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Research Article
Natural Fermentation of Orange Sweet Potatoes to Produce Brined Pickle under Different Salt Content

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Abstract

Background and Objective: The lactic acid fermentation without starter addition (natural fermentation) may provide a standard preservation technique to produce sweet potatoes pickle that can be adopted at the household level. The objective of this study was to investigate the potential use of natural fermentation with variants of salt concentration to produce acceptably pickled of orange-fleshed sweet potatoes. **Materials and Methods:** The cubes were pickled by lactic fermentation by brine the cut and blanched cubes in five concentration level of common salt (NaCl, 1-6%) solutions and incubated for 12 days. Every 2 days, the sample was withdrawn for the various analysis, i.e., total acidity pH, total soluble solid, reducing sugar and total lactic acid bacteria. Meanwhile, the sensory was measured only for day 12 fermentations. **Results:** All physicochemical and sensory of pickled were affected by salt concentration during fermentation. Higher salt concentration increased total soluble solid and reducing sugar of the pickle but decreased total acidity and consequently influenced the aroma, color, texture and overall appearance of the pickle. About 5% of salt concentration was found to be organoleptically most acceptable (moderately like). **Conclusion:** The sweet potatoes pickle prepared using 5% of salt concentration could be a good prospect for commercialization in small-scale industries and could be used to fulfill the growing demands of foods with low sodium content.

Key words: Lactic acid fermentation, sweet potatoes pickle, natural fermentation, vegetable pickles, preservation technique

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The most lactic acid fermented vegetable pickles are mainly produced from cabbage and cucumber[1]. More types of vegetables used to produce pickled products including root vegetables such as carrot, radish and onion[1,2]. Another potential root vegetable to be processed for the production of fermented pickle through lactic acid fermentation is sweet potatoes (*Ipomoea batatas*)[3-5]. Sweet potatoes are important root vegetables having the essential nutritional value of starch, sugar, vitamin C, provitamin A, iron and minerals[6,7]. Some varieties of sweet potatoes contain β-carotene and anthocyanin that are believed as anti-oxidant having physiological attributes such as anti-oxidation, anti-cancer, protection against night blindness, aging and liver injury[6,7].

To bring into being a brined pickle, lactic acid fermentation is applied to sweet potatoes tubes which are combined with salt to select and control the micro-organism and the fermentation process. The fermentation can be performed either by spontaneous fermentation or by addition of starters' cultures. Previous work demonstrated the lactic acid fermentation of sweet potatoes with salt (NaCl 8-10%) solution and with subsequently culturing of *Lactobacillus plantarum* (MTCC 1407)[3,4]. Yuliana *et al.*[5] reported the effect of a mixed starter of *Lactobacillus plantarum* and *Leuconostoc mesenteroides* on the sweet potatoes pickle. However, whether a similar acceptable product can be preserved using spontaneous (natural) lactic acid fermentation is not documented. Also, researches on using sweet potatoes for pickle fermentation have been very few. The main reason for natural fermentation interest due to it is a standard preservation technique that can be adopted at the household level. This technique could be beneficial in the preservation of orange sweet potatoes which are the primary sources of carbohydrate, β-carotene, vitamin and mineral[5].

Numerous factors influence the rate and extent of various micro-organisms as well as their sequence of appearance, during fermentation. In pickling, the addition of salt initiates a microflora selection process which favors lactic acid bacteria. Also salt withdraws juice from the vegetable as a media, thus making nutrients are available in the brine[8]. These provide a suitable environment for lactic acid bacteria to grow which impart the sour flavor to the pickle. According to Fleming and McFeeters[9], the number of fermentable carbohydrates in the vegetable and the availability of nutrients in the brine are among essential factors that affect the fermentation. For obtaining good quality fermented pickle products, the process must be appropriately prepared in order that only desirable lactic acid bacteria fermentation occurs. Since there is no standardization method of sweet potatoes pickles spontaneous manufacture, it was desirable to learn more about the effects of varying concentrations of salt brine on the natural fermentation of sweet potatoes cube. The objective of the study was to investigate the potential use of spontaneous fermentation with variants of salt concentration to produce acceptable pickle of orange-fleshed sweet potatoes.

MATERIALS AND METHODS

Collection and preparation of plant sample: This study was performed in the laboratory of Agricultural Products, The University of Lampung, Indonesia. The primary material used was orange flesh sweet potatoes obtained from the local market in Bandar Lampung-Indonesia. The freshly orange sweet potatoes roots were adequately washed, peeled and cut into small cubes (approximately 1×1 cm). These sweet potato cubes (40 g) were blanched for 1.5 min at 70°C and were then dispersed in 150 mL bottle glass.

Pickling of sweet potato: This preparation followed procedure by Yuliana *et al.*[5]. Brine solution of salt concentrations (1-6%) containing 1% sugar (sucrose) was prepared by dissolving salt (NaCl) and sucrose in distilled water and 110 mL of the prepared brine solution was added to each above bottle and capped tightly. Three replicates were maintained and the data from the biochemical analyses were calculated as a means of three replications. The sweet potato brine solutions were fermented on the laboratory bench at room temperature (28-30°C) during 12 days.

Physicochemical analysis: Sweet potato cubes and brine (1:5 ratios) were homogenized and the equilibrated mash was used for physicochemical analyses (pH, total acidity, reducing sugar and total soluble solids). The pH values were determined by a glass electrode pH meter. Titratable acidity was determined by the titration method (AOAC)[10] and the data were expressed as equivalent (%) of lactic acid (LA). Reducing sugar of sweet potato pickle (expressed as %) was determined by the procedure given by Sudarmadji *et al.*[11]. Total soluble solids were determined using an Abbe refractometer[12].

Microbiological analysis: The Man Rogosa agar (Oxoid) was used for enumeration of total lactic acid bacteria. Samples were serially diluted 10 fold with 1% peptone-water. One milliliter of the appropriate dilutions was inoculated onto

duplicate plates using selective media for lactic acid producing bacteria (MRS agar+1% $CaCO_3$). Plates were incubated aerobically for 48 h. After incubation, single colonies were counted and the results were expressed as the log10 of the colony-forming unit (CFU) per milliliter[5].

Sensory analysis: Sample of the day 12 fermentation was subjected to sensory evaluation. The sensory properties of fermented pickle were evaluated by the panel group of 15 students using 7 points hedonic system.

Statistical analysis: The mean values were calculated from the data obtained with triplicate trials. The analysis of variance (one-way) was used to examine the statistical significance ($p<0.05$) treatments during fermentation. Means were separated using polynomial orthogonal.

RESULTS

Changes in physicochemical during fermentation: Changes in the physicochemical characteristics of a pickle during fermentation are presented in Fig. 1- 2. Salt concentration had a quadratic effect ($p<0.05$) on all physicochemical parameter of the pickle. There was a tendency for higher addition of salt concentration would increase TSS and reducing sugar of the pickle, as well as increased Total Acidity (TA) and consequently decreased the pH value. The amount of the change was varied depending on the salt concentration.

The marked increase in TA was observed until 6 days and constant afterward for fermented sweet potatoes pickle with 1-5% salt brine, meanwhile those with 6% salt brine continue to increase until 12 days of fermentation (Fig. 1a). Likewise, the pH decrease of sweet potatoes with 1-5% salt brine, while the 6% treatment had a slower rate of pH decrease (Fig. 1b). A decrease in pH of all fermented sweet potatoes pickle was observed throughout fermentation from the initial pH of 6.12-3.3.

Total soluble solid was slightly increase at the initial fermentation of orange sweet potatoes pickle and decrease afterward (Fig. 2a). In all pickle samples, total soluble solid was highest in 6% brine salt samples during 12 days of fermentation. The initial TSS of sweet potatoes fermentation were found 2-6° Brix dependent on the salt concentration. After fermentation of 9-12 days, the TSS of this product were found 3-7.2°Brix. Likewise, the residual reducing sugar in 5-6% salt treatment had a higher amount than those in smaller salt concentration (1-4%) (Fig. 2b). All of the treatment showed a quadratic pattern on TSS and residual reducing sugar changes.

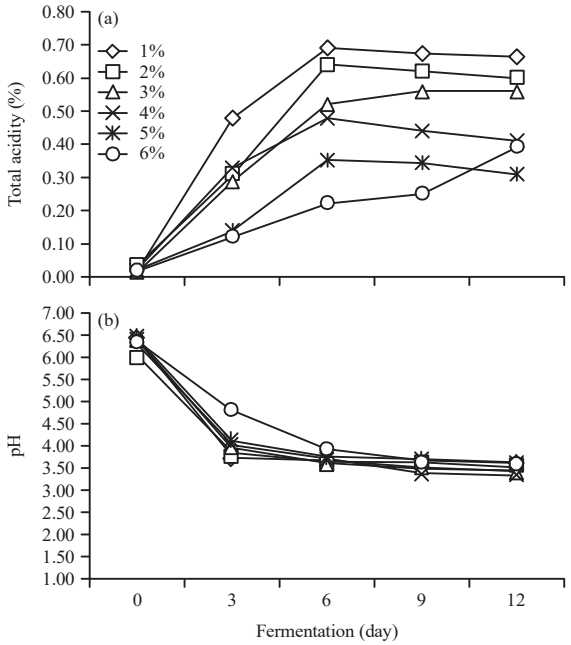

Fig. 1(a-b): Changes of (a) Titratable acidity and (b) pH values during fermentation of fermented orange sweet potatoes pickle with 1-6% brine salt (n = 3)

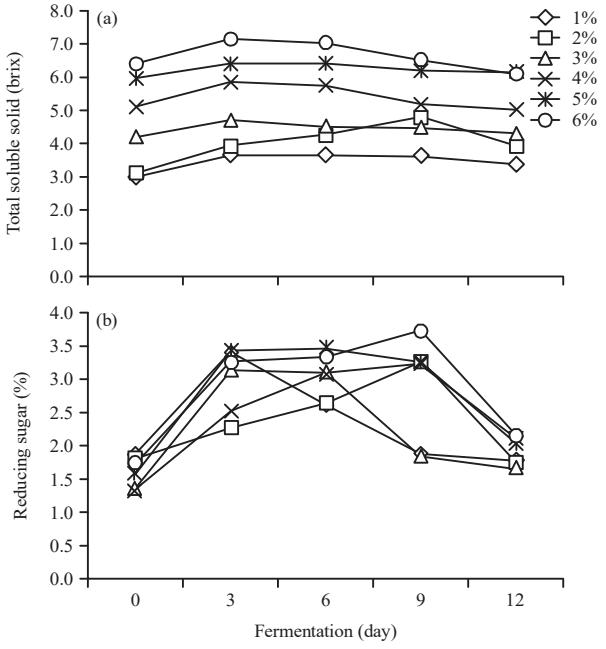

Fig. 2(a-b): Changes of (a) Total soluble solid and (b) Reducing sugar during fermentation of fermented orange sweet potatoes pickle with 1-6% brine salt (n = 3)

Changes in total lactic acid bacteria: Figure 3 illustrated the changes in the microflora of LABs during orange sweet potatoes pickle fermentation. The salt concentration

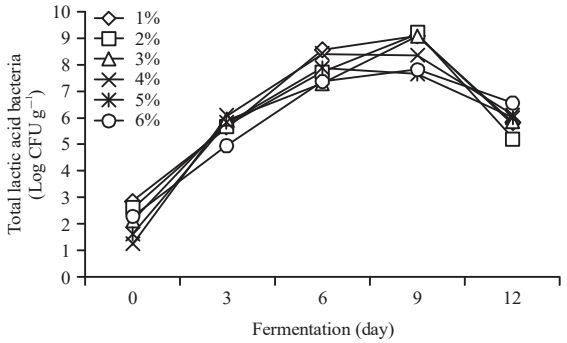

Fig. 3: Changes of viable cells of lactic acid bacteria (log CFU mL^{-1}) during fermentation (12 days) of fermented orange sweet potatoes with 1-6% brine salt (n = 3)

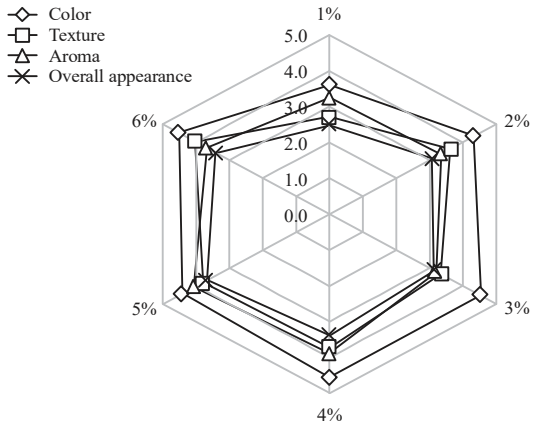

Fig. 4: Characteristic of sensory of fermented sweet potatoes pickle at day 12 of fermentation
Score 1: Extremely not like, 4: Moderately like, 7: Extremely like

had a quadratic effect ($p<0.05$) on total lactic acid bacteria. Lower salt concentration showed a higher amount of LAB in initial of fermentation. Throughout the 12 days fermentation process, there was a rapidly increased from the initial count of 2.1207 log-8.5088 log CFU g^{-1} on day 9 of fermentation and then decreased to 5.9067 CFU g^{-1} from day 9-12. The changes in LAB counts over time indicated that salt treatment resulted in a well-established population (stationary phase) from 6-9 days of fermentation. Salt had a significant inhibitory effect on the growth of LAB in brine at the early stage of fermentation but the effect was not significant on the last stage fermentation of sweet potatoes.

Sensory characteristic: The salt concentration significantly affected the aroma, color, texture and overall appearance, where higher salt concentration (5-6%) had a higher hedonic score on all parameters attribute (Fig. 4).

DISCUSSION

Increases of TA during the SP fermentation indicated that LAB grew and utilized sugars in plant materials to produce primarily lactic acid and other by-products. Increases of TA was in line with the changes in the pH value. It indicated that the breakdown of sweet potatoes as a carbohydrate-rich materials-induced by LAB with resulting organic acid was at a slower rate on the 6% of salt concentration media. Panda *et al.*[3] reported a similar gradual but quick fall of pH during the first 7 days fermentation of orange sweet potatoes using a strain of *L. plantarum* as an inoculant.

Treatment of 6% salt concentration also showed a lower amount of total LAB than those in 1-5% of salt concentration. It is suggested that the Lactic Acid Bacteria (LAB) in this fermentation was more favorable to growth in the media with low salt concentration (1-5%). The growth of LAB was low with increased NaCl concentration during fermentation. A similar pattern was observed in pickled cucumber and cabbage with low salt concentration (below 5%), LAB counts increased markedly[13] within 24 h and when the salt concentration was above 6%, the growth of LAB was inhibited initially[14]. The different NaCl levels (4-8%) on the microbiological evolution of naturally black olives showed that LAB presence was increased to 4 and 6% NaCl instead of higher NaCl level[15]. The LAB comprise a large and diverse group of Gram-positive, able to produce lactic acid as the main end-product of the fermentation of carbohydrates[16] and their response to salt is highly variable.

Salt concentration had a significant effect on the residual reducing sugar of sweet potatoes pickle. High concentration (5 and 6%) had higher reducing sugar than that of lower salt concentration treatment. The lower the salt concentration was the lower the content of residual reducing sugar in pickle was. This pattern was probably attributed to the amount of LAB, where a higher amount of LAB in low salt treatment lead to a presumably higher amount of simple sugar utilization during fermentation. Thus, their residual reducing sugar becomes low. Other researchers in cabbage fermentation reported a similar pattern in glucose concentration[17].

The TTS was significantly affected by salt concentration where higher soluble solid was observed by increasing salt concentration. The soluble solids are formed by the addition of salt and any soluble materials that leach from the sweet potatoes during fermentation, as well as probably contributed from simple sugar and other derivatives of a

fermentation metabolite such as organic acid. Thus, the TSS of sweet potatoes pickle was found to increase in initially fermentation. However, small reductions insoluble solids in the brine during the later fermentation days was observed. This probably because the effect of utilization of simple sugar by lactic acid bacteria during fermentation and ultimately resulted in a slightly decrease in TSS after 6-9 days of fermentation. This data was in line with a pattern of residual reducing sugar (Fig. 2a). Joshi and Sharma[18] and Vatansever *et al*.[19] also observed an increase in TSS value of initial fermentation period, which then decreased with continued fermentation.

All of the physicochemical changes during fermentation influenced the hedonic score of the pickle. Among the sensory attributes, the color showed the highest hedonic score with an average of 4.5 (moderately like). The attractive color of yellow sweet potato pickle is caused by the presence of beta-carotene pigments which are insoluble in fermentation solutions so that the color of sweet potato pickle remain orange. Lactic fermentation could retent 93.97% β-carotene of sweet potatoes pickle[4]. Based on the overall acceptance preference score, the preferred treatment was a 5% salt content as these pickles prepared in 5% brine were good in color and texture aspects (Fig. 4). The LAB play a vital role in the development of the organoleptic properties of the products, through their metabolic activities, LAB produces great aroma and flavor compounds[20]. Salt concentration affected saline taste and microbial structure of brine so affected the quality and flavor. The 5% salt content may have varian micro-organisms including LAB contributing to the preferred aroma and overall appearance of the pickle. Similar studies on the effect of different salt concentration on the vegetable pickle were mentioned, there were found that the salting process affected the final product quality. The blanched garlic treated with 5% brine showed significantly better quality parameter[21]. It is, therefore, the sweet potatoes pickle prepared without starter added (natural fermentation) would have a prospect to have similar characteristics to lactic-fermented sweet potatoes with culturing LAB. Besides, these products will meet consumers who demand foods with low-sodium content. For some reasons, the intake of high contents of sodium is linked to adverse effects on human health[22]. Sweet potatoes pickle prepared using 5% of salt concentration under natural fermentation would be an excellent prospect for commercialization in small-scale industries.

CONCLUSION

Sweet potatoes pickle prepared without starter added (natural fermentation) would have a characteristic slightly similar to lactic-fermented sweet potatoes with culturing lactic acid bacteria. Sweet potatoes pickle prepared using 5% of salt concentration with modification would be a good prospect for commercialization in small-scale industries.

SIGNIFICANCE STATEMENT

This study discovers the producing of acceptable naturally flesh orange sweet potatoes fermentation that can be beneficial for the home industry. This study will help the researcher to uncover the critical areas of suitable media preparation, e.g., brine concentration that many researchers were not able to explore. Thus a new theory on the technique may be arrived at.

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