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A report of 26 unrecorded bacterial species in Korea, belonging to the *Bacteroidetes* and *Firmicutes*

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An outcome of the study to discover indigenous prokaryotic species in Korea, a total of 26 bacterial species assigned to the classes *Bacteroidetes* and *Firmicutes* were isolated from diverse environmental samples collected from soil, tidal flat, freshwater, seawater, wetland, plant roots, and fermented foods. From the high 16S rRNA gene sequence similarity (>99.0%) and formation of a robust phylogenetic clade with the closest species, it was determined that each strain belonged to each independent and predefined bacterial species. There is no official report that these 26 species have been described in Korea; therefore 14 strains for the order *Flavobacteriales* and two strains for the order *Cytophagales* were assigned to the class *Bacteroidetes*, and 8 strains for the order *Bacillales* and 4 strains for the order *Lactobacillales* were assigned to the class *Firmicutes* are reported for new bacterial species found in Korea. Gram reaction, colony and cell morphology, basic biochemical characteristics, isolation source, and strain IDs are also described in the species description section.

Keywords: 16S rRNA, bacterial diversity, *Bacteroidetes*, *Firmicutes*, unrecorded species

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Introduction

Firmicutes includes industrially important groups as well as causative agents of various diseases. Lactic acid bacteria are the representative probiotic bacteria, and thus one of the most industrially important bacterial groups (Tannock, 2005). In contrast, some species of *Bacillus* (anthrax, food poisoning), *Clostridium* (tetanus, food poisoning, gas gangrene), *Enterococcus* (urinary tract infection), *Streptococcus* (pneumonia, meningitis, dental caries) and *Staphylococcus* (scalded skin syndrome) are some examples of medically significant bacteria of *Firmicutes* (Dworkin *et al*., 2006).

The phylum *Firmicutes* encompasses broad bacterial taxa that have Gram positive cell walls and low DNA G+C contents (Dworkin *et al*., 2006; De Vos *et al*., 2009). The phylum currently contains three classes, namely *Bacilli*, *Clostridia* and *Erysipelotrichia* (De Vos *et al*., 2009). The class *Bacilli* includes endospore-forming groups and lactic acid producing groups, *Clostridia* includes endospore forming or non-forming anaerobic groups and anoxygenic phototrophic groups, and *Erysipelotrichia* includes non-motile, non-spore-forming and aerobic groups.

The phylum *Bacteroidetes* is a very diverse bacterial phylum, the name of which changed several times over the past years. It is also known as the *Cytophaga-Flexibacter-Bacteroides* (CFB) group, an appellation that reflects the diversity of organisms found in this phylogenetic group (Woese, 1987; Woese *et al*., 1990). Among this phylum, members of the genus *Bacteroides* are the

most abundantly represented in the fecal microbiota (Moore and Holdeman, 1974; Sghir *et al*., 2000) and normal microbiota of the oral cavity, either in the saliva or dental plaque (Keijser *et al*., 2008; Nasidze *et al*., 2009a, 2009b). The largest class of *Bacteroidetes* is *Flavobacteria* (Thomas *et al*., 2011). These bacteria are all Gram-negative, covering a mixture of physiological types, from strictly anaerobic *Bacteroides* to strictly aerobic *Flavobacteria*. They are non-motile, flagellated, or motile by gliding.

In 2013, we collected diverse environmental samples and isolated myriads of novel bacterial species and unrecorded bacterial species in Korea. As a subset of this study, the present report focuses on the description of unrecorded species belonging to the *Bactroidetes* and *Firmicutes*. Here we report 26 unrecorded bacterial species in Korea belonging to 2 orders in the *Bactroidetes* and 2 orders in the *Firmicutes*.

Materials and Methods

A total of 28 bacterial strains assigned to the classes *Bacteroidetes* and *Firmicutes*. The strains were isolated from diverse environmental samples such as freshwater, lagoon water, seawater, tidal flat, sand of seashore, plant roots, ginseng field and fermented food *kimchii*. Each sample was processed separately, spread onto diverse culture media including R2A, Marine Agar 2216 and Tryptic Soy Agar, and incubated at 20-30°C for 2-3 days. The designated strain IDs, sources, culture media, and incubation conditions are summarized in Table 1. All strains were purified as single colonies and stored as 10-20% glycerol suspension −80°C as well as lyophilized ampoules.

The phylogenetic position of the strains assigned to the *Bacteroidetes* and *Firmicutes* was investigated by 16S rRNA gene analysis. The 16S rRNA genes were amplified by PCR and sequenced. The 16S rRNA gene sequences of the strains assigned to the *Bacteroidetes* and *Firmicutes* were analyzed using the EzTaxon-e server (Kim *et al*., 2012b) and confirmed using GenBank database (http://ncbi.nlm.nih.gov). For phylogenetic analyses, the 16S rRNA gene sequences were aligned using the SILVA Incremental Aligner (SINA v.1.2.11) (Pruesse *et al*., 2012). Phylogenetic tree was constructed by neighbor-joining (Saitou and Nei, 1987) and maximum-likelihood (Felsenstein, 1981) methods in MEGA version 6 (Tamura *et al*., 2013). The topology of phylogenetic tree was evaluated via a bootstrap analysis (Felsenstein, 1985), based on 1000 replications.

Colony morphology of the strains was observed on agar plates with a magnifying glass after cells grew up to stationary phase. Cellular morphology and cell size were examined by either transmission electron microscopy or scanning electron microscopy. Gram staining was performed using a Gram-staining kit or the standard procedures. Biochemical characteristics were tested by using API 20NE galleries (bioMérieux) according to the manufacturer's instructions.

Results and Discussion

Strains assigned to the *Bacteroidetes*

On the basis of 16S rRNA gene sequence comparisons and phylogenetic analyses, a total of 16 strains were assigned to the class *Bacteroidetes*. The 16 strains were distributed in 2 orders of the *Bacteroidetes*; 14 strains for the order *Flavobacteriales* and two strains for the order *Cytophagales* (Table 1). These strains were Gram-staining-negative, chemoheterotrophic and rod-shaped bacteria except for strain BM17 showing coccoid- or oval-shaped (Fig. 1). Colony size, morphology and physiological characteristics are also shown in the species description section.

Fig. 3 shows phylogenetic assignment of 16 strains into 14 species of the orders *Flavobacteriales* and *Cytophagales*. These strains belonged to *Flavobacterium anhuiense* (Liu *et al*., 2008), *F. compostarboris* (Kim *et al*., 2012a), *F. glaciei* (Zhang *et al*., 2006), *F. glycines* (Madhaiyan *et al*., 2010), *F. xinjiangense* (Zhu *et al*., 2003), *Arenibacter echinorum* (Nedashkovskaya *et al*., 2007), *Cloacibacterium normanense* (Allen *et al*., 2006), *Cellulophaga lytica* (Johansen *et al*., 1999), *Chryseobacterium rhizosphaerae* (Cho *et al*., 2010), *Elizabethkingia miricola* (Kim *et al*., 2005), *Lacinutrix himadriensis* (Srinivas *et al*., 2013) and *Maribacter orientalis* (Nedashkovskaya *et al*., 2004) of the family *Flavobacteriaceae* and *Algoriphagus mannitolivorans* (Shahina *et al*., 2014) and *Fluviimonas pallidilutea* (Sheu *et al*., 2013) of the family *Cytophagales*.

There is no official report that these 14 species have been isolated in Korea; therefore 12 species in 8 genera of one family in the order *Flavobacteriales* and two species in the order *Cytophagales* are reported for *Bacteroidetes* species found in Korea.

Strains assigned to the *Firmicutes*

On the basis of 16S rRNA gene sequence comparisons and phylogenetic analyses, a total of 12 strains were assigned to the class *Firmicutes*. The 12 strains were distributed in 2 orders of the *Firmicutes*; 8 strains for the order *Bacillales* and 4 strains for the order *Lactobacillales* (Table 1). These strains were Gram-staining-positive, chemoheterotrophic and rod- or coccus-shaped bacteria (Fig. 1). Colony size, morphology and physiologi-

Table 1. Summary of strains isolated belonging to the *Bacteroidetes* and *Firmicutesand* and their taxonomic affiliations.

Phylum	Family	Genus	Strain ID	NIBR ID	Most closely related species	Similarity (%)	Isolation source	Medium	Incubation conditions
Bacteroidetes	*Flavobacteriaceae*	*Flavobacterium*	WM10	NIBRBA0000114425	*F. anhuiense* D3^T	99.5	Freshwater	R2A	25°C, 3d
		Flavobacterium	WW2	NIBRBA0000114435	*F. compostarboris* 15C3^T	99.3	Freshwater	R2A	25°C, 3d
		Flavobacterium	JJ9006	NIBRBA0000114157	*F. glaciei* 0499^T	100.0	Freshwater	R2A	25°C, 2d
		Flavobacterium	JJ9011	NIBRBA0000114162	*F. glycines* Gm-149^T	99.9	Freshwater	R2A	25°C, 2d
		Flavobacterium	HME8661	NIBRBA0000114392	*F. xinjiangense* JCM 11314^T	99.6	Freshwater	R2A	20°C, 2d
		Arenibacter	HME9268	NIBRBA0000114395	*A. echinorum* KMM 6032^T	99.7	Lagoon water	R2A	30°C, 3d
		Cellulophaga	M-M24	NIBRBA0000114319	*C. lytica* DSM 7489^T	99.8	Sand of seashore	MA	25°C, 3d
		Chryseobacterium	BM17	NIBRBA0000114306	*C. rhizosphaerae* RSB3-1^T	99.7	Tidal flat	MA	30°C, 3d
		Cloacibacterium	2013 C18	NIBRBA0000114166	*C. normanense* CCUG 46293^T	99.7	Freshwater	R2A	25°C, 2d
		Elizabethkingia	JJ9009	NIBRBA0000114160	*E. miricola* GTC862^T	99.8	Freshwater	R2A	25°C, 2d
		Lacinutrix	HDW8	NIBRBA0000114317	*L. himadriensis* E4-9a^T	99.2	Sand of seashore	MA	25°C, 3d
		Maribacter	HD32	NIBRBA0000114316	*M. orientalis* KMM 3947^T	99.3	Tidal flat	MA	30°C, 3d
	Cyclobacteriaceae	*Algoriphagus*	2013 C56	NIBRBA0000114169	*A. mannitolivorans* IMSNU 14012^T	99.2	Seawater	MA	25°C, 2d
	Leadbetterella_f	*Fluviimonas*	HME8520	NIBRBA0000114391	*F. pallidilutea* TQQ6^T	99.7	Freshwater	R2A	30°C, 2d
Firmicutes	*Bacillaceae*	*Bacillus*	G9-2	NIBRBA0000114358	*B. algicola* KMM 3737^T	99.5	Tidal flat	MA	25°C, 2d
		Bacillus	DT7-08	NIBRBA0000114189	*B. gibsonii* DSM 8722^T	99.8	Plant root	TSA	30°C, 2d
		Bacillus	DT2-01	NIBRBA0000114177	*B. hunanensis* JSM 081003^T	99.9	Plant root	TSA	30°C, 2d
		Bacillus	M4Y-2-1	NIBRBA0000114264	*B. thuringiensis* ATCC 10792^T	99.9	Ginseng soil	MA	30°C, 3d
	Paenibacillaceae	*Paenibacillus*	JJ9001	NIBRBA0000114152	*P. typhae* xj7^T	99.6	Freshwater	R2A	25°C, 2d
	Planococcaceae	*Paenisporosarcina*	G-M13	NIBRBA0000114315	*P. quisquiliarum* SK 55^T	99.0	Sand of seashore	MA	25°C, 3d
	Sporolactobacillaceae	*Fictibacillus*	2013 C17	NIBRBA0000114165	*F. nanhaiensis* JSM 082006^T	99.9	Freshwater	R2A	25°C, 2d
	Staphylococcaceae	*Staphylococcus*	ST5-08	NIBRBA0000114182	*S. hominis* subsp. *novobiosepticus* GTC 1228^T	99.9	Plant root	TSA	30°C, 2d
	Lactobacillaceae	*Lactobacillus*	WT2K-1	NIBRBA0000114227	*L. brevis* ATCC 14869^T	99.9	*Kimchi*	R2A	25°C, 2d
		Lactobacillus	PA4	NIBRBA0000114226	*L. coryniformis* subsp. *torquens* KCTC 3535^T	100.0	*Kimchi*	R2A	25°C, 2d
		Lactobacillus	EMB6	NIBRBA0000114225	*L. harbinensis* SBT10908^T	100.0	*Kimchi*	R2A	25°C, 2d
		Lactobacillus	WT2K-2	NIBRBA0000114228	*L. pentosus* JCM 1558^T	100.0	*Kimchi*	R2A	25°C, 2d

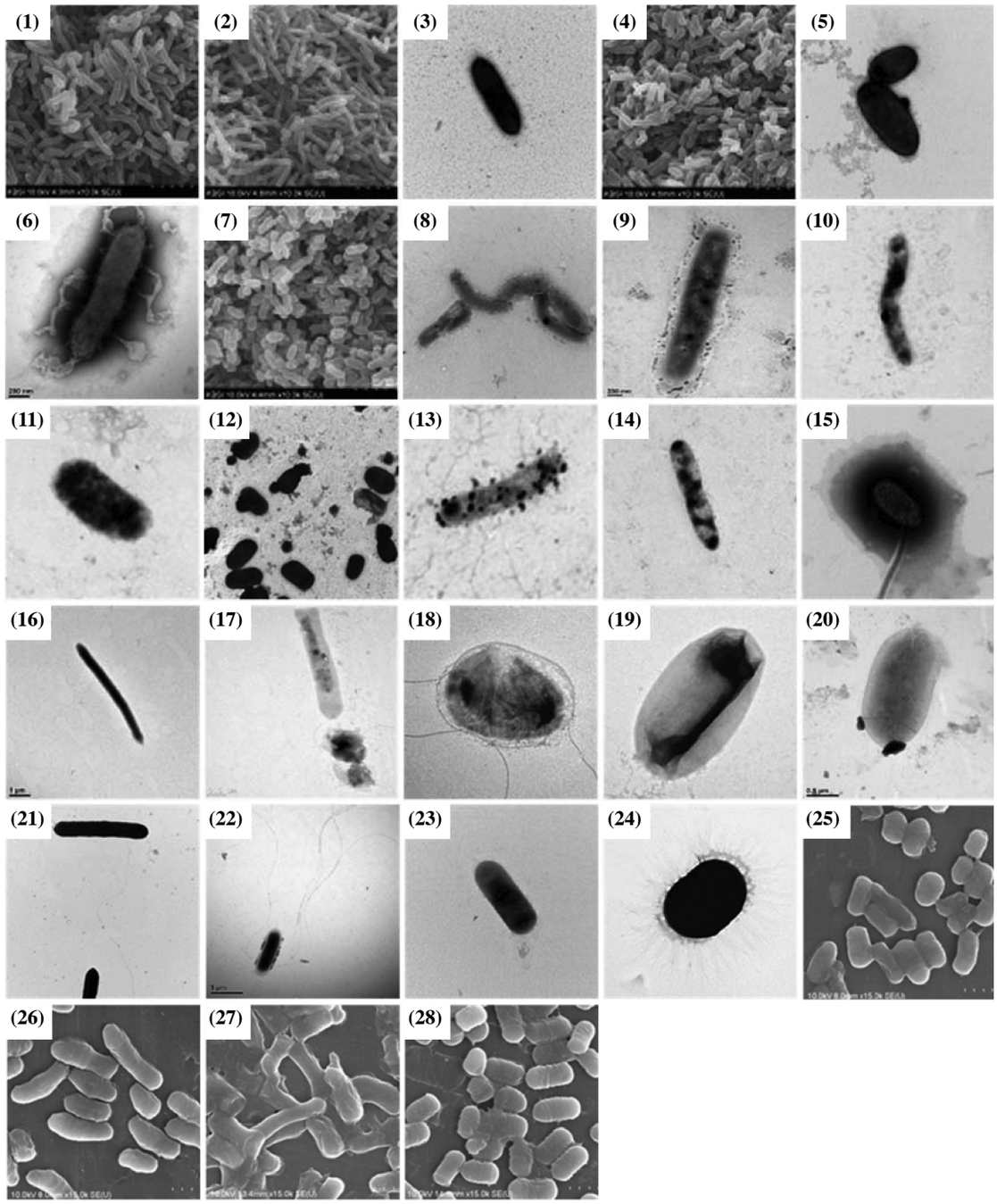


Fig. 1. Transmission electron micrographs or scanning electron micrographs of cells of the strains isolated in this study. Strains: 1, WM10; 2, WW2; 3, JJ9006; 4, WS101; 5, JJ9011; 6, HME8661; 7, WS78; 8, 2013 C18; 9, HME9268; 10, M-M24; 11, BM17; 12, JJ9009; 13, HDW8; 14, HD32; 15, 2013 C56; 16, HME8520; 17, G9-2; 18, DT7-08; 19, DT2-01; 20, M4Y-2-1; 21, JJ9001; 22, G-M13; 23, 2013 C17; 24, ST5-08; 25, WT2K-1; 26, PA4; 27, EMB6; 28, WT2K-2.

cal characteristics are also shown in the species description section.

Fig. 3 shows phylogenetic assignment of 12 strains into 12 species of the orders *Bacillales* and *Lactobacillales*. These strains belonged to *B. algicola* (Ivanova *et al*., 2004a), *B. gibsonii* (Nielsen *et al*., 1995), *B. hunanensis* (Chen *et al*., 2011), *B. thuringiensis* (Berliner, 1915), *P. typhae* (Kong *et al*., 2013), *P. quisquiliarum* (Krish-

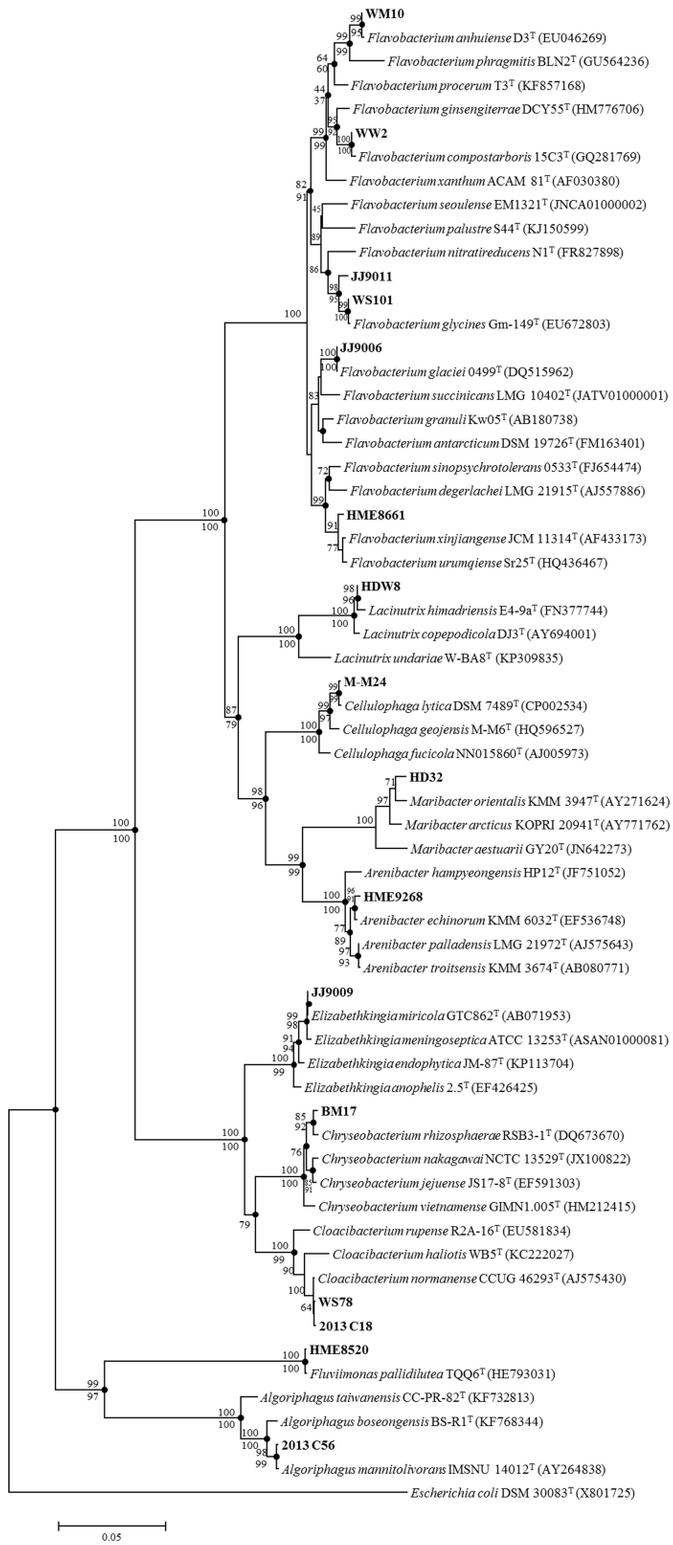


Fig. 2. Neighbor-joining phylogenetic tree, based on 16S rRNA gene sequences, showing the relationship between the strains isolated in this study and their relatives of the class *Bacteroidetes*. Bootstrap values (>70%) are shown above nodes for the neighbor-joining and below nodes for the maximum-likelihood methods. Filled circles indicate the nodes recovered by the two treeing methods. Bar, 0.05 substitutions per nucleotide position.

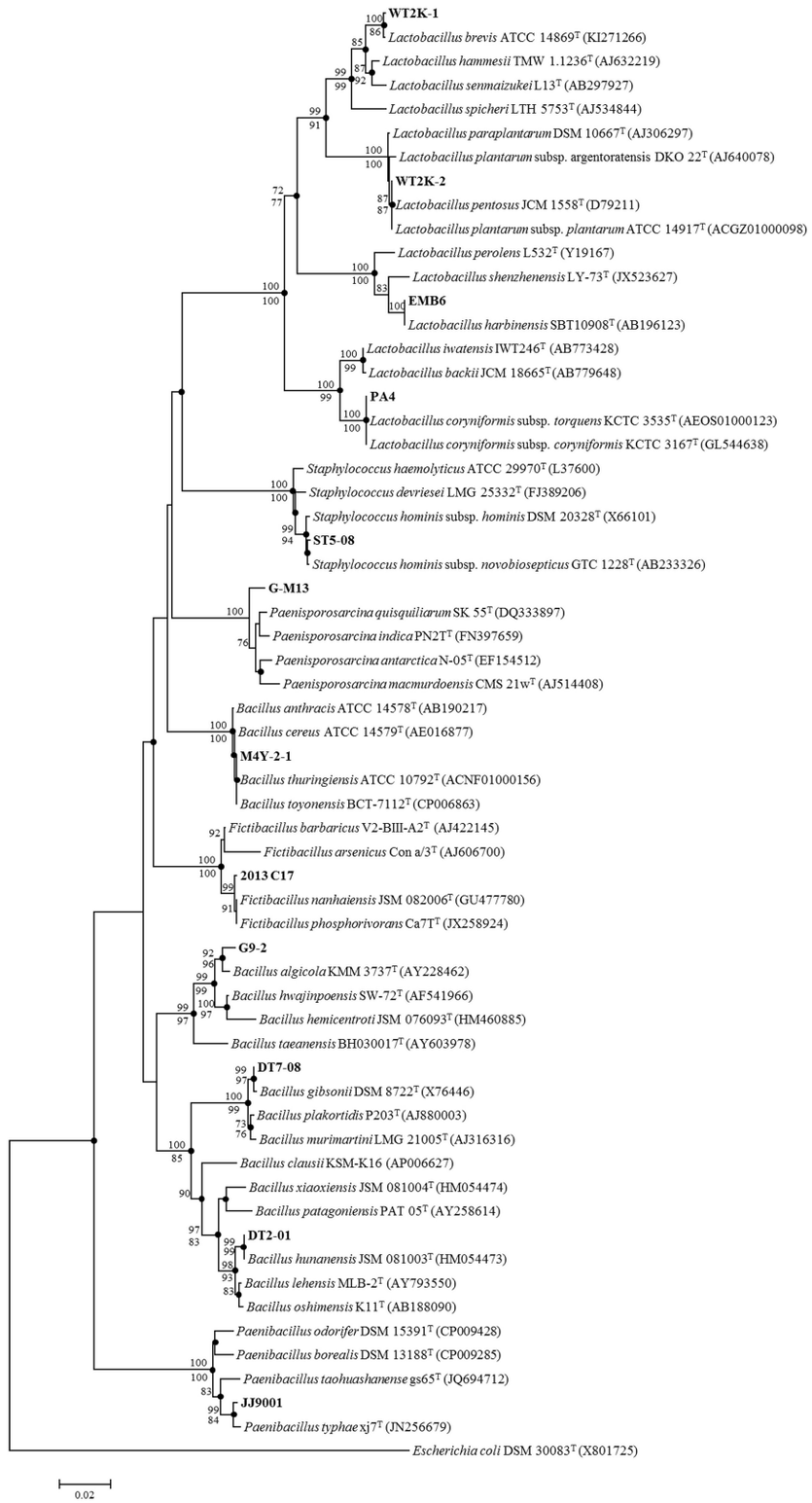


Fig. 3. Neighbor-joining phylogenetic tree, based on 16S rRNA gene sequences, showing the relationship between the strains isolated in this study and their relatives of the class *Firmicutes*. Bootstrap values (>70%) are shown above nodes for the neighbor-joining and below nodes for the maximum-likelihood methods. Filled circles indicate the nodes recovered by the two treeing methods. Bar, 0.02 substitutions per nucleotide position.

namurthi *et al*., 2009), *F. nanhaiensis* (Glaeser *et al*., 2013) and *S. hominis* subsp. *novobiosepticus* (Kloos *et al*., 1998) of the family *Bacillales* and *L. brevis* (Ivanova *et al*., 2004b), *L. coryniformis* subsp. *torquens* (Abo-Elnaga and Kandler, 1965), *L. harbinensis* and *L. pentosus* (Zanoni *et al*., 1987) of the family *Lactobacillales*.

There is no official report that these 12 species have been isolated in Korea; therefore 8 species in 5 genera of one family in the order *Bacillales* and 4 species in the order *Lactobacillales* are reported for *Firmicutes* species found in Korea.

Description of *Flavobacterium anhuiense* WM10

Cells are Gram-staining-negative, non-flagellated and rod-shaped. Colonies are raised, entire and light yellow colored after 3 days on R2A at 25°C. Oxidase- activity is positive. In the API 20NE strip, esculin hydrolysis, gelatinase and β-galactosidase activities and assimilation of D-glucose, L-arabinose, D-mannose, *N*-acetyl-glucosamine and D-maltose are positive, but nitrate reduction, indole production, glucose fermentation, arginine dihydrolase and urease activities and assimilation of D-mannitol, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate and phenylacetic acid are negative. Strain WM10 (=NIBRBA0000114425) has been isolated from a fresh water sample, Woopo wetland, Changnyeong, Korea.

Description of *Flavobacterium compostarboris* WW2

Cells are Gram-staining-negative, non-flagellated and rod-shaped. Colonies are round, smooth, translucent and dark-yellow colored after 3 days on R2A at 25°C. Oxidase- activity is negative. In the API 20NE strip, esculin hydrolysis, gelatinase and β-galactosidase activities and assimilation of D-glucose, L-arabinose, D-mannose, *N*-acetyl-glucosamine and D-maltose are positive, but nitrate reduction, indole production, glucose fermentation, arginine dihydrolase and urease activities and assimilation of D-mannitol, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate and phenylacetic acid are negative. Strain WW2 (=NIBRBA0000114435) has been isolated from a fresh water sample, Woopo wetland, Changnyeong, Korea.

Description of *Flavobacterium glaciei* JJ9006

Cells are Gram-staining-negative, non-flagellated and rod-shaped. Colonies are circular, convex and yellow colored after 2 days of incubation on R2A at 25°C. Oxidase- activity is positive. In the API 20NE strip, nitrate reduction, esculin hydrolysis and β-galactosidase activity are positive, but indole production, glucose fermentation, arginine dihydrolase, urease and gelatinase activities and assimilation of D-glucose, L-arabinose, D-mannose, D-mannitol, *N*-acetyl-glucosamine, D-maltose, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate and phenylacetic acid are negative. Strain JJ9006 (=NIBRBA0000114157) has been isolated from a fresh water sample, Wanju, Korea.

Description of *Flavobacterium glycines* JJ9011

Cells are Gram-staining-negative, non-flagellated and rod-shaped. Colonies are circular, convex and yellow colored after 2 days of incubation on R2A at 25°C. Oxidase- activity is positive. In the API 20NE strip, nitrate reduction, esculin hydrolysis and β-galactosidase activity and assimilation of D-glucose, L-arabinose, D-mannose and D-maltose are positive, but indole production, glucose fermentation, arginine dihydrolase, urease and gelatinase activities and assimilation of D-mannitol, *N*-acetyl-glucosamine, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate and phenylacetic acid are negative. Strain JJ9011 (=NIBRBA0000114162) has been isolated from a fresh water sample, Juwang Mountain, Cheongsong, Korea.

Description of *Flavobacterium glycines* WS101

Cells are Gram-staining-negative, non-flagellated and rod-shaped. Colonies are opaque, round, umbonate and yellow colored after 3 days on R2A at 25°C. Oxidase-activity is positive. In the API 20NE strip, nitrate reduction, glucose fermentation, esculin hydrolysis and β-galactosidase activity and assimilation of D-glucose, L-arabinose, D-mannose, *N*-acetyl-glucosamine and D-maltose are positive, but indole production, arginine dihydrolase, urease and gelatinase activities and assimilation of D-mannitol, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate and phenylacetic acid are negative. Strain WS101 (=NIBRBA0000113915) has been isolated from a fresh water sample, Woopo wetland, Changnyeong, Korea.

Description of *Flavobacterium xinjiangense* HME8661

Cells are Gram-staining-negative, non-flagellated and rod-shaped. Colonies are circular, convex, entire and yellow colored after 2 days on R2A at 20°C. Oxidase-activity is positive. In the API 20NE strip, esculin hydrolysis and β-galactosidase activity and assimilation of D-glucose, D-mannose and D-maltose are positive, but nitrate reduction, indole production, glucose fermentation, arginine dihydrolase, urease and gelatinase activities and assimilation of L-arabinose, D-mannitol, *N*-acetyl-glucosamine, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate and phenylacetic acid are

negative. Strain HME8661 (=NIBRBA0000114392) has been isolated from a fresh water sample, Inje, Korea.

Description of *Cloacibacterium normanense* 2013 C18

Cells are Gram-staining-negative, non-flagellated and rod-shaped. Colonies are round, waxy and yellow colored after 2 days of incubation on R2A at 25°C. Oxidase- activity is positive. In the API 20NE strip, nitrate reduction, glucose fermentation, esculin hydrolysis, arginine dihydrolase and urease activities and assimilation of D-mannose are positive, but indole production, gelatinase and β-galactosidase activities and assimilation of D-glucose, L-arabinose, D-mannitol, *N*-acetyl-glucosamine, D-maltose, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate and phenylacetic acid are negative. Strain 2013 C18 (=NIBRBA0000114166) has been isolated from a fresh water sample, Andong, Korea.

Description of *Cloacibacterium normanense* WS78

Cells are Gram-staining-negative, non-flagellated and rod-shaped. Colonies are opaque, round, smooth, convex and yellow colored after 3 days of incubation on R2A at 25°C. Oxidase- activity is negative. In the API 20NE strip, nitrate reduction and esculin hydrolysis are positive, but indole production, glucose fermentation, arginine dihydrolase, urease, gelatinase and β-galactosidase activities and assimilation of D-glucose, L-arabinose, D-mannose, D-mannitol, *N*-acetyl-glucosamine, D-maltose, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate and phenylacetic acid are negative. Strain WS78 (=NIBRBA0000114432) has been isolated from fresh water sample, Woopo wetland, Changnyeong, Korea.

Description of *Arenibacter echinorum* HME9268

Cells are Gram-staining-negative, non-flagellated and rod-shaped. Colonies are circular, convex, entire and yellow colored after 3 days on R2A at 30°C. Oxidase- activity is positive. In the API 20NE strip, esculin hydrolysis and β-galactosidase activity and assimilation of D-glucose, D-mannose, *N*-acetyl-glucosamine and D-maltose are positive, but nitrate reduction, indole production, glucose fermentation, arginine dihydrolase, urease and gelatinase activities and assimilation of L-arabinose, D-mannitol, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate and phenylacetic acid are negative. Strain HME9268 (=NIBRBA0000114395) has been isolated from a lagoon sample, Gangneung, Korea.

Description of *Cellulophaga lytica* M-M24

Cells are Gram-staining-negative, non-flagellated and rod-shaped. Colonies are irregular, smooth, glistening and yellow colored after 3 days on MA at 25°C. Oxidase- activity is positive. In the API 20NE strip, esculin hydrolysis and β-galactosidase activity and assimilation of D-glucose, D-mannose, D-mannitol, *N*-acetyl-glucosamine and D-maltose are positive, but nitrate reduction, indole production, glucose fermentation, arginine dihydrolase, urease and gelatinase activities and assimilation of L-arabinose, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate and phenylacetic acid are negative. Strain M-M24 (=NIBRBA0000114319) has been isolated from a sand of seashore, Pohang, Korea.

Description of *Chryseobacterium rhizosphaerae* BM17

Cells are Gram-staining-negative, non-flagellated and coccoid- or oval-shaped. Colonies are Irregular, smooth, convex, glistening and cream yellow colored after 3 days on MA at 30°C. Oxidase- activity is positive. In the API 20NE strip, nitrate reduction, esculin hydrolysis, urease, gelatinase and β-galactosidase activities and assimilation of D-glucose, D-mannose, D-mannitol, D-maltose and trisodium citrate are positive, but indole production, glucose fermentation and arginine dihydrolase activity and assimilation of L-arabinose, *N*-acetyl-glucosamine, potassium gluconate, capric acid, adipic acid, malic acid and phenylacetic acid are negative. Strain BM17 (=NIBRBA0000114306) has been isolated from a tidal flat sample, Wando, Korea.

Description of *Elizabethkingia miricola* JJ9009

Cells are Gram-staining-negative, non-flagellated and rod-shaped. Colonies are circular, convex and beige colored after 2 days of incubation on R2A at 25°C. Oxidase- activity is positive. In the API 20NE strip, indole production, esculin hydrolysis, urease, gelatinase and β-galactosidase activities and assimilation of D-glucose, D-mannose, D-mannitol, *N*-acetyl-glucosamine, D-maltose, malic acid and trisodium citrate are positive, but nitrate reduction, glucose fermentation and arginine dihydrolase activity and assimilation of L-arabinose, potassium gluconate, capric acid, adipic acid and phenylacetic acid are negative. Strain JJ9009 (=NIBRBA0000114160) has been isolated from a fresh water sample, Juwang Mountain, Cheongsong, Korea.

Description of *Lacinutrix himadriensis* HDW 8

Cells are Gram-staining-negative, non-flagellated and rod-shaped. Colonies are irregular, smooth, convex, glistening and strong orange yellow colored after 3 days

on MA at 25°C. Oxidase- activity is positive. In the API 20NE strip, gelatinase activity is positive, but nitrate reduction, indole production, glucose fermentation, esculin hydrolysis, arginine dihydrolase, urease and β-galactosidase activities and assimilation of D-glucose, L-arabinose, D-mannose, D-mannitol, *N*-acetyl-glucosamine, D-maltose, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate and phenylacetic acid are negative. Strain HDW 8 (=NIBRBA0000114317) has been isolated from a sand of seashore sample, Pohang, Korea.

Description of *Maribacter orientalis* HD32

Cells are Gram-staining-negative, non-flagellated and rod-shaped. Colonies are circular, smooth, convex, glistening and yellow colored after 3 days on MA at 30°C. Oxidase- activity is positive. In the API 20NE strip, nitrate reduction, esculin hydrolysis and β-galactosidase activity are positive, but indole production, glucose fermentation, arginine dihydrolase, urease and gelatinase activities and assimilation of D-glucose, L-arabinose, D-mannose, D-mannitol, *N*-acetyl-glucosamine, D-maltose, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate, phenylacetic acid are negative. Strain HD32 (=NIBRBA0000114316) has been isolated from a sand of seashore sample, Pohang, Korea.

Description of *Algoriphagus mannitolivorans* 2013 C56

Cells are Gram-staining-negative, non-flagellated and rod-shaped. Colonies are convex, opaque and orange-colored after 2 days of incubation on MA at 25°C. Oxidase- activity is positive. In the API 20NE strip, glucose fermentation, esculin hydrolysis, arginine dihydrolase, urease and β-galactosidase activities and assimilation of D-glucose, D-mannose and D-maltose are positive, but nitrate reduction, indole production and gelatin hydrolysis and assimilation of L-arabinose, D-mannitol, *N*-acetyl-glucosamine, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate and phenylacetic acid are negative. Strain 2013 C56 (=NIBRBA0000114169) has been isolated from seawater, Yeongdeok, the East Sea, Korea.

Description of *Fluviimonas pallidilutea* HME8520

Cells are Gram-staining-negative, non-flagellated and rod-shaped. Colonies are circular, convex, entire and orange colored after 2 days on R2A at 30°C. Oxidase-activity is positive. In the API 20NE strip, esculin hydrolysis and β-galactosidase activity and assimilation of D-glucose, L-arabinose, D-mannose, *N*-acetyl-glucosamine and D-maltose are positive, but nitrate reduction, indole production, glucose fermentation, arginine dihydrolase, urease and gelatinase activities and assimilation of D-mannitol, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate and phenylacetic acid are negative. Strain HME8520 (=NIBRBA0000114391) has been isolated from a fresh water sample, Yongin, Korea.

Description of *Bacillus algicola* G9-2

Cells are Gram-staining-positive, flagellated and rod-shaped. Colonies are circular, raised, entire and white colored after 2 days on MA at 25°C. In the API 20NE strip, nitrate reduction, esculin hydrolysis, gelatinase and β-galactosidase activities and assimilation of D-mannose, potassium gluconate and malic acid are positive, but indole production, glucose fermentation, arginine dihydrolase and urease activities and assimilation of D-glucose, L-arabinose, D-mannitol, *N*-acetyl-glucosamine, D-maltose, capric acid, adipic acid, trisodium citrate and phenylacetic acid are negative. Strain G9-2 (=NIBRBA0000114358) has been isolated from a tidal flat sample, Taean, Korea.

Description of *Bacillus gibsonii* DT7-08

Cells are Gram-staining-positive, flagellated and coccus-shaped. Colonies are circular, glistening, moist and yellow-colored after 2 days of incubation on TSA at 30 °C. Oxidase- activity is negative. In the API 20NE strip, nitrate reduction, esculin hydrolysis, gelatinase and β-galactosidase activities and assimilation of D-glucose, D-mannose, D-mannitol, D-maltose and malic acid are positive, but indole production, glucose fermentation, arginine dihydrolase and urease activities and assimilation of L-arabinose, *N*-acetyl-glucosamine, potassium gluconate, capric acid, adipic acid, trisodium citrate and phenylacetic acid are negative. Strain DT7-08 (=NIBRBA 0000114189) has been isolated from a plant root sample, Daejeon, Korea.

Description of *Bacillus hunanensis* DT2-01

Cells are Gram-staining-positive, non-flagellated and rod-shaped. Colonies are circular, glistening, moist and beige colored after 2 days of incubation on TSA at 30°C. Oxidase- activity is positive. In the API 20NE strip, nitrate reduction, esculin hydrolysis, urease and β-galactosidase activities and assimilation of D-glucose, L-arabinose, D-mannose, D-mannitol, *N*-acetyl-glucosamine, D-maltose are malic acid are positive, but indole production, glucose fermentation, arginine dihydrolase and gelatinase activities and assimilation of potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate and phenylacetic acid are negative. Strain DT2-01 (=NIBRBA0000114177) has been isolated from a

plant root sample, Daejeon, Korea.

Description of *Bacillus thuringiensis* M4Y-2-1

Cells are Gram-staining-positive, non-flagellated and rod-shaped. Colonies are Circular, entire, rough, convex and yellow colored after 3 days of incubation on MA at 30°C. Oxidase- activity is negative. In the API 20NE strip, nitrate reduction, esculin hydrolysis arginine dihydrolase and gelatinase activities and assimilation of D-glucose, *N*-acetyl-glucosamine and D-maltose, potassium gluconate and malic acid are positive, but indole production, glucose fermentation, urease and β-galactosidase activities and assimilation of L-arabinose, D-mannose, D-mannitol, capric acid, adipic acid, trisodium citrate and phenylacetic acid are negative. Strain M4Y-2-1 (=NIBRBA0000114264) has been isolated from a ginseng soil sample, Anseong, Korea.

Description of *Paenibacillus typhae* JJ9001

Cells are Gram-staining-positive, flagellated and rod-shaped. Colonies are circular, and ivory colored after 2 days on R2A at 25°C. Oxidase- activity is positive. In the API 20NE strip, esculin hydrolysis is positive, but nitrate reduction, indole production, glucose fermentation, arginine dihydrolase, urease, gelatinase and β-galactosidase activities and assimilation of D-glucose, L-arabinose, D-mannose, D-mannitol, *N*-acetyl-glucosamine, D-maltose, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate and phenylacetic acid are negative. Strain JJ9001 (=NIBRBA0000114152) has been isolated from a fresh water sample, Wanju, Korea.

Description of *Paenisporosarcina quisquiliarum* G-M13

Cells are Gram-staining-positive, flagellated and rod-shaped. Colonies are irregular, smooth, glistening, and pale orange yellow colored after 3 days on MA at 25°C. Oxidase- activity is positive. In the API 20NE strip, nitrate reduction, esculin hydrolysis and gelatinase activity are positive, but indole production, glucose fermentation, arginine dihydrolase, urease and β-galactosidase activities and assimilation of D-glucose, L-arabinose, D-mannose, D-mannitol, *N*-acetyl-glucosamine, D-maltose, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate and phenylacetic acid are negative. Strain G-M13 (=NIBRBA0000114315) has been isolated from a sand of seashore sample, Pohang, Korea.

Description of *Fictibacillus nanhaiensis* 2013 C17

Cells are Gram-staining-positive, non-flagellated and straight rod-shaped. Colonies are flat, translucent, glistening and yellow colored after 2 days of incubation on R2A at 25°C. Oxidase- activity is negative. In the API 20NE strip, esculin hydrolysis, urease and gelatinase activities and assimilation of D-glucose, D-maltose, potassium gluconate and malic acid are positive, but nitrate reduction, indole production, glucose fermentation, arginine dihydrolase and β-galactosidase activities and assimilation of L-arabinose, D-mannose, D-mannitol, *N*-acetyl-glucosamine, capric acid, adipic acid, trisodium citrate and phenylacetic acid are negative. Strain 2013 C17 (=NIBRBA0000114165) has been isolated from a freshwater sample, Andong, Korea.

Description of *Staphylococcus hominis* subsp. *novobiosepticus* ST5-08

Cells are Gram-staining-positive, flagellated and coccus-shaped. Colonies are circular, glistening, butyrous, and beige colored after 2 days on TSA at 30°C. Oxidase-activity is negative. In the API 20NE strip, nitrate reduction, and urease activity are positive, but indole production, glucose fermentation, esculin hydrolysis, arginine dihydrolase, gelatinase and β-galactosidase activities and assimilation of D-glucose, L-arabinose, D-mannose, D-mannitol, *N*-acetyl-glucosamine, D-maltose, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate and phenylacetic acid are negative. Strain ST5-08 (=NIBRBA0000114182) has been isolated from a plant root sample, Daejeon, Korea.

Description of *Lactobacillus brevis* WT2K-1

Cells are Gram-staining-positive, non-flagellated and rod-shaped. Colonies are circular, raised, entire and white colored after 2 days of incubation on R2A at 25°C. Oxidase- activity is negative. In the API 20NE strip, glucose fermentation, esculin hydrolysis and β-galactosidase activity and assimilation of D-glucose, L-arabinose and D-mannitol are positive, but nitrate reduction, indole production, arginine dihydrolase, urease and gelatinase activities and assimilation of D-mannose, *N*-acetyl-glucosamine, D-maltose, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate and phenylacetic acid. Strain WT2K-1 (=NIBRBA0000114227) has been isolated from a kimchi sample, Daejeon, Korea.

Description of *Lactobacillus coryniformis* subsp. *torquens* PA4

Cells are Gram-staining-positive, non-flagellated and rod-shaped. Colonies are circular, raised, entire and beige colored after 2 days on R2A at 25°C. Oxidase-activity is negative. In the API 20NE strip, glucose fermentation, esculin hydrolysis and β-galactosidase activity and assimilation of D-glucose, D-mannose, D-mannitol and *N*-acetyl-glucosamine are positive, but nitrate reduction, indole production, arginine dihydrolase, urease

and gelatinase activities and assimilation of L-arabinose, D-maltose, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate and phenylacetic acid are negative. Strain PA4 (=NIBRBA0000114226) has been isolated from a kimchi sample, Daejeon, Korea.

Description of *Lactobacillus harbinensis* EMB6

Cells are Gram-staining-positive, non-flagellated and rod-shaped. Colonies are circular, raised, entire and beige colored after 2 days on R2A at 25°C. Oxidase- activity is negative. In the API 20NE strip, glucose fermentation, esculin hydrolysis and β-galactosidase activity and assimilation of D-glucose and *N*-acetyl-glucosamine are positive, but nitrate reduction, indole production, arginine dihydrolase, urease and gelatinase activities and assimilation of L-arabinose, D-mannose, D-mannitol, D-maltose, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate and phenylacetic acid are negative. Strain EMB6 (=NIBRBA0000114225) has been isolated from a kimchi sample, Daejeon, Korea.

Description of *Lactobacillus pentosus* WT2K-2

Cells are Gram-staining-positive, non-flagellated and rod-shaped. Colonies are circular, raised, entire, and white colored after 2 days on R2A at 25°C. Oxidase-activity is negative. In the API 20NE strip, glucose fermentation, esculin hydrolysis and β-galactosidase activity and assimilation of D-glucose and *N*-acetyl-glucosamine are positive, but nitrate reduction, indole production, glucose fermentation, arginine dihydrolase, urease and gelatinase activities and assimilation of L-arabinose, D-mannose, D-mannitol, D-maltose, potassium gluconate, capric acid, adipic acid, malic acid, trisodium citrate and phenylacetic acid are negative. Strain WT2K-2 (=NIBRBA0000114228) has been isolated from a kimchi sample, Daejeon, Korea.

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