SUBMISSION OF FINAL REPORT OF WORK FOR MAJOR RESEARCH PROJECT

To

University Grant Commission (U G C)

Bahadur Shah Zafar Marg,

New Delhi, Pin - 110 002, India

On

Processing and packaging of various edible bamboo shoot species growing in different agro-ecological regions of Assam

F. No. 39-92/2010 (SR)

Submitted By:

Dr. Laxmikant S. Badwaik
Assistant Professor and Principal Investigator
Department of Food Engineering and Technology
Tezpur University, Napaam, Tezpur – 784028
Assam, India

UNIVERSITY GRANTS COMMISSION
BAHADUR SHAH ZAFAR MARG
NEW DELHI – 110 002

THE FINAL REPORT OF THE WORK DONE ON THE PROJECT

1. NAME AND ADDRESS OF THE PRINCIPAL INVESTIGATOR:

Dr. Laxmikant S. Badwaik,
Dept. of Food Engineering and Technology, Tezpur University,
Napaam, Tezpur- 784028, Assam, India

2. NAME AND ADDRESS OF THE INSTITUTION:

Tezpur University, Napaam, Tezpur- 784028, Assam, India

3. UGC APPROVAL NO. AND DATE : F. No. 39-92/2010 (SR)

4. DATE OF IMPLEMENTATION : 01/02/2011

5. TENURE OF THE PROJECT : 3 Years

6. TOTAL GRANT ALLOCATED : Rs. 11,54,467/-

7. TOTAL GRANT RECEIVED : Rs. 10,65,400/-

8. FINAL EXPENDITURE : Rs. 10,24,066/-

9. TITLE OF THE PROJECT :

Processing and packaging of various edible bamboo shoot species growing in different agro-ecological regions of Assam

10. OBJECTIVES OF THE PROJECT :

a) To study the effect of processing on quality and shelf life of various bamboo shoot species of Assam

b) To evaluate the suitability of packaging materials and methods for extending the shelf life of fresh and processed bamboo shoot

c) To validate the indigenous knowledge for bamboo shoot processing of tribals and non tribals people of Assam

11. WHETHER OBJECTIVES WERE ACHIEVED (GIVE DETAILS) : YES
(The details are discussed under summary of findings)

a) With respect to first objective of the project, the effect of various processing methods viz. blanching, fermentation and osmotic dehydration on bamboo shoot quality was studied.

b) To achieve the second objectives, the antimicrobial and antibrowning edible coating and film was prepared and applied on fresh bamboo shoot pieces for extending its shelf life.

c) The fermented bamboo shoot product of Assam i.e. *Khorisa* was analyzed for its nutritional and quality criteria. Scientific validations of indigenous knowledge of bamboo shoot fermentation were carried out to achieve the third objective of study.

12. ACHIEVEMENTS FROM THE PROJECT:

a) The developed antimicrobial and antibrowning coating was successfully applied on fresh bamboo shoot pieces and coating effect on quality of bamboo shoots were studied and compared with uncoated shoot. The film was successful in lowering the browning of bamboo shoots, and also inhibited surface microbial load. Also, coating of shoot reduces the weight loss by 7% compared to uncoated shoots.

b) This study is acknowledged and story based on this research has been published by one of the writer in 'Down To Earth' magazine on 30 April, 2014. (Copy of article is attached)

c) Osmotic dehydration technique was implemented for partial dehydration of bamboo shoot. Osmotic dehydration is mainly affected by process variables, such as process time, solution temperature and the concentration of the osmotic agent. But use of centrifugal force and pulsed vacuum showed the enhancement of osmotic drying process resulting in product of better quality.

d) Vacuum pressure up to 400 mm Hg causes more water loss compared with that of the centrifugal force. But, at the same time, solid gain is also quite more. As high solid gain is not desirable during osmotic dehydration, therefore, the use of centrifugal force for more water loss and lesser solid gain is suggested. The best levels of centrifugal force and vacuum were noticed to be 2,800 rpm and 400 mm Hg, respectively.

e) Significant increase in total phenolics and antioxidant activity during fermentation of bamboo shoots highlighted its nutritional status and importance. Addition of Garcinia pedunculata Roxb. in bamboo shoot not only enhances the fermentation process but also imparts significant desirable changes in the product. The technology and information now in public domain which is helpful to understand the significance of bamboo shoot fermentation.

13. SUMMARY OF THE FINDINGS (IN 500 WORDS) : The detail summary is attached herewith.

14. CONTRIBUTION TO THE SOCIETY (GIVE DETAILS):

a) This research mainly focused on bamboo shoot and its related processes. In the Northeastern states of India, bamboo shoot has been widely used as an ideal vegetable in diet because of its high dietary fiber, low in fat and potential medicinal applications.

b) Bamboo shoots are harvested from homestead in clumps and brought to the local market for sale. The shelf life of bamboo shoot is limited and they have to be sold immediately after harvest. The preservation and storage is the main concern for the people handling bamboo shoot.

c) This work will help the people of Northeastern states of India for effective handling of bamboo shoot by avoiding microbial contamination and enzymatic browning with application of edible coatings. Osmotic drying of bamboo shoots helps to preserve its nutrition and quality for long time.

d) Fermented bamboo shoots are the main part of diet of people of Assam and other Northeastern states of India and are extensively used as a main ingredient in different food items like meat, fish preparations, preparing pickles etc. The study mainly focused on the quality and safety aspects of fermented bamboo shoots of Assam and identified the changes takes place during fermentation.

15. WHETHER ANY PH.D. ENROLLED/PRODUCED OUT OF THE PROJECT : NO

16. NO. OF PUBLICATIONS OUT OF THE PROJECT (PLEASE ATTACH RE-PRINTS) : 05 (Journal Publications)

1. Badwaik, L. S., Borah, P. K., & Deka, S. C. 2014. Antimicrobial and enzymatic antibrowning film used as coating for bamboo shoot quality improvement. Carbohydrate Polymers, 103, 213-220.
2. Badwaik, L. S., Borah, P. K., Borah, K., Das, A. J., Deka, S. C., & Sharma, H. K. 2014. Influence of Fermentation on Nutritional Compositions, Antioxidant Activity, Total Phenolic and Microbial Load of Bamboo Shoot. Food Science and Technology Research, 20(2), 255-262.
3. Badwaik, L. S., S Choudhury, P K Borah, N Sit, and S C Deka. (2013). Comparison of kinetics and other related properties of bamboo shoot drying pretreated with osmotic dehydration. *Journal of Food Processing and Preservation*. (DOI: 10.1111/jfpp.12077).
4. Badwaik, L. S., Choudhury, S., Borah, P. K., & Deka, S. C. (2013). Optimization of osmotic dehydration process of bamboo shoots in mixtures of sucrose and sodium chloride solutions. *Journal of Food Processing and Preservation*, *37*(6), 1068-1077.
5. Badwaik, L. S., Borah, P.K., Borah, K., Sit, N. and Deka, S. C. 2012. Antimicrobial Activity of Indegenous Medicinal Plant Extract on Spoilage Microbes present in Bamboo Shoots. International Journal of Agriculture and Food Science Technology, 3(3), 234-237.

LSBadwaik

(Laxmikant S. Badwaik)
Principal Investigator

SUMMARY OF THE FINDINGS

Some of the findings of study were submitted during Mid Term review of project. However some of the major findings with respect to different objectives are as follows.

1. Collection of bamboo shoots and its analysis

Bamboo shoots of *Dendrocalamus hamiltonni* (Kako), *Bambusa balcooa* (Bhaluka), *Bambusa pallida* (Makal/ Bijuli), *Bambusa tulda* (Jati) species were collected from Tezpur, Nagaon and Karbi Anglong in Assam, India. All the shoot samples were analyzed for moisture content, protein, fat, carbohydrate, crude fiber, ash, vitamin C, total phenol, antioxidant activity etc. The results are as follows.

Table 1: Nutritional composition of different species of bamboo shoot on fresh weight basis

Parameters	*D. hamiltonii*	*B. balcooa*	*B. pallida*	*B. tulda*
Moisture (g/100g)	90.71±1.46	91.12±132	91.56±1.18	91.93±1.28
Protein (g/100g)	3.28±0.34	3.42±0.12	3.34±0.18	3.32±0.22
Fat (g/100g)	0.67±0.05	0.52±0.01	0.31±0.07	0.46±0.03
Carbohydrate (g/100g)	4.46±0.16	4.08±0.36	3.89±0.44	4.70±0.27
Ash (g/100g)	0.88±0.03	0.86±0.07	0.90±0.05	0.82±0.04
Crude fiber (g/100g)	3.88±0.41	3.51±0.32	3.16±0.54	3.92±0.25
Vitamin C (mg/100g)	1.45±0.14	2.72±0.18	2.10±0.09	1.39±0.21
Total phenols (mg/100g)	88.23±4.38	101.65±2.75	79.85±3.98	80.54±3.21
% DPPH free radical scavenging activity	23.12±1.34	27.12±1.05	19.17±0.98	21.73±1.24
Reducing sugars (g/100g)	1.3±0.07	1.33±0.11	1.25±0.12	1.26±0.05

All data are the mean ± SD of three replicates.

2. Effect of blanching on bamboo shoot quality

Effect of blanching temperature (75, 85 and 95 °C) and time (5, 10, 15, 20, 25 and 30 min) on different physicochemical properties of bamboo shoot cubes were assessed. Blanching time and temperature have significantly influenced the nutrient like protein, carbohydrate and reducing sugar and the influence was less on ash and crude fiber. Retention of ascorbic acid, total phenolic and antioxidant 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. Some of the results are as follows.

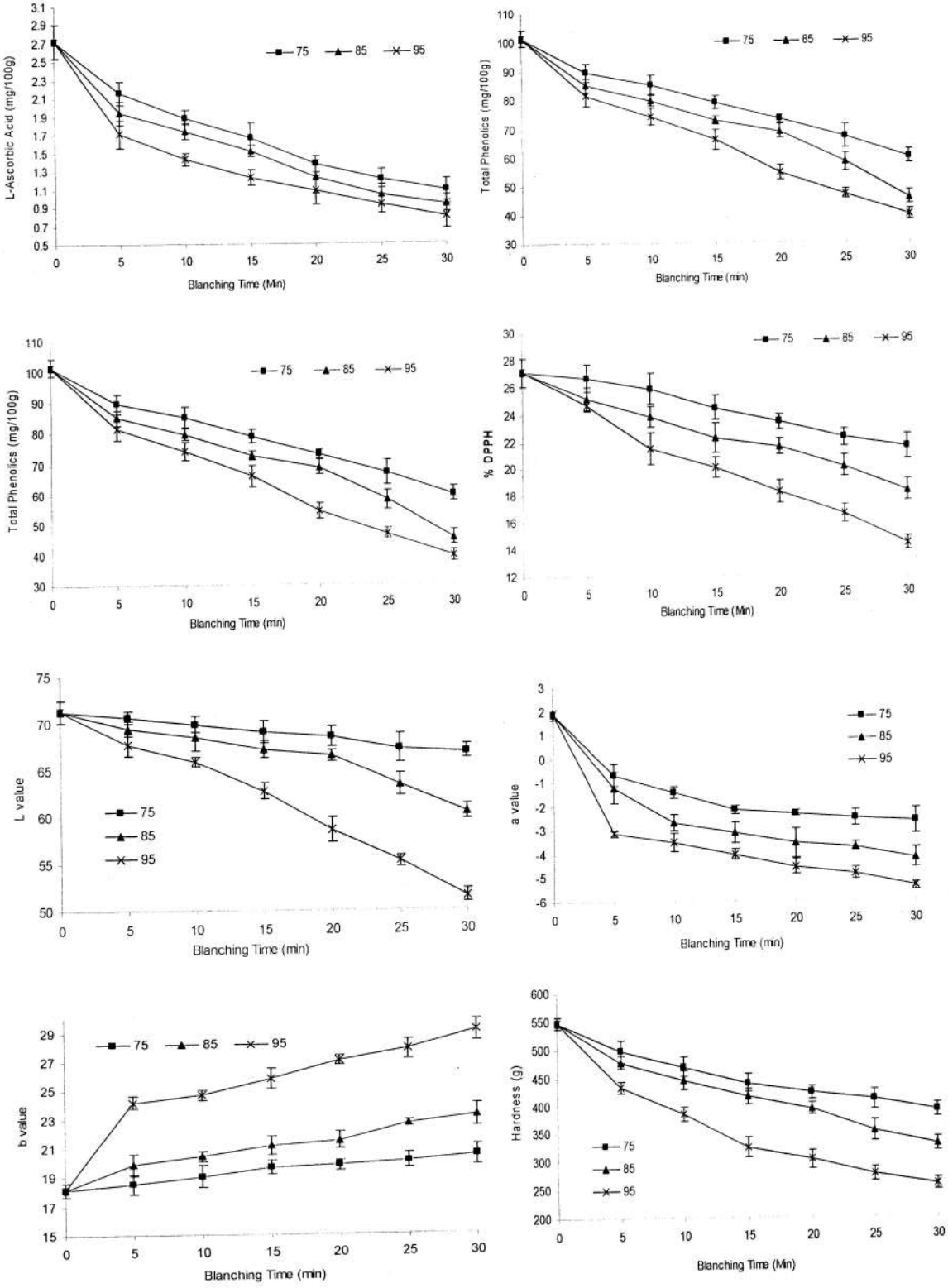


Fig. 1 Effect of blanching temperature on various quality attributes of bamboo shoot

3. Effect of osmotic dehydration on bamboo shoot quality

Bamboo shoots of *Bambusa pallida* variety were taken for osmotic dehydration. Central Composite Rotatable Design (CCRD) was used for design of experiments. Three process variables viz. solution concentration (5-15% salt + 50^0 Brix sucrose), solution temperature (30-50 °C) and process time (30-240 min) were taken for study. The experimental design, along with values of various responses, is given in Table 2.

Table 2: Experimental designs and responses for different experimental run

Expt. No.	Coded process variables			Uncoded process variables			Responses			
	Conc. (%) (x_1)	Time (Min) (x_2)	Temp (°C) (x_3)	Conc. (%) (X_1)	Time (Min) (X_2)	Temp (°C) (X_3)	Water loss (Y_1)	Solids gain (Y_2)	Rehy. ratio (Y_3)	Sensory score (Y_4)
1	-1	-1	-1	7.02 + 50°Brix	72.57	34.05	39.73	11.58	1.25	5.50
2	1	-1	-1	12.97 + 50°Brix	72.57	34.05	36.06	12.04	1.07	6.70
3	-1	1	-1	7.03 + 50°Brix	197.43	34.05	46.76	18.83	0.97	6.00
4	1	1	-1	12.97 + 50°Brix	197.43	34.05	44.10	16.08	1.17	9.00
5	-1	-1	1	7.03 + 50°Brix	72.57	45.95	43.44	14.43	1.02	5.70
6	1	-1	1	12.97 + 50°Brix	72.57	45.95	45.50	14.46	0.87	8.50
7	-1	1	1	7.03 + 50°Brix	197.43	45.95	40.90	16.65	1.02	6.00
8	1	1	1	12.97 + 50°Brix	197.43	45.95	38.45	14.40	0.96	9.00
9	-1.68	0	0	5.00 + 50°Brix	135.00	40.00	35.12	12.04	1.05	5.00
10	1.68	0	0	15.00 + 50°Brix	135.00	40.00	37.29	19.36	0.82	8.00
11	0	-1.68	0	10.00 + 50°Brix	30.00	40.00	39.75	8.64	0.89	6.00
12	0	1.68	0	10.00 + 50°Brix	240.00	40.00	42.93	20.66	0.92	7.00
13	0	0	-1.68	10.00 + 50°Brix	135.00	30.00	38.45	15.50	1.18	7.00
14	0	0	1.68	10.00 + 50°Brix	135.00	50.00	36.04	11.76	1.13	8.00
15	0	0	0	10.00 + 50°Brix	135.00	40.00	33.23	13.51	0.99	6.50
16	0	0	0	10.00 + 50°Brix	135.00	40.00	34.00	12.51	1.02	6.60
17	0	0	0	10.00 + 50°Brix	135.00	40.00	32.19	13.11	1.00	6.70
18	0	0	0	10.00 + 50°Brix	135.00	40.00	34.76	13.51	1.15	6.50
19	0	0	0	10.00 + 50°Brix	135.00	40.00	36.87	12.59	1.17	6.60
20	0	0	0	10.00 + 50°Brix	135.00	40.00	36.35	13.12	1.08	6.50

Linear, quadratic and interaction effects were observed for each model. The correlation coefficients sum of squares and *p-value* for each model are shown in Table 3. The correlation coefficients for the responses water loss, solids gain, rehydration ratio and sensory score (R^2 = 90.05%, 83.44%, 83.22% and 95.86%) are quite high for response surfaces and indicate that fitted quadratic model accounted for more than 83% of the variance in the experiment data which were found to be highly significant. Based on t-statistics, the only regression coefficient significant at 95 and 99% probability levels were selected for developing the model.

Table 3: Coefficients of responses, sum of squares and *p-value* of osmotic dehydration of bamboo shoots

	Water loss (%)			Solids gain (%)			Rehy. Ratio (%)			Sensory score	
	Coef.	SS	*p*-value*	Coef.	SS	*p*-value*	Coef.	SS	*p*-value*	Coef.	SS
	p-value										
Model	--	268.35	0.0144	--	119.65	0.0476	--	0.182	0.0492	--	22.94
	< 0.0001										
Intercept	34.46	--	--	13.06	--	--	1.06	--	--	6.56	--
	--										
X_1: Conc.	-0.22	0.69	0.7547	0.57	4.47	0.3337	-0.041	0.023	0.0907	1.1	16.58
	< 0.0001										
X_2: Time	0.79	8.59	0.2838	2.47	83.02	0.0014	2.439 x 10-3	0.08 x 10-3	0.9141	0.39	2.04
	0.0011										
X_3: Temp.	-0.18	0.43	0.8058	-0.36	1.75	0.5393	-0.049	0.033	0.0488	0.27	0.99
	0.0101										
X_1^2	1.29	24.07	0.0871	0.94	12.84	0.1158	-0.036	0.019	0.1248	0.019	0.01
	0.8258										
X_2^2	3.11	139.21	0.0010	0.57	4.74	0.3200	-0.047	0.032	0.0535	0.019	0.01
	0.8258										
X_3^2	1.66	39.72	0.0351	0.21	0.65	0.7070	0.042	0.025	0.0809	0.37	2.00
	0.0012										
X_1X_2	-0.44	1.53	0.6427	-0.69	3.77	0.3729	0.057*	0.026	0.0751	0.25	0.50
	0.0485										
X_1X_3	0.74	4.41	0.4358	6.87 x 10-3	3.77 x 10-4	0.9927	-0.029	0.007	0.3405	0.2	0.32
	0.1026										
X_2X_3	-3.08	76.01	0.0071	-1.14	10.38	0.1524	0.036	0.010	0.2389	-0.25	0.50
	0.0485										

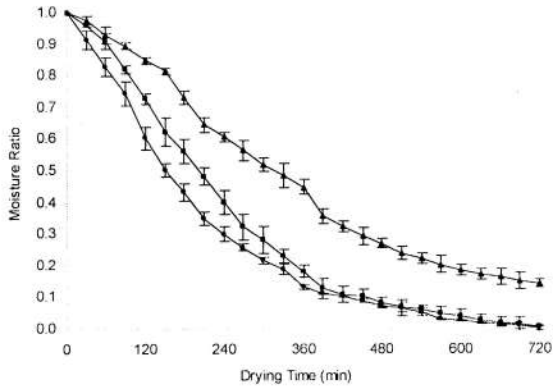
* Significant at 99% level if *p*-value < 0.01 and 95% level if *p*-value < 0.05; SS- Sum of squares: Coef. -correlation coefficient

The optimization of the process variables i.e. process time, solution temperature and concentration were done using a superimposed graph to find out the conditions when we can get the best results for osmotic dehydration of bamboo shoots. Optimization was done for getting maximum water loss with minimum uptake of solids by the bamboo shoots and for maximum values of rehydration ratio and sensory score. From the superimposed graphs the different optimized range for the process variables were obtained from the feasible zone in the graph. The range of osmotic solution concentration was found to be 8.89-11.08 % sodium chloride in 50 °Brix sucrose syrup, 34.09 - 44.54 °C for osmotic solution temperature and 72.64-104.48 min range of process duration, were found to be optimum for osmotic dehydration of the bamboo shoots. The responses were found to be in the range of 34.99-38.58 % for water loss, 10.60-11.99 % for solids gain, 0.99-1.16 for rehydration ratio and 6.00-8.00 for sensory score.

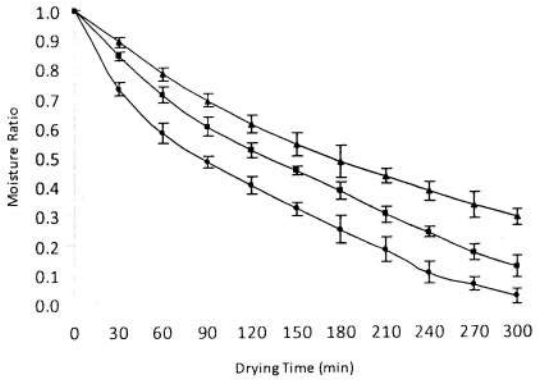
(Full published paper of this work is attached with this report)

4. Drying of osmotically dried bamboo shoots

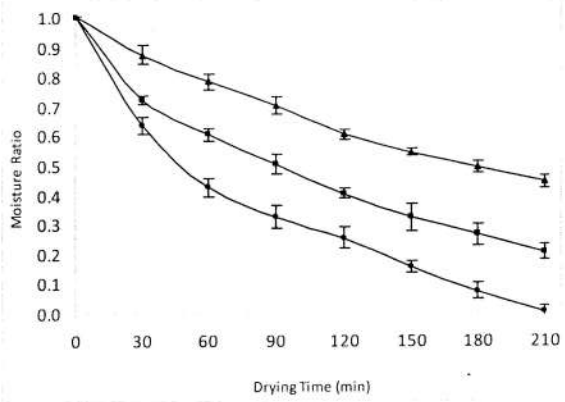
Osmotic dehydration (OD) of bamboo shoots were carried out at 50°B sucrose syrup and 10% salt using temperature and time of 40°C and 90 min respectively. These shoots were dried at temperatures of 45, 55 and 65°C using three drying methods viz., tray drying, vacuum drying and fluidized bed drying. Drying kinetics and other related properties at all three temperatures were studied and exponential model were fitted. R^2 values were found above 0.9 and k values were increased with temperature. Rehydration ratio was found more for osmo-vacuum dried (OD-VD) shoot; however, it was high at 55°C. Firmness and shrinkage were also reported more for vacuumed dried shoot. Microstructure of bamboo shoots were mostly affected by the drying methods. 'L' values for OD-VD method were found slightly less whereas 'a' and 'b' value were found high compared to other drying metnods. Shoot tretaed with OD-VD at 55°C was found acceptable. The results are shown below.



TRAY DRYING (TD)



VACUUM DRYING (VD)



FLUIDIZED BED DRYING (FBD)

Fig. 2. Drying curve of osmotically treated bamboo shoots at 45°C (▲), 55°C (■) AND 65°C (•).

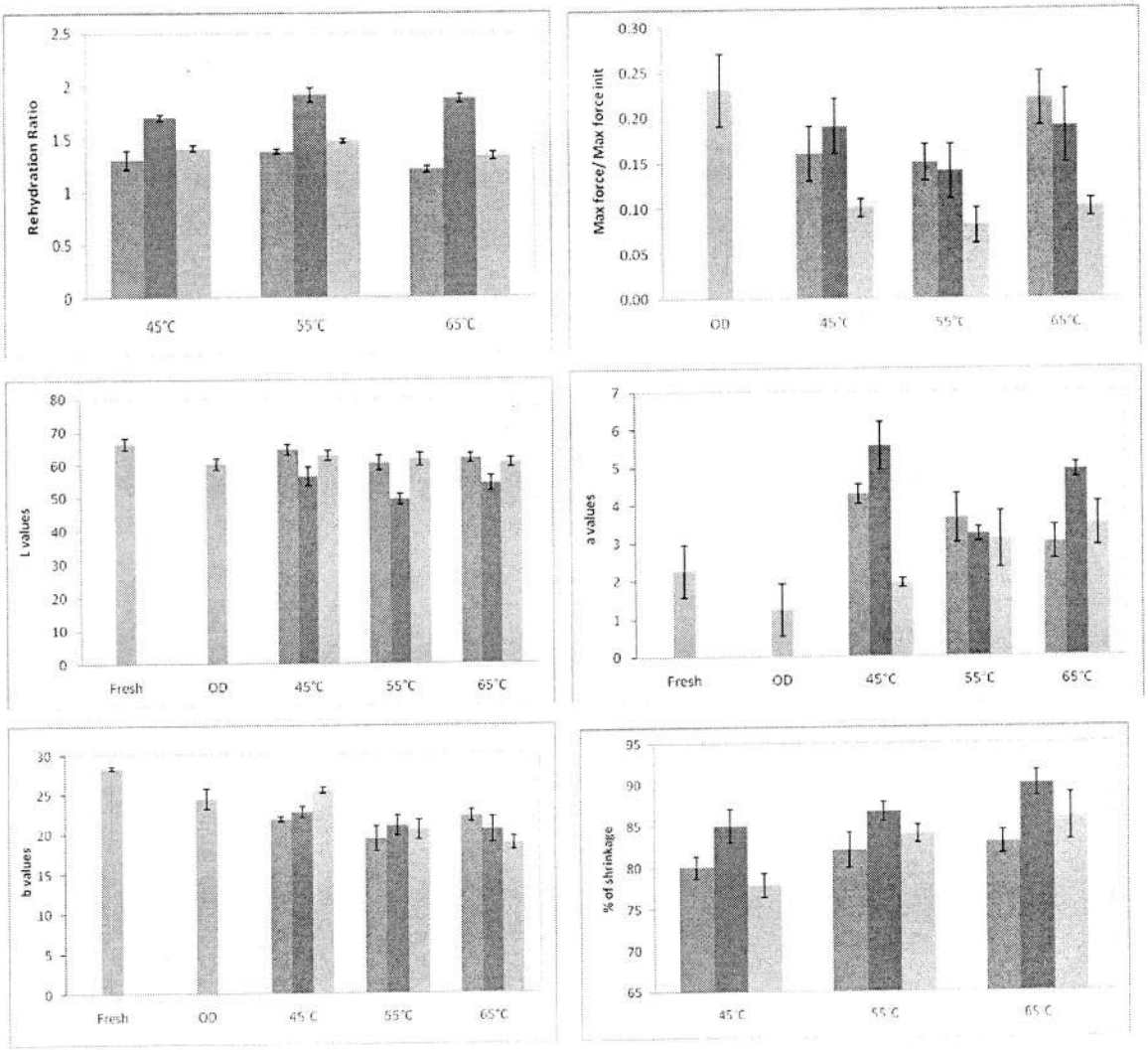


Fig. 3. Rehydration Ratio, Texture, Color Values, % Shrinkage of bamboo shoot samples dried at temperatures of 45°C, 55 °C and 65 °C using TD, VD and FBD.

(Full published paper of this work is attached with this report)

5. Effect of fermentation on bamboo shoot quality

Physicochemical and microbiological changes during the fermentation of bamboo shoot were investigated for 12 days at regular intervals of 48 hours. Bamboo shoot was fermented in two batches. In one batch, bamboo shoots were grated and kept for natural anaerobic fermentation at 32°C for 12 days (Batch-1) and in the second batch pieces of *Garcinia pedunculata* Roxb. were mixed (1%) along with shoot (Batch-2). Fresh and fermented shoots were analyzed for proximate constituents, total phenol content, antioxidant activity, reducing sugars, pH, acidity, total plate count, yeast and mould, lactic acid bacteria, *Salmonella* and *Shigella*, FTIR, and HPLC analysis for organic acids and carbohydrate profile. Marked increase in total phenolics from 97.5mg/100g to 255 mg and 239 mg/100g were observed for batch-1 and batch-2 respectively. The antioxidant

activity for fresh and fermented shoot (batch-1 & batch-2) was found to be 26.62, 49.20 and 55.35 % DPPH radical scavenging activity respectively. The details results are as follows.

Table 4: Chemical composition of fresh and fermented shoot.

	Fat (%)	Protein (%)	Carbohydrate (%)	Ash (%)	Vitamin C (mg/100g)	Total Phenolics (mg/100g)	Antioxidant activity (%DPPH)	pH	acidity (% LA)	Reducing Sugar (g/100g)
Fresh Shoot	0.67 ± 0.8^{a}	3.78 ± 1.4^{a}	4.50 ± 1.0^{a}	0.86 ± 0.05^{a}	2.45 ± 0.5^{a}	97.5 ± 4.2^{a}	26.67 ± 1.6^{a}	6.40 ± 0.15^{a}	0.89 ± 0.25^{a}	1.37 ± 0.05^{a}
Khorisa (Batch-1)	0.44 ± 0.1^{b}	2.56 ± 0.8^{b}	1.45 ± 1.2^{b}	0.83 ± 0.01^{a}	1.09 ± 0.2^{b}	255 ± 4.4^{b}	49.20 ± 1.5^{b}	4.52 ± 0.19^{b}	2.82 ± 0.16^{b}	0.32 ± 0.06^{a}
Khorisa (Batch-2)	0.41 ± 0.2^{b}	2.40 ± 0.5^{b}	1.39 ± 0.9^{b}	0.81 ± 0.02^{a}	1.37 ± 0.3^{b}	239 ± 5.2^{b}	55.35 ± 1.2^{c}	4.09 ± 0.23^{c}	3.75 ± 0.19^{c}	0.26 ± 0.09^{a}

All data are the mean ± SD of three replicates. Mean followed by different letters in the same column differs significantly ($P \leq 0.05$). n=3

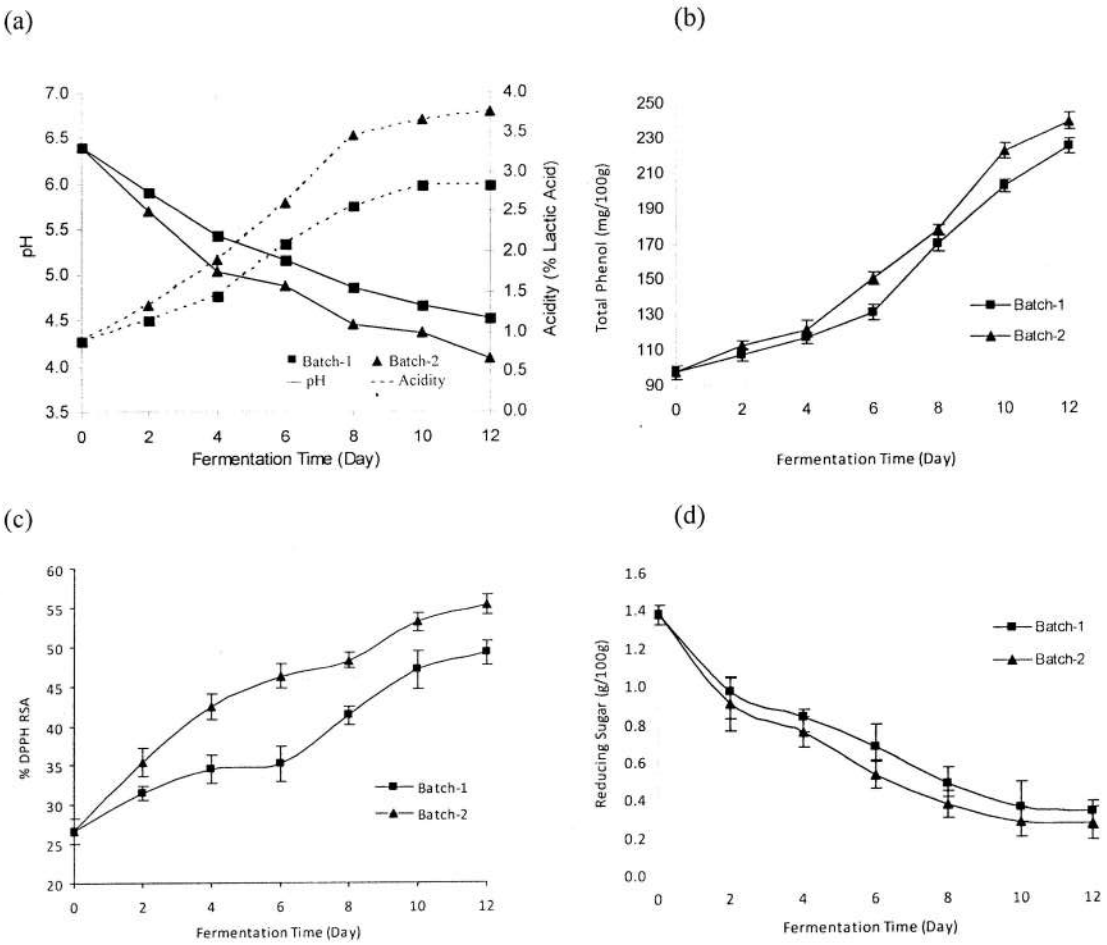


Fig. 4. Change in (a) pH and acidity; (b) total phenol; (c) antioxidant activity; (d) reducing sugar of bamboo shoot during fermentation. In Batch-1 grated bamboo shoots were kept for natural anaerobic fermentation and in Batch-2 pieces of *Garcinia pedunculata* Roxb. were mixed (1%) along with grated bamboo shoot. Vertical bars represent standard errors of means, n = 3.

Table 5: Characteristics of organic acids and carbohydrates present in fresh and fermented bamboo shoots.

Peak No.	Ret.Time Min	Peak Name	Amount (mg/g) Fresh shoot	Khorisa (Batch-1)	Khorisa (Batch-2)
Organic Acids					
1	3.89	Oxalic Acid	0.001	ND	ND
2	4.29, 4.23	Tartaric Acid	1.733	32.041	51.021
3	4.53, 4.57	Formic Acid	0.012	2.965	ND
4	4.63	Pyruvic Acid	0.037	ND	0.452
5	4.93, 4.89	Lactic Acid	2.824	37.030	39.492
Carbohydrates					
1	8.42, 8.70	Raffinose	0.092	ND	16.741
2	8.80	Trehalose	ND	11.022	ND
3	9.16	Sucrose	0.514	ND	ND
4	10.35, 10.37	Glucose	23.801	ND	13.119
5	11.80, 11.82, 11.73	Galactose	2.296	31.277	23.480
6	14.22, 14.12, 14.02	Inositol	0.131	0.201	0.223

ND – Not Detected

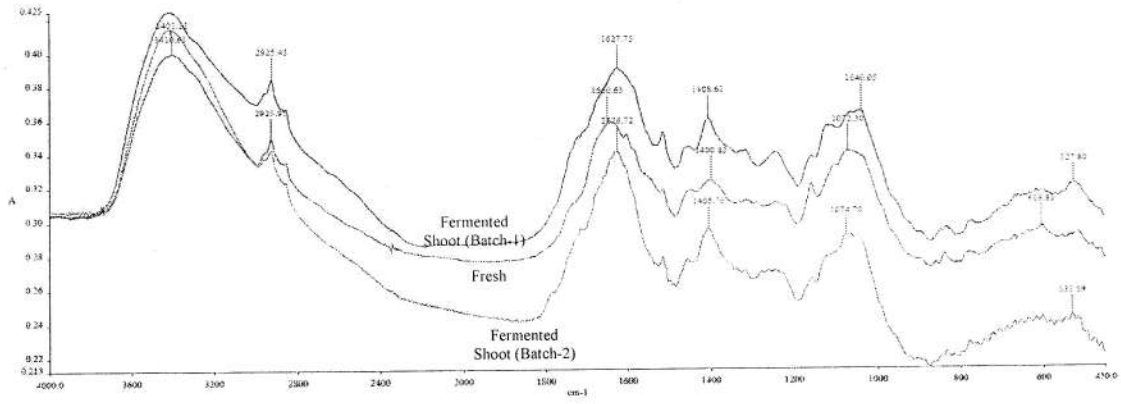


Fig. 5. FTIR spectrum pattern for fresh and fermented shoots of Batch-1 and Batch-2.

Table 6: Peak assignment and their related compounds present in fresh and fermented bamboo shoots.

Peak value			Peak assignments	Compounds
Fresh	Fermented (Batch-1)	Fermented (Batch-2)		
3410.61	3401	3401	O-H Stretching	Alcohols/ Phenols
2925.91	2925.43	2925	C-H Stretching	Alkanes (methylene)
1650.63	1627.75	1626.72	C=C Stretching	Aromatic
1400.82	1408.62	1405.70	C-H bending	Alkanes
1072.30	1040.05	1074.70	C-O Stretching	Carboxylic acid

(Full published paper of this work is attached with this report)

6. Development of antimicrobial and antibrowning edible coating for bamboo shoot quality improvement

Edible films were prepared with varying proportion of alginate and starch in the ratio of 2:0(F_1), 2:1(F_2), 1:1(F_3), 1:1.5(F_4), 1:2(F_5), 0:2(F_6) with added carboxymethyl cellulose (15% w/w of starch). The film F_5 had superior barrier, mechanical and thermal properties over the other films. Water vapour permeability, moisture absorption, water solubility, breakage strength and elongation capacity of F_5 film was reported as 1.21×10^{-9} g /Pa h m, 9.37%, 40%, 977.3 g and 14.62 mm respectively. However, surface characteristics showed the smooth and uniform film and thermal decomposition took place above 200°C. The film forming solution of selected F_5 film, added with antioxidant and antimicrobial extracts was coated on bamboo shoots and stored for 5 days. The film was successful in lowering the browning of bamboo shoots, and also successfully inhibited surface microbial load. Moreover, the moisture loss of coated shoot was less compared to uncoated.

Antioxidant compounds were extracted from *Garcinia pedunculata* Robx. using microwave assisted extraction. In preliminary experiments the extraction process was optimized at 180 Watt microwave power. The optimized values recorded were, solvent concentration of 70.79%, solvent to sample ratio of 20:1 and irradiation time of 4.73 min. Under these optimized conditions, the antioxidant activity of extract was found to reach upto 85.98% DPPH radical scavenging activity and 19.23% ABTS radical scavenging activity. The extract was filtered through cellulose acetate syringe filters and stored at 4 °C for further use.

Biometabolites were extracted and purified from a *lactobacillus* strain isolated from fermented bamboo shoot of Assam and it was assessed for antimicrobial activity for three indicator strains of food contaminating microbes' viz., *Escherichia coli*, *Streptococcus aureus* and *Bacillus cereus*. In preliminary study, submerged fermentation technique was used for the fermentation of biometabolite, and was purified by liquid-liquid extraction with chloroform. Minimum lethal dose concentration (LD_{min}) assay of the chloroform extract were reported as 27 mg/ml, 1.68 mg/ml and 1.68 mg/ml for *E. coli, S. aureus and B. cereus* respectively. The cell free purified supernatant was stored at 4 °C and used as antimicrobial agent during this study.

The properties of prepared films and effect of antimicrobial and antibrowning edible coating for bamboo shoot quality is given below.

Table 7: Properties of film prepared from different compositions of alginate, starch and CMC

FILM	Water Vapor Permeability (g /Pa h m)	Moisture Absorption (%)	Solubility in water (%)	Breakage Strength (g)	Elongation capacity (mm)	Color Value		
						L	a	b
F_1 (2:0)	$4.01 \times 10^{-9\,a}$	18.29 ± 0.82^{a}	89.38 ± 2.65^{a}	273.2 ± 11.23^{a}	49.43 ± 2.45^{a}	63.16 ± 1.34^{a}	6.66 ± 0.31^{a}	11.59 ± 0.37
F_2 (2:1)	$3.13 \times 10^{-9\,b}$	15.67 ± 1.05^{b}	55.21 ± 1.57^{b}	411.5 ± 15.68^{b}	31.55 ± 1.73^{b}	67.19 ± 2.36^{b}	6.29 ± 0.30^{ab}	10.02 ± 0.25
F_3 (1:1)	$2.90 \times 10^{-9\,c}$	13.97 ± 1.23^{c}	53.56 ± 1.84^{b}	488.9 ± 9.42^{c}	22.23 ± 1.02^{c}	74.61 ± 1.39^{c}	6.22 ± 0.26^{b}	9.85 ± 0.13^{b}
F_4 (1:1.5)	$1.26 \times 10^{-9\,d}$	11.64 ± 0.68^{d}	52.16 ± 1.65^{bd}	856.5 ± 10.59^{d}	21.02 ± 1.32^{c}	81.67 ± 2.67^{d}	5.74 ± 0.18^{c}	9.40 ± 0.26^{c}
F_5 (1:2)	$1.21 \times 10^{-9\,d}$	9.37 ± 1.12^{e}	40.00 ± 2.45^{c}	977.3 ± 17.42^{e}	20.76 ± 1.14^{c}	85.47 ± 1.73^{e}	4.39 ± 0.38^{d}	7.60 ± 0.63^{d}
F_6 (0:2)	$4.06 \times 10^{-9\,a}$	17.43 ± 0.45^{a}	50.91 ± 1.23^{d}	208.4 ± 12.42^{f}	14.62 ± 1.08^{d}	90.36 ± 2.69^{f}	1.66 ± 0.10^{e}	2.59 ± 0.12^{e}

All data are the mean ± SD of three replicates. Mean followed by different letters in the same column differs significantly ($P \leq 0.05$).

Different letters in superscripts along the column represent the significance difference between the values.

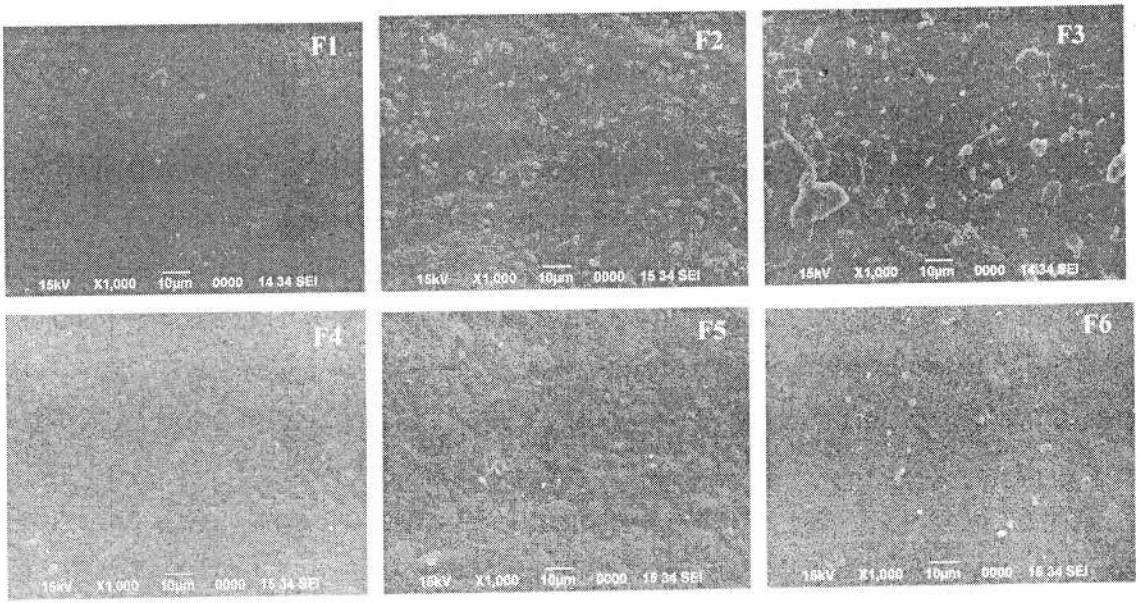


Fig. 6. Scanning electron micrographs of blend films

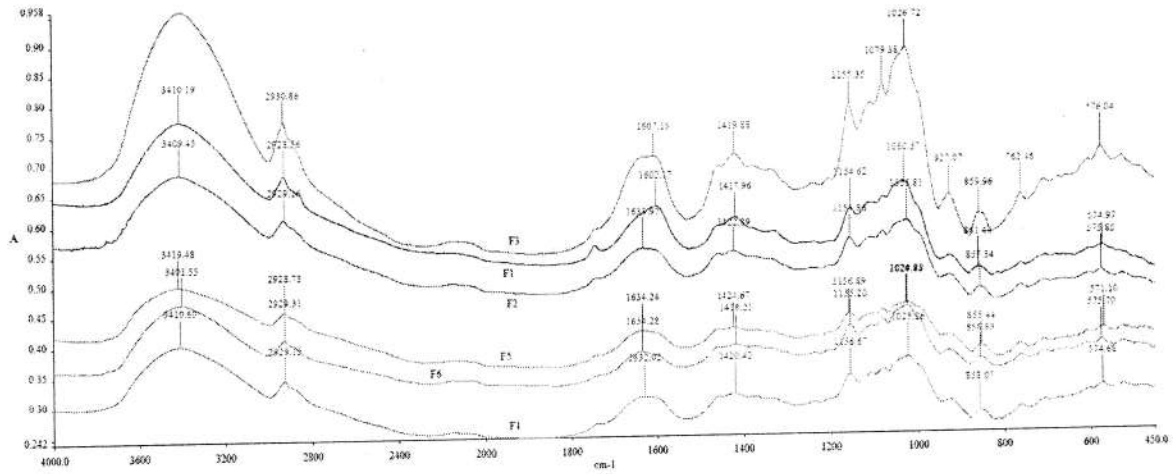


Fig. 7. FTIR spectra of films and individual polymers

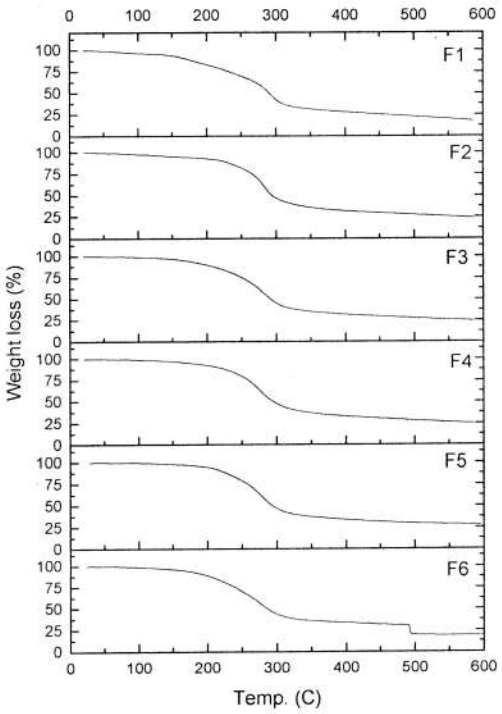


Fig. 8. Thermo gravimetric analysis curves of blended films.

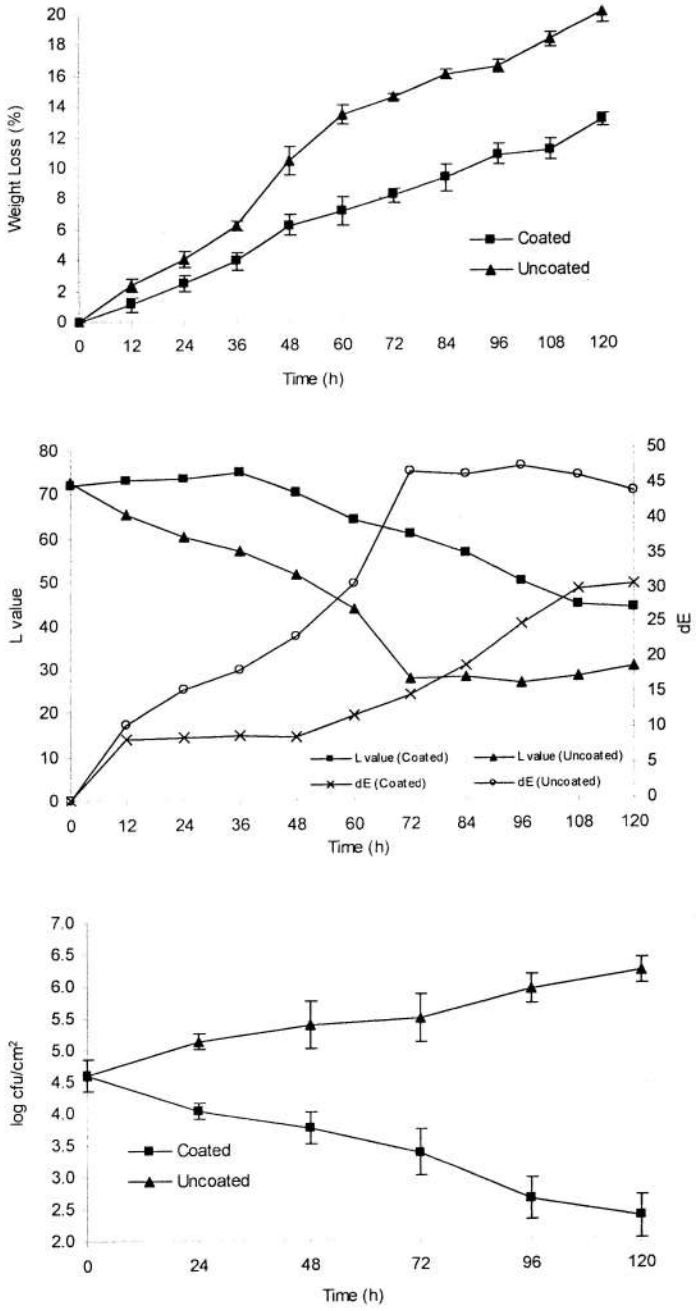


Fig. 9. Effects of coating on weight loss, surface color and microbial count in coated and uncoated bamboo shoot.

(Full published paper of this work is attached with this report)

7. Suitability of packaging materials for bamboo shoots

To evaluate the suitability of packaging materials and methods for extending the shelf life of fresh and processed bamboo shoot, treated and untreated shoots were packed in two different LDPE pouches and then stored at room and refrigerated temperature. Different conditions during packaging are as follows.

- Shoot condition: Treated (TR) & untreated (UT)
- Packaging Materials: LDPE-200µm (P200) & LDPE-25µm (P25)
- Storage Conditions: Room Temperature (27±2°C) (RT) & Refrigerated Temperature (4±1°C) (Ref)

Combination of all above parameters, gave eight experimental setup.

P200-TR-Ref;	P200-UT-Ref;	P200-TR-RT;	P200-UT-RT;
P25-TR-Ref;	P25-UT-Ref;	P25-TR-RT;	P25-UT-RT

Water vapour transmission rate (WVTR) of packages was calculated by Package Method (Ranganna, 1986). WVTR = slop/ area; slop was calculated by plotting the graph between days and weight gain by package.

WVTR for P200= 6.78 g/m^2. 24h & P25= 9.32 g/m^2. 24h

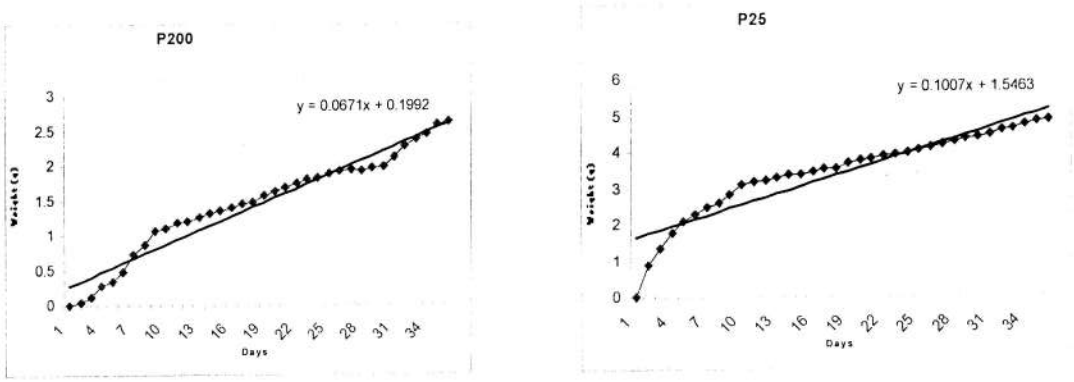


Fig. 10. Weight gain by packaging material during WVTR experimental setup.

Responses which were calculated for all eight experimental setup are visual examination (discoloration & texture), weight reduction (%), vitamin C, phenolic content, total antioxidant activity, reducing sugar and microbial activity.

Visual Examination: Both treated and untreated shoots, which were stored in refrigerated temperature in LDPE-200μm pouches, were found acceptable and very less changes in color observed at six month storage. Whereas in LDPE-25μm pouches, shoot were acceptable up to 4 months storage at refrigerated temperature. Although at room temperature, shoots were discolored rapidly. But untreated shoots were more stable than treated shoots. Treated shoots were not acceptable after one month of storage (Table 8).

Table 8: Degree of discoloration of bamboo shoots stored at different temperatures

Storage condition	Months					
	1	2	3	4	5	6
P200-TR-Ref	***	***	***	***	***	***
P200-UT-Ref	***	***	***	***	***	***
P200-TR-RT	**	*	x	x	x	x
P200-UT-RT	***	**	**	*	x	x
P25-TR-Ref	***	***	***	***	**	**
P25-UT-Ref	***	***	***	***	**	**
P25-TR-RT	*	*	x	x	x	x
P25-UT-RT	**	**	*	x	x	x

***: Very Good; **: Good; *: Poor; x: Sample Discarded

Weight Reduction: Reduction in weight was observed during storage of bamboo shoot in different packaging materials. It was higher for untreated samples and LDPE-25μm pouches.

Antioxidant activity and total phenolics content: % DPPH free radical scavenging activity of shoot was found to decrease during storage. Losses were more for treated samples. Similar type of trend was observed for total phenol content degradation.

Vitamin C: Loss in vitamin content found during storage period. Losses were more prominent in LDPE-25μm pouches compared to LDPE-200μm pouches. Also reduction was more in treated samples.

Microbial Count: Total plate count for both the refrigerated package were increased from 3log cfu/g to 4.53log cfu/g and above during six month of storage. But shoots which were stored at room temperature were discarded between 2-3 months. Similar type of trends observed for yeast and mold count, but for untreated samples count was found less as compared to treated samples.

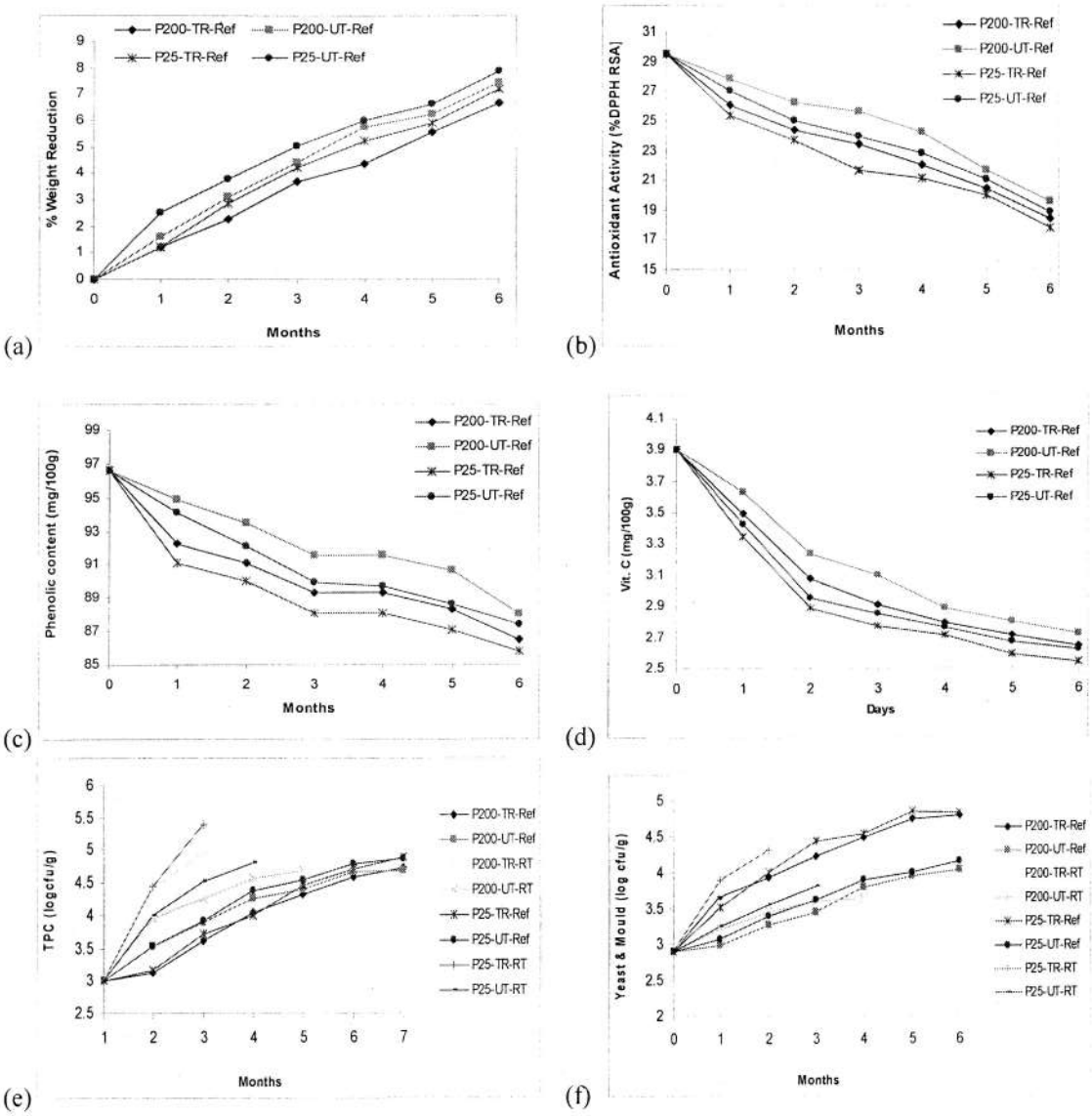


Fig. 11. Effect of packaging materials and storage temperature on (a) weight reduction (b) antioxidant activity (c) total phenolics content (d) vitamin C (e) total plate count (f) yeast and mold count

8. Antimicrobial Activity of Indegenous Medicinal Plant Extract on Spoilage Microbes present in Bamboo Shoots

Four herbs which have traditional medicinal value were selected for testing their antimicrobial activity viz, Manimooni (*Oxalis corniculata*), Curry leaves (*Murraya koenigii*), Neem (*Azadiracta indica*), Turmeric (*Curcuma longa*). Antibacterial activity of extracts was determined by disc diffusion method, on nutrient agar medium and potato dextrose medium against *E. coli, Staphylococcus aureas, Candida albicans* and *Lactobacillus planterum*. Turmeric and Curry leaves at concentration of 10% or greater, showed total inhibition of *E.coli* and *Staphylococcus*, good inhibition against *Candida*, and the least inhibition of *L. plantarum*. Mixed extract of Turmeric and Curry leaves (1:1) when added at 15% concentration showed complete inhibition of *Stphylococcus aureus*, E. coli after 4 and 6 hour respectively, in case of *Candida albicans* showed complete inhibition by mixed extract after 10 hr. *L. plantarum* was more tolerant to the mixed extract and retained a healthy number of cells. In-situ study in post harvest bamboo shoots with the mixed extract showed reduction in total plate count, yeast and mould count, and coliform counts. This study confirms the efficacy of turmeric: curry leaf mixed extract as a natural antimicrobial against food pathogens, and ensures the sustainability of lactic acid bacteria in khorisa. The detail results are as follows.

Table 9: Production of zone of inhibition by different herb extracts

Plant name	Concentration	Zone of Inhibition(mm)			
		E. coli	*St. aureous*	*Candida albicans*	*L. plantarum*
Turmeric	25	17.27	20.20	6.35	5.50
	50	18.50	21.00	14.00	12.34
	100	24.23	28.00	19.00	18.00
	Distilled water	10.10	13.00	4.50	4.78
Curry leaves	25	13.50	13.25	5.50	6.50
	50	15.70	15.00	12.10	11.00
	100	22.00	25.50	19.40	15.00
	Distilled water	17.00	13.00	5.10	4.50
Neem	25	7.40	6.80	7.00	5.60
	50	9.60	12.60	11.00	11.00
	100	16.00	16.80	15.00	14.00
	Distilled water	6.50	5.50	4.60	3.50
Manimooni	25	5.50	6.60	6.34	4.50
	50	10.00	12.00	10.50	9.00
	100	12.00	14.00	14.20	12.00
	Distilled water	6.60	4.50	3.40	3.56
Tetracyclin	as positive control	25.10	29.37	18.70	20.37
Distilled water	as negative control	0.00	0.00	0.00	0

(Full published paper of this work is attached with this report)

UNIVERSITY GRANTS COMMISSION
BAHADUR SHAH ZAFAR MARG
NEW DELHI – 110 002

STATEMENT OF EXPENDITURE IN RESPECT OF MAJOR/MINOR RESEARCH PROJECT

1. Name of Principal Investigator : Dr. Laxmikant S. Badwaik

2. Deptt. of University/College : Dept of Food Engineering and Technology, Tezpur University, Napaam, Tezpur- 784028, Assam, India

3. UGC approval No. and Date : F. No. 39-92/2010 (SR)

4. Title of the Research Project : Processing and packaging of various edible bamboo shoot species growing in different agro-ecological regions of Assam

5. Effective date of starting the project: 01/02/2011

6. a. Period of Expenditure: From 01/04/2011 to 30/09/2014

b. Details of Expenditure

S. No.	Items	Amount Approved (in Rs)	Expenditure Incurred (in Rs)
1	Books & Journal	Nil	NA
2	Equipments	2,00,000/-	1,99,910/-
3	Honorarium	Nil	NA
4	Contingency	45,000/-	42,076/-
5	Travel/fieldwork	45,000/-	39,921/-
6	Chemicals & Glassware	2,25,000/-	2,25,000/-
7	Hiring Services	45,000/-	11,759/-
8	Overhead	63,800/-	63,800/-
9	Any other items (please specify)	Nil	NA
10	Honorarium to Principal Investigator	Nil	NA
11	Staff	4,41,600/-	4,41,600/-
	Total	10,65,400/-	10,24,066/-

31-5-16
Finance Officer
Tezpur University

c . Staff : Project Fellow

Date of Appointment: 12th April, 2011 to 24th July, 2013 (for 1st project fellow)
19th Aug, 2013 to 27th Dec, 2013 (for 2nd project fellow)

S. No.	Expenditure Incurred	From To	Amount Approved(Rs.)	Expenditure Incurred(Rs.)
1	Project Fellow (Mr. Pallab Kumar Borah) Salary @ Rs.14,000/- p.m.	12th April, 2011 to 11th April, 2013	4,41,600/-	3,36,000/-
2	Project Fellow (Mr. Pallab Kumar Borah) Salary @ Rs.16,000/- p.m.	12th April, 2013 to 24th July, 2013		54,254/-
3	Project Fellow (Ms. Gitanjali Gautam) Salary @ Rs.14,000/- p.m.	19th Aug, 2013 to 27th Dec, 2013		51,346/-
		Total	4,41,600/-	4,41,600/-

1. It is certified that the appointment(s) have been made in accordance with the terms and conditions laid down by the Commission.

2. It as a result of check or audit objective, some irregularly is noticed, later date, action will be taken to refund, adjust or regularize the objected amounts.

3. Payment @ revised rates shall be made with arrears on the availability of additional funds.

4. It is certified that an amount of **Rs. 10,24,066/-** (Rupees Ten lakh twenty four thousand sixty six only) out of the total grant of grant of Rs. **10,65,400/-** (Rupees Ten lakh sixty five thousand four hundred only) received from the University Grants Commission under the scheme of support for Major Research Project entitled "Processing and packaging of various edible bamboo shoot species growing in different agro-ecological regions of Assam " vide UGC letter No. F. **39-92/2010 (SR)** dated___Nil__ has been utilized for the purpose for which it was sanctioned and in accordance with the terms and conditions laid down by the University Grants Commission.

(Principal Investigator)

(Finance Officer)
Finance Officer
Tezpur University

(Registrar)
Registrar
Tezpur University

For SURAJIT CHAKRABORTY & CO.
CHARTERED ACCOUNTANTS
04.06.2016
CA. SURAJIT CHAKRABORTY
(Proprietor)
Membership No.: 305054

UNIVERSITY GRANTS COMMISSION
BAHADUR SHAH ZAFAR MARG
NEW DELHI – 110 002

UTILIZATION CERTIFICATE

Certified that an amount of **Rs. 10,24,066/-** (Rupees Ten lakh twenty four thousand sixty six only) out of the total grant of **Rs. 10,65,400/-** (Rupees Ten lakh sixty five thousand four hundred only) received from the University Grants Commission under the scheme of support for Major Research Project entitled "Processing and packaging of various edible bamboo shoot species growing in different agro-ecological regions of Assam " vide UGC letter No. F. **39-92/2010 (SR)** dated___Nil__ has been utilized for the purpose for which it was sanctioned and in accordance with the terms and conditions laid down by the University Grants Commission and the unspent amount of **Rs. 41,334/-** (Rupees Forty one thousand three hundred thirty four only) is returned to UGC.

LSBadwaik

(Principal Investigator)

(Finance Officer)
Finance Officer
Tezpur University

(Registrar)
Registrar
Tezpur University

For SURAJIT CHAKRABORTY
CHARTERED ACCOUNTANT
04.06.2016
CA. SURAJIT CHAKRABORTY
(Proprietor)
Membership No.- 306054

UNIVERSITY GRANTS COMMISSION
BAHADUR SHAH ZAFAR MARG
NEW DELHI – 110 002

STATEMENT OF EXPENDITURE INCURRED ON FIELD WORK

Name of the Principal Investigator: Dr. Laxmikant S. Badwaik

Name of the Place visited	Duration of the Visit		Mode of Journey	Expenditure Incurred (Rs.)
	From	To		
Guwahati, Assam (Project fellow visited to IASST for sample analysis)	28-01-2012	30-01-2012	Bus	2,750/-
New Delhi (PI visited to UGC for Mid Term Evaluation on 30th Oct. 2012)	29-10-2012	01-11-2012	Air & Taxi	22,011/-
Guwahati, Assam (PI visited to IICPT Regional Center)	14-06-2013	15-06-2013	Taxi	3,450/-
Jorhat, Assam (PI visited to Assam Agriculture University)	19-07-2013	20-07-2013	Taxi	2,720/-
Guwahati, Assam (PI visited to IICPT Regional Center)	30-11-2013	01-12-2013	Taxi	3,450/-
Guwahati, Assam (PI visited for project related activities)	13-09-2014	14-09-2014	Taxi	5,540/-
			TOTAL	39,921/-

Certified that the above expenditure is in accordance with the UGC norms for Major Research Projects.

L.S.Badwaik
(Principal Investigator)

31/5/16
(Finance Officer)
Finance Officer
Tezpur University

(Registrar)
Registrar
Tezpur University

For SURAJIT CHAKRABORTY & CO.
CHARTERED ACCOUNTANTS
04.06.2016
CA. SURAJIT CHAKRABORTY
(Proprietor)
Membership No.- 305054