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Lactic Acid Fermentation of Sweetpotato

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ABSTRACT

Sweetpotato was saccharifed by the combination of amylolytic enzymes; alpha amylase and glucoamylase. Steamed and mashed sweetpotato was blended with enzyme solution at 1 : 2 ratio, w/w. The saccharification process was terminated after 90 minutes incubation at 55°C when 0.1% of alpha amylase and 0.15 - 0.2% of glucoamylase were used. When using 0.1% each of alpha amylase and glucoamylase, longer period of saccharification (up to 150 - 180 min.) was required to yield comparable amount of reducing sugars. Saccharified sweetpotato was subjected to lactic acid fermentation with a mixed cultures of *Streptococcus thermophilus and Lactobacillus bulgaricus* using 1% starter of each culture. The fermentation was carried out for 18 - 21 hours at 37°C. The resulted product socalled lactic fermented sweetpotato (LFSP) contained about 12% soluble solid; 0.7% acidity as lactic acid; 7% sugar and 6.8×10^8 CFU/g viable cell count. It possessed slightly yellow color, relatively thick body with a pleasant aroma of cooked sweetpotato and acidic smell. The product could be blended with fruit juice such as orange juice or added with yogurt flavor to make a drinking yogurt-type beverage.

Key words : lactic fermented sweetpotato, saccharified sweetpotato, sweetpotato fermentaion, lactic acid fermentation

INTRODUCTION

Lactic acid fermentation of legumes, especially soybeans have been studied extensively by many researchers. Non-dairy lactic fermented beverages have been developed from soy milk (Mital and Steinkraus, 1974; Wang *et al.* 1974).; soy protein concentrate and soy protein isolate (Kim and Ko, 1987).

In the past few decades, yogurt and drinking yogurt-type beverages have been consumed widely and the industry are growing very fast in Asian countries. Many attempts have been made to use non-dairy raw materials as a substitution of milk. A yogurt-like product was made from liquefied rice, using a mixed culture of *Streptococcus thermophilus. Lactobacillus bulgaricus* and *Lactobacillus plantarum* (Shin, 1989). Other substrates for cereal-based lactic fermented products included extruded rice (Viet *et al.*, 1992), bread (Barwald, 1992) and corn, sorghum and millet (Nashiru *et al*, 1992).

A paste-type lactic fermented rice (LFR) with improved quality by amylolytic enzyme treatment during fermentation was developed by Mok *et al.* (1991a). Rice and soybean mixture which is well recognized for their complimentary properties on essential amino acid composition, has been used as raw materials to produce nutritious yogurt-like product (Lee *et al.*, 1988; Souane and Lee, 1992; and Mok *et al.*, 1991b).

Nevertheless, research on using tubers and roots such as tapioca, potato and sweetpotato for lactic fermentation have been very few. In Nigeria,

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lactic acid fermentation of cassava to make a staple diet has been produced at a partially commercial scale (Nashiru *et al.*, 1992). Sweetpotato is a kind of root crops which is underutilised in Thailand. Apart from fresh consumption, sweetpotato are processed mainly at home and cottage-scales and only in the forms of chips and glaze. Study on chemical properties of 34 cultivars of sweetpotato in Thailand for flour and starch production to develop snack foods and other products at commercial level had been conducted (Maneepun *et al.*, 1992). Research on pre-fried and frozen sweetpotato french-fry type product has been carried out by Reungmaneepaitoon *et al.*, 1994. High protein snacks from sweetpotato have been produced as reported by Prabhavat et al. (1995). Fermented products from sweetpotato by lactic acid bacteria, however, have never been recorded. Thus, in an attempt of finding a way to enhance utilization and consumption of sweetpotato, this paper investigated the possibility on development of non-dairy lactic fermented product similar to drinking yogurt-type beverage from sweetpotato.

MATERIALS AND METHODS

Sweetpotato

Sweetpotato, white variety, was purchased from local market in Songnum, Korea. Each root had an average weight of 200 - 400 grams. They were purchased in single lot and kept in the dark room at 4°C throughout the experiment.

Enzymes

Alpha amylase (EC 3.2.1.1) from Bacillus species was obtained from Sigma Chemical Company. One unit will liberate 1.0 mg of maltose from starch in 3 min. at pH 6.9 at 20°C. Glucoamylase (Amyloglucosidase) from Rhizopus mold (EC 3.2.1.3) was also from Sigma. One unit will liberate 1.0 mg. of glucose from starch in 3 min. at pH 4.5 at 55°C.

Saccharification of sweetpotato

Sweetpotato was washed, peeled, sliced and steamed for 15 min. Steamed sweetpotato was mashed while hot and blended with enzyme solution at 1 : 2 ratio, w/w in a mixer (Osterizer). Two trials of enzymes treatments were carried out in this experiment to search for optimum concentrations for saccharification process. In the first treatment, the amount of alpha amylase was fixed at 0.1% with various concentrations (0.05 - 0.2%) of glucoamylase. The second treatment was vise versa. The enzymes were suspended in excess amount of water to ensure complete solution. Saccharification process was carried out at 55°C in an incubator for a maximum of 3 hrs. Samples were drawn at intervals for reducing sugars determinations.

Lactic acid bacteria

S. thermophilus, KCTC 2185 and *L. bulgaricus*, KCTC 2179 were obtained from Physical Property Laboratory, Korea Food Research Institute. Saccharified sweetpotato obtained from the above process was centrifuged to get clear supernatant and sterilised at 121°C for 15 minutes. The cultures were propagated separately in this saccharified sweetpotato supernatant for 40 hrs at 37°C or until the pH dropped to 3.2 - 3.4 and viable cell count was in the range of 10^8 - 10^9 CFU/g.

Preparation of lactic acid fermented sweetpotato

Saccharified sweetpotato was blended in a mixer for 5 min, heated to 95°C and held for 30 min. to inactivate the enzymes and destroy some undesirable organisms. Lactic acid fermentation was performed at 37°C using 1% each of starter cultures. Kinetic growth of lactic cultures at intervals of fermentation period was measured. The product was then homogenized in an Omni mixer (Omni 500, Omni International Inc., USA) at 15,000

rpm for 10 min. Yogurt flavors and/or fruit juice were blended-in at this step to give a more palatable beverage.

Analytical methods

Reducing sugar was determined by Lane Eynon Method (AOAC, 1990). pH was measured using pH meter (Corning. Model 240). Titratable acidity was determined by titrating 9 g of sample with standard 0.1 N NaOH and calculated as% lactic acid (Frazier *et al.*, 1968). Viable cell count of lactic acid bacteria (CFU/g) was enumerated by plating method on MRS medium (deMan *et al.*, 1960). Viscocity was determined by a Brookfield Viscometer Model LV (Brookfield Engineering Laboratories, USA).

RESULTS AND DISCUSSIONS

Effects of alpha amylase and glucoamylase concentrations on saccharification process of sweetpotato are shown in Figures 1 and 2. In the first treatment, when 0.1% of glucoamylase plus 0.05 - 0.2% alpha amylase were used, reducing sugar content was increased from 1.18% at 0 min. (before adding enzymes) to 6.33 and 7.19% with 0.05 and 0.2% amylase, respectively, after 180 min. incubation (Figure 1). Sugar was produced rapidly within 30 min. contact time of enzymes and starch in sweetpotato yielding about 70% of the total sugar produced. Between 90 - 150 min., the amounts of sugar produced increased gradually and were comparable for alpha amylase concentrations of 0.1, 0.15 and 0.2%. However, slightly increase of sugar contents were observed at 180 min. of incubation. At 0.05% alpha amylase concentration, the sugar contents were about 0.4 and 0.7% lower than those liberated at 0.1% concentration after 60 and 180 min., respectively. Thus, the minimum concentration of alpha amylase to be used effectively would be 0.1%.

Effect of glucoamylase in saccharification process was more pronounced than that of alpha amylase. Figure 2 shows that at 0.05% level, the rate of saccharification was considerably slower than at 0.1 - 0.2%. At concentration of 0.1% glucoamylase, the minimum incubation period of 150 min. was required before relatively stable amount of sugar produced was obtained. When glucoamylase concentrations were used at 0.15 - 0.20%, only slight increase of reducing sugars were observed during 90 - 180 min. of incubation.

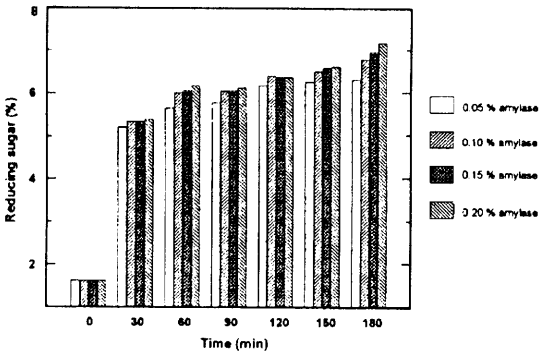

Figure 1 Changes of reducing sugar during saccharification of sweet potato treated with 0.1% glucoamylase plus various concentrations of alpha amylase.

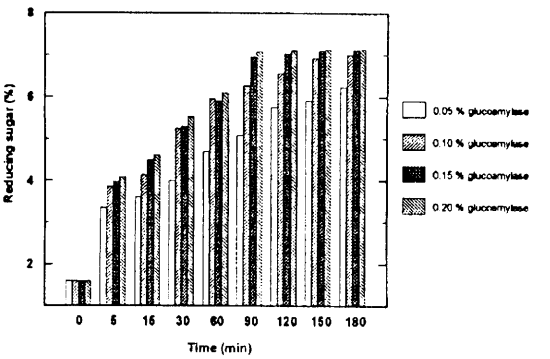

Figure 2 Changes of reducing sugar during saccharification of sweet potato treated with 0.1% alpha amylase plus various concentrations of glucoamylase.

Thus, for energy conservation, saccharification period of 90 min. using 0.15% glucoamylase could be considered appropriate. Rapid increase of sugar was also observed with over 60% of total sugar produced after 5 min for every concentration of the enzymes used. For further experiment, enzyme concentrations at the level of 0.1% alpha amylase and 0.15% glucoamylase were selected.

Radley (1976) stated that sweetpotato contains about 56 - 71% moisture content; 9.8 - 29% of starch with an average of 22% and 0.5 - 2.5% reducing sugar. Analysis of 34 varieties of sweetpotato grown in Thailand revealed that starch and reducing sugar contents were in the ranges of 16.79 - 31.14 and 5.0 - 9.63%, respectively (Maneepun *et al.*, 1992). In this study, the weight of peeled sweetpotato after steaming was about 10% less than in the fresh root. Thus, upon diluting 3 folds, the starch content should be in the range of 7 - 8%. Determination of reducing sugar content before saccharification process was found to be 1.18%. It was also reported that sweetpotato cultivars produced commercially contain amylolytic enzyme which decreases starch content upon storage (Walter *et al.*, 1992).

Lactic acid fermentation of saccharified sweetpotato was carried out and changes occured during fermentation period were determined as shown in Figure 3. Acidity was increased from 0.15% to 0.68%; pH decreased from 4.85 to 3.33; and viable cell count of lactic acid bacteria increased about 1 log cycle, from 1.7×10^7 CFU/g to 6.8×10^8 CFU/g at 0 and 21 hrs, respectively. It was noted that pH was markedly decreased within 15 hrs. of fermentation. Acidity, however, was gradually increased up to 21 hrs. while total viable count was about 1 log cycle higher after 12 hrs. and remained relatively unchanged. Dairy yogurt normally contains 0.8 - 1.0% acidity with pH in the range of 4.2 - 4.5. Its high pH inspite of higher acidity might be attributed to the buffering property of protein in milk. This was also observed in the case of lactic fermented isolated soy protein (LFISP) and lactic fermented rice (LFR) reported by Mok *et al.* (1991b).

Some physical and chemical characteristics of lactic fermented sweetpotato (LFSP) in comparison wih LFISP and LFR are shown in Table 1. The sourness of LFSP was quite pronounced when acidity was greater than 0.7% or pH lower than 3.3. Thus, suitable fermentation period should be between 18 - 21 hrs. which yielded the product of pH 3.3 - 3.4 and acidity of 0.65 - 0.7%. Reducing sugar left after fermentation was around 7% which provided for agreeable taste of the finished product. To start with lower content of reducing sugar in order to reduce the amount of enzymes and the time required for saccharification process, it was presumably not only giving unacceptably sour taste but also yielding sandiness and starchy mouthfeel to the finished product.

Lactic fermented sweetpotato obtained was a sour, yellowish liquid with rather thick body and

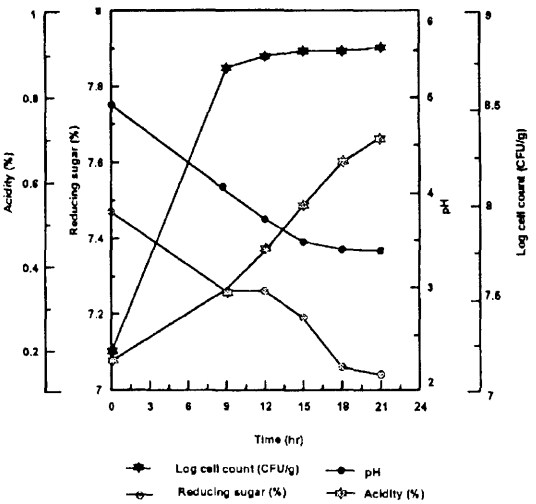

Figure 3 Changes of pH, acidity, reducing sugar and viable cell count of lactic acid bacteria during lactic fermentation of saccharified sweetpotato.

Table 1 Some characteristics of lactic fermented sweetpotato (LFSP) as compared to lactic fermented isolated soy protein (LFISP) and lactic fermented rice (LFR).

	LFSP	LFISP*	LFR*
Acidity (%)	0.68	0.86	0.53
Saccharometer Reading (Brix)	12.0	ND	24.0
pH	3.33	3.6	2.95
Reducing sugar (%)	7.04	ND	ND
Viable Cell count (CFU/g)	6.8×10^8	1.46×10^{10}	1.54×10^8
Viscosity (mPa.s)	82	ND	31.7

*Mok *et al.* (1991b) ND = No Data

smooth mouthfeel. The aroma was the mixture of cooked sweetpotato and acidic smell. Addition of 0.4% yogurt flavor (SKF - 1738, T. Hasegawa Co. Ltd., Japan) and 4% sugar gave a more palatable yogurt taste and completely masked the smell of cooked sweetpotato. By blending with 25-50% orange juice, the taste and consistency was improved markedly.

It can be concluded that there was a virtuous possibility to develop a similar product of drinking yogurt-type beverage from lactic fermentation of saccharified sweetpotato. Research study, in terms of selection of lactic bacteria strains, saccharification and fermentation processes, blending and nutritional quality of the finished product could be elaborated for further improvement.

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LITERATURE CITED

A.O.A.C. Official Method of Analysis, 15th Edition (1990). Association of Official Analytical Chemists,Washington D. C.

Barwald, G. 1992. Lactic acid fermentation for bread-drink production, pp 131-148 *In* UNIDO International Workshop on Lactic Acid Fermentation of Non-Dairy Food and Beverages Proceedings. June 25 - 27, 1992. Korea Food Research Institute, Songnam, Korea.

Frazier, W. C., E.H. Marth, and R.H. Diebel. 1968. Laboratory Manual for Food Microbiology. Fourth Edition. Burgess Publishing Company, Minneapolis, Minn., USA. 122p.

Kim, Kyung-Hee and Young-Tae Ko. 1987. Study on growth and acid production by lactic acid bacteria in soy milk. Korean J. of Food Sc. Technol. 19. : 151-156.

Lee, Cherl Ho, M. Souane, and Ki-Hyung Rhu. 1988. Effects of prefermentation and extrusion cooking on the lactic fermentation of rice-soybean based beverage. Korean J. of Food Sc. Technol. 20 : 666-673.

deMan, J.C., M.C. Rogasa, and M.E. Sharpe. 1960. A medium for the cultivation of lactobacilli. J. Appl. Bacteriol. 23 : 130-135.

Maneepun,S., S. Reungmaneepaitoon, and M. Yunchalad. 1992. Sweetpotato starch and flour research in Thailand, pp. 229-241. *In* Product Development for Root and Tuber Crops. Volume I - Asia. International Potato Center.

Mital, B.K. and K.H. Steinkraus. 1974. Growth of lactic acid bacteria in soy milks. J. Food Sci. 39 : 1018.

Mok Chulkyoon, Jinsuk Han, Young Jin Kim, Namsoo Kim, Dae Young Kwon, and Young June Nam. 1991a. Lactic acid fermentation of rice and quality improvement by amylolytic enzyme treatment during fermentation. Korean J. of Food Sc. Technol. 23 : 739-744.

Mok Chulkyoon, Jinsuk Han, Young Jin Kim, Namsoo Kim, Dae Young Kwon and Young June Nam. 1991b. Risogurt, a mixture of lactic acid fermented rice and soybean protein : development and properties. Korean J. of Food Sc. Technol. 23 : 745-749.

Nashiru, T.O., Chulkyoon Mok and Se-Young Lee. 1992. Comparative studies on lactic acid fermentation of different cereals for the production of non-alcoholic yogurt-like beverage, pp.90-98 *In* UNIDO International Workshop on Lactic Acid Fermentation of Non-Dairy Food and Beverages Proceedings. June 25-27, 1992. Korea Food Research Institute, Songnam, Korea.

Prabhavat, S., S. Reungmaneepaitoon, and D. Hengswadi. 1995. Production of high protein snacks from sweetpotato. Kasetsart J. (Nat. Sci.) 29 : 131-141.

Radley, J.A. 1976. Starch Production Technology. Applied Science Publishers Ltd, London. 320 p.

Reungmaneepaitoon, S., S. Tippayang and S. Yaieim. 1994. Process for preparing pre-fried and frozen sweetpotato french-fry type products, pp. 314-316. *In* 5th ASEAN Food Conference, Conference Paper, Kuala Lumper. 26-29 July 1994,

Shin Dong Hwa. 1989. A yogurt like product development from rice by lactic acid bacteria. Korean J. Food Sci. Technol. 21 : 686-690.

Souane, M. and Cherl-Ho Lee. 1992. Production of high protein content lactic beverage from rice-soymilk mixture, pp. 26-47. *In* UNIDO International Workshop on Lactic Acid Fermentation of Non-Dairy Food and Beverages Proceedings. June 25-27, 1992. Korea Food Research Institute, Songnam, Korea..

Viet, V. N., D.J.Park, and K.M.Chee. 1992. Nutritional value of Risogurt prepared from rice extrudate and soyprotein isolate, pp.81-89 *In* UNIDO International Workshop on Lactic Acid Fermentation of Non-Dairy Food and Beverages Proceedings. June 25-27, 1992. Korea Food Research Institute, Songnam, Korea.

Walter, W.M. Jr., H.P. Fleming, and R.F. McFeeters. 1992. Firmness control of sweetpotato french fry-type product by tissue acidification. J of Fd. Sci. 57 : 138-142.

Wang, H.L., L. Kraidej and C.W. Hesseltine. 1974. Lactic acid fermentation of soybean milk. J. Milk Food Technol. 37 : 71.