

**EFFECT OF PROCESSING TECHNIQUES ON HOLISTIC
QUALITY OF BAMBOO SHOOT (*Bambusa vulgaris*)**

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CENTRE FOR RURAL DEVELOPMENT AND TECHNOLOGY

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**EFFECT OF PROCESSING TECHNIQUES ON HOLISTIC
QUALITY OF BAMBOO SHOOT (*Bambusa vulgaris*)**

by

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Centre for Rural Development and Technology

Submitted

in fulfilments of the requirements of the degree of Doctor of Philosophy

to the



**INDIAN INSTITUTE OF TECHNOLOGY DELHI
OCTOBER 2016**

DEDICATED TO....

**MY BELOVED PARENTS, LOVING
HUSBAND &
LATE GRANDFATHER**

CERTIFICATE

This is to certify that the thesis entitled “**Effect of Processing Techniques on Holistic Quality of Bamboo Shoot (*Bambusa vulgaris*)**” being submitted by **Mrs. Poonam Singhal** to the **Indian Institute of Technology Delhi** for the award of **Doctor of Philosophy** is a record of bonafide research work carried out by her under our guidance and supervision in conformity with the rules and regulations of Indian Institute of Technology Delhi. The research report and results presented in this thesis have not been submitted, in part or in full, to any other university or institute for the award of any degree or diploma.

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ABSTRACT

*In recent years there has been a marked interest in health related issues due to increasing trend of lifestyle diseases amongst the urban population. Researchers are trying to explore the potential of lesser known traditional plant products having abundant bioactive constituents. Therefore, present research work was undertaken to study a non-conventional vegetable i.e. bamboo shoot species (*Bambusa vulgaris*) owing to its special nutritional characteristics. Since edible bamboo species has cyanogenic toxicity, hence it is important to develop a system of processing and preservation for keeping nutritive quality and antioxidant activity intact along with minimizing toxic content.*

The effect of different domestic cooking processes i.e. Ordinary cooking (OC), Pressure cooking (PC) and Microwave cooking (MW) was investigated on the proximate composition, minerals, cyanogen content and antioxidant capacity using standard methods. Major nutrients like ash content (i.e. minerals), crude protein, carbohydrate, crude fiber and crude fat were found to decrease with all the three cooking treatments, but maximum reduction took place in the PC method. MW cooking showed maximum nutrient retention and the reason for this could be short time exposure to food matrix. Both macro elements like Ca, Mg, P, Na, K and the micro elements like Fe, Cu, Mn, Se and Zn were reduced to significant levels in the cooked samples but with a less percent decrease in the MW cooked sample. The cyanogen content also showed maximum reduction (90.22%) in MW cooked sample. The total phenol and flavonoid content in the fresh shoots was found to be 29.0 mg GAE/100g and 49.7 mg CE/100g respectively but the content decreased with cooking treatments. Antioxidant capacities determined by ABTS, DPPH, FRAP assays was also found to decrease in the cooked sample due to degradation of the antioxidant compounds and its leaching in the cooking medium.

Drying of bamboo shoot is attempted by different methods viz. Tray drying (TD), Sun drying (SD), Oven drying (OD), and Microwave drying (MWD). The effect of drying was studied on the physico-chemical characteristics of bamboo shoots. The dried samples were analyzed for change in nutritional composition, cyanogenic toxicity, antioxidant capacity, color, texture and rehydration potential. Amongst all the drying methods, MWD led to a faster drying whereas SD took the maximum time. The rehydration ratio of FD sample both at 25°C and 100°C was found to be highest in the beginning. After 60 min the rehydration ratio of FD and SD samples was found to be comparable. Fresh shoots have hard casing requiring a puncture force of 10.08 N but drying results in softening of the tissues. Amongst all the drying methods, FD required the least puncture force indicating its porous structure. As for the color of the dried shoot sample, FD sample exhibited the highest L value, lowest a and b values indicating lightness and giving an appearance close to the natural product. Dark color was induced in other treatments due to non-enzymatic browning.

The proximate composition of the bamboo shoot sample dried by different techniques was also estimated and compared with the fresh sample on dw basis. It was found that there was a reduction in all the major nutrients like protein (ranging from 3.51-33.38%), fat (ranging from 47.59-70.56%), fiber (ranging from 1.32-6.76%) and vitamin C (ranging from 6.34-

29.76%) during drying. All the major and micronutrients were reduced to considerable amounts during different drying methods. Highest reduction in the cyanogenic content was observed in the MWD sample due to high heat as compared to FD i.e at very low temperature.

Bamboo shoot fermentation is a traditional process carried out in different communities of the North-Eastern region. Therefore, to understand the mechanism involved in the traditional process and further improvement, its scientific validation was done. The shoots were fermented for a period of 30 days with the addition of inoculum (2 year previously fermented shoot) and see the effect of fermentation on the cyanogens content and acidity Initial investigation showed that the acidity increased and cyanogenic toxicity decreased (14.7 ppm dw basis) at the end of fermentation period (30 days) with a level reaching close to the permissible limit (< 10 ppm dw basis) as prescribed by WHO standards. The final fermented bamboo shoot product was further analyzed for the proximate composition, minerals and antioxidant capacity. An increase in the protein content (+17.28%) was found in the fermented sample while other nutrients like fat and vitamin C were found to decrease i.e. 90.2% and 35.77% respectively as these were used up by the growing micro-organisms. Fermentation leads to reduction in the mineral content but Fe content did not change significantly. A significant increase in the phenol (29.0 to 42.06 mg GAE/100g) and flavonoid content (49.7 to 59.44 mg CE/100g) was observed. Antioxidant capacity was also found to increase in fermented shoots indicating their potential for scavenging free radicals to protect human health.

Further, for in-depth understanding of microbial aspect of traditional knowledge, using certain additives like salt, sugar, mustard seeds, acetic acid and above inoculum, a 10 days experiment was set up. Microbial activity (TVC and LAB) was found to be at the initial stage and increased upto 6th day of fermentation, after which it decreased and became stable as the nutrients for the metabolic activity of the micro-organism were depleted. Genus *Lactobacillus* was found to be involved in the fermentation process. It was also found that additives like salt, mustard seeds and inoculum can help in fastening the fermentation process and can also enhance the taste of the product.

Overall, the research findings would help in developing an integrated system for processing and preservation of bamboo shoots. Microwave cooking can be explored as a new technique for cooking shoots at the domestic level. Freeze drying giving a good quality product can be used by the small-medium food processing enterprises to dry highly perishable bamboo shoots. Improved solar drying system can be employed as another alternative for this purpose. Fermentation of bamboo shoots with additives like salt, sugar, mustard seeds, inoculum not only help in reducing the fermentation time but also add flavor to the final product. It can easily be incorporated in traditional bamboo shoot fermentation technique for its further improvisation.

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LIST OF ABBREVIATIONS

| S. No. | Abbreviation | Full form |
|---------------|---------------------|---|
| 1. | NTFP | Non-timber forest products |
| 2. | MFP | Minor forest produce |
| 3. | FAO | Food and Agricultural Organization |
| 4. | USD | United State Dollar |
| 5. | ERG | Engineering Resources Group |
| 6. | US | United States |
| 7. | USA | United States America |
| 8. | TERI | Tata Energy Research Institute |
| 9. | DPPH | 2, 2-diphenyl-1-picrylhydrazyl |
| 10. | ORAC | Oxygen radical absorbance capacity |
| 11. | AOA | Anti-oxidant activity |
| 12. | HCN | Hydrogen cyanide |
| 13. | TPO | Thyroid peroxidise |
| 14. | DPSD | Double-pass solar drier |
| 15. | CD | Convection solar drier |
| 16. | OSD | Open-sun dryer |
| 17. | RSM | Response surface methodology |
| 18. | OC | Open cooking |
| 19. | PC | Pressure Cooking |
| 20. | MWC | Microwave cooking |
| 21. | fw basis | Fresh weight basis |
| 22. | dw basis | Dry weight basis |
| 23. | CHN Analyzer | Carbon Hydrogen Nitrogen Analyzer |
| 24. | ICP-AES | Inductively Coupled Plasma Atomic Emission Spectrometer |
| 25. | TPC | Total phenolic content |
| 26. | GAE | Gallic acid equivalent |
| 27. | FRAP | Ferric Reducing Antioxidant Power |
| 28. | CE | Catechin equivalent |
| 29. | TETZ | Tripyridyltriazine |
| 30. | TE | Trolox Equivalent |
| 31. | IP | Inhibition percentage |

| | | |
|-----|--------------------------------------|--|
| 32. | TEAC | Trolox equivalent antioxidant capacity |
| 33. | OD | Open drying |
| 34. | SD | Sun drying |
| 35. | MWD | Microwave drying |
| 36. | TD | Tray drying |
| 37. | FD | Freeze drying |
| 38. | TVC | Total Viable Count |
| 39. | LAB | Lactic acid bacteria |
| 40. | NA | Nutrient Agar |
| 41. | PDA | Potato Dextrose Agar |
| 42. | MRS | Man, Rogosa and Sharpe |
| 43. | cfu | Colony-forming units |
| 44. | MR | Methyl Red |
| 45. | VP | Voges-Proskauer |
| 46. | RW | Refractance Window |
| 47. | UV | Ultra violet |
| 48. | IMViC | Indole Methyl Red (MR), Voges-Proskauer (VP) and Citrate |
| 49. | RF | Radio-frequency |
| 50. | NaCl | Sodium chloride |
| 51. | NaOH | Sodium hydroxide |
| 52. | HCl | Hydrochloric acid |
| 53. | H ₂ SO ₄ | Sulphuric acid |
| 54. | NaNO ₂ | Sodium nitrite |
| 55. | AlCl ₃ .6H ₂ O | Aluminum Chloride Hexahydrate |
| 56. | FeCl ₃ | Iron chloride |
| 57. | CO ₂ | Carbon dioxide |
| 58. | \$ | Dollar |
| 59. | ° | Degree |
| 60. | % | Percentage |
| 61. | C | Celsius |
| 62. | min | Minutes |
| 63. | max | Maximum |
| 64. | sec | Seconds |

| | | |
|-----|--------|------------------------|
| 65. | cms | Centimeters |
| 66. | mm | Millimeter |
| 67. | approx | Approximately |
| 68. | hrs | Hours |
| 69. | mg | Milligram |
| 70. | g | Gram |
| 71. | µg | Microgram |
| 72. | ml | Microlitre |
| 73. | l | Litre |
| 74. | µl | Microlitre |
| 75. | ppm | Parts per million |
| 76. | kg | Kilogram |
| 77. | nm | Nanometer |
| 78. | mM | Millimolar |
| 79. | w/v | Weight by volume |
| 80. | v:v:v | volume:volume:volume |
| 81. | rpm | Rotations per minute |
| 82. | psi | Pounds per square inch |
| 83. | mbar | millibar |
| 84. | mHz | Megahertz |
| 85. | W | Watt |
| 86. | kw | kilowatt |
| 87. | Ca | Calcium |
| 88. | Mg | Magnesium |
| 89. | P | Phosphorous |
| 90. | Na | Sodium |
| 91. | K | Potassium |
| 92. | Zn | Zinc |
| 93. | Fe | Iron |
| 94. | Cu | Copper |
| 95. | Se | Selenium |
| 96. | Ar | Argon |