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Study on Improving Liquor Yield of Potato Liquor Brewed by Liquid Method

Shudong Zhao, Qiao Lin[a, *], Liuwei Yang, Yumei Zong, Dongmei Yan and Bangzhou Luo

Xichang University, xichang 615000, China

[a]1104419850@qq.com

*Corresponding author: 1104419850@qq.com

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Abstract: This experiment with potatoes, corn, buckwheat, oats, Angela could as raw material, adopts the traditional liquid liquor brewing process, using the single factor experiment design method, the control of a single variable, respectively, of the liquid in the process of brewing in the mash feed water ratio and the pH of the fermentation, fermentation time, fermentation temperature, yeast inoculation quantity, adding amount of these six aspects to explore the optimum conditions in the process of liquid potato liquor brewing. The results showed that the fermentation time and the ratio of feed to water had a great influence on the yield of potato wine. Good quality can be obtained under the condition that the ratio of feed to water is 3:4, the pH is 5.5, the fermentation time is 7d, the fermentation temperature is about 27℃, the inoculation amount of yeast is 2% and the addition amount of enzyme is 0.2%.

1. Introduction

Potato wine generally refers to the wine made from cassava, sweet potato, potato and other potatoes instead of traditional grains as the main raw materials [1]. In foreign countries, there are a few countries that directly brew wine with potato residue left after starch production or fresh potatoes. China is a big potato planting country, but its secondary processing is still relatively lagging behind. The potato production in China is mainly used for starch, vermicelli, potato chips, etc.while the potato wine in China is still in the primary research and development stage and has not yet entered the production field [2]. Therefore, the application of potato resources for alcohol fermentation is an important research topic in the research of new brewing technology.

As a new product in liquor industry, potato liquor can further promote the development of liquor industry. Promoting the development of potato liquor brewing industry is conducive to changing the current situation of "high yield but no bumper harvest" of potatoes and promoting potato cultivation.The brewing industry is a single fermentation product industry with a long history and large output in fermentation industry. China is also one of the first countries to master brewing technology. Liquid brewing uses grain as raw material, directly adds grain, and makes white spirit through water saccharification, fermentation and distillation. The original wine obtained through liquid fermentation and liquid distillation is relatively pure.Liquid fermented liquor can realize high mechanization operation. The whole fermentation process is carried out in liquid state, which has the advantages of high liquor yield, less auxiliary materials, more varieties of available raw materials, high production efficiency, reduced energy consumption, etc. At the same time, liquid

liquor also has the disadvantages of high higher alcohol content and insufficient ester content. In this new brewing method, how to effectively improve liquor yield is one of the research focuses [3]. How to effectively improve the liquor yield in the brewing process of potato liquor directly affects the popularization of this emerging commodity. Therefore, improving the liquor yield of potato liquor is the core content of the project research.The success of this research and its popularization and application will realize the transformation from advantageous resources to products, enrich the domestic liquor market, help to increase the demand for potatoes, and provide new development models and economic benefits for China's potato industry. The realization and promotion of potato wine can not only improve the economic value of potato processed products, but also extend the potato industry chain in China.

2. Materials and methods

2.1 Material

Potato, corn, Tartary buckwheat, oats, angel liquor qu, active dry yeast, saccharifying enzyme, beta, beta - amylase, cellulase, medium temperature amylase: Xichang city, Sichuan province.

2.2 Reagent

Sodium hydroxide, hydrochloric acid, phenolphthalein indicator, guangzhou incisui technology co., LTD.

Distilled water, laboratory supply;

2.3 Instruments and equipment

Alcohol meter, sugar meter, shenzhen liangyi laboratory instrument co., LTD.

Electronic balance, Shanghai fangrui instrument co., LTD.

Xf-30 vertical fermentation box, Shanghai baozhu machinery technology development co., LTD.

Refrigerator, guangdong cologne instruments co., LTD.

Small steamed wine pot, shenzhen boda equipment co., LTD.

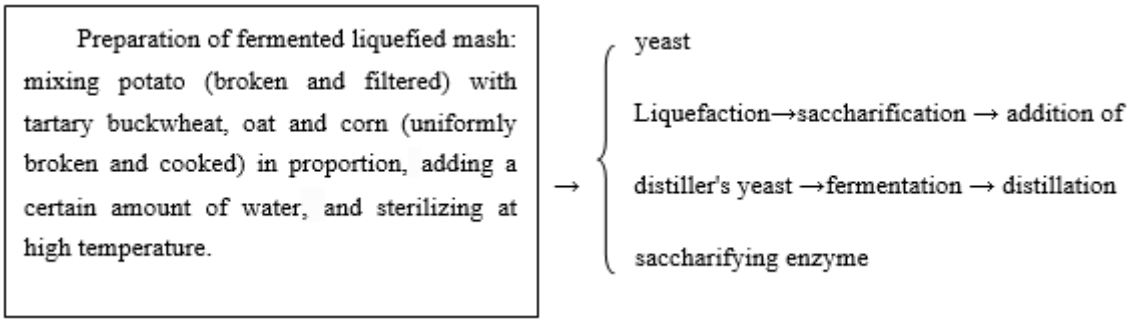
Base titrator, glass altar, mercury thermometer, pipette, glass bar, induction cooker, shenzhen tianbo instrument co., LTD.

2.4 Test methods

2.4.1 Production of potato liquor

2.4.1.1 Production process

Firstly, the liquor-making experiment of liquid potato and liquor is carried out [4]. The technological process we plan to set is as follows:



2.4.1.2 Key points of operation

(1) Cooking: Wash potatoes, wrap them with gauze, put them into a pot, and steam for 40min. The steamed potatoes have no white heart inside, are soft inside and outside, transparent but not rotten, and then peel and mash. The corn is soaked for one day and then boiled for 3 hours, and the boiled corn blooms without pasting.

(2) Raw material mixing: potatoes are mixed with tartary buckwheat, oat and corn according to different proportions.

(3) Material-water ratio: mixing the raw materials and water according to different ratios

(4) Liquefaction: adding 5 U/g of thermostable A-amylase and liquefying at 90℃ for 60 min to obtain liquefied liquid.

(5) Saccharification: after the liquefied liquid is cooled to room temperature, heat preservation and saccharification are carried out at 60 deg c for 90 min, and after cooling to 30 deg c, supernatant is filtered to obtain saccharified liquid.

(6) Adding distiller's yeast and enzyme: after activating a certain proportion of distiller's yeast with 5 times of 30 degrees celsius and 5% sugar water for 30min according to the quality of the raw materials, evenly spreading on the cooled potato and corn mixed raw materials, simultaneously adding four enzymes of high temperature amylase, neutral amylase, cellulase and saccharifying enzyme according to the proportion, loosely placing the crushed mud in a glass jar after cleaning and blanching, and flattening to facilitate ventilation.

(7) Fermentation: 1‰ Saccharomyces cerevisiae is added into the saccharified liquid and fermented at 30℃ for 36 hours. Set the fermentation tank 30℃ in advance, and then put the fermentation tank in the 30℃ fermentation tank for 7 days. Stir 1~2 times a day.

(8) Distillation: putting the fermented blank into a wine steaming pot, controlling the temperature of the wine steaming to be 80-150 deg c, and collecting the finished potato white spirit by a measuring cylinder.

(9) Detection: measure the alcohol content, color, aroma, taste and style of the final liquid [5].

2.4.2 Test Methods and Counting

2.4.2.1 Inquires into the Influence of Material-Water Ratio of Liquid Saccharification Mash

Under the conditions of 1% koji addition, 1:1 ratio of potato to corn and other raw materials, 25°C fermentation temperature, 7d fermentation time and 1% yeast inoculation amount, the effects of the ratio of material to water of 1:2, 1:3, 1:4, 2:3, 3:4 and 4:5 on potato wine were adjusted respectively, and the optimal inoculation amount was obtained through the determination of alcohol content, liquor yield and sensory perception of potato wine.

2.4.2.2 Explores the Effect of pH on Liquor Yield

Under the conditions of 1% koji addition and 1:1 water content of koji material, the ratio of potato to corn and other raw materials is 1: 1, the fermentation temperature is 25°C, the fermentation time is 7d, and the yeast inoculation amount is 1% of the raw materials, the effects on potato wine when the fermentation pH is 4.5, 5.0, 5.5, 6.0 and 6.5 are adjusted respectively, and the optimal inoculation amount is obtained through the determination of alcohol content, wine yield and senses of potato wine.

2.4.2.3 Explores the Influence of Fermentation Time on Liquor Yield

Under the conditions of 1% koji addition and 1% water content of koji material, the ratio of potato to corn and other raw materials is 1:1, the fermentation temperature is 25°C, the fermentation pH is constant, and the yeast inoculation amount is 1% of the raw materials, the influence of fermentation time on potato wine is explored for 3 days, 5 days, 7 days, 9 days and 11 days respectively, and the optimal time is obtained through the determination of alcohol content, wine yield and sense organ of potato wine.

2.4.2.4 Explores the Influence of Fermentation Temperature on Liquor Yield

Under the conditions of 1% koji addition, 1:1 water content of koji material, 1: 1 ratio of potato to corn and other raw materials, 1% yeast inoculum, 1% yeast inoculum and 1% fermentation time, the effects on potato wine at 18°C, 22°C, 25°C, 27°C and 30°C in the fermentation process were investigated by adjusting the temperature of the vertical fermentation tank, and the optimal temperature was obtained through the determination of alcohol content, wine yield and senses of potato wine.

2.4.2.5 Explores the Influence of Yeast Inoculation Amount on Liquor Yield

Under the conditions of 1% koji addition and 1:1 water content of koji material, the ratio of potato to corn and other raw materials is 1: 1, the fermentation time is the best condition for inquiry, the fermentation temperature is the best condition for inquiry, the fermentation pH is kept constant, the effects of yeast inoculation amount of 1%, 2%, 3%, 4% and 5% of raw materials on potato wine in the fermentation process are explored respectively, and the optimal inoculation amount is obtained through the determination of alcohol content, liquor yield and sensory quality of potato wine.

2.4.2.6 Explores the Effect of Enzyme Addition Ratio on Liquor Yield in Fermentation Process

Under the conditions of 1% koji addition, 1:1 water content of koji material, 1: 1 ratio of potato to corn and other raw materials, constant fermentation pH, 1% inoculum of yeast, optimal fermentation time, and optimal fermentation temperature, At the same time, when adding 0.1%, 0.2%, 0.3%, 0.4% and 0.5% of high temperature amylase, neutral amylase, cellulase and saccharifying enzyme as raw materials (equal weight, assuming the same enzyme activity) to the potato wine, the optimal concentration was obtained through the determination of alcohol content, wine yield and senses of potato wine [6].

2.4.3 Detection Methods

Determination of alcohol content: pour the sample into the measuring cylinder, slowly place the alcohol meter into the measuring cylinder, and slowly press a bit after it is not shaken. When it is not shaking, keep the line of sight and liquid level, check the scale to see the concentration of alcohol. Check the temperature at the same time. According to the obtained temperature and concentration, look at the "alcohol meter temperature and alcohol content conversion table", which is converted into the concentration of alcohol (%volume fraction) at 20℃, and the alcohol content value of the liquor can be obtained.

Determination of liquor yield:

$$\text{Liquor yield} = \frac{\text{alcoholic strength} \times \text{Capacity for liquor}}{\text{Quality of raw materials（Including water）}} \times 100\%$$

Acidity determination: refer to GB/T 10345-2007, liquor analysis method [7];

Sensory evaluation: The sensory evaluation of potato liquor is based on taste, aroma, color and style. Ten food professionals were selected to evaluate liquor, and the liquor yield was comprehensively evaluated with the average value. The evaluation criteria are shown in Table 2. Absorb 30m L of potato wine and pour it into a 50m L dry and clean beaker to observe the color of potato wine, which is transparent and free of precipitation and impurities. The taste of it has the unique aroma and taste of potato wine, without mildew, rancidity and peculiar smell, and should conform to the rules of GBT 10345-2007 liquor analysis method.

Table 1 Potato wine sensory evaluation table

Scoring standard		Score
Color	Clarification and transparency	10
	Clarification and no sundries	6-9
	Turbidity and poor gloss	3-5
	Turbidity	0-2
Aroma	Mellow	25
	Mellow but not rich.	22-24
	The bouquet is slightly lighter.	15-21
	Have bad smell	0-14
Taste	Mellow and very rich	50
	Tasty, mellow but not soft enough	44-49
	It is more harmonious and has less wine flavor.	35-43
Taste	Light-bodied, slightly astringent and ripe	25-34
	Light-bodied and a little bitter	15-24
	Light-bodied, bitter and sour	10-14
	Sour, astringent, bitter, with peculiar smell	0-9
style	Impressive, Pleasant and Satisfied, Taste Duration	15
	The aftertaste is longer and can last for about 10 s.	12-14
	It is still delicious and lasts about 5 seconds.	5-11
	The aftertaste is light or bitter and lasts for 2~3s	0-4

Microbial index detection: colony count: refer to GB 4789.2-2016 for determination of colony count; Coliform: refer to GB 4789.36-2016 coliform count; Salmonella testing: refer to GB 4789.4-2016 Salmonella testing.

3. Results and discussion

3.1 Effect of Liquid Saccharification Mash to Water Ratio on Quality of Potato Liquid Fermented Wine

The liquid mash formed by the ratio of potato and other raw materials (including the water content of potato itself) to water has obvious influence on the liquid fermentation of potato. In order to study the influence of the ratio of potato raw materials (potato: corn flour: oat flour: tartary buckwheat flour: 3: 1: 1: 1) to water on the overall situation of potato liquor, a single variable method was used to carry out the test, and the test results are shown in the table.

Table 2 Effect of water ratio of liquid saccharified mash to potato wine

Ratio of material to water	alcoholic strength/%	Liquor yield/%	Sensory score
1:3	32	7.88	82.67
1:4	33	6.65	86.30
2:3	39	10.54	88.54
3:4	43	12.58	89.39
4:5	41	11.23	88.56

It can be seen from the table that under the same and suitable conditions, the ratio of liquid mash to water is 1:3, 1:4, 2:3, 3:4 and 4:5 respectively, which have different effects on the quality of potato liquor [8]. Under the same fermentation time, water content, koji addition and other conditions, when the liquid mash ratio is 1:3 and 1:4, the alcohol content and taste of potato wine are poor, and the wine yield is low. When the ratio is 2:3, 3:4 and 4:5, the yield, sensory and alcohol content of potato liquor are better. Table 1 shows that when the ratio of liquid saccharification mash is 3:4, the quality of potato liquor is the best.

When the ratio of raw materials to water is small, the mash concentration is high, the sugar content is high, and the alcohol content of the fermented mash is relatively high; When the amount of water added is small, the potato feed liquid is too viscous, amylase is destroyed in the fermentation process, which affects the enzyme activity and leads to insufficient liquid fermentation, and the final liquid fermentation result is not ideal. When too much water is added and the mash concentration is too thin and thick, the alcohol content of the fermentation liquor will also decrease, which will affect the formation of flavor substances (acids and esters) in the fermentation system [9], and the quality of liquor is not high, although it is conducive to the infiltration and flow of materials and cooking.

3.2 Effect of pH on Liquid Fermentation of Potato and Other Raw Materials

The pH value is the concrete expression of the hydrogen ion concentration in the feed liquid, so the pH value has a great influence on the liquid fermentation of potatoes, especially on the alcohol content, alcohol output, etc. During the fermentation, the pH value of the pit will drop due to the occurrence of lactic acid and other byproducts. Under normal circumstances, the pH value in the feed liquid will be controlled between 4.5 and 6.5. In order to study the effect of pH on potato white spirit, a single control variable method is used to carry out the test. The test results are shown in the table.

Table 3 Effect of pH on potato liquid fermentation

pH	alcoholic strength/%	Liquor yield/%	Sensory score
4.5	40	14.87	86.67
5.0	43	15.30	87.09
5.5	45	15.85	89.24
6.0	41	14.70	88.39
6.5	41	14.67	86.28

It can be seen from the table that under the same and suitable conditions, the fermentation pH values of 4.5, 5.0, 5.5, 6.0 and 6.5 have different effects on the liquor yield, alcohol content and sensory quality of potato liquor. When the fermentation pH is 4.5 and 5.0, the overall alcohol

content, liquor yield and sensory score are not very good. When the fermentation time is 5.5, 6.0 and 6.5, the overall alcohol content, liquor yield and sensory score are better. Among them, when the pH is 5.5, the quality of potato liquor is the best.

If the pH value is too low, it is conducive to the reproduction of lactic acid bacteria and other miscellaneous bacteria and inhibits the reproduction and metabolism of yeast. However, too high a pH value in the initial fermentation environment will also inhibit the growth of yeast. With the increase of pH, liquor yield and alcohol content increase. A higher initial fermentation pH environment is conducive to the removal of yeast growth inhibition and yeast proliferation, and provides previous conditions for anaerobic respiration fermentation [10]. When the pH value reaches the optimum value and then increases, the liquor yield, alcohol content and sensory score will decrease. Excessive or too small pH value can denature enzyme protein, reduce glucoamylase activity and thus reduce saccharification efficiency. As can be seen from Table 2, the liquid fermentation is the best when the pH is 5.5.

3.3 Effect of Fermentation Time on Liquor Yield

Fermentation time has a significant impact on the quality of brewed wine, especially on alcohol content and liquor yield.According to the single variable method, the test results are as shown in the table. The effects of fermentation time on the samples were investigated at 3d, 5d, 7d, 9d and 11d respectively. The optimal fermentation time was obtained through alcohol content, liquor yield and sensory evaluation of potato liquor.

Table 4 Effect of fermentation time on potato liquor

Time/d	alcoholic strength/%	Liquor yield/%	Sensory score
3	25	6.38	86.47
5	36	6.40	87.25
7	45	6.42	89.03
9	43	7.98	89.75
11	43	7.12	88.12

It can be seen from the table that under the same and suitable conditions, the fermentation time has significant difference on the quality of potato wine when the fermentation time is 3 days, 5 days and 7 days, while the fermentation time has no significant effect on the quality of potato wine when the fermentation time is 9 days and 11 days, and other factors are dominant at this time. Therefore, the quality of potato liquor is the best when the fermentation time is 9 days.

The fermentation time is too short, the growth and metabolism activities of microorganisms are weak, the ethanol yield is low, and the liquor yield is low. When the fermentation time is moderate, the growth and metabolism of microorganisms are vigorous, the ethanol yield is the highest, and the liquor yield is high. If the fermentation time is too long, the growth and metabolism of microorganisms will be inhibited under the influence of metabolites, and the increase of impurity content will lead to the reduction of ethanol ratio and low liquor yield. It can be seen from Table 3 that under other suitable conditions, the fermentation effect is best when the fermentation time is 7 days.

3.4 Effect of Fermentation Temperature on Liquor Yield

The fermentation temperature further affects the growth and metabolism of microorganisms by affecting the activity of enzymes, thus affecting the quality of brewed wine.Under other suitable

conditions, the effects of fermentation temperatures of 18℃, 22℃, 25℃, 27℃ and 30℃ on potato wine were investigated respectively. The optimum fermentation temperature was obtained by measuring the alcohol content, wine yield and sensory quality of potato wine.

Table 5 Effect of fermentation temperature on potato liquor

Temperature/℃	alcoholic strength/%	Liquor yield/%	Sensory score
18℃	32	10.34	85.55
22℃	40	12.50	86.96
25℃	43	13.77	87.24
27℃	45	15.29	88.00
30℃	45	14.26	86.65

It can be seen from the table that under the same and suitable conditions, when the fermentation temperature is 18℃, 22℃, 25℃, 27℃ and 30℃, the fermentation temperature has a significant effect on potato liquor. When the fermentation temperature is higher than 30℃, the alcohol content of potato liquor decreases, and other factors dominate. Therefore, when the fermentation temperature is 27℃~30℃, the quality of potato liquor is the best.

If the fermentation temperature is too low, the activity of enzymes related to yeast respiration will decrease and the growth of yeast will decrease. The alcohol content, alcohol yield and organoleptic degree of potato wine are relatively low. When the fermentation temperature increases gradually, the inhibition of respiration is relieved, the enzyme activity increases, yeast grows rapidly, and enters the anaerobic respiration stage in a short period of time, and the alcohol content, wine yield and organoleptic degree of potato wine are significantly increased [11]. It can be seen from the table that when the fermentation temperature is about 27℃, the quality of the potato wine brewed at this time is the highest. When the fermentation temperature continues to rise, the alcohol fermentation process is blocked and the alcohol yield decreases. As can be seen from table 4, when the fermentation temperature is about 27℃, the liquid fermentation effect is the best.

3.5 Influence of Yeast Inoculation Amount on Liquor Yield

Inoculation quantity of yeast affects the quantity of effective enzymes by affecting the growth quantity of microorganisms, thus affecting the quality of brewed wine. Under other suitable conditions, the effects of yeast inoculation amount of 1%, 2%, 3%, 4% and 5% of raw materials on potato wine were investigated respectively. The optimal inoculation amount was obtained through the determination of alcohol content, liquor yield and sensory quality of potato wine.

Table 6 Effect of yeast inoculation on potato liquor

Amount/%	alcoholic strength/%	Liquor yield/%	Sensory score
1%	38	12.23	85.53
2%	44	14.54	88.51
3%	42	13.97	86.30
4%	37	12.21	82.52
5%	30	10.85	78.98

It can be seen from the table that under the same and suitable conditions, when the inoculation

amount of yeast is 1%, 2%, 3%, 4% and 5% of the raw materials respectively, the inoculation amount of yeast has a significant effect on the potato liquor. When the inoculation amount is higher than 3%, the alcohol content of the potato liquor decreases, the liquor becomes turbid and the sensory quality decreases. It can be seen that the potato liquor has the best quality when the yeast inoculation amount is about 2%.

The inoculation amount of yeast is too low, the utilization rate of raw materials is too low, and the alcohol content, wine yield and sensory score of potato wine are at a low level. With the gradual increase of yeast inoculation, the alcohol content, liquor yield and sensory quality of potato wine increased significantly. When the inoculation amount continues to increase, the competition relationship between strains is not conducive to the aerobic proliferation of yeast. At this time, the alcohol fermentation process is blocked and the liquor yield decreases. At the same time, excessive yeast will affect the quality of steamed wine. As can be seen from Table 5, when the inoculation amount is about 2%, the liquid fermentation effect is the best.

3.6 Effect of Enzyme Addition Ratio on Liquor Yield in Fermentation Process

The addition of enzymes will significantly affect the quality of brewed wine, especially the significant effects of enzymes on catalytic degradation of unrelated substrates and increasing available sugars on alcohol content and wine yield. According to the single variable method, the experimental results are shown in the table. The effects of adding amylase, saccharifying enzyme and cellulase at 0.1%, 0.2%, 0.3%, 0.4% and 0.5% of the raw materials on the samples were investigated. The best enzyme addition ratio was obtained through alcohol content, liquor yield and sensory evaluation of potato liquor.

Table 7 Effect of adding enzyme ratio on potato liquor

Amount /%	alcoholic strength/%	Liquor yield/%	Sensory score
0.1%	41	11.52	87.58
0.2%	45	12.55	90.68
0.3%	44	11.68	88.65
0.4%	40	10.78	84.54
0.5%	38	9.58	80.84

It can be seen from the table that under the same and suitable conditions, the quality of potato wine is significantly affected by the addition of 0.1%, 0.2% and 0.3% of enzyme. When the addition of enzyme is 0.4% and 0.5%, the quality of potato wine starts to decline, and the excessive enzyme starts to affect the fermentation process of wine in turn. It can be seen that the potato liquor has the best quality when the addition of enzyme is about 0.2%.

Appropriate addition of amylase, saccharifying enzyme and cellulase can promote the utilization rate of raw material substrate and convert the polysaccharide that cannot be decomposed by microorganisms into monosaccharide, which is conducive to microbial fermentation and improve the liquor yield. However, when the amount of enzyme added is too large, the presence of enzyme will in turn inhibit the growth of microorganisms, thus reducing the liquor yield. From Table 6, it can be seen that under other suitable conditions, when the addition amount of enzyme is about 0.2%, fermentation is most favorable.

4. Standard for Potato Liquor

According to the national liquor standards and the national fermented liquor standards, the potato liquor quality standards are as follows.

4.1 Physical and Chemical Index Detection

The physical and chemical indexes of potato liquor were tested, and the standards are shown in Table 9 [12].

Table 8 The pHysical and chemical indicators of potato wine

Projects	Quality standard
alcoholic strength (%Vol)	41.0-59.0
Acidity (g/L)	0.30-2.00
Ethyl acetate (g/L)	0.60-2.00
Methanol (g/100ml)	≤0.12g/100ml

4.2 Detection of Microbial Indicators

The detection results of microbial indicators, through the detection of microbial content in potato liquor, are shown in Table 10.

Table 9 Microbial indicators of potato wine

Detection Indicator	National standard
Total number of colonies ((Quantity/g)	≤1000
Coliform group (MPN/100g)	≤30
pathogenic bacteria	Not detectable

5. Conclusion

Under the condition of single-factor test, the optimum conditions for each factor can be obtained. After investigating the results of six aspects, the optimum brewing process conditions of potato white spirit are preliminarily obtained as follows: material-water ratio 3:4, pH 5.5, fermentation time 7d, fermentation temperature about 27℃, yeast inoculation amount 2%, enzyme addition amount 0.2%.

The deficiency of the experiment lies in that the orthogonal experiment based on the single factor experiment cannot be further comprehensively explored, only the control variable method is used for preliminary exploration, and the optimal conditions still have room for improvement. In addition, there are many factors that affect the fermentation results in the process of optimizing the brewing process of potato liquor. In actual experiments, other optimization should be carried out, such as the selection of fermentation vessel, the soaking time of bottom materials, the cooking time of substrate, etc. Because of insufficient time and heavy workload, only the brewing process of potato liquor is preliminarily optimized.

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