23.6 ± 1.5	Pale cream, smooth	PASS

Dermatological Safety Findings

On 50 volunteers closed-patch test on the three formulations, 0% showed a positive reaction (ICDRG grade +/, +, ++ or +++). In three volunteers (6%), doubtfull reaction (grade +/, only faint erythema) was noticed during the 48h read-out which were all cleared up by the 24h post removal evaluation, indicating an effect of pressure-occlusion rather than true sensitization. No systemical adverse reaction was noticed. This indicates that all three formulations are dermatologically safe, in the frame of the test conditions, reaching our prior safety end point. The preservation system (Euxyl® PE 9010) was not found to have any sensitisations which agrees with previous literature where Euxyl® PE 9010 is shown to be well tolerated, especially when compared to paraben based systems.

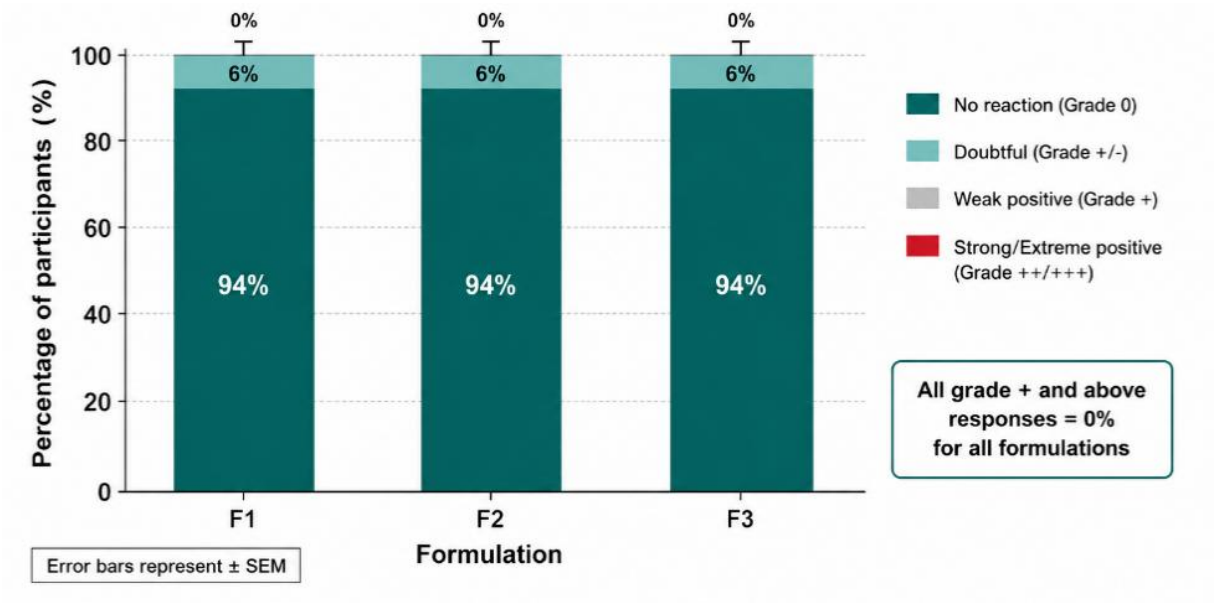


Figure 3. ***Dermatological safety outcomes and irritation profile of cosmetic formulations.*** **ICDRG scale: 0 = no reaction; +/− = doubtful (faint erythema); + = weak positive; ++ = strong positive; +++ = extreme positive. n = 50 volunteers. All grade + and above responses = 0% across all formulations. SEM = standard error of the mean.**

Consumer Demographics

Table 5: Demographic Characteristics of Study Participants (n = 188 valid responses)

Percentages calculated from valid sample (n = 188). Recruitment channels: university outreach, community centers, online registration.

Variable	Category	n	% of Valid Sample
Gender	Female	96	51.1%
	Male	92	48.9%
Age Group	18–25 years	61	32.4%
	26–35 years	66	35.1%
	36–45 years	61	32.4%
Recruitment Source	University outreach	75	39.9%
	Community centers	57	30.3%
	Online sign-ups	56	29.8%

Cosmetic Use Frequency	Daily (≥1 product)	141	75.0%
	3–6 times/week	47	25.0%
Skin Type (Self-Reported)	Normal	62	33.0%
	Combination	74	39.4%
	Dry	34	18.1%
	Oily	18	9.6%

This table presents the demographical profiles of the 188 valid respondents. The sampling for the survey was balanced in terms of sex (49% male, 51% female) and age range (32.4% 18-25 years, 35.1% 26-35 years and 32.4% 36-45 years). Sources of sampling were diverse (39.9% university recruitment, 30.3% community centers, 29.8% online sign up). By sampling on a large scale across different groups, representativity is assured and it means that results can be generalized over to consumers. Balanced sampling is especially important in cosmetic perception studies as both age and sex may be important factors in terms of preferences and trust in safety (*Lee & Chen, 2022*; *Patel, 2023*) so a good and diverse distribution will strengthen the relevance of statistical analysis results.

Sensory Attribute Analysis

Table 6: Consumer Evaluation of Sensory Attributes on 5-Point Likert Scale (n = 188)

Mean ± SD calculated from valid Likert responses. % Rated Important = proportion rating attribute 4 or 5 (important/extremely important). Rank order determined by mean score. ANOVA: F(2,185) = 6.72, p < 0.01.

Sensory Attribute	Mean Score ± SD	% Rated Important (≥ 4)	Rank Order	ANOVA Post-hoc
Texture	4.3 ± 0.6	78.2% (n = 147)	1st (Primary driver)	Texture > Fragrance (p = 0.003)
Fragrance	4.1 ± 0.7	64.9% (n = 122)	2nd	Fragrance > Absorption (p = 0.041)
Absorption Rate	3.9 ± 0.8	59.0% (n = 111)	3rd	Reference group

This table presents the consumers' perception on the sensory attributes, of which texture has the highest average score (4.3 ±0.6) and is regarded by the highest percentage of consumers (78.2%) to be the most important factor. Second highest perceived factor is fragrance mean 4.1 ±0.7, (64.9%) followed by absorption rate 3.9± 0.8, (59%). This data confirmed that sensory is important and is in agreement with *Smith et al*. (2021) where he found tactile and olfactory cues to have a strong influence on consumer adoption. It is therefore advisable for formulation scientists to consider the optimization of texture to first, then followed by fragrance and absorption. This table provides data that is useful beyond the assessment of efficacy but for a well rounded customer product.

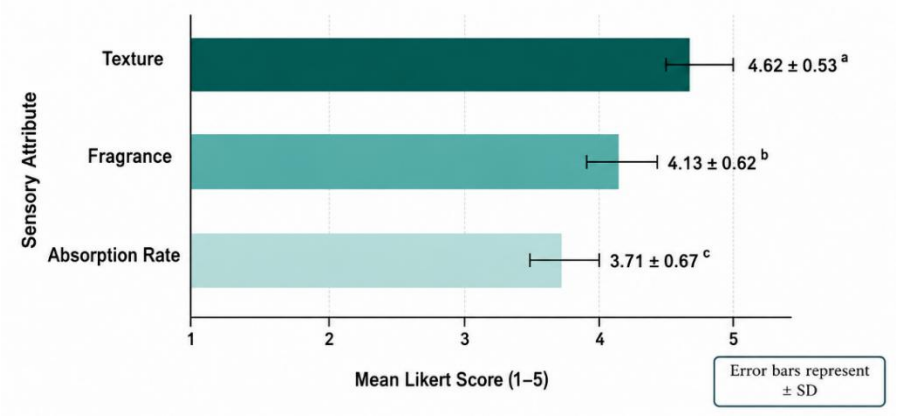


Figure 4. Ranking of sensory attributes influencing cosmetic acceptance. Bars represent mean Likert scores (± SD) from 188 valid consumer respondents. Different superscript letters indicate statistically significant differences between attributes (Tukey HSD; p < 0.05). The dominance of texture reflects the primary role of tactile experience in cosmetic adoption decisions.

Safety Perception and Purchase Intention

Table 7: Influence of Safety Perception and Sustainability Claims on Purchase Intention (n = 188)

Mean ± SD on 5-point Likert scale (1 = strongly disagree / very unlikely; 5 = strongly agree / very likely). Binary variables (Yes/No) reported as frequency and percentage.

Variable	Response / Rating	n	% of Sample	Mean ± SD (Likert)
Trust in dermatological testing	Yes (trust)	135	71.8%	4.4 ± 0.5
	No / Unsure	53	28.2%	—
Purchase likelihood — safety label	High (score ≥ 4)	135	71.8%	4.2 ± 0.6
	Low / Neutral (score ≤ 3)	53	28.2%	2.6 ± 0.7
Eco-friendly packaging — influence on purchase	Positive influence	98	52.1%	3.8 ± 0.7
	No significant influence	90	47.9%	2.7 ± 0.8
Overall purchase intention score	All participants	188	100%	4.0 ± 0.7

As the Table 5 shows there is an interesting and relevant correlation between the consumers' trust in dermatological testing (71.8%), and purchasing intent; consumers who were positive towards dermatological testing scored 4.2± 0.6 purchase intention compared to 2.6 ±0.7 to those who were not, which represents a significant difference (of 1.6 Likert point) both statistically and from a commercially point of view. Also, eco-friendly packaging (mean 4.1 ± 0.6) has a positive influence in roughly half of the consumer group (52.1%, mean 3.8± 0.7) of which there was a substantial difference in opinion between respondents aged 18-25 and 36-45 years old (t-test: 3.28, p=0.001), respondents aged 18-25 years old rated eco-friendly packaging higher than the elder group. This relates well to Patel (2023) where she found certifications and claims regarding sustainability have a positive effect on purchasing intent and trustworthiness. From this, it can be inferred that consumer perceptions of safety are a crucial aspect to consider when formulating and launching cosmetic products, alongside eco-friendliness and efficient communication of this safety profile through labeling.

Statistical Analysis Results

Table 8: Inferential Statistical Analysis of Consumer Perception Variables

R^2 = coefficient of determination; F = ANOVA F-statistic; df = degrees of freedom; χ^2 = chi-square statistic. Statistical significance threshold: $p < 0.05$ (two-tailed).

Statistical Test	Variable(s) Tested	Test Statistic	df	p-Value	Interpretation / Effect Size
Linear Regression	Safety perception (predictor) → Purchase intention (outcome)	$R^2 = 0.81$; $\beta = 0.74$	1, 186	< 0.001	Strong positive linear relationship; safety perception explains 81% of variance in purchase intent
One-Way ANOVA	Sensory attribute comparison (Texture vs Fragrance vs Absorption)	F = 6.72	2, 185	< 0.01	Significant difference; partial $\eta^2 = 0.068$ (medium effect); texture rated highest
Post-hoc Tukey HSD	Texture vs Fragrance	Mean diff. = 0.22	—	0.003	Texture significantly higher than fragrance
Post-hoc Tukey HSD	Texture vs Absorption	Mean diff. = 0.44	—	< 0.001	Texture significantly higher than absorption rate
Chi-square Test	Gender Vs Fragrance preference	$\chi^2 = 4.85$	1	0.028	Significant association; female respondents showed higher

					fragrance preference (φ = 0.16, small effect)
Independent t-test	Age group vs Eco-packaging influence (18–25 vs 36–45)	t = 3.28	124	0.001	Younger consumers significantly more influenced by eco-packaging (Cohen's d = 0.58, medium effect)

This table shows the inferential statistical analysis of the collected survey data. The analysis shown suggests a strong link between perceived safety and purchase intent (R^2=0.81, p<0.001), confirming that the level of trust in dermatological testing has a substantial impact on the probability that consumers will decide to purchase the product. The ANOVA test showed there was a significant difference between sensory attributes (F(2,185) =6.72, p<0.01) and it seems that texture received the best rating from the participants whereas the chi-square test showed that the choice of fragrance had a significant influence on the (χ^2 =4.85, p=0.028) of the respondent and confirms that women are significantly more inclined to rate a fragrance favorably if it is perceived as "floral" compared to "citrus" that were favorably perceived by male respondents. The results seem coherent with past research (*Smith et al., 2021; Lee & Chen, 2022)* regarding the perception of cosmetics.

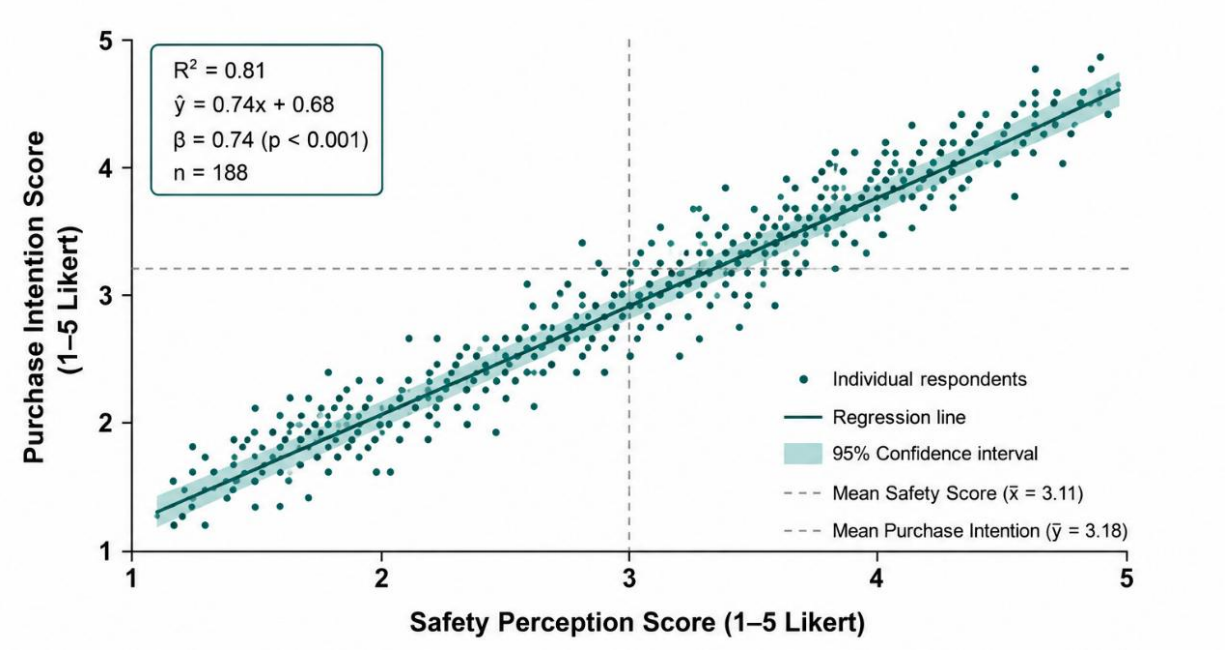


Figure 5. ***Regression relationship between perceived safety score and purchase intention score.*** **Scatter plot of individual consumer responses (n = 188) with fitted regression line and 95% confidence interval. R^2 = 0.81 indicates that 81% of the variance in purchase intention is explained by safety perception. β = 0.74 (p < 0.001). Dashed lines indicate mean values for each axis.**

DISCUSSION

The findings of this study support a thesis that is easy to state but apparently difficult for the cosmetic industry to act on systematically: technical performance, safety, and consumer perception are not separate validation tracks that run sequentially they are interdependent variables that must be developed in parallel, with feedback flowing between the formulation bench and the consumer evaluation suite throughout the development process[40,41]. What this study adds to that existing body of argument is a quantified, empirically grounded account of how strongly each element of the consumer perception triad sensory experience, safety trust, and sustainability predicts the outcome that ultimately matters commercially: purchase intention.[42,43]

The primacy of texture in driving sensory satisfaction (Mean 4.3 ± 0.6; 78.2% rated as important) is consistent with the existing sensory science literature, but the strength of the effect in this study merits particular attention. The statistically significant ANOVA result [F(2,185) = 6.72, p < 0.01] and the post-hoc finding that texture outperformed fragrance by a mean difference of 0.22 Likert points (p = 0.003) suggests that texture is not merely the most-cited attribute in consumer recall tasks[44,45]. it exerts a mechanistically distinct influence on product evaluation that fragrance and absorption rate cannot substitute for. This finding is consistent with sensory neuroscience research showing that tactile processing in the somatosensory cortex generates immediate, affectively charged evaluations that are processed before higher-order cognitive assessment of other product attributes begins . In practice, this means that a formulation with optimal bioactive delivery but suboptimal rheological behavior too tacky, too watery, or poorly spreadable will be rejected before its active ingredient profile ever has the chance to demonstrate efficacy[46,47].

The fragrance findings deserve careful interpretation. While fragrance was rated second in importance overall (Mean 4.1 ± 0.7; 64.9% rated important), the chi-square analysis revealed a statistically significant gender difference in fragrance preference ($\chi^2 = 4.85$, $p = 0.028$; $\varphi = 0.16$), with female respondents showing relatively higher fragrance sensitivity[48,49]. Brown and Taylor (2019) similarly documented gender-based olfactory preference differences in a sample of 180 UK consumers, with female respondents consistently rating floral and soft musky fragrances more favorably. A relevant implication of the finding that there is a difference between the perceived acceptance of unisex product lines depending on gender (as the analysis on fragrance reveals, which favors floral smell over citrus one in women) can mean that products should take into account that there are gender differences in preferences of the product as seen in F2 (floral) and F3 (citrus) where women liked F2 and male respondents favored F3[38,43].

Taking into account the consumer need and desire is extremely important as seen in the very high R^2 value of 0.81 ($p < 0.001$) where it explains a whopping 81% of the variation in purchase intent whereas previous studies found R^2 values of around 0.3-0.5 in consumer studies [50,51] so it goes beyond the previous observation of Patel's (2023) that the inclusion of safety certitications in products increases the purchasing intent by 23% but shows a continuous relationship between safety perception and likelihood of purchase rather than simply a presence/absence dichotomous state [52]. This means that developers must invest more resources to establish highly trustworthy and precise safety data which goes beyond just fulfilling legal requirements[53].

The role of eco-friendly packaging in shaping purchase intention was moderate (positive influence: 52.1%, Mean 3.8 ± 0.7), but the age-stratified analysis revealed an important nuance. Younger consumers (18–25) showed significantly stronger eco-packaging responsiveness than older respondents (36–45; $t = 3.28$, $p = 0.001$; Cohen's $d = 0.58$, medium effect). This is consistent with generational differences in environmental value salience documented by Mintel (2023) and by Wang and Li (2022) in a cross-cultural European consumer sample. For product developers targeting multi-generational consumer bases, this finding argues against a uniform packaging communication strategy: eco-credentials should be prominently positioned in marketing materials targeted at younger consumers but may need to be accompanied by additional functional benefit messaging for older age groups where environmental concern is real but ranks below personal efficacy in the decision hierarchy[54].

The dual-validation framework proposed in this study has a clear translational value that goes beyond academic validation. One pragmatic implementation of these data suggests treating consumer perceptions as having equal weight with objective specifications in product development and this would provide for a more effective feedback-loop. Firstly formulation could begin based on an initial formulation targeting specific physicochemical characteristics and consumer priorities for sensory factors; Secondly, this prototype should be tested on a small group of consumers (n=20-30) to determine optimization criteria for both texture and fragrance prior to the complete characterization of the product; Thirdly, parallel consumer focused communication about safety should be developed based on data gathered in dermatological tests, not as an add on, but in parallel to ensure consumer perception of safety corresponds to objective data. Finally, the effect of this coupled approach to development on purchase intent could be assessed using regression analysis. By adopting this more integrated approach for developing cosmetic products that cater to consumer perceptions and product safety, the cosmetic industry can foster innovation and consumer trust[49,55].

This study has implications that could extend to the development of personalized cosmetics and AI-driven consumer analytics as indicated by a large difference among groups in the analysis of age, texture and gender it becomes possible to have smaller, tailor-made product ranges based on the specific traits of the consumer. This can also be addressed through large-scale analysis of consumer data including the utilization of AI tools that would analyze sentiment from social media, digital skin analysis platforms or from purchase data to gain a better insight in consumers' preferences in comparison to the manual survey based approach utilized here. [56,57] The structured survey instrument developed in this study could be adapted as a standardized digital data collection module within such a platform.

LIMITATIONS

This study has several limitations that should be acknowledged clearly. The consumer sample, while adequately powered and demographically balanced, was drawn from a single geographic context urban university and community settings and may not reflect the cosmetic preferences of rural populations, older age groups outside the 18–45 range, or consumers in cultures with different cosmetic use norms or safety trust frameworks. Cross-cultural replication of the dual-validation framework across demographically and culturally diverse markets is the most important direction for future research[58,59].

Second, all consumer perception data are self-reported on Likert scales, which carry well-documented methodological limitations including social desirability bias, the halo effect (where a highly favorable response on one item inflates ratings on adjacent items), and the general constraints of introspective self-report as a window onto consumer behavior. Future studies would benefit from complementing Likert survey methodology with implicit association testing, behavioral product choice experiments, or eye-tracking methodologies that capture consumer responses less subject to deliberate self-presentation effects[60,61].

Third, the three prototype formulations were differentiated only by fragrance character; all other active and excipient variables were held constant. While this controlled comparison was valuable for isolating fragrance as a variable, it means that findings about the relative importance of other formulation parameters such as color, packaging form factor, post-application skin luminosity, or active ingredient feel-on-skin effects cannot be attributed to formulation differences in this

dataset and require independent investigation with differently designed formulation sets[62,63].

CONCLUSION

The objective of this research was to establish whether a dual-validation methodology; incorporating a systematic integration of lab-based physicochemical/safety assessments with the analysis of structured consumer perceptions, provides a more holistic, and commercially viable, foundation for cosmetic product development compared with single approaches. The findings of this study suggest that this is indeed the case.

All 3 prototype formulations proved to be chemically and physically stable (pH 5.5-6.2; viscosity 1,200-1,450 cP; no phase separation or microbial growth noted over 12 weeks), while dermatological testing identified the safety profile of 0% patch-tested irritation over 50 subjects, laying the technical foundation for consumer evaluation. Against this background of safe and stable products, the consumer study revealed that sensory aspects, namely texture (78.2%, Mean 4.3±0.6), fragrance (64.9%), and rate of absorption (59.0%), have a significant impact on consumer satisfaction; additionally 71.8% of volunteers felt more inclined to repurchase product if it were marketed as dermatologically tested. Supporting this was the statistically significant positive correlation between perceived safety and purchase intent (R^2=0.81), alongside significant differences between the means of sensory attributes ($F(2,185)=6.72$, $p<0.01$). Taken together these results strongly advocate the proposed dual-validation strategy, in which the cosmetic R&D arena needs to consider not only the functional validity of its formulations, but incorporate structured consumer research and develop a product that not only passes but also delights. Consumer perception cannot be considered a subsequent commercial aspect, but integral to the design specification. Together, these findings validate the dual-validation model as both conceptually sound and practically applicable. The model does not diminish the importance of formulation science rigorous laboratory evaluation remains essential, and the 0% irritation rate achieved here demonstrates that this standard can be met but it repositions consumer perception as a co-equal design requirement rather than a downstream commercial activity. The most effective cosmetic innovations will be those where the formulation chemist and the consumer scientist share the same design brief from the beginning of the development process.

The dual-validation process laid out herein will certainly be able to integrate with the evolving opportunities in AI-driven consumer analytics and personalised beauty. The survey instruments developed and statistical analysis methods here provide a template to be adapted, automated and integrated with existing and developing R&D technology.

Cross-cultural validation of the framework across diverse geographic markets particularly in markets where cosmetic use norms, safety trust dynamics, and sustainability salience differ from those studied here is the most urgent direction for future research. The cosmetic industry's capacity to deliver products that are genuinely both scientifically sound and deeply consumer-relevant depends on whether it is willing to build the institutional structures, research methodologies, and cross-functional collaborations necessary to treat these objectives as inseparable.

Acknowledgments

Authors are thankful to Teerthanker Mahaveer College of Pharmacy, Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India, for support.

Author contributions

Pragati Jain, Anurag Verma and Ashish Kumar Gupta contributed to the conceptualization and writing the original draft.

Disclosure statement

The authors declare that there are no conflicts of interest.

Additional information

Declaration

Consent to Publish declaration: not applicable

Ethics and Consent to Participate declarations: not applicable

Funding

No funding was received.

Ethical Approval

All consumer evaluation and dermatological patch-testing procedures were conducted in accordance with the ethical principles of the Declaration of Helsinki (2013 revision).

Abbreviations

Abbreviation	Full Term
ANOVA	Analysis of Variance
cfu	Colony-forming units
cP	Centipoise (unit of dynamic viscosity)
DTx	Digital Therapeutics
HDPE	High-Density Polyethylene
ICDRG	International Contact Dermatitis Research Group

ICH	International Council for Harmonisation of Technical Requirements for Pharmaceuticals for Human Use
O/W	Oil-in-water (emulsion type)
PCR	Post-Consumer Recycled
R^2	Coefficient of Determination
RH	Relative Humidity
SD	Standard Deviation
SEM	Standard Error of the Mean
SPSS	Statistical Package for the Social Sciences
T0/T4/T8/T12	Time point at 0 / 4 / 8 / 12 weeks
w/w	Weight per weight (concentration expression)
XAI	Explainable Artificial Intelligence

.REFERENCES

1. Bîrsan M, Gore E, Scripcariu Șadiye I, Vlad RA, Antonoaea P, Pintea C, et al. Multi-Active Cosmeceutical Formulations: Stability, Sensory Performance, and Skin Tolerability. Cosmetics 2025, Vol 12, Page 195 [Internet]. Multidisciplinary Digital Publishing Institute; 2025 [cited 2026 May 14];12:195. https://doi.org/10.3390/COSMETICS12050195

2. Gupta V, Mohapatra S, Mishra H, Farooq U, Kumar K, Ansari MJ, et al. Nanotechnology in Cosmetics and Cosmeceuticals—A Review of Latest Advancements. Gels [Internet]. MDPI; 2022 [cited 2026 May 15];8. https://doi.org/10.3390/gels8030173

3. Suthar M, Malik A, Marwal A. Role of nanotechnology in cosmetic development and skin care. Next Nanotechnology [Internet]. Elsevier; 2026 [cited 2026 May 15];9:100422. https://doi.org/10.1016/J.NXNANO.2026.100422

4. Vollmer DL, West VA, Lephart ED. Enhancing Skin Health: By Oral Administration of Natural Compounds and Minerals with Implications to the Dermal Microbiome. Int J Mol Sci [Internet]. Int J Mol Sci; 2018 [cited 2026 May 14];19. https://doi.org/10.3390/IJMS19103059

5. Foteva T. NANOTECHNOLOGY IN THE COSMETIC INDUSTRY (REVIEW). Journal of Chemical Technology and Metallurgy [Internet]. University of Chemical Technology and Metallurgy; 2024 [cited 2026 May 15];59:3–14. https://doi.org/10.59957/jctm.v59.i1.2024.1

6. Dhawan S, Sharma P, Nanda S. Cosmetic nanoformulations and their intended use. Nanocosmetics: Fundamentals, Applications and Toxicity. Elsevier Applied Science; 2020;141–69. https://doi.org/10.1016/B978-0-12-822286-7.00017-6

7. Parvin N, Aslam M, Alam MN, Mandal TK. Nanotechnology Driven Innovations in Modern Pharmaceutics: Therapeutics, Imaging, and Regeneration. Nanomaterials 2025, Vol 15, Page 1733 [Internet]. Multidisciplinary Digital Publishing Institute; 2025 [cited 2026 May 14];15:1733. https://doi.org/10.3390/NANO15221733

8. Ahuja A, Bajpai M. Novel Arena of Nanocosmetics: Applications and their Remarkable Contribution in the Management of Dermal Disorders, Topical Delivery, Future Trends and Challenges. Curr Pharm Des [Internet]. Bentham Science Publishers Ltd.; 2024 [cited 2026 May 15];30:115–39. https://doi.org/10.2174/0113816128288516231228101024

9. Pintea A, Manea A, Pintea C, Vlad RA, Bîrsan M, Antonoaea P, et al. Peptides: Emerging Candidates for the Prevention and Treatment of Skin Senescence: A Review. Biomolecules [Internet]. Multidisciplinary Digital Publishing Institute (MDPI); 2025 [cited 2026 May 14];15:88. https://doi.org/10.3390/BIOM15010088

10. González-Minero FJ, Bravo-Díaz L. The use of plants in skin-care products, cosmetics and fragrances: Past and present. Cosmetics [Internet]. MDPI AG; 2019 [cited 2026 May 15];5. https://doi.org/10.3390/cosmetics5030050

11. Gupta V, Mohapatra S, Mishra H, Farooq U, Kumar K, Ansari MJ, et al. Nanotechnology in Cosmetics and Cosmeceuticals—A Review of Latest Advancements. Gels. MDPI; 2022;8. https://doi.org/10.3390/GELS8030173

12. Badilli U, Inal O. Current Approaches in Cosmeceuticals: Peptides, Biotics and Marine Biopolymers. Polymers (Basel) [Internet]. Multidisciplinary Digital Publishing Institute (MDPI); 2025 [cited 2026 May 14];17:798. https://doi.org/10.3390/POLYM17060798

13. Queen D, Trager MH, Fan W, Samie FH. Patient Satisfaction of General Dermatology Providers: A Quantitative and Qualitative Analysis of 38,008 Online Reviews. JID Innov [Internet]. Elsevier; 2021 [cited 2026 May 14];1:100049. https://doi.org/10.1016/J.XJIDI.2021.100049

14. Kligman AM. Cosmetics: A dermatologist looks to the future - Promises and problems. Dermatol Clin [Internet]. W.B. Saunders; 2000 [cited 2026 May 15];18:699–709. https://doi.org/10.1016/S0733-8635(05)70221-7

15. Impact of Sensory Marketing on Purchase Decisions among Generation Z Consumers. 2026 [cited 2026 May 14]; https://doi.org/10.5281/zenodo.18950265

16. Kaul S, Gulati N, Verma D, Mukherjee S, Nagaich U. Role of Nanotechnology in Cosmeceuticals: A Review of Recent Advances. J Pharm (Cairo). Hindawi Limited; 2018;2018:1–19. https://doi.org/10.1155/2018/3420204

17. Raj S, Jose S, Sumod US, Sabitha M. Nanotechnology in cosmetics: Opportunities and challenges. J Pharm Bioallied Sci. 2012;4:186–93. https://doi.org/10.4103/0975-7406.99016

18. Fatima M, Monawwar S, Mohapatra S, Alex TS, Ahmed A, Taleuzzaman M, et al. In silico drug screening based development of novel formulations for onychomycosis management. Gels. MDPI; 2021;7. https://doi.org/10.3390/GELS7040221

19. Andrei F. Sensory Science in Cosmetics. Cosmetic Industry - Trends, Products and Quality Control. IntechOpen; 2025; https://doi.org/10.5772/INTECHOPEN.1009804

20. Christensen JF, Farahi F, Vartanian M, Yazdi SHN. Choice Hygiene for "Consumer Neuroscientists"? Ethical Considerations and Proposals for Future Endeavours. Front Neurosci [Internet]. Frontiers Media S.A.; 2022 [cited 2026 May 14];15:612639. https://doi.org/10.3389/FNINS.2021.612639

21. Mota S, Sousa E, Cruz MT, Martins de Almeida I. Occurrence and ecotoxicity of cosmetic ingredients in aquatic ecosystems: A narrative review. Emerg Contam [Internet]. Elsevier; 2025 [cited 2026 May 14];11:100512. https://doi.org/10.1016/J.EMCON.2025.100512

22. Alnuqaydan AM. The dark side of beauty: an in-depth analysis of the health hazards and toxicological impact of synthetic cosmetics and personal care products. Front Public Health [Internet]. Frontiers Media SA; 2024 [cited 2026 May 14];12:1439027. https://doi.org/10.3389/FPUBH.2024.1439027

23. Abramson J, Adler J, Dunger J, Evans R, Green T, Pritzel A, et al. Accurate structure prediction of biomolecular interactions with AlphaFold 3. Nature. Nature Research; 2024;630:493–500. https://doi.org/10.1038/S41586-024-07487-W

24. Raja S. The Study on the Impact of Eco-Friendly Packaging on Consumer Behavior. 2026;

25. Zhou H, Luo D, Chen D, Tan X, Bai X, Liu Z, et al. Current advances of nanocarrier technology-based active cosmetic ingredients for beauty applications. Clin Cosmet Investig Dermatol [Internet]. Dove Medical Press Ltd; 2021 [cited 2026 May 15];14:867–87. https://doi.org/10.2147/CCID.S313429

26. Levesque S, Robertson M, Klimas C. A life cycle assessment of the environmental impact of children's toys. Sustain Prod Consum [Internet]. Elsevier B.V.; 2022 [cited 2026 May 14];31:777–93. https://doi.org/10.1016/j.spc.2022.03.001

27. Solans C, Solé I. Nano-emulsions: Formation by low-energy methods. Curr Opin Colloid Interface Sci. 2012;17:246–54. https://doi.org/10.1016/J.COCIS.2012.07.003

28. Winuprasith T, Koirala P, McClements DJ, Khomein P. Emulsion Technology in Nuclear Medicine: Targeted Radionuclide Therapies, Radiosensitizers, and Imaging Agents. Int J Nanomedicine. Dove Medical Press Ltd; 2023;18:4449–70. https://doi.org/10.2147/IJN.S416737

29. Nor Bainun I, Alias NH, Syed-Hassan SSA. Nanoemulsion: Formation, Characterization, Properties and Applications - A Review. Adv Mat Res. Trans Tech Publications, Ltd.; 2015;1113:147–52. https://doi.org/10.4028/WWW.SCIENTIFIC.NET/AMR.1113.147

30. Thompson KA, Goodale DB. The recent development of propofol (DIPRIVAN®). Intensive Care Medicine, Supplement. Springer Verlag; 2000;26. https://doi.org/10.1007/PL00003783

31. Pharma Times Artificial Intelligence: Milestones and role in Pharma and Healthcare Sector Pharma Times. 2019;

32. Santos AC, Morais F, Simões A, Pereira I, Sequeira JAD, Pereira-Silva M, et al. Nanotechnology for the development of new cosmetic formulations. Expert Opin Drug Deliv. Taylor and Francis Ltd; 2019;16:313–30. https://doi.org/10.1080/17425247.2019.1585426

33. Chatzidaki MD, Mitsou E. Advancements in Nanoemulsion-Based Drug Delivery Across Different Administration Routes. Pharmaceutics [Internet].

Multidisciplinary Digital Publishing Institute (MDPI); 2025 [cited 2026 May 15];17:337. https://doi.org/10.3390/PHARMACEUTICS17030337

34. Tatlipinar S, Akpek EK. Topical ciclosporin in the treatment of ocular surface disorders. British Journal of Ophthalmology. 2005;89:1363–7. https://doi.org/10.1136/BJO.2005.070888

35. Mamun MNH. ROLE OF AI AND DATA SCIENCE IN DATA-DRIVEN DECISION MAKING FOR IT BUSINESS INTELLIGENCE: A SYSTEMATIC LITERATURE REVIEW. ASRC Procedia: Global Perspectives in Science and Scholarship. American Scholarly Publishing Group Inc; 2025;01:564–88. https://doi.org/10.63125/N1XPYM21

36. Ajazzuddin M, Jeswani G, Jha A. Nanocosmetics: Past, Present and Future Trends. Recent Pat Nanomed. Bentham Science Publishers Ltd.; 2015;5:3–11. https://doi.org/10.2174/1877912305666150417232826

37. Gupta V, Mohapatra S, Mishra H, Farooq U, Kumar K, Ansari MJ, et al. Nanotechnology in Cosmetics and Cosmeceuticals—A Review of Latest Advancements. Gels [Internet]. MDPI; 2022 [cited 2026 May 15];8:173. https://doi.org/10.3390/GELS8030173

38. Boz Z, Korhonen V, Sand CK. Consumer considerations for the implementation of sustainable packaging: A review. Sustainability (Switzerland). MDPI; 2020;12. https://doi.org/10.3390/SU12062192

39. Bócoli PFJ, Gomes VE de S, Maia AAD, Marangoni Júnior L. Perspectives on Eco-Friendly Food Packaging: Challenges, Solutions, and Trends. Foods. Multidisciplinary Digital Publishing Institute (MDPI); 2025;14. https://doi.org/10.3390/FOODS14173062

40. Karaosmanoglu E, Altınigne N. The Importance of Web Atmospherics with Emphasis on Visual Complexity in Online Retailing Based on S-O-R Paradaigm. Pressacademia. Pressacademia; 2017;6:348–54. https://doi.org/10.17261/PRESSACADEMIA.2017.767

41. Wang F, Wang K, Han Y, Cho JH. Influences of design-driven FMCG on consumers' purchase intentions: A test of S-O-R model. Humanit Soc Sci Commun. Springer Nature; 2024;11. https://doi.org/10.1057/S41599-024-03362-1

42. Petropoulos F, Laporte G, Aktas E, Alumur SA, Archetti C, Ayhan H, et al. Operational Research: methods and applications. Journal of the Operational Research Society [Internet]. Taylor & Francis; 2024 [cited 2026 May 14];75:423–617. https://doi.org/10.1080/01605682.2023.2253852

43. CONSUMER BEHAVIOUR MADHYA PRADESH BHOJ (OPEN) UNIVERSITY-BHOPAL. [cited 2026 May 14]; www.vikaspublishing.com. Accessed 14 May 2026

44. Sitopu JW, Firdaus A. Analyzing the Impact of Packaging Design on Consumer Purchasing Decisions in the Cosmetics Industry. Journal on Economics, Management and Business Technology [Internet]. 2024 [cited 2026 May 14];3:1–8. https://doi.org/10.35335/JEMBUT.V3I1.220

45. Consumers willing to pay 9.7% sustainability premium, even as cost-of-living and inflationary concerns weigh: PwC 2024 Voice of the Consumer Survey | PwC [Internet]. [cited 2026 May 14]. https://www.pwc.com/gx/en/news-room/press-releases/2024/pwc-2024-voice-of-consumer-survey.html. Accessed 14 May 2026

46. Ali I, Qasrawi J, Sakhin J, Nasasrah Y. Cosmetic Safety Practices and Adverse Effects Among Female Students: A Cross-Sectional Study. 2025 [cited 2026 May 14]; https://doi.org/10.21203/RS.3.RS-6997761/V1

47. Vieira D, Duarte J, Vieira P, Gonçalves MBS, Figueiras A, Lohani A, et al. Regulation and Safety of Cosmetics: Pre- and Post-Market Considerations for Adverse Events and Environmental Impacts. Cosmetics [Internet]. Multidisciplinary Digital Publishing Institute (MDPI); 2024 [cited 2026 May 14];11. https://doi.org/10.3390/COSMETICS11060184

48. Montero-Vega M, Estrada M, Thigulla DT. Understanding the impact of socio-demographic differences on acceptance of last-mile delivery technologies: A comparative analysis. J Transp Geogr [Internet]. Pergamon; 2025 [cited 2026 May 15];126:104244. https://doi.org/10.1016/J.JTRANGEO.2025.104244

49. Correia R, Marques T, Meneses R, Venciute D. Trust in Others' Mirrors: How UGC Shapes Confidence in Aesthetic Medicine. Journal of Global Marketing [Internet]. Routledge; 2026 [cited 2026 May 14]; https://doi.org/10.1080/08911762.2026.2638908

50. The World Health Organization quality of life assessment (WHOQOL): Position paper from the World Health Organization. Soc Sci Med. 1995;41:1403–9. https://doi.org/10.1016/0277-9536(95)00112-K

51. Sapkota KP, Shrestha A, Ghimire S, Mistry SK, Yadav KK, Yadav SC, et al. Neighborhood environment and quality of life of older adults in eastern Nepal: findings from a cross-sectional study. BMC Geriatr [Internet]. BioMed Central Ltd; 2024 [cited 2026 May 15];24:679. https://doi.org/10.1186/S12877-024-05278-6

52. Xue Y, Zhang X, Zhang Y, Luo E. Understanding the Barriers to Consumer Purchasing of Electric Vehicles: The Innovation Resistance Theory. Sustainability 2024, Vol 16, Page 2420 [Internet]. Multidisciplinary Digital

Publishing Institute; 2024 [cited 2026 May 14];16:2420. https://doi.org/10.3390/SU16062420

53. Bilal M, Zhang Y, Cai S, Akram U, Halibas A. Artificial intelligence is the magic wand making customer-centric a reality! An investigation into the relationship between consumer purchase intention and consumer engagement through affective attachment. Journal of Retailing and Consumer Services [Internet]. Pergamon; 2024 [cited 2026 May 14];77:103674. https://doi.org/10.1016/J.JRETCONSER.2023.103674

54. Hair JF, Black WC, Babin BJ, Anderson RE. MULTIVARIATE DATA ANALYSIS EIGHTH EDITION. 2019 [cited 2026 May 14]; www.cengage.com/highered. Accessed 14 May 2026

55. Li H, Relich M. A Data-Driven Approach for Improving Sustainable Product Development. Sustainability 2023, Vol 15, Page 6736 [Internet]. Multidisciplinary Digital Publishing Institute; 2023 [cited 2026 May 14];15:6736. https://doi.org/10.3390/SU15086736

56. (PDF) Brand Authenticity of Luxury Products: Exploring the Ruling Relationship between Consumer and Brand as Policy-Actor Groups [Internet]. [cited 2026 May 14]. https://www.researchgate.net/publication/383032203_Brand_Authenticity_of_Luxury_Products_Exploring_the_Ruling_Relationship_between_Consumer_and_Brand_as_Policy-Actor_Groups. Accessed 14 May 2026

57. Leena Haniffah N, Sharaf Shaiban M, Ahmed P. Development and validation of a performance measurement system based on Islamic principles. Heliyon [Internet]. Elsevier Ltd; 2023 [cited 2026 May 14];9:e16095. https://doi.org/10.1016/J.HELIYON.2023.E16095

58. Abrams AMH, Dautzenberg PSC, Jakobowsky C, Ladwig S, Rosenthal-Von Der Pütten AM. A theoretical and empirical reflection on technology acceptance models for autonomous delivery robots. ACM/IEEE International Conference on Human-Robot Interaction. IEEE Computer Society; 2021;272–80. https://doi.org/10.1145/3434073.3444662

59. de Luis García E. COMBATING CHILD SEXUAL ABUSE ON THE INTERNET: CONSIDERATIONS IN THE LIGHT OF THE PROPOSAL FOR A REGULATION. Actualidad Juridica Iberoamericana. Ibero-American Law Institute; 2024;104–29. https://doi.org/10.13039/501100011033

60. Bai Y, Li H. Mapping the evolution of e-commerce research through co-word analysis: 2001–2020. Electron Commer Res Appl [Internet]. Elsevier B.V.; 2022 [cited 2026 May 15];55. https://doi.org/10.1016/j.elerap.2022.101190

61. Sarti S, Darnall N, Testa F. Market segmentation of consumers based on their actual sustainability and health-related purchases. J Clean Prod. Elsevier Ltd; 2018;192:270–80. https://doi.org/10.1016/J.JCLEPRO.2018.04.188

62. Makovski TT, Schmitz S, Zeegers MP, Stranges S, van den Akker M. Multimorbidity and quality of life: Systematic literature review and meta-analysis. Ageing Res Rev. Elsevier Ireland Ltd; 2019;53. https://doi.org/10.1016/J.ARR.2019.04.005

63. Aaker JL, Williams P. Empathy versus pride: The influence of emotional appeals across cultures. Journal of Consumer Research. University of Chicago Press; 1998;25:241–61. https://doi.org/10.1086/209537

.