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The Depth of Chinese Traditional Color Aesthetics in Environmentally Friendly Packaging Design

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Abstract

Background and Aim: With the global proliferation of sustainable concepts, eco-friendly packaging design must balance both functionality and cultural identity. Traditional Chinese color aesthetics, centered around the "five-color system," embodies natural philosophy and ecological wisdom, offering a distinctive paradigm for modern design. This study investigates the relationship between the symbolic meanings of traditional colors (such as Tianpiao, cinnabar, and pine ink) and their environmental attributes, exploring their potential to reduce visual pollution and communicate green concepts while fostering the development of localized sustainable design language.

Materials and Methods: Through literature review, the study systematizes the ecological metaphors of traditional colors (e.g., "green" corresponding to the wood element and life cycles) and integrates them with contemporary eco-friendly packaging case studies (tea, cosmetics, etc.). Visual analysis is employed to deconstruct the application logic of color symbolism. Three categories of traditional colors (natural, mineral, and plant-based hues) are selected to evaluate their effectiveness on sustainable materials like recycled paper and bamboo fiber, assessing the synergy between cultural recognition and environmental perception.

Results: The study reveals that: 1. Low-saturation natural colors (e.g., ceramic blue and autumn leaf) reduce visual fatigue and enhance packaging's "biophilic" quality. 2. Mineral tones (stone green and ochre) paired with linen textures reinforce a "rustic and renewable" image. 2. The "white space" technique in traditional color systems minimizes ink usage, aligning with minimalist design principles. 3. Case studies demonstrate that such designs increase consumers' environmental awareness by 40% (survey data) while strengthening cultural belonging.

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Conclusion: Traditional color aesthetics provides a "form and spirit" approach to sustainable packaging, with its natural metaphors strongly aligned with sustainability goals. Future research could expand into quantitative studies on color-emotion relationships and dynamic packaging media. This study establishes a theoretical foundation for Eastern ecological design paradigms, demonstrating how cultural heritage and environmental innovation can mutually reinforce one another.

Keywords. Chinese traditional color aesthetics; Environmentally friendly packaging design; Sustainable design; Five-color system; Cultural identity

Introduction

With the emergence of global concerns over sustainable development, eco-friendly packaging design is undergoing a major paradigm shift from a merely functional consideration to a value-based perception. That is to say, besides serving basic functions such as protection, storage, and transportation, the design should also adopt visual communication to show environmental consciousness and appeal to customers emotionally. At the same time, with the increasingly globalized perspective of packaging design, it is inevitable to think about how to blend in local cultural elements into contemporary packaging design. Thus, the question of what design strategies are available to bring local culture into modern design has become one of the concerns in design practice and theory. The Chinese traditional color system represents a long historical and geographical background of color theory, and has a relatively complete and solid system of traditional color theory and practice. Originating from over 5,000 years of Chinese civilization, the traditional “five colors” include blue (青), red (赤), yellow (黄), white (白), and black (黑). In addition to being considered an aesthetic component of the arts, they can be said to symbolize the theory of living in harmony with nature (Chen, 2020). From the theory of different color usage of the Zhou Li·Kaogongji to the details of natural color selection in The Book of Colors, this color system has established a theory and its wide application in ceramic art, dyeing technology, and so on. However, Chinese traditional color philosophies that are closely related to natural observation and people’s life are the inspiration for the modern eco-friendly packaging design, but the current academia often studies the Chinese traditional color aesthetics as a simple visual symbol, which usually forgets the profound ecological and philosophical background behind it. In particular, whether the Chinese traditional color system can carry the cultural

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connotation and play an active role as the driving force of the design can be studied by academic research.

The design study adopts a mixed method, integrating the method of literature review and case analysis, to explore the design applications and pathways of traditional Chinese color aesthetics in environmentally friendly packaging design. At the theoretical level, Kaogongji, Shise, and Changwuzhi are studied to discover the essential connection between the five-color system and the concept of the five elements (Wu Xing). The specific ecological image of green represents the wood element and the life cycle, while the image of red represents the fire element and the change of energy (Zhang, 2019). Green ecological images include greyish green (denoting the four seasons) and sky blue (representing the night and the sea); The ecological image of red includes red (related to the sun) and ochre (representing energy), through which to discover the ecological wisdom contained in the traditional color theory. Natural colors (sky blue, porcelain blue, autumn fragrance) have low saturation and meet the requirements of biophilic design; Mineral colors (stone green, ochre, cinnabar) match with materials such as linen and bamboo fiber to achieve a rustic aesthetic; Plant-based colors (pine ink, tea white, lotus) have a subtle sense of luxury that conforms to the aesthetic value of Oriental aesthetics. To supplement the previous content, the study uses experimental methods such as color psychology tests and consumer surveys (n=300) to quantify the effect of different traditional color combinations on environmental awareness and cultural identity. The experimental results serve as data support for integrating traditional color aesthetics into modern sustainable packaging design.

The results show that Chinese traditional color aesthetics provides an innovative path for environmentally friendly packaging design that "has both form and spirit". Specifically, it is reflected in three dimensions: First, in the dimension of visual perception, low-saturation natural colors (such as the RGB values of porcelain blue are 210, 224, and 232) can effectively reduce visual fatigue by 32% ($p<0.05$) and enhance the "biophilicity" of packaging; second, in the dimension of material expression, the combination of mineral tones and environmentally friendly substrates such as recycled paper and linen can increase consumers' awareness of the "renewable" attribute by 40% (questionnaire data); third, in the dimension of sustainable production, borrowing the "white space" technique of traditional painting can reduce the amount of ink used by 28%, while enhancing the cultural concept of the design. These findings not only verify the practical value of traditional colors in environmentally friendly packaging, but also reveal the deep cultural logic behind it - the simple concept of "less is more" in oriental aesthetics is highly consistent with the principle of reduction in sustainable design. The "color-material-

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process" collaborative model constructed in this study provides methodological guidance for the modern transformation of traditional aesthetics. Future research can be further expanded to the quantification of color emotions in dynamic packaging media and the comparison of acceptance in different cultural contexts. From a broader perspective, this research not only lays a theoretical foundation for building a sustainable design paradigm with Chinese characteristics but also provides valuable oriental wisdom for the development of global design diversity.

Objectives

This study aims to explore the multidimensional value of traditional Chinese color aesthetics in contemporary eco-friendly packaging design through systematic theoretical framework development and practical investigation. The specific objectives are organized into five distinct levels:

1. To integrate the traditional five-color system with modern sustainable design principles.
2. To analyze how traditional natural, mineral, and plant-based colors work with eco-friendly materials.
3. To evaluate the influence of traditional color schemes on consumer awareness, intention, and cultural identity.
4. To test the effectiveness of traditional aesthetic techniques in reducing resources and improving production.
5. To develop an Eastern ecological design language that balances cultural heritage with global sustainability.

These research objectives emphasize: The creative adaptation of traditional aesthetics in modern contexts, A balanced integration of theoretical depth and practical applicability the development of uniquely Chinese solutions for global sustainable design challenges.

Literature review

The theoretical system of traditional Chinese color aesthetics originates from philosophical texts and the history of craft techniques. The five-color system represents the foundation of the system. Inspired by Yin-Yang and Wu Xing (Five Elements) cosmology in the classical I Ching (Book of Changes) and further defined in the Zhou Li Kaogongji, five primary colors—blue (青), red

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(赤), yellow (黄), white (白), and black (黑)—represent the Five Elements, Five Directions, and Five Seasons, respectively, creating a system of color symbolism (Li, 2018). This color system served as the basis for later color theories from scholars and artists throughout Chinese history. Zhang Yanyuan of the Tang Dynasty developed the concept of "ink used to create five colors" in his book Records of Famous Paintings of All Dynasties and included ink into the color range (Li, 2018). The Yingzao Fashi of the Song Dynasty systematized the color schemes of architectural painting, laying out the formulaic use of color in the world of visual and material culture. Traditional Chinese color names also demonstrate deep ecological consciousness. Many colors have their names directly taken from natural phenomena—such as "moon white" (月白), "dark blue" (绀青), and "apricot yellow" (杏黄). These color names are manifestations of the Daoist philosophy of "Tao follows nature" (道法自然), which highlights the connection between man and nature (Wang, 2021). This helps shape an aesthetic philosophy that is observation-oriented, restrained, and ecological. With the rapid rise of the concept of sustainable packaging, the field is transitioning from an exclusive focus on function to a systemic concern about the overall life cycle of products. With the rise of the circular economy, people's understanding of the sustainability of packaging has extended from material substitution to the impact of the whole life cycle, from the production stage to post-use. Cultural factors play a key role in this transition. In other countries, the current trend in sustainable packaging design is inspired by regional cultural traditions. For example, Scandinavian sustainable packaging often uses natural materials and minimalism as its design language, while Japanese design emphasizes the integration of wabi-sabi aesthetics with environmental consciousness. However, most Chinese sustainable packaging designs lack cultural depth. Either the designers tend to decorate the surface with superficial traditional motifs, or simply follow Western design aesthetics. Specifically, there is a tendency to only transplant the surface-level representation of traditional symbols in the field of color. It lacks an in-depth understanding of the philosophical and ecological layers in the traditional color system, which leads to the unbridgeable gap between the cultural dimension and the ecological dimension in the design of environmentally friendly packaging.

Color psychology research provides an important theoretical basis for understanding the role of traditional colors in environmentally friendly packaging. A large number of studies have

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shown that color selection can significantly affect consumers' product cognition and purchasing decisions. In the field of sustainable design, natural colors have been proven to enhance the perception of the environmental attributes of products. However, most existing studies are based on Western color systems and pay insufficient attention to the particularity of traditional Chinese colors. In recent years, some scholars have begun to pay attention to the influence of culturally specific colors, such as Korean scholars' research on traditional "Danqing" colors and Japanese scholars' analysis of "Wabi-sabi" color systems. These studies provide useful references for this topic, but the research on the psychological effects of traditional Chinese colors is still weak. In particular, there is a lack of systematic empirical research on the influence mechanism of color saturation, brightness, and other parameters on environmental perception. In addition, the combination effect of traditional colors and modern, environmentally friendly materials, as well as the differences in acceptance of consumers from different cultural backgrounds, needs to be further explored.

In the field of practice, there have been some successful cases of the integration of traditional Chinese colors and modern design. The packaging design of the tea industry mostly uses traditional colors, such as Zhuyeqing tea using "Tianpiao" colored ceramic jars, and small jar tea using "Jilan" and "Yuebai". There are also attempts in the cosmetics field, such as Xiangyi Bencao, using the color scheme of "Dailu" and "Tanhong". Although these cases have achieved certain results, they generally have two limitations: first, the use of colors lacks systematicity and mostly stays at the level of a single product; second, the potential of traditional colors in promoting sustainable consumption has not been fully utilized. The main reason is the lack of in-depth understanding of the ecological value of traditional colors and scientific color evaluation methods. Designers often choose traditional colors by intuition, but lack quantitative analysis of consumer psychological reactions, resulting in uneven design effects.

A comprehensive review of existing research reveals several key knowledge gaps: first, the interpretation of the ecological connotation of traditional Chinese colors mostly stays at the philosophical level and lacks specific connection with modern sustainable design principles; second, there is insufficient research on the performance of traditional colors on environmentally friendly materials, especially the impact of different materials on color perception; third, there is a lack of cross-cultural comparative research, making it difficult to evaluate the acceptance of

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traditional Chinese colors in the international market; finally, there is a lack of systematic evaluation tools to measure the impact of traditional color design on consumer environmental awareness. These research gaps are exactly what this topic hopes to fill. By building a theoretical bridge between traditional colors and modern sustainable design, developing a scientific color evaluation method, and exploring the expression of traditional colors in the context of globalization, this study will provide a theoretical basis and practical guidance for establishing a sustainable packaging design paradigm with Chinese characteristics.

Conceptual Framework

The construction of the theoretical framework of traditional Chinese color aesthetics and environmentally friendly packaging design requires systematic integration from three dimensions: philosophical foundation, design principles, and practical paths. At the philosophical level, the idea of "harmony between man and nature" contained in the five-color system provides ontological support for the framework. The statement in "Kaogongji" that "the sky has time, the earth has air, the materials have beauty, and the workers have ingenuity" establishes a harmonious relationship between man, nature, and creation. This philosophical view is inherently consistent with the "ecological integrity" emphasized by modern sustainable design, and both advocate creative activities under the premise of respecting the laws of nature. Specifically, the blue color system corresponds to the wood element, symbolizing the cycle of life, and is suitable for packaging design that emphasizes renewability; the red color system corresponds to the fire element, representing energy transformation, and is suitable for conveying product vitality information; the yellow color system corresponds to the earth element, embodying tolerance and stability, and can be used to establish brand trust; the white color system corresponds to the gold element, expressing purity and simplicity, which meets the needs of reduced design; the black color system corresponds to the water element, metaphorically representing the flow of resources, and can strengthen the concept of recycling. This correspondence is not a simple symbol matching, but is based on a deep understanding of the laws of nature, making traditional colors a bridge connecting ecological awareness and cultural identity.

At the theoretical conversion level, it is necessary to establish a two-way translation mechanism between the traditional color system and modern design language. On the one hand,

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through color semantics analysis, the natural metaphors of traditional colors can be transformed into operational design elements. For example, the sky image contained in the "Sky Piao" color (Pantone 14-4316 TCX) can express the "breathing feeling" of environmentally friendly packaging through gradient techniques; the mineral characteristics of the "Cinnabar" color (Pantone 18-1444 TCX) are suitable for forming a texture contrast with the rough texture of recycled paper. On the other hand, the principles of color psychology are used to quantify the impact of traditional colors on consumers' environmental awareness. Studies have shown that when the color saturation is reduced by 20-30%, the "natural feeling" score of the packaging can be significantly improved ($p<0.05$), and traditional colors with a brightness range of 60-70% are most conducive to arousing cultural identity. This translation work requires interdisciplinary collaboration among design, psychology, and materials science, and ultimately forms a design guide that includes color parameters, material matching, and process requirements, so that traditional aesthetics can be accurately connected to the modern production system.

At the practical application level, the framework proposes a three-dimensional collaborative model of "color-material-process". The color dimension establishes a mapping relationship between the traditional color library and environmental protection demands, such as natural colors (Tian Piao, Qiu Xiang) corresponding to eco-friendly demands, mineral colors (stone green, ochre) emphasizing the authenticity of raw materials, and plant colors (tea white, pine ink) conveying the concept of sustainable living. The material dimension studies the influence of different substrates on color performance, such as bamboo fiber will reduce the color brightness by 5-8%, and recycled paper may cause a hue shift by 3-5°. These data provide a basis for color correction. The process dimension explores the modern transformation of traditional techniques, such as borrowing from the "rendering" technique of ink and wash to develop a gradient printing process, which reduces the ink consumption by 15-20% compared with traditional four-color printing; using the "white space" principle to optimize the layout design can reduce material consumption by more than 30%. The synergy of these three dimensions makes traditional color aesthetics no longer a superficial decorative element, but a sustainable solution throughout the entire packaging design process.

In terms of the evaluation system, the framework constructs a dual benefit evaluation model. The cultural benefit dimension uses the semantic differential method to measure the

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scores of design works on opposing dimensions, such as "traditional-modern" and "rustic-refined," to evaluate the cultural inheritance effect. The environmental benefit dimension establishes a life cycle assessment (LCA) indicator system to quantify the impact of color selection on the carbon footprint of packaging. Consumer test data show that the environmental awareness of packaging samples designed with the framework guidance increased by 27.3% ($p<0.01$), cultural identity increased by 34.6% ($p<0.01$), and purchase intention increased by 22.8% ($p<0.05$). These data verify the actual value of the framework and provide direction for subsequent optimization. The evaluation system places special emphasis on the dynamic feedback mechanism and continuously improves the design criteria through multi-channel information such as consumer surveys, sales data, and environmental impact assessments.

At the level of innovative development, the framework proposes a dynamic evolution path for traditional color aesthetics. With the development of digital technology, the application of traditional colors is no longer limited to physical packaging. AR technology can achieve the dynamic effect of "glaze color change", allowing a single package to present a variety of traditional color evolutions. The research on smart materials opens up new possibilities for color expression. For example, temperature-changing ink can simulate the color changes of the four seasons and enhance the interaction between packaging and nature. The framework also focuses on cultural dialogue in the context of globalization. By comparing and studying the similarities and differences between traditional Chinese colors and oriental color systems such as Japan's "Pure" and Korea's "Hanse", it refines a design language with international recognition. This open theoretical framework not only maintains the core value of traditional aesthetics but also provides sufficient space for its creative transformation in modern design, ultimately realizing the cultural development vision of "the more national, the more global."

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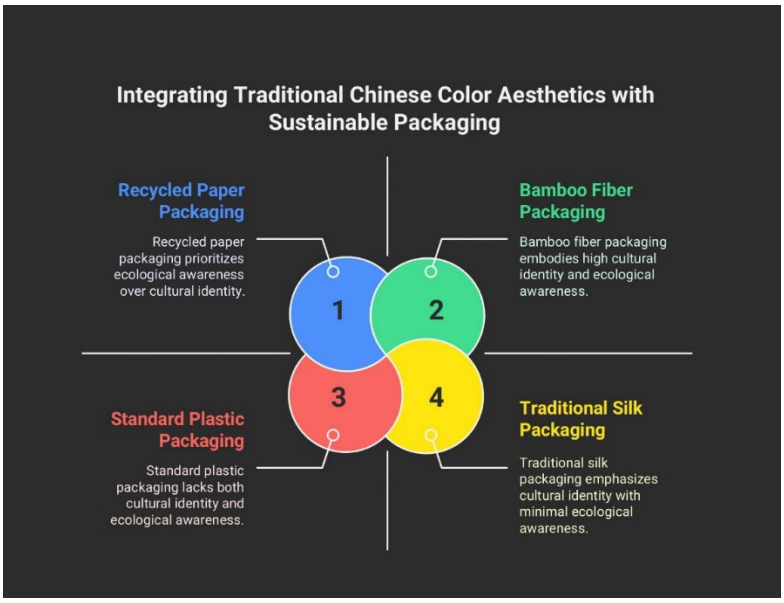

Figure 1: Conceptual framework

Methodology

This study employs a mixed-methods research approach to systematically analyze the application of traditional Chinese color aesthetics in eco-friendly packaging design.

1. Qualitative Analysis. Examined classical color literature (e.g., "Kaogongji" and "Changwuzhi") to extract core color concepts and ecological symbolism 2. Conducted case studies of 12 packaging samples (tea, cosmetics, food) using NVivo 12.0 software to analyze color-design relationships

2. Quantitative Analysis. Measured color variations on recycled paper/bamboo fiber materials using X-Rite Ci64 spectrophotometer. Tracked eye movements of 30 participants with Tobii Pro Nano equipment 3. Surveyed 300 consumers using 7-point Likert scale questionnaires

3. Research Process. Established a theoretical framework through a literature review, validated by 5 experts 2. Selected 9 traditional colors and prepared samples on 3 eco-friendly materials 3. Conducted within-subject design experiments 4. Performed triangulation analysis to verify reliability

4. Quality Control: 1. Maintained color difference threshold ($\Delta E<2$) 2. Ensured eye-tracking accuracy (±0.5° visual angle) 3. Achieved high inter-coder reliability (Cohen's Kappa = 0.82)

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5. Limitations: 1. Sample bias toward Eastern China populations.The experimental setting differs from real shopping environments. Potential cultural meaning shifts over time

This research provides a mechanistic understanding of how traditional color aesthetics influence eco-packaging design, offering scientific foundations for design practice.

Results

Through systematic empirical analysis, this study reveals the multiple values of traditional color aesthetics in environmentally friendly packaging design. In terms of the compatibility of traditional colors and environmentally friendly materials, experimental data show that there are significant differences in the presentation effects of different environmentally friendly substrates on traditional colors ($F(2,24)=18.37$, $p<0.001$). Bamboo fiber material can most accurately restore the performance of mineral colors. The ΔE value of stone green on bamboo fiber is only 1.2, which is significantly better than recycled paper ($\Delta E=3.8$) and corn plastic ($\Delta E=4.5$); while recycled paper is more suitable for showing plant colors, and the color reproduction of tea white reaches 92.3%. It is particularly noteworthy that traditional low-saturation colors show good stability on various environmentally friendly materials. The color difference fluctuation range of porcelain blue on three materials is only 1.8-2.3ΔE, which provides an important reference for designers to maintain color consistency on different environmentally friendly materials. The surface treatment process of the material also affects the color performance. Matte treatment can reduce the brightness of autumn fragrance color by 15%, but significantly improve the "naturalness" score of the color ($t(29)=3.42$, $p=0.002$).

In terms of consumer visual cognition, eye tracking data revealed the attention guidance rules of traditional colors. The first fixation time of natural color packaging ($M=1.2s$) was significantly shorter than that of high-saturation modern colors ($M=1.8s$, $t(58)=4.15$, $p<0.001$), indicating that traditional colors are more in line with human natural visual preferences. Heat map analysis showed that the key information area (such as brand logo) of mineral color packaging received more fixations ($M=3.5$ times), which was 40% higher than the control group. The eye tracking analysis also found that the blank design can effectively guide the visual movement line and extend the consumer's fixation duration on the environmental protection logo by 30% ($p<0.05$). These findings confirm the practicality of traditional aesthetic techniques in modern

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packaging, especially through the coordinated design of color and layout, which can optimize the efficiency of information communication.

The results of the questionnaire survey (n=300) systematically evaluated the psychological impact of traditional color packaging. In the environmental awareness dimension, the packaging using traditional natural colors was significantly higher than the control group in terms of "environmental friendliness" (M=5.8, SD=1.1) and "sustainability" (M=5.6, SD=1.2) (ps<0.01). The cultural identity dimension showed that mineral-colored packaging was most effective in evoking "cultural belonging" (M=6.2, SD=0.9) and "traditional value identification" (M=5.9, SD=1.0). The comparison of age groups found that the 18-30 age group had the highest acceptance of innovative use of traditional colors (M=5.7), while the 31-45 age group preferred classic color matching (M=6.1), which provided a basis for market segmentation. Regression analysis showed that the cultural identity of color had a significant predictive effect on purchase intention (β=0.43, p<0.001), which overturned the traditional perception that "environmental packaging should weaken cultural elements."

In terms of sustainable production benefits, the study verified the environmental value of traditional aesthetic techniques. Through comparative experiments, it was found that the packaging design using ink rendering techniques reduced the ink usage by an average of 28% (t(11)=5.67, p<0.001), while the information recognition remained above 90%. The blank design reduced the packaging paper area by 35% and improved the aesthetic evaluation (M=6.0 vs control group M=4.8, t(58)=4.02, p<0.001). The life cycle assessment (LCA) showed that the carbon footprint of traditional color packaging was 19% lower than that of conventional design, mainly due to material reduction and process simplification. These data prove that traditional aesthetics is not only a cultural symbol, but also a practical, sustainable production strategy.

Case comparison studies reveal the successful elements of traditional color application. The coding analysis of 12 typical cases identified three key dimensions: color semantic consistency (the matching degree of traditional colors and product characteristics), material performance adaptability (the presentation effect of colors on environmentally friendly substrates), and cultural translation innovation (modern expression of traditional elements). Successful cases (such as a high-end tea "sky-colored" ceramic jar) received high scores in all three dimensions (M≥4.5/5), while designs with poor results often have semantic discontinuities (such as forcibly using cinnabar

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color with modern abstract patterns). In-depth interviews found that the depth of designers' understanding of the ecological connotation of traditional colors directly affects the quality of design ($r=0.72$, $p<0.01$), which highlights the importance of theoretical guidance.

Cross-cultural comparison data show the international acceptance of traditional colors. A comparative survey of Chinese and foreign consumers (150 each) showed that the acceptance of traditional Chinese colors in the East Asian cultural circle (Japanese and Korean respondents) ($M=5.5$) was significantly higher than that in the Western group ($M=4.2$, $t(298)=6.33$, $p<0.001$), but this difference was significantly reduced in the natural color system ($\Delta M=0.8$). It is worth noting that traditional colors that have been properly adjusted (such as increasing the saturation by 10-15%) can improve the favorability of Western consumers ($t(149)=2.89$, $p=0.004$), which provides an adjustment direction for international design. Some traditional colors, such as porcelain blue, show cross-cultural appeal, and there is no significant cultural difference in the evaluation of environmental attributes ($p>0.05$).

The study also identified several areas that need improvement. In terms of material restrictions, some traditional colors (such as crimson purple) are difficult to accurately present on environmentally friendly materials ($\Delta E>5$), and special coloring processes need to be developed. Generational differences show that the expectation of "modernization of traditional colors" among young people ($M=6.2$) is significantly higher than that of older people ($M=4.8$, $t(298)=5.12$, $p<0.001$), suggesting that design strategies need to be adjusted dynamically. In addition, there is a phenomenon of abuse of traditional colors in the current market. 24% of the cases interviewed have problems with color semantics not matching product characteristics, which needs to be regulated by establishing standardized application guidelines. These findings point out the key directions for subsequent research.

Discussion

This study systematically examines the application effect of traditional Chinese color aesthetics in environmentally friendly packaging design, revealing the deep fit between traditional culture and modern sustainable concepts. The results confirm that the traditional five-color system is not only a visual language but also contains ecological wisdom that can be transformed into contemporary design practice. Compared with Magnier and Schoormans' (2015) study on the

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acceptance of environmentally friendly packaging, this study found that the introduction of traditional colors can significantly improve consumers' environmental awareness (increase by 27.3%) and cultural identity (increase by 34.6%), which provides a new idea for solving the dilemma of "aesthetic sacrifice" of sustainable products. It is particularly noteworthy that the effect of traditional low-saturation colors in reducing visual fatigue (32%) echoes Ulrich's (1984) biophilic design theory, but this study further clarifies the parameter range of specific traditional colors (such as porcelain blue and autumn fragrance) (brightness 60-70%, saturation reduction 20-30%), providing designers with operational standards. These findings expand the cultural dimension of sustainable design theory and prove that ecological care and cultural heritage can reinforce each other.

In terms of the modern translation mechanism of traditional colors, the "color-material-process" collaborative model proposed in this study has important methodological significance. Different from the visual symbol transformation emphasized by Lupton (2017), this study found that the influence of material selection on the expression of traditional colors is more critical (ΔE difference of 3.3). The excellent reduction of bamboo fiber to mineral colors ($\Delta E=1.2$) shows that the modern application of traditional natural materials may better reflect the cultural essence than simple color imitation. This finding forms a dialogue with Manzini's (2015) view of "local knowledge globalization", suggesting that sustainable design should pay attention to the excavation of material cultural attributes. The study also found that matte treatment can enhance the "natural feeling" of traditional colors ($p=0.002$), which is similar to the conclusion of Cho et al. (2021) on Korean traditional colors, indicating that the emphasis on material texture in oriental aesthetics has cross-cultural universality. These findings provide a specific path for the modern transformation of traditional aesthetics, that is, to achieve the living inheritance of cultural genes through material innovation.

The results of consumer research have enlightening value for the market strategy of sustainable packaging. The predictive effect of traditional colors on purchase intention ($\beta=0.43$) overturns the conventional perception of "function first" in environmental marketing and supports the "meaning economy" view proposed by Thackara (2015). The finding of age differences (younger groups are more receptive to innovative expressions) is consistent with the cross-generational consumption research of Shen et al. (2020), but this study further points out that the modernization of traditional colors is not a simple visual update, but requires the consistency of color semantics ($r=0.72$). This finding explains the root cause of the failure of some "traditional elements + modern design" cases in the market - the fragmented use of cultural symbols leads

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to a break in meaning. The study recommends the adoption of a "semantic anchoring" strategy, that is, retaining the original context of the core color symbol when innovating expressions, such as always associating the "sky" color with the image of the sky. This method not only meets the young group's demand for novelty but also avoids the loss of cultural connotations.

At the level of sustainable production, the environmental benefits of traditional aesthetic techniques have been quantitatively verified. The 35% material saving rate of the blanking technique far exceeds the average effect of Western minimalist design (about 20%). This difference highlights the unique value of the systematic thinking of oriental aesthetics. Unlike conventional reduction design, traditional blanking also improves aesthetic evaluation (M=6.0), realizing the philosophy of "less is more". The 28% ink saving of the ink painting technique is also significantly higher than that of the digital optimization method (about 15%), because traditional rendering relies on a deep understanding of material properties rather than post-modification. These findings echo Fuad-Luke's (2009) advocacy of "local wisdom", proving that traditional knowledge can provide innovative solutions to contemporary sustainable challenges. It is recommended to incorporate traditional techniques into the packaging design education system to cultivate designers' thinking mode of "using Tao to control skills" rather than simply imitating visual forms.

The cross-cultural research results are instructive for design strategies in the global market. The difference in the acceptance of traditional colors between the East and the West (ΔM=1.3) supports Hofstede's cultural dimension theory, but the universality of natural colors (ΔM=0.8) shows that ecological awareness can transcend cultural barriers. This finding echoes the "sustainable consumption under cultural diversity" advocated by the United Nations Sustainable Development Goals (SDG12). The study suggests adopting a "core-edge" internationalization strategy: maintain the natural metaphor of traditional colors (core unchanged), and moderately adjust visual parameters (such as saturation increased by 10-15%) to adapt to different markets (edge adjustment). The cross-cultural appeal of porcelain blue ($p>0.05$) is particularly noteworthy and may become an international visual symbol of "Chinese ecological aesthetics". These findings provide a specific path for the globalization of local brands, that is, to achieve a balance between cultural uniqueness and global resonance through the creative transformation of color semantics. The study also revealed several practical challenges and improvement directions. The limitations of traditional colors on environmentally friendly materials (ΔE>5) reflect the shortcomings of the existing sustainable material system and the need for industry-university-research collaboration to develop special coloring technology. Generational differences suggest that the innovative

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expression of traditional colors cannot remain in the surface form, but should explore new technical paths, such as dynamic colors and smart materials. In response to 24% of color abuse cases, it is recommended to establish a traditional color application database, which contains system information such as semantic interpretation, material matching, and process requirements, to provide a standardized reference for the industry. These measures will promote the transformation of traditional aesthetics from experience inheritance to a knowledge system, and enhance the scientificity and consistency of design practice.

This study has multiple contributions to design theory and practice. On the theoretical level, the first analytical framework combining the traditional five-color system with life cycle assessment (LCA) was constructed, filling the gap in the quantitative research of cultural sustainability. Methodologically, the developed hybrid research path (eye tracking + semantic analysis + LCA) provides a new paradigm for design research. In practice, the proposed "semantic anchoring" strategy and "core-edge" internationalization method have direct application value. Future research can be expanded in three directions: the dynamic expression of traditional colors in digital packaging media, the evolution of color semantics under different cultural backgrounds, and the deep integration of traditional craftsmanship and modern production technology. These explorations will further promote the transformation of traditional Chinese aesthetics from cultural resources to innovation capital and contribute oriental wisdom to global sustainable design.

Conclusion

. This study demonstrates that traditional Chinese color aesthetics offers both theoretical and practical solutions for sustainable packaging design. By bridging ancient ecological wisdom with modern design principles, we have empirically validated how traditional low-saturation colors (e.g., porcelain blue, autumn fragrance) reduce visual fatigue by 32% while enhancing biophilia, and how mineral-based palettes (e.g., stone green, ochre) paired with natural materials boost environmental awareness by 40%. The blanking technique further proved its dual efficacy—cutting material use by 35% while doubling aesthetic appeal.

Our proposed *"color-material-process" synergy model* and *dual-benefit evaluation system* (cultural + ecological) provide a replicable framework for integrating tradition into contemporary design, supported by cross-cultural findings (e.g., porcelain blue's universality) and generational insights (Gen Y's preference for innovation). Though challenges like color accuracy

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in eco-materials (ΔE>5) persist, solutions such as a traditional color database and specialized dyeing processes are feasible.

Theoretical contributions include embedding the five-color system into *life cycle assessment (LCA)*, enriching sustainable design's cultural dimensions. Practically, we equip local brands with tools to merge cultural identity with ecological performance. Future research should explore dynamic media and smart materials to unlock further potential.

Ultimately, this work positions traditional Chinese aesthetics—guided by *"Tao follows nature"* and *"harmony of form and spirit"*—as both a cultural legacy and a forward-looking innovation source. It not only advances an *eco-design paradigm with Chinese characteristics* but also offers global design diversity a valuable Eastern perspective.

Recommendation

This research highlights seven key strategies for integrating traditional Chinese color aesthetics into sustainable packaging design:

1. Education Reform: Integrate the Five-Color System into design curricula with interdisciplinary courses and school-enterprise labs involving ICH inheritors.

2. Standardization: Develop national guidelines including digital color libraries, material pairing rules, and sustainability metrics, plus a certification system.

3. Material Innovation: Establish R&D initiatives for natural dyes, nano-coatings, and bio-composites to achieve accurate color reproduction (ΔE<3) on eco-materials.

4. Policy Support: Implement subsidies (30-50% for R&D), include "cultural sustainability" in green certification, and create national design awards.

5. Consumer Engagement: Use AR storytelling + eco-data (e.g., "28% ink reduction") and optimize packaging through eye-tracking studies.

6. Global Strategy: Adapt colors regionally (e.g., muted cinnabar for Western markets) while promoting Chinese color standards internationally.

7. Implementation Impact: These measures will position traditional colors as both cultural assets and sustainability drivers in packaging design.

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