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Effect of Bamboo(*Pseudosasa japonica* Makino) Leaves on the Quality and Sensory Characteristics of *Dongchimi*

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Abstract

Effect of covering various levels(0, 1, 3, 5, and 7% per Chinese radish weight) of bamboo(*Pseudosasa japonica* Makino) leaves on the surface of *Dongchimi* was studied in the course of fermenting at 10°C up to 75 days. Physicochemical, microbiological, and sensory characteristics of Dongchimi were analyzed at regular intervals of 5 to 7 days during fermentation. Both the degree of pH drop from the initial 6.47~6.54 and increase total acid content from the initial 0.004%, with the accumulation of organic acids tended to be more gradual depending upon the amounts of bamboo leaves covered. The increases of total solid content and turbidity were also suppressed in similar patterns, notably after 13 days of fermentation. The growth of total bacteria(1.5×10^4cfu/ml, initial) was partly inhibited while that of lactic acid bacteria(1.8×10^4cfu/ml, initial) was favorably encouraged by the presence of bamboo leaves. As a result of sensory evaluation, *Dongchimi* covered with 1 and 3% bamboo leaves on showed the higher scores significantly($p<0.05$, $p<0.01$, $p<0.001$) in overall acceptability till 39 days. But after 61 days, those covered with 3 and 5% bamboo leaves were rather preferable than any other one.

Key words: *Dongchimi*, *Kimchi*, fermentation, bamboo leaves

INTRODUCTION

Due to its characteristic taste of refreshing juices and crispy radishes, *Dongchimi* has been usually favored as one of the major side dishes in Korean diets. However, *Dongchimi*, on the same principle with *Kimchi*, is apt to be deteriorated in its quality due to the acidification and softening caused by the early fermentation, i.e., over-ripening or quality deterioration after ripening. In order to appreciate the good taste of *Dongchimi* for an extended period of time, various approaches have been proposed, among which the introduction of natural preservatives(1-4) is most noteworthy.

Historically, the covering of *Dongchimi* with bamboo leaves during fermentation has long been used in the traditional home preparation of *Dongchimi* to keep freshness, as well as to raise refreshness of the juice by lowering the turbidity. In addition, bamboo leaves had offered preservation effects in many foodstuffs. Members of the bamboo family which include the bamboo tree is a perennial plant of indeciduous arbor grown worldwide with 47 genera and over 1,250 species. Bamboo trees consist of 5 genera, 10 species and 4 varieties are spread latitudinally at below central district of the Korean peninsular; with typical varieties of *Sasamorphapurpurascens* Nakai var. *borealis* Nakai(Joretdae), *Phyllostachys reticulata* Koch(Chamdae), *Sasa coreana* Nakai(Shinuidae) and *Pseudosasa japonica* Makino(Leedae, Shinwedae).

Little has ever been tried to use bamboo leaves as preservatives or antibiotics, but Jung and Yu(5) recently reported the antibiotic effects of bamboo leaves on *Kimchi* fermentation. Similarly, based on the physiologically and biologically active effects of bamboo leaves verified in the previous reports(1,6) of the *id.*, we investigated the effects of bamboo-leaf coverings on *Dongchimi* fermentation with respect to physicochemical, microbiological and sensory characteristics.

MATERIALS AND METHODS

Raw materials

Local breed Chinese radishes(*Raphanus Sativus* L., Taeback) grown at Koch'ang-gun area, Chollabuk-do were purchased from Karak-dong Agricultural and

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Fishery Wholesale Market in Seoul in Nov. 18, 1995, along with green thread onion, garlic, and ginger for the preparation of *Dongchimi*. The radishes were in good condition, not notably desiccated, diseased, or mechanically damaged. A commercially refined salt(purity over 88%, Shinjin Salt Co.) was used for brining. Wildly-grown bamboo leaves(*Pseudosasa japonica* Makino, Leedae)(7) were collected from the hillocks at Sindong-gun in Iksan-shi, Chollabuk-do. All the chemicals used for the analysis were of reagent grade._

Preparation of *Dongchimi*

The Chinese radishes were throughly washed with tap water then allowed to drain. They were then cut into cubes(4×1.5×1cm in size) after trimming 5cm apart from each end of the radishes. Chopped or sliced sub-ingredients(garlic and ginger) were packed in a cheese-cloth bag(15×15cm in size) for complete immersion into brine solution during storage fermentation. The formulation for the preparation of *Dongchimi* is shown in Table 1. Brining is accomplished by dissolving salt into distilled water to the final salt concentration of 3%(w/v) which is known as the best(8) for optimum fermentation and quality. Samples of radish and brine(1/1.5, w/v, Chinese radish: salt solution) were blended to homogeneity. Bamboo leaves of the similar sizes(around 12cm length) are ripped off from the branch, throughly washed, and allowed to drain. The collected leaves were evenly laid in layers on top of *Dongchimi*. Care was taken to cover all the surface area with bamboo leaves and avoid vacant air spaces between layers. The final preparation of *Dongchimi* is allowed to ferment at 10°C under laboratory conditions in a hermetically sealed 8L clear bottle(18 dia.×31cm in size) which had been previously rinsed with a 8% $KMnO_4$ solution.

Table 1. Formula of *Dongchimi* prepared in each 8L glass jar

Ingredients	Weight(g)	Ratio(%, w/w)
Raw Chinese radish	2,800	100
Small green onion	28	1
Garlic	14	0.5
Ginger	8.4	0.3
Water(ml)	4,200	150
Bamboo leaves[1)]		

[1)]Varied with experimental treatments; 0, 1, 3, 5 and 7% to the Chinese radish weight

Determination of pH and total acid content

From the liquid portion of *Dongchimi*, pH was directly measured using pH meter(model 8519, Hanna Instruments, Singapore) at room temperature. The acidity was determined by titrating 10ml of sample juice with 0.1N NaOH, then the lactic acid content was calculated and expressed as the acidity(%, w/v).

Determination of solid content

20ml of *Dongchimi* juice, filtered through three layers of cheese clothes was collected in a aluminum container and preliminarily dried at 80°C, followed by drying at 105°C for 2 hr.

Measurement of turbidity

The turbidity of *Dongchimi* juice was determined by measuring the absorbance at 580nm using spectrophotometer(model UV-240, Shimazu, Japan).

Microbial analysis

For the microbial enumeration of *Dongchimi*, a 1ml of sample juice was serially diluted with sterilized 0.85% saline solution under aseptic condition. One ml of final dilution was poured into plate count agar(total bacteria count) and MRS agar(lactic acid bacteria) according to the pouring culture method. The plates were incubated at 30°C(total bacteria) and 37°C(lactic acid bacteria) for 48 to 72hr, then viable cell numbers were counted using Quebec Colony Counter and expressed as colony forming units(cfu/ml).

Sensory analysis

Sensory characteristics of *Dongchimi* prepared with the addition of different ratios of bamboo leaves were evaluated starting from day 13 when the pH reached to about 3.9±1(9). A series of twelve tests have been performed at the intervals of 5 day at the initial and middle periods and 7 days at the later stage during the 75 days of fermentation period. Two cubes of radishes along with 50ml of *Dongchimi* juice were given in a clear Pyrex glass jar indicated by three digit numbers for testing. A panel of 10 experienced judges(graduate students in Department of Food Science and Nutrition) evaluated the descriptive terms; turbidity of juice, ripeness, carbonated taste, flavor, texture and overall acceptability using a nine point scale test(9: like

extremely, 1: dislike extremely). Average values from the duplicate responses for each questionnaire were computed with the General Linear Model Procedure of SAS (SAS Institute, Inc.; Cary, NC, USA). Mean separation was accomplished using Duncan's multiple range test.

RESULTS AND DISCUSSION

pH and total acidity

Fig. 1 and 2 show the pH changes in *Dongchimi* juice covered with different ratios(0, 1, 3, 5, and 7%) of bamboo leaves during fermenting at 10°C for 75 days. The initial pH value, immediately after preparation was in the range of 6.48~6.54 in all treatments. As shown in Fig. 1, the pH values of all samples decreased as fermentation proceeded as influenced by the accumulation of organic acids. However, the decrease in pH tended to be more gradual when bamboo leaves were being covered on the surface of *Dongchimi* depending on the amounts. Granting that the organoleptically optimum pH of *Dongchimi* is 3.9±1(9), the periods for reaching optimum tastes were counted as 13(0 and 1%), 23(3%), and 38 days(7%), respectively. This strongly indicates the proportionally regulating effects of bamboo leaves on *Dongchimi* fermentation depending on the amounts of coverings.

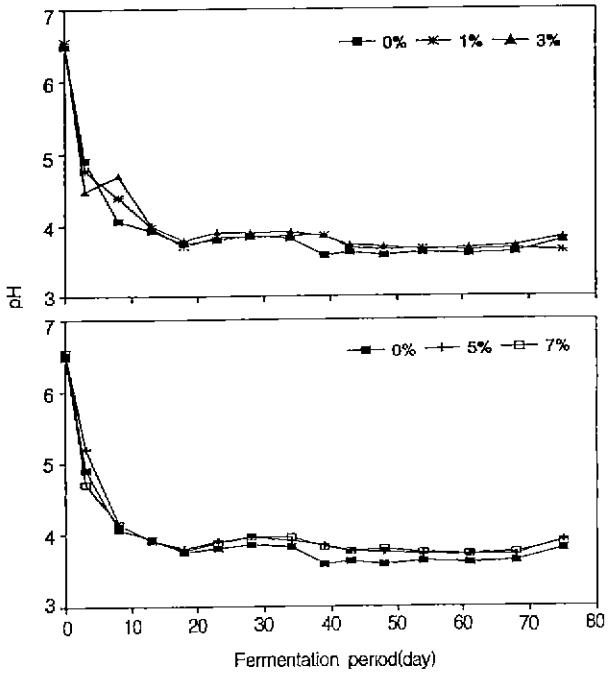

Fig. 1. Changes in pH during fermentation of *Dongchimi* covered with various levels(0, 1, 3, 5, 7%) of bamboo leaves at 10°C.

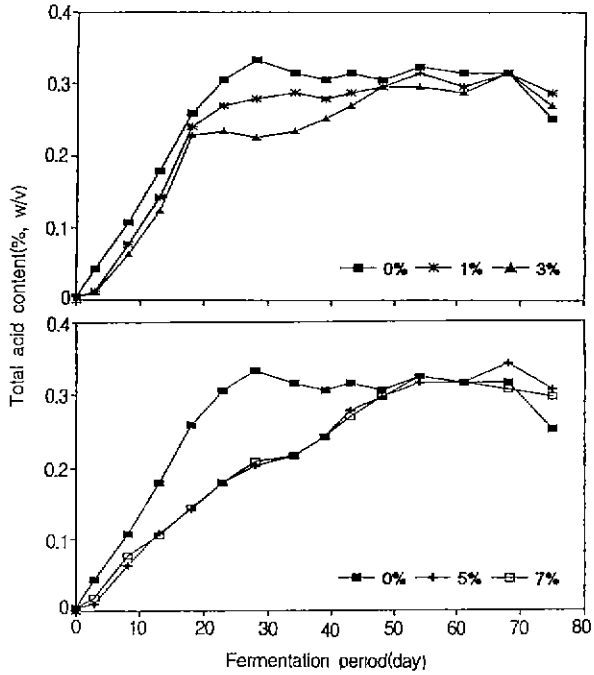

Fig. 2. Changes in total acid content during fermentation of *Dongchimi* covered with various levels(0, 1, 3, 5, 7%) of bamboo leaves at 10°C.

Changing pattern of total acidity in *Dongchimi* juice is consistent with that of pH changes(Fig. 2). At beginning(0 day fermentation), the initial acidity was as low as 0.004% in all samples regardless of bamboo leaves, then it increased slowly as fermentation went on. However, the increasing rate was rather extensively slowed down by the presence of bamboo leaves. Again, the accumulation of acidity was inversely affected depending on the amounts of bamboo leaves covered on *Dongchimi*. To say, total acid contents of the samples were in the reverse order with the increased amounts of bamboo leaves -0, 1, 3, 5 and 7%. In the control sample (*Dongchimi* without the addition of bamboo leaves) where the highest total acidity has been maintained throughout the whole fermentation period, showed its maximum 0.35% on day 28. However, even with the presence of 1% bamboo leaves, the increase became more gradual, thus reaching its maximum 0.31% on day 40. Similar patterns were also shown with the bamboo leaves ranging at 3, 5 and 7% treatments. The optimum acidity, about 0.6% as proposed by Kang(10) was attained on day 23(0 and 1%), 48(3%), 53(5%) and 61(7%), respectively. Overall, it can be said again that bamboo leaves could extend the acceptable quality and long shelf life through controlled fermentation as evidenced by the gradual pH drops and formation of total

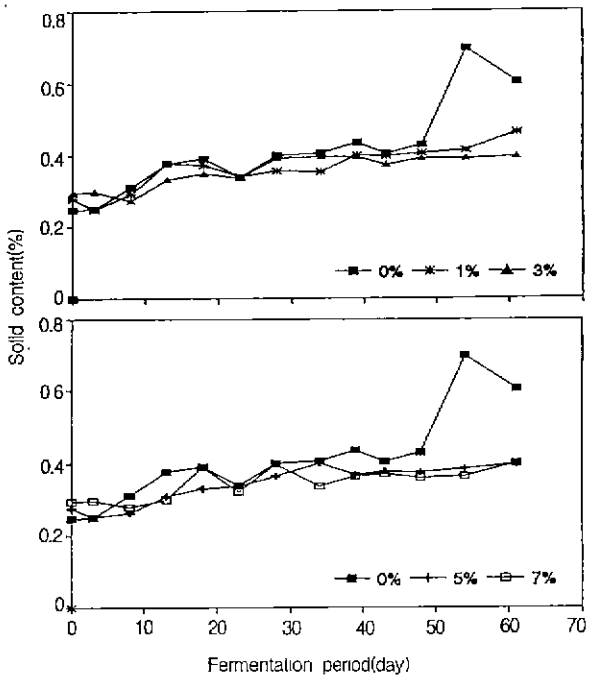

Fig. 3. Changes in solid content during fermentation of *Dongchimi* covered with various levels(0, 1, 3, 5, 7%) of bamboo leaves at 10°C.

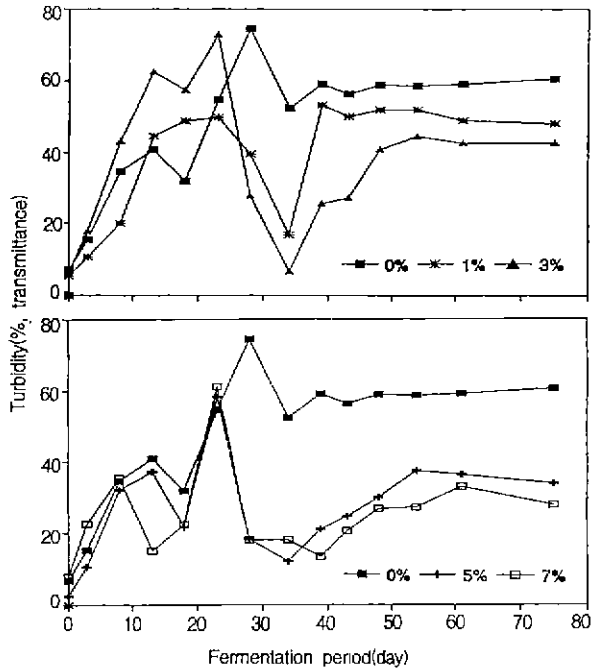

Fig. 4. Changes in turbidity during fermentation of *Dongchimi* covered with various levels(0, 1, 3, 5, 7%) of bamboo leaves at 10°C.

acid content in *Dongchimi*. This might be due to the involvement of strong antioxidative and antibacterial activities originating from the bamboo leaves as previously reported by Kim et al.(6).

Total solid content

The changing patterns of total solids in *Dongchimi* juice during fermentation is shown in Fig. 3. The initial amounts of total solids, 0.247~0.295% slowly increased during fermentation in all samples. At intial stages of fermentation, the amounts of total solid were nearly stabilized at about 0.247~0.298%(on day 2) to 0.262~0.310%(on day 7), regardless of the amounts of bamboo leaves. However, after 13 days, total solids started to increase gradually until the final stage of fermentation. Here again, the more bamboo leaves exist (i.e., increasing order of ratios; 0, 1, 3, 5, and 7%), the less soluble solids appeared in *Dongchimi* juice. This view was in accord with that explained by Kang(10) and Moon et al.(8). The partial drop of total solids on day 13 might be explained by the sequential phenomena of: 1) disintegration of soluble solids into lower molecular weight compounds by the action of tissue-softening enzymes as a result of increased microorganisms, 2) consumption of such materials for the metabolism by microorganisms and 3) the used-up amounts in "2)" exceeded the newly diffusing one from the Chinese radishes. The successive re-increasing of the total solids after 23 days could be due to the followings: 1) the microbial metabolism is reduced by the lowered pH of the environment, thus the disappearance of soluble materials was decelerated, 2) however, disintegration and dissolution of the Chinese radish components still continue and 3) more salt- and/or water-soluble materials are dissolved into the juice with the extended period. Additionally, the antibacterial and antioxidative properties of bamboo leaves might have favorably affected the quality of *Dongchimi* by inhibiting the microbial metabolism which could bring the disintegration of particles.

Turbidity

The changing pattern of turbidity in *Dongchimi* juice is shown in Fig. 4. No appreciable differences in turbidities were noted among the sample juice and distilled water on day 0. However, on day 13, sharp rises of turbidity occurred in all samples, raising the values from the lowest at 7% treatment to the highest at 3% treatment. However, on day 28, the degree of turbidity was recorded from the lowest(at 7% treatment) to the highest(at 0% treatment) depending upon the amounts of bamboo leaves. After this, only 0% sample has failed

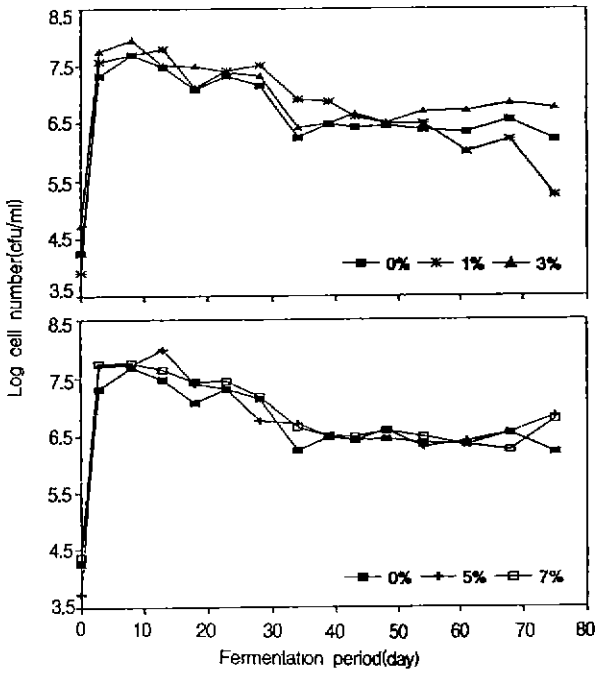

Fig. 5. Changes in total viable cell number during fermentation of *Dongchimi* covered with various levels(0, 1, 3, 5, 7%) of bamboo leaves at 10°C.

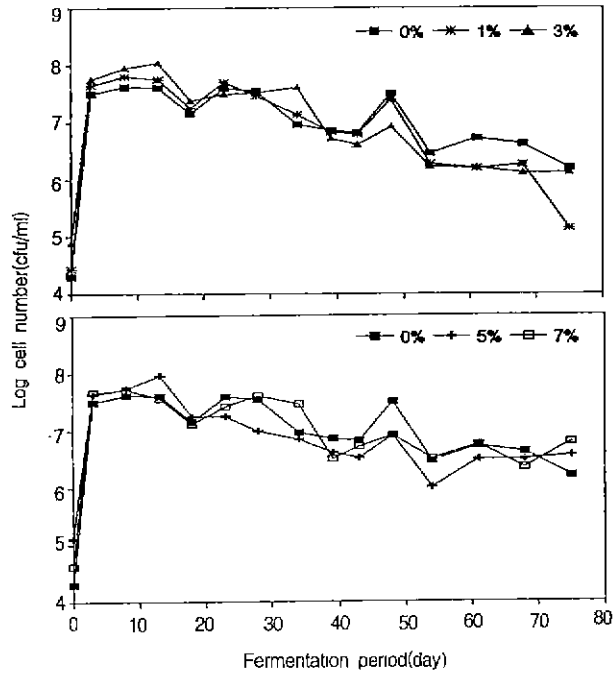

Fig. 6. Changes in lactic acid bacteria during fermentation of *Dongchimi* covered with various levels(0, 1, 3, 5, 7%) of bamboo leaves at 10°C.

to maintain the acceptable clarity in *Dongchimi* juice. However, these results are partly disagreeable with Kang's research(10) where the turbidity of *Dongchimi* had made no appreciable change at the initial and middle stages, then sharply increased at a certain point of the later period, and again slowly increased during fermentation.

These changes in turbidity is closely related with the previously mentioned theory that the change in the amounts of soluble solids was attributed to the dissolution of components and multiplication of microorganisms in *Dongchimi*.

Change in total bacteria and lactic acid bacteria cell number

Fig. 5 shows the changes in total bacterial count in *Dongchimi* during fermentation. Initiation of the 'stationary phase' where the maximized total bacterial cell counts are stabilized was found on day 8(0, 1, 7% treatments) or 13 day(3, 5% treatments). On day 39, the numbers had fallen down in all samples and then continuously decreased afterwards excepting a short increase at around on 61 days. Relating to this, it is noteworthy that all samples treated with bamboo leaves have shown relatively smaller total bacterial counts than *Dongchimi* without them. This indicates that bamboo leaves have been deeply involved in the course of microbial fermentation of *Dongchimi*. After 39 days, the variation of total bacterial counts at high magnitude during the early and middle stages(up to 28 days) of fermentation was replaced by a gradually decreasing pattern.

Variation in the lactic acid bacterial count is shown in Fig. 6. The changing patterns are not far different from that of the total bacterial counts, showing its maximum on day 8(0, 3, 7% treatments) or 13(1, 5% treatments). The alteration in the predominance of lactic acid bacteria in *Dongchimi* as influenced by the amounts of bamboo leaf is a matter of concern and interest. Among the all treatments, 1% treatment affected most during 28 to 43 days in encouraging the propagation of lactic acid bacteria, while the same role has been succeeded by a 3% one after 43 days up to 75 days of fermentation. In consequence, it is very important to timely apply, to say, during the initial and optimum fermentation period, the adequate amounts of bamboo leaves to maximize the growth of lactic acid bacteria in *Dongchimi*. On the whole a quantity of 1% bamboo leaf could provide the most favorable conditions to support the multiplication of lactic acid bacteria without the interrupted growth throughout the whole fermentation

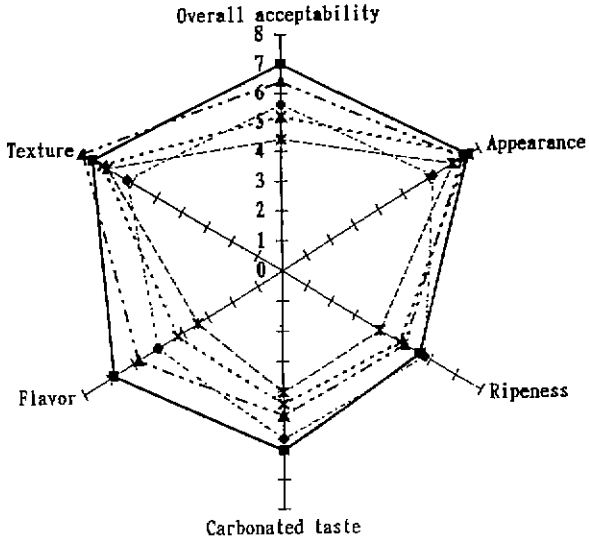

Fig. 7. QDA(Quantitative Descriptive Analysis) profiles of *Dongchimi* covered with various levels of bamboo leaves at 13-day fermentation at 10°C. -·-◆-·-: 0%, —■—: 1%, -·-▲-·-: 3%, --×--: 5%, --*--: 7%

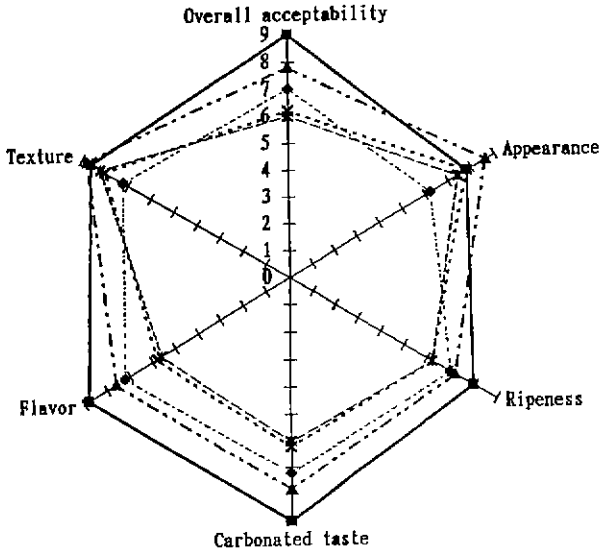

Fig. 8. QDA(Quantitative Descriptive Analysis) profiles of *Dongchimi* covered with various levels of bamboo leaves at 23-day fermentation at 10°C. -·-◆-·-: 0%, —■—: 1%, -·-▲-·-: 3%, --×--: 5%, --*--: 7%

period. The overall changing pattern of lactic acid bacterial count duplicated that of the total bacterial cell count except the initiation of 'death phase' which came on day 34 of fermentation, a little earlier than that of the latter. This is also consistent with the previously demonstrated result of turbidity changes where the clarity of *Dongchimi* juice was enhanced with the help

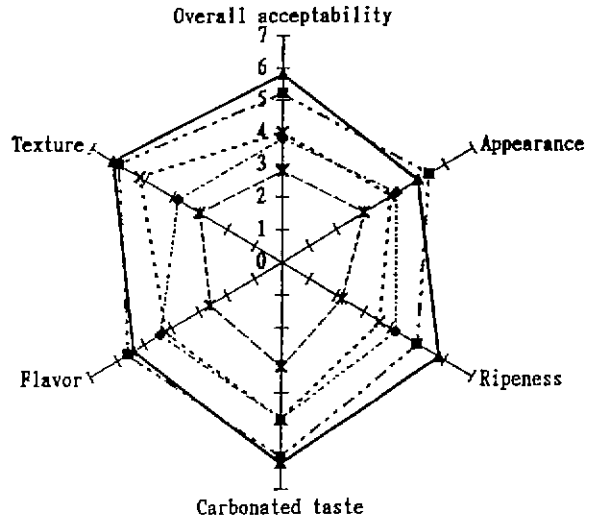

Fig. 9. QDA(Quantitative Descriptive Analysis) profiles of *Dongchimi* covered with various levels of bamboo leaves at 48-day fermentation at 10°C. -·-◆-·-: 0%, —■—: 1%, -·-▲-·-: 3%, --×--: 5%, --*--: 7%

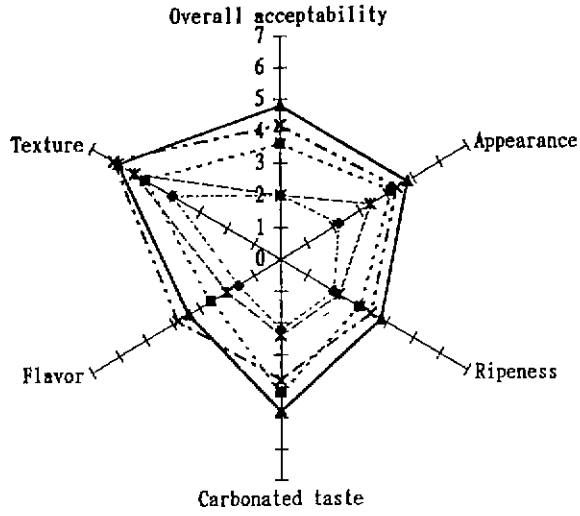

Fig. 10. QDA(Quantitative Descriptive Analysis) profiles of *Dongchimi* covered with various levels of bamboo leaves at 68-day fermentation at 10°C. -·-◆-·-: 0%, —■—: 1%, -·-▲-·-: 3%, --×--: 5%, --*--: 7%

of bamboo leaves. It might be stated that the bamboo leaves have favorably encouraged the growth of lactic acid bacteria which is related to the clarification of *Dongchimi* juice while the growth of general bacteria while have been suppressed.

The result of microbial study is coincided with those of other researchers including Jang and Moon(3), Moon et al.(8), Ko et al.(11) and Pie and Jang(12) who com-

Table 2. Sensory evaluation scores[1] of *Dongchimi* with various levels of bamboo leaves during fermentation at 10°C

Sensory characteristics	Fermentation period (days)	Percentage of bamboo leaves added					F-value
		0	1	3	5	7	
Apperance	13	$^{B}6.2^{a}$	$^{A}7.6^{a}$	$^{A}7.4^{b}$	$^{A}7.6^{ab}$	$^{A}7.0^{ab}$	7.91***
	18	$^{B}6.2^{a}$	$^{A}8.2^{a}$	$^{A}8.4^{ab}$	$^{A}8.2^{a}$	$^{A}7.8^{a}$	12.63***
	23	$^{C}6.2^{a}$	$^{B}7.8^{a}$	$^{A}8.6^{a}$	$^{B}7.8^{ab}$	$^{B}7.4^{ab}$	16.00***
	28	$^{BC}6.4^{a}$	$^{A}7.6^{a}$	$^{A}7.8^{ab}$	$^{AB}7.2^{bc}$	$^{C}6.2^{b}$	5.77**
	33	$^{C}5.2^{b}$	$^{A}7.4^{a}$	$^{B}6.0^{c}$	$^{BC}5.8^{d}$	$^{D}4.2^{c}$	24.50***
	38	$^{B}5.2^{b}$	$^{A}6.4^{b}$	$^{AB}5.8^{cd}$	$^{A}6.4^{cd}$	$^{C}4.0^{cd}$	12.60***
	43	$^{B}4.6^{bc}$	$^{A}5.8^{bc}$	$^{A}5.8^{cd}$	$^{BC}4.2^{e}$	$^{C}3.8^{cd}$	19.27***
	48	$^{B}4.2^{c}$	$^{A}5.4^{c}$	$^{AB}5.2^{cde}$	$^{BC}4.0^{e}$	$^{C}3.0^{cd}$	7.27***
	53	$^{B}4.0^{c}$	$^{A}5.0^{cd}$	$^{AB}4.4^{ef}$	$^{B}3.6^{e}$	$^{C}2.6^{d}$	10.68***
	61	$^{B}2.4^{d}$	$^{A}3.8^{e}$	$^{A}4.4^{ef}$	$^{A}4.0^{e}$	$^{AB}3.0^{cd}$	3.40*
	68	$^{B}2.2^{de}$	$^{A}4.2^{de}$	$^{A}4.8^{def}$	$^{A}4.4^{e}$	$^{AB}3.4^{cd}$	3.96*
	75	$^{B}1.6^{e}$	$^{A}3.6^{e}$	$^{A}4.0^{f}$	$^{A}4.2^{e}$	$^{AB}2.6^{d}$	3.43*
F-value		48.04***	26.41***	21.07***	30 80***	19.14***	
Ripeness	13	$^{A}5.8^{b}$	$^{AB}5.6^{ca}$	$^{AB}5.0^{d}$	$^{BC}4.8^{bc}$	$^{C}4.0^{cd}$	5.77**
	18	$^{A}6.8^{a}$	$^{A}6.6^{b}$	$^{A}6.0^{bc}$	$^{B}4.6^{bcd}$	$^{B}4.4^{bc}$	14.90***
	23	$^{BC}7.0^{a}$	$^{A}8.0^{a}$	$^{AB}7.2^{a}$	$^{C}6.2^{a}$	$^{C}6.2^{a}$	6.81**
	28	$^{B}7.2^{a}$	$^{A}8.4^{a}$	$^{B}7.0^{a}$	$^{C}5.6^{ab}$	$^{C}5.2^{ab}$	20.90***
	33	$^{B}5.6^{bc}$	$^{A}6.6^{b}$	$^{AB}6.0^{bc}$	$^{C}4.6^{bcd}$	$^{C}3.8^{cd}$	14.90***
	38	$^{B}5.0^{c}$	$^{A}6.4^{bc}$	$^{A}6.4^{ab}$	$^{B}4.8^{bc}$	$^{C}3.4^{cde}$	18 81***
	43	$^{B}4.2^{d}$	$^{A}5.6^{cd}$	$^{A}6.0^{bc}$	$^{B}4.0^{cde}$	$^{C}2.2^{ef}$	47.08***
	48	$^{BC}4.2^{d}$	$^{AB}5.0^{d}$	$^{A}5.8^{bcd}$	$^{C}3.6^{cde}$	$^{D}2.2^{ef}$	28.84***
	53	$^{BC}3.8^{d}$	$^{AB}4.8^{d}$	$^{A}5.4^{cd}$	$^{C}3.6^{cde}$	$^{C}2.8^{de}$	8.22***
	61	2.2^{e}	3.2^{e}	4.0^{e}	3.2^{e}	2.4^{ef}	2.20
	68	2.0^{ef}	3.0^{e}	3.8^{def}	3.4^{de}	2.2^{ef}	2.21
	75	$^{B}1.4^{f}$	$^{A}2.4^{e}$	$^{A}3.0^{f}$	$^{A}3.0^{e}$	$^{B}1.4^{f}$	8.53***
F-value		68.07***	48.23***	19.33***	5.54***	12.64***	
Carbonated taste	13	$^{A}5.6^{bd}$	$^{A}6.0^{c}$	$^{B}4.8^{efg}$	$^{BC}4.4^{bcd}$	$^{C}4.0^{bcd}$	13.23***
	18	$^{B}6.0^{b}$	$^{A}6.8^{bc}$	$^{BC}5.4^{def}$	$^{CD}5.0^{b}$	$^{D}4.4^{bc}$	16.38***
	23	$^{C}7.0^{a}$	$^{A}9.0^{a}$	$^{B}7.8^{a}$	$^{D}6.2^{a}$	$^{D}6.0^{a}$	27.14***
	28	$^{B}7.4^{a}$	$^{A}8.8^{a}$	$^{B}7.2^{ab}$	$^{C}5.4^{ab}$	$^{C}5.0^{ab}$	20.23***
	33	$^{BC}6.0^{b}$	$^{A}7.4^{b}$	$^{AB}6.6^{bc}$	$^{C}5.4^{ab}$	$^{D}4.0^{bcd}$	11.44***
	38	$^{BC}5.6^{bc}$	$^{AB}6.4^{c}$	$^{A}6.8^{bc}$	$^{C}5.4^{ab}$	$^{D}4.4^{bc}$	9.08***
	43	$^{B}4.8^{cd}$	$^{A}6.4^{c}$	$^{A}6.6^{bc}$	$^{B}4.8^{bc}$	$^{B}4.0^{bcd}$	15.90***
	48	$^{D}4.8^{cd}$	$^{A}6.0^{c}$	$^{A}6.2^{cd}$	$^{B}4.8^{bc}$	$^{C}3.2^{cde}$	27.69***
	53	$^{BC}4.2^{d}$	$^{B}4.6^{d}$	$^{A}5.6^{de}$	$^{B}4.6^{cd}$	$^{C}3.4^{cde}$	8.32***
	61	$^{B}2.4^{e}$	$^{A}4.2^{d}$	$^{A}4.6^{fg}$	$^{AB}3.8^{cd}$	$^{B}2.8^{de}$	5.61**
	68	$^{B}2.0^{e}$	$^{A}4.2^{d}$	$^{A}4.8^{efg}$	$^{A}3.8^{cd}$	$^{B}2.4^{e}$	7.88***
	75	$^{B}2.0^{e}$	$^{AB}3.8^{d}$	4.2^{g}	$^{ABC}3.4^{d}$	$^{BC}2.6^{e}$	3.33*
F-value		30.60***	38.10***	18.00***	5.39***	6.62***	
Flavor	13	$^{BC}5.0^{h}$	$^{A}6.8^{bc}$	$^{AB}5.8^{cd}$	$^{BC}4.2^{bc}$	$^{C}3.4^{h}$	6.41**
	18	$^{A}6.8^{a}$	$^{A}7.0^{b}$	$^{A}7.0^{ab}$	$^{B}5.4^{ab}$	$^{C}4.6^{a}$	37.75***
	23	$^{B}7.2^{a}$	$^{A}8.8^{a}$	$^{B}7.6^{a}$	$^{C}5.8^{a}$	$^{C}5.6^{a}$	25.88***
	28	$^{B}6.8^{ab}$	$^{A}8.2^{a}$	$^{B}6.6^{bc}$	$^{C}5.4^{ab}$	$^{C}4.6^{a}$	17.07***
	33	$^{B}5.2^{b}$	$^{A}6.8^{bc}$	$^{AB}6.0^{cd}$	$^{C}3.8^{c}$	$^{B}2.4^{bcd}$	37.53***
	38	$^{B}5.0^{b}$	$^{A}6.0^{d}$	$^{AB}5.6^{cd}$	$^{C}4.2^{b}$	$^{D}3.2^{b}$	18.53***
	43	$^{BC}4.8^{b}$	$^{A}6.2^{cd}$	$^{AB}5.8^{cd}$	$^{C}4.0^{c}$	$^{D}2.6^{bc}$	15.83***
	48	$^{B}4.4^{b}$	$^{A}5.6^{d}$	$^{A}5.4^{d}$	$^{B}4.2^{bc}$	$^{C}2.6^{bc}$	25.50***
	53	$^{BC}3.8$	$^{B}4.6^{e}$	$^{A}5.4^{d}$	$^{B}3.8^{c}$	$^{C}1.4^{de}$	31.11***
	61	$^{BC}2.2$	$^{ABC}3.2^{f}$	$^{A}3.8^{e}$	$^{AB}3.4^{c}$	$^{C}2.0^{cde}$	3.48*
	68	$^{B}1.6$	$^{AB}2.6^{f}$	$^{A}3.4^{e}$	$^{A}3.8^{c}$	$^{B}2.0^{cde}$	5.20**
	75	$^{B}1.0$	$^{A}2.6^{f}$	$^{A}3.0^{e}$	$^{A}3.2^{c}$	$^{B}1.0^{e}$	29.20***

Continued

Sensory characteristics	Fermentation period (days)	Percentage of bamboo leaves added					F-value
		0	1	3	5	7	
F-value		61.90***	48.23***	19.33***	4.12***	19.14***	
Texture	13	$^{C}6.2^{a}$	$^{AB}7.6^{abc}$	$^{A}8.0^{b}$	$^{B}7.2^{ab}$	$^{B}7.0^{bc}$	9.58***
	18	$^{B}6.6^{a}$	$^{A}8.2^{ab}$	$^{A}8.2^{ab}$	$^{A}8.2^{a}$	$^{A}8.0^{ab}$	5.08**
	23	$^{B}7.2^{a}$	$^{A}8.6^{a}$	$^{A}8.8^{a}$	$^{AB}8.0^{a}$	$^{A}8.2^{a}$	5.11**
	28	$^{B}7.0^{a}$	$^{A}8.2^{ab}$	$^{AB}7.6^{bc}$	$^{AB}7.6^{a}$	$^{B}7.2^{abc}$	3.53*
	33	$^{B}5.0^{a}$	$^{A}7.4^{bc}$	$^{A}7.2^{c}$	$^{AB}6.2^{bc}$	$^{AB}6.2^{cd}$	4.26*
	38	$^{B}4.8^{bc}$	$^{AB}6.6^{cd}$	$^{A}7.0^{cd}$	$^{A}6.4^{bc}$	$^{B}4.4^{ef}$	10.32***
	43	$^{C}4.0^{bcd}$	$^{A}6.8^{cd}$	$^{A}6.4^{de}$	$^{B}5.4^{c}$	$^{C}3.6^{fg}$	37.87***
	48	$^{C}3.8^{bcd}$	$^{A}6.0^{d}$	$^{A}6.2^{e}$	$^{B}5.2^{c}$	$^{D}3.0^{g}$	30.44***
	53	$^{C}3.6^{cde}$	$^{D}5.0^{e}$	$^{A}6.0^{e}$	$^{AB}5.2^{c}$	$^{C}3.0^{g}$	18.85***
	61	$^{C}3.4^{de}$	$^{A}4.8^{e}$	$^{AB}5.8^{ef}$	$^{A}6.2^{bc}$	$^{AB}5.0^{e}$	6.64**
	68	$^{B}4.0^{cd}$	$^{A}3.0^{e}$	$^{A}6.2^{e}$	$^{A}6.2^{bc}$	$^{AB}5.4^{de}$	3.22*
	75	$^{C}2.6^{e}$	$^{AB}4.6^{e}$	$^{AB}5.2^{f}$	$^{A}6.2^{bc}$	$^{AB}5.2^{de}$	13.97***
F-value		15.96***	20.35***	18.05***	8.05***	27.91***	
Overall acceptability	13	$^{BC}5.4^{b}$	$^{A}7.0^{d}$	$^{AB}6.4^{bc}$	$^{CD}5.2^{bc}$	$^{D}4.4^{b}$	9.92***
	18	6.8^{a}	7.6^{c}	6.8^{b}	5.6^{ab}	4.8^{b}	18.22***
	23	$^{C}7.0^{a}$	$^{A}9.0^{a}$	$^{B}7.8^{a}$	$^{D}6.2^{a}$	$^{D}6.0^{a}$	27.14***
	28	$^{B}6.8^{a}$	$^{A}8.4^{b}$	$^{B}6.8^{b}$	$^{C}5.6^{ab}$	$^{C}5.0^{b}$	17.12***
	33	$^{B}5.0^{bc}$	$^{A}7.0^{d}$	$^{A}6.4^{bc}$	$^{C}4.2^{d}$	$^{D}2.8^{c}$	59.42***
	38	$^{C}4.8^{bc}$	$^{B}6.0^{e}$	$^{A}6.8^{b}$	$^{C}4.4^{cd}$	$^{D}2.6^{c}$	43.20***
	43	$^{B}4.2^{cd}$	$^{A}6.2^{e}$	$^{A}6.2^{bc}$	$^{B}4.4^{cd}$	$^{C}2.2^{c}$	62.91***
	48	$^{C}3.8^{d}$	$^{B}5.2^{f}$	$^{A}5.8^{c}$	$^{C}4.0^{cd}$	$^{D}2.8^{c}$	44.13***
	53	$^{C}3.6^{d}$	$^{AB}5.0^{f}$	$^{A}5.8^{c}$	$^{BC}4.2^{d}$	$^{D}2.2^{c}$	19.67***
	61	$^{C}2.2^{e}$	$^{B}3.4^{g}$	$^{A}4.6^{d}$	$^{B}3.6^{d}$	$^{C}1.8^{cd}$	13.83***
	68	$^{C}2.0^{e}$	$^{B}3.6^{g}$	$^{A}4.8^{d}$	$^{AB}4.2^{d}$	$^{C}2.0^{cd}$	18.55***
	75	$^{C}1.2^{f}$	$^{B}2.8^{h}$	$^{A}3.8^{e}$	$^{A}3.2^{d}$	$^{C}1.0^{d}$	45.15***
F-value		50.52***	132.44***	23.59***	8.09***	19.14***	

[1)]Ranked from 9-like extremely to 1-dislike extremely

Means with the same letters are not significantly different at the 5% level

*p<0.05, **p<0.01, ***p<0.001

[A-D]Means of Duncan's multiple range test for various levels of bamboo leaves(row)

[a-f]Means of Duncan's multiple range test for fermentation days(column)

monly reported the initial great increase and the subsequent gradual decrease of total viable cell counts during *Dongchimi* fermentation. The remarkable propagation of lactic acid bacteria in *Dongchimi,* especially at 1 and 3% treatments of bamboo leaves in this research might lead to analogical interpretations as following: *Dongchimi* fermented with bamboo leaf treatments partly owes its better acceptable appearance, long shelf life and pleasant taste(see, "Sensory analysis" result) to thus produced lactic acid and various kinds of other organic acids of moderate amount.

Sensory analysis

Table 2 shows the sensory evaluation scores of *Dongchimi* fermented with various ratios of bamboo leaves covering 13 to 75 days of fermentation at 10°C. Among them, the data for four selected points of day are specially schematized at Fig. 7(on day 13), Fig. 8(on day 23), Fig. 9(on day 48) and Fig. 10(on day 68) using QDA (Quantitative Descriptive Analysis) profile method.

In appearance, a significant difference($p<0.001$) was found at 1% and above amounts of treatment during all testing period. Among which *Dongchimi* treated with 1 and 3% bamboo leaves were more favored in appearance than others by panelists. However, the absolute scores for rating dropped against the over-ripened samples with a long fermentation period and a 7% sample was hard to be satisfied organoleptically at any testing point, possibly due to the presence of the characteristic bamboo flavor leached from the bamboo leaves.

Ripeness became significantly different($p<0.001$) among treatments as fermentation proceeded. Apart from other parameters, ripeness was not significantly different($p<0.001$) among the samples during 61 and 68 days of fermentation. Regarding the treated amounts of bamboo leaves, *Dongchimi* has ripened slower in proportion to the amounts during 38 days of initial fermentation. However, on certain days between 48 and 53, 1 and 3% treatments were more liked than others even though the scores had jumped down and thus maintained at the bottom after 61 days.

Carbonated taste of *Dongchimi* was also more favored from 1 and 3% samples. *Dongchimi* with too much bamboo leaves(i.e., at above 5%) was not desirable because it could suppress the fermentation, the source for carbonation in *Dongchimi* juice.

Flavor tended to be less liked from the samples collected after 33 days of fermentation which previously had shown the best scores on day 23 and 28. Again, 1 and 3% treatments got the highest scores for the flavor, possibly due to the enhanced fragrance and taste while the bamboo flavor was being masked by them. The amounts more than 5% were not desirable because the characteristic bamboo flavor could penetrate into *Dongchimi* juice.

Textural quality of *Dongchimi* was similar to the ratings for flavor. However, the scores has dropped at an early stage, only after 38 days of fermentation when the amounts of *Dongchimi* was as high as 7%.

Overall acceptability showed a generally declining tendency after 23 or 28 days of fermentation. In the aspects of the bamboo leaves, 1 and 3% treatments were also more favored than others as being affected by the combined contribution of separate parameters as above : appearance, ripeness, carbonated taste, flavor and textural quality.

As a result of sensory evaluation, the most preferable period was on day 23 and *Dongchimi* covered with 1, and 3% bamboo leaves on showed the higher scores in overall acceptability than that with more than 3% bamboo leaves on because of the specific odor of the bamboo leaves.

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