J. Food Sci. Nutr.
Vol. 1, No. 1, p. 30~36(1996)

A Study on Wooung(Burdock, *Arctium lappa*, L) Kimchi

–Changes in Chemical, Microbial, Sensory Characteristics and Volatile Flavor Components in Wooung Kimchi during Fermentation–

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Abstract

This study was conducted to investigate the changes in chemical, microbial, sensory characteristics and volatile flavor components of wooung(burdock, *Arctium lappa*, L) kimchi during fermentation at 15°C. Three types(A, B, C) of wooung kimchi were prepared. Sample A was prepared with basic ingredients, on the other hand, sample B was prepared with all sorts of ingredients. These samples were mixed after salting the sliced burdock with 4% brine for 30min. Sample C was prepared mixing with all sorts of ingredients after blanching the sliced burdock with 2% vinegar solution. pH decreased slowly until 3 days, and then decreased rapidly for 4~7 days in all samples. Total acidity increased gradually in all samples. The changes of pH and total acidity were the smallest in sample C and were the greatest in sample B. The reducing sugar contents decreased slowly until 7 days, and then decreased rapidly for 8~14 days in sample B and C. The numbers of lactic acid bacteria and total bacteria reached maximum value at 14 days in sample A and B, and at 10 days in sample C, respectively. The numbers of lactic acid bacteria and total bacteria of sample B were much greater than those of other samples. In sensory evaluation, sample B exhibited the best scores and sample C showed the worst scores in all characteristics. The major volatile components in wooung kimchi were identified as ethanol, hexanal, 2-hexenal, disulfide di-2-prophenyl, zingiberene and β-sesquiphellandrene. The relative amounts of hexanal, 1-hexanol and ethanol were decreased, while the relative amounts of acetic acid ethyl ester, 3-hydroxy-2-butanone and acetic acid were increased gradually during fermentation.

Key words: wooung(burdock, *Arctium lappa*, L) kimchi, fermentation, chemical, sensory characteristics, volatile flavor component

INTRODUCTION

Burdock(wooung in Korean) recommended traditionally as the diuretic and diabetic remedy is rich in inulin and potassium content, and has the unique flavor and taste(1,2). The desmutagenic factor of burdock, which was shown to be a complex polymer having a molecular weight of about 300,000, was reported not a protein because of the low content of nitrogen and the non-color reaction of its hydrolysate with ninhydrin, but a lignin-like compound having a 10% sugar content (3-5). Burdock is mainly cultivated in Jinju city area of Korea and used as a main source of special kimchi and other dishes(2).

Kimchi is a traditional unique fermented vegetable product in Korea. The kinds of kimchi may count up to more than 180 varieties depending on the use of raw materials and processing methods, and also on the season and locality of the preparation(6-8). In these various kimchi, wooung kimchi is the traditional special kimchi in Kyungsang province, southern part of Korea, adding various condiments such as red pepper powder, fermented anchovy juice, crushed garlic and crushed ginger to the sliced burdock(9,10). Although many studies have been conducted on the kimchi, most of them were focused on baechu(Chinese cabbage) kimchi. There has little been reported on quality characteristics during fermentation of wooung kimchi.

Three different preparation methods of wooung kimchi were chosen through the survey in Kyungsang province and using the literatures including cooking books(9). In order to investigate quality characteristics of wooung kimchi and differences of fermented characteristics among its three different preparation meth-

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ods, the changes of reducing sugar, pH, total acidity, lactic acid bacteria counts, total bacteria counts, sensory evaluation and volatile flavor components were determined during the fermentation at 15°C.

MATERIALS AND METHODS

Wooung and wooung kimchi preparation

Burdock(*Arctium lappa*, L, wooung), red pepper powder, fermented anchovy juice, garlic, ginger, glutinous rice, green thread onion, sesame, salt and vinegar were purchased from Agricultural Cooperative Association and Onchun market in Pusan, Korea, in July, 1995. The burdock was cut diagonally into 1mm thick, and three types(A, B, C) of wooung kimchi were prepared. Ingredients ratio of burdock kimchi was standardized data reported in the previous paper(9). After salting the sliced burdock(100%) with 4% brine for 30min, sample A was mixed with basic ingredients of red pepper powder(6.8%), fermented anchovy juice(15.1%), crushed garlic(5.7%) and crushed ginger(2.2%), and sample B was prepared with the above basic ingredients(29.8%), pluse glutinous rice paste(18.0%), chopped green thread onion (13.5%) and sesame(1.2%). After blanching the sliced burdock(100%) with 2% vinegar water for 1min, sample C was made with the basic ingredients(29.8%), plus glutinous rice paste(18.0%), chopped green thread onion (13.5%) and sesame(1.2%). The initial salt contents of sample A, B and C were adjusted to 2.8% with fermented anchovy juice. The prepared wooung kimchi was put into pint jars, the stuff pushed down, and the lid closed tightly, and then fermented for 21 days at 15°C, which was the suitable temperature in the fermentation of wooung kimchi as a result of the preliminary test.

Determination of pH and acidity

The samples from each jar were blended using stomacher(Seward Medical London SE1) and filtered by sterilized gauze. The pH of the filtrate was measured using a pH meter. The acidity was determined by the method of AOAC(11). Phenolphthalein solution(0.1%) was dropped to the kimchi filterate and titrated with 0.1N NaOH and the lactic acid content calculated and expressed as the acidity(%).

Determination of reducing sugar

In order to analyze the content of reducing sugar, 100ml of distilled water was added to the filterate, added to the Fehling solution, heated and then cooled. The amount of reducing sugar was determined by the method of Schoorl(12) using titration with 0.1N $Na_2S_2O_3$ standard solution. All determinations were triplicated.

Microbial analysis

For the enumeration of lactic acid bacteria, 1ml of sample juice was diluted with sterilized saline solution, a MRS medium was used. The lactic acid bacteria were incubated for 2 days at 37°C, and then were counted by the pour plate method(13). For total bacteria count, 1ml of sample juice was diluted with sterilized saline solution and plate count agar(PCA) medium was used. The plates were incubated for 2 days at 37°C.

Sensory evaluation

Sensory evaluations were judged by 7 trained panelist(graduate students in Dept. of Food Science & Nutrition). Characteristics of wooung kimchi were appearance, odor, taste, texture and overall acceptability using a five point scale test(14). Sensory scores were statistically analyzed according to the one way ANOVA and Duncan's multiple range test(15).

Preparation and analysis of volatile flavor components

A volatile concentrate of wooung kimchi was obtained by the simultaneous steam distillation-ether extraction method(16). Steam distillation of a 150g homogenized sample in a 10 liter glass vessel was performed for 1 hour under atmospheric pressure. The steam distillate was simultaneously extracted with diethyl ether. The ether extract of the volatiles of wooung kimchi was dehydrated with anhydrous sodium sulfate, concentrated under atmospheric pressure, then subjected to GC and GC/MS analysis. The volatile flavor components were analyzed by HP 5890A Mass Spectrometer connected with HP 5890 Series II Gas Chromatograph. The ionization voltage was 70eV and ion source temperature kept at 200°C. FFAP column(50m×0.2mm ×0.33μm) was used. The oven temperature was programmed from 60°C to 230°C at a rate of 2°C/min and the injection port temperature was 240°C. Helium was used as the carrier gas at a flow rate of 1.0ml/min with a split ratio of 1 : 50.

RESULTS AND DISCUSSION

Chemical changes during wooung kimchi fermentation

Fig. 1 showed the changes of pH during fermentation of wooung kimchi at 15°C. The pH decreased slowly until 3 days, and then decreased rapidly for 4~7 days in all samples. The initial pH of sample C was lowest due to blanching with vinegar solution. The changes of pH were the smallest in sample C and were the greatest in sample B. The optimum ripened wooung

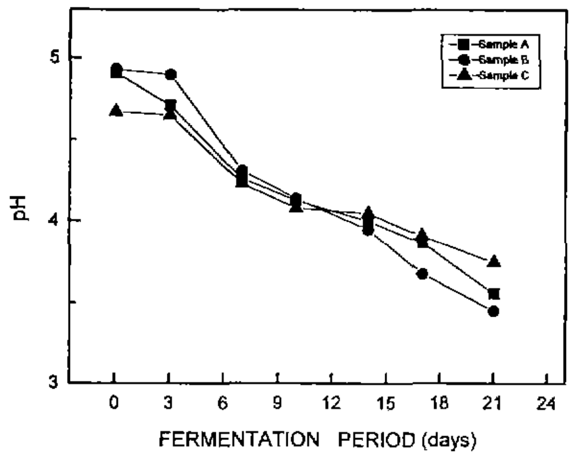

Fig. 1. Changes in pH of wooung(burdock) kimchi[1] during fermentation at 15°C.
See Materials and Methods in detail.
A: Salted and prepared with basic ingredients
B : Salted and prepared with all sorts of ingredients
C : Blanched and prepared with all sorts of ingredients

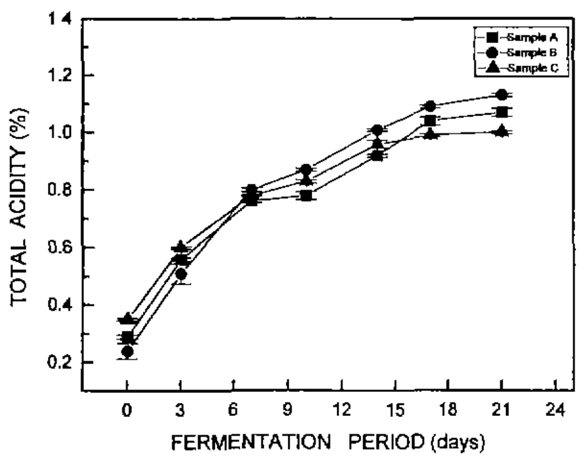

Fig. 2. Changes in total acidity of wooung(burdock) kimchi during fermentation at 15°C.
A, B and C: See the legend in Fig. 1.

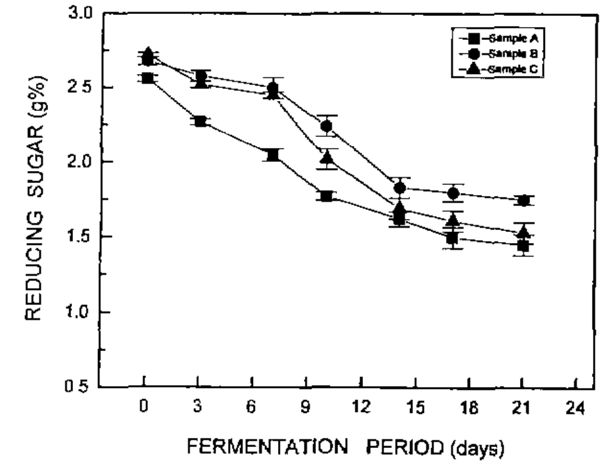

Fig. 3. Changes in reducing sugar of wooung(burdock) kimchi during fermentation at 15°C.
A, B and C: See the legend in Fig. 1.

kimchi as judged by pH 4.3~4.1 was reached at 7~10 days of the fermentation. Mheen et al.(17,18) reported that the pH of optimum quality of kimchi was 4.2 and initial pH of kimchi started from 5.5, decreased to 4.2 at the optimum time and dropped to 4.0 upon over ripening.

Fig. 2 showed that total acidity increased gradually as the pH decreased in all samples. Kim and Rhee(19) reported that the increase in total acidity was mainly due to lactic acid and succinic acid formed in baechu kimchi fermentation and these acids had a connection with flavorus sour taste. Total acidity changed more rapidly in sample B than that of other samples. Total acidity was higher in the sample made with all sorts of ingredients than the sample made with basic ingredients after salting the burdock with 4% brine for 30min, after 7days. Lee and Yang(20) reported that acidity at the optimum ripening period of kimchi was 0.4~0.75%(as lactic acid), reaching 1.0% upon over-ripening and reached 1.5~2.0% at the stage of spoilage.

The contents of reducing sugar decreased slowly until 7 days, then decreased rapidly for 8~14 days in samples B and C. The initial contents of reducing sugar of samples A, B and C were 2.56, 2.68 and 2.72g%, while they were decreased to 1.45, 1.75 and 1.53g% after 21 days, respectively(Fig. 3). It seemed that the initial content of reducing sugar was higher in the samples of B and C than that of the sample A due to the addition of glutinous rice paste or blanching. The changes of reducing sugar in wooung kimchi prepared after salting the sliced burdock with 4% brine showed similar patterns to those of wooung kimchi prepared after blanching the sliced burdock with 2% vinegar solution. Ha et al.(21,22) reported that the major sugars in kimchi were mannose, fructose, glucose and galactose, and they were reduced gradually with fermentation time because microorganisms present in kimchi consumed the reducing sugars as energy sources.

Microbial changes during wooung kimchi fermentation

Fig. 4 and 5 showed the changes of lactic acid bacterial counts and total bacterial counts during the fermentation of wooung kimchi at 15°C. The changes

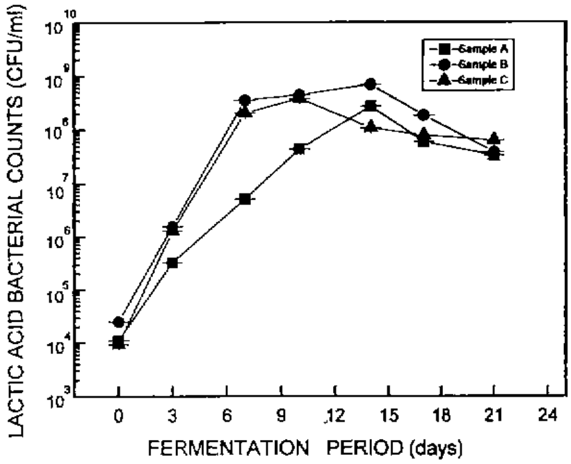

Fig. 4. Changes in lactic acid bacterial counts of wooung(burdock) kimchi during fermentation at 15°C.
A, B and C: See the legend in Fig. 1.

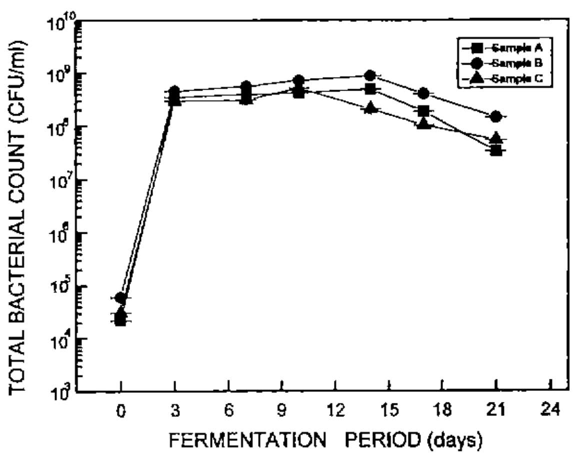

Fig. 5. Changes in total bacterial counts of wooung (burdock) kimchi during fermentation at 15°C.
A, B and C: See the legend in Fig. 1.

of lactic acid bacterial counts were similar to those of total bacterial counts. In all samples, lactic acid bacterial counts and total bacterial counts increased sharply at the early stage of the fermentation, increased slowly at 7~14 days, but decreased after 14 days as the acidity increased. The numbers of lactic acid bacteria and total bacteria of sample B were much greater than those of the other samples. The initial numbers of lactic acid bacteria in samples A, B and C were 1.1×10^4, 2.5×10^4 and 9.4×10^3CFU/ml, repectively. The numbers of lactic acid bacteria at 10 days, the optimum ripening time of wooung kimchi, were 4.5×10^7, 4.5×10^8 and 4.0×10^8CFU/ml in samples A, B and C, respectively. They decreased to 3.4×10^7, 4.0×10^7 and 6.5×10^7CFU/ml after 21 days, respectively. For the total plate counts, the initial numbers in samples A, B and C were 2.2×10^4, 6.1×10^4 and 3.1×10^4CFU/ml, respectively. The number of total bacteria reached optimum value at 10 days in samples A(4.3×10^8CFU/ml), B(7.3×10^8CFU/ml) and C(5.5×10^8CFU/ml), respectively. They decreased to 5.5×10^7, 1.5×10^8 and 9.8×10^7CFU/ml after 21 days, respectively. Mheen and Kwon(17) reported that the total viable count in baechu kimchi increased rapidly at the beginning of the fermentation and reached its maximum number at optimum ripening time and then decreased slowly. The patterns of microbial changes during wooung kimchi fermentation was similar to those of the microbial changes during baechu kimchi fermentation. Kim and Chun(23) observed that the number of aerobic bacteria decreased rapidly at the begining of kimchi fermentation, while anaerobic bacteria dominates, however, at the later stage of the fermentation, surface film forming aerobic bacteria started to grow and texture softening and taste deterioration took place.

Changes of sensory characteristics

Table 1 demonstrated that the sensory characteristics for appearance, odor, taste, texture and overall acceptability of wooung kimchi during the fermentation. The 7~10 days of the fermentation were optimum ripening time and eatable period of the wooung kimchi ($p<0.05$). It was also in accordance with the fact that the pH 4.1~4.3, value of optimum ripening period of kimchi, reached at 7~10 days(Fig. 1). Sample B obtained the highest sensory score on appearance during the fermentation. Fresh acidic odor showed a high score

Table 1. Sensory scores of wooung(burdock) kimchi during fermentation at 15°C

Characteristics		Days / Samples[1)]	3	7	10	14
Appearance		A[3)a]	3.6 ± 0.5[2)]	3.6 ± 0.5	3.4 ± 0.5	2.8 ± 0.8
		B[a]	4.0 ± 0.7[C]	4.2 ± 0.4[C]	4.2 ± 0.4[CD]	3.4 ± 0.5[D]
		C[b]	3.0 ± 1.0	3.0 ± 1.0	2.8 ± 0.8	2.0 ± 0.7
Odor	Fresh acidic odor	A[a]	3.6 ± 0.5	3.8 ± 0.4	4.4 ± 0.5	3.2 ± 0.5
		B[b]	3.4 ± 0.5[C]	3.6 ± 0.7[C]	4.4 ± 0.5[D]	3.2 ± 0.4[D]
		C[a]	2.0 ± 0.7	3.0 ± 1.0	4.0 ± 0.7	3.0 ± 0.5
	Sour odor	A[a]	1.2 ± 0.4	1.6 ± 0.5	2.0 ± 0.7	3.6 ± 0.5
		B[a]	1.0 ± 0.0[C]	1.4 ± 0.5[C]	1.4 ± 0.5[D]	1.6 ± 0.6[D]
		C[b]	1.6 ± 0.5	1.6 ± 0.5	2.6 ± 0.7	3.6 ± 0.7
	Moldy odor	A[a]	1.6 ± 0.4	1.3 ± 0.4	1.2 ± 0.5	1.2 ± 0.5
		B[a]	1.6 ± 0.5[C]	1.2 ± 0.0[CD]	1.2 ± 0.0[D]	1.2 ± 0.0[E]
		C[a]	1.4 ± 0.5	1.2 ± 0.4	1.2 ± 0.0	1.2 ± 0.4
Taste	Fresh acidic taste	A[a]	2.4 ± 0.5	2.8 ± 0.8	3.4 ± 0.5	2.6 ± 0.4
		B[a]	3.0 ± 1.0[C]	3.2 ± 0.4[D]	4.2 ± 0.4[DE]	2.6 ± 0.5[E]
		C[b]	2.0 ± 0.7	2.8 ± 0.6	3.4 ± 0.5	2.4 ± 0.4
	Sour taste	A[a]	2.2 ± 0.4	2.8 ± 0.8	3.4 ± 0.5	4.4 ± 0.5
		B[b]	3.0 ± 1.0[C]	3.4 ± 0.4[D]	4.0 ± 0.7[D]	4.6 ± 0.5[E]
		C[a]	2.2 ± 0.4	3.0 ± 1.0	3.6 ± 0.5	4.2 ± 0.4
	Moldy taste	A[a]	1.2 ± 0.4	1.4 ± 0.5	1.4 ± 0.5	4.6 ± 0.5
		B[a]	1.2 ± 0.4[C]	1.2 ± 0.4[C]	1.6 ± 0.5[C]	3.0 ± 1.0[D]
		C[a]	1.6 ± 0.5	1.6 ± 0.5	1.8 ± 0.4	3.0 ± 0.5
Texture	Fracturability	A[a]	3.4 ± 0.5	2.4 ± 0.5	2.4 ± 0.5	2.4 ± 0.5
		B[a]	3.6 ± 0.5[C]	2.8 ± 0.8[CD]	2.8 ± 0.8[C]	2.0 ± 0.7[D]
		C[a]	2.4 ± 1.1	2.2 ± 0.8	2.8 ± 0.3	2.8 ± 0.3
	Chewiness	A[ab]	2.8 ± 0.8	2.8 ± 0.8	2.4 ± 0.8	2.8 ± 0.2
		B[a]	2.8 ± 0.8[C]	2.8 ± 0.5[C]	2.4 ± 1.1[C]	2.0 ± 0.0[D]
		C[b]	1.0 ± 0.0	1.0 ± 0.0	1.0 ± 0.0	1.0 ± 1.1
Overall acceptability		A[a]	2.8 ± 0.8	3.6 ± 0.5	3.8 ± 0.4	3.0 ± 1.0
		B[a]	3.0 ± 1.0[C]	3.8 ± 1.2[DE]	4.4 ± 0.5[D]	3.2 ± 0.5[CE]
		C[b]	2.0 ± 0.7	2.8 ± 0.8	3.0 ± 1.0	2.0 ± 0.7

1)Samples A, B and C : See the legend in Fig. 1
2)Mean±S.D.(n=7)
3)Means with the different letters(a-e, column: small letters, row: capital letters) beside data are significantly different at the 0.05 level of significance as determined by Duncan's multiple range test
The rating score was: exellent/strong, 5: very good, 4; good, 3; normal, 2, and bad/weak, 1

at 7~10 days, sour odor had the highest score at 14 days and it began to appear moldy odor after 14 days in all samples. Sour odor showed higher score in sample C than the other samples. Fresh acidic taste also showed a high score at 7~10 days, sour taste had the highest score at 14 days and there seemed to be a moldy taste after 14 days in all samples. Sample B resulted in the most tasty kimchi among the samples. No notable difference has been observed in the changes of texture among all samples during the fermentation, but texture of the sample B was evaluated better than the other samples. Sample B exhibited the highest scores, while sample C showed the lowest scores in overall acceptability($p<0.05$). The numbers of lactic acid bacteria and total bacteria of sample B were much greater than those of the other samples. In sensory evaluation, sample B

Table 2. The changes of major volatile flavor components of wooung(burdock) kimchi during fermentation at 15°C

PN	RT	Components	Periods(days)				
			0	3	7	10	14
1	6.805	acetic acid ethyl ester	ND	1.24[1)]	ND	3.06	ND
2	7.696	ethanol	30.18	37.15	11.1	20.5	22.95
3	10.200	α-pinene	0.55	0.29	ND	ND	ND
4	10.863	1-propanol	0.35	1.41	0.63	1.53	0.95
5	11.850	camphene	1.18	0.56	0.38	0.63	0.57
6	13.007	hexanal	3.33	2.78	ND	ND	ND
7	14.107	2-propen-1-ol	0.88	0.59	ND	0.58	0.38
8	19.812	β-thujene	1.67	0.96	1.26	1.06	0.89
9	20.779	2-hexenal	2.46	2.82	ND	0.21	ND
10	24.759	methyl 2-propenyl disulfide	0.94	0.53	0.54	1.55	0.28
11	25.011	3-hydroxy-2-butanone	ND	2.09	2.67	8.82	3.65
12	28.927	1-hexanol	0.74	4.75	1.40	0.85	0.64
13	31.114	dipropyl disulfide	0.93	0.66	0.77	0.78	0.30
14	34.608	1,2-dithiacyclopentane	1.18	0.80	1.22	1.12	0.57
15	35.835	acetic acid	ND	1.05	2.44	5.38	5.20
16	38.393	di-2-prophenyl disulfide	11.17	9.97	13.9	9.70	7.31
17	41.697	linalool	0.23	0.24	ND	0.50	0.23
18	47.107	butanoic acid	ND	ND	1.07	2.61	1.04
19	48.877	benzeneacetaldehyde	0.14	ND	0.29	0.30	0.04
20	50.832	α-bergamotene	1.44	0.72	1.91	1.06	1.19
21	51.390	1-α-terpineol	0.22	0.12	0.56	0.27	ND
22	51.704	endo-borneol	0.58	0.32	1.07	0.48	0.37
23	52.820	zingiberene	2.74	2.08	3.42	1.80	0.55
24	53.173	β-bisabolene	1.47	1.07	2.16	1.14	1.48
25	53.448	(+)-aromadendrene	0.35	0.16	0.52	0.24	0.25
26	55.791	β-sesquiphellandrene	2.41	1.69	4.20	1.91	2.96
27	56.115	(-)-ar-curcumene	3.37	2.66	5.92	2.96	4.06
28	59.941	trans-geraniol	0.29	ND	1.35	0.68	0.69
29	69.983	d-nerolidol	0.13	ND	0.28	0.14	0.25

PN : Peak number RT : Retention time ND : Not detected
[1)]Relative amounts of peak area

exerted best scores in all characteristics of wooung kimchi during fermentation.

Changes of volatile flavor components

Table 2 indicated the major volatile flavor components of wooung kimchi(sample B) obtained the best scores in sensory evaluation during the fermentation. The chromatogram showed the presence of over 100 components, of which 29 major volatile flavor components were listed. Peak numbers(PN) 2, 6, 9, 16, 23, 26 and 27 were the major volatile flavor components and were identified as ethanol, hexanal, 2-hexenal, disulfide di-2-prophenyl, zingiberene, beta-sesquiphellandrene and (-)-ar-curcumene, respectively. Their relative amounts of peak area were gradually decreased, while the relative amounts of acetic acid ethyl ester, 3-hydroxy-2-butanone and acetic acid were gradually increased during the fermentation of wooung kimchi. It was reported that the major volatile components obtained from baechu(Chinese cabbage) kimchi were ethanol, methyl allyl sulfide, dimethyl sulfide, methyl allyl disulfide, dipropyl disulfide and diallyl disulfide, most of them were increased during fermentation, and then gradually decreased(24,25). Dipropyl disulfide, which was considered to be formed from s-n-propylcysteine sulfoxide in Chinese cabbage during fermentation(26), ethanol, acetic acid, β-bisabolene and β-sesquiphellandrene in baechu kimchi were also identified in wooung kimchi. But hexanal, 1-hexanol, α-bergamotene and zingiberene were the components that are not found in the baechu kimchi. Disulfide, methyl-2-prophenyl disulfide, dipropyl, 1,2-dithiacyclopentane and di-2-prophenyl disulfide, which were the major volatile components of garlic, onion and green thread onion(26), were identified as the major volatile components of wooung kimchi during the fermentation. Zingiberene, curcumene and geraniol, which were the major volatile components of ginger(26), camphene, β-thujene, linalool, endo-borneol, β-bisaborene, aromadendrene and β-sesquiphellandrene were also identified. Ethanol and acetic acid were the components that exhibited larger changes than the other components during the fermentation. Ethanol content increased for 3 days, and then decreased rapidly after 7 days, whereas, acetic acid was not detected at the early stage, but increased gradually after 7 days as the ethanol level decreased.

ACKNOWLEDGEMENTS

This work was supported by a 95/96 National Project Fund from the Ministry of Science and Technology, Korea.

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(Received April 15, 1996)