Study on the technology of kumquat grapefruit sour beer

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Abstract. A kumquat-grapefruit acid beer was brewed with Australian barley malt, lactobacillu, D17 yeast, Qingdao hop flower, kumquat concentrated juice and grapefruit concentrated juice as raw materials by using special mash and fermentation process. The effects of acidification degree, the addition amount of kumquat and grapefruit juice concentrate and the addition time on beer flavor were studied in this paper. The results showed that when the pH was adjusted to 3.5 by acidification, the sour beer produced by adding 6% kumquat concentrated juice and 4% grapefruit concentrated juice before the CO_2 pressure of the tank rised, the beer has white and exquisite foam with prominent fruit aroma, especially those of kumquat and grapefruit. The beer body was clear and transparent, with about 5% residual sugar. The sweet and sour taste of the beer was balanced. The beer contained unique nutrients of kumquat and grapefruit also, and was especially suitable to drink for brewers and ladies.

Keywords: Kumquat grapefruit; Lactobacillus; Beer; Fermentation process.

1. Introduction

Kumquat, also known as kumquat, belongs to rutaceae, is a famous fruit-viewing plant. Especially in Guangdong and Hong Kong, many people buy for Tujili during the Spring Festival. Kumquat is an evergreen shrub. Flowers solitary, white, aromatic. Fruit for oval, golden, shiny, some varieties edible. Kumquat is not only beautiful, its fruit contains rich vitamin C, kumquat glucoside and other components, to maintain cardiovascular function, prevent vascular sclerosis, hypertension and other diseases have a certain effect. Regulating qi, relieving depression, eliminating phlegm, quenching thirst, resolving food stagnation, and sobering up. Kumquat can enhance the body's cold resistance, prevent and treat cold, and reduce blood lipids[1–3]. Grapefruit is extremely rich in vitamin C, which can promote antibody production and enhance the body's detoxification function. One of the natural folic acid can also prevent anemia, reduce the risk of maternal birth defects. For girls who love beauty, the vitamin P contained in the grapefruit can enhance the elasticity of the skin and narrow the pores. Grapefruit has a variety of ways to eat, in addition to when the fruit to eat, but also squeezed into a salad and cold dishes; Add some when making seafood, can have the effect that removes fishy smell. Grapefruit contains cellulose, pectin, potassium, vitamin C, folic acid, inositol, bioflavonoids, and limonene [4–7], so it has high nutritional value and health care effect.

2. Materials and Methods

2.1. Materials and Equipment

2.1.1 Materials and Reagents

Tsingtao hops (Jinan Shuangmai Beer Raw Material Co., Ltd.);

Imported Australian malt: Yongshuntai (Changle) Malt Co., Ltd.;

D17yeast (qilu university of technology);

Kumquat juice concentrate, grapefruit juice concentrate (Heheyuan Food Co., Ltd.)

Lactic acid bacteria (LALLEMAND Company of Canada);

iodine solution, sodium hydroxide, phenolphthalein, hydrochloric acid, organic silicon defoamer (Tianjin Fuchen Chemical Reagent Factory);

o-phenylenediamine (analytical purity, Tianjin Beilian Fine Chemicals Development) Co., Ltd.);

2.1.2 Instruments and Equipment

YXQ-LS-75SII vertical pressure sterilizer (Shanghai Boxun Industrial Co., Ltd.Medical Equipment Factory);

SW-CJ-1BU sterile ultra-clean workbench (Suzhou Shangtian Clean Technology Co., Ltd.);

SD9012BEBC colorimeter (Shanghai Xin Rui Instrument Equipment Co., Ltd.);

WGZ-2PJ Turbidity Meter (Shanghai Xin Rui Instrument Equipment Co., Ltd.);

SPL-250 Biochemical Incubator (Tianjin Laibo Terui Instrument Co., Ltd.);

WYT-J Handheld Brix Meter (Chengdu Haochuang Photoelectric Instrument Co.,Ltd.);

EBC standard mill grinder (Tianjin Laibo Terui Instrument Co., Ltd.);

GSP-77-03 magnetic stirrer (Jiangyan Analytical Instrument Factory, Jiangsu);

ME204 analytical balance: METTLER TOLEDO Instrument (Shanghai) Co., Ltd.;

UV2350 ultraviolet-visible spectrophotometer: Unico (Shanghai) Instrument Co., Ltd.

2.2. Test Method

2.2.1 Process Flow

Spend grains↖ lactobacillus↖

Malting→mashing→wort filtration→boiling for 15min→cooling→lactobacillus fermentation→wort boiling→whirlpool separator→wort cooling→fermentation→

↖hops ↖O_2,yeast

Tank sealing→wort cooling→filling→pasteurising

↖Kumquat juice concentrate, grapefruit juice concentrate

2.2.2 Operating Points

Malting: Australian barley malt is crushed by humidifying crushing method. The crushed barley malt should be crushed without crushing, with proper thickness, without unbroken whole grains, and should not be crushed too finely, so as to avoid the crushing of barley bran and the high proportion of fine powder, which will prolong the filtering time and increase the risk of wort oxidation [8].

Saccharification: single mash heating leaching saccharification method is adopted [9]. See Table 1 for saccharification temperature. Material-water ratio is 1: 3.5, hot water is used for blanking at 50℃, after blanking, it is stirred and kept at constant temperature for 20 min, heated to 65℃, kept for 40 min, heated to 68℃, kept for 30 min, heated to 72℃ and kept for 10 min. At this time, for iodine inspection, dip the glass rod into the wort solution and put it on the iodine reaction porcelain plate. After cooling, drop the iodine solution into the wort. Using the principle that iodine turns blue when meeting starch, if the iodine solution turns blue and black, the starch decomposition is incomplete, it is necessary to increase the saccharification time until iodine does not change color. When the iodine test reaction does not change color, it is heated to 78℃, filtered and saccharified. In the process of saccharification, different saccharification stages at different temperatures have different effects on enzymes. Proper control of temperature can provide different optimum temperatures for various enzymes, and various desired products can be obtained.

Table 1. Saccharification Temperature and Its Effect

Temperature/℃	effect
50	The role of organic carboxypeptidase, the formation of low-molecular-weight nitrogen-containing substances. And there is partial protein decomposition, β-glucan decomposition, and R-enzyme debranching effect on pullulan
65	Conducive to the action of α-amylase, the action of β-amylase is relatively weakened, the production of maltose is reduced, and the production of dextrin is relatively increased
68	Endopeptidase, phosphatase, β-amylase, etc. are inactivated, and a large amount of short-chain dextrin is produced
72	The reaction speed of malt alpha-amylase is accelerated and a large amount of dextrin is formed
78	Alpha-amylase and certain high-temperature-resistant enzymes still work, and the leaching rate begins to decrease

Wort filtration: First, add 78 ~ 82℃ hot water into the filter tank, and the water will not pass through the sieve plate, so as to exhaust the air inside and preheat the sieve plate. Pour the saccharified wort into a filter tank and stand for 20 min to form a filter layer; Then, reflux operation is carried out, and the wort can be filtered when it begins to clarify; Then, wash the grains twice with 78℃ water, and the filtration speed in the whole process should be stable to ensure the clear wort.

Wort boiling: Wort boiling: counting from wort boiling to 15min.

Wort cooling: cooling the boiled wort with cooling coils to 40℃, and fermenting with lactobacillus.

Acidification of wort: in the process of acidification of wort, measure the pH value every 2 hours, and boil the wort when the pH value reaches 3.5.

Wort boiling[10]: From the beginning of wort boiling, add 0.36 g/L tsingstao hops in three times. 16% of wort was added 15min after boiling; Adding 68% 30 min after boiling; Add 16% 50 min after boiling. The appropriate hop addition amount gives beer refreshing bitterness and unique flavor, which makes beer more layered[11].

Whirlpool [12]: After the wort is boiled, it enters the whirlpool separator, stands for 20min minutes, and separates the heat condensate to obtain clear wort.

Wort cooling[13] : The temperature of wort is reduced to about 20℃ by the plate heat exchanger which has been sterilized, and the wort is put into the tank, and the oxygen content of wort is 8-9mg/L by venturi tube.

Fermentation: inoculated with D17, the yeast inoculation amount is about 2×107 cells /mL. The fermentation temperature is kept at 11℃ until the sugar content of the fermentation liquid drops to 4±0.2°P, the jar is sealed, and the post-fermentation stage is entered. At this time, zinc ions in beer promote the reduction of diacetyl [14], and the diacetyl content is detected every 24 hours. When the diacetyl content drops below 0.1 mg/L, the temperature is reduced [15-16], and then it is stored cold for about 7 days.

2.3. Evaluation Criteria

The beer sensory evaluation team of the Sino-German Beer Technology Center Laboratory of Qilu University of Technology evaluated the Schisandra sour beer. The comments were made on the appearance, foam, aroma, and taste of the beer [17]. The specific scoring rules are shown in Table 2.

Table 2. Sensory Evaluation Rules

project	Full score requirements	Deduction content	Deduction standard
Appearance (8 points)	Clear and transparent, without obvious suspended matter and sediment, light yellow	Poor gloss	1~2
		Obviously suspended matter	1~2
		Poor color	1~2
		Poor foam	1~2
Foam (12 points)	Pour into the cup, there is obvious foam rising, the foam is white and delicate, and the foam hangs in the cup for a long time	The foam is not white	1~3
		Thick foam	1~3
		Short lasting time	1~3
		Poor hanging cup	1~3
Aroma (20 points)	There is obvious sour taste of schisandra, pure, no peculiar smell, no aging smell and other peculiar smell	The slightly sour smell of schisandra is not obvious	1~2
		Have raw hop fragrance	1~2
		Beer is too light	1~2
		The beer is greasy and thick	1~2

		Impure taste	1~2
		Have a bitter taste	1~2
		Bitterness is rough and unpleasant	1~2
		Has a strange fragrance	1~3
		Smell of aging	1~3
Taste (60 points)	Pure taste; carbon dioxide stimulation, unique flavor characteristics, soft and harmonious wine body; no obvious taste defects	Softness and poor coordination	1~3
		Rough taste	1~3
		Pungent sourness	1~3
		Pollution odor	1~3
		The taste of diacetyl	1~3
		Yeast taste	1~3
		High mellow taste	1~3
		Iron taste	1~3
		Epidermis	1~3
		Squirt	1~3
		Other unpleasant	1~30

3. Results and analysis

3.1. Optimization of the Technology of Kumquat Pomelo Acid Beer

Taking sensory evaluation as the main evaluation index, the effects of kumquat juice addition, grapefruit juice addition and kumquat grapefruit juice addition time on the aroma of kumquat grapefruit sour beer were explored. Three-factor and three-level orthogonal test was used for analysis, and the most suitable balanced fragrance was obtained. See Table 3 for the design results of the test scheme. From Table 4 and Table 5, it can be seen that the F ratio is as follows: the adding time of kumquat grapefruit juice (3.021) > the adding amount of grapefruit juice (1.991) > the adding amount of kumquat juice (0.285), and the larger the F ratio, the more significant the influencing factors are, so the adding time has the most significant influence on beer, followed by the adding amount of grapefruit juice, and finally the adding amount of kumquat juice. From Figure 1, it can be seen that the changing trend of kumquat juice addition influencing the evaluation score is gradually rising and changing gently, while the change of grapefruit juice addition influencing the evaluation score is rapid, and the adding time of kumquat grapefruit concentrated juice first rises rapidly and then drops rapidly, which intuitively shows that the adding time and the adding amount of grapefruit juice have a great influence on the evaluation score of kumquat grapefruit sour beer, so the best combination is to add 6% kumquat juice and 4% grapefruit juice before sealing.

Table 3. Orthogonal test factors and levels of sour beer technology

Level	factor		
	A Kumquat juice addition/%	B Grapefruit juice addition amount/%	C Adding time of orange grapefruit juice
1	4	4	After boiling 55 min
2	6	6	Before sealing
3	8	8	Filling

Table 4. Visual Analysis Table of Orthogonal Test of Schisandra Sour Beer Technology

Test number	A	B	C	Sensory Evaluation/Points
1	1	1	1	79
2	2	1	2	95
3	2	2	1	78
4	3	2	2	89
5	2	3	3	75
6	1	3	2	80
7	3	1	3	86
8	1	2	3	78
9	3	3	1	75
Mean 1	79.000	86.667	77.333	
Mean 2	82.667	81.667	88.000	
Mean 3	83.333	76.667	79.667	
Range	4.333	10.000	10.667	

Table 5. Variance analysis table of orthogonal test of kumquat grapefruit sour beer technology

factor	Deviation sum of squares	Degree of freedom	F ratio	Significance
A	**32.667**	**2**	**0.285**	
B	**150.000**	**2**	**1.991**	**
C	**188.667**	**2**	**3.021**	***

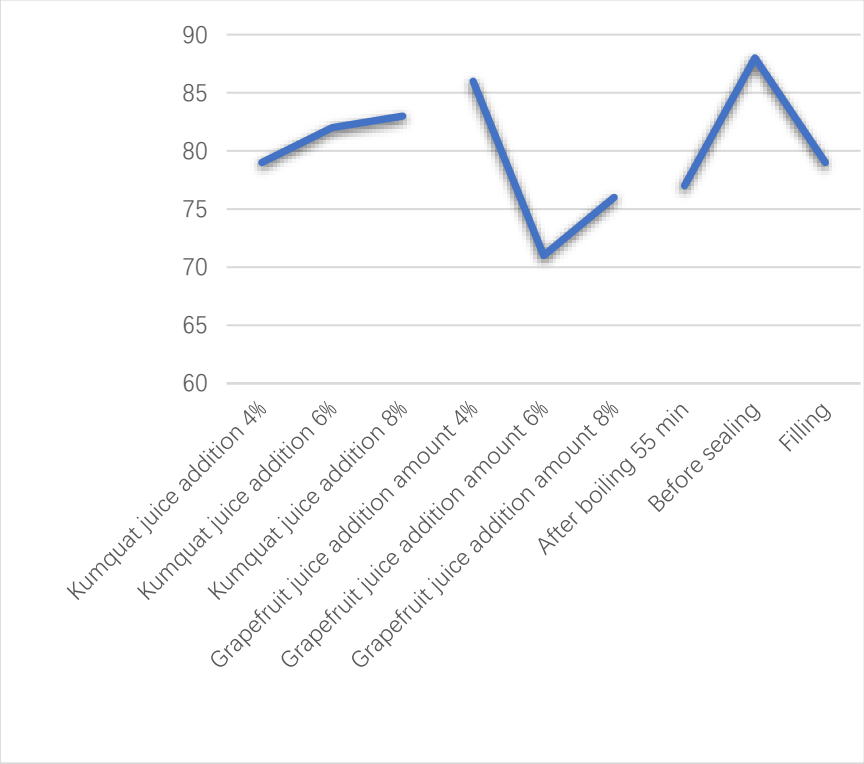

Fig. 1 Orthogonal test effect curve of rose beer technology

3.2. Quality analysis of kumquat grapefruit sour beer

3.2.1. Physical and chemical indicators

According to the results of orthogonal experiment, the optimal scheme was worked out. Under this optimized condition, kumquat grapefruit acid beer was brewed, and its quality was detected and analyzed. The results are shown in Table 6.

Table 6. Physical and chemical indexes of finished sour beer

Physical and chemical indicators	result
Original wort concentration /°P	15.9
Bubble retention /s	240
pH	3.24
Alcohol content / %vol	4.62
Acid value / (mL·100 mL-1)	4.7
Diacetyl/ (mg·L-1)	0.05
Chroma (EBC)	12.3
Turbidity (EBC)	138
Carbon dioxide content (m/m%)	0.51

The results showed that the beer was very good in soaking pool and high in alcohol content, so it was not suitable for drinking. Diacetyl has reached the national standard[18]. And the color and turbidity are high, the wine body is turbid and orange juice-like, and the carbon dioxide content also meets the national standard requirements. After adding fruit juice, the wine is still fermenting, and some fruit juice is fermented into alcohol, which leads to the alcohol content still rising after sealing. After adding fruit juice, because the fruit juice contains acid, the total acid rises, but it does not affect the taste, and the sweet and sour feeling is balanced, which makes the taste sweet but not greasy.

We bought several commercially available fruity sour beers for comparison, namely Lindemans cherry, Lindemans peach, craftsman 24H kumquat beer and Lorenzo strawberry sour beer. After tasting, cherries and peaches in Lindemans are thin in taste, not as mellow as kumquat grapefruit sour beer. The acidity of craftsman 24H kumquat beer and Lorenzo strawberry sour beer is sharper than kumquat grapefruit sour beer, but not as sweet as kumquat grapefruit sour beer. To sum up, kumquat grapefruit sour beer is sweeter than other sour beers, which is suitable for Chinese population.

3.2.2. Sensory evaluation

Physical and chemical indexes and instrumental analysis of beer are not enough to fully express beer flavor substances, and sensory evaluation also plays a decisive role in beer quality supervision. It is difficult for instruments to make comprehensive judgments about people's preferences, but people's senses can make comprehensive judgments directly through many senses such as sight, hearing, touch, smell and taste.

After sensory evaluation, kumquat grapefruit sour beer is light yellow; The foam is white and rich, and the cup hanging time is longer; The aroma contains the wheat aroma of barley malt, the fragrance of hops and the fruit aroma of kumquat and grapefruit. The taste is neat, fresh, pure, with no off-flavor, no top taste of higher alcohol, and fresh and killing taste. Among them, the beer with 6% kumquat concentrated juice and 4% grapefruit concentrated juice before can sealing has the highest score, all kinds of flavors reach the common balance point, and it is a beer that meets the standard. This optimized process is consistent with the prediction, which proves the feasibility of the scheme.

4. Conclusion

The results showed that the optimal combination of production technology was that 6% kumquat juice concentrate and 4% grapefruit juice concentrate were added before sealing, and D17 yeast was used to ferment at 20℃. The kumquat grapefruit acid beer brewed under this optimized condition is white and delicate in foam, pure in taste and fresh in taste, accompanied by a faint kumquat grapefruit acid flavor, which has health care function while enjoying the beer flavor, and is a new beauty and health care product. According to the consumers' demand for healthy living and the market demand for diversified beer, kumquat grapefruit sour beer has great market potential.

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