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ONE-PIECE SUSTAINABLE TABLEWARE PACKAGING DESIGN BASED ON AN INTEGRATED APPROACH

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*Abstract**. The purpose** of this study is to research the concept of sustainable development used in specific packaging issues, which is a tableware packaging design innovation to achieve the extension of the packaging life cycle, facilitate production, promote the concept of green packaging.*

***Methodology.** An integrated approach was used in this study. Literature analysis of sustainable packaging concepts was reviewed. Case studies were used to collate and analyze the existing one-piece paper packaging and reduction packaging on the market. Through the comparative study of the existing packaging and the reduced packaging, the advantages and disadvantages were analyzed between before and after packaging reduction. Then, the hierarchical analysis method was used to rank the design factors and obtain an objective design focus.*

***Results of the research.** The article explores sustainable design methods in tableware packaging. Considering packaging design, production, transport and sales as a whole, sustainable analysis and design are carried out from all aspects. A series of tableware packaging designs with strong practicality, high feasibility and outstanding significance are obtained.*

***The scientific novelty.** This study considered packaging design in terms of the packaging life cycle and expanded the functions of packaging beyond protection, transport and distribution, such as recycling, etc.*

***The practical significance.** The sustainable packaging design in this study addresses the issue of packaging waste and recycling at source. It lays the foundation for environmental protection and sustainable development between consumers and producers. Through the one-piece paper packaging structure reduction design, the reduction of packaging design not only reduces the consumption of raw materials and processing costs, but also alleviates the pressure on the environment and rationalises the arrangement of human resources.*

The study of one-piece paper packaging structure design has certain practical significance for contemporary packaging. Scientific design from the shape, size, function and other aspects greatly improves the efficiency and reliability of the design. Structural design enhances the comfort and pleasure of consumers in the process of use. As a green environmental protection issue, the design of one-piece sustainable

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packaging is in line with the international community's advocacy of resource-saving and environmentally friendly world.

Keywords: sustainable packaging, tableware packaging, analytic hierarchy process (AHP), graphic design, art, product design.

INTRODUCTION

With the development of the economy and the rapid increase in population, the issue of going green has become the focus of the design community. Over packaging has become a prevalent issue in the market in recent years, which not only greatly causes waste of resources, but also brings irreversible harm to the environment [9]. Therefore, a large number of scholars believe that it is urgent to explore the sustainable development pathway of packaging. Reducing the scale of packaging waste at source has become a significant task [14]. Optimisation of packaging design is related to the reduction of packaging waste at source and the way of separation and treatment, so the optimisation of packaging design using green design concepts is an important means of realising the sustainable development of packaging.

ANALYSIS OF PREVIOUS RESEARCH

In understanding sustainable packaging, many scholars have proposed different understandings and definitions. Lindh et al. defined the functions of packaging by analysing and summarising a large amount of literature [8], the main scope of which is protection, ease of loading, unloading and handling and communication, followed by containment, reduction of environmental pollution, and recycling of resources, etc., which has also been proposed by most of the scholars [4, 10, 15]. Lindh et al. also defined a wide range of packaging characteristics that contribute to sustainable development, providing the field of sustainable packaging research with a common terminology for packaging functions and characteristics [8], and laying the foundation for facilitating communication and understanding in the development and decision-making process.

The European Union was the first to propose the 3R policy on sustainable development. That is for Reduce, Recycle, Reuse [12, 16]. In addition, Joshi et al. argues that sustainable development goals are to be composed from six stages in the product life cycle. That is the concept of 6R: Recover, Reuse, Recycle, Redesign, Reduce, and Remanufacture [2, 5]. Therefore, considering packaging design, which is closely related to environmental issues, designers should simplify packaging materials, optimise packaging structure and rationalized packaging use while giving full play to the functions of containment, protection, convenience and communication, to explore the effective pathway of sustainable development of packaging. At the same time, designers should guide the concept of green packaging into people's minds through innovation.

In addition, many researchers have explored methods to sustainable packaging design in different areas. Emblem and Emblem argues that the physical design of packaging affects how it is handled during production, transport, storage, use and disposal. He suggests considering packaging characteristics in the design to make simple, convenient and safe [3]. The first step is primary packaging optimisation. Primary packaging should be sized to match the consumption habits of the user so that the product fulfils its function but does not result in unnecessary product 'leftovers' that are discarded by the user [11]. For example, Williams et al. showed that oversized packaging is a cause of food waste in households [19]. And incomplete packaging leads to food spoilage. Over-packaging using unnecessary packaging materials also increases the environmental burden [1]. Olsmats further suggests secondary and tertiary packaging should be combined comprehensively optimised, which is helping to improve transport fill rates and therefore packaging efficiency [13].

Sverko Grdic et al. quantitatively analyses the issue of packaging recycling rates in a circular economy model from a circular economy perspective [18]. Rutkowski designed P-EPR systems have been designed to drive the recycling industry, although none of them reduces waste generation [16]. However, the efficiency of recycling is improved. Singh and Cooper proposed business model seems to have the potential to reduce the environmental footprint of the current single-use packaging use and disposal system [17]. The proposed business model focuses on reducing the use and purchase of single-use plastic bags, increasing resource recovery from discarded plastic bags and reducing the use of single-use packaging.

These studies have demonstrated that there are ways to address the issue of sustainable packaging. But for different practical problems, packaging design involves different scopes

and degrees, thus designers should to analyse specific problems.

STATEMENT OF THE PROBLEM

China is the most populous country in the world and has a rich and varied cuisine, so tableware with Chinese culinary characteristics that meets the needs of different catering preparations has become an essential tool in every household. Consequently, the demand for tableware packaging is substantial. In light of environmental considerations and the heightened awareness of eco-friendliness, designers, manufacturers, and governmental entities bear greater responsibilities toward environmental sustainability. Designers must prioritize environmental consciousness and innovation, while manufacturers need to enhance the efficiency and quality of packaging production. Simultaneously, governmental bodies ought to strengthen supervision over packaging standards and regulations, collectively propelling the packaging industry towards a more environmentally friendly and sustainable trajectory. Presently, several design flaws contribute to inadequacies in environmental friendliness, resource utilization efficiency, and sustainability in tableware packaging.

– complex packaging structures and bulky volume: current tableware packaging designs commonly feature intricate structures and large volumes, resulting in low packaging fill rates and increased resource wastage.

– non-environmentally friendly materials: many tableware packaging materials are non-environmentally friendly, comprising various material combinations and excessive printing, thus exacerbating the environmental burden of packaging, especially concerning non-biodegradable plastic materials.

– disposable designs: many tableware packaging designs are disposable, leading to low packaging reuse rates and extensive resource wastage.

– printing ink pollution: excessive printing and ink usage may lead to environmental pollution, particularly regarding non-degradable printing materials.

In summary, addressing these issues necessitates concerted efforts from stakeholders to innovate designs, adopt sustainable materials, minimize waste, and reduce environmental impact throughout the tableware packaging lifecycle.

RESULTS OF THE RESEARCH

After research and analysis, it is found that with the improvement of people's quality of life, the audience of tableware packaging is very wide. The audience of this design is the majority of families and people who love cooking, who need to consider price, quality, hygiene and other factors when buying tableware. More and more consumers are very sensitive to the environmental message conveyed by the packaging. In view of the above problems, the study of packaging design that focuses on "Reduce" can promote sustainable development from the source. Qiao and Feng believes the source of packaging waste reduction and effective recycling can maximise to ensure the recycling of resources and energy, thereby reducing energy consumption and promoting the harmonious development of man and nature. Some data show that the recovery of 20,000 tonnes of flexible packaging waste can save 20,000 cubic metres of landfill space. Therefore, to achieve the reduction of packaging waste, harmless is an important way to make full use of packaging resources [14]. The one-piece paper packaging refers to the use of one piece of paper to package items, which is to reduce the waste of packaging materials under the condition of ensuring the safety of commodities, and at the same time to give the packaging a certain degree of functionality.

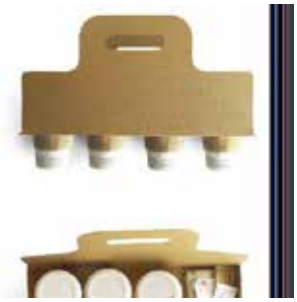
Case study. Through market research, analysis of the case found that one-piece packaging structure is not very common. Most of the products in the beginning of the packaging design is still mainly considered of the protective function, with complex structures and functional materials for packaging. Though most packaging designers will consider the cost factor, seldom consider whether the packaging is environmentally friendly. Therefore, simple, reduced and innovative structural designs are not common.

A comparative study of common packaging and one-piece paper packaging was carried out through case studies. For example, the Pepsi in cans in groups of 6 is simply packaged by a plastic film in general, which is not easily degradable, not liftable, and without any decoration (Table 1, Case 1). Coca-Cola, on the other hand, uses easily degradable, portable and reduced paper integrated packaging with promotional effects. From the perspective of packaging structure and materials, the packaging is interspersed with paper and folded as a locking structure, which is not only environmentally friendly but also adopts scientific and reasonable packaging structure. From the perspective of conveying information, Coca-Cola packaging provides more product information to consumers.

Another example is the coffee takeaway packaging shown in Case 2. More and more coffee brands are using easily degradable and

Table 1

Case comparisons between original packaging and one-piece paper packaging

No.	Sources	Original packaging	One-piece paper packaging	Functions
1	https://item.taobao.com/item.			Protection Communication
2	https://image.baidu.com/search/			Protection Portable Display
3	https://cn.bing.com/images/			Protection Display
4	https://image.baidu.com/search/ Instagram: jopack_co			Protection Portable Display
5	https://cn.bing.com/images/search? Instagram: designwanted			Protection Display

environmentally friendly paper materials to replace the non-biodegradable plastic bags. From the packaging structure point of view, the coffee cups are securely stuck in the curved surface structure of the simple one-piece paper packaging and the top of the package has the function of lifting and carrying. This transformation of Coca not only reduces the source pollution, but also affects the waste disposal.

In Case 3, compared to the light bulb packaging with a mixed material of blister and cardboard, the one-piece light bulb packaging

combines both protection and display functions. The design of the corrugated paper structure is simple but creative. Due to the single material, it is easy to recycle and dispose.

In Case 4, from the point of view of packaging materials, first of all, the package uses good tensile strength, good toughness, lightweight biodegradable kraft paper as packaging materials, compared with the traditional type of packaging structure of the wine, one-piece paper wine is packed with smaller size and less types of materials, which is easy to unfold, recycling, lead to close to the world's "green" theme. Secondly, the overall packaging structure of the one-piece paper wine packaging adopts the hollow structure of the wine bottle half exposed, which can visually present the appearance of the wine bottle and use the packaging structure to give it the function of carrying.

Case 5 is flower packaging. Most of the traditional flower packaging forms are a piece of plastic film and a piece of paper, and then use the rope to tie up the rolled-up bouquet. The one-piece paper flower packaging is a conceptual design with innovative structure that allows the packaging to serve both protective and display functions. When the package is extended, it wraps around the bouquet. When the package is folded down, the bouquet is stably displayed.

Therefore, one-piece packaging design for tableware requires comprehensive consideration of the following design principles. From the perspective of production, one of the important elements is to reduce costs. Enhance technology, improve efficiency, reduce personnel input, improve equipment performance can be cost reduction. The one-piece paper packaging is to reduce the consumption of packaging materials under the premise of ensuring the integrity of the product, increase the new value of the product, so that the product packaging has the function of protection, display or other functions. On this basis, whether the packaging can be rapid prototyping and batch production is the concern of producers, because batch production can reduce the time of production and processing and speed up the speed of commodity circulation. From the recycling point of view, the environmental impact of packaging materials is also different whether they are used reasonably or not [6].

The one-piece paper packaging adopts a single packaging material, which is easy to be recycled, separated, processed, reconstructed, and can be naturally weathered and returned to nature, avoiding the waste of subsequent labour brought about by over-packaging. At the same time, it is undoubtedly greener for the ecological environment. From the consumer's point of view, creative and simple structural design, convenient using process will awaken the consumer's recognition of environmental protection, thus generating goodwill towards the brand. Environmental awareness spreads silently in the pup society [7].

Demand Hierarchy Analysis of Sustainable tableware Packaging. Through user surveys and expert interviews, the demand for sustainable tableware packaging is summarized, organized, categorized, and expanded into three levels: the goal level, indicator level, and solution level. The first level is the goal level, which represents the total demand A for collapsible dining tables. The second level is the indicator level, which divides the user demand for sustainable tableware packaging into four indicators: environmental friendliness A1, product protection A2, production cost A3, and packaging efficiency A4. The third level is the solution level, which further subdivides the indicator level into more specific requirements, as shown in Fig. 1. Clarifying the demand hierarchy of tableware packaging, the subsequent matrix analysis begins.

After establishing the user demand hierarchy, the Analytic Hierarchy Process (AHP) is used to construct the user demand judgment matrix, enabling the hierarchical processing of complex multi-objective problems. Through decision assessment consistency testing, the weights of user demands are further determined to reduce decision biases.

Step 1: Constructing the judgment matrix. Firstly, five experts are invited to score pairwise the total demand A for collapsible dining tables and the specific requirements of indicator level A_1-A_4, constructing the judgment matrix.

Step 2: Using methods such as geometric mean, arithmetic mean, etc., calculate the weights W of user demands and the maximum characteristic root λmax of the judgment matrix. Conducting a one-time consistency test, where CI represents the consistency index and CR represents the consistency ratio, calculated as follows:

$$CI = \frac{\lambda_{max} - n}{n-1}$$

$$CR = \frac{CI}{RI}$$

Generally, when the CR value is less than 0.1, it meets the consistency test; if the consistency test fails, the judgment matrix needs to be reconstructed. Following the aforementioned steps, the weights of the indicator level demands on the goal level in the collapsible dining table user demand hierarchy, as well as the weights of various solution levels

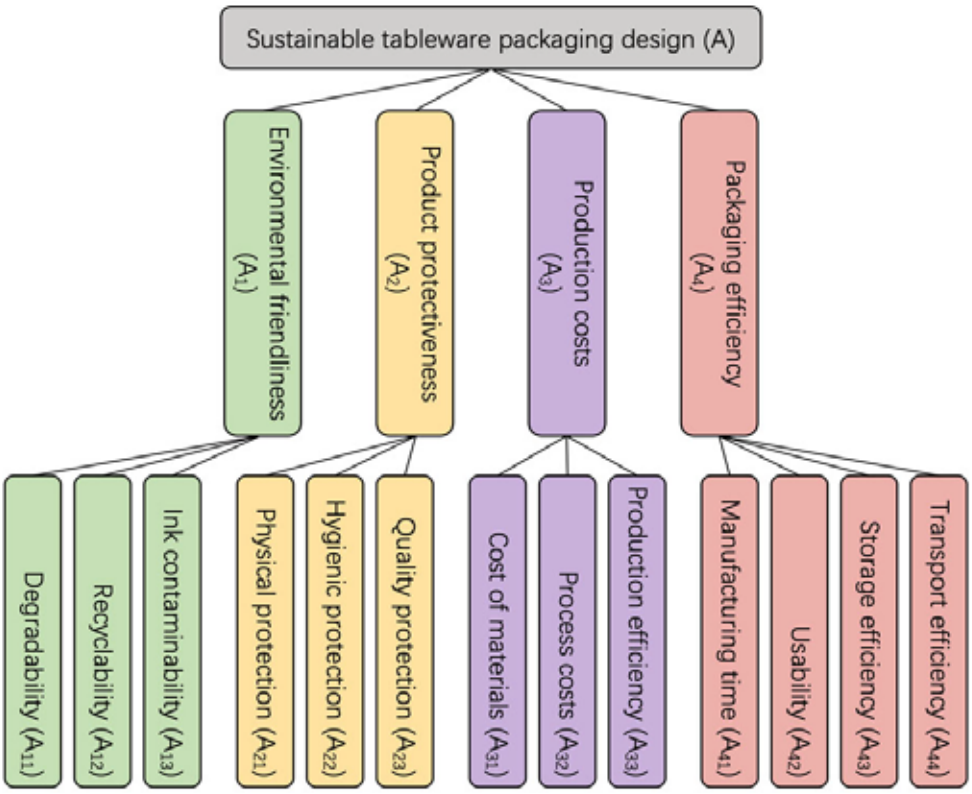


Fig. 1. Hierarchical classification of demand for sustainable tableware packaging design

on the indicator level, are calculated. According to the matrix calculations, all CR values are less than 0.1, meeting the consistency test.

By multiplying the weights of each item in the dining table user demand solution level by its corresponding weights in the indicator level, the comprehensive weight of each specific demand in the entire goal demand system can be calculated. From this, the importance ranking of demands in sustainable tableware packaging can be obtained as follows: high recyclability and low material costs, good product quality protection, minimal environmental pollution, and high portability, serving as the primary considerations for tableware packaging design.

Sustainable tableware Packaging Design Practice. Based on the results obtained from literature research, case analysis, and hierarchical analysis, product design and positioning are conducted according to product characteristics and user needs. Firstly, China has a wide variety of tableware, among which bowls, plates, and cups are prone to breakage and require designs with shock-absorbing structures and materials to ensure product quality protection. Additionally, current chopstick packaging tends to be highly decorative, utilizing various composite materials, which pose challenges for recycling and result in significant packaging waste. Therefore, designs for different tableware or combinations thereof should be tailored to their specific characteristics. Secondly, considering high recyclability, low material costs, good product quality protection, minimal environmental pollution, and high portability as primary considerations for tableware packaging design, integrated paper design, shock-absorbing structure design, and reusability design are prioritized choices to meet these demands.

Corrugated cardboard material is chosen for its excellent shock absorption, lightweight, space-saving, and easy assembly advantages. It is more environmentally friendly compared to other materials such as wood, metal, and plastic.

Through integral paper structure design, issues such as material waste, inconvenient processing, and low production efficiency are effectively addressed, leading to cost savings. Additionally, an integral paper structure simplifies recycling processes as the packaging is made of only one material.

The design incorporates a suspended shock-absorbing structure, suspending the product within the packaging to provide better protection.

Display functionality is equally important for tableware packaging. Display structures allow for showcasing product features in advance, attracting consumers.

Based on the above specific design concepts, we have developed three sustainable tableware packaging designs.

(1) Bamboo and wood non-slip chopsticks packaging can be displayed.

This packaging adopts one-piece paper molding structure with adhesive edges (Fig. 2). The flap can be turned into a display packaging for better display of the product. At the same time, the one-piece structure can reduce the number of processing steps, which is convenient for processing and production. The display packaging can be used to display the products in supermarkets, so that consumers can fully and intuitively contact the products and provide convenience for consumption. After the product is dried, the packaging can also be used as a chopsticks storage box.

(2) Recycled shockproof household heirloom mug packaging

This packaging adopts a one-piece paper molding structure, with no adhesive edges (Fig. 3). Improve production efficiency and facilitate the production of enterprises, while the packaging adopts a suspended cushioning anti-shock structure, through the upper and lower layers of the packaging within the slot to fix the wine glass, the lower slot function is to fix the wine glass, while so that the wine glass is not in contact with the bottom of the packaging. The upper part keeps the wine glass from contacting the top of the packaging. Therefore, the wine glass is not in contact with the packaging at the top and bottom, which reduces the damage to the fragile glass during transport, and also replaces the cushioning foam, inflatable bags and other shock-proof products outside the packaging itself. It can also replace the cushioning foam, inflatable bag and other shockproof products outside the packaging itself. After opening the packaging can be flipped to turn the packaging into a cup holder for display.

(3) Recycled shockproof household shallow flat fruit plate packaging

This packaging adopts a paper molding structure, with no adhesive edges (Fig. 4.). Left and right flap to open, the packaging adopts a suspended cushioning anti-vibration structure, through the packaging inside the upper and lower two hollow slot (upper slot for rectangular, lower slot for trapezoidal) fixed plate, hollow slot in the middle of the packaging, while the packaging inside the overall larger than the size of the plate, so that the plate is not in contact with the upper and lower right and lower surface of the packaging to achieve the effect of anti-vibration cushioning. After opening the packaging, fold the flap and insert the edge of the trapezoidal slot into the rectangular slot, so that it can be turned into a plate holder for product display.

CONCLUSIONS

This study understands the significance of the concept of sustainable development for packaging design and innovation of tableware packaging. Factors such as environmental friendliness, product protection, manufacturing cost and packaging efficiency are refined through literature analysis, case study

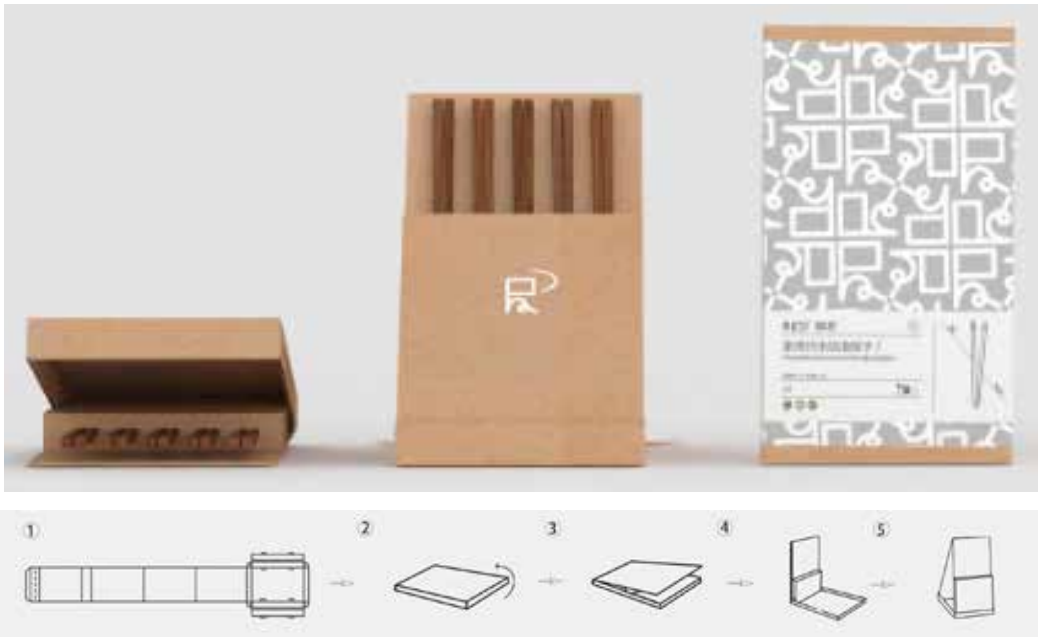


Fig. 2. Bamboo and wood non-slip chopsticks packaging can be displayed

Fig. 3. Recycled shockproof household heirloom mug packaging

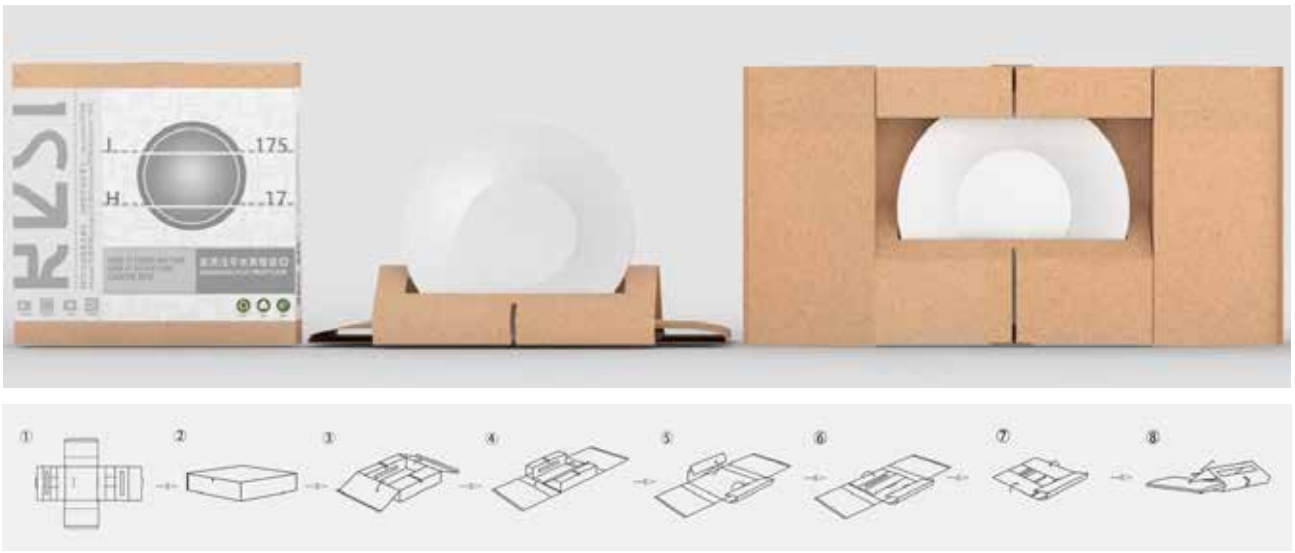


Fig. 4. Recycled shockproof household shallow flat fruit plate packaging

analysis and AHP hierarchical analysis to fully understand the product characteristics and establish sustainable tableware packaging solutions with functional features such as one-piece paper structure, reuse, and shock-proof and cushioning, which are of great significance to the sustainable development of packaging in the future. First, the one-peace paper can effectively reduce the waste of resources in tableware packaging and alleviate the pressure on the environment. Secondly, the shockproof buffer structure can fully play the protective function of the packaging and effectively reduce the damage of fragile products in the transport process. Finally, the reuse of part of the packaging can effectively extend the use cycle of the packaging and alleviate the difficulty of packaging recycling. According to the research and analysis, the demands of tableware packaging design are summarised from multiple perspectives of production, environment and consumers. According to the theoretical summary and practical problems to locate the product, collate and conceptualise the packaging design methods and approaches, and apply them to design practice. In conclusion, this study hopes that the sustainable design of packaging can stimulate more consumers' environmental

awareness and contribute to the goal of sustainable development.

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АНОТАЦІЯ

Тан Цун, Пашкевич К. Л. Екологічний дизайн пакування для посуду на основі інтегрованого підходу

Мета *– дослідження концепції сталого розвитку для інноваційного дизайну суцільного пакування столового посуду з метою продовження життєвого циклу упаковки, полегшення виробництва та просування концепції екологічності.*

Методологія. *У дослідженні використовувалися комплексний підхід та аналіз літературних джерел щодо концепцій сталого пакування. Тематичні дослідження були використані для порівняння та аналізу існуючої суцільної паперової упаковки та економічної упаковки на споживчому ринку. Завдяки порівняльному аналізу проаналізовано переваги та недоліки екологічного пакування. Використано метод ієрархічного аналізу для ранжування факторів та отримання об'єктивного фокусу дизайну.*

Результати дослідження. *У статті досліджуються методи екологічного дизайну в пакуванні посуду. Розглянуто дизайн пакування, процес його виробництва, транспортування та продажу з погляду екологічності. Розроблено серію дизайнів пакування столового посуду, що відрізняються практичністю, інноваційністю та покращеними характеристиками. Екологічний дизайн пакування у цьому дослідженні стосується проблеми відходів пакування та переробки. Це закладає основу для захисту навколишнього середовища та сталого розвитку між споживачами та виробниками. Завдяки зменшеній структурі цілісного паперового пакування зменшується споживання сировини та витрати на обробку, а також негативний вплив на навколишнє середовище та раціоналізується розміщення людських ресурсів.*

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Наукова новизна. *У дослідженні дизайн пакування розглядався з погляду його життєвого циклу. Отримані дані дали можливість розширити функції пакування щодо захисту товару, транспортування, переробки тощо.*

Практична значущість. *Дослідження конструкції структури цілісного паперового пакування має практичне значення для сучасної упаковки. Науковий підхід до дизайну пакування з погляду форми, розміру, функції та інших аспектів значно підвищує його ефективність і надійність.*

Ключові слова: екологічне пакування, пакування посуду, суцільне пакування, аналітичний ієрархічний процес (AHP), графічний дизайн, мистецтво, дизайн продукту.

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