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Changes of Partial Salinity and Cutting force of Chinese Cabbage with Brine Concentration and Salting time

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Abstract

To establish the optimum conditions for salting, 3, 5 and 10% brines were used, and whole Chinese cabbage was classified into four parts, i.e, the outermost, outer, middle and inner leaves. In addition, each leaf was divided into three pieces, that is, the upper and lower stems, and leaf part. From the measurement of salinity in each part of Chinese cabbage, salting with 3% brine appeared most uniformly distributed inside raw cabbage sample after seven days' salting. For 5 and 10% brine, salinity in part of cabbage leaves significantly differed. The maximum cutting force in salted Chinese cabbage salted in brine decreased in all parts of each cabbage sample, regardless of salt concentration, and furthermore, if salinity in salted cabbage sample was higher, its decreasing rate in cutting force appeared great.

Key words: *Kimchi*, Salting process, Chinese cabbage, cutting force, textural change

Introduction

Kimchi is a traditional Korean dish, which is a group of delicate, fermented vegetable foods and consumed all the year round. According to a national nutritional survey, adult takes 50-100 g of *Kimchi*/day in winter(Report on Nutritional Survey, 1974), to be 12.5% of total daily food intake.

About 1.7 million tons of *Kimchi* was consumed only in Korea, and 11,090 tons, which were mostly commercially produced, were exported. Many types of *Kimchi* are available depending on the raw materials, processing methods, seasons and localities. Although the proper combination of minor ingredients is said to be a key for delicious and palatable *Kimchi*, the more important factors seem to be salinity, fermentation and storage temperature.

The number of *Kimchi* manufacturing company has been rapidly increasing, and will increase continuously, because of changes in life style and type of housing especially in urban, and in young age groups, and of both increase in its consumption domestically and abroad, which has, in turn, adapted from home-making to commercial production in *Kimchi*. But the quality of commercially produced *Kimchi* is generally lower than that of ones made at home, due to its mass production. It could be because most *Kimchi* manufacturing companies do not carefully control salt concentration during salting of raw cabbage (Han, 1994, 1993a, 1993b).

Among all the raw materials used to make *Kimchi*, Chinese cabbage has been most frequently used in Korea. Chinese cabbage has been salted by using three different methods, that is, dry, brine and mixed salting methods. For dry salting method, Chinese cabbages are half-cut along the length, stacked in one layer in the salting tank, sprinkled dry salt inside them in a fairly amount, and salted them at room temperature for a while to get less crispy texture. In this method, the salinity of brine is different from tank to tank. For the brine salting, half-cut cabbage are stacked layer by layer in the tank, pressed by heavy stainless plate in salting tank and then poured brine into the tank(Kim *et al.*, 1993). Even though brine salting is more proper than dry or mixed salting method to obtain uniform salinity in all cabbage tanks, Chinese cabbages are not equally salted among each section of cabbage, such as stem and leaf etc., by this brine salting.

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That is, stem part is usually less salted, whereas the leaf part is more salted. Furthermore, unevenly distributed salinity in salted Chinese cabbage would affect the final quality of *Kimchi* which are commercially mass-produced from the plants, indeed.

Therefore, to improve the quality of *Kimchi* produced from the plant, a new salting method must be developed, because the amount of salts in salted Chinese cabbage has immense effect on the quality and taste of *Kimchi*. Short salting time-high salted Chinese cabbage was generally known to have some difference in salinity between stem and leaf parts. For this, salting process with long salting time-low salt content in the brine was recommended to make less difference in salt contents of salted Chinese cabbage.

In this study, to make uniform distribution in salinity in all parts of salted Chinese cabbage with less crispy texture, we attempted to analyze salinity in salted Chinese cabbage during salting by using various salinity of brine, and to determine textural property of each leaf in salted Chinese cabbage.

Materials and Methods

Materials

Chinese cabbages were cultivated in Kwangju area and harvested on October 1999. Brine was made of bay salt and tap water. Chinese cabbages were weighed 2.7~3.1 kg, and then, trimmed immediately in order to remove damaged leaves and heads.

Salting of Chinese cabbage

Trimmed, half-cut lengthwise Chinese cabbages were stacked in salting plastic tank (70l capacity) and pressed with bricks. Brine was poured into the salting tank. The ratio of brine to raw Chinese cabbages was 2.5 : 1 (w/v). The concentrations of brine was 3, 5, and 10%, and Chi-

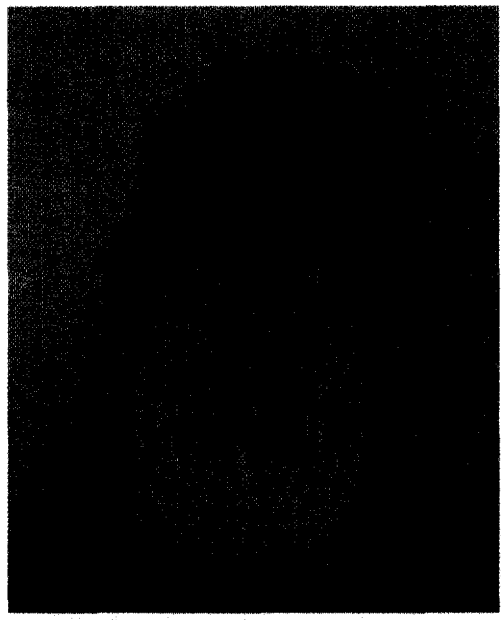

Fig. 1. Cross section of Chinese cabbage sample.

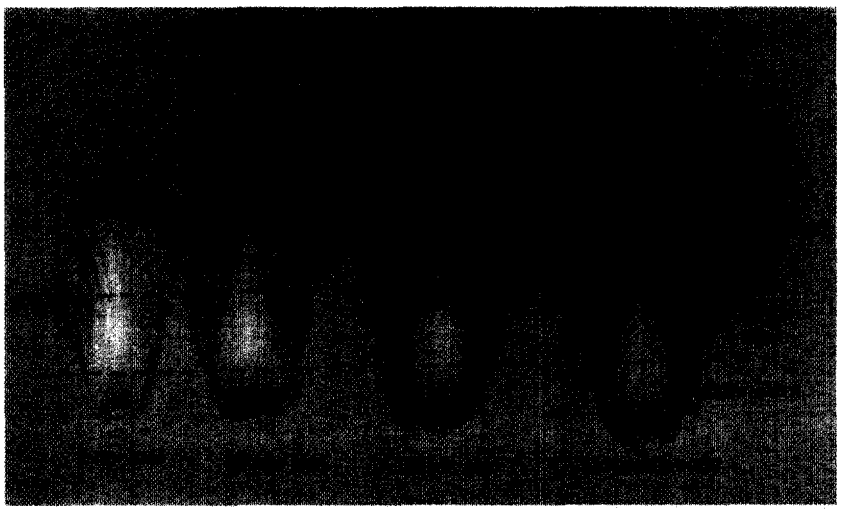

Fig. 2. Three parts of each leaf sorted from four different sections of whole Chinese cabbage.

nese cabbages were salted between 4 and 7°C. Salted Chinese cabbages were washed with tap water for two minutes and drained for one hour

Salinity of salted Chinese cabbage

The leaves of whole salted Chinese cabbage were classified into four groups, that is, the outermost, outer, middle and inner parts (Fig. 1), and each leaf was divided into three pieces, i.e., the upper stem (top) and lower stem (middle), and leaf (Fig. 2). Each leaf was cut, shredded and pressed by juice grinder (wonjin co., multiplus power HWF-714, Korea) and the salinity of juice were measured with salinometer (Orion, model 140, Germany).

Table 1. Operation conditions for TA-XT2

Mode	Measure force in compression
Option	Return to Start
Pre-test speed	5.0 mm/s
Test speed	1.7 mm/s
Post speed	10.0 mm/s
Distance	85.0 %
Trigger type	Auto-10 g
Data aquisition rate	200 pps

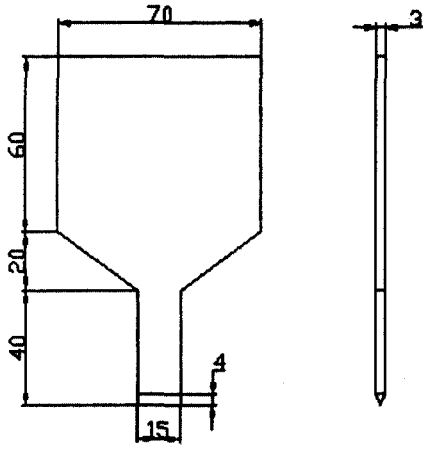

Fig. 3. Schematic diagram of probe for cutting test (unit: mm).

Texture of salted Chinese cabbage

The texture of salted, less crispy cabbage samples, cut into small pieces(2×3 cm), was determined by Texture Analyzer(TA-XT2, Stable Micro Systems, England) and its operating condition was as follows (Table 1). The shape and dimension of device made of stainless plate for cutting test was shown in Fig. 3. All assays were performed at least in triplicate.

Result and Discussions

Salinity of Chinese cabbage salted in brine

As shown in Table 2, the amounts of salt in Chinese cabbage were all increased gradually up to 7 days' salting, and then the slope of increasing in salt concentration got lower and lower with slight decrease after 9 days. In the initial stage of salting process, salt was penetrated rapidly into Chinese cabbage, because the larger the difference in salt concentration between cabbage sample and brine for salting in the tank is, the faster salting process continued.

The salinity of Chinese cabbages salted in 3% brine increased evenly and slowly up to seven days' salting. In case of the outermost leaf, the salinity of whole leaf were increased to get nearly the same salinity throughout the outermost leaf. The maximum salinity showed 2.5, 2.4 and 2.3% for upper and lower stem, and leaf parts, respectively.

For the outer leaf, salinity of leaf part increased almost

Table 2. Distribution of salinity in salted Chinese cabbage during 3% brine salting

Salting time (Day)	Outermost leaf			Outer leaf			Middle leaf			Inner leaf		
	Top stem	Middle stem	Leaf part	Top stem	Middle stem	Leaf part	Top stem	Middle stem	Leaf part	Top stem	Middle stem	Leaf part
0	0.33	0.09	0.20	0.20	0.11	0.16	0.15	0.03	0.09	0.05	0.02	0.06
1	0.13	0.08	0.25	0.23	0.19	0.34	0.21	0.32	0.34	0.18	0.37	0.44
2	0.77	1.01	0.88	0.58	0.48	0.79	0.30	0.77	0.57	0.18	0.44	0.72
3	0.96	1.02	1.16	0.53	0.56	1.10	0.53	0.86	1.10	0.53	0.56	1.10
7	2.54	2.37	2.04	1.00	1.21	1.67	0.68	1.45	1.53	0.69	1.60	1.55
9	2.44	2.40	2.28	0.74	0.86	1.59	0.98	1.23	1.45	0.86	1.52	1.65

Table 3. Distribution of salinity in salted Chinese cabbage during 5% brine salting

Salting time (Hr)	Outermost leaf			Outer leaf			Middle leaf			Inner leaf		
	Top stem	Middle stem	Leaf part	Top stem	Middle stem	Leaf part	Top stem	Middle stem	Leaf part	Top stem	Middle stem	Leaf part
0	0.40	0.20	0.30	0.20	0.11	0.16	0.15	0.03	0.09	0.05	0.02	0.06
4½	1.50	1.19	1.75	0.55	0.44	1.18	0.26	0.18	0.58	0.11	0.23	0.48
18	1.53	1.05	1.60	0.74	0.61	1.53	0.21	0.16	0.74	·	·	·
22	1.68	2.17	2.53	0.54	0.73	1.25	0.20	0.15	0.76	0.13	0.28	0.57
25½	1.74	2.12	2.81	0.37	0.28	1.25	0.12	0.13	0.62	0.18	0.35	0.80
28	2.00	2.37	2.48	0.30	0.33	0.88	0.15	0.26	0.58	0.21	0.49	1.01
45	2.96	2.75	3.02	1.12	1.27	2.18	0.31	0.50	1.52	0.29	0.92	1.52
69	2.39	1.78	3.14	0.56	0.53	2.35	0.26	0.57	1.70	0.43	1.23	2.25

Table 4. Distribution of salinity in salted Chinese cabbage with 10% brine salting

Salting time (Hr)	Outermost leaf			Outer leaf			Middle leaf			Top stem		
	Inner leaf	Middle stem	Leaf part	Top stem	Middle stem	Leaf part	Top stem	Middle stem	Leaf part	Top stem	Middle stem	Leaf part
0	0.40	0.20	0.30	0.20	0.11	0.16	0.15	0.03	0.09	0.05	0.02	0.06
1	0.69	0.77	1.40	0.24	0.31	0.75	0.17	0.13	0.32	0.10	0.11	0.29
3	1.16	0.99	2.54	0.51	0.40	0.87	0.40	0.30	0.52	0.14	0.13	0.35
4	1.34	1.22	3.51	0.57	0.47	1.36	0.26	0.17	0.64	0.25	0.23	0.50
5½	2.67	2.07	3.61	0.50	0.52	1.59	0.40	1.43	0.91	0.27	0.33	0.88
7	3.12	2.67	3.49	0.41	0.34	1.56	0.37	1.29	0.88	0.28	0.28	0.70

double times than that of stem parts after 3 days' salting, and the maximum salt content reached to 1.0, 1.2 and 1.7% for upper stem and lower stem, and leaf one, respectively. In case of middle leaf and inner leaf, the salinity of middle stem parts and leaf parts increased greatly after 3 days' salting but those of top stem parts did evenly and slowly.

More than 3% of salt concentration in brine shortened salting time for making less crispy texture of salted cabbage. At table 3, the salinity of Chinese cabbages salted in 5% brine had little change until 28 hours except the outermost leaf, was increased tremendously up to 45 hours, and then, however, either decreased slightly or the same amount. The salinity of the outer leaves showed 0.3, 0.3 and 0.9% after 28 hours' salting, but 1.1, 1.3 and 2.2% for upper stem and lower stem, and leaf one, respectively for 45 hours' salting. However, since the salinity of the middle and the inner leaf increased continuously, the salinity of salted Chinese cabbage seemed not to reach the equilibrium. The final salinity of the middle leaf were 0.3, 0.6 and 1.7%, and those of the inner leaf were 0.4, 1.2 and 2.3% for upper stem and lower stem, and leaf one, respectively. As shown table 3, the salinity of the outermost leaf were 3 to 6 times higher than that of raw Chinese cabbage, and the maximum salinity were obtained after 45 hours' salting (i.e., 3.0, 2.8 and 3.0% for each fractions in the outermost leaf). After 69 hours, the salt content of the stem part was slightly decreased and that of the leaf section was slightly increased. The same is true for the outer leaf before and after 69 hours' salting. We found that the salinity were not continuously increased, instead, the content of salt in each part was increased until 22 hours, slightly decreased between 22 and 28 hours' salting, then increased again. This seemed that at first, the salts were penetrated vigorously, and then the moisture was penetrated into the inside of cabbage temporarily to equalize osmotic pressure in those parts of each leaf.

At table 4, the salinity in salted Chinese cabbages using 10% brine gave much differences between the outermost and other leaves. While the salinity of the outermost leaf were 3.1, 2.7 and 3.5% for top and middle stems and leaf parts, respectively, for 7 hours' salting, other leaves did not yet reached 1% salt content

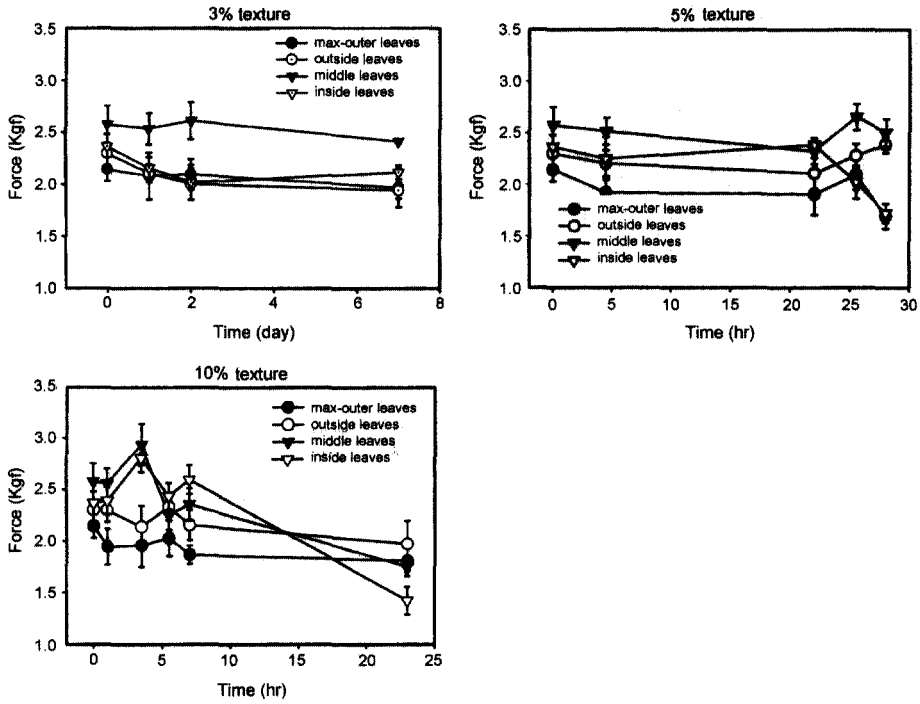

Fig. 4. Cutting force of Chinese cabbage during brine salting.

except leaf part in the outer leaf (1.6%). Using 10% brine, the distribution of salt in all parts of salted Chinese cabbage was tremendously differed during salting, compared to those of salted cabbage by using 3 and 5% brine.

Textural property of Chinese cabbage salted in brine

As shown in Fig. 4, the textural property of Chinese cabbage salted in 3, 5 and 10% brines was measured by Texture Analyzer. As expected, most of the maximum cutting force of salted Chinese cabbage was all decreased. For salted Chinese cabbage by using 3% brine, the max cutting force was decreased about 8.3, 15.6, 6.2 and 10.6% for outermost, outer, middle and inner leaves, respectively during 7 days' salting. For the middle leaf, however, the max cutting force was slightly increased at the second day, compared to the fresh Chinese cabbage sample.

In case of 5% brine salting, the maximum cutting forces of the outermost and the inner leaves were reduced 21.0 and 27.3%, respectively after 28 hours. For the outer and the middle leaf samples, the cutting forces were decreased 8.3 and 9.7%, respectively up to 22 hours, but those forces were much increased for next 2.5 hours, and at 28 hours' salting, more increased 3.7% for the outer leaf sample, or slightly decreased 2.8% for the middle leaf, compared to that of raw Chinese cabbage.

The maximum cutting forces of all the parts in Chinese cabbage salted in 10% brine showed large fluctuation during salting. From the measurement, we found a decrease in the maximum cutting force of 13.0, 6.3 and 8.5% for the outermost, outer and middle leaves, respectively up to 7 hours, but that of the inner leaf was increased a little (9.6%), which seemed that it was not easy to rationalize the general conclusion on estimating the changes in the maximum cutting forces of the whole Chinese cabbage samples up to 7 hours. For 23 hours' salting, the cutting forces of all the parts of Chinese cabbage were tremendously decreased about 14.3~39.9%, probably due to its softening effect of the salting solution.

From these results, measuring the maximum cutting

force of Chinese cabbage did not seem to be a proper method, because the general trend did not show to speculate well the relationship between the maximum cutting force and less crispy salted Chinese cabbage texture by using brine. Unfortunately, we could not draw general conclusion on the specific parameter for textural property of salted Chinese cabbage sample salted in the brine, at this time. For this experiment, thus, it might be that several aspects should be considered, such as the structural characteristics of Chinese cabbage, uniform collection of Chinese cabbage sample, accurate extraction of salted leaf liquids, cultivation method, and harvest time, etc.

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