Quality Characteristics of Sauerkraut from Cabbage *(Brassica oleracea)* during Fermentation and Variation of Salt Concentration

Rahmat Fadhil, Rahmah Hayati, Raida Agustina

Abstract— Cabbage *(Brassica oleracea)* has short storage time due to its high-water content so that it is easily get rotten. The vegetable putrefaction can be prevented through preservation (fermentation), where the fresh cabbage is fermented to become sauerkraut by using salt as inoculum. This research is purposed to analyze the quality of sauerkraut for seven days of fermentation with variation of salt concentration, through examination of its physical and chemical properties by using analysis of variance (ANOVA) at significant level of P≤0.05. The factor that was examined was salt concentration variation, which consisted of 2.25% (K1), 2.50% (K2), 7.50% (K3) and 12.50 (K4). The study result showed that the best treatments were at samples with salt concentration by 2.25% (K1) and 2.50% (K2). Average values for treatment with 2.25% of salt concentration (K1) are: 20.75% weight loss, pH 3.56, 77.5 g*kg-1 Total Soluble Solids (TSS), 0.074 g*kg-1 vitamin C, 90.93% water content, and 0.0096% lactic acid, while the average values obtained for treatment with 2.50% of salt concentration (K2) are: 20.05% weight loss, pH 3.69, 75.5 g*kg-1 TSS, 0.132 g*kg-1 vitamin C, 92.10% water content, and 0.0095% lactic acid. In general, it shows that the variation of salt concentration in sauerkraut has significant effect to the value of TSS, weight loss, water content, and lactic acid, but it does not have significant impact on pH and vitamin C.

Index Terms — cabbage, fermentation, quality, salt concentration, sauerkraut.

1 Introduction

Cabbage *(Brassica oleracea)* is one of vegetables that are widely grown Indonesia, and its product is abundant. Cabbages that are not sold in traditional market are usually thrown away. Therefore, the advanced treatment for the post-harvested cabbages is necessary, in between is by processing cabbages into sauerkraut. Fermentation is one of food preservation methods, which is very ancient and able to maintain the nutrition of food. Fermented vegetable products that are famous today are sauerkraut (German), kimchi (Korea), pickles, and salted vegetables. Sauerkraut can be made from various vegetables such as yellow velvetleaf, mustard leaf, cabbage, water spinach, and bamboo sprouts. Fresh cabbages that were fermented into sauerkraut were using salt with certain concentration, so the addition of other microorganism as inoculum or yeast is not necessary, because the lactic acid bacteria are already existed in cabbages [1]. The growth and activity of lactic acid bacteria can be selectively stimulated with the addition of salt before fermentation process. The given concentration of salt will affect the quality of sauerkraut [2], [3], [4], [5], [6]. Several other researchers reported that the use of chilies, shallots, pepper, and ginger also give effect to the quality of sauerkraut produced [7], [8], [9]. The process of making sauerkraut is not much different from the making of salted vegetables; just the vegetables for sauerkraut are finely cut.

Sauerkraut is still uncommon because the consumption of sauerkraut is still narrow. But in foreign country, such as Europe in form of "sauerkraut", Korea in form of "kimchi", Japan in form of "tsukemono", it is daily consumed in an unneglectable amount. Therefore, this vegetable processing can also become and initiative for Indonesia to supply vegetables to those countries, and it is expected to become export product with good prospect.

The purpose of the study is to analyze the characteristic of sauerkraut made-from-cabbage during fermentation and the variation of salt concentration. By knowing the right concentration of salt during fermentation according to the quality of physical and chemical properties from the sauerkraut produced, it will be useful to maintain its quality during the storage later.

2 Materials and Methods

Cabbages that were used in this study were obtained from farmland in Takengon, Aceh Tengah, Province of Aceh, Indonesia. Sixteen kilograms of fresh cabbages was sorted, washed, and then finely cut in ± 2-3 mm size (the bone leaf and core was not included as much as possible) for all types of treatment. Determination of cabbage initial weight for each sample was represented by 0.200 kg cabbage slices. Variation of salt concentrations that were used was: 2.25% (K1), 2.50% (K2), 7.50% (K3) and 12.50% (K4). To add flavor and play as anti-microbial agent, pepper was added by 1% for all treatments. Salting method that was used was dry salting, which used solid or crystal salt. Addition of salt and pepper was done by smearing them on cabbage slices, after that the cabbage slices were stirred until even, and then were placed in transparent glass jar while pressing them until compact. The jar was tightly sealed until air-tight and fermented for 7 days in ambient temperature by 20 – 25 ^{o}C. After that, the physical property (weight loss) and chemical properties (pH, TSS, water content, vitamin C, and lactic acid) of all treatments were analyzed. pH measurement was done by using Benchtop meter (type AZ-86505, USA). Analysis of water content used

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vacuum oven method AOAC [10] and was stated in dry weight (% dw). TSS measurement used refractometer ATAGO (PR-32ALPHA, USA), while Vitamin C and lactic acid level measurement was using procedure of AOAC [10]. The analysis of research data was using non-factorial Completely Randomized Design (CRD) with one primary factor that consists of four levels of salt concentration and each treatment was repeated twice, so that there were 8 units of experiment. The data obtained were processed by using analysis of variance (ANOVA) at significant level P≤0.05 by using SPSS Version 22.

3 Results and Discussion

3.1 Weight Loss

Weight loss is one of factors that can be used for identifying sauerkraut physical quality. Weight loss that was occurred in sauerkraut is caused by addition of salt into the vegetables, where the higher salt concentration is given, the greater the weight that loses. The salt that was added into the tissue of fresh vegetables can pushes the liquid out of the vegetables through osmosis process, so that the weight loss of vegetables will increase. The weight losses of sauerkraut for all treatments were changing along with the length of fermentation time that the longer the fermentation time, the more weight to lose. The amount of weight loss during the seven days of fermentation was ranged between 4.6 – 7.9% (Figure 1).

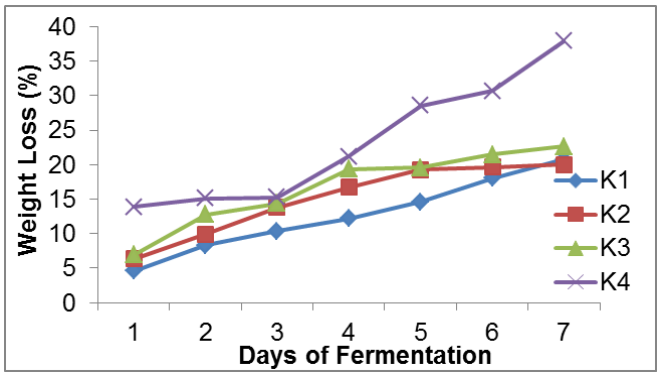

Figure 1. Sauerkraut weight loss during

Variation of salt concentration gave different response to the weight loss. The expected result is the smallest weight loss after fermentation. From Duncan post-hoc test result at the significant level of P≤0.05, the effect of salt concentration towards the weight loss, between samples with 2.25% (K1), 2.50% (K2) and 7.50% (K3) salt concentrations, has no significant difference, whereas at 12.50% salt (K4), the weight loss is significantly different (Table 1).

3.2 pH

pH of sauerkraut during the fermentation for all treatments is ranged between 3.56 - 5.71 (Figure 2). The longer the fermentation, the lower the pH that turned into acidic condition. The higher salt concentration causes the pH of sauerkraut to increase, while the bacteria fastest growth is in acidic condition. According to study by Pundir and Jain [1], they stated that the good sauerkraut is the one who has pH that ranges between 3.1 - 3.7, whereas according to Felix [11], the best quality of sauerkraut is at pH 3.8. Thus, pH of sauerkraut that was produced in this study, at 2.25% (K1) and 2.50% (K2) salt concentration, is already classed as good. Based on the result of sauerkraut analysis of variance, variation of salt concentration does not significantly affect the pH of sauerkraut.

TABLE 1
EFFECT OF SALT CONCENTRATION VARIATION TOWARDS SOME PARAMETERS OF PHYSICAL AND CHEMICAL QUALITIES OF SAUERKRAUT BY USING DUNCAN TEST AT 95% LEVEL OF SIGNIFICANT

Parameters	K1	K2	K3	K4
Weight loss (%)	20.75[a]	21.30[a]	22.65[a]	37.90[b]
pH	3.62[a]	3.74[a]	4.02[a]	4.15[a]
Water content (%)	90.93[a]	92.10[a]	86.25[b]	83.69[b]
TSS (g*kg^{-1})	77.50[a]	80.50[a]	123.50[b]	157.5[c]
Vitamin C (g*kg^{-1})	0.355[a]	0.366[a]	0.370[a]	0.330[a]
Lactic acid (%)	0.0096[a]	0.0095[b]	0.0049[c]	0.0022[c]

Notification by same letter on each row denote that there is no significant difference (P ≤ 0.05)

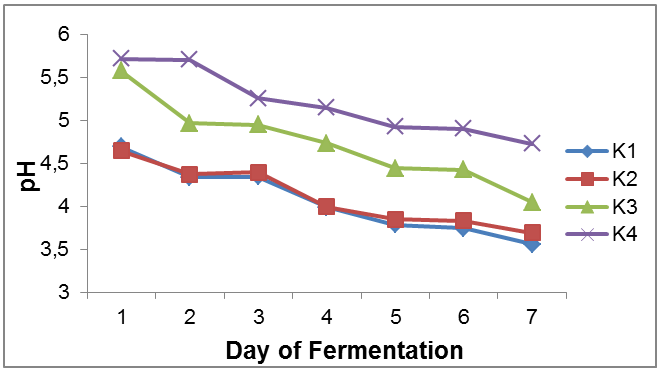

Figure 2. pH of sauerkraut during fermentation

3.3 Water Content

Water content is a number of water contained in foodstuff. Water content of sauerkraut is changing during the fermentation in accordance with its circumstance. Water content of fresh cabbage used before the fermentation was 91.99%. Cabbage in jar was experiencing gas evaporation due to the fermentation in anaerobic condition, so that the water in sauerkraut overflowed from the lid. On the first day of sauerkraut fermentation, there was a decline in water content for all treatments, and then it increased again on the 7th day, except on the treatment with 7.50% salt concentration (K3) (Figure 3).

Based on analysis of variance of sauerkraut, variation of salt concentration has significant effect to the water content. This shows that variation of salt concentration gave different response to the water content of sauerkraut, because the water contained in foodstuff will changes according to its circumstances. Referring to data by United States department of Agriculture (USDA) [12], sauerkraut contains 0.092 kg water. It can be concluded that the best treatment is on

treatment with 2.50% salt concentration (K2), with final water content by 0.092 kg (has met the nutritional standard by USDA [12]. Duncan post-hoc test showed that the effects of salt concentration towards sauerkraut water content between treatments with 2.25% (K1) and 2.50% (K2) salt are not significantly different, and so are between the treatments with 7.50% (K3) and 12.50% (K4) salt, there is no significant difference. However, the water content in sample treated with 2.25% salt (K1) is significantly different to those treatments with 7.50% (K3) and 12.50% (K4) salt concentration; and so is it for treatment with 2.50% salt (K2), which has significant difference to treatments with 7.50% (K3) and 12.50% (K4) salt concentration (Table 1).

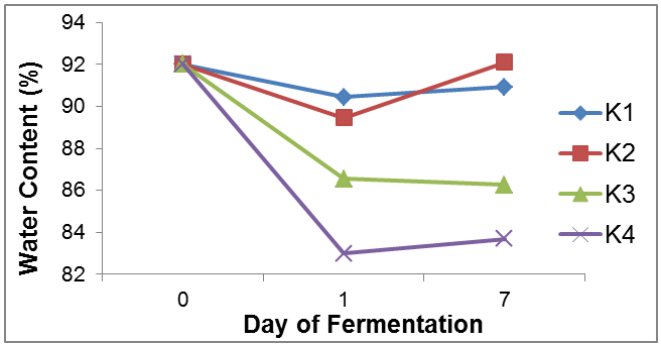

Figure 3. Water content of sauerkraut during fermentation

3.4 Total Soluble Solids

Content of Total Soluble Solids (TSS) in sauerkraut during the fermentation is relatively stable (Figure 4). The higher salt concentration is given, the higher the TSS value of sauerkraut. Measurement of total dissolved solid (TSS) is specified in Bix unit, where the dissolved dry solid in a solution is counted as sucrose (sugar). According to Thakur and Kabir [3], TSS contained in sauerkraut is ranged between 7.4 – 8.0 oBrix or 74 – 80 g*kg-1. According to data from USDA [12], amount of sugar in sauerkraut is only by 18 g*kg-1, but from data obtained from this study, the amount is much higher than data from USDA [12], which is ranged between 81.50 – 157.50 g*kg-1. This is caused by the difference of cabbage varieties used in the making of sauerkraut. Cabbages that were obtained directly from farmland in Takengon-Province of Aceh have higher sugar content compared to the cabbages that were studied by Thakur and Kabir [3]. However, the proportion of sugar in cabbage depends on its variety and growth. Essentially, sauerkraut is a low-sugar and high-vitamin C food [13]. Result of this study showed that the best sauerkraut with low sugar content was found in sample with 2.50% concentration of salt (K2) treatment (Figure 4).

According to sauerkraut analysis of variance, variation of salt concentration has significant effect on TSS of sauerkraut (Table 1). Variation of salt concentration gives different response towards the TSS content.

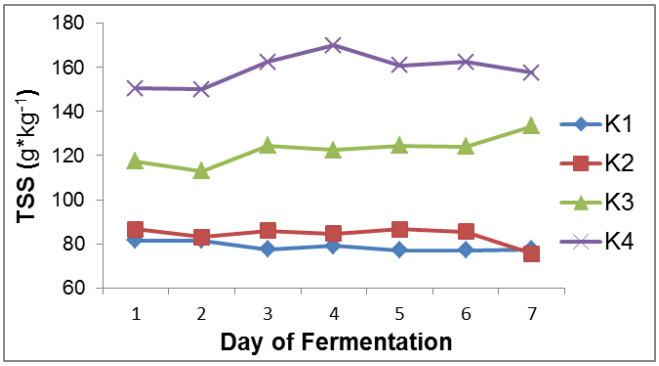

Figure 4. Total dissolved solids of sauerkraut during fermentation.

3.5 Vitamin C levels

Referring to Thakur and Kabir [13], ascorbic acid (vitamin C) contained in sauerkraut is by 0.133 – 0.209 g*kg-1. In this study level of vitamin C in sauerkraut during fermentation for all treatments was ranged between 0.074 – 0.616 g*kg-1 (Figure 5). The longer the fermentation time, the lower the vitamin C content; applied all treatments. The decrease in vitamin C during the fermentation is caused by the properties of vitamin C that is easily dissolved in water, and therefore, it is easily lost due to the slicing of cabbages (*due to the size of cabbage). According to the result from analysis of variance of sauerkraut, variation of salt concentration does not have significant effect to the vitamin C contained in sauerkraut. Thus, it can tell that variation of salt concentration does not have different response to the vitamin C content.

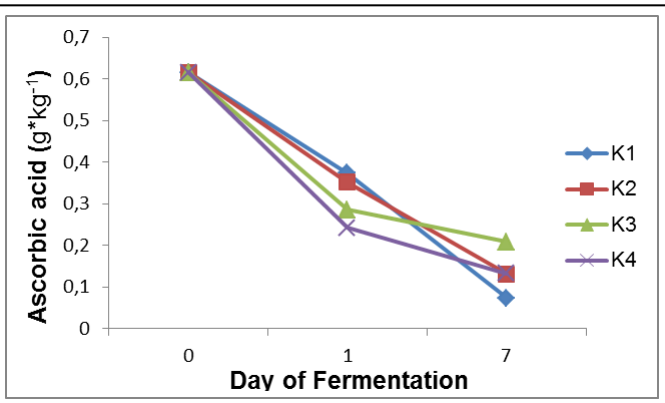

Figure 5. Vitamin C of sauerkraut during fermentation

3.6 Lactic acid

During fermentation of sauerkraut, the growing bacteria will converse the sugar into lactic acid [14]. In the absence of air condition (anaerobic), microorganism in cabbage will produce lactic acid about 1.5% - 2.0% with 1.5% salt addition [1]. According to Prant et al. [15], sauerkraut contains lactic acid by 0.228%, but the result obtained from this study is much smaller from that value, which is ranged between 0.0022 - 0.0095%. The higher salt concentration is given, the lower lactic acid produce, and vice versa [2]. Lactic acid that is

produced will inhibit the growth of mold and yeast by Lactobacillus plantarum that grow in the sauerkraut [1], [16], [17].

According to the result of analysis of variance of sauerkraut, it showed that variation of salt concentration has significant effect to the lactic acid content of sauerkraut. This condition indicates that variation of salt concentration gives different response to the lactic acid content. From the result of Duncan post-hoc test, it was obtained that the effect of salt concentration towards the lactic acid, in sample with concentration of salt at 2.25% (K1), is significantly different to samples with salt concentration by 2.50 (K2), 7.50% (K3) and 12.50% (K4), and so is it in 2.50% salt concentration, the lactic acid content is significantly different to the samples with 7.50% (K3) and 12.50% (K4) salt concentration, whereas in 7.50% (K3) and 12.50% (K4) samples, there is no significant difference (Table 1).

4 Conclusion

According to the study result, it can be concluded that during the 7 days of sauerkraut fermentation, the best treatment was found in treatment with 2.25% (K1) and with 2.50% (K2) salt concentration. Average values treatment with 2.25% salt concentration (K1) are: 20.75% weight loss, pH 3.56, 77.5 g*kg-1 Total Soluble Solids (TSS), 0.074 g*kg-1 vitamin C, 90.93% water content, and 0.0096% lactic acid, while the average values obtained for treatment with 2.50% of salt concentration (K2) are: 20.05% weight loss, pH 3.69, 75.5 g*kg-1 TSS, 0.132 g*kg-1 vitamin C, 92.10% water content, and 0.0095% lactic acid. Variation of salt concentration in sauerkraut has significant effect towards the total dissolved solids (TSS) content, weight loss, water content, and lactic acid, but it does not significantly affect the pH and vitamin C. This study had successfully performed sauerkraut fermentation in a relatively short time, which is only 7 days, but able to produce sauerkraut with quality that meets the standard specified by United Stated Department of Agriculture (USDA).

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