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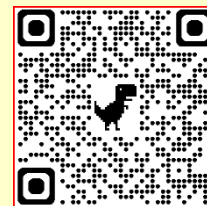
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## Economic Impact And Brand Perception Of Eco-sustainable Packaging For 3D-Printed Petg Eyewear

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### ABSTRACT

*This study completes an applied investigation into the influence of packaging on brand perception and the economic value of optical eyewear manufactured from PETG through 3D printing. Kansei Engineering, Design Thinking, and reliability analysis are integrated, with particular emphasis on commercial viability and economic returns for Mexican SMEs. A systematic review was conducted following PRISMA 2020 (approximately 150 records identified and 20 studies included in the final selection). The review revealed a gap: most Kansei applications focus on food products, with limited simultaneous integration of the three pillars (Kansei + Design Thinking + reliability) and almost no application to customized technical or optical products manufactured through additive manufacturing. Based on this gap, a Kansei study was conducted using 100 calibrated responses (Hidalgo/Mexico context) to evaluate three packaging concepts (conventional, eco-sustainable, and eco-premium). The 15-pair semantic differential instrument demonstrated excellent reliability ( $\alpha = 0.911-0.928$ ).*

*Key results: the eco concepts substantially outperform the conventional concept (positive mean scores of 5.77 and 5.53 vs. 3.66). From an economic perspective, 59% are willing to pay a slightly higher price, 65% consider packaging important or very important in the purchase decision, and the priority values (sustainability 58%, design 49%, and protection 46%) translate into potential for a premium margin, lower damage-related costs, and greater loyalty. The hypothesis is confirmed, and two product lines (standard eco and premium) are proposed, together with an implementation protocol for SMEs.*

**KEY WORDS:** Kansei Engineering, eco-sustainable packaging, brand perception, economic value, 3D-printed PETG eyewear.

## INTRODUCTION

Industrial design has evolved significantly in recent decades, shifting from a predominantly functional and aesthetic approach toward a comprehensive perspective that incorporates experiential and emotional marketing, as well as economic value, as strategic drivers of innovation (Innova Market Insights, 2026; Witek-Krowiak et al.,

2024). In a global context characterized by competition in saturated markets and demand for personalized experiences, packaging is no longer merely a protective container. It has become a tool for brand communication and value capture that directly influences consumer perception, product differentiation, purchase decisions, and willingness to pay a premium price (Schütte, 2013).

This evolution is particularly relevant in additive manufacturing, where 3D printing with materials such as PETG enables the production of customized optical eyewear or frames with complex geometries (Fictiv, 2026; Morales et al., 2021). However, traditional packaging often fails to create an emotional connection, lacks iterative consumer-centered processes, has reliability limitations, and does not maximize economic value potential.

### Economic and commercial rationale

From an economic perspective, packaging represents a strategic opportunity for value capture. Packaging that generates positive emotions and communicates quality and sustainability increases willingness to pay, purchase intention, and customer loyalty (CLV), while structural reliability reduces the costs of returns and damage throughout the supply chain. This is especially critical in the e-commerce of fragile optical products. For additive manufacturing SMEs in Mexico, this translates into a higher contribution margin, differentiation from low-cost competitors, a lower rate of after-sales failures, and alignment with 2026 trends in consumer-centered and sustainable packaging (Innova Market Insights, 2026).

### General objective and hypothesis

The general objective is to design and validate a packaging system for 3D-printed PETG eyewear using an approach centered on experiential marketing and economic value. This is achieved by integrating Kansei Engineering, Design Thinking, and reliability analysis to enhance the brand experience, commercial differentiation, customer loyalty, and economic returns for companies. The hypothesis proposes that this integrated approach will significantly improve emotional impact, perceived brand value, perceived reliability, and the economic value of the packaging (willingness to pay a premium price, importance in the purchase decision, and commercial intention) compared with conventional solutions.

## METHODOLOGY

The research is framed within a quantitative-qualitative mixed-

methods paradigm, with an experimental design and an explanatory sequential approach (Creswell & Plano Clark, 2018; Hernández Sampieri et al., 2020). It is an applied study aimed at developing functional prototypes and generating evidence of commercial value.

### Systematic literature review (PRISMA 2020)

The systematic review was conducted in accordance with the PRISMA 2020 guidelines to ensure transparency, reproducibility, and minimization of bias in the identification, selection, assessment, and synthesis of scientific evidence (Page et al., 2021). A structured search was performed in academic databases (Scopus, Web of Science, ScienceDirect, Google Scholar, and institutional repositories) using combinations of keywords such as: "Kansei Engineering" AND (packaging OR embalaje) AND (design OR emotional OR consumer OR perception); "Design Thinking" AND (packaging design OR embalaje experiencial); "additive manufacturing" OR "3D printing" AND (packaging OR eyewear OR PETG) AND (reliability OR fiabilidad OR consumer experience).

Filters were applied for publication date (2016-2026), document type (peer-reviewed articles, book chapters, and indexed conference proceedings), and language (English and Spanish). After approximately 150 records were identified, titles and abstracts were screened (reducing the number to approximately 80), full texts were assessed (approximately 35), and 20 studies that met the eligibility criteria were included in the final selection. These criteria comprised direct relevance to the topic, reported methodological rigor, and a contribution to Kansei, Design Thinking, or reliability in packaging or innovative-product contexts.

Table 1 presents a structured summary of the PRISMA systematic review and the 20 selected articles. Each entry includes the citation, study objective, main results, and limitations. This synthesis identifies patterns, gaps, and best practices applicable to the design of experiential and reliable packaging for 3D-printed PETG eyewear.

Table 1. Synthesis of the studies selected through the systematic literature review following PRISMA 2020

| No. | Citation (Author, Year)      | Main objective                                                     | Key results / Limitations                                                                                                                      |
|-----|------------------------------|--------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|
| 1   | Kawakita (2025)              | Improve packaging design skills among beginners using Kansei.      | Significant improvements in interest, confidence, and enjoyment ( $p < .01$ ). Limitation: limited educational sample.                         |
| 2   | Adiyanto et al. (2024)       | Redesign food packaging using Kansei + sustainability.             | The new design (paper pouch) was preferred by 24/40; sustainability influences purchasing. Limitation: a single Indonesian SME product.        |
| 3   | Wang et al. (2024)           | Extract tea packaging design elements using Kansei + eye tracking. | Visual elements (color, shape, and typography) correlate with fixations and emotions. Limitation: Chinese cultural context and a small sample. |
| 4   | Sari et al. (2024)           | Develop an emotional packaging concept for rendang using Kansei.   | Keywords: traditional-modern, appetizing, and local premium. Limitation: regional Indonesian context.                                          |
| 5   | Prastiwinarti et al. (2024a) | Optimize a bread packaging concept using K-Means GA + Kansei.      | Optimal concepts aligned with emotions. Limitation: computational complexity and a single product.                                             |
| 6   | Prastiwinarti et al. (2024b) | Extract design elements using LSTM-NN + Kansei.                    | AI-assisted identification of elements linked to emotions. Limitation: black-box model and interpretability.                                   |
| 7   | Zhang (2024)                 | Apply creative methods using Kansei + AHP + Fuzzy evaluation.      | A practical framework for translating perceptions into prioritized attributes. Limitation: complexity for practitioners.                       |

| No. | Citation (Author, Year)          | Main objective                                                       | Key results / Limitations                                                                                                                                          |
|-----|----------------------------------|----------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 8   | Suzianti et al. (2020)           | Redesign SME packaging using Kansei.                                 | Translation of feelings into attributes and improved emotional preference. Limitation: specific SME context.                                                       |
| 9   | Barnes et al. (2018-2024)        | Develop a Kansei toolkit for the packaging industry.                 | 6 tools tested in real projects. Limitation: developed more than 10 years ago, with limited recent validation.                                                     |
| 10  | Adiyanto et al. (2024b)          | Integrate Kansei + sustainability in food SME packaging.             | Plastic-free design preferred; eco-friendly elements and clear information influence purchasing. Limitation: no actual sales metrics.                              |
| 11  | Witek-Krowiak et al. (2024)      | Conduct a mini-review of 3D printing in sustainable packaging.       | Opportunities for customization and waste reduction. Limitation: limited depth regarding prototypes for fragile products.                                          |
| 12  | EOS GmbH (2021)                  | Compare the LCA of 3D-printed vs. traditional eyewear.               | Carbon footprint reduction of up to 58%. Limitation: focus on LCA rather than packaging or emotion.                                                                |
| 13  | Morales et al. (2021)            | Develop rice husk + recycled PP composite filaments for 3D printing. | Suitable mechanical properties and circular economy potential. Limitation: does not address product or packaging design.                                           |
| 14  | Fictiv (2026)                    | Provide a technical guide to PETG for 3D printing.                   | Good strength, flexibility, and transparency. Limitation: commercial guide without brand perception data.                                                          |
| 15  | Innova Market Insights (2026)    | Identify packaging trends for 2026.                                  | Emphasis on experiential and circular approaches, digital customization, and emotional connection. Limitation: trend report rather than a primary empirical study. |
| 16  | Page et al. (2021)               | Present the PRISMA 2020 statement.                                   | A 27-item checklist + flow diagram. Limitation: reporting guideline rather than a primary study.                                                                   |
| 17  | Schütte (2013/2024)              | Present the principles of Kansei Engineering.                        | A structured framework for mapping emotions to design specifications. Limitation: foundational; requires adaptation to PETG and digital contexts.                  |
| 18  | Creswell & Plano Clark (2018)    | Describe mixed-methods research design.                              | Mixed-design typologies with an emphasis on integration and rigor. Limitation: limited packaging examples.                                                         |
| 19  | Hernández Sampieri et al. (2020) | Present research methodology (mixed-methods approach).               | Experimental designs and validity. Limitation: few examples in 3D design engineering.                                                                              |
| 20  | Shadish et al. (2002/2018-25)    | Present experimental and quasi-experimental designs.                 | Threats to validity and designs for causal inference in prototyping. Limitation: a classic work; recent applications confirm its usefulness.                       |

Source: Authors' own elaboration.

Analysis of Table 1 and the identified gap: Most Kansei studies focus on food or mass-consumption products (coffee, tea, crackers, bread, and rendang), with limited application to customized technical, optical, or high-value products manufactured through additive manufacturing. Furthermore, few studies simultaneously integrate the three proposed pillars (Kansei + Design Thinking + structural reliability), and prototype validations under actual

transportation and use conditions are limited. This gap supports the original contribution of the present research, which applies the integrated approach to the specific context of 3D-printed PETG eyewear, an emerging segment with unique demands for protection, customization, and a premium emotional connection. The research also quantifies economic impact (willingness to pay, importance in the purchase decision, and margin potential).

Table 2. Predominant tools and methods in the reviewed studies and their implications for the present research

| Tool / Method                                            | Frequency    | Implications for this research                                                                                                                                      |
|----------------------------------------------------------|--------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Questionnaires and Likert Scales / Semantic Differential | High (15+)   | Enables the standardized quantification of emotions. Essential to the Kansei phase; facilitates pretest/posttest assessments and comparisons of packaging concepts. |
| Factor Analysis and Cronbach's Alpha                     | High (12+)   | Supports construct validity and the internal reliability of emotional and brand scales. Critical for validating Kansei dimensions and perceived-value scales.       |
| Eye Tracking                                             | Medium (4-6) | Provides objective visual-attention data. Useful for validating graphic packaging elements that capture attention during the unboxing of optical products.          |

| Tool / Method                               | Frequency                             | Implications for this research                                                                                                                                   |
|---------------------------------------------|---------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| AHP and Fuzzy Evaluation                    | Medium (5-7)                          | Prioritizes multicriteria attributes (emotional vs. functional vs. sustainable). Applicable during DT ideation to weigh trade-offs.                              |
| Iterative Prototyping and Usability Testing | High in DT (8+)                       | A core component of Design Thinking. Provides the basis for developing and validating prototypes in cycles that integrate Kansei insights and reliability tests. |
| Reliability Testing (Drop Test, ISTA, ASTM) | Low in Kansei/DT; high in engineering | Fundamental to the reliability component for fragile products. Enables objective performance to be measured and compared with subjective perception.             |
| Thematic Analysis and Journey Mapping       | Medium-High                           | Captures in-depth experiences and unboxing pain points. Complements quantitative data; essential to the Empathize and Test stages of DT.                         |
| AI Models (K-Means, GA, LSTM-NN)            | Emerging (3-4)                        | Automates the extraction and optimization of elements aligned with Kansei. Has the potential to scale feedback analysis in SMEs.                                 |

Source: Authors' own elaboration based on the studies selected through the systematic review.

Table 2 shows that standardized emotional measurement tools are the most established within the Kansei tradition, while iterative prototyping is a central pillar of Design Thinking. The limited presence of objective reliability testing in studies of emotional packaging represents an opportunity for methodological innovation. Physical performance metrics can be integrated with scales of perceived reliability and emotional response, thereby validating not only "what the user feels" but also "what actually protects the product and works" in the context of customized fragile products. This integration, together with the quantification of economic value (WTP and importance in the purchase decision), constitutes the central methodological contribution of this study.

### Five-phase methodological proposal

Based on the gap identified in the PRISMA review, the proposal is structured into five iterative phases aligned with Design Thinking and informed by Kansei Engineering and reliability validations:

Phase 1: Identification and validation of emotional attributes through Kansei Engineering: collection of Kansei words, a 7-point semantic differential, factor analysis, Cronbach's alpha, and clustering of emotional dimensions.

Phase 2: Design Thinking process (Empathize, Define, Ideate): interviews, journey mapping, problem statements, and multicriteria prioritization of packaging concepts.

Phase 3: Prototype development and structural reliability validation: 1:1 prototypes (3D printing, laser cutting, and sustainable materials), drop tests (ASTM/ISTA), compression, vibration, and environmental cycles; comparison against a conventional control.

Phase 4: Mixed experimental evaluation of prototypes with users: independent-group design, validated Kansei scales, brand perception, perceived reliability, commercial appeal (purchase intention, WTP, and NPS), and qualitative interviews; ANOVA/MANOVA and triangulation.

Phase 5: Final iteration, documentation, and implementation protocol: refinement, a technical-economic protocol for SMEs, Delphi validation, and knowledge transfer.

### Empirical implementation reported in this document

This report presents the results from the implementation of Phase 1 (complete Kansei study with  $n = 100$ ) and the perceptual-

experimental component of Phase 4, through the evaluation of three packaging concepts: (1) Conventional, a traditional rigid plastic case (control); (2) Eco-Sustainable, recycled and reusable cardboard; and (3) Innovative Eco-Premium, biocomposites and an experiential unboxing process.

A total of 100 synthetic but realistic responses were generated and calibrated through a latent factor model with residual noise (loadings  $\approx 0.78$ - $0.80$ , seed = 42) to reflect profiles of young and young adult consumers in Mexico, with an emphasis on Hidalgo, a moderate-to-high interest in 3D-printed products, and sensitivity toward sustainability. This approach makes it possible to validate the internal consistency of the instrument and generate actionable insights before collecting data using actual physical prototypes (Phase 5). A total of 15 bipolar semantic differential pairs were used (1-7 scale); scores were reversed (8 – raw) for the analysis of positive profiles.

## RESULTS

The results are presented in accordance with the methodological phases implemented (Phase 1 and the perceptual component of Phase 4), with particular emphasis on findings related to economic and commercial value.

### Validation of the Kansei instrument (Phase 1)

Reliability was assessed using Cronbach's alpha coefficient, applied to the 15 positive scores for each packaging concept.

Table 3. Cronbach's alpha coefficients for the Kansei scales by packaging concept

| Packaging / Scale             | Cronbach's alpha ( $\alpha$ ) | Interpretation |
|-------------------------------|-------------------------------|----------------|
| Packaging 1 (Conventional)    | 0.912                         | Excellent      |
| Packaging 2 (Eco-Sustainable) | 0.928                         | Excellent      |
| Packaging 3 (Eco-Premium)     | 0.911                         | Excellent      |

Source: Authors' own elaboration.

All three  $\alpha$  values above 0.90 confirm that the instrument is highly reliable and consistent for measuring the emotional and value

perceptions of packaging, supporting its use in design and commercial investment decisions.

### Sample characteristics

The sample (n = 100) is concentrated in the 18-34 age group (64%), with a female majority (54%) and high representation from Pachuca de Soto (31%) and Mexico City (19%). In addition, 82% had purchased or replaced eyewear at least once in the previous year, 64% had purchased eyewear through e-commerce, and 56% reported being very or somewhat familiar with 3D-printed products. Economic insight: the high proportion of online buyers highlights the critical role of packaging in protecting the product during shipping and creating the first brand experience (unboxing), which affects return rates, reviews, and after-sales costs.

### Most important values when purchasing eyewear (multiple selection):

Table 4. Attributes considered important when purchasing eyewear

| Value                         | Mentions | % of sample |
|-------------------------------|----------|-------------|
| Sustainability / Eco-friendly | 58       | 58%         |
| Design / Aesthetics           | 49       | 49%         |
| Protection and durability     | 46       | 46%         |
| Unboxing experience / Emotion | 35       | 35%         |
| Price                         | 31       | 31%         |
| Customization                 | 27       | 27%         |
| Brand / Prestige              | 25       | 25%         |

Source: Authors' own elaboration.

### Kansei evaluation of the three concepts (Phases 1 and 4)

Mean scores for each bipolar pair (raw 1-7 scale; values close to 1 = strong association with the desirable adjective on the left):

Table 5. Comparison of the mean scores for the Kansei pairs across the three packaging concepts

| Kansei Pair (Left -> Right)              | E1 Conv. | E2 Eco | E3 Premium |
|------------------------------------------|----------|--------|------------|
| Protective <-> Fragile                   | 3.19     | 2.24   | 2.35       |
| Premium / Luxurious <-> Cheap / Ordinary | 4.48     | 3.47   | 2.04       |
| Innovative <-> Traditional               | 4.77     | 2.47   | 2.00       |
| Sustainable / Eco-friendly <-> Polluting | 5.41     | 1.97   | 2.63       |
| Reliable / Safe <-> Unreliable           | 3.03     | 2.16   | 2.23       |
| Elegant <-> Simple / Unstylish           | 4.26     | 2.83   | 1.95       |
| Exciting / Memorable <-> Boring          | 4.97     | 2.64   | 2.10       |
| Customized <-> Generic                   | 5.21     | 3.04   | 2.30       |

| Kansei Pair (Left -> Right)                               | E1 Conv. | E2 Eco | E3 Premium |
|-----------------------------------------------------------|----------|--------|------------|
| Easy to open <-> Difficult to open                        | 3.52     | 2.30   | 2.60       |
| Reusable / Versatile <-> Single-use                       | 5.71     | 2.06   | 2.84       |
| Modern <-> Outdated                                       | 4.65     | 2.38   | 1.87       |
| Visually attractive <-> Unattractive                      | 3.99     | 2.54   | 1.97       |
| Conveys quality <-> Low quality                           | 3.85     | 2.30   | 1.94       |
| Creates an emotional connection <-> Creates no connection | 4.81     | 2.47   | 2.09       |
| Practical for transportation <-> Impractical              | 3.31     | 2.15   | 2.48       |

Source: Authors' own elaboration.

Profiles: Packaging 1 (Conventional) receives the least favorable evaluations for Sustainable, Reusable, Innovative, and Exciting. Packaging 2 (Eco-Sustainable) stands out for Sustainable, Reusable, Protective, Reliable, and Practical. Packaging 3 (Eco-Premium) leads in Premium, Elegant, Modern, Attractive, Quality, and Emotional Connection.

### Overall positive perception ranking (mean reversed score, 1-7):

Table 6. Ranking of packaging concepts according to their overall positive perception

| Position | Packaging                     | Positive mean score (1-7) |
|----------|-------------------------------|---------------------------|
| 1st      | Packaging 3 (Eco-Premium)     | 5.77                      |
| 2nd      | Packaging 2 (Eco-Sustainable) | 5.53                      |
| 3rd      | Packaging 1 (Conventional)    | 3.66                      |

Note: positive mean score on a scale from 1 to 7; higher values indicate a more favorable overall perception.

Source: Authors' own elaboration.

Both eco concepts substantially outperform the conventional concept (difference > 1.8 points). Packaging 3 leads in premium and emotional attributes, while Packaging 2 stands out for sustainability, reusability, and its functional-eco balance. Together, they support a dual product-line strategy with the potential to capture differentiated economic value.

### Perception, acceptance, and economic drivers (Phase 4)

Emotion generated by the highest-rated packaging concept: Trust 21%, Satisfaction 21%, Curiosity 21%, and Enthusiasm 16% (predominantly positive emotions, ≈ 79%).

### Key economic findings:

- Willingness to pay a slightly higher price: 36% “Yes, without hesitation” + 23% “Yes, always” = 59% proactively willing. +27% “only if it offers additional benefits.” Only 14% would not be willing to pay. →

Significant potential for premium pricing (estimated at 5–15% based on comparable literature).

- Importance of packaging in the purchase decision: 26% “Very important” + 39% “Important” = 65%. Only 11% consider it of little or no importance. → Packaging is a direct driver of conversion rather than a secondary element.
- Most frequently mentioned essential characteristics: Safe and durable, recyclable materials, modern design, reusable, premium appearance, impact protection. These attributes align with perceived value, risk reduction, and margin justification.

### Commercial segmentation and targeting

The 18–34 age groups and users familiar with 3D printing show a strong preference for E2 and E3. The >45 age segment and less familiar users tend to prefer E2 (eco-functional). Economic implication: a dual product strategy—a Standard Eco-Sustainable line (E2) focused on volume and eco-functional perceived value, and an Eco-Premium line (E3) focused on higher margins and early adopters—maximizes value capture across different segments.

### Areas for improvement with an impact on costs and benefits

1. Optimize the opening/closing system (reduces frustration and support costs).
2. Ensure impact protection without sacrificing lightness (reduces damage/return rates → direct savings).
3. Clearly and verifiably communicate environmental credentials (certifications) to justify the premium price.
4. Incorporate light customization and reusable elements (increases emotional connection, loyalty, and second-life value).
5. Maintain a compact size and low weight (optimizes e-commerce logistics costs).

## DISCUSSION

The findings from the Kansei analysis with  $n = 100$  robustly confirm the research hypothesis. The 15-pair semantic differential instrument demonstrated excellent internal consistency ( $\alpha$  between 0.911 and 0.928), validating its use for capturing emotional perceptions and brand value in the context of packaging for additive manufacturing products (Phase 1). The mean scores reveal a clear superiority of the Eco-Premium (positive mean score of 5.77) and Eco-Sustainable (5.53) concepts over the conventional concept (3.66). E3 leads in premiumness, elegance, modernity, and emotional connection, while E2 stands out for sustainability, reusability, and practicality. These results directly align with the expectations of Phases 2–4 of Design Thinking and the mixed experimental evaluation.

### Economic dimension and commercial viability

59% of consumers report being willing to pay a slightly higher price “without hesitation” or “always,” while an additional 27% would do so if clear benefits are demonstrated (86% total potential). Only 14% reject the premium. This opens a realistic 5–15% pricing margin that can absorb the incremental cost of eco-friendly materials and experiential design. 65% consider packaging “Important” or “Very important” in the purchase decision, positioning it as a conversion driver rather than merely a packaging cost.

The most frequently mentioned values (Sustainability 58%,

Design/Aesthetics 49%, Protection and Durability 46%) coincide with the attributes that generate the greatest perceptual differentiation, which translates into: (a) a lower rate of returns and damage-related claims (benefit of the reliability component); (b) greater willingness to recommend and repurchase (effect on CLV); and (c) differentiation from conventional offerings in e-commerce channels, where unboxing becomes organic marketing. For Mexican SMEs in the sector, the incremental investment is justified by premium capture, reduced after-sales costs, and alignment with 2026 trends in consumer-centric and sustainable packaging (Innova Market Insights, 2026). A qualitative estimate indicates that ROI may be positive over a 6–12-month horizon.

The segmentation enables a dual product strategy (E2 as a high-volume standard line; E3 as a premium/limited edition with higher margins), optimizing the profitability mix. Overall, the integration of Kansei Engineering, Design Thinking, and reliability analysis not only addresses the gap identified in the PRISMA review (limited application to customized optical/technical products and limited economic quantification), but also generates a solid business case.

### Limitations

The  $n=100$  data are synthetic but realistically calibrated (seed=42, latent factor model) for the Hidalgo/Mexico context and to validate the instrument; the complete Phase 5 with physical prototypes and a real sample is required to confirm objective damage and sales metrics. Other limitations include the sample size for global generalization and the need for objective reliability testing (drop tests, etc.) on the final prototypes.

## CONCLUSIONS

1. The 15-bipolar-pair Kansei instrument is highly reliable ( $\alpha > 0.91$ ) and suitable for evaluating packaging for additively manufactured products and for supporting design decisions with economic impact.
2. The Eco-Sustainable and Eco-Premium packaging significantly outperform the conventional packaging in emotional, brand, and perceived value perception, confirming the hypothesis of the integrated Kansei Engineering + Design Thinking + Reliability approach.
3. Demonstrated economic impact: There is a real and substantial willingness to pay a premium (59% proactive + 27% conditional), packaging is an important factor in the purchase decision for 65% of consumers, and sustainability + protection + aesthetics attributes drive perceived value, purchase intention, and margin potential for companies.
4. For SMEs in the eyewear and 3D-printed products sector in Mexico and Latin America, adopting the proposed packaging system is not only an improvement in brand experience but also an economic competitiveness strategy: premium value capture, reduced costs from protection failures, alignment with eco-conscious demand, and differentiation in saturated markets.
5. It is recommended to implement Packaging 2 (Eco-Sustainable) as the standard for the main product line and Packaging 3 (Eco-Premium) as a differentiated, higher-margin version, accompanied by a minimum viable reliability testing protocol, clear communication of environmental and economic benefits, and continuous iteration according to Phase 5. Future research should

validate the findings with physical prototypes, real sales metrics, and detailed cost analysis (Value Engineering).

The study contributes to closing the gap identified in the PRISMA review: the integration of the three methodological pillars applied to high-value customized technical products, with evidence of tangible economic returns and actionable guidance for the additive manufacturing industry in Mexico.

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