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Research on the Intangible Cultural Heritage Protection and Modern Inheritance Path of Yuyue Traditional Brewing Technique

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Abstract Yuyue Brewing Food Company was founded in 1919 and carries the millennium-old brewing culture of Lishui. Its traditional brewing skills have been included in the list of intangible cultural heritage, which has important cultural value and inheritance significance. This study systematically sorted out the historical origins, process composition, intangible cultural heritage value and cultural inheritance significance of Yuyue brewing skills, analyzed the standardization problems and replication difficulties faced in the inheritance process, and further explored the modernization inheritance path and technology integration strategy of Yuyue intangible cultural heritage skills on this basis, such as realizing intelligent assistance and experience explicitness of the brewing process through digital sensing, temperature and humidity monitoring, and experience database construction. Taking the practice of Yuyue Company as an example, it expounds its innovative exploration in brand reshaping, functional new product development, and the integration of traditional craftsmanship with modern scientific research and consumption trends. The protection and inheritance of Yuyue's traditional brewing skills is not only related to the continuation of regional cultural identity and craftsman spirit, but also provides an example for the integration of intangible cultural heritage into modern life and the promotion of sustainable development of industry and culture. This study hopes to summarize the practical experience of Yuyue and provide a strategic reference for traditional craft intangible cultural heritage projects that integrates protection and development, innovation and persistence.

Keywords Intangible cultural heritage; Brewing skills; Craft inheritance; Intelligent brewing

1 Introduction

The predecessor of Lishui Yuyue Brewing Food Co., Ltd. can be traced back to the "Desheng Sauce Garden" founded in 1919. After public-private partnership and restructuring, it has changed its name and moved its address many times, and has a history of 100 years. As the largest traditional brewing company in Lishui, Yuyue Company has witnessed the changes and inheritance of the local brewing industry in modern times. The company adheres to the concept of "not seeking to be among the top 100, but seeking to be a hundred years old", and continues the hand-made brewing technology passed down from generation to generation to this day, forming a unique corporate culture and quality reputation in long-term practice. Yuyue brewing skills are said to be derived from the folk brewing methods in the Northern Song Dynasty, and condense the experience of Lishui folk wine, vinegar, and sauce making. These traditional skills have lasted for hundreds of years and contain profound regional cultural heritage and skill inheritance. Yuyue Company not only produces liquor and rice wine, but also expands to the fields of condiments such as soy sauce and vinegar, becoming an enterprise in Lishui City that has obtained four food production certifications for liquor, rice wine, soy sauce, and vinegar. Its "Yuyue" brand series of products have won national, provincial and municipal honors many times. For example, Yuyue rice vinegar and soy sauce are known as brewing models and are widely loved by consumers. In recent years, the company's "Yuyue Green Valley Qiongye" liquor has been selected as the reception wine for the Lishui Municipal Party Committee and Municipal Government due to its pure quality and mellow taste, and won the gold medal of the Agricultural Expo. Another example is the functional new product "Yuyue Original Juice Health Orange Vinegar" developed based on the traditional vinegar brewing process, which won the Science and Technology Progress Award and the Gold Medal of the Agricultural Expo. These practices show that Yuyue enterprises actively innovate while adhering to tradition, making the century-old brewing skills revitalized in the contemporary era (Wang, 2023).

As a local skill, traditional brewing techniques such as wine brewing have outstanding intangible cultural heritage value. On the one hand, these skills condense the experience and wisdom created by the long-term production and life practices of people in a specific region, and embody the craftsman spirit and cultural memory passed down from generation to generation. Taking Yuyue brewing skills as an example, its process is strict and complicated, and it requires rich experience to master the essence, which represents the unique local food culture tradition of Lishui. On the other hand, traditional brewing techniques have both social and cultural functions. They not only meet the daily dietary needs of the people, but also carry cultural expressions such as festival rituals and folk beliefs. Intangible cultural heritage emphasizes the significance of living inheritance and cultural identity. These brewing techniques as "living culture" are an important part of the identity of local communities (Du et al., 2024).

UNESCO regards intangible cultural heritage as an important resource for community cultural identity and cohesion. The century-old brewing history of Yuyue shows that protecting and inheriting such traditional crafts will help to continue the regional cultural bloodline and enhance the cultural identity and pride of the group (Yan and Chiou, 2021). At the same time, the concepts of "slow work" and "harmony between man and nature" contained in brewing techniques also have practical enlightenment value for today's society pursuing sustainable development. Therefore, incorporating Yuyue's traditional brewing techniques into intangible cultural heritage for protection is not only a preservation of precious historical experience, but also a need to promote excellent traditional culture and maintain cultural diversity in modern society (Cui et al., 2021).

At present, the wave of industrialization and digitalization has brought challenges and opportunities to the inheritance of traditional brewing techniques. Traditional brewing skills often rely on oral experience and are facing problems such as a decrease in inheritors, environmental changes, and changes in market demand in modern society. It is necessary to explore new inheritance and protection models. This study takes Yuyue traditional brewing skills as the object, systematically sorts out its process composition, analyzes the difficulties encountered in the process of standardization and modernization, explores the inheritance path of integrating modern science and technology with traditional brewing experience, and proposes strategies and blueprints for the protection and inheritance of Yuyue brewing skills in the context of the intelligent era, that is, how to introduce modern technology to improve process stability and inheritance efficiency without destroying the core value of traditional craftsmanship, and achieve a dynamic balance of "keeping the integrity and innovating". This study hopes to provide theoretical support and practical reference for the protection and development of traditional brewing intangible cultural heritage skills, and realize the living inheritance and sustainable development of traditional craftsmanship.

2 Composition of Traditional Brewing Techniques

2.1 Raw material selection and natural microbial inoculation

Yuyue brewing technique adheres to the traditional principle of "grain must be fine, water must be sweet" in the selection of raw materials. It mainly uses natural raw materials such as high-quality grains (such as glutinous rice, sorghum, soybeans, etc.) and mountain spring water to provide sufficient nutrients and suitable minerals for fermentation. During the process of koji making and fermentation, no industrial pure strains are inoculated, but the microorganisms naturally existing in the workshop environment, the so-called "natural inoculation", are used to establish the fermentation microecology. This natural inoculation relies on the environmental flora accumulated in the brewing site for many years and the functional microbial community enriched in the koji (Figure 1; Figure 2) (Mao et al., 2023). For example, in the koji making stage of Yuyue soy sauce, steamed soybeans and flour are spread out to cool and exposed to the air, so that the Aspergillus in the air naturally falls into the culture, so that the koji is covered with natural hyphae. This practice forms a unique "workshop colony" and gives the product a special flavor. However, the microbial diversity of natural inoculation is very high, and the composition of the microbial community may vary greatly between different batches and even different seasons. Studies have shown that traditional Chinese brewing relies on the spontaneous fermentation of environmental microorganisms. For example, in the fermentation of liquor, the cellar mud and Daqu provide a rich and diverse functional flora, which plays a decisive role in the fermentation process and aroma production (Han, 2024).

Figure 1 Lishui Yuyue Brewing Food Co., Ltd.

Figure 2 Yuyue traditional brewing technique

In the brewing of Yuyue vinegar, the "mother of vinegar" flora of old vinegar is also used for natural inoculation, allowing the acetic acid bacteria of the previous batch to be brought into the new material for fermentation, thereby maintaining the continuation of the traditional flavor. This fermentation model based on environmental microorganisms has built a unique microecological system for Yuyue brewing techniques. The characteristics of the microecological basis are: multi-bacteria co-fermentation and dynamic balance. Its advantage is that it can produce rich flavor substances and unique taste, but its disadvantage is that it is easily affected by climate and location and fluctuates. Molecular biology research in recent years has further revealed the complexity and function of these traditional brewing microbial communities. For example, the metagenome and metabolome analysis of fermentation samples of Guangdong traditional soy sauce at different times found that in the early stage of fermentation, saccharifying enzymes were mainly produced by fungi such as Aspergillus, and in the later stage, lactic acid bacteria and yeast were dominant, and the metabolism produced flavor substances such as amino acids and esters. This shows that in the traditional natural fermentation process, the succession and cooperation of different microorganisms form a unique flavor trend. Yuyue brewing technique cleverly utilizes the microecological basis of environmental microorganisms to give its products a unique aroma and quality. However, this mode of dependence on the environment also leads to unstable quality between batches.

2.2 Key steps: koji-making, fermentation, filtration, and aging

The production process of Yuyue traditional brewing technique includes a series of key steps that are interconnected, and each step is crucial to the quality of the final product. Taking the brewing of Yuyue soy sauce as an example, its traditional process can be summarized as: "three fermentations, two sinkings and one pressing" (Figure 3) (Yang et al., 2017; Jin et al., 2024). The first step is to make koji: After the selected soybeans and wheat bran are steamed and cooled, natural inoculation is used to allow microorganisms in the air to attach and reproduce, and cultivate into a bean cake-like koji. This step is equivalent to the saccharification stage of brewing. The Aspergillus and bacteria in the koji produce amylase and protease, which partially decompose the starch and protein in the raw materials to produce soluble sugars and amino acids for subsequent fermentation. Yuyue Brewing insists on making koji by hand, and experienced craftsmen judge the koji making temperature by observing the mycelium growth on the surface of the koji and smelling the odor (Liu et al., 2024).

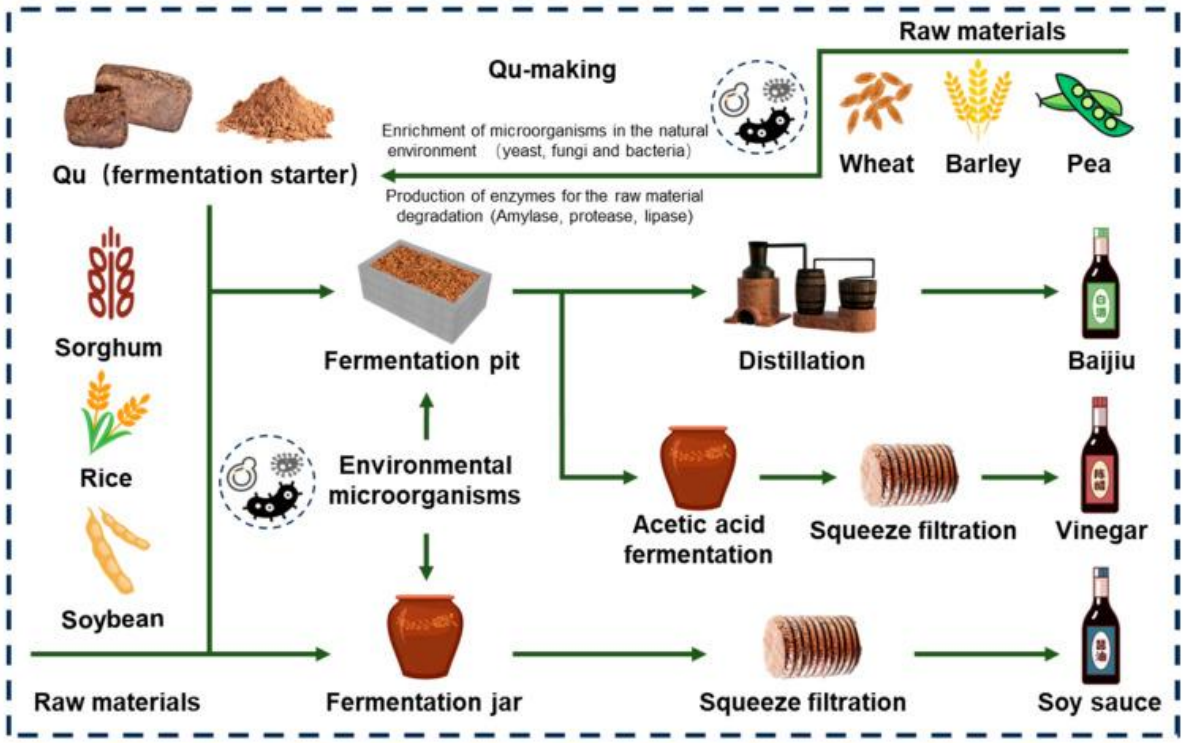

Figure 3 Schematic diagram of the production process of traditional Chinese SSF foods (Baijiu, vinegar, soy sauce) (Adopted from Jin et al., 2024)

The next step is the main fermentation (making mash): the mature koji material is mixed with salt water to make fermented mash, which is fermented in a tank for a long time. In the traditional process of Yuyue soy sauce, this stage needs to be left to ferment in the open air for at least 180 days. During this period, the microorganisms in the koji material slowly ferment in a high-salt environment to produce soy sauce-flavored substances and a brown-red color. During the fermentation process, the mash needs to be manually stirred every day to ensure uniform fermentation from top to bottom. At the same time, the craftsmen will judge the fermentation progress based on the changes in smell and color (Song et al., 2024). Pressing: After fermentation is completed, the solid and liquid of the mash are separated by a wooden press to squeeze out the original soy sauce juice. Traditional workshops use a lever-type wooden press to slowly pressurize to avoid instantaneous high pressure from destroying the flavor, and the squeezed soy sauce has a strong soy sauce aroma. Frying/sterilization: Heat the original soy sauce in an iron pan over a slow fire, commonly known as "frying soy sauce", which not only concentrates the flavor but also kills the bacteria, and then pours it into a pottery jar and seals it while it is hot. The last step is aging: seal the pottery jar with mud and place it in a ventilated and cool place for aging for several months to make the flavor of the soy sauce more mellow and stable. For the traditional brewing of Yuyue Baijiu, the key steps include the preparation of koji (selecting the local special medium-high temperature koji as the saccharification and

fermentation agent), saccharification and fermentation (mixing steamed glutinous rice with koji powder and stacking and fermenting for several days, then adding clean water to the jar and sealing it to continue slow fermentation), opening the raking (opening the mash for ventilation and aroma in the middle), distilling and taking the wine (distilling in a traditional steamer barrel, pinching off the head and tail to take the wine core), etc. Each step of the operation depends on the manual control and experience judgment of the winemaker. For example, during distillation, the craftsman judges the alcohol content and aroma of the distilled wine by sensory perception to decide when to pinch off the head and tail to ensure the high quality requirement of "pinching off the head and tail, taking the middle section". The process of Yuyue vinegar is to add acetic acid fermentation to the fermentation of wine mash: the fermented wine mash is squeezed to extract wine, and then the old vinegar acetic acid bacteria are added for secondary fermentation. Finally, it is aged for more than half a year to make the vinegar rich in acid and aroma. The key steps of Yuyue brewing technology include koji making (saccharification), alcohol fermentation, acetic acid fermentation (for vinegar), distillation, pressing and filtering, frying and sterilization, aging, etc. These links are closely linked and indispensable, and together they shape the unique color, aroma and taste of the product. Traditional craftsmen play a leading role in each step, ensuring the correct process through manual operation and experience control. However, this all-manual, multi-step process also leads to a long production cycle, high labor intensity and limited output, which is one of the obvious differences between traditional skills and modern industrial production.

2.3 Multi-type fermentation: solid-state, liquid-state, and open-air exposure

A notable feature of Yuyue's traditional brewing process is the comprehensive use of multiple forms such as solid-state fermentation, liquid fermentation and open-air sun drying to meet the brewing needs of different products and form a unique flavor. First, solid-state fermentation is mainly used in the process of making koji and fermenting baijiu and Daqu soy sauce. The so-called solid-state fermentation refers to microbial fermentation on a solid matrix with a low water content. Yuyue baijiu brewing uses brick cellars and pottery jars to seal and pile up grains or rice after mixing koji for fermentation, allowing microorganisms to complete saccharification and wine production in a solid environment. Its process is similar to that of traditional Chinese famous liquors such as Maotai and Fenjiu, all of which belong to solid-state distilled wine fermentation. This solid-state fermentation method has complex interactions because there is no free water, and there is a gradient in fermentation temperature and bacterial distribution, which gives the wine complex and rich aroma substances (Zuo et al., 2020). Secondly, liquid fermentation is combined in the brewing stage of vinegar and some soy sauce. The acetic acid fermentation of Yuyue vinegar is a liquid surface fermentation in a large vat: the taken out mash, koji and acetic acid bacteria "mother" are put into a pottery jar or a wooden barrel, and a certain amount of water is added to make the mash paste or semi-liquid, and acetic acid bacteria aerobic fermentation is carried out under open conditions. This fermentation requires constant stirring and oxygen supply, so that acetic acid bacteria can multiply in the liquid phase to produce acetic acid. Compared with solid state, liquid fermentation has full contact and faster fermentation rate, but it is more sensitive to contamination by bacteria (Liu et al., 2020). Thirdly, open-air sun drying is a special part of Yuyue brewing skills, which is mainly used in the later fermentation of soy sauce and the aging stage of vinegar. The traditional process of Yuyue soy sauce requires that the prepared soy sauce mash be placed in an outdoor sunning yard and fermented under natural sunlight for up to half a year. It must be manually turned and stirred before sunset every day to make it fully fermented by "morning dew and night dew". Open-air sun drying uses solar radiation and the temperature difference between day and night to promote the metabolism of microorganisms and accelerate the formation of flavor substances on the one hand, and to increase the concentration and gloss of soy sauce through evaporation and concentration on the other hand. Although this ancient method of sun-drying soy sauce is time-consuming and occupies a large area, the soy sauce produced is reddish-brown and translucent, fresh and fragrant, and is considered to be incomparable to industrial short-term brewing. Modern industrial soy sauce is mostly fermented in closed tanks at controlled temperature for 10 to 30 days to be finished, but the flavor complexity is insufficient. Yuyue craftsmanship combines the above-mentioned fermentation forms: solid first, liquid second, and natural sun exposure. For example, soy sauce is first solid-state koji, then liquid fermentation with brine, and then open-air sun exposure; vinegar is solid-state saccharification alcohol fermentation, then liquid acetic acid fermentation, and finally open-air vinegar; white

wine is solid-state fermentation throughout the process with open environment slow fermentation and storage. This combination of multiple forms gives Yuyue products unique quality, but it also increases the complexity of the process and dependence on the natural environment (Gong et al., 2021). It should be noted that the combination of different fermentation forms requires flexible regulation by craftsmen. For example, on rainy days, the sun field needs to be covered to prevent dilution of the mash, and on hot days, the sun exposure time should be controlled to prevent excessive volatilization. It can be said that the integrated use of multiple fermentation forms is a major feature of Yuyue brewing techniques, and it is also a vivid embodiment of traditional brewing techniques adapting to nature and adapting to local conditions.

3 Intangible Cultural Heritage Significance

3.1 Regional identity and cultural continuity of Lishui's brewing traditions

One of the significances of protecting intangible cultural heritage is to preserve the unique identity of regional culture and continue the vitality of cultural traditions (Figure 4). Yuyue traditional brewing skills are deeply rooted in Lishui and are an important symbol of Lishui's food culture. Lishui is located in the mountainous area of southwestern Zhejiang. Since ancient times, it has lacked plain arable land. In order to make full use of grain, the ancestors developed the tradition of making wine with glutinous rice, making sauce with beans and wheat, and making vinegar with rice. It can be said that Yuyue's liquor, soy sauce, and rice vinegar are the crystallization of the wisdom of local people's life, integrating regional customs and humanistic connotations, and carrying the collective memory of Lishui people. Therefore, these brewing skills, as regional cultural symbols, have a strong sense of local identity. When people mention Lishui specialties, Yuyue's wine, vinegar, and soy sauce are often on the list. They represent the "Lishui taste" and local image. Through the identification of the intangible cultural heritage list, Yuyue's brewing skills have been recognized by the government and society as a regional cultural symbol. For example, Yuyue's traditional wine-making skills, vinegar-making skills, and sauce-making skills have been successively selected into the intangible cultural heritage list of Lishui City. In 2024, Yuyue Company was rated as a Chinese time-honored brand, and its soy sauce-making skills were further selected into the Zhejiang Province Intangible Cultural Heritage Protection List. These honors not only affirm the cultural value of Yuyue's skills, but also strengthen its status as a cultural business card of Lishui.

Figure 4 Building Yuyue's Regional Cultural Symbol

More importantly, the protection of intangible cultural heritage enables Yuyue's brewing skills to continue and continue to be inherited and developed in modern society. The government and the community have provided institutional support for these skills through measures such as establishing a list and identifying representative inheritors. For example, after Lishui City included Yuyue's skills in the intangible cultural heritage list, it

designated Yuyue Company as a protection unit and encouraged it to carry out activities such as skill inheritance and publicity and display. Lishui City has also built the "Yuyue 1919 Cultural Industry Park" and Yuyue Museum to display Yuyue's century-old history and traditional skills to the public, allowing local residents and tourists to experience the brewing culture up close. During traditional festivals, Yuyue brewing skills are also integrated into community life through intangible cultural heritage performances and brewing experiences, becoming part of mass cultural activities. These measures allow intangible cultural heritage skills to "live in the present" and enhance the regional society's recognition and love for local culture. Studies have shown that the integration of intangible cultural heritage into community public life helps to reconstruct people's cultural identity and ethical relations. Yuyue skills are rejuvenated with the joint participation of local society (Yan and Chiou, 2021). As a symbol of Lishui's regional culture, the successful protection and inheritance of Yuyue brewing skills has effectively continued the brewing tradition of Lishui. This not only maintains cultural diversity, but also injects cultural heritage and soft power into local development.

3.2 Knowledge systems and generational transmission of craftsmanship

The inheritance of traditional brewing skills is actually an intergenerational continuation of craftsman wisdom and implicit knowledge system. This type of skills usually does not exist in the form of written theory, but relies on oral transmission from master to apprentice, forming unique craft secrets and techniques in long-term practice. The essence of Yuyue brewing skills is contained in the experience of brewing masters of all generations. For example, how to judge the temperature of fermentation, how to adjust the recipe according to the season, and how to distinguish the state of mash and sauce mash through sensory perception, these experience and skills are often difficult to quantify and can only be mastered through practical experience. This is a typical manifestation of "tacit knowledge". Guo and Ahn (2023) pointed out that the tacit knowledge of the craft makes its sustainable inheritance face challenges, and it is necessary to enhance the inheritance ability through the collaboration between craftsmen and apprentices and knowledge sharing. In the case of Yuyue, several generations of inheritors passed down the brewing tips from generation to generation through "master-apprentice", forming a stable knowledge spectrum. For example, Chen Xudong, the current representative inheritor of Yuyue's brewing skills, learned from the previous generation of brewing masters. For many years, he has taught by words and deeds, and taught the key points of the brewing process. This master-apprentice inheritance model ensures the continuity of tacit knowledge, so that many skills that "can only be understood but not expressed in words" have not been lost in the changes of the times.

The wisdom of craftsmen is not only reflected in specific operations, but also contains a kind of professionalism and value concept. Brewing skills require patience, meticulousness and perseverance. The craftsmen of Yuyue have adhered to the creed of "making friends by brewing a cooking wine" and integrated the pursuit of quality into their daily work. This craftsman spirit has also become part of the inheritance content through words and deeds. The establishment of the intangible cultural heritage inheritor system is conducive to protecting and promoting the spirit of craftsmen. Since the 2000s, the government has recognized a group of national, provincial and municipal representative inheritors of intangible cultural heritage, given them honor and support, and encouraged them to teach apprentices. For example, Yuyue Company currently has two municipal-level intangible cultural heritage inheritors and several district-level inheritors. They not only stick to the production line themselves, but also regularly accept apprentices to train young technicians in the company, forming a good atmosphere of mentoring within the company. According to statistics, as of 2020, there are more than 90,000 representative inheritors of intangible cultural heritage at all levels in my country, among which many enterprises and folk artists are playing the role of "mentoring, helping and guiding". Studies have shown that the dominant position of inheritors in the protection of intangible cultural heritage should be respected, and they should be encouraged to innovate on the basis of inheritance, which is the core of intangible cultural heritage protection (Wang et al., 2024). The inheritance practice of Yuyue confirms this point: under the leadership of the older generation of brewing masters, the younger generation not only learned the traditional craftsmanship, but also developed new products and improved processes on this basis, injecting new vitality into the craftsmanship. This shows that the wisdom of craftsmen can continuously adapt to the needs of the times and achieve creative development through

intergenerational inheritance and knowledge sharing (such as scientific research cooperation with universities). The intergenerational inheritance of Yuyue brewing skills is essentially the transmission of implicit knowledge system and craftsman spirit. This kind of inheritance requires not only long-term running-in between masters and apprentices, but also institutional support and social respect. Only when implicit knowledge is effectively inherited can traditional skills maintain vitality among the emergence of new people.

3.3 Official recognition and listing in the Lishui City intangible heritage catalog

The intangible cultural heritage list system is an important part of my country's intangible cultural heritage protection system. The inclusion of Yuyue's traditional brewing skills in the intangible cultural heritage list of Lishui City reflects the official recognition of its value and brings substantial protection support and social attention. After my country joined the UNESCO "Convention for the Safeguarding of Intangible Cultural Heritage" in 2004, it gradually established a four-level intangible cultural heritage representative list system at the national, provincial, municipal and county levels. The Yuyue craft was included in the Zhejiang Province and Lishui City list, which belongs to the Province-level and City-level list. This recognition first has legal protection significance. According to the "Law on Intangible Cultural Heritage" and local regulations, the inheritors and protection units of the projects included in the list can enjoy support measures according to law, including subsidies for inheritance activities, support for inheritance venues and facilities, etc. As a responsible unit for protection, Yuyue Company, due to its status as a listed project, received special funds from the local government in the 2010s to build an intangible cultural heritage exhibition hall and purchase traditional brewing utensils. These supports have created favorable conditions for the continued practice of Yuyue craft. Secondly, the list recognition has increased social awareness and attention, allowing Yuyue craft to go out of the company's workshop and enter a wider public vision. Local media have reported on the Yuyue intangible cultural heritage story many times, enhancing the protection awareness and participation enthusiasm of the community people. Since 2019, Lishui City has used the "Cultural and Natural Heritage Day" in June every year as a publicity node. Yuyue brewing skills have appeared in the intangible cultural heritage display activities, inviting the public to visit the brewing process and taste handmade soy sauce, which has received a warm response. This kind of public participation helps intangible cultural heritage enter life and realize the living inheritance of "seeing people, seeing things and seeing life".

At a higher level, the protection of the list has given new development opportunities to Yuyue skills. After the project was selected for the list, the local government actively incorporated it into the cultural industry and tourism development plan. For example, the "Lishui Brewing Cultural Tour" tourist route was established, and Yuyue 1919 Cultural Park was used as an important node to attract tourists to experience brewing skills. In 2022, the Ministry of Culture and Tourism issued the "Notice on Promoting the In-depth Integration and Development of Intangible Cultural Heritage and Tourism", encouraging all localities to create intangible cultural heritage experience bases and characteristic tourist routes. Lishui City took the opportunity to launch the Yuyue Brewing Intangible Cultural Heritage Study Course, and organized students to learn traditional winemaking and sauce making knowledge in the Yuyue workshop, with good results. This integration of intangible cultural heritage + tourism not only expands the channels for the inheritance of Yuyue skills, but also brings new economic benefits to enterprises, achieving a win-win situation of cultural and economic benefits. It can be said that the protection of the list has played a "brand" effect and enhanced the cultural content and market competitiveness of Yuyue products. Consumers trust its quality more because of its intangible cultural heritage status, which helps the revival and growth of traditional brands. Of course, the protection of the list also requires Yuyue Company to assume corresponding responsibilities, such as improving the inheritance pedigree archives, cultivating successors, and cooperating with the government to carry out publicity. These measures further standardize and strengthen the protection and inheritance of intangible cultural heritage skills. Lishui City included Yuyue's traditional brewing skills in the intangible cultural heritage list, which is not only an official endorsement of its cultural value, but also an important measure to give it new vitality and development space (Wang and Zaibon, 2024). With the joint efforts of the government and society, it has enabled an ancient skill to be protected, inherited and developed in a modern environment, reflecting the positive value of the intangible cultural heritage list system.

4. Challenges in Technique Standardization

4.1 Lack of process digitization and dependence on master expertise

Yuyue's traditional brewing techniques have a significant low degree of automation in terms of modern industrial standards. A large number of process details lack quantitative parameter support, and production continuity is mainly ensured by experience inheritance. From koji making to fermentation, all links are mainly monitored and adjusted manually, and quantifiable control indicators and automatic feedback systems are rarely set in production. For example, there is no constant temperature device for the control of fermentation temperature, and the master relies on experience to increase or decrease straw coverage or turn the pile to dissipate heat; the fermentation time is not an exact number of hours or days, but is determined based on the vague judgment of fermentation aroma and state "almost done" (Jin et al., 2024). Ye et al. (2021) pointed out in a review of the intelligent solid-state fermentation of Chinese liquor that many traditional workshops currently have almost no recordable process parameters except for the raw material formula, and all operations are based on the master-apprentice oral transmission. The direct result of this model is that the process is difficult to replicate: without experienced masters, it is difficult to restore the same quality of products based on written process flow alone. For modern enterprises, this undoubtedly increases the uncertainty of large-scale production. In recent years, Yuyue Company has encountered such a bottleneck when expanding production: when there are no old craftsmen in charge of the new production line, the taste of the brewed soy sauce has fluctuated, and there are large differences between different batches. This shows that over-reliance on experience inheritance has led to insufficient controllability of the process. If this oral and mental transmission method can still maintain production in the traditional small workshop period, in the current market environment, with the increase in production batches and the increase in personnel mobility, it is difficult to ensure stable quality output by experience alone. Standardization requires quantification and proceduralization of process parameters, but many factors involved in Yuyue brewing techniques (such as fermentation microbial dynamics, environmental climate change, etc.) are difficult to quantify simply. Jin et al. (2024) emphasized that the traditional solid-state fermentation food industry generally has the problem of "low efficiency of experience production methods, high energy consumption, unstable product quality and susceptibility to environmental and human factors." This just reveals one of the practical problems currently faced by Yuyue techniques. Although Yuyue Company has also formulated some basic process codes (such as the koji making time is not less than a certain number of days, the sun-dried fermentation is at least a certain number of months, etc.), these are only rough ranges and still need to rely on experience for dynamic adjustments. Another consequence of the lack of automated parameter control is that it is difficult to achieve large-scale mechanical replacement: machinery and equipment require clear control parameters to operate, and traditional skills often cannot provide these parameters, so that machines cannot completely take over manual operations (Guo and Ahn, 2023). The primary difficulty faced by the standardization of Yuyue brewing skills is experience rigidity: the know-how of the process is all in experience rather than in data. This is also the common dilemma of many traditional intangible cultural heritage skills, that is, "the skill lies in the person, not the tool". How to extract experience into standardized parameters is a key step in achieving modern inheritance.

4.2 Batch instability due to microbial and environmental variability

Yuyue brewing skills are deeply rooted in the local natural environment, and its fermentation process is highly sensitive to microbial flora and climatic conditions, which also creates the problem of process instability. Traditional solid-state fermentation is carried out in an open environment, and environmental temperature, humidity, and seasonal changes will affect the fermentation process and product quality. For example, when the humidity is too high in the rainy season, the koji is easily infected with miscellaneous bacteria, resulting in a decrease in the quality of the koji; when the temperature is too high in summer, the surface of the sauce mash may produce acid too quickly and die. Even with the same recipe and the same cellar, the yield and flavor of wine will be different in different years due to the climate differences of the year. This phenomenon is common in many traditional brewing intangible cultural heritage projects. Taking Kweichow Moutai as an example, the winery adopts a production method that conforms to the weather - Chongyang Xiasha, and only feeds and ferments in specific seasons to avoid the adverse climate effects of other seasons. Although Yuyue Brewing is smaller in scale, it also follows the experience of "living by the weather": for example, some processes are suspended during the

high temperature period in midsummer and resumed after the temperature drops to ensure normal fermentation. Although this approach guarantees quality, it also shows that the process is difficult to operate completely according to a fixed cycle, but is affected by the natural environment. Microbial instability is the main factor affecting product quality consistency. Due to the use of natural inoculation and open fermentation, the dominant fermentation flora in each batch may be different. Studies have shown that there are obvious differences in the microbial communities of different rounds of liquor fermentation, which will lead to different proportions of aroma components in each round of liquor (Wu et al., 2021). For soy sauce and vinegar, outdoor fermentation is affected by local indigenous flora, and the flora combination of the same factory will change when the location is changed. This regionality of environmental microorganisms makes the intangible cultural heritage brewing techniques "unique to this place", which is also one of the reasons why traditional flavors are difficult to replicate. However, this is a disadvantage for standardized production because product quality fluctuates with environmental changes. Jin et al. (2024) pointed out that the solid-state fermentation system is difficult to monitor and control in time because of the heterogeneity of the medium and the coexistence of solid, liquid and gas. This makes mass transfer and heat transfer complex. This means that once environmental factors change (temperature rises or falls suddenly, air humidity changes suddenly, etc.), it is difficult to quickly correct them under the framework of traditional processes, resulting in fermentation disorders. The Yuyue technique relies on the experience of craftsmen to alleviate instability to a certain extent. For example, experienced masters can adjust the sequence or intensity of the process by predicting the climate. However, this kind of human intervention also has its limits. When faced with abnormal weather or external pollution, traditional workshops often lack countermeasures. For example, one summer, continuous rain and overcast weather prevented the sun drying and fermentation in the drying field. The sauce and mash had a strange smell after being simmered for a long time, and they had to be discarded and started over. It can be seen that the uncertainty brought by fermentation microorganisms and the environment makes it difficult for traditional processes to meet the quality requirements of "consistent batches" in modern industry (Ye et al., 2021). In order to solve this problem, it is necessary to introduce modern technology to monitor and regulate the environment and flora, which will be discussed later. However, at this stage, the non-standardization of Yuyue's skills is closely related to the natural environment, which is also a "double-edged sword" for intangible cultural heritage brewing products to maintain their individual flavor: it brings uniqueness and introduces volatility (Zhao et al., 2020).

4.3 Difficulty in intergenerational training and scale reproduction

Due to the above reasons, the replicability of Yuyue's traditional brewing skills is poor, which is specifically manifested in two aspects: first, it is difficult to mass teach in talent training, and second, the process flow is difficult to fully industrialize and replicate. First, in terms of talent training, the inheritance of traditional skills mainly depends on one-on-one and hand-to-hand teaching by the master, and new apprentices often need several years or even more than ten years to master the core essentials. Even if you have mastered the formula and basic process, it is difficult to replicate products of the same quality based on books without long-term on-site experience accumulation. This means that the effect of mass training of inheritors of brewing skills through school classrooms or short-term training courses is limited. Especially for skills like Yuyue brewing that involve more sensory experience and implicit knowledge, apprentices need to "immerse" in the workshop for a long time and master the tricks by osmosis. However, modern young people rarely have the conditions to invest in such a long learning cycle. In addition, the cultural level of traditional masters is limited and the teaching methods are not systematic, resulting in the speed of training new people far behind the speed of skill loss. Studies have pointed out that many traditional craft intangible cultural heritage projects in my country have the phenomenon of aging inheritors and lack of successors. One important reason is that the teaching model is backward and it is impossible to train new people on a large scale (Wang et al., 2024). Yuyue brewing skills are currently mainly inherited within the family and by a very small number of apprentices. The skills are in the hands of a few people. Once these people can no longer continue to work, the skills are in danger of interruption. Poor replicability is also reflected in the difficulty of replication in different places: if you try to establish the same Yuyue brewing production line in a different place, it is likely that the original flavor will not be brewed due to different environmental flora and climate. This has been verified in practice - some companies have tried to replicate the

Jiangnan ancient soy sauce craftsmanship to factories in other provinces, but were forced to give up because the product taste was distorted due to changes in water quality and bacterial phase. Secondly, in terms of industrial replication, it is difficult to directly apply the traditional brewing process to the industrialized mass production model (Ye et al., 2021). Modern factories emphasize continuous operation of the assembly line and full control, while the Yuyue brewing process has a long cycle and each batch may be different. For example, soy sauce is exposed to the sun for 180 days, and it is difficult for the industry to give such a long cycle; solid-state fermentation requires a lot of manual turning, which is difficult to completely replace by machines. Industrial replication requires a set of clear and stable process parameters to design equipment and processes, but many detailed parameters of traditional techniques are unknown or vague. Therefore, when expanding the Yuyue technique to an industrial scale, it often requires repeated trials and adjustments, which is costly and risky. This is also one of the reasons why many wineries and sauce gardens are willing to stick to traditional small-scale production instead of expanding rashly. Traditional brewing techniques have inherent limitations in standardization and replication: the technique is too dependent on specific people and environments, and its knowledge form is mainly implicit experience, lacking explicit standard texts. To solve this problem, it is necessary to make implicit knowledge explicit and to parameterize experience to provide a basis for teaching and industrialization. However, this transformation is not easy and requires close cooperation between traditional craftsmen and scientific experts. For example, it is possible to consider establishing a "digital archive of intangible cultural heritage brewing technology" to record in detail the environment, operation, quality and other data of each production, so as to gradually explore the rules. The poor replicability of the process has brought practical challenges to the inheritance of Yuyue skills, which is also one of the driving forces for its modernization transformation.

5. Pathways to Modernized Inheritance

5.1 Modular division of traditional processes for semi-automation

In view of the situation that the whole process of traditional brewing relies on manual work, a realistic and feasible modern path is to modularize the process flow, select relatively mature or controllable links, and give priority to introducing mechanical equipment to achieve semi-automation, thereby reducing labor dependence and improving stability (Ye et al., 2021). Yuyue brewing skills can divide the entire production chain into several modules, such as raw material pretreatment module (rice washing, steaming), fermentation module (saccharification fermentation, acetic acid fermentation), post-processing module (pressing, distillation, filtration, sterilization), aging module, etc. For some links with clear mechanical performance requirements, automation can be used first. For example, Yuyue Company has tried to use automatic grain steaming equipment to replace traditional earth stove steaming, and accurately control the steaming temperature and time to ensure that the degree of steaming of each pot of grain is consistent. For another example, in the pressing link, a small hydraulic press can be used to set a constant pressure to slowly press the sauce or vinegar mash, which not only increases the juice yield but also ensures the flavor. These are relatively easy to standardize physical processes and are suitable for modular transformation first. Semi-automation does not mean that the whole process is unmanned, but that mechanical or instrument assistance is introduced while retaining key empirical steps. The advantage of this is to maintain a balance between traditional flavor and automated stability. For example, the alcohol fermentation stage of Yuyue vinegar still uses traditional ceramic jars, but a slowly rotating mechanical stirring paddle can be installed for stirring and oxygen supply, and the motor can be used to stir regularly, thereby reducing the workload of frequent manual stirring. The speed and frequency of this stirring paddle can be determined through preliminary experiments to an empirical value to approximate the effect of replacing manual operation. For another example, in the koji making process, a combination of a constant temperature room + an automatic koji turning machine can be used: a koji room with controllable temperature and humidity is built, and a simple manipulator is installed to turn the koji regularly. Tian et al. (2022) reported an exploratory practice of a solid-state fermentation tank system for edible vinegar, that is, traditional vinegar mash is placed in a special fermentation tank to control temperature and humidity, and equipped with mechanical stirring to achieve an effect similar to open-air fermentation. The experimental results show that this tank fermentation can shorten the fermentation cycle and the product quality is close to traditional, which shows that modular semi-automatic

substitution is feasible. For Yuyue brewing skills, it is possible to give priority to introducing equipment in links with high labor intensity and links with strong controllability. For example, the steaming and cooling of rice wine can be done on an assembly line; in the sun-drying stage of soy sauce, a photothermal device that simulates sunlight can be used to replace part of the exposure time. Module splitting also allows for inheritance in steps: some key links are still controlled by old craftsmen, and other links are gradually handed over to technicians and equipment to reduce the reliance on the all-round talents of a single inheritor. It should be noted that modular automation does not replace craftsmen in a one-size-fits-all manner, but rather "machines assisting labor." Through such gradual transformation, Yuyue's traditional skills can gradually establish some standardized processes. In this process, the impact of mechanical intervention on the flavor of the product should be closely monitored to ensure that "machine replacement" does not damage the inherent quality characteristics of the product. If deviations are found, the plan should be adjusted in a timely manner. These experiences all show that process module splitting + semi-automatic substitution is one of the effective paths to the modernization of traditional brewing. It not only retains the artificial intelligence of the core links, but also uses machinery to improve efficiency and stability.

5.2 Integration of sensors and intelligent fermentation control systems

In order to overcome the problem that the traditional brewing process is difficult to monitor, modern inheritance needs to introduce digital monitoring means to sense and record the key parameters of the fermentation process in real time, so as to achieve scientific cognition and control of the process. Yuyue brewing techniques can deploy sensors and data recorders in multiple links. For example, temperature and humidity sensors are buried in the cellar or fermentation tank of solid-state fermentation to monitor the temperature and humidity changes inside the fermentation pile in real time. Traditional craftsmen sensed the temperature by touch, but now they can use digital thermometers to accurately measure and automatically record at regular intervals. Zhang et al. (2021) reported a real-time temperature monitoring system for solid-state fermentation in cellars based on ZigBee technology. Wireless temperature nodes are arranged in the liquor fermentation cellar to transmit fermentation temperature data to the monitoring terminal. This system allows brewers to remotely view the fermentation temperature curve and take timely control measures when the temperature of a cellar rises abnormally. Yuyue workshops can also try to introduce similar wireless monitoring networks to achieve unified monitoring of the temperature of dozens of sauce tanks on the open-air drying field. In addition to temperature and humidity, the fermentation gas composition can also be monitored. For example, a simple CO_2 sensor is installed to track the fermentation intensity: the CO_2 production rate can reflect the activity of microorganisms, and a fermentation curve can be drawn. Through these sensor data, the traditional fermentation process can be presented as a quantitative curve for the first time. From the curve, the master can more intuitively understand when the fermentation reaches its peak and when it tends to stabilize, so as to make more scientific decisions on the timing of operations such as turning the pile and ventilation (Ye et al., 2021; Chen, 2024). It is also feasible to use digital cameras or image recognition technology to visually monitor the surface of the koji and the surface of the mash. Through image analysis, the area and color of Aspergillus growth, or the distribution of film-forming yeast on the surface of the mash can be determined, providing an objective reference for the master. The introduction of digital means also includes information management: establishing a fermentation batch database, recording the environmental parameters, operation records and finished product quality of each batch, and finding empirical rules with the help of statistical analysis. For example, it can be found that "when the humidity in the koji room is maintained at around 70%, the wine yield is the highest", which provides a basis for improving the process. At present, some large brewing companies are exploring the use of the Internet of Things and big data to assist traditional brewing. In 2023, Chen Bairong, a member of the National People's Congress, suggested using Internet of Things sensors to collect data such as cellar temperature, humidity, acidity and alcohol content in real time, establish a mathematical model, and realize intelligent monitoring of the fermentation process. This is exactly the direction in which digitalization has great potential in intangible cultural heritage brewing. For Yuyue, it can start with low-cost means, such as using a household electronic thermometer and hygrometer with a mobile phone app to monitor the temperature of several key points, so as to cultivate the habit of craftsmen to use data. Then gradually expand to a complete intelligent monitoring system and automatic control. It should be emphasized that digital means assist

rather than replace craftsmen's decision-making. It provides objective data to help craftsmen grasp the craft more accurately, but the final judgment still needs to be combined with experience. Through the integration of digitalization and experience, traditional skills can improve their adaptability and controllability to external changes while maintaining their internal logic.

5.3 Establishment of digital archives for process parameters and artisan notes

In order to achieve the long-term protection and dissemination of traditional skills, it is necessary to systematically collect and organize the relevant parameters and experience of Yuyue brewing skills, and establish a digital archive and knowledge base. This work includes several levels: first, text and multimedia records, shooting the oral experience and key points of the old craftsmen into images or documentaries, transcribing them into text, and forming a comprehensive skill manual. In the past, many valuable experiences were elusive because they were only passed on orally, but now they can be fully preserved by recording and video. Secondly, the key parameters of the process flow should be standardized and recorded.

For example, the proportion of materials used, temperature and humidity curve, fermentation time, output, quality test results, etc. of each batch of brewing should be recorded in detail to form a database. The long-term accumulated data can be used to explore the laws of stable production of the process. At the same time, an experience database of inheritors is established to collect cases of problem solving by masters of all generations. For example, the remedial measures and effects taken by the master when a batch of fermented sour in summer are recorded. This is similar to an expert system for reference by future generations. Zeng (2021) pointed out that the core of digital technology empowering the dissemination of intangible cultural heritage lies in systematizing and structuring scattered knowledge to make it a shareable digital resource. Through digital archives, the Yuyue technique will no longer exist only in the master's memory, but will become a common wealth of society. Building a scientific and systematic intangible cultural heritage digital database protection system not only ensures the accurate and efficient preservation of intangible cultural heritage, but also provides a convenient retrieval method for innovative research on intangible cultural heritage. For the Yuyue brewing technique, with parameter archives, the younger generation can get guidance by consulting archives even if they do not have long-term experience. For example, the archives can tell them: "The humidity in the koji making room should be maintained at 80% in winter to prevent the koji from drying and cracking", "If the pH of the mash is lower than 4, ventilation should be used to reduce the acidity", etc. These are explicit knowledge extracted from experience, which can greatly reduce the learning curve. The experience database can also be connected to artificial intelligence analysis to achieve intelligent auxiliary decision-making.

Using AI technologies such as knowledge graphs to reconstruct fermentation optimization technology, this can be understood in the context of intangible cultural heritage as letting AI learn a large amount of historical data and make suggestions for abnormal situations in the future. For example, AI can analyze the changes in production under different climatic conditions over the years, predict this year's situation and suggest adjustment strategies. Of course, it takes energy and technology to establish such a database. But some basic work can be gradually carried out, such as introducing tablet computers on the production line, allowing the master to enter the daily operation log on site; or cooperating with universities to develop a simple intangible cultural heritage knowledge management system. In recent years, the cultural department has also been promoting the intangible cultural heritage recording project, recording the skills of national intangible cultural heritage inheritors in text and images, and preserving archives. The fish leaping skill can be fully included in this type of recording project, leaving detailed information in the form of government support. The establishment of archives and databases is not only for preservation, but also for dissemination and reuse. In the future, Yuyue brewing skills can play a greater role in skill training and cultural promotion through digital archives, and even develop digital teaching materials, VR interactive teaching, etc., to achieve the unity of living inheritance and mass communication. Building a systematic intangible cultural heritage brewing skills archive and experience database is a basic project to realize the modernization of traditional skills and inheritance, and will provide solid data support for subsequent intelligent integration.

6. Case Applications and Innovation Practices of Yuyue

6.1 Experimentation with digital temperature/humidity tracking in koji rooms

Yuyue's exploration of modern brewing techniques has been carried out in some links. One important attempt is to introduce a digital temperature control system in the koji making link to realize the intelligent transformation pilot of the traditional koji making process. Traditional koji making takes a long time (usually several weeks) and has strict requirements on temperature and humidity. In the past, it was all adjusted by the master's experience. As mentioned above, Yuyue's koji making is easily disturbed by mold in the rainy season and the temperature may be insufficient in winter. The company introduced a digital temperature and humidity control system in the koji making workshop: temperature and humidity sensors and automatic heating and humidification equipment are installed in the koji room, and the microcomputer controls the maintenance of the koji room environment. For example, the temperature is set at 28 ℃~30 ℃ and the humidity is set at about 85%, and the best natural conditions are simulated through the linkage of the heater and humidifier. This system greatly reduces the influence of seasons on the koji making process. It was observed in the pilot that even if the outdoor temperature in winter was only about 10 ℃, the koji room was still stable at 28 ℃, ensuring the normal growth and reproduction of microorganisms. In addition, the system can also achieve staged temperature control: more bioheat is generated in the early stage of koji making, and the system automatically reduces the heating power to prevent temperature overshoot; in the later stage, when fermentation slows down, the temperature is slightly increased to promote aroma. Through this intelligent regulation, the quality of koji making is more uniform and stable. Experimental data show that the output rate of Daqu under digital temperature control conditions has increased by about 5%, and the enzyme activity and aroma precursor content in the koji have also increased (Shakya and Vagnarelli, 2024). It is worth mentioning that Yuyue did not completely eliminate the manual role in the pilot, but adopted a combination of "manual + digital": experienced masters still check the growth of the koji every day. If abnormalities are found (such as mold on local koji), the local temperature and humidity can be adjusted or an alarm can be issued through the operation terminal. This reflects the idea that digital systems serve craftsmen rather than replace craftsmen. Through the pilot, the company has trained a group of "digital brewers": they understand traditional craftsmanship and master basic data analysis skills, and can assist in decision-making based on sensor data (Ye et al., 2021). This has opened up new ideas for the inheritance of skills. The digital temperature control system also records a large number of data curves of the koji making process, forming valuable empirical data. For example, it is possible to draw a temperature change curve of a batch of koji from culture to maturity, corresponding to the change of enzyme activity in the koji. These data are helpful for in-depth research on the koji making mechanism and optimization of process parameters.

6.2 Partial mechanization of mixing, pressing, and liquid separation

In the process of modernizing Yuyue's skills, another focus is to carry out mechanical assisted transformation for the mixing and pressing links with high physical labor intensity to improve efficiency and reduce labor intensity, while ensuring stable product quality (Figure 5). In the mixing link, traditionally, making mash or vinegar mash requires multiple people to repeatedly stir and mix with wooden rakes, which is time-consuming and laborious. For this reason, Yuyue introduced a small horizontal ribbon mixer for experimental transformation. When the steamed rice or bean material is cooled to the appropriate temperature, it is manually poured into the mixer with koji powder in proportion, and low-speed stirring is started for a few minutes to achieve the mixing task that originally required more than half an hour of manual labor. The test results show that the uniformity of mechanical mixing is no less than that of manual mixing, and it reduces the exposure time of raw materials and reduces the probability of contamination by miscellaneous bacteria. After the mixing is completed, the master will check the moisture and looseness of the materials, and make slight adjustments if necessary to ensure that they do not deviate from traditional requirements. This practice shows that the use of mechanical assistance for rough processing and then manual fine adjustment is a feasible combination. In the pressing process, Yuyue Brewing traditionally uses a lever-type wooden press, and the manual winch slowly applies pressure. This process is very labor-intensive, and a strong laborer will be extremely tired after pressing for half a day. At the same time, it is difficult to maintain a constant pressure for manual pressing, which affects the juice yield. For this reason, the company purchased a 5-ton small hydraulic press for modification. The fermented sauce or vinegar mash is loaded

into a stainless steel filter barrel, and the hydraulic press is used to pressurize at a constant speed to slowly squeeze out the liquid. In order to simulate the traditional slow pressing process, the technicians set the pressure of the hydraulic press at 0.2 MPa and control it to gradually reach the maximum pressing force within 30 minutes, thereby avoiding one-time sudden pressing. The trial results show that the soy sauce squeezed by the hydraulic press has higher clarity, the juice yield is about 10% higher than that of manual pressing, and the cake residue contains less liquid after pressing (Wang, 2023). The taste test found no obvious difference in flavor. The improvement of pressing efficiency allows the same manpower to take care of multiple presses at the same time, greatly improving production capacity. Of course, some problems were encountered: at the beginning, the improper pressure control of the hydraulic press crushed some of the koji cakes, resulting in the smell of impurities in the soy sauce. Later, the problem was solved by adjusting the pressure curve and adding filter cloth (Tian et al., 2022). In addition to mixing and pressing, Yuyue also tried mechanized transformation in the distillation process - introducing a continuous small distillation device to replace the traditional single-steamer distillation. This device uses steam to continuously flow through the fermented mash and recover the wine in stages. The experiment found that although continuous distillation is efficient, the taste of the wine is slightly inferior and needs further improvement. Therefore, traditional steamer barrel distillation is still retained as the main method, and continuous distillation is only tried on small batches (Ye et al., 2021). The practice of mechanical-assisted transformation has proved that for some time-consuming and labor-intensive links, mechanical equipment can be competent under the guidance of craftsmen and ensure that the product quality is not distorted. This human-machine collaboration model reduces the absolute dependence on manual labor and experience, making the process more stable and controllable, and also creates conditions for training a new generation of technicians - young people are more willing to operate machinery combined with skills rather than pure physical work. It should be emphasized that in the process of mechanical transformation, it is necessary to respect the traditional process logic and ensure that the mechanical action is consistent with the principle of manual operation (Tian et al., 2022). Yuyue's experience is: old craftsmen participate in mechanical design and debugging, and convert their experience into mechanical parameters. For example, to determine the speed of the mixer, ask the master to try mixing and judge based on the feel, and then adjust the machine settings. This approach ensures that mechanical apprentices can gradually replace part of the manual labor without destroying the essence of the process.

Figure 5 Modern production scenario of Yuyue

6.3 Revitalization of Yuyue green valley liquor as an official hospitality product

Yuyue's major innovation in the new era is to combine traditional brewing techniques with the local government's brand strategy and successfully create the "Green Valley Qiongye" liquor as the official reception wine for Lishui City. This case shows that traditional intangible cultural heritage techniques can serve modern government affairs and city image promotion through brand remodeling, achieving a win-win situation in cultural and economic benefits. Lishui has always been known as the "Green Valley" and has a superior ecological environment. Yuyue was famous for its glutinous rice wine as early as the last century, but its brand influence was limited to the people. Around 2010, the Lishui Municipal Government hoped to launch a local specialty reception wine to highlight the green ecology and cultural heritage. Yuyue seized this opportunity, selected traditional recipes, integrated modern brewing monitoring methods, iteratively upgraded the product, and launched a new product "Yuyue Green Valley Qiongye". The wine is highly recognized by city leaders and experts for its pure hand-made brewing, no additives, sweet taste and mellow aftertaste, and has been officially designated as the reception wine for the Lishui Municipal Party Committee and Municipal Government. This move not only greatly enhanced the social popularity of Yuyue Baijiu, but also allowed the traditional brewing skills to be endorsed at the government level and established a high-quality image.

The successful experience of the "Green Valley Qiongye" brand reshaping lies in the ingenious integration of tradition and modernity (Bu et al., 2024). On the one hand, it adheres to the ancient brewing method and highlights the scarcity and cultural value of the century-old heritage; on the other hand, it injects modern elements into the packaging design and brand story, such as taking the fresh image of "Lishui Green Valley" as the theme, designing environmentally friendly and simple wine bottles and gift boxes, emphasizing the concept of pure grain brewing and healthy wine to cater to contemporary consumption concepts. Furthermore, through the promotion of official government channels, "Green Valley Qiongye" quickly became a wine for important occasions in Lishui, and gained a firm foothold in the official and business markets. This brought considerable sales and profits to the company, and also fed back to the protection of intangible cultural heritage. For example, the company invested part of its revenue in upgrading the brewing workshop and cultivating inheritors, forming a virtuous circle. What is more worth mentioning is that "Green Valley Qiongye" won the gold medal at the Zhejiang Agricultural Expo in 2012 and became famous throughout the province. This shows that as long as traditional craft products are of high quality and well-marketed, they can also win competitiveness in a larger market.

This practice is instructive for other intangible cultural heritage enterprises: the combination of government resources and intangible cultural heritage brands can quickly increase brand added value. But the premise is to have excellent product quality as a foundation. Yuyue has insisted on hand-brewing for many years and has not sacrificed quality due to expanded production. This is the fundamental reason why "Green Valley Qiongye" has been able to gain a foothold in high-end occasions. At the same time, brand building is also inseparable from cultural empowerment. Yuyue cleverly integrated the local cultural IP "Green Valley" into the brand, making the product transcend the attributes of ordinary liquor and become a symbol of urban culture. Now, "Green Valley Qiongye" is not only a bottle of wine, but also a representative of Lishui's green humanistic image. In some major reception occasions, the host will proudly introduce the millennium-old inheritance story behind this wine to the guests, which invisibly spreads the intangible cultural heritage. Therefore, through brand reshaping, Yuyue has achieved a gorgeous transformation of intangible cultural heritage from a workshop product to a city business card. This is a successful example of the integration of intangible cultural heritage and modern brand strategy, and provides experience for the branding of traditional skills in other places (Hou et al., 2023).

7 Concluding Remarks

As a typical brewing intangible cultural heritage, Yuyue traditional brewing skills contain a rich and complete knowledge system and skill logic. From the perspective of knowledge, it not only has the understanding of natural elements such as raw materials, microorganisms, and the environment, such as the experience and wisdom of selecting specific grains and using environmental bacteria for fermentation; it also has technical knowledge of process flow, equipment use, and human-machine collaboration, such as the flexible use of multi-stage fermentation and multiple containers. From the perspective of skill logic, Yuyue brewing takes "conforming to

nature and cleverly borrowing the power of microorganisms" as its core concept, which is reflected in the use of natural inoculation, open-air sun drying and other methods to obtain unique flavors. This skill logic is in line with the traditional agricultural civilization's idea of "adapting to the times and the unity of man and nature". At the same time, Yuyue skills emphasize the inheritance of craftsmanship, and the inheritance methods such as master-apprentice teaching and sensory quality testing are also an important part of the knowledge system.

In the process of modern inheritance of traditional skills, how to maintain craftsmanship and make good use of modern technology is a dynamic balance that must be deeply considered. This study repeatedly emphasized in the case of Yuyue brewing skills that "technical empowerment" is by no means a replacement for "craftsman value." The ideal state is to be both orthodox and innovative: to keep the essence and core values of traditional craftsmanship (i.e., craftsmanship and flavor quality), and to solve those problems that do not affect the core values (such as low efficiency, insufficient stability, etc.) through technical means. For example, in Yuyue's exploration, we saw that they did not completely hand over key flavor decisions to machines, but let machines help complete heavy and trivial physical labor and monitoring work, freeing craftsmen from physical constraints, so that they can focus on flavor control and skill teaching. This division of labor makes craftsmanship and technology complement each other: craftsmen use data to understand the secrets of fermentation more deeply, and technology is closer to traditional requirements under the guidance of craftsmen. Of course, balance is not achieved overnight and needs to be constantly adjusted in practice. If technology is excessively involved, there may be a tendency to "abandon slowness for speed", which will damage the flavor and cultural connotation of the product; on the contrary, rejecting technology due to conservatism may cause the skills to lose their adaptability to the environment and decline. Therefore, the inheritance practice of Yuyue's skills provides valuable experience: through "small steps and fast walks", gradually test technologies, introduce one, verify one, and ensure that each new measure is subject to traditional quality requirements. For example, they tried mechanical stirring and temperature control, carefully observing the flavor changes at every step, and listening to the feedback from the old craftsmen in time. This reflects a concept of dynamic adjustment. The ethical reflection of "technology-led and emotion-free" - that is, technology cannot deprive the emotional value and humanistic significance contained in the intangible cultural heritage, but should serve its protection and inheritance. For Yuyue, keeping the craftsmanship is to keep the persistence in the ultimate flavor, the respect for the master-disciple relationship, and the adherence to the cultural identity; the introduction of technology is to allow this craftsmanship to continue to shine in the new era, rather than being annihilated in the torrent of the times. Craftsmanship is the root, and technology is the end; craftsmanship is immortal, the soul of the skill is there, and the technology will not lose its direction no matter how new it is. In this balancing process, the inheritors themselves also need to keep pace with the times, improve their scientific literacy, and make themselves a new type of craftsman who "can both hold the Qu plate and read the instrument". Only in this way can traditional skills really come alive in the contemporary era.

Looking to the future, Yuyue's traditional brewing skills and even the entire traditional brewing intangible cultural heritage field are ushering in a new blueprint for intelligent development. This blueprint includes the following visions: First, to achieve a leap from experience inheritance to data inheritance. In the future, digital models will be established for all key links of Yuyue skills, such as fermentation curve models and flavor prediction models, so that new inheritors can use these models to assist in learning and practice. This does not negate the importance of experience, but allows experience to exist in a more easily spreadable form. Secondly, build a "digital virtual brewing workshop" and use VR/AR technology to reproduce the traditional workshop scene for apprentices to conduct virtual practice and immersive learning. For example, through VR simulation of the entire process of open-air mash drying, learners can perceive how changes in temperature and humidity affect fermentation in a virtual environment, thereby deepening their understanding of the logic of skills. Third, realize the "intelligent consultant" system for intangible cultural heritage brewing. Based on big data and AI algorithms, build an intelligent decision support system to provide advice to craftsmen. For example, when the temperature of a batch is abnormal, the system can prompt possible reasons and treatment plans for the master's reference; or when blending liquor, AI gives a preliminary blending ratio plan based on massive formula data. This kind of "master +

AI" cooperation will become the norm in the future. Fourth, fully integrate creative industries and tourism experiences. In the future, the Yuyue Brewing Cultural Park may be combined with intelligent display facilities. Visitors can understand the details of each step of brewing through interactive devices and even participate in simple operations in person, while the intelligent system behind the scenes ensures safety and effect. This will greatly enhance the social influence and commercial value of traditional skills, allowing intangible cultural heritage to "see people, see things, and see life". Finally, at a more macro level, as multiple traditional brewing intangible cultural heritage projects are digitally upgraded, different projects can share experience and resources through cloud platforms. For example, the national soy sauce brewing intangible cultural heritage can establish an alliance and share a set of flavor databases to promote innovation in the entire industry (Xie Mei et al., 2022). In short, the future protection of traditional brewing intangible cultural heritage will be based on digitalization, networking, and intelligence, and achieve a comprehensive upgrade from production to dissemination. However, no matter how technology develops, we must always keep in mind that the core of intangible cultural heritage lies in "people" - it is people's wisdom and skills that are passed on. The intelligent blueprint should serve the development of inheritors and communities. Only on the premise of respecting human values can the application of technology truly promote the sustainable inheritance of intangible cultural heritage. The development of Yuyue's traditional brewing technique proves this point: through scientific empowerment, this ancient technique has regained vitality and is heading towards a more glorious tomorrow.

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