ePDH online.com

Credit: 1 PDH

Course Title:

Concept of Nuruk on Brewing Technology

Approved for Credit in All 50 States

Visit epdhonline.com for state specific information including Ohio's required timing feature.

3 Easy Steps to Complete the Course:

1. Read the Course PDF
2. Purchase the Course Online & Take the Final Exam
3. Print Your Certificate

Chapter 6

Concept of *Nuruk* on Brewing Technology

Jang-Eun Lee and Jae-Ho Kim

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/intechopen.69380

Abstract

Nuruk is a traditional Korean fermentation starter that is used to produce starch-based alcoholic beverages using various cereals as raw material. As a determinant factor for flavor, taste, and color of alcoholic beverages, *Nuruk* is an indispensable ingredient for brewing alcoholic beverages in Korea. *Nuruk* shows significant variation in the shape, and in the brewing and fermentation methods, which are dependent on the unique climate in each area. Therefore, it is worthy to note that the characteristics of Korean traditional *Nuruk* are based on its diversity. Thus, this chapter is aimed to scientifically identify the characteristics of traditional *Nuruk* on brewing technology. In this chapter, the concept of *Nuruk* will be discussed in terms of its history, production, microorganism diversity, and enzymatic function.

Keywords: fungi, microorganisms, *Nuruk*, saccharification power, yeast

1. Introduction

Nuruk, a fermentation starter used for brewing alcoholic beverages from grains, is a dough made from grains, such as wheat, barley, or rice that are germinated by enzyme-releasing microorganisms. In Asian countries, starch is the main ingredient for alcohol fermentation, which is first hydrolyzed to glucose through the saccharification process by fungi. *Nuruk*, also called "Gokja" in Korea, contains naturally occurring and multiplying microorganisms such as wild fungi, yeast, and lactic acid bacteria. Traditionally, *Nuruk* has been made from several grains such as wheat, barley, rice, and millet etc., and grains are used as the main raw material for *Nuruk* and alcohol beverages processing.

In Korea, *Nuruk* shows significant variation in the shape, and in the brewing and fermentation methods, which are dependent on the unique climate in each area. It has been shown that *Nuruk* production can be adapted to suit the geographical area and climate. With the

development of molded *Nuruk* in China and the dispersed *Koji* in Japan, Korean traditional *Nuruk* has been developed with a wide variety of materials and shapes. For its development, the humidity and the amount of sunshine strongly influences the width and thickness of *Nuruk* originating from different areas in Korea from the wide and thin *Nuruk* in the mountainous areas, to the thick and small *Nuruk* in the flat areas. In addition, the main raw materials used to produce *Nuruk* vary widely according to the production area. Therefore, it is worthy to note that the characteristics of Korean traditional *Nuruk* depend on the geographical and climatic diversities of their production area. However, the use of traditional *Nuruk*, in a variety of traditional brewing method is dwindling due to the recent increase in the use of industrial commercial fermentation starter [1]. In Korea, research on traditional *Nuruk* was started in the early 1900s by the Japanese, but had not actively progressed until recently. Currently, research on the production of certain traditional *Nuruk* [2–4], *Nuruk*-derived microorganisms [5–9], traditional *Nuruk*-derived Korean alcoholic beverages [10–13], and their physiological functions [14–17] are being performed. In addition, investigation on the *Nuruk* microbial communities [18–20] as well as the metabolite analysis of *Nuruk* [20] was recently performed.

In this chapter, the use of *Nuruk* in brewing technology will be discussed in terms of its history, production, microorganism diversity, and enzyme function.

2. History of *Nuruk*

Nuruk was first made in Asia in the fifth century BC. It is believed that *Nuruk* was first used in Korea before the "three kingdoms period," and records show *Nuruk* being used for Korean alcohol production in the 1123 CE book *Goryeo Dogyeong* (Chi.: *Gaolitujing*) by Xu Jing. *Hallimbyeolgok* from the Goryeo period mentions an alcohol brewed with a special type of *Nuruk*, indicating the existence of several types of *Nuruk* in Korea at that time. *Gyugonsiuibang* (1670), a classic text about food in the mid-Joseon period, records the names and detailed manufacturing methods for different types of *Nuruk*, highlighting that a diverse range of traditional *Nuruk*s were manufactured during that period. In classic texts, *Nuruk* was called Guk, and after 1918, it was called Gokja; however, currently the term "*Nuruk*" is more common than Gokja.

During the reign of the Joseon dynasty, *Nuruk* was classified into two categories: the *ddeok-Nuruk* was made of a lump of grain powder and the *Heuchim-Nuruk* was made of cereal grains. The appearances of *ddeok*-and *Heuchim-Nuruk* are presented in **Figure 1**. The *ddeok-Nuruk* contained a variety of microorganisms such as fungi, lactic acid bacteria, and yeasts deep inside the lump, which imparted rich and complex flavor to alcohol. In contrast, fungi germinating only on the surface of the *heuchim-Nuruk*, provided simple and light tastes.

The dry climate of China favored the development of the shaped *Nuruk* from wheat, whereas the humidity of the Japanese climate promoted the development of dispersed *Nuruk* from rice. Meanwhile, Korea developed both the types of *Nuruk*. Thus, *Nuruk*s differ in particle shape, manufacturing methods, and fermentation time, depending on the unique climate and environment of the manufacturing country, thereby exemplifying the adaptation ability of

Nuruk to climatic and geographical conditions. In contrast to the shaped and dispersed *Nuruk* developed by China and Japan, respectively, Korea developed *Nuruk*s with diverse ingredients and appearances. For example, *Nuruk* grain particles of mountainous regions tend to be broad and flat, whereas *Nuruk* particles of the plains are thick and small, and those in the Jeju region are small and flat. These regional differences occur due to variations in the content of the main ingredients and the environment, such as the levels of humidity and sunlight. Several kinds of representative traditional Korean *Nuruk* are displayed in **Figure 2**. As shown in **Figure 2**, this diversity is the characteristic of the traditional Korean *Nuruk*, which has been promoted by the development of a unique and varied traditional home brewing culture.

Figure 1. Dispersed *heuchim-Nuruk* (A) and shaped *ddeok-Nuruk* (B and C).

Figure 2. Appearance of various traditional Korean *Nuruk* [21].

3. *Nuruk* production

To ferment *Nuruk*, fungi or bacteria are germinated on a culture medium which is made of starchy grains such as rice, wheat, and barley. Wheat and barley are the most popular materials for *Nuruk* fermentation as they impart quality taste and flavor to *Nuruk*.

The *Nuruk* manufacture method is summarized in **Figure 3**. Traditionally, ground wheat is mixed with water, put in a mold, and pressed into the desired shape (**Figure 4**). Whole grains are thoroughly ground and finely sifted, mixed with other supplemental materials, and pressed into a frame to shape *Nuruk*. The shaped *Nuruk* is germinated with microorganisms for 2–3 days buried under supplementary materials such as straw or wormwood at a temperature of 30–35°C. The growth of yellowish fungi in the center of the pressed mass indicates that the *Nuruk* should be dried under the sun, thoroughly crushed, and finely sifted. Favorable temperature and humidity are critical to the culture of fungi on *Nuruk. Nuruk* can be globe-shaped, flat round disk-shaped, or rectangular with a hole in the center. *Nuruk* must be made in just the right size and thickness. Small and thin *Nuruk* loses moisture easily, which causes incomplete germination of fungi and defective fermentation, resulting in undesirable flavor, and low alcohol yield. In contrast, a thick *Nuruk* limits moisture loss and increases the temperature inside the fermentation jar. A well-cultured *Nuruk* is critical for the clear color and fresh flavor of fermented grain.

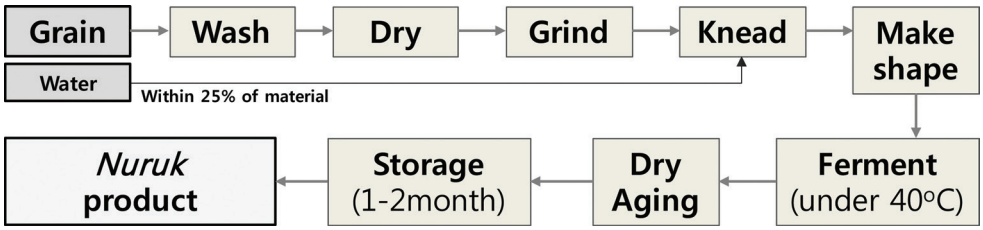

Figure 3. *Nuruk* production.

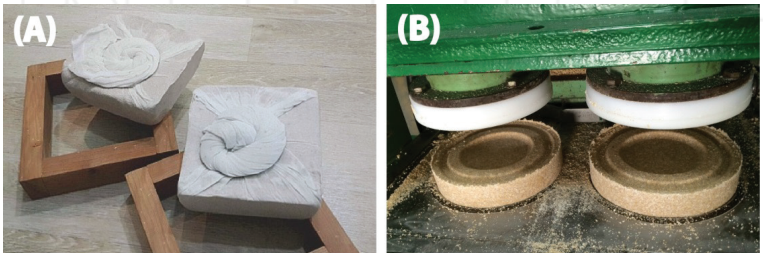

Figure 4. *Nuruk* is put in a mold and pressed into the desired shape. (A) traditional molding method, (B) mechanization for mass produce Nuruks.

http://dx.doi.org/10.5772/intechopen.69380

4. Microorganisms in *Nuruk*

Various types of microbes exist in *Nuruk* because of the coexistence of raw material (raw starch)-derived microorganisms and environment-derived microorganisms that were acquired during the fermentation. Since *Nuruk* mainly consists of starch, microorganisms that are capable of degrading beta-starch are predominant in *Nuruk*. Specifically, various types of yeast, lactic acid bacteria, and aerobic bacteria that cause alcoholic fermentation are present in *Nuruk*. Some kinds of *Nuruk* derived microorganisms that were found by Kim et al. [14] are shown in **Figure 5**.

In general, the fungus that grows in yeast has high starch decomposition activity, and thus hydrolysis of starch during alcoholic fermentation produces fermentable saccharides. In addition, fungi also produce alcohol from fermentable sugars. Lactic acid bacteria are involved in maintaining the acidity of the fermentation environment, which enables progression of alcoholic fermentation by acid-producing fungi. Mold, a group of mesophilic fungi that grows well at 25–30°C and in weakly acidic conditions, plays an important role in brewing because it secretes glycosylation enzymes required for hydrolyzing starch into fermentable saccharides. Therefore, fermentative molds in low pH environment exhibit high liquefaction and glycation

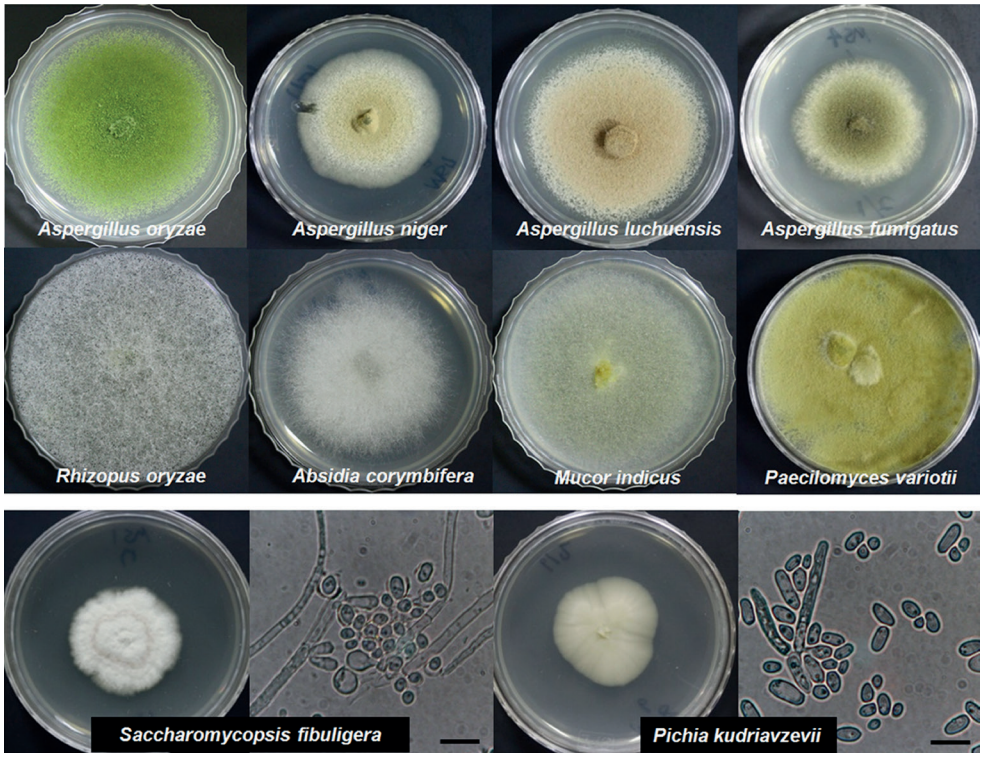

Figure 5. The filamentous fungi and yeasts isolated from various *Nuruk* samples (scale bar = 5 μm) [14].

abilities. The most common molds found in *Nuruk* are *Absidia* sp, *Aspergillus oryzae, Rhizopus* sp., *Penicillium* sp., and *Muco* sp., which secrete various amylases such as α-amylase and glucoamylase that act on stored starch of cereals. The molds most frequently isolated from *Nuruk* are *R. oryzae* and *A. oryzae*. In Asia, these two strains are important fungi in the food industry because they are used in the manufacture of traditional fermented foods. *R. oryzae* is a pathogenic fungus that causes zygomycosis [22] and, is a pioneer saprotroph that initially infects dead plants and rapidly penetrates inside degradable substrates. Recent genomic studies showed that *R. oryzae* does not contain the genes necessary for exo-cellulose degradation and is an auxotroph for degradation of pectin, xyloglucan, xylan, and inulin. Thus, the ability to degrade simple polysaccharides, such as monosaccharides and starches, underscores the dominance of *R. oryzae* over other fungi [23].

Among yeasts, *R. oryzae* acts as a primary colonizer in the early stages of fermentation and participates in the decomposition of yeast constituents. However, as the internal temperature of the mold increases with progression of fermentation, the temperature-sensitive *R. oryzae* gradually falls out of competition with the high temperature-resistant fungi such as *A. oryzae* [24]. *A. oryzae* possesses high glycation ability and secretes α-amylase [25], and is therefore important for glycosylation and liquefaction [8, 24]. However, it is difficult to distinguish *A. oryzae* from aflatoxin-producing *A. flavus* using conventional taxonomic criteria because of its close relationship with *A. flavus*; thus, *A. oryzae* should be tested for its ability to produce aflatoxin [26, 27]. The members of the aflatoxin biosynthetic pathway are encoded by a cluster of 25 genes [28], the expression levels of which are primarily regulated by aflR, a transcriptional activator [29]. Therefore, polymorphism, deletion, and the presence of aflR binding sites have been used as important indicators to determine aflatoxin biosynthesis [26]. Particularly, the aflR binding sites of *norB* and *cypA* are critical for the expression of the entire aflatoxin biosynthesis-associated gene group. In general, *A. oryzae* and *A. flavus* are divided into type I deletion (0.3 kb) and type II deletion (0.8 kb) groups based on the partial deletion pattern of *norB-cypA* (1.8 kb), and it was found that the type I deletion group does not produce aflatoxin [27, 30, 31].

5. Enzymatic activity of *Nuruk*

There are a variety of microorganisms in fermented *Nuruk* and enzymes secreted by these microorganisms differ depending on the type of wild microorganism. Enzymatic activity of *Nuruk* can mainly be estimated by the index of saccharification power (sp). This saccharification power represents the index of how much soluble starch can be enzymatically converted to simpler sugars by diastatic enzymes in *Nuruk*. Previous studies on the enzymatic activity of early *Nuruk* showed that the saccharification power (sp) of Korean *Nuruk* was 1.39, which was slightly lower than the saccharification power of malt (1.5 sp), and significantly lower than that of Chinese *Nuruk* (11.1 sp) [32]. According to previous study [33], it has been reported that the saccharification power of *Backguk* produced by *Aspergillus kawachii and Hwangguk* produced by *Asp. oryzae* were being used in all areas of Korea in the mid-1900s. The saccharification power values were the highest in *Bungok* (791 sp), followed by *Gokja* (421 sp), *Hwangguk* (226 sp), and *Backguk* (195 sp).

No.	*Nuruk*	Saccharification power	Enzyme activity[a]				
			α-Amylase (U/g *Nuruk*)	β-Amylase (U/g *Nuruk*)	Protease (μg/ml trypsin)	β-Glucanase (U/g *Nuruk*)	Glucoamylase (U/g *Nuruk*)
1	JuKokBangMun	325.43 ± 50.97	1.58 ± 0.36	2.82 ± 0.17	1.53 ± 0.09	0.048 ± 0.008	0.16 ± 0.10
2	ChuMoGok	194.82 ± 0.10	17.42 ± 1.10	1.44 ± 0.76	1.57 ± 0.07	0.191 ± 0.020	0.17 ± 0.06
3	OMeKiGok	151.44 ± 16.11	17.84 ± 0.86	0.72 ± 0.13	9.90 ± 7.28	0.348 ± 0.022	0.48 ± 0.29
4	JukGok-1	319.34 ± 76.83	10.75±1.81	3.13±0.25	1.77±0.41	0.042±0.001	0.75±0.58
5	JukGok-2	265.93 ± 18.50	6.72 ± 1.02	3.35 ± 0.52	1.61 ± 0.10	0.041 ± 0.004	0.43 ± 0.57
6	KongByungGok	318.83 ± 17.74	39.07 ± 6.70	4.58 ± 0.36	1.42 ± 0.87	0.108 ± 0.014	1.05 ± 0.09
7	Gok-1	346.75 ± 14.76	1.47 ± 0.43	3.83 ± 0.24	1.48 ± 0.36	0.046 ± 0.016	0.05 ± 0.02
8	MyunGok-1	292.22 ± 12.14	8.76 ± 1.77	4.37 ± 0.11	1.75 ± 0.22	0.057 ± 0.008	0.27 ± 0.06
9	SinGok-1	137.46 ± 10.23	6.0251.29	1.01 ± 0.31	2.31 ± 0.61	0.187 ± 0.017	0.16 ± 0.05
10	JinjuchunchuGok	163.53 ± 0.09	16.61 ± 2.85	0.18 ± 0.02	1.76 ± 0.31	0.091 ± 0.007	0.31 ± 0.06
11	YeoGok-1	85.53 ± 6.12	9.45 ± 6.73	0.05 ± 0.01	1.51 ± 0.25	0.082 ± 0.011	0.15 ± 0.03
12	SeolhangGok	211.52 ±1 8.21	2.73 ± 1.82	1.83 ± 0.30	1.63 ± 0.07	0.049 ± 0.007	0.04 ± 0.00
13	YeonHwaGok-1	112.67 ± 18.18	2.44 ± 0.57	0.05 ± 0.02	1.43 ± 0.13	0.161 ± 0.052	0.29 ± 0.08
14	BackGok-1	150.76 ± 11.76	11.47 ± 4.56	1.31 ± 0.07	1.59 ± 0.05	0.047 ± 0.008	0.04 ± 0.04
15	BackGok-1	164.61 ± 4.65	46.09 ± 10.57	1.56 ± 0.20	2.08 ± 0.09	0.047 ± 0.010	0.13 ± 0.01
16	YeoGok-2	370.09 ± 6.05	0.96 ± 0.05	2.74 ± 0.13	1.63 ± 0.08	0.043 ± 0.003	0.03 ± 0.01
17	BunGok	565.54 ± 22.67	65.53 ± 2.42	3.80 ± 0.34	1.82 ± 0.13	0.121 ± 0.043	0.50 ± 0.03
18	ByungGok	395.20 ± 47.49	53.20 ± 7.42	4.58 ± 0.19	1.61 ± 0.26	0.070 ± 0.013	0.37 ± 0.12
19	IWhaJuGok	241.07 ± 12.05	29.61 ± 3.60	0.09 ± 0.02	1.69 ± 0.30	0.334 ± 0.023	0.45 ± 0.06
20	IWhaGok	351.28 ± 10.74	19.90 ± 2.50	0.08 ± 0.00	2.09 ± 0.31	0.255 ± 0.014	0.46 ± 0.02
21	JoGokBeok	283.77 ± 17.23	2.33 ± 1.41	4.31 ± 0.02	1.61 ± 0.08	0.043 ± 0.010	0.10 ± 0.02

http://dx.doi.org/10.5772/intechopen.69380

No.	*Nuruk*	Saccharification power	Enzyme activity[a]				
			α-Amylase (U/g *Nuruk*)	β-Amylase (U/g *Nuruk*)	Protease (μg/ml trypsin)	β-Glucanase (U/g *Nuruk*)	Glucoamylase (U/g *Nuruk*)
22	HyangOnGok-1	353.82 ± 35.81	0.69 ± 0.03	2.05 ± 0.19	1.58 ± 0.09	0.041 ± 0.009	0.04 ± 0.03
23	HyangOnGok-2	408.60 ± 42.88	0.78 ± 0.07	3.44 ± 0.56	1.62 ± 0.02	0.036 ± 0.004	0.03 ± 0.02
24	BakSuHwanDongJuGok	512.81 ± 6.26	28.09 ± 0.80	0.38 ± 0.07	2.64 ± 0.26	0.070 ± 0.011	1.07 ± 0.07
25	Nebubijeongok	565.20 ± 3.54	33.20 ± 2.24	4.11 ± 0.16	1.76 ± 0.29	0.050 ± 0.011	0.24 ± 0.03
26	NokMiJuGok	217.74 ± 24.29	21.17 ± 4.13	0.40 ± 0.05	3.33 ± 0.90	0.083 ± 0.032	1.09 ± 0.07
27	NokDuGok	210.59 ± 7.15	2.27 ± 1.01	0.10±0.01	1.78 ± 0.12	0.032 ± 0.003	0.17 ± 0.02
28	Gok-2	334.91 ± 21.23	16.42 ± 8.45	4.17 ± 0.26	2.75 ± 0.97	0.043 ± 0.005	0.34 ± 0.30
29	MiGok-1	547.90 ± 18.10	22.18 ± 6.78	4.77 ± 0.36	2.11 ± 0.33	0.041 ± 0.004	0.21 ± 0.07
30	MyunGok-2	265.45 ± 46.99	4.54 ± 0.73	3.78 ± 0.92	1.98 ± 0.20	0.053 ± 0.006	0.18 ± 0.04
31	Gok-3	190.28 ± 7.11	2.32 ± 2.10	4.27 ± 0.15	1.62 ± 0.12	0.042 ± 0.012	0.10 ± 0.07
32	YoGok	143.42 ± 10.75	1.33 ± 0.26	0.07 ± 0.02	1.59 ± 0.12	0.173 ± 0.085	0.04 ± 0.05
33	DaeJuBackTaGok	189.51 ± 0.59	3.62 ± 1.06	2.38 ± 0.07	1.66 ± 0.20	0.077 ± 0.008	0.14 ± 0.07
34	BackRyoGok	244.06 ± 2.56	4.23 ± 0.65	1.12 ± 0.07	1.70 ± 0.15	0.083 ± 0.021	0.07 ± 0.01
35	YangNeungGok	183.92 ± 35.08	0.71 ± 0.09	1.71 ± 0.07	1.64 ± 0.03	0.037 ± 0.004	0.01 ± 0.01
36	BackJuGok-1	214.55 ± 57.45	1.10 ± 0.07	0.04 ± 0.02	1.71 ± 0.27	0.282 ± 0.013	0.04 ± 0.01
37	BackJuGok-2	222.16 ± 20.73	2.69 ± 0.38	0.05 ± 0.02	1.43 ±0.15	0.046 ± 0.005	0.27 ± 0.05
38	ManJeonHangJuGok	267.99 ± 22.97	0.74 ± 0.03	2.84±0.19	1.65±0.04	0.037±0.003	0.02±0.02
39	JeongHwaGok	324.33 ± 5.46	43.41 ± 8.91	4.64 ± 0.62	2.16 ± 0.94	0.055 ± 0.003	0.47 ± 0.02
40	YeonHwaGok-2	516.06 ± 5.50	63.37 ± 5.13	0.68 ± 0.01	2.12 ± 0.15	0.046 ± 0.003	0.30 ± 0.02
41	DongYangJuGok	207.22 ± 87.05	23.14 ± 3.29	5.28 ± 0.36	2.11 ± 0.22	0.092 ± 0.006	0.21 ± 0.07
42	MiGok-2	101.99 ± 12.02	1.03 ± 0.12	0.05 ± 0.02	1.72 ± 0.06	0.043 ± 0.007	0.03 ± 0.01

No.	*Nuruk*	Saccharification power	Enzyme activity[a]				
			α-Amylase (U/g *Nuruk*)	β-Amylase (U/g *Nuruk*)	Protease (μg/ml trypsin)	β-Glucanase (U/g *Nuruk*)	Glucoamylase (U/g *Nuruk*)
43	ShinGok-1	356.61 ± 7.28	2.52 ± 0.63	0.30 ± 0.02	1.69 ± 0.33	0.038 ± 0.005	1.94 ± 0.17
44	ShinGok-2	340.37 ± 36.95	29.52 ± 4.28	4.14 ± 0.70	1.86 ± 0.20	0.174 ± 0.011	0.56 ± 0.12
45	ShinGok-3	215.02 ± 26.57	12.69 ± 0.80	1.79 ± 0.13	1.78 ± 0.22	0.050 ± 0.003	0.48 ± 0.09
46	HaDongShinGok	268.30 ± 8.59	4.29 ± 0.17	1.00 ± 0.06	1.88 ± 0.26	0.163 ± 0.013	0.07 ± 0.01
47	Commercial-1	423.59 ± 8.64	26.02 ± 5.22	4.23 ± 0.26	2.79 ± 1.58	0.150 ± 0.005	0.42 ± 0.08
48	Commercial-2	460.12 ± 18.81	30.33 ± 8.43	5.01 ± 0.47	5.04 ± 1.52	0.186 ± 0.025	0.53 ± 0.06
49	Commercial-3	356.56 ± 40.15	38.23 ± 17.56	5.18 ± 0.52	3.23 ± 2.60	0.133 ± 0.025	0.58 ± 0.33
50	Commercial-4	220.99 ± 23.81	21.98 ± 6.05	3.10 ± 0.20	1.70 ± 0.08	0.116 ± 0.012	0.75 ± 0.12
51	Commercial-5	418.80 ± 15.53	3.54 ± 0.65	0.90 ± 0.79	1.74 ± 0.11	0.047 ± 0.006	0.16 ± 0.06
52	Commercial-6	346.28 ± 57.71	3.46 ± 1.40	0.11 ± 0.03	1.72 ± 0.14	0.042 ± 0.006	0.13 ± 0.06
53	Commercial-7	229.63 ± 14.59	8.01 ± 1.27	1.98 ± 0.06	1.72 ± 0.09	0.083 ± 0.002	0.27 ± 0.02
54	Self-produced-1	255.12 ± 24.15	8.77 ± 3.51	1.45 ± 0.32	1.88±0.73	0.212±0.125	0.35±0.18
55	Self-produced-2	268.78 ± 37.49	12.00 ± 3.67	3.48 ± 0.30	1.78 ± 0.09	0.039 ± 0.006	0.52 ± 0.17
56	Self-produced-3	250.13 ± 26.04	3.87 ± 0.24	1.15 ± 0.14	1.74 ± 0.03	0.155 ± 0.003	0.15 ± 0.01
57	Self-produced-4	402.10 ± 38.38	55.49 ± 27.03	2.97 ± 0.16	10.32 ± 0.36	0.239 ± 0.045	1.52 ± 0.20
58	Self-produced-5	175.49 ± 16.92	6.61 ± 0.26	2.44 ± 0.16	1.69 ± 0.46	0.175 ± 0.031	0.25 ± 0.10

[a] Means ± SD (n = 3).

Table 1. Saccharification power and enzyme activities of Korean traditional *Nuruk* [21].

http://dx.doi.org/10.5772/intechopen.69380

In Lee et al.'s study [21], 58 different kinds of traditional *Nuruk* were prepared, including 46 types of restored *Nuruk* mentioned in ancient documents. The saccharification power and glucoamylase, α-amylase, β-amylase, protease, and β-glucanase activities of each *Nuruk*s were reported. Among the 46 different kinds of restored and 12 types of collected *Nuruk*, the saccharification power values were the highest in *Bungok* (791 sp), followed by *Gokja* (421 sp), *Hwangguk* (226 sp), and *Backguk* (195 sp). The saccharification power of 12 kinds of commercial and self-produced *Nuruk* and their measured enzymeatic activities have been reported through Lee's study [21] that can be shown in **Table 1**. The range of saccharification power of the restored *Nuruk* was 85–565 sp. *Nuruk* with the highest saccharification power was shown in *Bungok* (565.5 sp), *Naebubijeon* (565.2 sp), and *Migok* (547.9 sp). This indicate that some restored *Nuruk* has a significantly higher saccharification power value than *Jinjugokja* (Keumkang wheat, 460.1 sp), which is a commercial *Nuruk*, and *ShinDaRi Nuruk* (477.2 sp), which is a self-produced *Nuruk*. The higher α-amylase activities of restored *Nuruk* were recorded in *Bungok* (65.53 U/g) and *Byunggok* (53.2 U/g), which was higher than *JinjuGokja* (26–38 U/g) showing a high activity among collected *Nuruk. Bungok* had higher α-amylase activity than self-manufactured *Nuruk, Igasubul* (55.49 U/g). Also, the β-amylase activity was the highest in *Jinjugokja* which is commercially available, and protease activity was highest in the self-manufactured *Igasubul* (10.32 μg/mL), followed by restored *Omegigok* (9.9 μg/mL). The α-amylase and β-amylase activities correlated significantly with the saccharification power value ($p < 0.001$). The correlation between the glucoamylase activity and saccharification power was also confirmed ($p < 0.05$). On the other hand, the activities of β-glucanase and protease in traditional *Nuruk* were not correlated with saccharification power value.

Author details

Jang-Eun Lee* and Jae-Ho Kim

*Address all correspondence to: jelee@kfri.re.kr

Traditional Alcoholic Beverages Research Team, Korea Food Research Institute, Gyeonggi-do, Republic of Korea

References

[1] Yu TS, et al. Bibliographical study on microorganisms of Nuruk (until 1945). Journal of the Korean Society of Food and Nutrition. 1996;**25**(1):170-179

[2] Back SY, et al. Assessment of the quality characteristics of mixed-grain Nuruk made with different fungal strains. The East Asian Society of Dietary Life. 2012;**22**(1):103-108

[3] Kim M, et al. Characteristics of Byeo-Nuruk according to the mixing ratio of wheat and the addition rate of moisture. The East Asian Society of Dietary Life. 2011;**21**(6):897-904

[4] Lee Y, So M. Effects of culture conditions of rhizopus sp. ZB9 on the production of saccharifying amylase during the preparation of rice Koji. The Korean Journal of Food and Nutrition. 2009;**22**(4):644-649

[5] Hong Y, et al. Microflora and physicochemical characteristics of Nuruk and main mashes during fermentation of a traditional andong soju. Foods and Biotechnology. 1997;**6**(4):297-303

[6] Kim H, et al. Characteristics of useful fungi isolated from traditional Korean Nuruk. Journal of the Korean Society of Food Science and Nutrition. 1997;**26**(5):767-774

[7] Kwon S, Shon J. Analysis of microbial diversity in Nuruk using PCR-DGGE. Korean Journal of Life Science. 2012;**22**(1):110-116

[8] Song SH, et al. Analysis of microflora profile in Korean traditional Nuruk. Journal of Microbiology and Biotechnology. 2013;**23**(1):40-46

[9] Yang S, et al. Aspergillus oryzae strains isolated from traditional Korean Nuruk: Fermentation properties and influence on rice wine quality. Food Science and Biotechnology. 2013;**22**(2):425-432

[10] Lee G, et al. Quality characteristics of Takju, Yakju, spirit made by pulse crop Nuruks. The Korean Journal of Culinary Research. 2015;**21**(3):232-247

[11] Lee J, Kang S, Cheong C. Quality characteristics of distilled alcohols prepared with different fermenting agents. Journal of the Korean Society for Applied Biological Chemistry. 2015;**58**(2):275-283

[12] Park J, Jeong J. Characteristics of takju (a cloudy Korean rice wine) prepared with nuruk (a traditional Korean rice wine fermentation starter), and identification of lactic acid bacteria in Nuruk. Korean Journal of Food Science and Technology. 2014;**46**(2):153-164

[13] Takamine K, et al. Characterization of Yeast for Soju (distilled spirits) from Korean traditional Nuruk. The Korean Journal of Mycology. 2015;**43**(3):196-199

[14] Kim M, et al. Diversity, saccharification capacity, and toxigenicity analyses of fungal isolates in Nuruk. The Korean Journal of Microbiology. 2014;**42**(3):191-200

[15] Kim M, et al. In-vitro anti-thrombosis activity of R4-Nuruk made from rhizopus oryzae KSD-815. Korean Journal of Microbiology and Biotechnology. 2015;**43**(2):169-174

[16] Lee S, et al. Inhibitory effects of ethanol extracts from Nuruk on oxidative stress, melanogenesis, and photo-aging. Mycobiology. 2012;**40**(2):117-123

[17] Son J, et al. Anti-adipogenic, anti-inflammatory, and anti-proliferative activities of extracts from lees and Nuruk. Journal of Life Science. 2015;**25**(7):773-779

[18] Bal J, et al. Pyrosequencing reveals bacterial diversity in Korean traditional wheat-based Nuruk. Journal of Microbiology. 2015;**53**(12):812-819

[19] Bal J, et al. Mycoflora dynamics analysis of Korean traditional wheat-based Nuruk. Journal of Microbiology. 2014;**52**(12):1025-1029

[20] Ponnusamy K, Lee S, Lee C. Time-dependent correlation of the microbial community and the metabolomics of traditional barley Nuruk starter fermentation. Bioscience Biotechnology and Biochemistry. 2013;**77**(4):683-690

[21] Lee J, et al. Restoration of the traditional Korean Nuruk and the brewing characteristics analysis. Journal of Microbiology and Biotechnology. 2017. in press. 2017;**27**(5):896-908

[22] Ribes J, BD. Vanover-sams CL, zygomycetes in human disease. Clinical Microbiology Reviews. 2000;**13**:236-301

[23] Battaglia E, et al. Carbohydrate-active enzymes from the zygomycete fungus rhizopus oryzae: A highly specialized approach to carbohydrate degradation depicted at genome level. BMC Genomics. 2011;**12**(1):1-12

[24] Yang S et al. Fungi associated with the traditional starter cultures used for rice wine in Korea. Journal of the Korean Society for Applied Biological Chemistry. 2011;**54**:933-943

[25] Norihiro T, et al. Isolation of a cDNA encoding aspergillus oryzae taka-amylase A: Evidence for multiple related genes. Gene. 1989;**84**:319-327

[26] Chang P, Ehrich K, Hua S. Cladal relatedness among aspergillus oryzae isolates and aspergillus flavus S and L morphotype isolates. International Journal of Food Microbiology. 2006;**108**:172-177

[27] Hong S, et al. The propoortion of non-aflatoxigenic strains of the aspergillus flavus/oryzae complex from Meju by analyses of the aflatoxin biosynthetic genes. Journal of Microbiology. 2013;**51**:766-772

[28] Bhatnagar D, et al. Understanding the genetics of regulation of aflatoxin production and Aspergillus flavus development. Mycopathology. 2016;**162**:155-166

[29] Bhatnagar D, Ehrich K, Cleveland T. Molecular genetic analysis and regulation of aflatoxin biosynthesis. Applied Microbiology and Biotechnology. 2003;**61**:83-93

[30] Eun-Gyung M, et al. Aflatoxin biosynthesis cluster gene cypA is required for G aflatoxin formation. Applied and Environmental Microbiology. 2004;**70**:6518-6524

[31] Wei D, et al. Molecular characterization of atoxigenic aspergillus flavus isolates collected in China. The Journal of Microbiology. 2014;**52**:559-565

[32] Lee M, Lee S, Yoon T. The bibliographical study on Nuruk. The East Asian Society of Dietary Life. 1994;**4**:19-29

[33] Lee, SB. Studies on enzymic sources and method of effective addition in fermentation of Yack-Tack-Joo Korean liquors. The Korean Journal of Microbiology. 1967;**5**:43-54