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Intelligent food packaging design based on visual communication and multimedia technology

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Abstract: Intelligent food packaging has labels that cover a vast amount of information, but some labels may pop up a lot of information after scanning, which can easily cause interface confusion, and there may be a lack of single display channels, resulting in long search times for consumers. The aim of intelligent food packaging design research based on visual communication and multimedia technologies is to explore and develop innovative methods to improve the attractiveness, functionality, and interaction with consumers of food packaging. These all can directly affect consumers' purchasing intentions. This article was based on visual communication and multimedia technology for intelligent food packaging design to enhance the attractiveness of intelligent food packaging to consumers, enrich multimedia display content, and ultimately promote product sales. Intelligent food packaging involves art, information technology, and other aspects. This article categorized the field of intelligent food packaging design, elaborated on the forms of expression used in food packaging from existing intelligent multimedia technology, and analyzed the role of visual communication design and multimedia technology elements in food packaging. This article used a quantitative scoring table to evaluate the appearance design, interactive experience, information communication, and consumer response to food packaging. In the quantitative scoring experimental analysis, consumers evaluated the appearance of intelligent food packaging by 0.15 more than traditional food packaging and 0.03 more than conventional intelligent packaging. Ultimately, intelligent food packaging design could provide consumers with a sense of experience and clearer information transmission effects. Compared with traditional food packaging, it could quickly catch up with the development of the modern food industry.

Key words: Intelligent food packaging design, multimedia technology, visual communication, food information transmission, packaging design

1. Introduction

With the continuous development of science and technology and people's demand for improving the quality of life, food packaging is no longer just a simple container but has become an important visual communication medium. In this digital age, intelligent food packaging design combining visual communication and multimedia technology is gradually attracting people's attention. This article will explore this trend and analyze the potential benefits of smart food packaging design in enhancing user experience, product safety, and marketing promotion.

With the increasing demand of consumers for product quality and information transparency, traditional food packaging design can no longer meet people's needs. Smart food packaging design integrates visual communication and multimedia technology, which can not only attract the attention of consumers through visual effects but also present more rich and vivid product information through multimedia technology to enhance the user experience.

In the past, when consumers buy food, they mainly rely on the appearance and packaging of products to judge the quality and safety of products. Now, with the emergence of smart food packaging, consumers can understand the raw material source, production process, shelf life, and other key information through the visual information on the smart packaging, further improving the safety and trust of the product. Intelligent food packaging design based on visual communication and multimedia technology has many major contributions to the food industry, mainly reflected in the following aspects.

Through the application of visual communication and multimedia technology, intelligent food packaging design provides consumers with a richer and more vivid product experience. Through the introduction of dynamic images, visual effects, and interactive functions, food packaging is no longer a simple container, but a carrier that can interact with consumers, transmit information, and provide entertaining experiences. For example, a QR code or AR logo

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can be added to the package, and consumers can obtain product details, production process, nutritional value, and other content through mobile phone scanning, enhancing the attractiveness of the product and user experience.

Smart food packaging design can present product safety information and quality assurance measures through multimedia technology, which enhances consumers' trust and sense of security in products. By displaying product traceability information, raw material sources, production dates, and other key information on the packaging, consumers can more clearly understand the production process and quality control of the product, which helps consumers make more rational purchase decisions. In addition, some intelligent packaging designs can also achieve product anticounterfeiting functions, effectively prevent the flow of counterfeit and shoddy products into the market, and protect the legitimate rights and interests of consumers.

2. Related work

In today's digital and information age, food packaging is no longer just a protective shell for products, but also a powerful tool for brand marketing and consumer interaction. With the continuous innovation of technology, intelligent food packaging design based on visual communication and multimedia technology came into being. This trend has not only injected new vitality into the food industry but also established a unique image for the brand in the market. Traditional food packaging focuses on the basic information and appearance design of the product and smart food packaging will push it to a new realm. Through visual communication, we can create a more eye-catching and artistic packaging design, so that the product in the minds of consumers leaves a deep impression. At the same time, the introduction of multimedia technology has added rich interactivity to the packaging. Whether through QR codes, AR technology, or other innovative digital means, consumers can interact with packaging through smartphones or other devices to get more comprehensive and in-depth product information.

Food production and sales cannot be separated from packaging. Intelligent food packaging brings infinite possibilities to the development of the industry. It can transmit more information in various stages through rich and convenient forms. Many scholars have conducted research to improve the effectiveness of intelligent food packaging in transmitting information. Muhammad Sohail stated that the role of packaging in the lifecycle of any food was undeniable, and intelligent packaging was an emerging technology in the field of food packaging (Muhammad et al., 2018). Xiaoyu Luo demonstrated enhanced communication capabilities in intelligent food packaging systems by researching colorimetric indicator technology and provid-

ing dynamic product information to various stakeholders in the supply chain, such as consumers, retailers, and distributors (Xiaoyu et al., 2022). Ajit Kumar Singh reviewed the active packaging technology that supports the trend of clean labeling, with a focus on driving the clean label market. He discussed the various challenges of implementing clean-label food technology and its future in modern society. As customers drive modernization, the food processing industry shifted towards not using or reducing the use of active packaging solutions for ingredients. Food manufacturers were responding by integrating active packaging (Ajit et al., 2021). Chiara Chirilli believed that packaging was the main factor determining the overall environmental impact of food. He investigated consumers' understanding, behavior, and expectations of environmental sustainability in food packaging, and explored which factors have the greatest impact on consumers' behavioral choices, as well as how packaging conveys information related to environmental sustainability through labels, thereby promoting consumers to make more environmentally sustainable choices. The results indicated that sex, age, and education level were of great significance in shaping consumers' considerations and expectations for environmentally sustainable packaging. By creating eco-labels specifically designed for consumer needs, environmentally sustainable packaging could become a useful tool in the hands of food companies to encourage consumers to embrace the principles of environmental sustainability and guide them in making environmentally sustainable choices and actions (Chiara et al., 2022). Sophie Langley conducted a study on consumers' perspectives on the role of packaging and packaging labels in reducing household food waste, and the results showed that packaging designs that provided clear information and instructions to consumers were needed to reduce food waste (Sophie et al., 2021). The research of the above scholars indicates that the labeling of intelligent food packaging can achieve certain efficiency in information transmission, but the way of information transmission appears too simplistic. This article analyzed and cited visual communication and multimedia technology to select solutions suitable for intelligent food packaging design, attempting to improve the limitations of this problem.

In terms of information exchange, many researchers have applied multimedia technologies such as virtual reality and scanning quick response codes to further enhance the interaction between consumers and product design, thereby completing the transmission of information and enhancing the attractiveness of consumers to intelligent food packaging. Michalis Vrigkas conducted some research on the workflow of Augmented Reality (AR) for wine product labeling and believed that AR technology was constantly developing in various fields of communica-

tion such as entertainment, education, information, and marketing, as well as other fields such as industrial product design (Michalis et al., 2021). Olivia Petit's research showed that AR visualization for serving food improved the simulation of the eating process and had a positive impact on purchase intention. Three-dimensional visualization increased the willingness to purchase packaged products (with high tool attributes) rather than service products (with low tool attributes), while AR visualization was the opposite. In addition, interactivity and immersion mediated the impact of three-dimensional (relative to AR) on the psychological simulation of the dietary process of packaged products (Olivias et al., 2022). Liu Danfei conducted research on packaging indicator materials for real-time monitoring of food quality and explored intelligent packaging technology and new foods. This could monitor the quality and taste of fresh food packaging materials, such as time-temperature indicators, Radio Frequency Identification (RFID), biocomposites, and polymer nanocomposites in food packaging (Liu et al., 2019). Existing literature indicates that the exploration of AR technology and packaging materials that can transmit information opens up prospects for intelligent food packaging information interaction. A study conducted by Waihaideng Research Institute shows that 45% of consumers purchase products after viewing 2D printed materials. After experiencing AR technology in the product, 74% of consumers will purchase products, and the purchase rate has increased by nearly 30%. It can be seen that applying AR technology to product packaging has enormous potential to improve product sales. However, at the same time, it also brings confusion in the food information interface, and consumers' attention cannot be focused on product purchases. In response to these issues, this article cited visual communication and multimedia technology to design intelligent food packaging. The Internet of Things (IoT) provides opportunities for wearables, home appliances, and software to share and communicate information over the Internet. In the past, companies could rely on restricting themselves to specific geographic areas to conduct business. Today, businesses are becoming increasingly location-independent, finding themselves at a strategic disadvantage if they are confined to a particular location. Advances in information technology and changes in business boundaries have brought the importance of data and information to the fore. It is information that helps a company achieve its goals and helps managers make appropriate decisions. Because the shared data contains a lot of private information, maintaining the information security of the shared data is an important problem that cannot be ignored. This inspires practitioners and innovators to investigate opportunities to introduce new technologies in their organizations through research efforts (Agarwal Shivani et al., 2020).

The highly dynamic, decentralized, and opaque nature of cloud computing presents significant challenges to trust management. Scholars agree that trust and security are the two most important barriers to cloud computing adoption. There are SLAs (service level agreements) that alone establish trust between clouds that are unnecessary because of vague and unpredictable terms. Getting feedback from consumers is the best way to understand the trustworthiness of cloud services, which will help them in the future. Several researchers have pointed out the need for a robust management system for men and put forward a number of ideas based on consumer trust management. This article reviews various reputation-based trust management systems, including trust management in cloud computing, peer-to-peer systems, and AD hoc systems (Govindaraj R., et al., 2021).

In order to enhance the attractiveness of intelligent food packaging to consumers and improve the current situation of single multimedia display interfaces and chaotic information transmission, this article introduced visual communication and multimedia technology into intelligent food packaging design for analysis and used visual communication elements to design the appearance of intelligent food packaging. In terms of consumer satisfaction, this was compared with food packaging that has chaotic visual elements and no basis, causing visual confusion among consumers. The mobile food information interface displayed on scanned labels was designed. By comparing traditional and intelligent food packaging design based on visual communication and multimedia technology through a rating questionnaire, the final results showed that intelligent food packaging design based on visual communication and multimedia technology had the highest appeal to consumers, with a clear display information interface and rich and orderly content, and could better promote product promotion and sales. A quantitative evaluation scale was used to evaluate the appearance design, interactive experience, information exchange, and consumer response to intelligent food packaging. The results indicated that intelligent food packaging based on visual communication and multimedia technology was superior to traditional and conventional food packaging in all aspects. Intelligent food packaging also had advantages in increasing consumer purchasing intention and brand awareness. Consumers were more willing to purchase and recognize products that use smart food packaging.

3. Intelligent food packaging design

The so-called "intelligent packaging" is generally believed to be a packaging technology that has the ability to perform intelligent functions. The general intelligent functions refer to: recognition, detection, recording, tracking, and connecting to the Internet. The application of intelli-

gent packaging can extend the shelf life of goods, enhance the safety of goods, improve the quality of goods, provide consumers with information on the procurement of raw materials, production, packaging, transportation, and storage of goods, and warn consumers of potential problems when purchasing and using goods, thereby better-guiding consumers.

3.1. Visual communication and multimedia technology elements in intelligent food packaging design

Visual communication refers to the process of conveying information, ideas, emotions, or concepts through visual elements and graphics. In design, visual communication can be achieved through images, colors, shapes, typography, ICONS, symbols, and other visual elements. This is important in a variety of fields, including design, advertising, art, education, and media. The design of food packaging is closely related to human vision, and visual communication completes information exchange during the process of "seeing". With the development of multimedia technology, the content and methods of visual communication are constantly updated, and the visual content of food packaging is gradually increasing.

The information about food is mainly carried on the outer packaging through three elements of image, text, and color as communication media. Firstly, through image design, consumers can understand the brand logo and food types to form a preliminary understanding; through color recognition of food characteristics, understanding the emotions that color brings to consumers has a direct impact on human visual perception; finally, consumers pick up the item to view the desired information and expresses it in the most accurate and direct way through text.

Intelligent food packaging is classified, taking into account the special needs of different types of food and the different preferences of consumers. The performance and feedback of different types of packaging in the market are analyzed, and multimedia technologies suitable for intelligent food packaging are selected, such as augmented reality, virtual reality, and scanning fast response codes. The principle of visual communication is utilized to design the appearance of intelligent food packaging. Factors such as

color, graphics, logo, and font are taken into account to ensure that the packaging is visually attractive and conveys clear information. Visual communication is a communication method that uses the naked eye (or a telescope) to receive signals within the visual range. Visual communication includes flag or arm communication, flag communication, lighting communication, fireworks communication, body communication, and audio communication. Multimedia content, including images, videos, audio, etc., is also developed to enrich the information transmission of packaging. Finally, the content that conforms to the product characteristics and brand philosophy is ensured.

Aesthetic packaging can stimulate interest in buying. Food packaging can attract consumers through its appearance, effectively conveying information, and designing different styles based on consumers' psychological needs. This article randomly selected 90 customers from a large supermarket in A city, mainly investigated the factors that attract them to food packaging and recorded them. This article believed that five factors attracted customers to food packaging, as shown in Formula 1:

$$(\text{Packaging}=\text{Color}+\text{TextIntroduction}+\text{Interactive tags}+\text{Package modeling}+\text{Pattern}) \quad (1)$$

The food packaging factors are detailed in Table 1.

In Table 1, the details of the food packaging factors that attracted customers were described. A total of 5 factors were counted in this article, with a total of 301 feedback points. Among them, patterns account for 27%; color factors account for 20%; and text introductions account for 19%. This indicates that patterns and colors can provide the most intuitive visual impact compared to other factors. Consumers are first attracted by the patterns and colors, and then pick up the packaging to read the text, forming a simple information exchange process.

By investigating users' opinions on various factors, analyzing them from the perspective of consumers, and considering the appearance of food packaging, packaging visual communication design is carried out. The packaging must clearly convey the basic information of the product, including the product name, brand, ingredients, nutritional value, guidelines for use, and date of manufacture. This helps consumers make informed purchasing decisions.

Table 1. Details of food packaging factors.

Serial number	Attraction factors	Opinion	Percentage
1	Color	61	20%
2	Text introduction	58	19%
3	Interactive tags	48	16%
4	Package modeling	52	17%
5	Pattern	82	27%

Table 2. Factors for consumers to choose colors and text introduction.

Factors and proportion of consumer choice				
Factor	Color		Text introduction	
Number of comments	61		58	
Reason	Follow the trend	16%	Meet demand	47%
	Look comfortable	59%	Consider food safety	29%
	Color surprise	25%	Be drawn to copywriting	24%

Table 2 is a survey of the reasons why consumers are attracted by food packaging colors and text descriptions to choose to purchase products. Among the 301 recycling opinions, there are a total of 61 opinions on color selection. This article summarized the 61 opinions into three aspects: following the trend: consumers make purchases based on popular colors on the market and follow the public's aesthetic, accounting for 16% of the survey; comfortable color perception: the color matching of food packaging makes consumers visually comfortable, with 59% of the 61 color opinions; color surprise: when consumers discover their favorite or surprising color combinations on food packaging, they would promptly adjust their purchasing behavior. As can be seen from Table 2, this opinion accounted for 25%. Through Table 2, this article found that the proportion of color visual comfort was the highest. The color design of food packaging is reasonably matched, thereby providing buyers with visual and sensory comfort and achieving psychological comfort. Therefore, when designing food packaging in this article, full consideration would be given to the overall tone of the packaging and the color matching of various elements, in order to avoid the defect of disorderly colors in food packaging. The color configuration of packaging should focus on considering the relationship between the brightness and purity of various colors and studying people's feelings and preferences for different colors. The specific requirement for packaging color is to use simple colors, and it is best to use one color to unify the graphics, otherwise, it will give people a feeling of disorder and difficulty to recognize, making the packaging not play its due role.

Secondly, there are a total of 58 reasons why customers are attracted to text introductions on food packaging, with the highest proportion being in line with demand, accounting for 47%. The second consideration is food safety, accounting for 29%. The lowest proportion is attracted by advertising copy, which is 24%. This article would consider the reasonable layout of consumer demand information during design, and design a concise and intuitive layout.

The factors that consumers choose interactive labels, packaging styles, and patterns are shown in Table 3.

When organizing the recycling opinions in this article, it was found that many customers chose interactive tags as a reason to attract them to purchase products. Modern information technology also led to the gradual development of food packaging towards intelligence. From Table 3, it could be seen that the proportion of information traceability was the highest, with 31%. The second was to receive feedback and timely sharing, accounting for 25%. Other reasons accounted for 19%. A total of 52 opinions were collected on the reasons for choosing packaging styles to purchase goods, of which 38 were "novel and unique", accounting for 73%; reuse and other reasons accounted for 19% and 8% respectively. Among the dazzling array of products, specially designed packaging was more eye-catching, but the uniqueness of the design depended on technology and cost. If cost was not considered, the design could not be put into use.

Among the 301 recycling opinions, there were a total of 82 reasons why food packaging patterns attracted consumers to purchase, with 71% of the opinions stating that the patterns were attractive, followed by 13% for artistic and 16% for food-specific patterns. This article will refer to the opinions and data in Table 3 and combine the three opinions as the basis for designing food packaging patterns.

The traditional way of conveying information in food packaging mostly lies on the surface of the packaging, and visual design only focuses on "colorful and complex artistic expression", which only stops at designing an appearance that attracts people's attention. This leads to overly complex patterns and visual symbols that dazzle consumers, neglecting direct and effective information transmission. This article believes that the overall design of food packaging should have a high degree of uniformity, and conceptualizes food packaging design from aspects such as deconstruction elements, planning layout, and color application: the main display surface of the packaging accurately conveys the main information of the product name, logo, quick response code, pattern, date, etc. Generally, 3–5 visual symbols are used. The appropriate use of white space in pattern size, line length, and layout is appropri-

Table 3. Factors influencing consumers' selection of interactive labels, packaging styles, and patterns.

Factors and proportion of consumer choice						
Factor	Interactive tags		Package modeling		Pattern	
Number of comments	48		52		82	
Reason	Get feedback	25%	Novel and unique	73%	Fascinating	71%
	Information tracing	31%	Reutilization	19%	Artistic	13%
	Timely sharing	25%	Other	8%	Characteristic of food	16%
	Other	19%				

ate. Through visual transmission, a sense of psychological relaxation is given, making it easy to get close; utilizing the three elements of color, namely brightness, purity, and hue, can have an impact on people's visual and psychological well-being. Brightness is the luminance of a color, which expresses emotions based on the different brightness of different colors in the same image. Purity is the degree of vibrant color. The brighter the color, the higher the purity, and vice versa, the lower the purity. This is called "gray". The hue refers to the appearance and name of a color, such as red, yellow, blue, etc.

With the development of information technology, multimedia technology has enriched the content and form of visual communication. Generally speaking, the design methods of visual communication in the past were relatively single, staying at the visual senses. Nowadays, there is participation in multimedia technology, such as labeling on packaging, scanning and sensing through mobile devices, and viewing product information through mobile Applications (APP) and mini-programs. Users' access to information from the real world to the digital world has expanded the range of multiple senses such as vision and hearing that work together. In the past, design methods for visual communication focused on the visual senses and visual elements such as graphics, color, shape, and typography. However, as technology and design continue to evolve, the design approach to visual communication has become more integrated and diverse, taking into account more sensory and psychological needs. In terms of design scope and communication form, it has evolved from a relatively simple few media to today's comprehensive and diversified media era, and visual language has extended from "static" to "dynamic". It moves from a plane to a three-dimensional or even four-dimensional space, creating a new visual world with diverse information forms.

Multimedia technology plays an important role in visual communication, combining different media elements such as images, sound, video, and text to create a richer and more engaging experience. Multimedia technology is

the use of computer interactive synthesis technology and digital communication network technology to process various presentation media, namely text, graphics, images, videos, and sounds, to establish logical connections between various information and integrate them into an interactive system. It can be manifested in various ways in food packaging: utilizing technologies such as quick response codes and Near Field Communication (NFC) to develop interactive smart tags, consumers can scan the quick response code on their phones to open mini-programs, designated apps to view information or open the NFC function on their phones to approach packaging with interactive tags. NFC is a short-range wireless communication technology that enables data transmission and sharing between two devices equipped with NFC chips. At present, NFC technology has been widely used in mobile phone payment, smart door locks, bus and subway ticketing systems, and other fields. Detailed information could appear on their phones. The wireless operator payment management system only performs detailed transaction recording work after receiving operational instructions confirmed by consumers. At the same time, it will also issue instructions to financial institutions to clear payments between consumers and merchants, and notify merchants to provide transaction services. Quick response codes are favored by people due to their low cost, high error correction rate, and fast recognition speed (Lina et al., 2021). However, due to the limited size of the mobile interface, manufacturers need to place not only simple product information on the interactive interface but also focus on extending the added value of the product. Product-added value refers to the added value created through intellectual labor (including technology, intellectual property, management experience, etc.), manual processing, equipment processing, circulation marketing, etc., which exceeds the value of raw materials. The value created in the production process and the value created in the circulation process are both part of the added value of the product. For producers, if there are problems with food batches, it is more conve-

nient to retrieve them, and it is more conducive to controlling operations and sales; for consumers, it is important to highlight the characteristics of simplicity, understandability, liveliness, and portability.

When a food safety issue or recall occurs, traceability labeling can help producers quickly identify the affected product lot and distribution chain. This helps to reduce potential health risks and prevent unsafe products from entering the market. The use of traceable labels on food packaging is beneficial for ensuring food safety and facilitating the viewing of food information by producers and consumers. Food safety is the main factor affecting public health and social well-being. Due to underreporting and difficulty in establishing a causal relationship between food contamination and the resulting diseases or deaths, the burden of foodborne diseases on public health, welfare, and the economy is often underestimated. One possible solution for controlling foodborne diseases is through real-time monitoring of food quality throughout the entire food supply chain (Hanie et al., 2019). Consumers refer to labels to learn more detailed information about food. Although many factors (people's consumption behavior and purchasing decisions are largely influenced by cultural, social, personal, and psychological factors) can affect their perception and purchasing behavior, labels are still the main means of conveying food information that affects consumers' choices. Therefore, it represents the final step in the traceability path for consumers. Appropriate label design can improve the traceability process of food and reduce information asymmetry between producers and consumers (Angelo et al., 2021). The current food traceability system is challenged by frequent food safety incidents and food recalls, which have damaged consumer confidence, caused huge economic losses, and put pressure on food safety agencies. It focuses on the research of intelligent food traceability, believing that traceability has the potential to significantly improve food safety in the global food supply chain. It summarizes the basic concepts and key perspectives of various food safety detection strategies (Zhilong et al., 2022). Food packaging includes the local function of preserving food, ensuring the highest quality and safety throughout the entire production chain and storage process while extending its shelf life. Intelligent food packaging has further developed the functions of traditional packaging, introducing the ability to continuously monitor food quality throughout the entire chain to assess and reduce the surge in foodborne diseases and food waste. For this reason, several sensing systems based on different food quality indicators have been proposed in recent years, but commercial applications still pose a challenge (Andrea et al., 2021). Intelligent food packaging enables two-way information transmission between producers and consumers, allowing producers to understand

food transportation, shelving, shelf life, and user feedback; consumers can obtain food anticounterfeiting and humanized consumption reminders, and food packaging smart labels can transmit information to manufacturers and consumers in both directions. For manufacturers, they can obtain production information and sales record distribution in various regions, and records of storage, transportation, and quality changes, as well as consumer feedback; for consumers, information such as anticounterfeiting signs, food shelf life monitoring, marketing interactions, and dietary reminders are transmitted.

Smart packaging can provide supply chain information about food, including origin, production date, distribution route, etc. This helps to improve the transparency and traceability of the supply chain, reducing the risk of food fraud and counterfeit products. Food intelligent packaging continuously generates informative digital or analog content about the products it contains throughout its entire lifecycle, becoming one of the driving factors of the modern data-driven economy (Cecilia et al., 2020). Food sensors integrated into intelligent packaging systems are expected to extend the shelf life of food during transportation, distribution, storage, and sales (Bambang et al., 2022). Electronic devices can safely read the production information, usage, anticounterfeiting information, and other contents of products by noncontact scanning of wireless radio frequency identification tags. With the development of technology, RFID technology has been applied to the field of food packaging. The central server of the wireless radio frequency identification system delivers information to the Internet system, enters the information, and fixes the food production information on electronic labels. It completes production in the workshop warehouse and finally transports products with smart labels to physical stores for sale. Consumers can trace the detailed information of their purchased products through scanning, truly implementing a trustworthy purchase.

3.2. Design ideas

Based on the shortcomings of excessive information in food packaging, such as confusion in packaging appearance and virtual interface, improvements should be made to select a suitable packaging design scheme. It needs to achieve the following steps: understanding the characteristics and types of food; studying the visual characteristics of similar products in the market; extracting core features and functions; choose appropriate materials and processes. Firstly, this article determined the overall style tone of packaging based on visual design principles and then conducted a comprehensive analysis of existing multimedia technologies to determine the visual expression form of food packaging appearance. Packaging is an indispensable part of the food industry, which is related to food quality and safety (including food shelf life), as well as communi-

cation from a marketing perspective (Mary et al., 2022). Therefore, when designing the information interface that pops up on mobile devices, this article considered the perspective of consumers, placing information such as food origin, shelf life, and precautions that ensured food quality and safety on the same plane. Consumers can obtain the content they want to know by clicking. Finally, the design results of the appearance and information interface of food packaging are presented. Consumers can click for specific information based on their needs and interests, such as nutritional value, ingredients, recipe suggestions, or product stories. This personalized messaging can increase consumer satisfaction.

Packaging design helps brand promotion and recognition, especially in high competition where stunning and attractive packaging can attract consumers' attention and influence their final purchase decisions (Konstantinos et al., 2022). In terms of visual design, based on color characteristics, this article has decided to use warm color schemes in packaging design and use geometric elements to form simple and understandable patterns with food characteristics. Other characters and interactive labels are reasonably arranged to make the plane's appearance simple and not disorderly. Achieving rapid response requires starting from multiple aspects, including code optimization, asynchronous programming, CDN, resource compression, and database optimization. When designing packaging, this article mainly uses quick response codes as a part of the packaging appearance design. Quick response codes can use augmented reality technology for interactive interfaces and apply virtual data to real life on mobile device screens. Quick response codes (QR codes) are a common digital technique for applying virtual data to real-life situations. They can be scanned by a mobile device's camera for links, text, images, and more that contain information. Combined with augmented reality (AR) technology, QR codes can be used to create interactive interfaces and fuse virtual data into the real world.

This article assumes that consumers can scan the quick response code on their mobile device to pop up a mini program that follows the page prompts to obtain detailed food information. Interactive mini-games can also be added to the page to let consumers understand the process of food production while adding brand stories to make a deeper impression. This article believes that before setting up a virtual information display, food characteristics should be fully considered, such as fresh, fruits and vegetables, and recipes and precautions for preservation and cooking can also be added; leisure snacks can be added with fun interface gameplay and better ways to consume. Using quick response codes as a "medium", users extend their cognitive experience from reality to virtual reality and then apply sensory experiences and methods obtained from virtual

reality to reality. The quick response code on food packaging guides consumers to obtain entertainment and rich content, thereby increasing their willingness to use it. The use of quick response codes enables enterprises to provide timely and accurate information and has a positive impact on consumer purchasing behavior (Elkhattat et al., 2022). QR codes can quickly provide detailed information related to a product, promotion, brand, or event. This can help consumers better understand the product in order to make purchasing decisions. QR codes are linked to personalized content, which can satisfy the consumers' needs and preferences. This can increase their interest and loyalty. Consumers need to have more interaction with packaging, deepen their impression of the brand, and extract relevant memories at the beginning of their next consumption action, which is beneficial for promoting the brand image.

3.3. Intelligent food packaging display

Using computer image processing software to design smart food packaging is a modern way to help convey food information, attract consumers, and increase brand awareness.

It is considered based on the objectively existing appearance of an apple. The conventional intelligent food packaging information is messy, often attracting consumers through various variations of the logo, but often lacking a unique and unified logo pattern. This article takes the apple as the prototype and deconstructs and reorganizes geometric shapes. In people's inherent impression, apples are circular. In order to deepen consumers' impression of the intelligent food packaging logo designed in this article, a square was ultimately used as the intention logo for apples.

This paper assumes that the brand logo of the product is "YUMMY", which means delicious and delicious, and the word is popular with a high degree of recognition, which is more conducive to attracting customers. Below the logo, the geometric shapes are deconstructed and reorganized to create an apple pattern. This image summarizes the raw materials and characteristics of food, making it easy to understand. When people see red apples, they imagine words such as "mature" and "sweet". Below the pattern is the food name "dried apples", which is designed to quickly convey information. The quick response code is arranged in the lower right corner of the pattern, which is more intuitive and clear, making it easy to guide consumers to quickly scan and interact after a preliminary understanding of the product. The small saplings below the packaging represent apple trees one by one, with the aim of conveying to consumers the "raw ecology, natural and healthy" growth environment of dried apples' raw materials and conveying a signal of food safety, health, and peace of mind when purchasing to consumers.

When extending the visual range of food packaging to the virtual interface of the Internet, due to the different screen sizes and resolutions of consumer mobile devices, it

is necessary to consider the display effect of the interactive interface. It is crucial to adjust the perspective relationship of the interface and grasp the degree of freedom in the layout. Before publishing, it is necessary to ensure that virtual interfaces are tested on multiple devices, including smartphones, tablets, laptops, and desktops, and to ensure that the interface is displayed correctly on various devices and that the elements are not distorted or confused. Consumers can scan the quick response code of the packaging to obtain the display interface for purchasing food. Therefore, this article believes that the design of interactive elements should follow the principles of intuition, balance, and fluency. Firstly, the operation buttons on the interface adopt color icons and text, thus providing clear and concise product information and interactive gameplay and allowing users to click and operate without pressure; secondly, the interface uses appropriate image compression processing and data optimization techniques to reduce device operating pressure and improve information loading speed, enhancing the smoothness of entering the interface; thirdly, in interface design, color combinations that conform to the product's tone are selected, and overall, static and dynamic elements are combined for reasonable layout, with a design contrast. The overall color of the interface is light green, and the information keyword interface uses a white background to highlight the presence of keywords. The information content includes product name, net content, production date, shelf life, precautions for consumption, origin, consumption, or cooking method. This article has set up a circular gray button for playing videos under the food information, and a prompt to return to the homepage is designed at the bottom of the mini program page to facilitate consumers to exit the interface in a timely manner after understanding the information. The interface designed in this article is relatively simple and needs further improvement, but the basic display information prompts are all on the same interface. It takes food raw materials as the background, and then sequentially enters food information to effectively transmit it to consumers. The product name, raw materials, net content, shelf life, and consumption method are entered separately. The second image displays the true state of the apple. In the upper right corner is a video introducing the product. Consumers can watch on demand. This article assumes a combination of the brand name "YUMMY" and the slogans "Be healthy" and "Be happy". This is intended to convey to consumers the healthy, happy, original, and burden-free characteristics of the food, in order to promote sales.

4. Intelligent food packaging design experiment and evaluation

A total of 225 survey users were randomly selected in a certain city, and a total of 225 food packaging rating papers were distributed, of which a total of 200 valid rating papers were retrieved. The selection criteria were based on

a score of 1–10, with a score below 6 (including 6) being the lowest standard. A score of 6 was included in the final evaluation result. The data results were compared in descending order of 6, 7, 8, 9, and 10. The higher the proportion of scores, the higher the number of points in this item, and the higher the acceptance of the food packaging.

In order to effectively analyze the performance of intelligent food packaging design, this article sets up a control group to analyze and compare the intelligent food packaging based on visual communication and multimedia technology (hereinafter referred to as "intelligent food packaging") designed in this article with traditional food packaging and conventional intelligent food packaging (hereinafter referred to as "conventional food packaging").

4.1. Food packaging appearance design

This article adopts a comprehensive visual communication design method, aiming to carefully design the packaging appearance and elements. Multimedia technology is utilized to enhance the fun and appeal of intelligent food packaging. Through color matching, pattern design, and font selection, a striking exterior design is achieved, making packaging stand out on shelves. This article also introduces creative map elements to enhance the uniqueness of packaging. Combining visual communication with multimedia technology, the function of scanning QR codes is integrated into the packaging, and by scanning them, consumers can immediately obtain detailed information about the product. Intelligent packaging bags not only focus on visual communication in appearance design but also emphasize the organic integration of multimedia technology. This comprehensive design concept enables intelligent packaging to better meet consumer expectations in both form and function.

Beautiful packaging can immediately attract consumers' attention. By comparing the appearance of traditional and conventional intelligent food packaging with the intelligent food packaging designed in this article, the differences between the two designs can be compared by quantifying consumers' evaluations and preferences for packaging appearance. The comparison results are shown in Figure 1.

In Figure 1, consumers were asked to rate their satisfaction with traditional and conventional intelligent food packaging and the intelligent food packaging exterior design designed in this article through a rating questionnaire. The horizontal axis in the left figure represents the rating of food packaging, while the vertical axis represents the number of rating values for food packaging. Traditional food packaging received a total of 41 "6 points". There were 20 conventional and 19 intelligent food packaging. Intelligent food packaging was 22 fewer than traditional food packaging and 1 less than conventional packaging. A total of 29 "10 points" were awarded for intelligent food

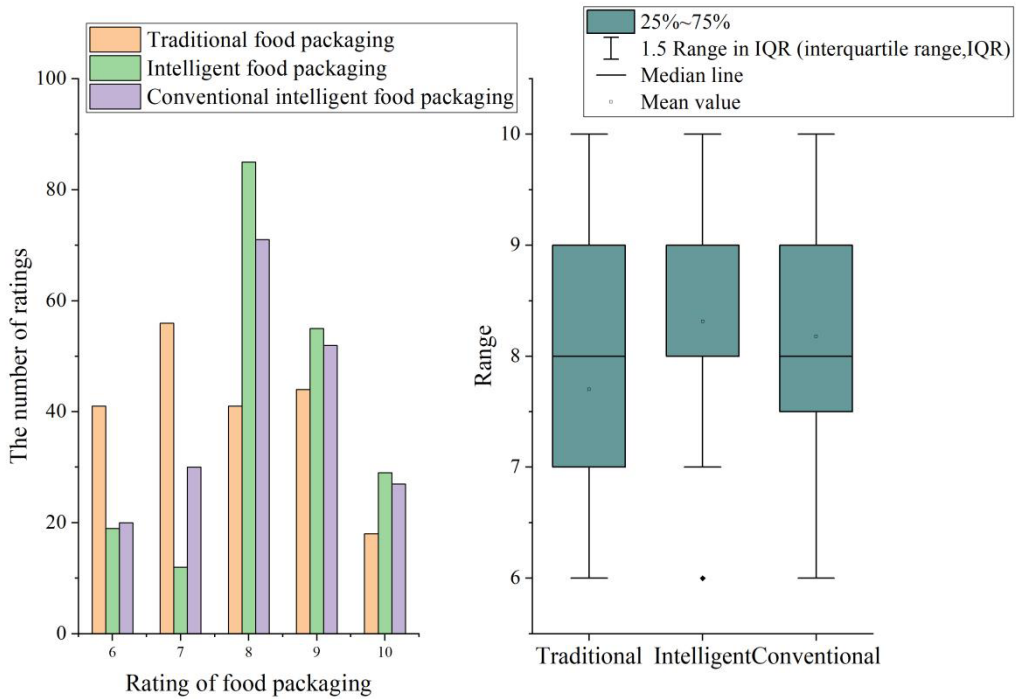


Figure 1. Comparison results of food packaging appearance.

packaging. There were 18 traditional food packaging options, which were 11 fewer than intelligent food packaging. There were 27 conventional intelligent food packaging, which was 2 fewer than intelligent food packaging. Traditional food packaging had more low scores than intelligent food packaging and fewer high scores than intelligent food packaging. However, the difference in quantity between conventional food packaging and intelligent food packaging was similar in terms of “6 points” and “10 points”.

From the left figure, it could be calculated that the evaluation proportion of traditional food packaging appearance design from 6 to 10 points was 0.51, 0.57, 0.21, 0.29, and 0.24. The proportion of intelligent food packaging appearance evaluation scores ranging from 6 to 10 was 0.24, 0.12, 0.43, 0.36, and 0.39. The proportion of conventional food packaging appearance design was 0.25, 0.31, 0.36, 0.34, and 0.36. In the “10 points” proportion of packaging appearance evaluation, intelligent food packaging was 0.15 more than traditional food packaging and 0.03 more than conventional intelligent packaging; The proportion of traditional food packaging receiving “6 points” was 0.27 more than that of intelligent food packaging; the proportion of intelligent food packaging in the “8 points” was 0.22 more than traditional food packaging and 0.07 more than conventional food packaging. In the “9 points”, it was 0.07 and 0.02 more than traditional and conventional, respectively.

In the right figure, the horizontal axis represents traditional, intelligent, and conventional food packaging, while

the vertical axis represents rating levels. The average score for traditional food packaging was 7.7. The intelligent food packaging was 8.315, while the conventional packaging was 8.18. The difference between intelligent food packaging and traditional average was 0.615 and 0.135, respectively. Through data analysis, it was found that the appearance of intelligent and conventional food packaging was more attractive to consumers than traditional packaging. However, both were intelligent food packaging, and there were inevitably similarities in appearance design, so the difference in ratings was relatively small.

This article believed that the information of intelligent food packaging was mainly carried by quick response codes and barcodes, which were more concise in appearance design compared to traditional packaging. However, there were two reasons why the rating was slightly higher than that of conventional food packaging: firstly, it was convenient for consumers to directly obtain the main information of food; secondly, the simple and aesthetically pleasing packaging appeared visually uncluttered, which could stimulate the potential demand of consumers to purchase a series of products.

4.2. Interactive experience

The fun design of the packaging bag needs to be considered, that is, whether there is a design that can interact with consumers, such as scanning QR codes to obtain information of interest, playing videos, or other multimedia content. It is also necessary to evaluate whether the exteri-

or design of the packaging bag is eye-catching and whether attractive patterns, colors, and visual elements are used to stimulate consumer interest. It is also essential to consider whether the bag has the function of resealing to maintain the freshness of the food and check the weight and size of the bag to ensure that it is lightweight and convenient for consumers to carry and use.

Intelligent food packaging places more emphasis on user experience and engagement than traditional food packaging. Comparing the fun and convenience of interactive experience between traditional food packaging and intelligent food packaging relying on multimedia technology, the comparison results are shown in Figure 2.

The horizontal axis of the left figure in Figure 2 (a) represents the rating level of food, while the vertical axis represents the number of food packaging ratings, that is, the number of rating values for each item. From the left figure, it could be seen that traditional food packaging obtained higher minimum scores than both intelligent and conventional food packaging, with fewer scores of 8, 9, and 10 compared to the other two types of food packaging. In the right figure of Figure 2 (a), the average values of traditional, intelligent, and conventional food packaging were 7.68, 8.01, and 7.81. The average difference between traditional

packaging and intelligent packaging was 0.33, while the average difference between intelligent and conventional packaging was 0.2. Overall, from Figure 2 (a), intelligent food packaging had a higher interest rating.

The comparison in Figure 2 (b) showed the convenience rating of information transmission in food packaging. From the left figure of Figure 2 (b), it was evident that intelligent food packaging had a higher quantity of 8 to 10 points than traditional and conventional food packaging. From the picture on the right, the average values of traditional, intelligent, and conventional food packaging were 7.935, 8.055, and 7.95. By analyzing the overall rating survey results in Figure 2, this article found that consumers believed that intelligent food packaging was more convenient and interesting for conveying information than the other two types of packaging.

Compared with previous studies, the intelligent food packaging design in this study has made significant progress in terms of fun and convenience. By introducing visual communication and multimedia technology, the fun of packaging has been successfully increased, and eye-catching exterior design and interactive elements have been adopted, which are more attractive to consumers than traditional packaging.

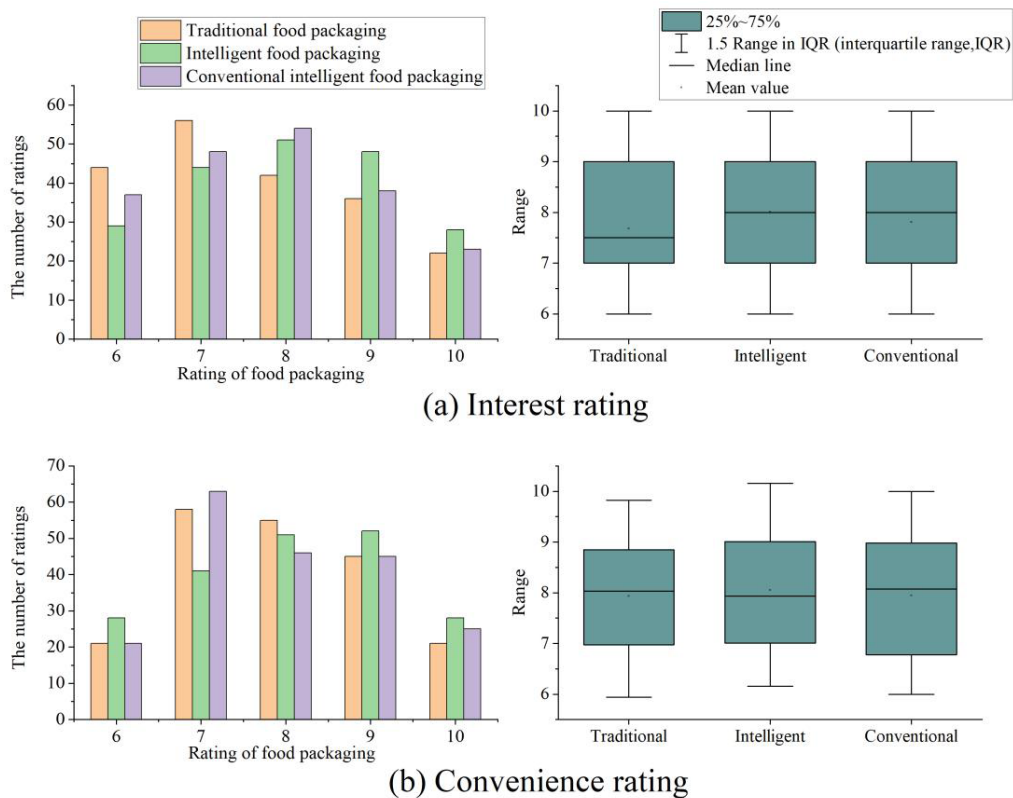


Figure 2. Comparison results of interactive experience in food packaging.

4.3. Information communication

The main function of food packaging is to transmit information, and this article believes that the information conveyed by food packaging should be easy for consumers to understand and obtain the completeness of the information. It also maintains food quality, facilitates consumers, and attracts their attention and interest in the product. Firstly, understandable information can help consumers quickly make judgments and decide whether to purchase; secondly, this article takes into account that consumers may have a detailed understanding of their consumption or cooking methods after purchasing, as well as their desire to have a detailed understanding of food safety issues before purchasing. For the sake of humanization, this article compares the level of understanding and completeness of information conveyed by conventional and intelligent food packaging, as shown in Figure 3.

In Figure 3, the comparison of consumers' communication effects on food packaging information is described. The lowest score was uniformly recorded based on 7 points (including below 7 points), and the scores from high to low were 10, 9, 8, and 7, respectively representing complete understanding, comparative understanding, general understanding, and difficult understanding. The larger the proportion of ratings, the more people were scoring.

In Figure 3, the horizontal axis of Figure 3 (a) represents the food packaging rating level, and the vertical axis represents the number of food packaging ratings, that is,

the number of rating values for each item. Figure 3 (a) clearly showed that conventional intelligent food packaging scored "7 points", which was the proportion of difficult to understand, which was more than half that of intelligent food packaging. It could be seen that the number of people who gave high scores to intelligent food packaging was higher than that of conventional food packaging.

Figure 3 (b) depicts a rating survey on the completeness of information obtained by consumers from two types of food packaging. The horizontal axis represents the rating level of food packaging, while the vertical axis represents the number of rating values for each item. It could be clearly seen that conventional intelligent food packaging scored lower. Consumers gave it a rating of 7 and 8 points, both of which exceeded the proportion of intelligent food packaging.

As shown in Figure 3, the application of multimedia technology and visual communication design in intelligent food packaging conveyed information content that was easier to understand and more complete than conventional intelligent food packaging. Due to the limited information-carrying capacity of conventional intelligent food packaging, it was not possible to fully improve food consumption methods. Intelligent food packaging compensated for this deficiency by fully showcasing food usage, expanding consumer information, and further improving the effectiveness of information transmission.

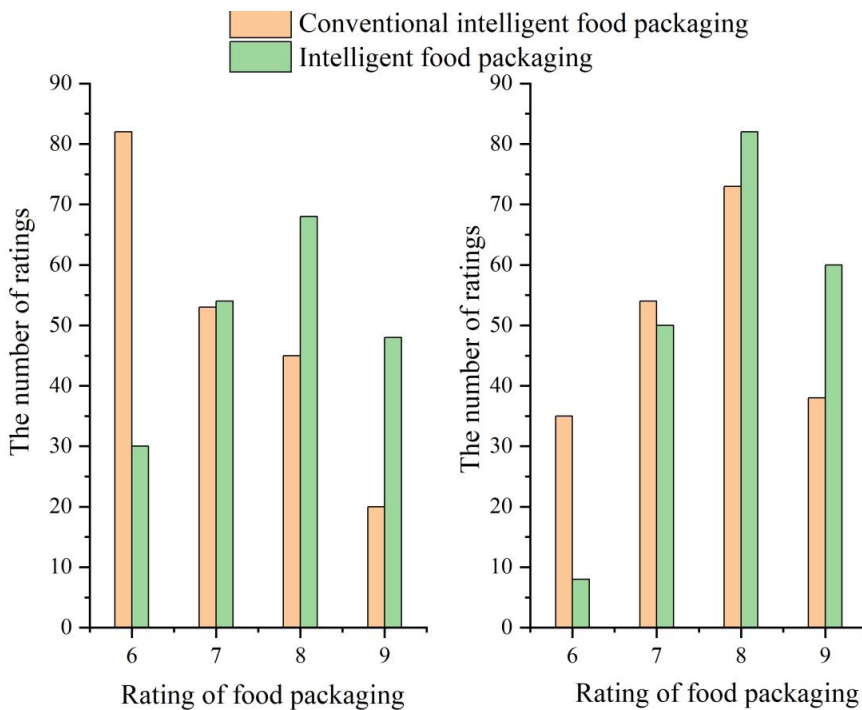


Figure 3. Comparison of food packaging information communication effects.

4.4. Consumer response

The ultimate purpose of production is to flow to the market for sale and promote economic circulation. The use of packaging to bridge the general consumer experience between digital marketing and physical shopping is a novelty in retail and brand management (Lydekaityte et al., 2020). Food packaging not only has the function of protecting food from pollution but also serves as a marketing tool to accelerate the sale of goods in the market. In the process of food packaging design, special attention should be paid to consumers' purchasing intentions. In addition, it can help consumers better identify and choose products, while also facilitating the dissemination of brand image. In fierce market competition, a good brand image affects consumers' purchasing behavior (Jalal Uddin Md et al., 2024). This article compares consumers' willingness to purchase different packaging designs and which packaging can better enhance brand awareness, as shown in Figure 4.

Figure 4 compares the data results of consumers' purchase intention and brand awareness enhancement for two types of food packaging. In the purchase intention described in Figure 4 (a), the vertical axis represents the rating quantity of the two food packaging items, and the horizontal axis represents the food packaging level score. It was observed that the "10 points" bar chart represented by conventional food packaging was much lower than that of intelligent food packaging. The proportion of conven-

tional food packaging from low to high scores was 67%, 72%, 40%, 36%, and 40%. The percentage range of intelligent food packaging from low to high was 33%, 28%, 60%, 64%, and 60%. The proportion of the two types of food packaging with the highest purchase intention scores was 40% and 60%, respectively. The higher the proportion of "10 points", the more willing consumers were to purchase the type. Through the overall comparison in Figure 4 (a), it was found that consumers were more willing to purchase food with intelligent food packaging. This was mainly due to the fact that intelligent food packaging could accurately trace food information with more user-friendly prompts, providing consumers with a special sense of experience (Ankit et al., 2023).

In Figure 4 (b), the comparison results of which packaging consumers believe can better enhance brand awareness are described. The vertical axis represents the quantity of various rating values for food packaging, while the horizontal axis represents the rating level for food packaging. The number of "10 points" given to conventional food packaging was 26, while intelligent food packaging was 49. Intelligent food packaging had 23 more high scores than regular food packaging. It could be seen that the lowest proportion of conventional food packaging was 76%, and the highest proportion was 35%. The lowest evaluation score for intelligent food packaging was 24%, and the highest evaluation score was 65%. Overall, from Figure 4,

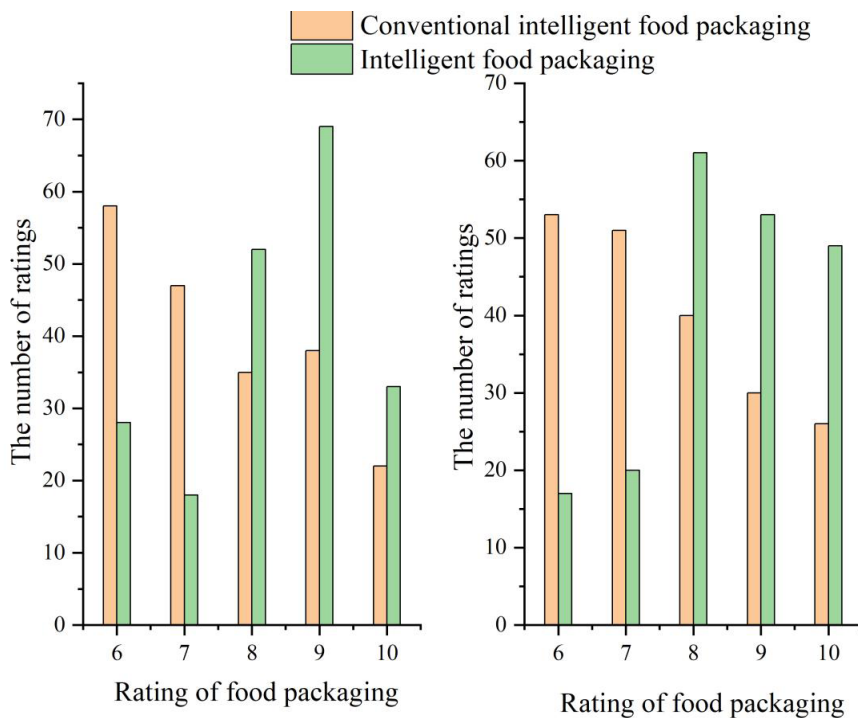


Figure 4. Comparison results of consumer purchase intention and brand awareness enhancement.

intelligent food packaging could enhance brand awareness more than regular food packaging. By using multimedia technology to achieve product information in the form of text, images, audio, and other forms through mobile devices, structural innovation, visual, and other means, the information it could carry was not limited to simple food information, but could also incorporate brand concepts into it, generating brand effects. Even if consumers have not purchased and used products, under the influence of the brand, it would subtly increase purchasing power.

5. Conclusions

With the rapid development of the economy, the progress of science and technology, and the increasing demand for a better life, food packaging is no longer just a container for goods but also has marketing, humanization, aesthetics, and other functions. Food packaging design based on visual communication and multimedia technology is the trend in the food industry. By utilizing visual design principles, Internet communication technology, and other methods in a reasonable manner, food packaging information transmission, interactive experience, and functional enhancement can be achieved, thereby unleashing market vitality.

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The contribution of this paper is that by introducing visual communication and multimedia technology, enterprises can provide more attractive and innovative product packaging, so as to stand out in the market and improve the market competitiveness of products. Intelligent food packaging design based on visual communication and multimedia technology aims to create a more attractive image for products by enhancing the beauty, functionality, and interactivity of packaging while meeting the needs of modern consumers for information access, interactive experience, and innovation.

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Data availability statement

This article does not cover data research. No data were used to support this study.

Declaration of conflicting interests

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