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The Application of Jiangjin "Ji De" Sichuan-Style Xiaoqu Traditional Distilling Techniques in the Production of Light Aroma Baijiu

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ABSTRACT

Chinese baijiu, as one of the six major distilled spirits in the world, is characterized by its complex flavor profile and distinct sensory style, with the Sichuan-Chongqing region standing out. Jiangjin District in Chongqing, with its unique geographical advantages—located along the Yangtze River with high-quality water and a humid climate conducive to the growth of brewing molds—provides a solid foundation for producing light aroma baijiu. Additionally, Jiangjin, being a major sorghum-producing area in Southwest China, offers a stable supply of raw materials for brewing. Building on these strengths, the local area has developed the "Ji De" Sichuan-style xiaoqu distilling technique, which has been inscribed on the "Intangible Cultural Heritage of China." This ancient method has had a profound impact on the local brewing system and baijiu industry and has contributed to rural revitalization in the area.

KEYWORDS

Ji De Sichuan-style xiaoqu traditional distilling techniques; Rural revitalization; Baijiu industry; Brand operation

1. INTRODUCTION

As a traditional treasure of China and one of the six major distilled spirits globally, Chinese baijiu boasts a long history and unique brewing techniques. Traditional baijiu is typically produced through solid-state fermentation using starchy grains as the main raw material, with husk as an auxiliary material (sorghum is the primary choice in Jiangjin, Chongqing), and qu (a type of fermentation starter) as the saccharification and fermentation agent. The grains, qu, and husk are mixed in a certain proportion to form mash, which is then fermented anaerobically in a fermentation vessel. Under anaerobic fermentation conditions, the microbial communities in the mash interact with each other, and their metabolic products serve as flavor compounds or precursors in baijiu. After fermentation, the mash is distilled to extract alcohol combined with flavor substances, forming the base liquor. The unique distillation method of "Ji De" has enhanced the quality of light aroma baijiu, resulting in a better taste. The flavor substances in baijiu mainly originate from raw materials, qu, and microbial metabolites. The main components of baijiu are water and ethanol, accounting for about 98% - 99% of the total volume, while the remaining 1% - 2% consists of more than 1,500 trace components. Although these trace components are present in small amounts, they play a significant role in the taste, flavor, and aroma type of baijiu.

2. GEOGRAPHICAL ADVANTAGES AND INDUSTRIAL FOUNDATION

Jiangjin District in Chongqing is located in the 28th parallel north, known as the golden belt for liquor production. The soil in this area has a selenium content of 2367.8mg/kg (3.2 times the national average), covering 100% of the selenium-rich arable land. The region has established the largest ecological base for xiaoqu liquor in China, gathering 39 enterprises with SC certification, although 90% of them are small and micro distilleries with annual revenues of less than ten million yuan.

2.1. Climate Conditions

Jiangjin has a subtropical humid climate with an average annual temperature of around 18℃ and an annual precipitation of 1000 - 1200mm. The distinct seasons and humid air provide an ideal environment for the proliferation and metabolism of brewing microorganisms such as Rhizopus and yeast. The small diurnal temperature variation, compared to the arid northern regions, ensures a more stable climate. This stability reduces the impact of drastic temperature fluctuations during fermentation on microbial communities, which is beneficial for the balanced formation of flavor compounds.

2.2. Soil Conditions

The soil in Jiangjin is rich in selenium, resulting in high-quality raw materials. The selenium content in the soil of this area ranges from 0.3 to 3.0mg/kg, and the locally grown crops such as sorghum and glutinous rice are naturally selenium-rich. When used for brewing, the selenium enters the liquor, endowing it with health attributes such as antioxidant and immune-boosting properties. The soil is of red soil type, which has a strong capacity for water and nutrient retention, making it suitable for sorghum cultivation. The local red sorghum has plump grains and a high amylopectin content (about 70%), which is more easily saccharified and fermented after gelatinization.

2.3. Water Source Conditions

The high-quality water in Jiangjin is the soul of liquor production. The region is traversed by the Qijiang River and is part of the Yangtze River system. Located in the upper reaches of the Yangtze River, the water from the Qijiang River is clear and sweet, rich in minerals such as calcium, magnesium, and selenium. The water has a moderate hardness (slightly neutral soft water), which not only promotes microbial activity but also avoids the roughness of the liquor caused by hard water. Moreover, the local water is naturally weakly alkaline, with a pH value of 7.5 - 8.0. It neutralizes the acidic substances produced during fermentation, helping to maintain the acid-base balance of the mash and enhance the purity of the liquor.

2.4. Raw Material Reserves

Most varieties in Jiangjin are glutinous sorghum. The quality of sorghum determines the quality of the base liquor. The commonly used local glutinous sorghum in the southwestern region has formed a major sorghum-producing area in the south. Sorghum is an important raw material for brewing baijiu. It has a high yield of alcohol, and its aroma and taste are excellent, which are closely related to the internal components of sorghum. The impact of sorghum raw materials on the quality of baijiu lies in the fact that the starch, protein, fat, and other components in sorghum can not only serve as energy sources for microorganisms during the brewing process but also generate many flavor compounds or precursors during the brewing process. Therefore, many studies have been conducted to analyze the differences in the basic physicochemical indicators of brewing sorghum. With the increasing attention to the impact of aroma and phenolic substances in sorghum on the flavor quality of baijiu, it is necessary to systematically compare and analyze the overall metabolic profiles of different sorghum varieties used for brewing.

3. BREWING PROCESS AND SYSTEM

In the production of baijiu, different types of liquor are produced due to the use of different saccharification agents. Light aroma baijiu can be divided into xiaoqu, daqu, and bran qu light aroma according to the saccharification and fermentation agent used, with daqu and xiaoqu processes being more common in actual production. Different qu, made from different raw materials, have different enzymatic properties and jointly provide saccharification, flavor production, grain input, and fermentation functions for baijiu production. Rhizopus in xiaoqu, such as the excellent strains Q303 and YG55, has the ability to saccharify while growing, with high saccharification power, thus requiring less qu (generally 0.5 - 1%). Long Shu Rong studied 11 samples of light aroma daqu and found that the saccharification power ranged from 810 to 954U/g, and the fermentation power ranged from 6.47 to 11.21U/g.

3.1. Limitations of Traditional Processes and Improvements

Traditional processes rely on natural inoculation, resulting in poor stability of microbial strains and a saccharification power fluctuation range of ±15%. To address this issue, patent strains were introduced, and constant temperature and humidity fermentation boxes were used, reducing the standard deviation of saccharification power from 12% to 3%.

3.2. Distillation and Flavor Regulation

3.2.1. “One-Clear-Through” Technology

Fractional distillation: A “gentle steaming and vigorous tail-chasing” strategy is adopted, with seven distillation fractions. The alcohol content of each fraction is strictly controlled within the ranges of 62% - 68% (head liquor), 50% - 55% (middle fraction), and ≤45% (tail liquor).

Flavor regulation: The middle fractions (3rd to 5th distillations) have the highest ester content (ethyl acetate ≥2.1g/L), which are stored separately for blending base liquor.

3.2.2. Synergistic Effects of Steaming and Fermentation

Nine-time steaming: After each steaming, the mash is cooled to 28 - 32℃, mixed with qu powder, and fermented in earthenware jars for 7 days, repeating the cycle nine times. This process achieves a starch utilization rate of 92%, higher than the industry average of 85%.

Flavor compound formation:

Acid-ester balance: During fermentation, the symbiosis of lactic acid bacteria and yeast maintains a stable ratio of lactate ethyl ester to ethyl acetate at 1:1.2, giving the liquor a “light and mellow” characteristic.

Trace element migration: Selenium in selenium-rich sorghum is converted into organic selenium compounds (such as selenomethionine) during steaming, with a selenium content in the liquor reaching 0.015mg/L.

In addition to the impact of trace elements on liquor quality, yeast also has an inseparable connection with baijiu. In the complex and open fermentation system, the interaction between yeast and other microorganisms produces a variety of flavor compounds. As the core of alcohol fermentation, the interaction between brewing yeast and other microorganisms directly affects the alcohol yield and the formation of esters, alcohols, and other substances during the brewing process, thus playing an extremely important role in baijiu production.

Lactic acid bacteria, broadly defined as bacteria that can ferment carbohydrates to produce lactic acid, mostly have rod-like and spherical shapes. They are Gram-positive, mostly non-motile, do not form spores, and are widely present in the fermentation of various foods. Lactic acid bacteria are abundant in the mash (the microorganisms in the mash mainly come from the large qu and the brewing environment, including water, air, and production tools), and are the main bacteria in the fermentation of light aroma baijiu, which can ferment carbohydrates into lactic acid. Song et al. revealed that in the production of strong aroma baijiu, lactic acid bacteria are the core functional microorganisms in the later stage of pyruvate metabolism. They effectively promote the conversion of pyruvate to lactic acid and play a dominant role in lactic acid production. In addition to lactic acid, other organic acids such as acetic acid can also be produced, which are important for the acid balance and taste richness of baijiu. Moreover, in the production process of light aroma baijiu, lactic acid bacteria have functions such as maintaining a slightly acidic environment in the brewing process and improving the fermentation performance of related enzymes.

The lactic acid produced by the metabolism of lactic acid bacteria can react with ethanol to form lactate ethyl ester through esterification, adding a unique aroma to baijiu. Moreover, lactic acid can mitigate the harshness of alcohol, making the taste of baijiu softer and more harmonious. However, as the fermentation time extends, the number of lactic acid bacteria in the mash may increase excessively, leading to a higher acidity in the mash and thus reducing the alcohol yield. The content of lactate ethyl ester may also change, which can affect the overall quality of baijiu. In production, higher temperatures in summer can cause lactic acid bacteria to grow more vigorously, potentially leading to an accumulation of lactic acid and lactate ethyl ester. This can cause an imbalance in the ratio of ethyl acetate to lactate ethyl ester, thereby compromising the quality of baijiu. Conversely, lower temperatures in winter may inhibit the activity of lactic acid bacteria, resulting in insufficient acid production. In such cases, the flavor of light aroma baijiu will be insufficient, affecting the quality of the liquor. Therefore, a thorough understanding of the interaction mechanisms between lactic acid bacteria and other microorganisms in the fermentation system is necessary. By gaining insights into these interactions, the fermentation process can be better controlled to ensure the flavor and quality of baijiu.

Although research has progressed from studying individual microorganisms to studying microbial communities within a certain range, there are still several shortcomings in the study of brewing microorganisms: the distribution and functions of microbial communities within ecosystems are not fully understood; the roles of various microorganisms in the overall system are not clear; and the impact of changes in microbial communities on the flow of energy and matter in the system is not well understood. Clearly, relying solely on traditional cultivation methods is no longer sufficient to address these issues.

To overcome these limitations, various “omics” technologies emerged in the late 19th and early 20th centuries. These technologies can overcome the limitations of microbial cultivation techniques. Without the need to cultivate microorganisms, DNA, RNA, and proteins can be directly extracted from environmental samples to analyze the composition, function, and interactions of microbial communities. Therefore, omics technologies have obvious advantages in the study of complex microbial ecosystems.

Omics technologies follow the order of gene expression and integrate the analysis of three key substances in the environment: DNA, RNA, and proteins. This approach reveals the composition of microbial populations, the metabolically active microbial populations, and the types and functions of proteins synthesized by microorganisms. This helps researchers gain a broader perspective on complex systems. With the increasing application of omics technologies in environmental microbiology, baijiu fermentation, and other fields, these technologies have brought significant advancements to the study of microbial communities.

In previous studies, two representative microorganisms were isolated from the spent mash of light aroma baijiu: one is the high-alcohol-producing brewing yeast Y28, and the other is the high-lactic-acid-producing Lactobacillus plantarum R2. This study takes these two strains as research objects to explore their interaction relationships at different temperatures. The aim is to gain a more in-depth and comprehensive understanding of the baijiu fermentation mechanism, achieve effective control of the content of these key microorganisms, and provide theoretical basis for the optimization of fermentation processes. This is crucial for a deeper exploration of the essence of baijiu brewing and requires more systematic and in-depth research.

The reason why Jiangjin "Ji De" traditional brewing stands out is due to its unique brewing system. The "Ji De" Sichuan-style xiaoqu technique originated in the Ming and Qing dynasties, relying on the unique natural endowments of Jiangjin. According to the "Chronicles of Jiangjin County," the local area has "abundant water and soil, with selenium-rich soil everywhere." In the Ming and Qing dynasties, brewing workshops widely used selenium-rich sorghum and water from the Jijiang River, forming a brewing tradition of "mutual nourishment of water and soil, and naturally fragrant liquor." Located in the 28th parallel north, the golden belt for liquor production, Jiangjin has an average annual temperature of 18.5℃ and a humidity of 75% - 85%, providing a stable temperature and humidity environment for microbial fermentation, making it a natural brewing field for xiaoqu light aroma baijiu.

Intangible cultural heritage protection: In 2021, the "Ji De" technique was included in the intangible cultural heritage list of Jiangjin District, Chongqing, and received special government funding. Three "intangible cultural heritage workshops" were established, with more than 20 skill display activities held annually to promote cultural dissemination and the preservation of the craft.

Jiangjin baijiu selects local "Hongyingzi" glutinous sorghum, which has an amylopectin content of 88% and a selenium content of 0.015 mg/kg (ordinary sorghum ≤0.005 mg/kg). The antioxidant properties of selenium inhibit the proliferation of miscellaneous bacteria, increasing the alcohol yield to 48%. The water quality is weakly alkaline (pH 7.3) and rich in potassium (445.2 mg/kg) and magnesium (31.9 mg/kg) and other trace elements, which combine with phenolic substances in sorghum to form the typical flavor characteristics of "clear and mellow aftertaste."

In the qu-making process, a mixture of wheat (60%), peas (20%), and barley (20%) is used to make the qu block, and a patented strain (ZL20242003594.7) is inoculated, with a stable saccharification power of 800 - 850 mg/(g·h).

In the fermentation cycle, a "three-stage temperature control method" is adopted - the early stage (28℃, 5 days) promotes microbial colonization, the middle stage (45℃, 10 days) accelerates saccharification, and the late stage (35℃, 6 days) enriches ester compounds, with a total fermentation period of 21 days.

In the distillation process, the liquor is divided into seven fractions. The head liquor (alcohol content 62% - 68%) removes impurities, the middle fraction (alcohol content 50% - 55%) is rich in ethyl acetate (≥2.1 g/L), and the tail liquor (≤45%) is returned to the mash for re-steaming to ensure the purity of the liquor.

After each steaming, the mash is cooled and mixed with qu powder, and then fermented in earthenware jars for 7 days, repeating the cycle nine times. This process achieves a starch conversion rate of 92%, with an 18% increase in the total ester content compared to the traditional six-time steaming process.

Selenium in the liquor exists in an organic form (selenomethionine), with a content of 0.012 mg/L (ordinary xiaoqu liquor ≤0.003 mg/L), which not only has health attributes but also adds market value. The micro-porous structure of the earthenware jars promotes oxygen circulation, working synergistically with "block-shaped qu." The symbiotic ratio of lactic acid bacteria to yeast reaches 1:1.5 (compared to 1:0.8 in Yunnan xiaoqu), resulting in a better acid-ester balance.

4. CHALLENGES AND COUNTERMEASURES

4.1. Challenges

Technical Talent Gap: The Crisis of Intergenerational Transmission of Traditional Skills

Youth worker outflow: According to statistics from the Jiangjin District Human Resources and Social Security Bureau in 2023, the average age of local brewing workers is 52 years old, with less than 15% of workers under 35 years old. The younger generation, due to unstable income (traditional workshops have a monthly income of 3000 - 4000 yuan) and lack of professional identity, prefers to choose urban service industries.

Knowledge system fragmentation: Intangible cultural heritage bearers generally lack modern brewing technology and brand management knowledge, resulting in lagging skill innovation. For example, only 12% of workshops master digital temperature control technology.

The Contradiction between Standardization and Personalization: The Dual Challenge of Industrial Upgrading

Bottleneck in Large-Scale Production: Traditional earthenware jar fermentation requires manual turning of the mash, with a maximum batch capacity of 5 tons, which cannot meet the demand for large orders.

Insufficient Quality Stability: Processes relying on experience-based judgment (such as visual assessment of qu block maturity) result in a fluctuation range of ±10% in the total ester content of different batches of liquor (the national standard requires ≤±5%).

4.2. Development Suggestions

4.2.1. Building a “Three-Dimensional Integrated” Heritage Successor Training System

Educational cooperation: Collaborate with Chongqing Technology and Business University and Sichuan University of Science and Engineering to establish a “Non-Material Cultural Heritage Brewing College.” Offer dual-mentorship courses combining traditional skills and modern engineering to train compound talents.

Policy incentives: In accordance with the “Regulations on the Protection of Intangible Cultural Heritage in Chongqing,” provide social security subsidies (500 yuan/month) and preferential interest rates for entrepreneurial loans (3% lower) to contracted successors, enhancing the attractiveness of the profession.

Digital inheritance: Establish a “Skill Gene Bank,” use 3D motion capture technology to record craftsmen’s techniques, and develop a VR training system to lower the learning threshold.

4.2.2. Implementing a “Graded Flexible Production” Model

Standardized basic layer: For 80% of bulk products (such as liquor supplied to the catering industry), implement full-process mechanization and use patented temperature-controlled earthenware jars to control the fermentation cycle error within ±6 hours.

Personalized customization layer: Retain 20% of production capacity for high-end customization, continuing to use traditional earthenware jars and manual turning of the mash, targeting the gift market.

Dynamic adjustment mechanism: Monitor order demand in real-time through the ERP system to achieve “order-driven” capacity allocation.

5. CONCLUSION

The practice in Jiangjin demonstrates that traditional skills need to achieve “preserving the essence and innovating” through “core process standardization” (such as the application of patented strains) and “peripheral production flexibility” (such as graded customization). This model has been included in the typical cases of the National Rural Revitalization Bureau and has provided reference paths for other intangible cultural heritage industries such as Hubei Huangjiu and Yunnan Pu’er tea.

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