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Research Article

The Mycobiota of Air Inside and Outside the *Meju* Fermentation Room and the Origin of *Meju* Fungi

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Abstract The fungi on *Meju* are known to play an important role as degrader of macromolecule of soybeans. In order to elucidate the origin of fungi on traditional *Meju*, mycobiota of the air both inside and outside traditional *Meju* fermentation rooms was examined. From 11 samples of air collected from inside and outside of 7 *Meju* fermentation rooms, 37 genera and 90 species of fungi were identified. In outside air of the fermentation room, *Cladosporium* sp. and *Cladosporium cladosporioides* were the dominant species, followed by *Cladosporium tenuissimum*, *Eurotium* sp., *Phoma* sp., *Sistotrema brinkmannii*, *Alternaria* sp., *Aspergillus fumigatus*, *Schizophyllum commune*, and *Penicillium glabrum*. In inside air of the fermentation room, *Cladosporium* sp., *Aspergillus oryzae*, *Penicillium chrysogenum*, *Asp. nidulans*, *Aspergillus* sp., *Cla. cladosporioides*, *Eurotium* sp., *Penicillium* sp., *Cla. tenuissimum*, *Asp. niger*, *Eur. herbariorum*, *Asp. sydowii*, and *Eur. repens* were collected with high frequency. The concentrations of the genera *Aspergillus*, *Eurotium*, and *Penicillium* were significantly higher in inside air than outside air. From this result and those of previous reports, the origin of fungi present on *Meju* was inferred. Of the dominant fungal species present on *Meju*, *Lichtheimia ramosa*, *Mucor circinelloides*, *Mucor racemosus*, and *Scopulariopsis brevicaulis* are thought to be originated from outside air, because these species are not or are rarely isolated from rice straw and soybean; however, they were detected outside air of fermentation room and are species commonly found in indoor environments. However, *Asp. oryzae*, *Pen. polonicum*, *Eur. repens*, *Pen. solitum*, and *Eur. chevalieri*, which are frequently found on *Meju*, are common in rice straw and could be transferred from rice straw to *Meju*. The fungi grow and produce abundant spores during *Meju* fermentation, and after the spores accumulate in the air of fermentation room, they could influence mycobiota of *Meju* fermentation in the following year. This could explain why concentrations of the genera *Aspergillus*, *Eurotium*, and *Penicillium* are much higher inside than outside of the fermentation rooms.

Keywords Air, Fungi, *Meju*, Mycobiota, Origin

Meju is the important raw material for traditional Korean *Jangryu* (the singular form, *Jang*) such as *Ganjang*, *Doenjang*, and *Gochujang* [1]. *Jangryu* are useful and important sauces in Korean cuisine. Moreover, *Jangryu* have been reported to have health benefits such as antioxidative activity, antithrombotic effects, cholesterol-lowering effects, mutation suppression effects, and antitumor activities [2]. The taste and quality of *Jangryu* are decided by the *Meju* used to make them [3]. Various microorganisms are associated with *Meju* fermentation, because traditional *Meju* is naturally fermented [3]. In particular, fungi, which produce various enzymes and degrade macromolecules in soybeans, are important microorganisms in *Meju* fermentation [3, 4]. The fungi *Aspergillus oryzae*, *Eurotium chevalieri*, *E. repens*, *Lichtheimia ramosa*, *Mucor circinelloides*, *M. racemosus*, *Penicillium polonicum*, *P. solitum*, and *Scopulariopsis brevicaulis* occur commonly on *Meju* [4-8].

In this study, we investigated the origins of the fungi on traditional *Meju* fermentation. This knowledge would help to control of fungi that are present during *Meju* fermentation, as some fungi on *Meju* are helpful for fermentation, but

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others are simply contaminants or toxigenic [2, 9]. Possible sources of the fungi on traditional *Meju* include rice straw, soybeans, and the air inside and outside the fermentation room. The fungi present on rice straw and soybean have been previously reported [10, 11]. Therefore, the aims of this study are to (1) identify the composition of the mycobiota in the air both inside and outside *Meju* fermentation room; (2) compare it with those of traditional *Meju*, rice straw, and soybeans; and (3) presume the origin of the fungi on traditional *Meju*.

MATERIALS AND METHDOS

Eleven air samples were collected from inside (the fermentation room) and outside (surrounding *Jang* factory) of 7 *Meju* fermentation rooms during November 2011, before starting *Meju* production (Table 1). The samples were collected using a MAS-100 Eco air sampler (Merck, Darmstadt, Germany) with malt extract agar (MEA; for general fungi), dichloran rose bengal chloramphenicol agar (for general enumeration of fungi), dichloran 18% glycerol agar (DG18; for xerophilic fungi), and tryptic soy agar (for the genus *Scopulariopsis*). The air sampler put on the central floor of fermentation room or on the ground outside the *Jang* factory. And, 50 L, 100 L, and 500 L of air were collected from inside of fermentation room and 100 L, 500 L, and 1,000 L of air were collected from the outside of *Jang* factory. The plates were incubated at 25°C in the dark for 3~5 days. The colonies grown on each plate were counted, and the average fungal concentrations of each plate were expressed as colony forming units per cubic meter (CFU/m^3). The fungi grown on media were transferred into new MEA or DG18 media. After incubation for several days, the fungi were examined by light microscope for simple identification, transferred into MEA or DG18 slant for further examination, and then maintained at 4°C.

Molecular and morphological characteristics were used to identify the fungi via methods previously described in Kim *et al.* [11].

RESULTS AND DISCUSSION

As determined from 11 air samples from 7 *Jang* factories, the average concentrations of fungi inside and outside

Table 1. Information about and fungal concentrations of air samples from *Jang* factories

Jang factories			Sampling date	Total fungal concentrations in outside air (CFU/m^3)	Total fungal concentrations in inside air (CFU/m^3)
Label	Geological location	Fermenting room type			
GBC	Gyeongbuk, Chilgok	Room (farm village)	1 Dec 2011	201	2,611
GGI	Gyeonggi, Icheon	Room (farm village)	28 Nov 2011	401	1,425
GGY	Gyeonggi, Yongin	Greenhouse (farm village)	28 Nov 2011	686	-
JBB	Jeonbuk, Buan	Room (fishing village)	29 Nov 2011	50	1,322
JBSd	Jeonbuk, Sunchang	Room (town)	30 Nov 2011	-	1,358
JBSh	Jeonbuk, Sunchang	Yard (town)	30 Nov 2011	1,699	-
JND	Jeonnam, Damyang	Storage (farm village)	29 Nov 2011	1,380	902

Table 2. List of fungal species from air of *Meju* fermentation room with their concentration in air

Fungal species	KACC No.	Sequence No.[a]	Outside air		Inside air	
			No. of factories[b]	Total concentrations[c] (CFU/m^3)	No. of factories[b]	Total concentrations[c] (CFU/m^3)
Acremonium			1	10	-	-
A. implicatum	47372	RDA0043336	1	10	-	-
Alternaria			3	112	2	72
Alternaria sp.	47373	RDA0043364	3	112	2	72
Arthrinium			3	52	2	12
A. sacchari	47374	RDA0043363	3	42	2	12
Arthrinium sp.	47375	RDA0043362	1	10	-	-
Aspergillus			4	156	5	3,274
A. caesiellus	47377	RDA0043360	-	-	1	20
A. creber	47378	RDA0043359	-	-	1	2
A. fumigatus	47379	RDA0043358	2	112	1	2
A. jensenii	47380	RDA0043357	-	-	2	30
A. nidulans	47382	RDA0043355	-	-	1	450
A. niger	47383	RDA0043354	1	3	4	292
A. ochlaceus	47384	RDA0043353	-	-	1	20
A. oryzae	47385	RDA0043352	2	3	4	1,396
A. restrictus	47386	RDA0043351	-	-	1	10
A. sclerotiorum	47387	RDA0043350	1	22	2	70

Table 2. Continued

Fungal species	KACC No.	Sequence No.[a]	Outside air		Inside air	
			No. of factories[b]	Total concentrations[c] (CFU/m³)	No. of factories[b]	Total concentrations[c] (CFU/m³)
A. steynii	47388	RDA0043349	-	-	2	130
A. sydowii	47389	RDA0043348	1	2	3	250
A. tubingensis	47391	RDA0043346	2	3	1	10
A. westerdijkiae	47394	RDA0043343	1	11	-	-
A. versicolor	47392	RDA0043345	-	-	2	160
Aspergillus sp.	47393	RDA0043344	-	-	3	432
Beauveria			1	10	3	50
B. bassiana	47395	RDA0043342	1	10	3	50
Bionectria			1	2	1	12
B. ochroleuca	47396	RDA0043341	1	2	1	2
Bionectria sp.	47397	RDA0043340	-	-	1	10
Bjerkandera			2	20	3	130
B. adusta	47398	RDA0043339	2	20	3	130
Ceriporia			2	11	-	-
C. lacerata	47399	RDA0043338	2	11	-	-
Chaetomium			1	40	2	22
C. globosum	47400	RDA0043337	1	40	2	22
Cladosporium			5	3,426	5	3,000
C. cladosporioides	47402	RDA0043391	1	1,360	2	380
C. pseudocladosporioides	47403	RDA0043390	1	8	-	-
C. tenuissimum	47405	RDA0043388	1	490	1	310
Cladosporium sp.	47404	RDA0043389	5	1,568	5	2,310
Cochliobolus			1	1	2	12
C. miyabeanus	47406	RDA0043387	1	1	1	10
Cochliobolus sp.	47407	RDA0043386	-	-	1	2
Coprinellus			-	-	1	20
C. radians	47408	RDA0043385	-	-	1	10
Coprinellus sp.	47409	RDA0043384	-	-	1	10
Curvularia			1	1	-	-
C. intermedia	47410	RDA0043383	1	1	-	-
Epicoccum			4	31	2	32
E. nigrum	47412	RDA0043381	3	26	2	12
Epicoccum sp.	47413	RDA0043380	1	5	1	20
Eurotium			5	411	5	850
E. chevalieri	47414	RDA0043379	1	30	1	10
E. herbariorum	47415	RDA0043378	2	54	2	280
E. repens	47417	RDA0043376	2	18	3	200
Eurotium sp.			4	309	5	360
Fusarium			5	84	4	120
F. acuminatum	47419	RDA0043374	-	-	1	20
F. asiaticum	47420	RDA0043373	4	43	2	80
F. proliferatum	47422	RDA0043371	1	10	1	20
Fusarium sp.	47421	RDA0043372	2	31	-	-
Irpex			-	-	1	20
I. lacteus	47423	RDA0043370	-	-	1	20
Isaria			-	-	1	20
I. fumosorosea	47424	RDA0043369	-	-	1	20
Lecanicillium			1	10	2	30
L. psalliotae	47425	RDA0043368	1	10	2	30
Lichtheimia			-	-	1	2
Lichtheimia sp.	47426	RDA0043367	-	-	1	2
Microsphaeropsis			1	10	-	-
Microsphaeropsis sp.	47427	RDA0043366	1	10	-	-
Mucor			1	2	2	4
M. circinelloides	47428	RDA0043365	1	2	-	-
M. circinelloides/racemosus	47430	RDA0043434	-	-	1	2
M. racemosus	47431	RDA0043433	-	-	1	2

Table 2. Continued

Fungal species	KACC No.	Sequence No.[a]	Outside air		Inside air	
			No. of factories[b]	Total concentrations[c] (CFU/m^3)	No. of factories[b]	Total concentrations[c] (CFU/m^3)
Penicillium			4	291	5	1,820
P. atramentosum	47432	RDA0043432	-	-	1	10
P. chrysogenum complex	47434	RDA0043430	-	-	2	976
P. citrinum	47435	RDA0043429	-	-	1	20
P. crustosum	47436	RDA0043428	-	-	1	180
P. glabrum	47438	RDA0043426	2	100	3	110
P. glandicola	47439	RDA0043425	1	10	-	-
P. herquei	47440	RDA0043424	1	1	-	-
P. malacaense	47441	RDA0043423	-	-	1	22
P. ochrochloron	47442	RDA0043422	1	90	-	-
P. oxalicum	47443	RDA0043421	-	-	1	10
P. paraherquei	47445	RDA0043419	-	-	1	10
P. paxilli	47446	RDA0043418	1	2	-	-
P. polonicum	47447	RDA0043417	-	-	1	8
P. ramulosum	47448	RDA0043416	-	-	1	2
P. sclerotiorum	47449	RDA0043415	-	-	1	10
P. simplicissimum	47450	RDA0043414	-	-	1	10
P. solitum	47451	RDA0043413	-	-	1	10
P. steckii	47452	RDA0043412	1	30	1	60
P. thomii	47453	RDA0043411	-	-	1	40
P. westlingii	47454	RDA0043410	1	30	-	-
Penicillium sp.			2	28	4	342
Peniophora			-	-	1	40
P. aurantiaca	47455	RDA0043409	-	-	1	40
Periconia			-	-	1	10
Periconia sp.	47457	RDA0043407	-	-	1	10
Pestalotiopsis			1	1	2	22
Pestalotiopsis sp.	47458	RDA0043406	1	1	2	22
Peziza			-	-	1	10
Peziza sp.	47459	RDA0043405	-	-	1	10
Phlebiopsis			-	-	1	20
P. gigantea	47460	RDA0043404	-	-	1	20
Phoma			4	140	3	64
Phoma sp.	47461	RDA0043403	4	140	3	64
Phomopsis			1	8	-	-
Phomopsis sp.	47462	RDA0043402	1	8	-	-
Pichia			-	-	1	110
P. burtonii	47463	RDA0043401	-	-	1	110
Rhizopus			2	3	2	22
R. microsporus	47464	RDA0043400	1	2	-	-
R. stolonifer	47465	RDA0043399	1	1	1	20
Rhizopus sp.	47466	RDA0043398	-	-	1	2
Schizophyllum			2	100	1	20
S. commune	47467	RDA0043397	2	100	1	20
Scopulariopsis			3	25	1	30
S. brevicaulis	47468	RDA0043396	3	25	1	30
Sistotrema			1	120	-	-
S. brinkmannii	47469	RDA0043395	1	120	-	-
Syncephalastrum			-	-	1	10
S. monosporum	47470	RDA0043394	-	-	1	10
Talaromyces			-	-	1	10
Talaromyces sp.	47471	RDA0043393	-	-	1	10

[a]The Rural Development Administration (RDA) numbers are DNA sequence accession numbers from the Korean Agricultural Culture Collection (KACC). Readers can access the sequences at the KACC homepage (http://www.genebank.go.kr) using the corresponding KACC numbers.

[b]The numbers indicates factories from which the species were isolated from 6 (outside air) and 5 (inside air) factories.

[c]The numbers indicates the sum of the maximum concentrations of each factory among concentrations on each media.

Table 3. List of fungi on *Meju* and their isolation frequencies from air of *Meju* fermentation room, rice straw, and soybeans

Scientific name	Incidence on *Meju*[a]	Air of *Meju* fermentation room				Rice straw[b]		Soybeans[c]	
		Outside air		Inside air					
		No. of factoreis[d]	Total concentration (CFU/m³)[e]	No. of factoreis[d]	Total concentration (CFU/m³)[e]	No. of factories	Maximum isolation frequency (%)	No. of factories	Maximum isolation frequency (%)
Aspergillus oryzae	***	2	3	4	1,396	10	31.9	7	7.2
Mucor circinelloides	***	1	2	-	-	1	2.1	-	-
Mucor racemosus	***	-	-	1	2	-	-	-	-
Penicillium polonicum	***	-	-	1	8	5	11.8	4	4.2
Eurotium repens	***	2	18	3	200	9	27.1	6	26.8
Scopulariopsis brevicaulis	***	3	25	1	30	-	-	-	-
Penicillium solitum	***	-	-	1	10	2	0.7	-	-
Eurotium chevalieri	***	1	30	1	10	12	25	3	3.2
Lichtheimia ramosa	***	-	-	-	-	2	1.4	2	3.8
Fusarium asiaticum	**	4	43	2	80	11	56.3	1	0.2
Penicillium paneum	**	-	-	-	-	-	-	-	-
Eurotium amstelodami	**	-	-	-	-	7	15.3	1	0.2
Aspergillus niger	**	1	3	4	292	7	9.7	-	-
Penicillium roqueforti	**	-	-	-	-	-	-	1	0.2
Paecilomyces variotii	**	-	-	-	-	-	-	-	-
Cladosporium tenuissimum	**	1	490	1	310	1	6.9	2	23.8
Rhizopus stolonifer	**	1	1	1	20	1	0.7	-	-
Eurotium herbariorum	**	2	54	2	280	5	22.9	8	44
Penicillium crustosum	**	-	-	1	180	-	-	-	-
Penicillium bialowiezense	**	-	-	-	-	-	-	-	-
Eurotium rubrum	**	-	-	-	-	5	16	3	3.8
Lichtheimia corymbifera	**	-	-	-	-	3	13.9	1	0.2
Aspergillus acidus	**	-	-	-	-	-	-	-	-
Aspergillus tamarii	**	-	-	-	-	1	5.6	-	-
Aspergillus fumigatus	**	2	112	1	2	3	4.2	1	0.2
Aspergillus flavus	**	-	-	-	-	2	3.5	-	-
Rhizopus delemar	**	-	-	-	-	-	-	-	-
Scopulariopsis candida	**	-	-	-	-	-	-	-	-
Cladosporium cladosporioides	**	1	1,360	2	380	10	48.6	1	9
Lichtheimia ornata	**	-	-	-	-	-	-	-	-
Aspergillus tubingensis	**	2	2	1	10	10	37.5	2	0.8
Rhizomucor pusillus	**	-	-	-	-	1	1.4	-	-
Mucor mucedo	**	-	-	-	-	-	-	-	-
Aspergillus nidulans	**	-	-	1	450	7	8.3	1	0.4
Penicillium commune	**	-	-	-	-	-	-	-	-
Penicillium palitans	**	-	-	-	-	-	-	-	-
Aspergillus sydowii	**	1	2	3	220	4	4.9	4	3.4
Monascus ruber	**	-	-	-	-	-	-	-	-
Geotrichum silvicola	**	-	-	-	-	-	-	-	-
Aspergillus versicolor	**	-	-	2	160	2	6.3	4	5.6
Neurospora intermedia	**	-	-	-	-	-	-	-	-
Aspergillus ochlaceus	**	-	-	1	20	3	4.2	4	2.6
Fusarium sp.	**	2	31	-	-	9	5.6	5	12.8
Penicillium chrysogenum	**	-	-	2	976	1	0.7	2	1.2
Mucor lusitanicus	**	-	-	-	-	-	-	-	-
Rhizopus oryzae	**	-	-	-	-	2	4.9	-	-
Epicoccum nigrum	**	3	26	2	12	3	14.6	1	0.2
Eurotium echinulatum	**	-	-	-	-	1	2.8	3	0.8
Fusarium cf. *incarnatum*	*	-	-	-	-	4	11.1	2	2.2
Fusarium graminiarum	*	-	-	-	-	-	-	-	-
Mucor hiemalis	*	-	-	-	-	-	-	-	-
Penicillium brevicompactum	*	-	-	-	-	2	1.4	-	-

Table 3. Continued

Scientific name	Incidence on *Meju*[a]	Air of *Meju* fermentation room				Rice straw[b]		Soybeans[c]	
		Outside air		Inside air					
		No. of factoreis[d]	Total concentration (CFU/m^3)[e]	No. of factoreis[d]	Total concentration (CFU/m^3)[e]	No. of factories	Maximum isolation frequency (%)	No. of factories	Maximum isolation frequency (%)
Aspergillus cibarius	*	-	-	-	-	-	-	1	0.8
Cladosporium velox	*	-	-	-	-	2	3.5	-	-
Syncephalastrum racemosum	*	-	-	1	10	2	3.5	1	0.2
Aspergillus candidus	*	-	-	-	-	-	-	-	-
Eurotium tonophilum	*	-	-	-	-	-	-	1	4
Penicillium coprohilum	*	-	-	-	-	-	-	-	-
Penicillium steckii	*	1	30	1	60	4	14.6	5	6.6
Trichosporon sp.	*	-	-	-	-	-	-	-	-
Aspergillus parasiticus	*	-	-	-	-	-	-	-	-
Cladosporium sphaerospermum	*	-	-	-	-	1	0.7	1	0.2
Paecilomyces formosus	*	-	-	-	-	-	-	-	-
Penicillium expansum	*	-	-	-	-	-	-	2	0.6
Penicillium oxalicum	*	-	-	1	10	1	1.4	1	4
Chaetomium cruentum	*	-	-	-	-	-	-	-	-
Fusarium acuminatum	*	-	-	1	20	1	4.2	-	-
Penicillium carneum	*	-	-	-	-	-	-	-	-
Penicillium cyclopium	*	-	-	-	-	-	-	1	0.4
Phycomyces blakesleanus	*	-	-	-	-	-	-	-	-
Cladosporium varians	*	-	-	-	-	-	-	-	-
Allantophomopsis cf. *lycopodina*	*	-	-	-	-	-	-	-	-
Alternaria sp.	*	3	112	2	72	6	5.6	7	12
Arthrinium phaeospermum	*	-	-	-	-	3	2.1	1	3.8
Aspergillus tritici	*	-	-	-	-	-	-	-	-
Aspergillus westerdijkiae	*	1	11	-	-	3	6.3	3	6
Botryotinia fuckeliana	*	-	-	-	-	-	-	-	-
Botrytis sp.	*	-	-	-	-	-	-	1	0.2
Chaetomium sp.	*	-	-	-	-	3	4.9	2	0.6
Cladosporium funiculosum	*	-	-	-	-	-	-	-	-
Cladosporium fusiforme	*	-	-	-	-	1	0.7	-	-
Cladosporium perangustum	*	-	-	-	-	-	-	-	-
Fusarium fujikuroi	*	-	-	-	-	5	9	5	19.6
Fusarium thapsinum	*	-	-	-	-	-	-	-	-
Geotrichum sp.	*	-	-	-	-	-	-	-	-
Lichtheimia hyalospora	*	-	-	-	-	-	-	-	-
Mucor fragilis	*	-	-	-	-	-	-	-	-
Mucor irregularis	*	-	-	-	-	-	-	-	-
Neurospora sitophila	*	-	-	-	-	-	-	-	-
Penicillium chermesinum	*	-	-	-	-	-	-	-	-
Penicillium glabrum	*	2	100	3	110	2	0.7	-	-
Penicillium griseofulvum	*	-	-	-	-	-	-	-	-
Penicillium hispanicum	*	-	-	-	-	2	4.2	-	-
Penicillium nordicum	*	-	-	-	-	-	-	-	-
Penicillium olsonii	*	-	-	-	-	-	-	-	-
Phoma sp.	*	4	140	3	64	6	13.9	5	1.8
Streptobotrys cf. *streptothrix*	*	-	-	-	-	-	-	-	-
Ulocladium sp.	*	-	-	-	-	-	-	-	-

[a]The species were isolated from *Meju*, with ***high frequency, **medium frequency, or *low frequency.

[b]The number of factories indicates factories from which the species were isolated from 12 factories. Maximum isolation frequency indicates maximum isolation frequency (among 144 pieces of rice straw) among 9 different isolation conditions [8].

[c]The number of factories indicates factories from which the species were isolated from 10 factories. Maximum isolation frequency indicates maximum isolation frequency (among 500 kernels) of untreated soybeans among 3 different media [9].

[d]The number indicates factories from which the species were isolated from 6 (outside air) and 5 (inside air) factories.

[e]The numbers indicate the sum of the maximum concentrations of each factory among concentrations on each media.

Meju fermentation rooms were 1,524 CFU/m^3 and 736 CFU/m^3 (Table 1), respectively, and they were identified into 37 genera and 90 species (Table 2). The fungal concentration in inside air of *Meju* fermentation room is similar or lower than that of green area in Seoul, Korea (average, 1,892 CFU/m^3 in winter) [12] and is similar to that of low clean zone of other food product manufacturing plants (average, 2,600 CFU/m^3) [13]. In this study, there was no significant difference of mycobiota according to *Jang* factories.

In the 6 outside air samples, 27 genera and 50 species were found (Table 2). The concentration of the genus *Cladosporium* was significantly high, followed by those of *Eurotium*, *Penicillium*, *Aspergillus*, *Sistotrema*, and *Schizophyllum* were followed (Table 2). *Cla. cladosporioides* and *Cladosporium* sp. were the dominant species, followed by *Cla. tenuissimum*, *Eurotium* sp., *Sistotrema brinkmannii*, *Asp. fumigatus*, *Schizophyllum commune*, *Phoma* sp., and *Alternaria* sp. However, *Cla. tenuissimum*, *Sis. brinkmannii*, *Asp. fumigatus*, and *Sch. commune* were detected only in 1 or 2 factories. In addition, almost all the other fungi except *Arthrinium sacchari*, *Epicoccum nigrum*, and *S. brevicaulis*, which were detected in 3 *Jang* factories, were also detected only in 1 or 2 factories.

Of the 32 genera and 72 species from the 5 inside air samples, the genus *Aspergillus*, *Cladosporium*, *Penicillium*, and *Eurotium* were collected with high concentrations (Table 2). *A. oryzae* and *Cladosporium* sp. were the dominant species and were detected in 5 and 4 factories, respectively. In addition, *Pen. chrysogenum* (found in 2 factories), *C. cladosporioides* (2), *Asp. niger* (4), *Eur. herbariorum* (2), *Aspergillus* sp. (3), *Penicillium* sp. (4), and *Asp. sydowii* (3) were frequently detected in inside air of the fermentation rooms. Although *Eur. repens*, *Pen. glabrum*, *Phoma* sp., *Bjerkandera adusta*, and *Beauveria bassiana* were infrequently detected in inside air of the fermentation rooms, they were detected in 3 factories. The other species detected in inside air samples were detected in only 1 or 2 factories.

The mycobiota of outside and inside air of the fermentation rooms differed (Table 2), and fungi detected from inside air were more diverse. Seventy-two species were detected from the inside air, whereas 50 species were detected from the outside air. The species belong to the genus *Alternaria*, *Arthrinium*, *Chaetomium*, *Cladosporium*, *Phoma*, and *Schizophyllum* were present in higher concentrations in outside air than in inside air. In particular, *Alternaria*, *Arthrinium*, and *Cladosporium* were significantly higher. Therefore, these fungi present in the inside air may have come in from outside when the inside air was ventilated. However, many fungi belonging to the genus *Aspergillus*, *Penicillium*, and *Eurotium* were frequently detected in inside air but were rarely or not detected in outside air. These observations indicate that these fungi were not influenced by the outside mycobiota but may have been influenced by previous *Meju* fermentation, because they frequently occurred on *Meju*.

The species, *Asp. oryzae*, *M. circinelloides*, *M. racemosus*, *Pen. polonicum*, *Eur. repens*, *Scopulariopsis brevicaulis*, *Pen. solitum*, *Eur. chevalieri*, and *L. ramosa* were the main species from *Meju* (Table 3). *A. oryzae*, *P. polonicum*, *E. repens*, *P. solitum*, *E. chevalieri*, and *F. asiaticum* are detected on rice straw with high frequency but are rarely isolated from outside air of *Jang* factories. Therefore, most of these could be transferred from rice straw to *Meju*, and they grow and produce abundant spores during *Meju* fermentation, and then as their spores would accumulated inside air of fermentation room, they could influence mycobiota of *Meju* fermentation in the following year. This could explain why concentrations of *Aspergillus*, *Eurotium*, and *Penicillium* in inside air of *Meju* fermentation room is much higher than those of outside air.

Lichtheimia ramosa, *M. circinelloides*, *M. racemosus*, and *S. brevicaulis* were rarely or not detected in rice straw and soybean. However, they were detected from outside air of *Meju* fermentation room, although their frequencies were not high, and they are generally known as common fungi in indoor environments [14]. Therefore, *L. ramosa*, *M. circinelloides*, *M. racemosus*, and *S. brevicaulis* on *Meju* might originate from outside (or inside) air of *Meju* fermentation room.

In this study, all main species on *Meju* except *L. ramosa* were detected both inside and outside of fermentation room. However, *L. ramosa* is usually known as an indoor fungus [14]. After all, *Meju* could be provided with almost fungi from air in and out *Meju* fermentation room, which is used for *Meju* fermentation for more than one time.

Rice straw comes into direct contact with soybeans in *Meju*, and so the fungi on rice straw can move to *Meju* and grow on it. Therefore, this has a great influence on *Meju* mycobiota. Rice straw could provide *Meju* with useful fungi for fermentation but also could provide unwanted fungi such as *Fusarium asiaticum*. Traditional *Meju* fermentation is composed of drying at a low temperature (low temperature fermentation process) and fermenting at a high temperature and humidity (high temperature fermentation process) [4]. *F. asiaticum* usually originates from rice straw and grows on it during fermentation at low temperatures. Therefore, in order to avoid contamination of *F. asiaticum*, a method could be developed to use rice straw only during high temperature fermentation. Without rice straw, *Meju* might be provided with main fungi from both inside and outside of *Meju* fermentation room during the low temperature fermentation process, if the fermentation room is used for *Meju* fermentation more than once.

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