Effect of incorporation of fermented bamboo shoot on physicochemical and microbial quality of pork pickle

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Abstract Replacement of commercial chemical preservative (Vinegar) by incorporating fermented bamboo shoot (FBS) products partially or completely and their effect on physicochemical, microbial and shelf life qualities on pork pickle products was studied. Different FBS products such as FBS extract, paste and powder were incorporated in the pork pickle products at the level of 50 to 100 % with or without vinegar and stored at room temperature for 90 days. Highest pH values and lowest titrable acidity was recorded in products with 50 and 100 % FBS powder. No significant differences were observed with respect to proximate composition i.e. percent moisture, protein, fat and ash contents among the products except the product with 100 % FBS powder which had significantly ($p < 0.01$) lower moisture content. Microbial load (Log total plate counts) and thiobarbituric acid (TBA) values were found to be increasing as the storage periods were advancing. Except the product with 100 % FBS powder which could be stored for 30 days only, other products could be stored upto 90 days without any physicochemical and microbial problems. It can be concluded from this study that natural and organic FBS extract and paste can be used successfully replacing the conventional chemical preservative (Vinegar) for preparation of pork pickle products and preserved more than 90 days at room

temperature. However, FBS powder can be used for preservation of the pickle products for a short period (30 days).

Keywords Fermented bamboo shoot · Pork pickle · Physicochemical · Microbial quality · Shelf life

Meat and meat products are an indispensable part of the human diet. They provide easily available proteins, minerals and all the B-complex vitamins. The excellent digestibility and well balanced composition of essential amino acids make the meat a highly demanded article of human nutrition. Pork and organ meats are good sources of linoleic and linolenic acid. Apart from all these nutrients, recent studies indicate that pork contains several bio-active peptides and nutraceutical substances required for promotion of health (Hazarika et al. 2008). Pork and pork products are very popular in North Eastern Region of India. Many conventional pork products like ham, bacon, sausages and salami etc. are being imported to this part of the country from other states. However, due to high price and exotic taste, low income group of consumers can not afford to buy and reluctant to consume regularly and they often express their desire to have pork products which are self stable, comparatively cheaper, easy to preserve even at room temperature and with an indigenous taste.

Pickling is one of the methods commonly practiced in preservation of fruits and vegetables for human consumption and could be a suitable method for preservation of avian and animal products like egg and meat as well (Pal 1990). High perishability of meat and meat products is a serious problem in tropical countries like India due to prevailing climatic conditions (Chatterjee 1987; Bachhil 1982). Pickle products may be a good alternative for solving both the problems. There is tremendous scope for research and development of recipes and technologies for indigenous meat products like pickles.

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Bamboo shoots are young, new clumps/canes that are harvested for food before they are 2 weeks old or one-foot tall (Das and Puzari 2007). Young and tender bamboo shoots are consumed as ingredient of food. They are consumed in the form of vegetables, pickles and salads in several countries (Das and Puzari 2007; NMBA 2008). The chemical analysis of bamboo shoot shows that it contains about 88.8 % moisture, 3.9 % protein, 0.5 % fat, 5.7 % carbohydrate and 1.1 % minerals (NMBA 2008). Bamboo shoot contains two antioxidants namely ‘Tricin’ and ‘Taxifolin’ and their antioxidative spectrum of activity is equivalent to approximately 10 and 1 % of that of α -tocopherol respectively (Katsuzaki et al. 1999).

Materials and methods

Soft succulent bamboo shoots which were harvested for food before they are 2 weeks old or one-foot tall were collected from local markets and blades were peeled off from the shoots. After slicing, the bamboo shoots were minced by hand mincer having plate with pore size 4 mm in a diameter. The minced bamboo shoots were kept in a covered glass container. The minced bamboo shoots were exposed to sunlight for about 21 days for fermentation. The typical ripening smell (very sharp, pungent with strong smell akin to phenolic compounds) which develops due to fermentation indicates the completion of the fermentation process. Raw extract was first separated from the fermented bamboo shoot with the help of muslin cloth by pressing and filtered through Whatman filter paper No. 1 to get the clean extract. The bamboo shoot extract was stored in a clean glass bottle and kept in a refrigerator at 4 ± 1 °C until further use.

To prepare the bamboo shoot paste, the fermented sliced bamboo shoot was ground at high speed for 3 min with the help of a mechanical mixer grinder viz. Philips HL7600 Mixer Grinder and packed in clean, dry glass bottle and preserved at 4 ± 1 °C until further use.

The fermented bamboo shoot powder was prepared by drying the product in a mechanical drier at 60.0 ± 2 °C for 6–8 h until a dried brown coloured mass was obtained. The fine powder was made by grinding in a mechanical grinder at a high speed for 3 min. The bamboo shoot powder was then packed in a clean, dry, food grade plastic bottle and placed in a cool and dry place for further use.

Fresh cuts of pig slaughtered at the age of 7–8 months preferably from ham region of the carcass were collected just after slaughter in food grade polythene bags. The pork was deboned, skinned and excessive fat and connective tissues were trimmed off and washed and stored at 4 ± 1 °C until further use. The formulations and the final pickle ingredients as mentioned in Table 1 were selected after conducting the preliminary trials.

The deboned pork was cut into small cubes of suitable size (1/2 cm to 1 cm). The pork cubes were cleaned, trimmed and then marinated by dry method with 4 % salt at room temperature. The cuts were pressure cooked at 15 lb pressure for 5–6 min and after cooking, the gravy was separated from the cubes. The cooked pork pieces were fried in mustard oil until the pieces developed brown colour. The spices were also fried in mustard oil for 2–3 min. The gravy was added in fried pork pieces and mixed properly. Measured amount of FBS products were added with or without vinegar at 50 % and 100 % level on mild heat and mixed well. The pickle products were packed in clean, dry, food grade plastic bottle of 200 g capacity, sealed, airtight and stored at room temperature. Before sealing, care was taken to cover the pickle ingredients with a layer of oil so as to prevent its exposure to air. The pickle products were kept for maturation for one week (7 days) at room temperature.

The quality of pork pickles with different FBS products were subjected to different physicochemical and microbial qualities. The pH of the pickle products were measured by a digital pH meter (systronic-361) as per the method described by Pippen, et al. (1965). The titrable acidity was determined as per the method described by Fisher and Peters (1968). Proximate composition (i.e. Moisture, Crude Protein, Ether Extract and Total Ash) was determined following the method of AOAC (1990). The TBA values of the pickle samples were determined as per the method of Witte et al. (1970). Microbial quality (Total plate count) was determined as per the method of International Commission on Microbiological Specifications for Food (ICMSF 1978) using standard plate count agar. The shelf-life of the products was determined by keeping the packed samples at room temperature and evaluating the Total Plate Count and other observable physical changes at 15 days interval until the products exhibited signs of spoilage. The maximum shelf-life of the product was determined as soon as the product exceeded the microbial load of 10^5 cfu/g; simultaneously other physical changes like development of off odour, sliminess, discoloration and TBA values were also recorded. Six batches of the pickle products were made and the means of the data generated were taken for inference. Standard statistical method as outlined by Steel and Torrie (1960) was followed to analyze the data.

Results and discussion

The average values of pH, titrable acidity and proximate composition of the pork products are presented in Table 2. The pH values of the pickles with different combinations ranged between 4.68 ± 0.076 to 5.17 ± 0.095 . The pH values were increasing with the increasing level of FBS products. Except the product with 100 % FBS powder which had shown significantly ($p<0.05$) higher pH values, no significant differences were

Table 1 Ingredients and quantity (g) to develop pork pickles with fermented bamboo shoot products

Sr. No.	Ingredients	Control	Treatments					
			I	II	III	IV	V	VI
1.	Pork cubes	1000	1000	1000	1000	1000	1000	1000
2.	Ginger	150	150	150	150	150	150	150
3.	Garlic	150	150	150	150	150	150	150
4.	Jeera (Anise)	25	25	25	25	25	25	25
5.	Mustard powder	25	25	25	25	25	25	25
6.	Chili powder	75	75	75	75	75	75	75
7.	Turmeric powder	10	10	10	10	10	10	10
8.	Salt	70	70	70	70	70	70	70
9.	Mustered oil (ml)	400	400	400	400	400	400	400
10.	Water (ml)	300	300	300	300	300	300	300
11.	Vinegar (ml)	300	150	–	150	–	150	–
12.	FBS Extract (ml)	–	150	300	–	–	–	–
13.	FBS Paste	–	–	–	150	300	–	–
14.	FBS Powder	–	–	–	–	–	30	60

Control: 100 % vinegar

I: 50 % vinegar+50 % F.B.S. extract

II: 100 % F.B.S. extract

III: 50 % vinegar+50 % F.B.S. paste

IV: 100 % F.B.S. paste

V: 50 % vinegar+50 % F.B.S. powder

VI: 100 % F.B.S. powder

observed among the means of other products. Pal (1990) reported pH values of 5.05–5.07 in pork pickles which were achieved after 7–8 days of maturation. He also observed that pH values 5.0 were very critical for storage stability. The values of titrable acidity of the pickle products revealed no significant differences among their means except the product with 100 % FBS powder which had significantly ($p<0.01$) lower titrable acidity than others. The reason of higher pH and lower titrable acidity in products with 100 % FBS powder might be due to partial evaporative loss of volatile organic acids and active principles on drying which developed during fermentation process. The pH and titrable acidity was found to be inversely related.

The data with respect to moisture percentage of the products show an increasing trend with the increasing level of FBS paste, extract and powder, however, significantly ($p<0.01$) lower percentage of moisture were observed in the products with 50 and 100 % FBS powder. No significant differences were observed among the mean values of ether extract, crude protein and ash contents of the products. A general trend was observed that all the FBS incorporated products had comparatively lower ether extract and higher crude protein contents than the control samples.

The thiobarbituric acid (TBA) values and log total plate counts (TPC) reveal the fact (Table 3) that these values were increasing gradually in all the pickle products including the control one as the storage periods were advancing from first day to 90 days of storage. The rate of increase of TBA and TPC values were not significant among the samples upto 30 days except the product with 100 % FBS powder in which the rate of TBA and TPC values were significantly ($p<0.01$) higher. This pickle product was discarded from the experimental study after 30 days of storage because of development

of clear sign of rancidity and excess microbial load. The FBS powder might lose its antioxidant and antibacterial potencies during its processing at higher temperature. Katsuzaki et al. (1999) stated that bamboo shoot contains definite antioxidant factors (Tricin and Taxifoline) and these may be destroyed during processing steps. With respect to TBA values, the FBS extract (100 %) had shown the best activities followed by combination of 50 % vinegar and 50 % FBS extract. The lowest activity was shown by the FBS powder. The FBS extract might have better penetration power into the meat matrix coupled with higher antilipolytic activity compared to paste and powder. Changmai et al. (2006) also reported that storage life of COSMORK—a cooked smoked pork product with bamboo shoot extract could be extended with addition of FBS extract. The shelf life study of the products at room temperature reveals that all products could be stored safely upto 90 days or beyond except the product with 100 % FBS powder which could be stored safely upto 30 days only.

Conclusion

From the results, it can be concluded that the FBS powder has lower antibacterial and antilipolytic activities than the paste and extract. The products with FBS paste and extract had shown either better or equal potencies as that of vinegar. Thus, there is potentiality of using the FBS products as preservative in meat pickle in future. Pork pickles incorporating FBS extract and paste to replace the conventional chemical preservative (Vinegar) could be developed and marketed and preserved without refrigeration which are highly nutritive, microbiologically safe and stable than the control recipe upto 90 days of

Table 2 Effect of incorporation of FBS products at different levels on physicochemical qualities of pork pickles

Physico-chemical qualities	Control	Treatments					
		I	II	III	IV	V	VI
pH	4.68 ^a ±0.08	4.73 ^a ±0.08	4.76 ^b ±0.09	4.78 ^a ±0.09	4.81 ^a ±0.12	4.92 ^{ab} ±0.12	5.17 ^b ±0.10
Titration acidity	1.20 ^a ±0.04	1.16 ^a ±0.05	1.15 ^a ±0.04	1.11 ^a ±0.05	1.10 ^a ±0.04	1.08 ^a ±0.04	0.64 ^b ±0.06
Moisture %	50.41 ^{bc} ±0.23	50.56 ^{bc} ±0.22	50.73 ^{bc} ±0.22	50.84 ^c ±0.22	50.89 ^c ±0.42	49.98 ^b ±0.24	49.15 ^a ±0.33
Protein %	22.24±0.36	22.79±0.33	23.28±0.31	22.67±0.23	23.09±0.24	22.95±0.28	23.54±0.12
Ether extract %	19.14±0.31	18.41±0.22	17.97±0.29	18.46±0.16	18.15±0.24	18.53±0.27	18.51±0.16
Ash %	4.73±0.26	4.54±0.13	4.32±0.15	4.65±0.16	4.48±0.15	4.95±0.18	5.11±0.20

Mean in row bearing a common superscript do not differ significantly ($P<0.01$)

$n=6$ for each treatment

Control: 100 % vinegar

I: 50 % vinegar+50 % F.B.S. extract

II: 100 % F.B.S. extract

III: 50 % vinegar+50 % F.B.S. paste

IV: 100 % F.B.S. paste

V: 50 % vinegar+50 % F.B.S. powder

VI: 100 % F.B.S. powder

Table 3 Effect of incorporation of FBS products at different levels on thiobarbituric acid value and log Total plate counts (cfu/g) of pork pickles

Days	Control	Treatment					
		I	II	III	IV	V	VI
Thiobarbituric Acid Value							
1st	0.31 ^a ±0.01	0.34 ^a ±0.01	0.31 ^a ±0.01	0.35 ^a ±0.02	0.37 ^a ±0.01	0.39 ^a ±0.01	0.92 ^b ±0.04
15th	0.37 ^a ±0.02	0.41 ^a ±0.03	0.37 ^a ±0.02	0.41 ^a ±0.03	0.45 ^a ±0.01	0.47 ^a ±0.03	1.15 ^b ±0.05
30th	0.42 ^a ±0.02	0.49 ^a ±0.05	0.42 ^a ±0.03	0.53 ^a ±0.04	0.54 ^a ±0.01	0.63 ^a ±0.06	2.16 ^b ±0.09
45th	0.63 ^a ±0.06	0.65 ^a ±0.05	0.65 ^a ±0.04	0.67 ^a ±0.05	0.68 ^a ±0.02	0.85 ^a ±0.07	—
60th	0.83 ^a ±0.07	0.82 ^a ±0.02	0.80 ^a ±0.02	0.87 ^a ±0.06	0.85 ^a ±0.02	1.06 ^a ±0.07	—
75th	1.01 ^a ±0.10	0.96 ^a ±0.02	0.95 ^a ±0.06	1.14 ^{ab} ±0.06	1.05 ^a ±0.05	1.42 ^b ±0.07	—
90th	1.41 ^{ab} ±0.06	1.37 ^{ab} ±0.06	1.22 ^a ±0.086	1.54 ^b ±0.06	1.49 ^{ab} ±0.07	1.85 ^c ±0.08	—
Total Plate Counts (log cfu/g)							
1st	2.33 ^a ±0.06	2.37 ^a ±0.04	2.37 ^a ±0.07	2.44 ^a ±0.11	2.45 ^a ±0.11	3.08 ^{ab} ±0.21	3.65 ^b ±0.10
15th	2.46 ^{ab} ±0.03	2.44 ^a ±0.06	2.42 ^a ±0.11	2.53 ^{ab} ±0.07	2.56 ^{ab} ±0.12	3.28 ^b ±0.21	4.55 ^c ±0.09
30th	2.63 ^a ±0.09	2.55 ^a ±0.10	2.51 ^a ±0.12	2.69 ^{ab} ±0.09	2.62 ^a ±0.23	3.53 ^b ±0.20	5.77 ^c ±0.09
45th	2.90 ^a ±0.06	2.74 ^a ±0.10	2.68 ^a ±0.14	2.81 ^a ±0.10	2.86 ^a ±0.18	3.78 ^b ±0.22	—
60th	3.23 ^{ab} ±0.08	2.93 ^a ±0.12	2.80 ^a ±0.14	3.08 ^a ±0.09	3.05 ^a ±0.18	3.94 ^b ±0.26	—
75th	3.86 ^{ab} ±0.09	3.19 ^a ±0.14	3.07 ^a ±0.14	3.39 ^a ±0.11	3.31 ^a ±0.16	4.22 ^b ±0.24	—
90th	4.28 ^{bc} ±0.09	3.62 ^{ab} ±0.20	3.36 ^a ±0.15	3.78 ^{abc} ±0.15	3.70 ^{ab} ±0.13	4.59 ^c ±0.21	—

Mean in row bearing a common superscript do not differ significantly ($P<0.01$)

$n=6$ for each treatment

Control: 100 % vinegar

I: 50 % vinegar+50 % F.B.S. extract

II: 100 % F.B.S. extract

III: 50 % vinegar+50 % F.B.S. paste

IV: 100 % F.B.S. paste

V: 50 % vinegar+50 % F.B.S. powder

VI: 100 % F.B.S. powder

storage period at room temperature. The products with 100 % FBS powder could be used for a short storage period.

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