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A New Horizon of Utilization of Bamboo for Production of food packaging Pulp, Paper and Board

Gunjan Dhiman
Junior Research Fellow
CPPRI

Dr. Priti Shivhare
Scientist E2
CPPRI

Dr. Arvind Sharma
Scientist B
CPPRI

Deepak Sharma
Junior Research Fellow
CPPRI

Aarti Saini
Junior Research Fellow
CPPRI

Dr. M.K. Gupta
Director
CPPRI

Abstract: ***The use of bamboo pulp for high quality writing and printing grade paper is well known fact. Bamboo pulp use in packaging related end products is a new application area and Central Pulp and Paper Research Institute is extensively working on it. In the present communication process know how of bamboo for development of food packing end products like food carry bags, wrapping paper, grease proof paper, boards like mono cartons, liner board, solid boards and the pulp application in production of table ware are high in demand. Pulp made packaging and molded products are biodegradable and environment friendly. The pulp quality varies with the application and hence there are different process to get the require pulp properties. The growing demand of virgin pulp for food packaging either kraft pulp or table ware grade pulp can be produced from bamboo through chemical, semichemical and CTMP process. The details of process conditions for different pulping of bamboo and prospective utilizations are covered in the present communication.***

Introduction :

The e commerce activities has grown significantly during the past few years. One of the commodity is food, vegetables and other edible products 2021, (Project320.com). The global biodegradable packaging market is expected to grow at CARG 20.8% during the period 2021 to 2027. According to Association of bioplastic (European bioplastic) global bioplastic production capacity increases around 2.11 million tons in 2019 to approximately 2.43 million tons in 2024 which was 969.9 kilo tons in 2016. Molded Pulp Packaging Market exhibit a CAGR of over 5.1% is estimated to 2021 to 2027 owing to the growing demand from USD 3.2 billion in 2020 as environment-friendly packaging solutions. (1-3)This segment needs only virgin pulp due to direct contact of food stuff.

There is growing concern on replacement of plastic based food packaging with biodegradable pulp based packaging. Food safety and standard Authority of India (FSSAI) has sanction the rule that only virgin grade packaging material should be used for direct food contact.(page 3)

Paper being biodegradable is the first and foremost choice of food packaging.(4-5)

Still some of food packaging area using recycled wood and non-wood materials such cup stocks, egg trays carrier in poultry and food & food service industries. Molded pulp splitters and clamshells are highly used in the agriculture and food industry. Pulp made products demand is growing with the increasing consumption of packaged goods subsequently enhancing the demand for molded pulps.(6) Pulp products can bring benefits of lower costs and a green image by replacing traditional packaging materials with eco-friendly materials such as molded pulp.

First, most of the current molded pulps are made from secondary fiber such as newspapers and used books. Such secondary fiber generally contains residual inks and other chemicals due to incomplete deinking during the pulping process, which is undoubtedly a concern for safety of food packaging. Virgin pulp has been used for food packaging fulfilling safety concerns.(6)

India is fibre deficit country and fast growing demand of virgin pulp in food packaging application has compelled to search for alternate source of industrial crop which can be utilized for the end uses related to food packaging.

So, the focus is now to find alternative species of trees which can be utilized efficiently in to meet increasing further demand of pulp, paper and board. Bamboo is green alternative raw material, which is potentially viable alternative of wood and agrobased raw materials..

Bamboo known as green gold is a woody perennial grass belongs to true grass family Poaceae. According to American Bamboo Society (ABS) there are more than 70 genera divided into about 1,450 species while 125 species of bamboos in India spread across 18 genera.15.4 million hectares land covered by Bamboos in India.Due to GOI initiative it is not considered as a forest based commodity through “Restructured National Bamboo Mission approved by the Cabinet Committee on Economic Affairs (CCEA) on 25-04-2018”. GOI is also giving subsidy to bamboo growers, which will result into sustainable source of fibre in future. With the innovation of pulping and papermaking technology, the use of bamboo to make bleached bamboo pulp is a very viable potential alternate of quality raw material.(7)

Bamboo properties has an advantage of having longer fibres, making it suitable for the production of pulp for paper and hardboard as well as mechanical pulp with high yield.

Main postulates of using mechanical pulping that very high percentage of wood component are retained in final product i.e. approx 85 to 96% which increased the yield of pulp. Mechanical pulping methods are RMP (Refiner Mechanical pulp), TMP (Thermo mechanical pulping), CTMP (Chemi Thermo mechanical pulping). These pulping processes based on principle of separation & fibrillation of fiber through mechanical power and emitted thermal energy .Mechanical pulping methods require high amount of electric energy which can be reduce by modified equipment design, chemical applications and thermal energy. (8)

Much effort has been spent to reduce the electrical energy consumption in mechanical pulping. Pretreatment of induced chemical reaction with alkali have great importance in most chemithermo mechanical processes. Higher Alkaline dose applying at high temperature gives more increase in fiber hydrophilicity by generating new carboxylic group promote swelling and thus weaker the fiber wall will results in cleavage of pactin polymer chain by β elimination, which will leads to dissolution of pectins, (9-11)

The paper pulp disposable tableware market is expected to be growing at a growth rate of 6.5% in the forecast period of 2021 to 2028.

Surge in the use of paper pulp for disposable tableware for commercial purpose and growing environment awareness among people are the major factors influencing the growth of the market. Also, increasing demand for conferences, office parties and meetings and rise in the policies associated with environment are the factors enhancing the growth of the market. Emerging new markets and growing demand for sustainable products will create lucrative market growth opportunities.(12)

- On the basis of product, the paper pulp disposable tableware market is segmented into plates, cups, bowls, trays and others.
- On the basis of customer, the paper pulp disposable tableware market is segmented into household, commercial, corporate offices and breakrooms. Commercial has been further sub-segmented into hotels, restaurants and parties and catering.

To provide qualities in modern food packaging material that makes food safe, reliable, and shelf stable and clean, most food packaging is designed to be single use and is not recycled. Which create white pollution and remain in ocean for thousand of year. To make food packaging environmental friendly paper and pulp based material need to be use. Some paper industry in India also initiated plants for pulp, paper and board for food packaging use.

EXPERIMENTAL

Chemical Analysis of Bamboo

Bamboo plants were collected from different sources and chipped into laboratory chipper. Chips sample was collected and store in polythene bags. Moisture analysis prior to pulping experiment calculated as per TAPPI T264. Classification of chips in chip classifier to remove over size chips (i.e. Rejects), Pin chips and dust particles was carried out. After the processing accepted chips are taken for determining the dryness for further experiment.(table 1)

Pulping of bamboo chips:

The bamboo pulping process for high strength unbleached kraft paper can be prepared following chemical pulping process (Kraft process), while the food grade board and moulded pulp can be produced following semichemical an CTMP process.

Chemical Pulp Production:

Pulping Experiment:

Experiments were carried out in a series digester consisting of six bombs, each with capacity of 2.5-liter, rotating in an electrically heated polyethylene glycol bath. At the end of the cooking time, the bombs were removed and quenched in the water tank to cool down and the cooked mass from each bomb was taken for washing. Washing was carried out with hot water till the cooked mass was free from spent liquor. After thorough washing, the unscreened pulp yield was determined and the pulp was screened in laboratory 'Serla' screen by using 0.25 mm. slot width mesh. Kappa number of the screened pulp was determined as per the Tappi standard procedure T-236-OS-76. The cooking conditions are given below:

Determination of pulp kappa number, brightness and viscosity:

Pulp in as such state was analyzed for yield, kappa number (Tappi T: 236 OM 99), brightness (ISO 2470) and intrinsic viscosity (Scan C: 15:62).

Pulping experiments were carried out using cooking chemical using 18%as Na2o Kraft process in to obtain bleachable grade pulps of kappa no. around 17. **(table 2)**

COOKING CONDITIONS:

Raw material taken in each bomb	:	200 gm. (B.D)
Bath ratio (raw material to liquor)	:	1:3
Sulfidity of cooking liquor	:	20 %
Cooking temperature	:	168 ºC
Cooking time	:	120 min.
Cooking schedule:		
Ambient to 100 ºC	:	30 min.
100 ºC to 165 ºC	:	90 min.
At 165 ºC	:	120 min.

Production of Semichemical and CTMP Pulp:

Pre Steaming & Chips Impregnation

A known mass of OD Chips is weighed and placed in the laboratory rotary digester. Chemical charge for optimization at different dose of NaOH and or Na2SO3 as per experiments designed. The calculated volumes of warm water are added to the chips to give chips to liquor ratio of 1:4. The digester is maintained at 130°C /150°C for 2 hour. Conditions of pre steaming and impregnation are given in table 4.The raw material or chips were impregnated with Chemical in digester having 6 bombs (STALSVETS, Alfa Aval Group, Sweden) with capacity 2.5 liters. Bombs are rotating in an electricity heated poly ethylene glycol bath.. At the end of the pretreatment the chips are removed from the digester and quenched to leach out the spent liquor.

Two or three round refining is carried out with hot water by maintaining consistency 3 in disc refiner of pretreated chips to fibrillate the bamboo chips into fibers. The pulp was screened in Somerville Vibrator screening using 0.25mm mesh to remove the rejects. The screened rejects were collected and dried in oven for determination of percent reject and screen pulp yield. Chips are fed between 2 disks. This refiner is based on the principle that one disk is always turning while the other can be fixed or turning. Pulp is collected and determines some parameter i.e. Freeness of Pulp (Canadian Standard Method), and Brightness. Spent liquor has been collected for pH and total solid analysis for mass balancing.(table 4 and 5)

Duplicate moist samples (25 g) are oven dried at 105±2°C and the 0.0. weight of the pulp calculated.

% Total yield = B x 100/ A

Where B = O. D. weight of pulp

A = O.D. weight of chips

Physical Properties at ~ 300 ml CSF

The hand sheet of 40/120/200 GSM were prepared with British sheet former machine according to the ISO 5269.1:2005 standard to measure apparent density (ISO 534:1988E), burst index (ISO 2758), Tensile index (ISO 1924), Tear Index (ISO 1974). Pulp sheet was pressed in lab press and put for 24 hour to air dry at atmospheric condition for 24 hours. Further, dry pulp sheet conditioned at temperature 27± 10C and relative humidity 65± 10C before measure the physical strength properties

RESULTS AND DISCUSSION :

Table 1: Results of Proximate Chemical Analysis of Bamboo

Sr. No	Parameters	Unit	Results
1.	Ash Content	%	2.15
2.	Cold Water Solubility	%	5.14
3.	Hot Water Solubility	%	7.44
4.	1/10 N NaOH Solubility	%	21.2
5.	Alcohal Benzene Solubility	%	2.23
6.	Pentosan	%	16.24
7.	Holocellulose	%	75.67
8.	Acid insoluble Lignin	%	25.0
9.	Acid soluble Lignin	%	1.23
10	Fibre length	mm	1.8

Proximate Chemical Analysis:

The results of chemical analysis of bamboo are depicted in table 1, justify the potential of bamboo for production of various grades of paper and board, which can be utilized for food packaging by converting pulp into different end products. Holocellulose is substantially high 75.67%, which makes its utilization an economical viable process.

Table 2: Results of Chemical (kraft) Pulping of Bamb

S.No	Parameter	Bamboo
1.	Cooking chemical applied, % as Na_2O	15
2.	Unscreened Pulp yield, %	46.4
3.	Kappa.no	17.5
4.	Reject, %	0.5
5.	Screened Pulp Yield, %	45.9
6.	Pulp viscosity cc/g	850
7.	Initial freeness, ml csf	690

Table 3:Physical Strength Properties of Bleached Pulps Of Bamboo :

Sl. No.	Properties	Bamboo (Jati) Pulp		
1.	PFI, (rev.)	0	3000	4000
2.	Freeness, CSF	690	330	240
3.	Apparent density, (g/cm3)	0.51	0.69	0.72
4.	Burst Index, (kPa m2/g)	1.00	4.60	5.00
5.	Tensile Index, (Nm/g)	12.0	68.0	72.0
6.	Tear Index, (mNm2/g)	5.4	9.45	9.35
7.	Fold Kohler (log)	*	2.46	2.58
8.	Bendtsan porosity (ml/min)	>3000	298	127

Chemical Pulp utilization in food packaging:

The long fibre bamboo pulp reflects substantially good physical strength properties as burst, tear and tensile index of bamboo unbleached kraft pulp is 5.0 kpam2/g, 9.35 mNm2/g and 72.0 Nm/g respectively and may be utilized for packaging of bulk materials like cereals,lentils, flour,sugar, fruits, frozen and non frozen confectioneries, vegetables etc.wax coated virgin kraft pulp can be used in packaging of bakery items.

Table 4: Semi chemical and CTMP Pulping of Bamboo

Parameters	CTMP	CTMP	Semi Chemical (soda)	Semi Chemical (soda)	Semi Chemical (NSSC)
Chemical applied	NaOH, low	NaOH high	NaOH low	NaOH high	NaOH+ Na_2SO_3
Time required to raise temp. from Ambient to 135° C/150°C, min	60	60	60	60	60
Time at Top temperature,min	120	120	150	150	150
Bath ratio	1:4	1:4	1:4	1:4	1:4
Refining clearance thou	25,10,8	25,10,8	25,10,8	25,10,8	25,10,8
Unscreened pulp yield, %	85.6	82.4	76.8	71.1	77
Rejects,%	7.8	6.4	3.8	2.7	2.1
Screened pulp yield, %	77.8	76	73	68.4	75.9
Unbleached pulp Brightness, %ISO	20.0	21.0	21.8	22.7	34

Table 5: Physical strength properties of Semichemical and CTMP pulp of Bamboo

S.No	Particulars	CTMP	CTMP	Semi Chemical (soda)	Semi Chemical (soda)	Semi Chemical (NSSC)	Semi Chemical (soda)	Semi Chemical (NSSC)
1	CSF (ml)	350	380	390	370	368	370	368
2	Hand sheet GSM	200	200	120	120	120	40	40
3	Burst index ($k.Pa.m^2/g$)	1.4	2.0	2.3	2.86	3.25	2.16	2.9
4	Tensile index (Nm/g)	11.9	16.6	30.0	35.1	38.0	30.0	31.1
5	Tear strength (mN.m2/g)	4.1	5.32	5.7	6.01	6.33	3.5	4.1

Use of semi-chemical (soda or NSSC)bamboo Pulp in food packaging pulp, paper and board:

There are various end use which converts pulp to board related to food packaging board, which includes liquid packging or solid board, mono cartons for dry food packaging where recycled fibre is not applicable, cup stocks for noodles with inner polymer coating.

Another application of bamboo soda or NSSC pulp can be greaseproof paper. Greaseproof paper is impermeable for fats and oils and has application for packing of butter and other fat containing food products. According to BIS (IS 6622-1972), the greaseproof paper should have a burst factor of minimum 20 and tear factor in any direction should be 30 with minimum grammage 30.g/m2.Due to very good fibre length and so the strength, bamboo is ideally good choice for production of low gsm food packaging paper.

Application of Bamboo CTMP pulp in food packaging

The very fast growing market of disposable table ware crockery a FMCG product required large quantity of pulp at competitive rates. In current scenario bagasse chemical pulp available in the market for the production of table wares. It is chemical grade pulp with yield ~50%. The requirement of pulp specifications for tableware end products is bare minimum. The pulp mould has density 200 g/m2 with burst factor 1-1.5 and moderate brightness. The high value chemical pulp may be replaced with high yield CTMP pulp of bamboo and other agroresidual raw material. The use of CTMP process

may convert the production of table ware pulp more economical and environment friendly. CPPRI has already developed CTMP of rice straw which after reinforcement of chemical pulp (10%) has converted into mounded pulp crockery very successfully.

Plates, bowl, cups, trays and other paper pulp for disposable tableware are some of the most ubiquitous and CTMP pulp of bamboo (100%) with yield more than 75% can be utilized for production of table ware grade pulp without any reinforcement as bamboo itself is long fibre and sufficiently stronger than any other raw material pulp.

In the present experiments the bamboo CTMP pulp sheet of 200g/m2 indicated sufficient strength (burst index 1.4 to 2.0(k.Pa.m2/g) with good drainage properties and ideally suitable for pulp mould crockery.

The CTMP of bamboo is also suitable for low strength board and filler pulp used in multilayer board for liquid packaging.

Conclusions:

With the experiments and results obtained it is well proven that bamboo is a potentially viable raw material for production of virgin pulp of different grades and have application of food packaging of different varieties. The Government of India support in cultivation of bamboo, market growth (because of growing demand), demand due to e commerce activities related to different range of food packaging explore the future prospects of utilization of bamboo for production of food packaging grade pulp and paper which is an environment and economical solution.

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