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Several Parameters Influencing To Production Of Fermented Bamboo Shoot

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Abstract.

Bamboo shoots possess high protein, moderate fiber, and less fat content. This is a promising source of soluble fiber and vitamin. Bamboo shoot is rich in both amino acids and antioxidants and tastes fresh, crisp with aromatic quality and are delicious with all essential nutritive components. One way to utilize bamboo shoot fruit is to process into pickle product. The objective of the present study was to evaluate different variables influencing to the fermentation of bamboo shoot such as concentration of $CaCl_2$, temperature and time for blanching; sugar supplementation; effect of ratio *Lactobacilus acidophilus* to the antioxidant of fermented bamboo shoot. Bamboo shoot fermentation is carried out in traditionally designed bamboo chamber with batch fermentation. Results showed that bamboo shoot should be blanched in hot water 95^oC in 15 seconds with the present of 2.0% $CaCl_2$. Moreover, the fermentation process for pickle bamboo shoot had the best antioxidant by addition of 12% sugar, *Lactobacilus acidophilus* at ratio 3.0 x 10^8 cells/ml. Blanching and fermentation had significantly affected to antioxidant capacity and firmness of pickle bamboo shoot. After 15th day of pickling the antioxidant value of all bamboo shoot was increased significantly. The pickle bamboo shoot had a high content of antioxidant as well as firmness appropriated for daily consumption.

Keywords: *Bamboo shoot, pickle, fermentation, blanching, Lactobacilus acidophilus, antioxidant*

I. INTRODUCTION

Bamboos, a group of large woody grasses belonging to the family Poaceae and subfamily Bambusoideae.[1] Juvenile shoots in bamboos usually emerge with the beginning of the rainy season, during which the young edible shoots are harvested. Shoots are normally harvested 7-14 days after the emergence from the ground and when the shoot height is about 15-30 cm depending upon the species.[2] The edible portion of bamboo shoot consists of meristematic cell tissue with regions of rapid cell division and differentiation, which is enveloped in protective, non-edible leaf sheaths.[3] The ideal edible bamboo for processing should be white, solid, and tender and should lack bitterness and acridness. Exposure to light causes bitterness as cyanogenic glycosides are formed in the shoot.[4]

Bamboo shoots contain several nutritional components like protein, carbohydrates, fat, vitamins, minerals, enzymes, coenzymes, reducing and nonreducing sugars, lactic and citric acids. Bamboo shoot is rich in fiber and low in fat.[1] The main fatty acids present in bamboo shoots are palmitic, linoleic, and linolenic acids.[5] These also contain antioxidants (flavones, phenols and steroids).[6] Bamboo shoots are available in most of the countries in dried, canned, boiled or fermented form.[7, 8]

Some researches mentioned to bamboo shoot processing. Nutritional and functional profle of traditional fermented bamboo shoot based products was mentioned.[9] **A** review aimed to deliberate over the nutritional and medicinal properties of bamboo shoots, their industrial importance and how these offer to be a rich niche for bioprospecting lactic acid bacteria.[6] A study aimed to determine the characteristic of tabah bamboo shoot pickle such as total of lactic acid bacteria (LAB), pH, total acidity, and hydro cyanic acid content, and also find the LAB's type involved during fermentation, and organic acids' profiles.[10]

The health and nutritional benefits of bamboo shoot have led to their increased demand and hence production. However, increased production is accompanied by increase in postharvest losses due to their perishable nature. Due to the relatively short postharvest life in fresh form, bamboo shoot can be converted to shelf stable forms through processing. One of the most commonly used processing methods is fermentation. The objective of this present study was to evaluate different variables affecting to the fermentation of bamboo shoot such as concentration of $CaCl_2$; temperature and time for blanching; sugar supplentation; effect of ratio *Lactobacilus acidophilus* to the antioxidant of pickle bamboo shoot.

II. MATERIALS AND METHOD

2.1 Material

We collected bamboo shoot in Soc Trang province, Vietnam. They must be cultivated following VietGAP to ensure food safety. After collecting, they must be conveyed to laboratory within 4 hours for experiments. They were washed under tap water to remove foreign matters. Besides bamboo shoot we also used other materials during the research such as $CaCl_2$, *Lactobacillus acidophilus*. Lab utensils and equipments included digital weight balance, fermentor.

Figure 1. Bamboo shoot

2.2 Researching procedure

2.2.1 Antioxidant in raw bamboo shoot

Total 9 samples of raw bamboo shoot were used to measure the antioxidant content (mmol TE/g) in raw material. The antioxidant activity of raw bamboo shoot was evaluated by FRAP (Ferric Reducing Ability of Plasma).[11]

2.2.2 Effect of $CaCl_2$ concentration for blanching to the antioxidant of fermented bamboo shoot

Whole bamboo shoot fruits were blanched with $CaCl_2$ in different $CaCl_2$ concentrations (0%, 0.5%, 1.0%, 1.5%, 2.0%, 2.5%) in water at 100°C for 10 seconds. *Lactobacillus acidophilus* was added at ratio 2.0 x 10^8 cells/ml. The fermentation process was carried out at ambient temperature for 15 days with 8% of sugar supplementation. Antioxidant activity (mmol TE/g) and firmness (sensory score) were analyzed in the samples to verify the appropriate $CaCl_2$ concentration for blanching.

2.2.3 Efwect of temperature and time for blanching to the antioxidant of fermented bamboo shoot

Whole bamboo shoot fruits were blanched with $CaCl_2$ in 2.0% of $CaCl_2$ in water at different time and temperature (100°C for 10 seconds, 95°C for 15 seconds, 90°C for 20 seconds and 85°C for 25 seconds). *Lactobacillus acidophilus* was added at ratio 2.0 x 10^8 cells/ml. The fermentation process was carried out at ambient temperature for 15 days with 8% of sugar supplementation. Antioxidant activity was analyzed in the samples to verify the appropriate temperature and time for blanching.

2.2.4 Effect of sugar supplementation to the antioxidant and firmness of fermented bamboo shoot

Whole bamboo shoot fruits were blanched with $CaCl_2$ 2.0% in water at 95°C for 15 seconds. *Lactobacillus acidophilus* was added for the fermentation with ratio 2.0x 10^8 cells/ml. Fermentation process was carried out at ambient temperature for 15 days under different sugar supplementation (0%, 4%, 8%, 12%, 16%). Antioxidant activity was analyzed in the samples to verify the appropriate ratio of sugar supplementaion for fermentation.

2.2.5 Effect of ratio Lactobacilus acidophilus to the antioxidant of fermented bamboo shoot

Whole bamboo shoot fruits were blanched with $CaCl_2$ 2.0% in water at 95°C for 15 seconds. *Lactobacillus acidophilus* was added for the fermentation with different ratio 0; 1.0 x 10^8; 2.0x 10^8; 3.0x 10^8; 4.0x 10^8 cells/ml. Fermentation process was carried out at ambient temperature for 15 days with 12% of sugar supplementation. Antioxidant activity was analyzed in the samples to verify the appropriate ratio of *Lactobacilus acidophilus* for fermentation.

2.2.6 Quality assessment of the fermented bamboo shoot

Sensory score of fermented Bamboo shoot was evaluated a group of panelists. They were required to evaluate the odour, colour, taste, sweetness and overall acceptance using the 9-point hedonic scale (1 = dislike extremely, 9 = like extremely). The antioxidant activity of fermented Bamboo shoot was evaluated by FRAP (Ferric Reducing Ability of Plasma).[11]

2.3 Statistical analysis

The experiments were run in triplicate with three different lots of samples. Data were subjected to analysis of variance (ANOVA) and mean comparison was carried out using Duncan's multiple range test (DMRT). Statistical analysis was performed by the Statgraphics XVI.

III. Result & Discussion

3.1 Antioxidant in raw bamboo shoot

Total 9 samples of raw bamboo shoot were used to measure the antioxidant content (mmol TE/g) in raw material. The antioxidant activity of raw bamboo shoot was evaluated. Results were depicted in table 1.

Nutritional composition of edible bamboo shoots of some commercially important bamboo species was investigated. It was observed that macronutrients like Protein: 1.66 - 3.45 g/100g Fresh Weight (FW); Carbohydrates: 4.9 – 7.1 g/100g FW; Fiber: 1.57 – 3.7 g/100g FW and mineral elements composition (Sodium: 9.23 – 15.04 mg/100g FW; Potassium: 268.33 – 515.67 mg/100g FW).[2] Meanwhile, bamboo shoot exhibited a value of 17.8 mmol trolox equivalent (TE) per kg fresh weight and hence seemed to show moderate antioxidant capacity as compared to the other light colored vegetables (32.3–0.7 mmol TE/kg) when determined by hydrophilic assays such as the oxygen radical absorbance capacity.[12]

3.2 Effect of $CaCl_2$ concentration for blanching to the antioxidant and firmness of fermented bamboo shoot

Blanching is a heat processing method applied to food and the changes in food during the heating process can be expected as loss in turgor in cells, loss of integrity of the cell membranes and partial degradation of cell wall components.[13] Whole bamboo shoot fruits were blanched with $CaCl_2$ in different $CaCl_2$ concentrations (0%, 0.5%, 1.0%, 1.5%, 2.0%, 2.5%) in water at 100°C for 15 seconds. *Lactobacillus acidophilus* was added at ratio 2.0 x 10^8 cells/ml. The fermentation process was carried out at ambient temperature for 15 days with 8% of sugar supplementation. Antioxidant activity and firmness (sensory score) were evaluated in the samples to verify the appropriate $CaCl_2$ concentration for blanching. Results were elaborated in table 2. From table 2, the antioxidant content was not significantly different by $CaCl_2$ concentration. However, the firmness (sensory score) of pickle bamboo shoot had significantly different by $CaCl_2$ concentration. Among these treatments, pickle bamboo shoot had the highest firmness by treatment at 2.0% of $CaCl_2$. So this value was selected for further experiments.

Blanching is a mild heat treatment. Fruit and vegetable are usually blanched by soaking in hot water or boiled in water for few minutes. This process destroys food enzymes and some anti-nutritional factors. Blanching can also aid the dehulling process. Blanching bamboo shoot in an open vessel can reduce the toxicity through the nonenzymatic hydrolysis of taxiphyllin.[1] With regards to removal of anti-nutrient components during post-harvest treatment, some valuable nutrients also may get loss. Usually bamboo shoots are boiled for particular time before consumption. The boiling time is dependent on the locality, traditional practices and the need for removal of bitterness of shoot. The processing conditions were optimized by varying NaCl concentration, thickness of bamboo shoot, amount of NaCl

solution and duration of treatment aiming reduction in cyanide content in fresh bamboo shoot.[14] Bamboo shoots were cooked (one part bamboo shoots, four parts water) for 20, 100, and 180 minutes at 98◦C/ambient pressure, 110◦C/14.5 × 104 kPa, and 122◦C/21.12 × 104 kPa. The shoots were then cooled in water, canned, and sterilized. The maximum removal of HCN was about 97% leaving a residue level of about 27 mg/kg HCN (1000 mg/kg in fresh shoots) in the canned sterilized product. The optimum conditions that resulted in this reduction of HCN were 98–102◦C for 148–180 minutes.[15]

3.3 Effect of temperature and time for blanching to the antioxidant and firmness of fermented Bamboo shoot

Time and temperature of blanching may help enzymes like peroxidases to inactivate, which is one of the most heat stable enzymes and often used as a marker of completion of blanching.[16]

Whole bamboo shoot fruits were blanched with $CaCl_2$ in 2.0% of $CaCl_2$ in water at different time and temperature (100^oC for 10 seconds, 95^oC for 15 seconds, 90^oC for 20 seconds and 85^oC for 25 seconds). *Lactobacillus acidophilus* was added at ratio 2.0 x 10^8 cells/ml. The fermentation process was carried out at ambient temperature for 15 days with 8% of sugar supplementation. Antioxidant activity and firmness (sensory score) were evaluated in the samples to verify the appropriate temperature and time for blanching. Results were elaborated in table 3. From table 3, the bamboo shoot should be blanched at 95^oC in 15 seconds to get the highest antioxidant and firmness of pickle product. So this value was selected for further experiments.

Effect of blanching temperature (75, 85 and 95° C) and time (5, 10, 15, 20, 25 and 30 min) on different physic-chemical properties of bamboo shoot cubes were assessed. Blanching time and temperature have significantly influenced the nutrients like protein, carbohydrate and reducing sugar contents. The highest changed in values of protein, carbohydrate and reducing sugar were reported from 3.42 to 2.24, 4.08 to 2.25, 1.33 to 0.87 g/ 100 g, respectively. The influence was less on ash and crude fiber. Retention of ascorbic acid, total phenolics and antioxidants were higher in 75° C and/or short time blanching (5- 10 min) which were gradually reduced at 85 and 95° C and/or long time blanching (20-30 min). The higher blanching temperature decreases in lightness value and long time blanching deteriorate the texture of bamboo shoot. Low temperature short time blanching was shown to result in better product quality with respect to physical properties besides nutrient retention.[13] Proper combination of time and temperature of blanching is very important to retain the nutrients and quality of bamboo shoot. Low temperature and short time blanching have better retention of the entire nutritional component along with colour and textural properties. Therefore low temperature treatment with short duration was most suitable method of blanching.

Table 1. Chemical composition Antioxidant (mmol TE/g) in raw bamboo shoot

Parameter	Moisture (%)	Carbohydrate (%)	Soluble fiber (%)	Vitamin C (mg/100g)	Antioxidant (mmol TE/g)
Value	80.14±0.02	6.39±0.01	3.04±0.01	8.14±0.03	6.23±0.01

Table 2. Effect of $CaCl_2$ concentration for blanching to the antioxidant (mmol TE/g) and firmness (sensory score) of fermented bamboo shoot

$CaCl_2$ (%)	0%	0.5%	1.0%	1.5%	**2.0%**	2.5%
Antioxidant (mmol TE/g)	6.23±0.01^b	6.29±0.01^{ab}	6.33±0.01^{ab}	6.49±0.02^{ab}	**6.65±0.02^a**	6.66±0.01^a
Firmness (sensory score)	5.44±0.01^c	6.04±0.02^{bc}	6.17±0.02^b	6.50±0.02^{ab}	**6.91±0.01^a**	6.93±0.02^a

Note: the values were expressed as the mean of three repetitions; the same character s (denoted above), the difference between them was not significant (α = 5%).

Table 3. Effect of temperature and time for blanching to the antioxidant and firmness of fermented bamboo shoot

Blanching	100^oC, 10 seconds	**95^oC, 15 seconds**	90^oC, 20 seconds	85^oC, 25 seconds
Antioxidant (mmol TE/g)	5.64±0.01^{ab}	6.63±0.02^a	5.97±0.02^{ab}	5.57±0.00^b
Firmness (sensory score)	6.90±0.02^{ab}	7.29±0.01^a	6.45±0.01^{ab}	6.11±0.03^b

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%).

Table 4. Effect of sugar supplementation to the antioxidant and firmness of fermented bamboo shoot

Sugar supplementation	0%	4%	8%	**12%**	15%
Antioxidant (mmol TE/g)	5.34±0.01^c	6.40±0.02^{bc}	6.75±0.01^b	**7.41±0.01^a**	7.42±0.00^a
Firmness (sensory score)	6.55±0.01^b	7.20±0.02^{ab}	7.31±0.02^{ab}	**7.74±0.01^a**	7.77±0.01^a

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%).

Table 5. Effect of *Lactobacilus acidophilus* ratio to the antioxidant of fermented Bamboo shoot

***Lactobacilus acidophilus* (cells/ml)**	0	1.0×10^8	2.0×10^8	**3.0×10^8**	4.0×10^8
Antioxidant (mmol TE/g)	5.55 ± 0.00^c	7.34 ± 0.01^b	7.62 ± 0.01^{ab}	**7.84 ± 0.00^a**	7.87 ± 0.00^a
Firmness (sensory score)	6.19 ± 0.01^b	7.73 ± 0.01^{ab}	7.81 ± 0.01^{ab}	**8.05 ± 0.04^a**	8.08 ± 0.04^a

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%).

3.4 Effect of sugar supplementation to the antioxidant and firmness of fermented Bamboo shoot

Whole Bamboo shoot were blanched with $CaCl_2$ 2.0% in water at 95°C for 15 seconds. *Lactobacillus acidophilus* was added for the fermentation with ratio 2.0×10^8 cells/ml. Fermentation process was carried out at ambient temperature for 15 days under different sugar supplementation (0%, 4%, 8%, 12%, 16%). Antioxidant activity was analyzed in the samples to verify the appropriate ratio of sugar supplementaion for fermentation. Results were elaborated in table 4. From table 4, the bamboo shoot should be added with 12% of sugar to get the highest antioxidant and firmness of pickle product. So this value was selected for further experiments.

The lactic acid bacteria used as the starters capable of using sugar as a substrate for their growth. The use of sugar by the starter bacteria can cause the deconstruction of glycoside binding between the flavonoid and sugar releasing the flavonoid in the form of aglycone. The sugar group removal from the glycoside was conducted under the purpose for the bioavailability and/or plant functional flavonoid.[17]

3.5 Effect of *Lactobacilus acidophilus* ratio to the antioxidant of fermented bamboo shoot

Fermented foods are not only attractive and palatable in terms of flavor, aroma, texture, and appearance but are also rich in nutrients and good for digestion. Whole Bamboo shoot were blanched with $CaCl_2$ 2.0% in water at 95°C for 15 seconds. *Lactobacillus acidophilus* was added for the fermentation with different ratio 0; 1.0×10^8; 2.0×10^8; 3.0×10^8; 4.0×10^8 cells/ml. Fermentation process was carried out at ambient temperature for 15 days with 12% of sugar supplementation. Antioxidant activity was analyzed in the samples to verify the appropriate ratio of *Lactobacilus acidophilus* for fermentation. Results were elaborated in table 5. From table 5, the bamboo shoot should be fermented at 3.0×10^8 cells/ml of *Lactobacillus acidophilus* to get the highest antioxidant in pickle product. So this value was selected for fermentation.

The fermentation process softened the structure of fruits and vegetables, making phenolic easily be extracted. Lactic acid fermentation increased the antioxidant activity than fermented material before. When adding lactic acid bacteria, lactic acid bacteria can produce β-galactosidase, catalyses the production of polyphenol compounds. The fermenting process increases the digestibility of plant proteins and also reduces the anti-nutritional factors. Fermentation enhances flavour, colour and texture of pickle bamboo. Prolonged fermentation also reduces the taxiphyllin content by lowering the pH through microbial activity. In a similar study upon natural fermentation of shoots of D. giganteus and B. Tulda as the pH drops, the lactic acid bacteria indirectly degrades taxiphyllin into HCN and other components by accumulating acid.[18] Nutritional and functional profle of traditional fermented bamboo shoot based products was mentioned. The protein content was signifcantly high (19.53-27.55%), carbohydrates, moisture and ash content (%) was found to be in the range of 7.27-25.88, 31.05-52.58 and 6.22-14.36, respectively. Phenolics, flavonoids and tannin varied between 718.03 and 920.1.01, 308.72-568.54 and 20.093-33.602 µg/g, respectively. All products exhibited signifcant radical scavenging activity and α-glucosidase inhibitory activity; IC50values found to be in the range of 23.70-31.16 ppm. Volatile organic compounds (VOCs) and vitamins (B9, B12 and vitamin C) were also detected. Cyanogen glycosides content was within the limit (<10 ppm).[9]

A study aimed to determine the characteristic of tabah bamboo shoot pickle such as total of lactic acid bacteria (LAB), pH, total acidity, and hydro cyanic acid (HCN) content, and also find the LAB's type involved during fermentation, and organic acids' profiles. The pickle was made by natural fermentation with 6% salt concentration and fermentation conducted for 13 days. The result showed during the fermentation time, in the 4th day LAB's number was highest as much as 72 x 107 CFU/ml and the lowest pH was 3.09. We also found decreasing in HCN from 37.8 ppm at the beginning to 20.52 ppm at the end of fermentation process. The organic acids detected during the fermentation were lactic acid with the highest concentration was 0.0546 g/100 g and small amount of acetic acid.[10]

IV. CONCLUSION

The utilization of soft, tender young juvenile shoots as food has been gaining increased global attention as an alternative horticulture crop for the high nutritional value and health benefits. They are consumed as vegetables, pickles, salads, and in various other forms. We have successfully investigated the pickle bamboo shoot fermented from *Lactobacillus acidophilus* by examining different variables in blanching and fermentation. This product was rich in important nutrients for good health. Pickling process is relatively a good method for the preservation of phenolic acids in bamboo shoot, and most of the antioxidant capacities remained after 15th day of fermentation. Fermented bamboo shoot is used for its antioxidant, anti-free radical, anti-aging and anticancer activity. Fermented bamboo shoots not only have extended shelf life but fermentation also enhances the safety of foods using the natural microflora and their antibacterial compounds. Lactic acid bacteria (LAB) are the dominant microorganisms in ethnic fermented bamboo.

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