Effects of *Lactobacillus plantarum* Inoculum on the Fermentation Rate and Rice Noodle Quality

Dong-Hui Geng, Lu Liu, Sumei Zhou, Xiaobin Sun, Lili Wang, Xianrong Zhou, and Li-Tao Tong*

Institute of Food Science and Technology, Chinese Academy of Agricultural Sciences/Key Laboratory of Agro-Products Processing, Ministry of Agriculture, Beijing, 100193, CHINA

Abstract: To accelerate the fermentation rate and reduce the adverse effects of undesirable microorganism contamination on rice noodle quality, the pure inoculum fermentation method was used to produce fermented rice noodles. The results indicated that the pure inoculum fermented rice slurry required 10 h to reach a stable pH value. While, the pH value of the natural, pure and natural inoculum fermented rice slurries required 54, 18 and 20 h to stabilize, respectively. Free amino acids and lactic acid concentrations of the pure inoculum fermented rice slurry were higher than those of the natural and natural inoculum fermented rice slurries. The pure inoculum fermentation modified the proximate composition and lowered the pasting viscosities of the rice flour. The texture, cooking and eating qualities of the pure inoculum fermented rice noodles were similar to those of the natural fermented ones. In addition, the pure inoculum fermented rice noodles had higher relative contents of aldehydes than other fermented rice noodles and thus had a better flavor. Therefore, pure inoculum fermentation accelerated the fermentation rate and improved the rice noodle flavor while maintaining the texture, cooking and eating qualities of the rice noodles.

Key words: *Lactobacillus plantarum*, inoculum, fermentation rate, rice noodle quality

1 Introduction

Rice noodles produced from *Indica* rice are widely consumed in Southeast Asian countries, and are classified into fermented and unfermented types according to production methods. Fermented rice noodles can be called different names, including *Sour Mifen* (China), *Khao Poon* (Laos), *Mohingar* (Myanmar) and *Khanom Jeen* (Thailand). Traditionally, rice grains are fermented for a few days without a starter culture and then produced into natural fermented rice noodles. Fermentation process can modify the concentrations of free amino acids and organic acids in rice slurry, and the proximate composition and pasting properties of rice flour. Free amino acids produced by lactic acid bacteria fermentation contribute to the flavor of fermented foods. The main organic acids produced during fermentation is lactic acid which lowers the pH value and inhibits the growth of harmful microorganisms. The pasting viscosities of rice flour decreased after the lactic acid bacteria fermentation. Fermented rice noodles had better texture and eating qualities than unfermented ones, and had a unique flavor. However, rice in natural fermentation process need to be soaked for 2-3 days, which increases the risk of harmful microbial contamination and reduces the quality of rice noodles.

To accelerate fermentation rate, fermentation with a starter is a good choice to produce fermented rice noodles. *Lactobacillus plantarum* is the dominant bacteria in natural fermented rice slurry and is a desirable strain for rice noodle fermentation, which can produce rice noodles with thick fermented rice fragrance. Our previous study showed that pure bacterial fermentation shortened the fermentation time from 54 h of natural fermentation to 18 h and reduced the contamination of undesirable bacteria. In addition, inocula are widely used to produce some fermented foods, such as yogurt, bread and steamed bread, and contribute to accelerate fermentation rate and improve the quality and safety of fermented products. Previous studies have reported that *Lactobacillus plantarum* inoculum can shorten fermentation time, inhibit the growth of harmful microorganisms, and increase lactic acid concentration and aminopeptidase activity values in fermented foods. However, fewer studies have focused on the effects of pure inoculum on the quality of fermented rice.
The objectives of this study were to evaluate the effects of *Lactobacillus plantarum* inoculum on the fermentation rate and rice noodle qualities. The pH value and the concentrations of free amino acids and lactic acid in the rice slurries were measured. It also measured the proximate composition and pasting properties of the rice flours. In addition, the texture, cooking and sensory qualities and volatile components of the fermented rice noodles were measured.

2 Materials and Methods

2.1 Materials

*Indica* rice was provided by the Xing da Rice Processing Factory (Yunnan, China). The amylose content of the rice was 17.15 ± 0.90%, and its moisture content was 13.06 ± 0.19% (w.b.). The raw material was stored at 4°C prior to fermentation and milling. *Lactobacillus plantarum* was a commercial mono bacterial starter with an amount of 1.0 × 10⁹ CFU/g. It was commonly used in the production of fermented foods and was provided by the Senfu Natural Products Co., Ltd. (Shanxi, China).

2.2 Milling and fermentation processing

The wet milling method was used to obtained a rice slurry using a wet grinder (YU8022, Hebei, China). The semidry milled rice flour was ground as previously described. In the natural fermentation, the rice slurry with a moisture content of 67% was fermented at 30°C without a starter. The fermentation conditions were similar to the traditional natural fermentation method, in which the tap water with twice the dry weight of rice was added to the raw material, and the slurry was fermented at ambient temperature (about 30°C on average). The pure fermentation conditions were based on previously described with some modifications. A starter of *Lactobacillus plantarum* (bacteria substrate ratio of 10⁶ CFU/g) was added to the rice slurry with a moisture content of 55%, and then was fermented at 37°C. *Lactobacillus plantarum* could grow and reproduce rapidly at the optimal growth temperature of 37°C. After fermentation, the rice slurry with a moisture content of 55% could be directly used to produce rice noodles. In the natural inoculum fermentation, an amount of the natural fermentation completed rice slurry was added to the unfermented rice slurry (67% moisture content), and the mixture was fermented at 30°C. In the pure inoculum fermentation, an amount of the pure fermentation completed rice slurry was added to the unfermented rice slurry (55% moisture content), and the mixture was fermented at 37°C. When the natural and natural inoculum fermentations completed, the rice grains were washed with plenty of deionized water, and then ground using a wet grinder at 55% moisture content. These samples were freeze-dried to obtain the rice flours, and then stored at 4°C.

2.3 Determination of the pH value

The pH value of the rice slurries (55% moisture content) during the fermentation process were determined using a pH meter (pH 400, Shanghai, China).

2.4 Free amino acids analysis

Free amino acids were determined using an Amino Acid Analyzer (Hitachi L-8900, Hitachi Inc., Tokyo, Japan). The extraction and chromatographic conditions were based on previously described with some modifications. The extraction solvent was 0.02 mol/L HCl. The extraction was performed three times and each extract was sonicated for 15 min, and then deproteinized with an equal volume of 3% sulfosalicylic acid solution. The final volume of the extracted sample was 50 mL. The sample was filtered through 0.45 μm syringe filter prior to determination and derivatization. Analytical column (4.6 mm × 60 mm) was used for free amino acid determination. After injection into the column, it was immediately derivatized by post-column derivatization with ninhydrin using an autosampler. Ninhydrin-derivatized amino acids were monitored at 570 and 440 nm. The standards of each amino acid (Hitachi Co.) were used for identification and quantification (external standard method). Individual free amino acid concentrations of the rice slurries are reported in μg/100 g.

2.5 Lactic acid analysis

Lactic acid concentration was measured as previously described with some modifications. A high-performance liquid chromatograph (HPLC) system equipped with a UV detector set at 210 nm was used to analyze lactic acid. A Cacpep PAK MG C18 column 4.6 mm × 250 mm, 5 μm particle size, was used at an operating temperature of 40°C. The concentration of lactic acid in the rice slurries is expressed as mg/g.

2.6 Proximate composition

The contents of total starch, damaged starch and amylose were determined using assay kits (Megazyme International Ltd., Wicklow, Ireland). The content of total nitrogen was determined by the Kjeldahl method using a Kjeltec analyzer (Foss Tecator AB, Hagonas, Sweden) with a conversion factor of 5.95 to estimate protein content. The content of lipid was determined using an analytical method provided by the Association of Official Agricultural Chemistry (AOAC, 945.16).

2.7 Pasting properties

The pasting properties of the rice flours were determined using a Rapid Visco Analyzer (RVA-Tecmaster,
Accelerating Fermentation Rate

J. Oleo Sci.

Perten Instruments, NSW, Australia). The RVA parameters were based on previously described with some modifications\(^2\). 3.0 g of rice flour (14% moisture basis) and deionized water were added to an RVA canister to attain a total sample weight of 28.0 g. The suspension was kept at 50°C for 1 min, heated to 95°C at 12.2°C/min and kept at 95°C for 2.5 min. It was then cooled to 50°C at 11.8°C/min and kept at 50°C for 2 min.

2.8 Preparation of rice noodles

The fermented rice noodles were prepared using a rice noodle machine (MOB 50 × 150, Hebei, China) as previously described\(^3\). Briefly, the fermented rice slurry was steamed for 15 min. The steamed rice sheet was extruded into rice noodles with a 2-mm diameter. The rice noodles were cooked in boiling water for 2 min and then cooled to room temperature with deionized water. After the water on the rice noodle surface was drained, the noodles were stored at 4°C until further analysis.

2.9 Texture profile analysis (TPA) and cooking qualities

The texture profile of the fermented rice noodles was determined using a Texture Analyzer (TA-XT 2i/5, Stable Micro System Ltd., Godalming, England) as previously described\(^3\). The rice noodles were tested using an HDP/LKB probe (light knife blade). The cooking properties of rice noodles were determined as previously described\(^3\).

2.10 Sensory evaluation

The sensory qualities of the fermented rice noodles were measured as previously described with some modifications\(^3\). The fermented rice noodles were served to 10 trained panelists within 10 min after cooking. They evaluated the shininess, flavor, tissue morphology and taste of the randomly coded rice noodle samples, and supplied sensory scores. The range of scores was: shininess, 1 (uneven color) to 15 (natural color); flavor, 1 (impure flavor) to 10 (fermented flavor); tissue morphology, 1 (rough surface) to 15 (smooth surface); and taste (1 to 60) which included hardness, 1 (too hard or too soft) to 15 (moderate hardness); viscosity, 1 (sticky tooth) to 20 (smooth); elasticity, 1 (poor elasticity) to 20 (moderate elasticity) and smoothness, 1 (crude) to 5 (smooth).

2.11 SPME/GC-MS measurement

The volatile components of the fermented rice noodles were measured using a 7890B/7000C GC/MS system. This experiment included volatile components extraction and determination, and the conditions were according to previous description with some modifications\(^3\). Volatile components were extracted using the SPME method. 5.0 g of the fresh fermented rice noodles was placed in a 20 mL headspace bottle, sealed at 60°C for 15 min and extracted for 40 min using a DVB/CAR/PDMS three-layer composite extraction head. The extraction head was connected to a GC inlet and desorbed at 250°C for 5 min. The GC conditions were as follows: an HP-5MS column (30 m × 0.25 mm, 0.25 μm), helium carrier gas, 1 mL/min column flow rate. The inlet temperature was held at 250°C. The initial column temperature was held at 40°C for 3 min, rose to 150°C at 4°C/min, and then rose to 250°C at 10°C/min and held at 250°C for 10 min. The MS conditions were as follows: EI ion source, electron energy at 70 eV, mass range of 35-350 AMU/s, GC-MS interface temperature at 250°C, ion source temperature at 230°C and quadrupole temperature at 150°C. The volatile compounds were calculated by normalization to explain their percentages of various fermented rice noodles.

2.12 Electronic nose measurement

The volatile profiles of the fermented rice noodles were determined using a PEN3.5 electronic nose (e-nose, AIRSENSE company, Germany) containing 10 metal-oxide semiconductors (W1C, W58, W3C, W6S, W5C, W1S, W1W, W2S, W2W, W3S). The e-nose analysis was according to previous description with some modifications\(^4\). 1.0 g of the fresh fermented rice noodle sample was placed in a 20 mL headspace tube, sealed at 4°C for 1 h, equilibrated at 25°C for 30 min, and then tested using the e-nose. The e-nose parameters were set to sample preparation for 5 s, sampling interval for 1 s, sensor automatic cleaning for 180 s, sensor return to zero for 5 s, injection flow rate at 600 mL/min, tested for 60 s.

2.13 Statistical analysis

The data were expressed as the mean ± standard deviation (SD) and analyzed by SPSS 13.0 for Windows (SPSS Inc., Chicago, USA) using Tukey Kramer’s multiple comparison post hoc tests. Variations were considered significant at p < 0.05.

3 Results

3.1 The pH value

The pH value of the fermented rice slurries tended to stabilize at 3.8 (Fig. 1). The natural and pure fermented rice slurries required 54 and 18 h to reach this level, respectively (Fig. 1A, B). In addition, the inoculum fermentations shortened the fermentation time (Fig. 1C, D). The fermentation rates of the 10% inoculum fermentations were faster than those of the 5% inoculum fermentations and were slightly slower than those of the 15% inoculum fermentations. In this study, the 10% inoculum fermentation methods were used to produce the inoculum fermented rice noodles. The pH value of the natural inoculum and pure inoculum fermented rice slurries required 20 and 10 h.

J. Oleo Sci.
3.2 Free amino acids
The compositions and concentrations of free amino acids in the rice slurries are shown in Fig. 2. After fermentation, the concentrations of Ser, Glu, Leu, Tyr, Phe and Arg in the natural and natural inoculum fermented rice slurries increased, and the concentrations of all free amino acids in the pure and pure inoculum fermented rice slurries increased except for Pro. The concentrations of Asp, Glu, Leu, Tyr, Phe, Lys and Arg in the natural inoculum fermented rice slurry were higher than those in the natural fermented rice slurry. The concentrations of free amino acids in the pure inoculum fermented rice slurry were similar to those in the pure fermented rice slurry, and were higher than those in the natural and natural inoculum fermented rice slurries.

3.3 Lactic acid
The lactic acid concentration of the fermented rice slurries was significantly higher than that of the unfermented rice slurries ($p<0.05$) (Fig. 3A). The lactic acid concentration of the natural inoculum fermented rice slurry increased by 98% compared to the natural fermented rice slurry, and that of the pure inoculum fermented rice slurry increased by 20% compared to the pure fermented rice slurry. In addition, the lactic acid concentration of the pure inoculum fermented rice slurry was 7.30-fold and 3.68-fold that of the natural and natural inoculum fermented rice slurries, respectively.
3.4 Proximate composition

The total starch content of the fermented rice flours increased when compared to the unfermented rice flours (Fig. 3B). The damaged starch content of the natural and natural inoculum fermented rice flours was lower than that of the wet milled rice flour (Fig. 3C). After fermentation, the amylose content of the pure and pure inoculum fermented rice flours decreased, while that of the natural and natural inoculum fermented rice flours slightly increased (Fig. 3D). The protein content of the pure and pure inoculum fermented rice flours was higher than that of the natural and natural inoculum fermented rice flours (Fig. 3E). The lipid content of the rice flours after fermentation decreased significantly ($p<0.05$) (Fig. 3F). In addition, the lipid content of the pure and pure inoculum fermented rice flours was lower than that of the natural and natural inoculum fermented rice flours.

3.5 Pasting properties

The pasting properties of the rice flours are summarized in Table 1. Compared with the unfermented rice flours, the peak, final and setback viscosities of the fermented rice
flours decreased. The peak, trough, breakdown, final and setback viscosities of the natural and natural inoculum fermented rice flours were significantly higher than those of the pure and pure inoculum fermented rice flours ($p < 0.05$). These viscosities of the pure and pure inoculum fermented rice flours did not differ significantly. The trough, final and setback viscosities of the natural inoculum fermented rice flour were significantly lower than those of the natural fermented rice flour.

### 3.6 Texture and cooking properties

As shown in Table 2, the hardness, adhesiveness, gum-
miness and chewiness of the fermented rice noodles did not differ significantly. The resilience and cohesion of the natural fermented rice noodles were the highest, while those of the pure fermented rice noodles were the lowest. The springiness of the pure fermented rice noodles was significantly higher than that of the others (p < 0.05). In addition, compared with the natural and pure fermented rice noodles, the water absorption rate of the natural inoculum and pure inoculum fermented rice noodles was slightly higher, and their cooking loss and water turbidity were slightly lower.

### 3.7 Sensory qualities

The sensory qualities of the fermented rice noodles are shown in Table 2. The shininess, tissue morphology, hardness, viscosity, elasticity, smoothness, taste and total scores of the four fermented rice noodles did not differ significantly (p > 0.05). The flavor score of the pure inoculum fermented rice noodles was the highest, and was significantly higher than that of the natural and natural inoculum fermented rice noodles (p < 0.05).

### 3.8 Volatile compounds by SPME/GC-MS

The volatile compounds of the fermented rice noodles concluded aldehydes, alcohols, hydrocarbons, acids, esters and others (Table 3). The relative contents of aldehydes, alcohols and hydrocarbons in the pure and pure inoculum fermented rice noodles were higher than those in the natural and natural inoculum fermented rice noodles. The relative contents of esters in the natural and natural inoculum fermented rice noodles exceeded 60%, while they did not detect in the pure and pure inoculum fermented rice noodles.
The natural and pure fermented rice slurries required 54 and 18 h to complete fermentation, respectively (Fig. 1A, B). The natural inoculum (10%) and pure inoculum (10%) fermentation methods significantly shortened the fermentation time to 20 and 10 h, respectively (Fig. 1C, D). Therefore, the natural inoculum and pure inoculum accelerated the fermentation rate of rice noodles. This may be due to the higher relative abundance of organic acid-producing bacteria in the inoculum fermented rice slurries, which accelerated the fermentation rate.

The concentrations of free amino acids and organic acids in rice slurry have changed during the fermentation process. After fermentation, the concentrations of Ser, Glu, Leu, Tyr, Phe and Arg in the natural and natural inoculum fermented rice slurries increased, and the concentrations of all free amino acids in the pure and pure inoculum rice slurries increased except for Pro (Fig. 2). The concentrations of free amino acids in the pure inoculum fermented rice slurry were similar to those in the pure fermented rice slurry. The concentrations of Asp, Glu, Leu, Tyr, Phe, Lys and Arg in the natural inoculum fermented rice slurry were higher than those in the natural fermented rice slurry. Previous studies have reported that the addition of Lactobacillus plantarum for fermentation increases the concentration of total free amino acids in cheese, wheat dough and meat. The dominant bacteria, such as Lactobacillus plantarum, in the inoculum fermented rice slurries might promote the production of free amino acids. Free amino acids contribute to the flavor of rice noodles, and the branched-chain amino acids (Val, Ile, Leu), aromatic amino acids (Tyr, Phe) and Met are the main precursors of key aroma compounds in cheese. The concentrations of these amino acids in the pure and pure inoculum fermented rice slurries were higher than those in the natural fermented rice slurry. Therefore, Val, Ile, Leu, Tyr, Phe and Met might be the key amino acids to improve the flavor of the pure and pure inoculum fermented rice noodles. In addition, compared with the natural and pure fermented rice slurries, the lactic acid content of the natural inoculum and pure inoculum fermented rice slurries increased by 98% and 20%, respectively (Fig. 3A). Previous studies have reported that Lactobacillus plantarum increases the lactic acid production in fermented rice. It might produce more lactic acid in the inoculum fermented rice slurries. Lactic acid lowers the pH value of rice slurry and inhibits the growth of undesirable bacteria.

The proximate composition of rice flour is related to its pasting properties and the structural properties of rice noodles. The total starch content of the fermented rice flours was higher than that of the unfermented ones (Fig. 3B), because the fermentation process purified rice starch by reducing other components. The damaged starch content of the natural and natural inoculum fermented rice flours decreased after fermentation (Fig. 3C). These
results indicated that the natural fermentation might alter the structure of rice grains and avoid the destruction of starch structure during milling process. The amylase content of the pure and pure inoculum fermented rice flours decreased after fermentation (Fig. 3D). These results were similar to previous studies that amylase molecules might be attacked due to the higher acidity and enzymatic activity, or be consumed by *Lactobacillus plantarum* [14, 30]. The protein content of the pure and pure inoculum fermented rice flours was higher than that of the natural and natural inoculum fermented rice flours (Fig. 3E). These results showed that the protein might dissolve in the soaking water and lost during the washing process. These findings were consistent with previous studies that *Clostridium*, one of the main bacteria in natural fermented rice slurry, could produce extracellular enzymes that degraded proteins into fermentable components [14, 31]. In addition, the lipid content of the fermented rice flours decreased significantly after fermentation (Fig. 3F). Lipids might decompose into fatty acids and then turn into volatile components [32].

The pasting properties of rice flour influence the texture, cooking and eating qualities of rice noodles [32]. Natural fermentation modifies the pasting properties of rice flour and yields a better eating quality for fermented rice noodles [33]. In this study, the peak, final and setback viscosities of the fermented rice flours were lower than those of the unfermented rice flours (Table 1). These decreases might be significantly correlated with the increases of lactic acid concentration in the fermented rice slurries [34]. The peak, trough, breakdown, final and setback viscosities of the pure and pure inoculum fermented rice flours were significantly lower than those of the natural and natural inoculum fermented rice flours (p < 0.05). In addition, the trough, final and setback viscosities of the natural inoculum fermented rice flour was significantly lower than that of the pure fermented rice noodles (p < 0.05). In the cooking process, the water absorption rate, cooking loss and water turbidity can reflect the solid loss and structural integrity retention ability of rice noodles [20, 34]. Thus, these parameters are important quality attributes of rice noodles. Compared with the natural and pure fermented rice noodles, the natural inoculum and pure inoculum fermented rice noodles had slightly higher water absorption rate and slightly lower cooking loss and water turbidity. These results indicated that the inocula might have a better effect on the texture of the fermented rice noodles [35]. Interestingly, these differences had no significant effect on the eating quality of rice noodles. The results of sensory evaluation indicated that there was no significant difference in sensory qualities except flavor of the four fermented rice noodles (Table 2). The scores of shininess and tissue morphology revealed that the surface of the pure inoculum fermented rice noodles was clean and smooth. The scores of hardness, viscosity, elasticity, smoothness and taste suggested that the pure inoculum fermented rice noodles had a pliable and smooth mouth feel. In addition, the total score indicated that the acceptability of the pure inoculum fermented rice noodles was similar to that of other rice noodles. Therefore, the pure inoculum fermentation maintained the eating quality of rice noodles.

Fermented rice noodles have a unique flavor under the action of microorganisms and enzymes [35]. The flavor score of the pure and pure inoculum fermented rice noodles was higher than that of the natural and natural inoculum fermented rice noodles (Table 2). The flavor score was related to the bacterial composition in fermented rice slurry and the volatile compounds produced during fermentation. *Lactobacillus plantarum*, the dominant bacteria in the pure and pure inoculum fermented rice slurries, produced rice noodles with thick fermented rice fragrance. These results were consistent with previous studies that the aroma characteristics of rice noodles fermented with pure starter culture are superior to those of the rice noodles fermented with mixed cultures [33]. In addition, the relative contents of aldehydes in pure and pure inoculum fermented rice noodles were higher than those in the natural and natural inoculum fermented ones (Table 3). Aldehydes with 5 to 10 carbon atoms have a low threshold and provide desirable aroma for the fermented rice noodles [35, 36]. Hydrocarbons were detected in the pure and pure inoculum fermented rice noodles, but they had a high threshold and contributed little to the flavor [37]. Esters were important volatile compounds in the natural and natural inoculum fermented rice noodles. Previous studies have reported that esters of low molecular mass have fruity odors, which may contribute to the flavor of the natural and natural inoculum fermented rice noodles [38]. In addi-
tion, Fig. 4 showed that the volatile profiles of the four fermented rice noodles did not differ significantly. These results indicated that the pure inoculum fermentation yielded a better flavor for the rice noodles.

5 Conclusions
This study demonstrated that the inoculum fermentation shortened the natural fermentation time from 54 h to 20 h and the pure fermentation time from 18 h to 10 h. The concentrations of free amino acids and lactic acid in the pure inoculum fermented rice slurry were higher than those in the natural and natural inoculum fermented rice slurries. Compared to the unfermented rice flours, the pure inoculum fermentation increased the content of total starch, and decreased the contents of amylase and lipids and the pasting viscosities of the rice flour. The texture, cooking and eating qualities of the pure inoculum fermented rice noodles were similar to those of the natural fermented ones. In addition, the pure inoculum fermented rice noodles had higher relative contents of aldehydes and thus had a better flavor. Therefore, Lactobacillus plantarum inoculum contributed to accelerate the fermentation rate and improve the rice noodle flavor while maintaining the texture, cooking and eating qualities of rice noodles.

Acknowledgments
This study was supported by the National Key Technologies R&D Program of China (Grant No. 2017YFD0401104-06).

Conflict of Interest
The authors declare no potential conflict of interests.

References
1) Srikaeo, K.; Laothongsan, P.; Lerdluksamee, C. Effects of gums on physical properties, microstructure and starch digestibility of dried-natural fermented rice noodles. Int. J. Biol. Macromol. 109, 517-523 (2018).
2) Lu, Z.H.; Cao, W.; Peng, H.H.; Wang, F.; Tatsumi, E.; Kohyama, K.; Li, L.T. Effect of fermentation metabolites on rheological and sensory properties of fermented rice noodles. J. Sci. Food Agr. 88, 2134-2141 (2008).
3) Guimaraes, A.; Santiago, A.; Teixeira, J.A.; Venancio, A.; Abrunhosa, L. Anti-infla-toxigenic effect of organic acids produced by, Lactobacillus plantarum. Int. J. Food Microbiol. 264, 31-38 (2017).
4) Ohishi, K.; Kasaï, M.; Shimada, A.; Hatae, K. Effects of acetic acid on the rice gelatinization and pasting properties of rice starch during cooking. Food Res. Int. 40, 224-231 (2007).
5) Zhu, Y.; Luo, Y.; Wang, P.; Zhao, M.; Li, L.; Hu, X.; Chen, F. Simultaneous determination of free amino acids in Pu-erh tea and their changes during fermentation. Food Chem. 194, 643-649 (2016).
6) Irigoyen, A.; Ortigosa, M.; Juansaras, I.; Oneca, M.; Torre, P. Influence of an adjunct culture of Lactobacillus on the free amino acids and volatile compounds in a Roncal-type ewe’s-milk cheese. Food Chem. 100, 71-80 (2007).
7) Aline, G.T.M.; Cintia, L.R.; Dias, D.R.; Schwab, R.F. Combination of probiotic yeast and lactic acid bacteria as starter culture to produce maize-based beverages. Food Res. Int. 111, 187-197 (2018).
8) Yang, Y.; Tao, W.Y. Effects of lactic acid fermentation on FT-IR and pasting properties of rice flour. Food Res. Int. 41, 937-940 (2008).
9) Keatkrai, J.; Jirapakkul, W. Volatile profile of khanom jeen, Thai fermented rice noodles, and the changes during the fermentation process. ScienceAsia 36, 46-51 (2010).
10) Lu, Z.H.; Li, L.T.; Cao, W.; Li, Z.G.; Tatsumi, E. Influence of natural fermentation on physico-chemical characteristics of rice noodles. Int. J. Food Sci. Tech. 38, 505-510 (2003).
11) Charles, A.L.; Huang, T.C.; Lai, P.Y.; Chen, C.C.; Lee, P.P.; Chang, Y.H. Study of wheat flour-cassava starch composite mix and the function of cassava mucilage in Chinese noodles. Food Hydrocoll. 21, 368-376 (2007).
12) Yi, C.; Yang, Y.; Zhou, S.; He, Y. Role of lactic acid bacteria in the eating qualities of fermented rice noodles. Cereal Chem. 94, 349-356 (2017).
13) Yi, C.; Zhu, H.; Tong, L.; Zhou, S.; Yang, R.; Niu, M. Volatile profiles of fresh rice noodles fermented with pure and mixed cultures. Food Res. Int. 119, 152-160 (2019).
14) Geng, D.H.; Liang, T.; Yang, M.; Wang, L.; Zhou, X.; Sun, X.; Liu, L.; Zhou, S.; Tong, L.T. Effects of Lactobacillus combined with semidry flour milling on the quality and flavor of fermented rice noodles. Food Res. Int. 126, 108612 (2019).
15) Kimaryo, V.M.; Massawe, G.A.; Olasupo, N.A.; Holzapfel, W.H. The use of a starter culture in the fermentation of cassava for the production of "kvundé", a traditional Tanzanian food product. Int. J. Food Microbiol. 56, 179-190 (2000).
16) Sawatari, Y.; Sugiyama, H.; Suzuki, Y.; Hanaoka, A.; Saito, K.; Yamashita, H. Development of fermented instant Chinese noodle using Lactobacillus plantarum. Food Microbiol. 22, 539-546 (2005).
17) Avila, M.; Garde, S.; Medina, M.; Nunez, M. Effect of milk inoculation with bacteriocin-producing lactic acid bacteria on a Lactobacillus helveticus adjunct cheese culture. J. Food Protect. 68, 1026-1033 (2005).
18) Ren, M.Y.; Tong, L.T.; Li, X.; Xie, D.; Wang, L.; Zhou, X.; Zhong, K.; Liu, L.; Zhou, S.; Yi, C. Effects of hot air treatment on the quality attributes of semidry-milled Indica rice. J. Cereal Sci. 79, 93-97 (2018).
19) Tong, L.T.; Gao, X.; Lin, L.; Liu, Y.; Zhong, K.; Liu, L.; Zhou, X.; Wang, L.; Zhou, S. Effects of semidry flour milling on the quality attributes of rice flour and rice noodles in China. J. Cereal Sci. 62, 45-49 (2015).
20) Zhang, H.; Wang, Z.Y.; Yang, X.; Zhao, H.T.; Zhang, Y.C.; Dong, A.J.; Jing, J.; Wang, J. Determination of free amino acids and 18 elements in freeze-dried strawberry and blueberry fruit using an Amino Acid Analyzer and ICP-MS with microwave digestion. Food Chem. 147, 189-194 (2014).
21) Duarte, W.F.; Dias, D.R.; Oliveira, J.M.; Teixeira, J.A.; Silva, J.B.A.; Schwan, R.F. Characterization of different fruit wines made from cacao, cupuassu, gabioba, jabuticaba and umbu. LWT-Food Sci. Technol. 43, 1564-1572 (2010).
22) Kim, Y.; Kee, J.I.; Lee, S.; Yoo, S.H. Quality improvement of rice noodle restructured with rice protein isolate and transglutaminase. Food Chem. 145, 409-416 (2014).
23) Bryant, R.J.; McClung, A.M. Volatile profiles of aromatic and non-aromatic rice cultivars using SPME/GC-MS. Food Chem. 124, 501-513 (2011).
24) Chen, Q.; Song, J.; Bi, J.; Meng, X.; Wu, X. Characterization of volatile profile from ten different varieties of Chinese jujubes by HS-SPME/GC-MS coupled with e-nose. Food Res. Int. 105, 605-615 (2018).
25) Li, Y.; Zheng, X.W.; Chen, J.Y.; Liang, J.F.; Yu, S.Z.; Han, B.Z. Lactic acid bacteria diversity of fresh rice noodles during the fermentation process, revealed by culture-dependent and culture-independent methods. Biotechnol. Biotechnol. Equip. 29, 915-920 (2015).
26) Valerio, F.; Conte, A.; Biase, M.D.; Lattanzio, V.M.T.; Lonigro, S.L.; Padalino, L.; Fontonio, E.; Lavermicocca, P. Formulation of yeast-leavened bread with reduced salt content by using a Lactobacillus plantarum fermentation product. Food Chem. 221, 582-589 (2017).
27) Fudda, S.; Chambon, C.; Champomier-Verges, M.C.; Talon, R.; Vignolo, G. Lactobacillus role during conditioning of refrigerated and vacuum-packaged Argentinean meat. Meat Sci. 79, 603-610 (2008).
28) Yvon, M.; Rijnen, L. Cheese flavour formation by amino acid catabolism. Int. Dairy J. 11, 185-201 (2001).
29) Sankar, G.S.; Sankar, S.S.; Subrata, S.; Venkatachalam, S.; Chang, P.S. Use of a potential probiotic, Lactobacillus plantarum 17, for the preparation of a rice-based fermented beverage. Front. Microbiol. 9, 1-11 (2018).
30) Wan, J.; Huang, W.; Zhong, J.; Huang, L.; Rayas-Duarte, P.; Liu, B. Effects of lab fermentation on physical properties of oat flour and its suitability for noodle making. Cereal Chem. 88, 153-158 (2011).
31) Tracy, B.P.; Jones, S.W.; Fast, A.G.; Indurthi, D.C.; Papoutsakis, E.T. Clostridia: the importance of their exceptional substrate and metabolite diversity for biofuel and biorefinery applications. Curr. Opin. Biotech. 23, 364-381 (2012).
32) Tong, C.; Chen, Y.; Tang, F.; Xu, F.; Huang, Y.; Chen, H.; Bao, J. Genetic diversity of amylose content and RVA pasting parameters in 20 rice accessions grown in Hainan, China. Food Chem. 161, 239-245 (2014).
33) Lu, Z.H.; Li, L.T.; Min, W.H.; Wang, F.; Tatsumi, E. The effects of natural fermentation on the physical properties of rice flour and the rheological characteristics of rice noodles. Int. J. Food Sci. Tech. 40, 985-992 (2005).
34) Yalcin, S.; Basman, A. Effects of gelatinisation level, gum and transglutaminase on the quality characteristics of rice noodle. Int. J. Food Sci. Tech. 43, 1637-1644 (2008).
35) Iizuka-Furukawa, S.; Isogai, A.; Kusaka, K.; Fujii, T.; Wakai, Y. Identification of 4-mercapto-4-methylpentan-2-one as the characteristic aroma of sake made from low-glutelin rice. J. Biosci. Bioeng. 123, 209-215 (2017).
36) Zhang, H.; Pu, D.; Sun, B.; Ren, F.; Zhang, Y.; Chen, H. Characterization and comparison of key aroma compounds in raw and dry porcini mushroom (Boletus edulis) by aroma extract dilution analysis, quantitation and aroma recombination experiments. Food Chem. 258, 260-268 (2018).
37) Zhang, Y.; Song, H.; Li, P.; Yao, J.; Xiong, J. Determination of potential off-flavour in yeast extract. LWT-Food Sci. Technol. 82, 184-191 (2017).
38) Medeiros, A.B.P.; Pandey, A.; Vandenbergh, L.P.S.; Pastore, G.M.; Soccol, C.R. Production and recovery of aroma compounds produced by solid-state fermentation using different adsorbents. Food Technol. Biotech. 44, 47-51 (2006).