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AN INVESTIGATION ON THE FERMENTATIVE CHANGES DURING BAMBOO SHOOT PROCESSING TO THE PRODUCTION OF SOIBUM

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ABSTRACT

Succulent bamboo shoots of *Bambusa nutan* and *Dendrocalamus latiflorus* were separately processed into Soibum by natural lactic acid fermentation adopting a traditional method. During 28 days fermentation, pH dropped in both mashes by same value of 1.33, but accumulation of titratable acidity in the former mash was lower although its level of reducing sugar had been rapidly reduced. The processing was accompanied with the increase in the levels of titratable acidity, pyruvic acid, α-Ketoglutaric acid, diacetyl, acetoin, alcohol and esters by values of 1.00 - 1.15%; 1.40-1.54, 0.88-1.38, 172.67-372.65, 15.79-33.29, 51.18-142.66 and 58.34-65.55 in mg/100g respectively during the entire period. The intermittent levels for each of these entities in the two mashes were also varied widely in most of the cases. Better quality of Soibum mash of *B. nutan* could be related with possession of lower levels of titratable acidity, diacetyl, acetoin and higher level of esters. Based on the present findings some suggestions have been made for improvement of traditional methods of Soibum processing and its quality.

INTRODUCTION

Fermentation as a method of preservation of perishable vegetables has been adopting since unpredictable historical date. It had reported that lactic acid bacteria (LAB) were microorganisms present in most of living plants and thus they caused lactic acid fermentation of most of vegetables (Andersson *et al.*, 1988). LAB belong to genera such as *Lactobacillus*, *Lactococcus*, *Leuconostoc, Streptococcus* and *Pediococcus* and their certain species involve in the lactic acid fermentation of vegetables (Chelule *et al.*, 2010 and Manas *et al.*, 2014). The most important processed foods produced by lactic acid fermentation are pickles, sauerkraut and olives (Andersson *et al.*, 1988). But most vegetables can be fermented by LAB (Somesh and Joshi, 2007) and in north east India, bamboo shoots have been naturally fermented by LAB for the production of various regional traditional foods such as Ekung, Eup, Hiring, Lung-siej, Mesu, Soibum, Soidon and Soijin (Buddhiman and Jyoti, 2009). Moreover, people of several countries consume pickles of bamboo shoots (Kumbhare and Bhargava, 2007). However, people of Manipur consume Soibum very favouritely. Regarding significance, lactic acid fermentation not only elongated the shelf life of vegetables, but it also enhanced nutritive value, flavour and reduced toxicity (Manas *et al.*, 2014).

Literature reveals about plenty of works on the chemical changes of lactic acid fermentation of vegetables (Frazier and Westhoff, 1978; Andersson *et al.*, 1988 and Sook *et al.*, 2011). Although lactic acid fermentation of vegetables can be narrated in general terms, there is difference of fermentative processes depending upon raw materials; but it can be undergone under controlled condition (Andersson *et al.*,1988). However, Soibum a chief fermented food of Manipur is processed by traditional fed batch, solid state fermentation methods exclusively from bamboo shoots of two or more different species. No salt is added during processing and fermentation is rather undergone under uncontrolled condition. Larger commercial scale production of Soibum is undergone in chambers made of split bamboo culms whereas for such small scale production the chambers used are roasted earthen pots. Such production is sustainably practicing by producers mostly tribal at places where raw materials are abundantly available and urban ways of earning are not available. As yet, such traditional methods have not been modified by any developmental device from concerned authorities and experts. Moreover, previous works on the biochemical and microbial aspects of Soibum (Giri and Janmejay, 1994a,b,2000; Giri, 1998; Dayanidhi *et al.*, 2011; Anil *et al.*, 2012; Mina *et al.*, 2010, 2014) could not render sufficient knowledge for fermentative changes preliminary needed for development of its processing methods and quality. To fill a part of the lacunae the present study aims at envisaging upon main chemical changes during active period of Soibum fermentation.

MATERIALS AND METHODS

Succulent bamboo shoots of the species *Bambusa nutan* and *Dendrocalamus latiflorus,* seemed to be at about same maturity stage and nearly of equal size for each species as well and healthy were procured from different places of Manipur valley. The scales and outer hard covering were manually removed and then cut into thin slices of about uniform thickness. Soibum was processed adopting Andro method (Mina, 2009) modified as batch fermentation for envisaging periodic chemical changes. It was done with immediate filling of slices into 15 Kg capacity roasted earthen pots compactly up to the capacity, doing so in three replications for each species. The mouths of the pots were then closed with thick clothes and then incubated at ambient temperature (24 $\pm$5.5°C). About 30 g sample was removed from each of the pots on each of the days 1, 2, 4, 6, 8, 10, 12, 14, 21 and 28 closing the mouth as above after each removal and these samples including zero day mashes were immediately subjected to the determinations of pH, titratable acidity (Ranganna, 1986) and reducing sugar (Sadasivam and Manickam, 1996).

On the other hand on each of days 7, 14, 21 and 28, 50 g mash was removed from each of the pots as above, then stored immediately inside refrigerator including zero day mashes. These samples were analyzed for the contents of alcohol, citric acid, α-ketoglutaric acid and pyruvic acid (Sidney and Nathan, 1957), esters, diacetyl and acetoin (Paech and Tracey, 1955). Statistical analysis of these data were carried out according to ANNOVA and Dunkan Multiple Test Range (Stephen and Ruth, 2000).

RESULTS AND DISCUSSION

As air had not been completely eliminated during processing, the situation inside the chamber, would not be absolutely anaerobic.Thus inside of the packed mash would have trace of air. In average succulent bamboo shoots possess 90.88% moisture, 3.29% crude proteins, 1.05% total soluble sugars and 3.30 mg/100g ascorbic acid etc. (Giri, 2013). Microorganisms capable of adapting to this situation would grow and carried out fermentative changes. Figs. 1 and 2 show that though titratable acidity increases gradually upto days 21 and 14 in the mashes of *B. nutan* (I) and *D. latiflorus* (II) respectively, gradual decrease of pH does not take place beyond day 10 in both mashes. Mash I excelled mash II in the accumulation of titratable acidity during the first six days, but latter excelled the former in doing so during second half of processing period. Such variation could be population density index of LAB. In a previous study it was reported that Soibum fermentation was caused by LAB and yeasts under the upperhand of the former (Giri, 1998). It had reported that LAB present naturally as microflora of vegetables (Andersson *et al.*, 1988) and they were micro aerobic in their physiological adaptation (Giri, 1988). Herein, it could be mentioned that Kimchi fermentation was also carried out by LAB originally present in raw materials (Cheigh and Park, 1994). Moreover, fermenting microorganisms of Gundruk were LAB (Buddhiman and Jyoti, 2010).

It has revealed that though the level of the reducing sugar has been extensively reduced, its continual availability during the progressing of fermentation is managed with somewhat replenishing activity (Figs.1 & 2). Giri and Janmejay (1994b) previously reported about elaboration of amylase and invertase activities due to microbial growth during Soibum fermentation. It seems that during the course of fermentation reducing sugar is more rapidly consumed in mash I (Figs. 1&2) and according to the view of Giri (1998) it could be due to more interference by yeasts,a situation intrinsically related with possession of lower level of total phenols by raw material. When compared with periodic mode of change of reducing sugar, pH and titratable acidity recorded during Kimchi fermentation (Sook *et al.*, 2011), similarity was noted for the change of latter two in both mashes I and II, but for the former case it was so in mash I only. In case of Ogi fermentation caused by LAB and yeasts, progressive decrease of reducing sugar was also noted during souring period (Omenu, 2011). Increase of reducing sugar during early days of fermentation and maintaining higher level of it in mash II in proceeding days (Fig. 2) might be due to lesser interference by yeasts. Since the level of titratable acidity seemed to be maintained during the last week and second half of the observation period in mashes I and II respectively, it could be assumed that at 24 $\pm$ 5.5°C complete lactic acid fermentation of Soibum needed a period of 2-3 weeks depending upon species of raw material subjected to fermentation. It could be inferred that LAB produced lactic, acetic, formic, phenyllactic and caproic acids (Reyhan and Gamze, 2012). Thus in common ground, elongation of processing period after third week could be treated as aging.

The level of alcohol increases gradually upto day 21, but always in relatively greater amount in mash I (Table 1). It might be due to denser growth of yeasts in this mash. But in both mashes, with the passage of processing time, there was

Table 1: Intermittent changes of some chemicals during Soibum processing.

Chemical, mg/100g	Mashes	Days 0	7	14	21	28
Citric acid	I	43.18	33.79	28.16	23.09	17.82
	II	44.70	35.24	14.87	15.32	22.39
Diacetyl	I	1.76	310.92	280.18	180.52	174.43
	II	1.57	560.23	401.53	375.99[a]	374.22[a]
Acetoin	I	0.59	27.76	22.87	6.72	16.38
	II	0.78	69.21	29.06	20.92	34.07
Alcohol	I	0.16	56.15	62.87	143.77	142.82
	II	0.25	40.92	60.52	88.02	51.43
Esters	I	0.25	20.87	50.75	58.93	65.90
	II	0.39	27.27	52.90	56.21	58.73
Pyruvic acid	I	0.56	0.68	0.98	1.80	1.96
	II	0.43	0.83	1.63	1.85	1.97
α-Keto-glutaric acid	I	0.53	0.77	1.04	1.33	1.46
	II	0.65	0.81	1.67	1.96	2.03

I: *Bambusa nutan*, II: *Dendrocalamus latiflorus*; Each value is a mean of three replications. Means with same superscript in a horizontal row do not differ significantly ($p > 0.05$)

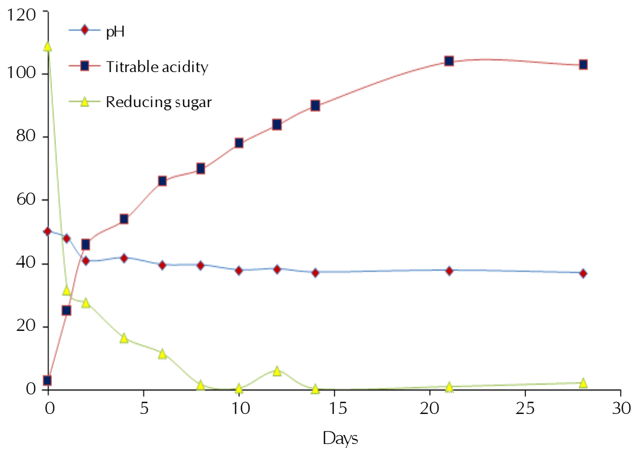

Figure 1: Changes in the level of pH, titratable acidity and reducing sugar in the mash of *B. nutan* during Soibum processing

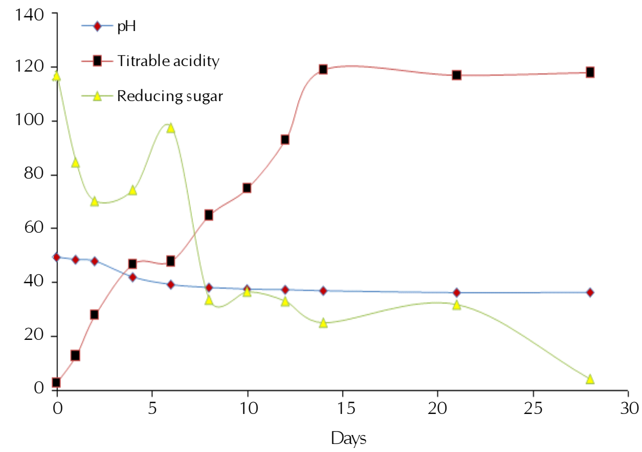

Figure 2: Changes in the level of pH, titratable acidity and reducing sugar in the mash of *D. latiflorus* during Soibum processing

The scale of Y-axis of both figures represents values of pH, percent titratable acid and reducing sugar (mg/100g) of mashes multiplied by 10, 100 and divided by 10 respectively. The scale of X-axis represents time in days.

increasing formation of esters, but at relatively higher extent in mash I in later period. It could be presumed from the narration of Giri (1988) that both LAB and yeasts were the microorganisms involved in the formation of these byproducts. Of course yeasts might be more active in the formation of esters.

During first half of the incubation period citric acid has been relatively more reduced in mash II, but during second half of the incubation period its level in mash I still declines while in mash II increases (Table 1). Further, it was observed that in both mashes I and II, level of diacetyl and acetoin increased appreciably during first week and afterwards their level declined upto day 21 the changes being with their relatively ever higher level in mash II (Table 1). During last week their level may be further decreased, increased and insignificantly changed. However as was in previous days, mash II possessed their higher level. From the present finding and contributions of Drinan *et al.* (1976) and Oberman *et al.* (1982), it could be opined that LAB with the utilization of citric acid would produce diacetyl and acetoin during Soibum fermentation. Reyhan and Gamze (2012) also mentioned about the capability of production of diacetyl by LAB. Based on the contributions of Yadav and Gupta (1977 & 1980), it could be mentioned that yeasts also might supplement the formation of diacetyl and acetoin during Soibum production. However, certain factors might favour their more formation in mash II.

The levels of pyruvic acid and α-Ketoglutaric acid also increased slowly and steadily during the course of fermentation, but ever in closer extents for each of them in the two mashes (Table 1). Pyruvic acid is an intermediate related with the formation of ethanol by yeasts; formic, acetic and lactic acids by LAB. Moreover, it is also utilized for the formation of diacetyl and acetoin by LAB (De Cardinas *et al.*, 1983). In accordance with the contribution of Novakovskaya *et al.* (1972), certain yeasts might involve in the formation of α-Ketoglutaric acid which could be used for the synthesis of L-glutamic acid by microbes (Haldia *et al.*, 2012). Slight increase in the level of pyruvic acid and citric acid amidst their use in the formation of above mentioned byproducts could be due to feeble aerobic respiration of certain microorganisms. Nevertheless, in spontaneous cucumber fermentation there was growth of aerobic microorganisms in post fermentation stage (Andersson *et al.*, 1988). It could be viewed that chemical changes during active period of Soibum fermentation would have been taken place in complex manner.

It can be reminded that diacetyl, acetoin and esters were among the aroma producing compounds of Soibum which include also 2-3 butanediol and volatile phenols (Giri, 1988). It can be mentioned that previous narration is conclusive about quantitative inter mash difference in the formation of intermediates and byproducts during the course of fermentation. Generally commercial producers started Soibum marketing onwards its age of about one month. It is conspicuous from Table 1 and Figs. 1 & 2 that one month old Soibum of *B. nutan* exhibits higher levels of pH, alcohol and esters while that of *D. latiflorus* possesses higher levels of the remaining byproducts. Such variation in the levels of byproducts of fermentation might have relation with recording of better sensory quality of Soibum of *B.nutan* among one month old Soibum products of different bamboo species (Mina *et al.*, 2014). Besides, sensory quality of Soibum had also been increased during aging practicable upto its shelf life which is more than two years (Giri and Janmejay, 1994b).Thus very conveniently Soibum can be made available all the year round.

From the present study it had concluded that the intermittent mode of utilization of reducing sugar and levels of byproducts formed during the course of fermentation could be depended upon the species of raw material. It could be pointed out that Soibum of better quality possessed lower levels of titratable acidity, diacetyl, acetoin and higher level of esters. In relation to this, the composition of chemical candidates of Soibum exerting better quality needs to be found out.

It is suggestible that improved technique for the production of better quality Soibum should be innovated rendering due consideration to selection of raw material, designing of fermentation chamber with provision of microaerobic physiological adaptation of LAB, growing of desirable microorganisms in proper sequence and densities and optimization of temperature etc. As hydrocyanic acid is also released out during Soibum processing (Mina *et al.*, 2014), the fermentation chamber should have safety outlet for removal of this gas and substantial commercial processing should be done at place farther from inhabiting area etc.

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