LWT - Food Science and Technology 56 (2014) 145–152

Contents lists available at ScienceDirect

LWT - Food Science and Technology

journal homepage: www.elsevier.com/locate/lwt

# Screening of rice cultivars for brewing high quality turbid rice wine

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ARTICLE INFO

*Article history:*
Received 22 September 2012
Received in revised form
18 October 2013
Accepted 22 October 2013

*Keywords:*
Turbid rice wine
Makgeolli
Rice screening
Wine properties
Fusel alcohols

ABSTRACT

To screen proper rice cultivars for brewing high quality turbid rice wine, 5 high-yield rice cultivars, 9 high-eating-quality rice cultivars and 5 glutinous rice cultivars were collected. At the end of fermentation, significant differences ($p < 0.05$) were observed in the fermentation properties, sensory properties and suspension stability of the original fermented mash (OFM) among individual rice cultivars. The assayed fermentation properties of OFM included pH value, total acidity, amino acidity, reducing sugar, alcohol yield, fusel alcohols and ethyl acetate. Seven rice cultivars were screened out for producing high quality wine by the comparative analysis. This research provided the basic scientific data for producing potential high quality turbid rice wine.



## 1. Introduction

Unlike European wine (Bautista-Ortín et al., 2013; Belisario-Sánchez, Taboada-Rodríguez, Marín-Iniesta, Iguaz-Gainza, & López-Gómez, 2012; Ivanova et al., 2013; Ivanova, Vojnoski, & Stefova, 2011; Morakul et al., 2013; Smit & du Toit, 2013), which is normally made from grapes, the alcohol beverage produced from rice is called rice wine. Turbid wine called as makgeolli in Korean (Kim, Kim, Park, Kang, Ryu and Kim, 2011), zhuojiu in Chinese (Jiang, 2009; Yu, 2009) and nigorizake in Japanese (Gauntner, 2013), is one kind of traditional cereal (generally rice) wine in eastern Asia area. However, turbid wine from Korea, China and Japan differs in wine starter, raw materials, alcohol content, color, flavor and so on. Korean turbid wine is made by fermentation with a traditional fermentation starter (*nuruk* in Korean), water and starch-containing materials (excluding germinated grains). During or after the fermentation process, extra sugar, fruits, vegetables or other legally permitted food additives may be added. Unlike other wines, no filtration process is performed at the end of the fermentation, which makes the wine having turbid appearance (Sol, 2007). The main nutritional components per 100 mL turbid rice wine (6 mL ethanol/100 mL) were 6 mL ethanol, 91.8 g water, 1.6 g protein, 2.4 g saccharide, 41 mg ashes and 1.34 mg vitamins (Park, Park, Kim, Lee, & Rim, 2010). Turbid wine is firstly characterized by the low alcohol content (2–6 mg/100 mL, and generally 6 mg/100 mL), secondly by the harmony attributes of sweetness, sourness, bitterness, piquancy, and bouquet (Lee & Choi, 1998), thirdly by nourishments (Lee & Joo, 2008), and finally by functional activities (Kim, Kim, & Bae, 2001; Kim & Cho, 2006; Shin, Kang, Kim, & Bae, 2008).

Turbid rice wine with its wellbeing characteristics was recognized as a sort of outstanding food in the early of 2000s, since then turbid rice wine consumption increased greatly over the years. The licenses issued for producing turbid rice wine were 768 in 2009 in Korea according to the official *Statistics Korea*, 2011. The amount of turbid rice wine sold in 2010 has already reached 412,279 tons whereas it was only 170,165 tons in 2006, and export of the wine was 3290 tons in 2006, and reached 19,407 tons in 2010 according to the official report of Korea National Tax Service in 2011. In addition, the number of published papers on turbid rice wine was 88 from 1990 to 2000, while it was 169 from 2001 to 2010. These papers can be sorted into 6 groups, i.e., raw materials, fermentation

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http://dx.doi.org/10.1016/j.lwt.2013.10.032

starter, fermentation conditions, nutritional functions, food quality and package design. In terms of raw materials, most studies focused on only 1–2 raw materials such as sweet potato (Kim, Choi, & Oh, 1972), puffed rice (Kim, Sung, Bae, & Lee, 2007), rice plus grape (Koo, Yook, & Kim, 2006), rice plus Yulmoo (Shin, Suh, Cho, Lee, & Hwang, 2003), rice plus cyclodextrin (Song, Park, & Shin, 1997) and etc. However there is no investigation on how rice cultivars affect turbid rice wine brewing. The reason is that rice was officially forbidden for using in making alcoholic drinks during 1965–1990 due to food shortage after the Korean War (Kim, Jeong, & Choi, 2011). However, since the late 1980s, the rice yearly yield in Korea was far more than consumption, and since 1990, the Korea government encouraged people to use rice for alcoholic beverage. Therefore, in the current study, the fermentation characteristics of 20 rice cultivars collected in Korea were comparatively investigated in order to provide some basic scientific data for producing potential high quality turbid rice wine.

## 2. Materials and methods

### 2.1. Rice cultivars

Eighteen Korean domestic rice cultivars produced in 2009 (including two sub-types: Japonica and Indica) were obtained from the National Institute of Crop Science, Rural Development Administration (RDA), South Korea. Among these, five cultivars were high yield rice (HY-rice), eight were high eating quality rice (HEQ-rice), and the other five were glutinous rice. In addition, rice cultivar Chucheong (produced in 2009, belonging to HEQ-rice) was bought from a local market and used as control. These rice cultivars are listed in Table 1.

### 2.2. Fermentation starters

#### 2.2.1. Modified starter

The modified starter was purchased from Korea Enzyme Company, Seoul Korea, which was modified from the Korean traditional starter by using wheat flour as raw material instead of wheat grain, and using screened pure microorganisms such as *Rhizopus japonicus*, *Aspergillus oryzae* and Hansenula yeast as inoculum instead of the microorganisms from environment. The general culture conditions were the same as those used by So, Lee, and Noh (1999).

**Table 1**
Rice type, producing region and grouping of rice cultivars.

| Rice group | Rice cultivar | Cultivation region | Rice type |
|---|---|---|---|
| HY-rice[a] | Dasan2 | Suwon | Indica type |
| | Deulaechan | Iksan | Japonica type |
| | Namchan | Miryang | Indica type |
| | Hanaleum | Miryang | Indica type |
| | Keunseom | Miryang | Indica type |
| HEQ-rice[b] | Gaopum | Iksan | Japonica type |
| | Miguang | Suwon | Japonica type |
| | Hanseol | Suwon | Japonica type |
| | Huaseong | Miryang | Japonica type |
| | Ju-an | Suwon | Japonica type |
| | Cheong-a | Iksan | Japonica type |
| | Jo-un | Suwon | Japonica type |
| | CHHjinmi | Suwon | Japonica type |
| Glutinous rice | Baekjinju | Suwon | Japonica type |
| | Baekjinju1 | Suwon | Japonica type |
| | Haepyeongchal | Miryang | Japonica type |
| | Hangangchal | Miryang | Indica type |
| | Huaseonchal | Miryang | Japonica type |
| Control rice[c] | Chucheong | Suwon | Japonica type |

[a] HY-rice: high yield rice cultivars.
[b] HEQ-rice: high eating quality rice cultivars.
[c] The control rice Chucheong, bought from market, belongs to HEQ-rice.

#### 2.2.2. Aspergillus kawachii-starter

*A. kawachii* (CF1005, Chung-mu Fermentation Company, Korea) starter was prepared in laboratory. The preparation process was as follows: rice (10 kg, *Odae* polished rice, Japonica type) was rinsed and then soaked in water for 2 h, and then the excess water was drained off for 1 h. The rice was then steamed for 40 min to allow the full gelatinization of rice. The steamed rice was cooled down to less than 30 °C and was inoculated with 800 mL cultured liquid of *A. kawachii* for 48 h (The components of the liquid medium per 100 mL consisted of 2.0 g glucose, 5.0 g rice powder, 0.80 g yeast extract and 100 mL water). Incubation was carried on for 44 h in an automatic rice fermenter (Mini 15 PX, Yaegaki Co., Japan), in which the humidity was maintained at 80% and temperature at 38 °C. After incubation, the starter was dried at 50 °C for around 12 h till the water content was less than 12 g/100 g. The dried starter was stored at 4 °C–10 °C for up to 12 months.

#### 2.2.3. Yeast

SAF-Instant Gold Label Yeast (consisting of yeast of *Saccharomyces cerevisiae*, sorbitan monostearate, and ascorbic acid) was purchased from Lesaffre Yeast Corporation, France. This yeast product was a granular free-flowing yeast which could be used in doughs with sugar levels from 10 to 30%, the suggested inoculum amount was 0.5–1% by dry weight.

#### 2.2.4. Activated starter

Activated starter was prepared by mixing 1 kg *A. kawachii* starter, 12.5 g SAF-Instant yeast and 1500 mL sucrose water solution of 15 g/1000 mL in a container, and incubated at 25 °C for 30 h under aerobic condition.

### 2.3. Fermentation process for original fermented mashes

One kilogram rice was rinsed 3 times to remove the impurities, followed by soaking in water (~25 °C) for 2 h until saturation of water adsorption. Excessive water was removed, and the soaked rice was then steamed for around 40 min to allow the full gelatinization of rice. The steamed rice was cooled down from more than 95 °C to less than 30 °C within 10 min in an air blast cooler (YW-30, Yaegaki Co., Japan), then the steamed rice was transferred to a 5 L plastic fermentation container. 2 L water, 20 g modified starter, and 200 g activated starter were added into the container and incubated at 22 °C until the completion of the fermentation, which took 7 days. At the end of fermentation, the whole mash was mixed and filtered, the coarse filtrate was used as original fermented mash (OFM). In the whole process of turbid rice wine preparation, no food additives were allowed to be added, so as to investigate the effects of different rice cultivars on the quality of turbid rice wine. Triplicate fermentations for each rice cultivar were carried out.

### 2.4. Making turbid rice wines by diluting OFM

Turbid rice wine was made by diluting OFM to the alcohol concentration of 6 mL/100 mL with cold boiled water. OFM and turbid rice wine were stored at −20 °C for further uses.

### 2.5. Assessment on chemical properties of OFM

To compare the fermentation characteristics of different rice cultivars under the same conditions, OFM instead of turbid rice wine was used for the assessment. The methods for assaying the general chemical properties of OFM such as pH, soluble solids, total acidity, amino acidity and reducing sugar were those recommended by *Analysis Regulation for Alcoholic Beverages* (National Tax