QUALITY CHARACTERISTICS AND LACTIC ACID BACTERIA DIVERSITY OF PORK SALAMI CONTAINING KIMCHI POWDER

Ji-Yeol Yoon, Dongwook Kim, Juae Gil, Hee-Jin Kim, Sung-Ki Lee, Aera Jang

Program of Animal Products and Food Science, Kangwon National University, 200-701 Chuncheon, Korea

Abstract –This study was conducted to identify properties and lactic acid bacteria diversity of pork salami containing kimchi powder (KPS). The pork salami was manufactured with treatments of commercial starter culture (Control), 1% (KPS1), 3% (KPS3), 5% (KPS5) kimchi powder. The moisture contents of all pork salami samples were decreased during ageing, and those of KPS were high than control. The pH of pork salami containing kimchi powder significantly decreased with the addition of kimchi powder. The water activities of pork salamis were decreased during ageing periods. The addition of kimchi powder to the pork salamis decreased hardness value. The result demonstrated that counts of lactic acid bacteria (LAB) and total microorganisms were increased as concentration of kimchi powder was increased. *E. coli* and *coliforms* were not detected. *Lactobacillales* ratios of KPS (maximum 29.15-31.97%) were higher than control (maximum 8.32%). *Leuconostoc* ratio of KPS was high than control, and that of KPS1 (8.38-40.45%) was the highest among all samples. This study shows that addition of kimchi powder to pork salamis can improve quality of pork salami, and provide potential as natural starter culture, particularly, KPS1 most beneficial to pork salami.

Key Words – Kimchi, Pork salami, Lactic acid bacteria

I. INTRODUCTION

In these days, scientists have found that the fermented meat products contain bioactive substance. Fermented sausages, traditional food of Europe, are made from fermentation of lactic acid bacteria (LAB), which are produced under controlled temperature and relative humidity [4]. The typical characteristics of fermented sausages are formed by biochemical and physical changes that occur during fermentation and ageing [3], [10]. *Kimchi*, traditional fermented food of Korea, is one of the most popular side dish which is manufactured from the addition of various components including green onion, red pepper, ginger, garlic, fermented shrimp or fish and so on. Main microbial species of kimchi are *Leuconostoc mesenteroides*, *Lactobacillus plantarum* and *Lacbacillus brevis*. Among this species, *Leuconostoc mesenteroides* was mainly involved in initial fermentation, and produced lactic acid and carbon dioxide [7], [11]. LAB is the most important in meat fermentation, since these microorganisms are used all kinds of sausages that are to be fermented [8]. The objectives of the present study were to evaluate the effect of kimchi on the fermented sausages, and to investigate quality characteristics and microbial community, especially LAB.

II. MATERIALS AND METHODS

The pork salamis were manufactured with commercial starter culture, 1% kimchi powder (KPS1), 3% kimchi powder (KPS3) and 5% kimchi powder (KPS5). The compositional properties were conducted according to methods of AOAC [1]. The pH and water activity (a_w) were measured by using pH meter (Orion 230A, USA) and Aquaspector (AQS-2-TC, NAGY, Germany). Texture profile analysis was conducted at room temperature with a Texture Analyzer (TA-1, LLOYD instruments, USA). To analyze LAB counts, a total of 10 g from each sample was homogenized in 90 ml 0.1% peptone water for 4 min in a Stomacher (Bag Mixer 400; Interscience, France). Next to 10-fold serial dilutions, 100 μl samples of appropriate dilutions were spread on the Lactobacilli MRS agar (Difco Laboratories, USA). Total microorganisms and E.coli/Coliform were measured by using petrifilm (Aerobic count plate, Coliform count Plate, 3M, USA). All of plates and petrifilms were incubated at 37℃ for 48h. To identify LAB diversity, DNA was extracted from pork salami and kimchi-powder as per the method described by soil DNA kit

(Macherey-Nagel GmbH & Co. KG, Germany). According to method of Takara Ex taq (Takara, Japan), 16S rRNA genes of extracted DNA were amplified by using Trio-thermoblock thermocycler (Biometra, Goettingen, Germany). PCR products were sequenced by using Miseq sequencer system (Illumina, USA). All of treatments were analyzed by General Linear Model (GLM) procedure of SAS software ($p<0.05$).

III. RESULTS AND DISCUSSION

The moisture contents of all pork salami samples were decreased during ageing. Also, drying speed of all KPS retarded with increase of kimchi powder concentration. (data not shown). The pH values of all treatments were decreased significantly during fermentation (Table 1). The pH values of pork salami varied from 5.62-5.71 to 4.41-4.60 with the lapse of ripening time. The pH values of all samples were rapidly decreased to 4.70-4.85 by day 3, to 4.53-4.75 by day 7, and maintained during ageing periods. Mugerza, Fista, Ansorena, Astiasaran, & Bloukas [9] found a similar change of pH in fermented sausages with 10, 20 and 30% pork back fat. The pH value of the KPS was lower than that of control, and ranged from 4.41 to 4.51 at day 56. Of these results, the pH value of KPS5 was the highest. These results show that the higher the concentration of kimchi powder, the lowered the pH value of pork salami. The water activity (a_W) of the pork salami samples was maintained prior to the fourteenth day of production in all treatment (data not shown). But, from the fourteenth day to the 56rd day, A_W values declined to approximately 0.82 in the control and to 0.83 in KPS.

Table 1 The changes in pH of pork salami formulated with different concentration of kimchi powder

Time (days)	Treatments 1)			
	Con	KPS1	KPS3	KPS5
0	5.71± 0.010^{ABa}	5.74± 0.009^{Ab}	5.68± 0.020^{Bb}	5.62± 0.007^{Cb}
1	5.72± 0.000^{Da}	5.88± 0.009^{Aa}	5.86± 0.003^{Ba}	5.76± 0.000^{Ca}
2	5.03± 0.012^{Cb}	5.15± 0.013^{Ac}	5.07± 0.003^{Bc}	5.14± 0.007^{Ac}
3	4.85± 0.003^{Ac}	4.75± 0.000^{Bd}	4.70± 0.000^{Dd}	4.73± 0.003^{Cd}
5	4.84± 0.007^{Ad}	4.65± 0.003^{Be}	4.64± 0.003^{Ce}	4.62± 0.006^{De}
7	4.75± 0.007^{Ae}	4.60± 0.003^{Bf}	4.53± 0.003^{Cf}	4.53± 0.003^{Cf}
14	4.69± 0.003^{Af}	4.61± 0.003^{Bf}	4.53± 0.003^{Cfg}	4.52± 0.003^{Cfg}
21	4.66± 0.000^{Ag}	4.54± 0.012^{Bg}	4.51± 0.003^{Cg}	4.50± 0.012^{Cgh}
28	4.64± 0.003^{Ag}	4.51± 0.012^{Bh}	4.51± 0.006^{Bg}	4.48± 0.015^{Bi}
35	4.65± 0.003^{Ag}	4.50± 0.003^{Bh}	4.44± 0.003^{Ci}	4.49± 0.003^{Bhi}
42	4.65± 0.000^{Ag}	4.52± 0.003^{Bgh}	4.47± 0.006^{Dh}	4.50± 0.003^{Cghi}
49	4.51± 0.003^{Ai}	4.38± 0.003^{Bi}	4.35± 0.000^{Dk}	4.36± 0.007^{Ck}
56	4.60± 0.006^{Ah}	4.51± 0.003^{Bh}	4.42± 0.003^{Cj}	4.41± 0.009^{Cj}

$^{A-D}$Mean±SE within same column with different superscript letters significantly at $p<0.05$.
$^{a-j}$Mean±SE within same row with different superscript letters significantly at $p<0.05$.
1) Con – Control; KPS1– pork salami containing 1% kimchi powder; KPS3– pork salami containing 3% kimchi powder; KPS5– pork salami containing 5% kimchi powder

Hardness values of all samples were also increased during ageing period, those of all samples were 3.0-4.4 kgf at day 7 and 8.3-12.5 kgf at day 56 (Table 2). However, the hardness values of KPS were low as concentration of kimchi powder increased. The KPS with high kimchi powder concentration showed high moisture contents and Aw values. This may due to high moisture absorption capacity of KPS and the capacity of KPS was enhanced with increase of kimchi powder concentration. Several studies presented that *Leuconostoc* produce dextran which has moisture absorption capacity [6], [12]. According to these studies, it can be explained that the reason why low hardness value of KPS was due to dextran produced by *Leuconostoc*.

Table 2 Hardness of pork salami formulated with different concentrations of kimchi powder (unit:kgf)

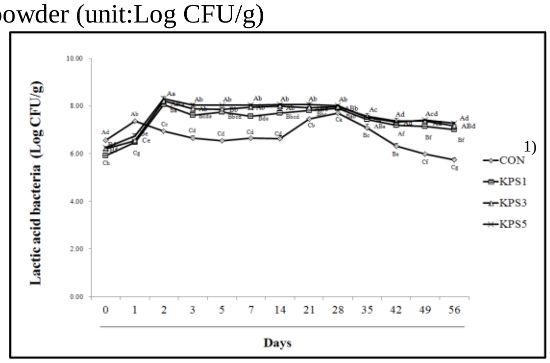
Time (days)	Treatments			
	Con	KPS1	KPS3	KPS5
7	4.4± 0.11^{Ah}	3.5± 0.14^{Bf}	3.4± 0.08^{BCg}	3.0± 0.18^{Cc}
14	5.3± 0.08^{Ag}	5.3± 0.15^{Ae}	4.7± 0.14^{Bf}	3.6± 0.06^{Cc}
21	6.0± 0.09^{ABf}	6.2± 0.13^{Ad}	5.7± 0.05^{Be}	4.9± 0.16^{Cb}
28	7.1± 0.09^{Ae}	6.9± 0.08^{Ac}	6.3± 0.12^{Bd}	5.2± 0.28^{Cb}
35	9.2± 0.16^{Bd}	10.5± 0.15^{Aab}	9.0± 0.18^{BCb}	8.6± 0.13^{Ca}
42	10.7± 0.26^{Ac}	10.0± 0.32^{Ab}	8.9± 0.21^{Bbc}	8.2± 0.22^{Da}

49	11.4± 0.17Ab	10.6± 0.17Da	8.4± 0.27Cc	8.7± 0.25Ca
56	12.5± 0.15Aa	10.5± 0.24Bab	11.1± 0.23Ba	8.3± 0.21Ca

A-CMean±SE within same column with different superscript letters significantly at $p<0.05$.
a-hMean±SE within same row with different superscript letters significantly at $p<0.05$.
1) Refer to Table 1

LAB counts of control were higher than those of kimchi powder samples at day one (Fig. 1). After that, LAB counts were significantly higher in KPS than in control. The high water content of Kimchi facilitated the growth of microorganisms, which contributed to catabolism of amino acids and proteolysis as well as the degradation of lactic acid [4]. The LAB counts of kimchi powder samples were attained maximum levels (8.05-8.31 Log CFU/g) at day 2. LAB counts of all pork salami samples which increased by about 2 log cycles and maintained during 4 weeks. LAB counts of control were 7.71 Log CFU/g, and those of KPS1, KPS3 and KPS5 were 7.89, 7.97, 8.02 Log CFU/g, respectively at day 28. Thereafter, LAB of all pork salami samples was rapidly decreased until the end of ageing periods. These results showed that LAB counts were increased with increase of kimchi powder concentration. The total microorganisms were increased or maintained in all pork salami samples during ageing periods (data not shown). These results indicate that LAB counts are similar to the total microorganisms. *E. coli* and *coliforms* counts were not detected in all pork salami samples at 0-56 days (data not shown).

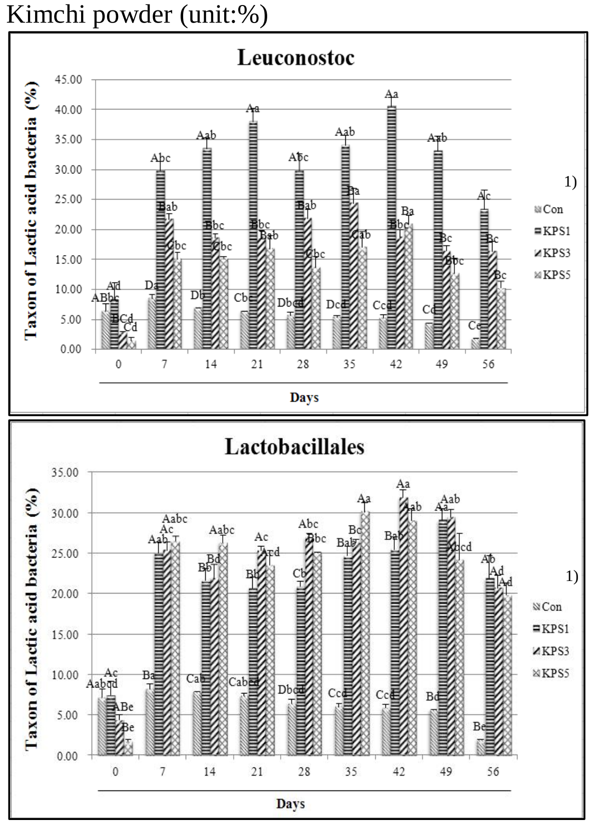
Figure 1. Number of lactic acid bacteria during fermentation and ageing in pork salami with kimchi powder (unit:Log CFU/g)



A-CValues of bar with different letters during ageing differ significantly at $p< 0.05$
a-fValues of bar with different letters among treatments differ significantly at $p< 0.05$
1) Refer to Table 1

The changes in taxa of 16S rRNA genes of LAB in pork salami samples are shown in Fig. 2. The ratios of order *Lactobacillales* were significantly higher in KPS than in control during ageing. Order *Lactobacillales* contains genus *Lactobacillus*. One study shows that the fermented lamb sausage inoculated probiotic *Lactobacillus plantarum* has soft texture and was improved quality [2]. The ratios of genus *Leuconostoc* in KPS were rapidly increased at day 7, and were significantly higher than control. The genus *Leuconostoc* in KPS1 showed the highest ratio, which ranges from 8.38 to 40.45%, and also kimchi powder itself showed the highest genus *Leuconostoc* ratio (22.53%). *Leuconostoc* are regarded as important for the development of flavor and specific taste in fermented sausage since they produce other metabolites such as lactic acid, acetic acid, dextran, acetaldehyde, diacetyl and ethanol [5], [8]. Judging by this study, KPS is more effective than control because of high ratio of *Leuconostoc*. Also, KPS1 is most effective because that has the highest ratio of *Leuconostoc*.

Figure 2. Changes in taxa of 16S rRNA genes of pork salami formulated with different concentrations of Kimchi powder (unit:%)



[A-D]Values of bar with different letters during ageing differ significantly at $p < 0.05$
[a-d]Values of bar with different letters among treatments differ significantly at $p < 0.05$
[1)] Refer to Table 1

IV. CONCLUSION

As a result, the addition of kimchi powder in fermented sausages decreased pH value and Aw value, and increased LAB and total microorganism counts compare with control. The ratios of *Leuconostoc* and *Lactobacillales* were higher in KPS1, KPS3 and KPS5 than in control. According to these result, we know that major microorganism of kimchi is *Leuconostoc*. In conclusion, the use of kimchi powder in pork salami could improve functionality and quality characteristics of fermented sausages, and also adding 1% kimchi powder was the most effective to make pork salami.

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