

ABSTRACT

Paper has been a very important part of a human life. It is the most versatile material with diverse uses like writing, printing, packaging, and cleaning. Traditionally, paper was produced by beating cellulose fibres which were extracted either from wood or non-wood plants. These fibres undergo varied chemical treatments that is not very environmental friendly. However, it is very necessary to make sure paper production process and raw materials used does not intent any harm to environment. In addition, discharge of foul smelling waste of vegetables and fruits from households pose various major problems like foul smell, pollution and filthy environment. To minimize such issues, a paper is produced from fruit and vegetable residuals like cabbage, lime and orange pulp, spinach, guava, potatoes and radish leaves with the inclusion of oriental lily leaves, natural binders, anti-microbial agent and non-chlorinated bleaching agent. Quality of the paper is estimated by measuring bursting factor and moisture content using Bursting Strength Tester and Hydromette respectively. This research mainly deals with making non-chemical based, eco-friendly and cost effective paper from vegetable and fruit residuals and replace the normally used paper in future.

KEYWORDS: Paper- making process, Citrus peels, Vegetable residuals, Binders, Additives

INTRODUCTION

Paper is one of the most competent materials which is technically produced by pressing moist fibers together. These fibers are mainly the cellulose which is derived from wood, rags, or grasses and then dried into sheets. Cotton linters, silk, bamboo, etc. are used for paper production as well. Paper pulps are obtained initially from wood by separating lignin and cellulose in which lignin is dissolved by cooking (boiling). The pulp then, undergoes bleaching to produce colorless paper, but it results into unwanted reduction in the composition of fibers. Bleaching agents such as sodium hypochlorite, calcium hypochlorite, and hydrogen peroxide are most commonly used.

Paper during the process go through numerous chemical processes where chemicals like sodium hydroxide for washing fibers, chalk and rosin for sizing, silicate of magnesia for high finish, and titanium dioxide for acquiring bright colour are used. Furthermore, shelf life of the paper is one of the main factors and needs to be improved by adding appropriate binders and additives. Paper making also involves the use of enzymes like amylases for hydrolysis of starch and treating pulp. Raw materials used for making paper may not have any detrimental effect on environment but fibers, are heavily treated with chemicals. Chemical based papers are economically viable and easily available, but not very environmentally friendly. However, there is availability of other resources that can be used to make eco-friendly paper. These sources include fruit and vegetable pulps, and fibres, which are discharged from various food processing industries, houses, and restaurants.

An attempt is made to produce a paper from these residuals. These residuals involve the leftovers of cabbage, spinach, guava pulp, potato pulp, radish leaves, and orange and lime pulp. Additionally, an equal portion of oriental lily leaves are incorporated along with these residuals as it has excellent fiber content and increases the life of paper (from results obtained). Binders and anti-microbial substances are required to improve the strength of the paper and prevent the bacterial and fungal growth. Non-chlorinated bleaching agent, hydrogen peroxide is

put in use as they do not reduce the structure and composition of fibres. After the formation of paper, bursting factor and moisture content of the paper are measured using Bursting Strength Tester and Hydromette respectively to evaluate the quality of paper.

Bursting Strength Tester:

- This device is used to measure bursting strength of paper.
- Bursting strength: The maximum uniformly distributed pressure, applied at right angle to its surface that a test piece will stand under standardized conditions.
- Measuring unit: Kg/cm², lbs/in² and KPa.



Fig. Bursting Strength Tester

Parts and identification:

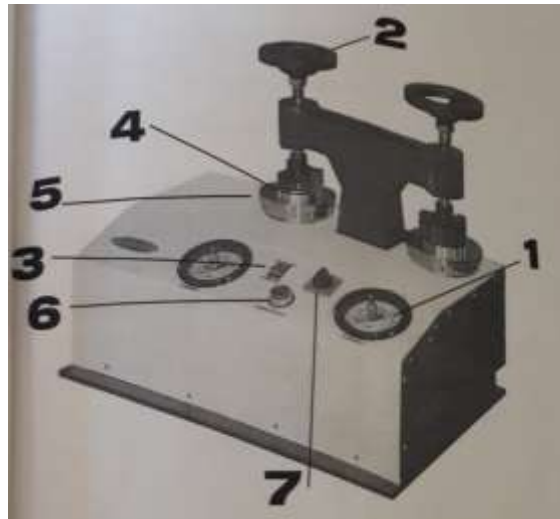


Fig. Parts of Bursting Strength Tester

1. Pressure Gauge: bourdon type, body mounted on pressure gauges in two ranges. The paper head has its connections with the lower range gauge and the board head has its connection with the higher range gauge.

2. Clamp wheel and tripod: the clamping wheel has tripod and screw plunger to necessitate sample clamping. The tripod is attached to the clamping shaft; this clamping head with marked graduations is what finally clamps the sample.
3. Main switch: to give power to the machine.
4. Diaphragm plate: sample test area, its plate where the sample is to be placed. It has a opening through which the diaphragm applies the pressure for bursting of the sample.
5. Diaphragm nut: this nut is used to lock the diaphragm plate which in turn is placed above the diaphragm to clamp the rubber diaphragm.
6. Push button: press this button and keep it pressured till the sample ruptures.
7. Selector switch: turn this switch to select the head, and the pressure gauge for testing.

Grammage Machine:

This device is used to measure mass of paper per unit area.



Fig. Grammage machine

Grann Hydromette Compact:

- This instrument is a universal instrument, which can measure moisture content in many different materials.
- Some of the known uses of the Gann Hydromette are in paper, paper boards, corrugated boxes, fruits and vegetables, plaster, cloth yarn rolls, etc.
- The principle of measurement used by the instrument is “Resistivity”.
- This device in practical terms measures this change in resistivity.

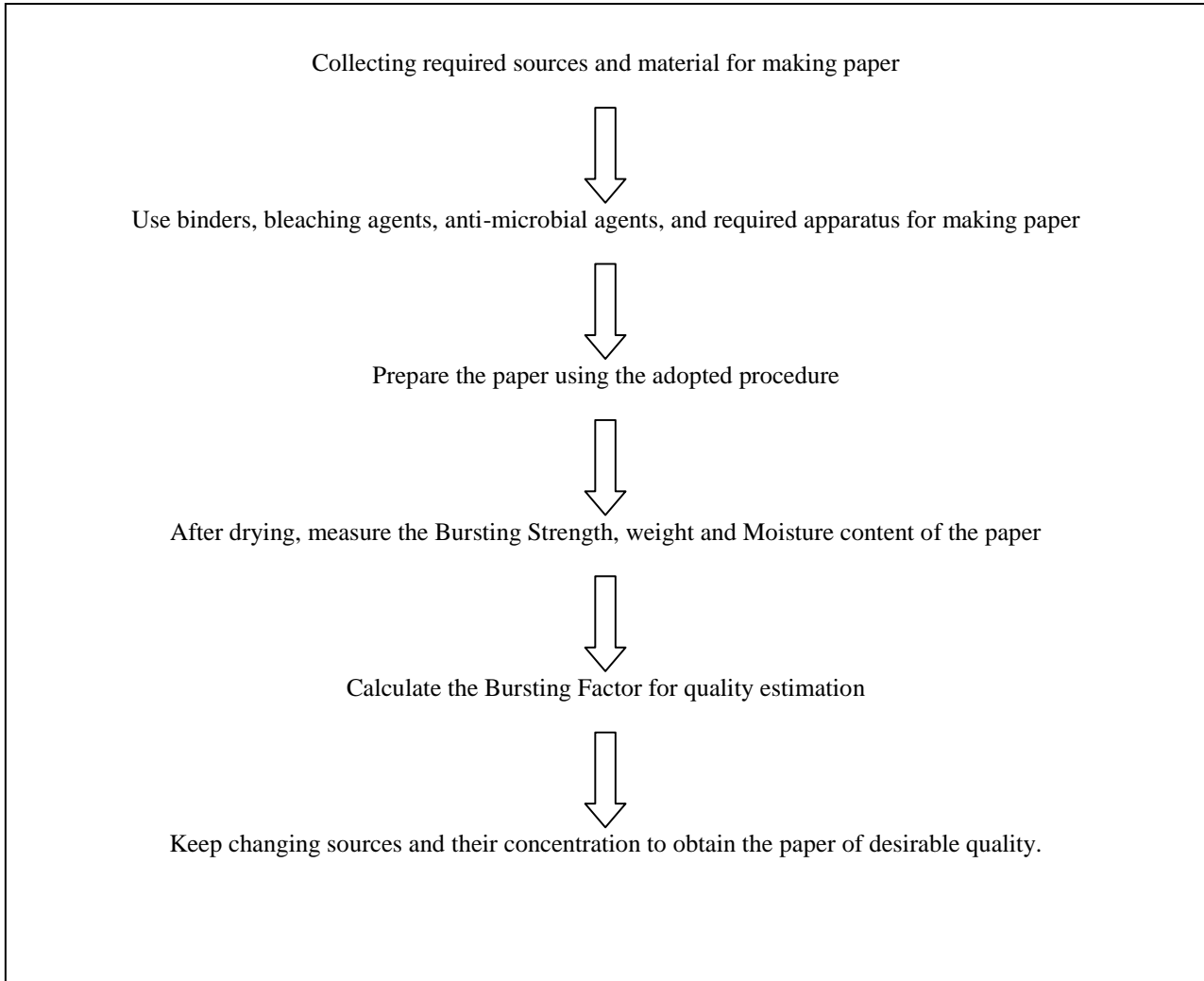


Fig. Hydromette

According to results, making such papers contribute in obtaining a paper with the least use of a chemical, making use of discharged fruits and vegetables into a usable paper and minimizing overall cost of paper as well as the production.

MATERIALS AND METHODS

Plan of work:









Method:






1. **Collecting:** Discharged domestic residual like cabbage, lime and orange pulp, spinach, guava, potatoes and radish leaves are collected. One source is used at a time for the experiment along with incorporation of garden lily leaves. However, in few experiments more than one residual source is used for the making paper. In later experiments, cotton is also used for obtaining better strength of the paper. Lily leaves plays a very important role in paper making in terms of strength and providing longer shelf life to paper. Also, gather the other raw materials required for soaking, binding and bleaching.
2. **Cutting:** Cut all the residuals and the raw materials with the help of scissors and sharp knife. It is very necessary to cut them uniformly for acquiring consistent and smooth paper pulp.






3. Soaking: All residuals, lily leaves and cotton (if used) which are cut uniformly are afterwards soaked in the mixture of cold water and baking soda for at least an hour. Cold water is put in used so that content boils readily after soaking them. Baking soda loosens up the fibers present in residuals and lily leaves. Moreover, baking soda helps maintaining alkalinity in water.
4. Boiling: Later after soaking, all the soaked matter is either boiled on stove (100 degrees Celsius) for 15-20 minutes or autoclaved at 15 lbs pressure for 15 minutes. Residuals are boiled to break down the cell wall making it easy to blend the materials into smooth and fine pulp.
5. Bleaching: Bleaching is very crucial part of paper making. Boiled residuals are bleached using hydrogen peroxide to obtain light colored paper. Hydrogen peroxide though is not a very effect bleaching source but however, it a non-chlorinated bleaching chemical which is harmless to fiber structure and composition.
6. Preparing Binder: Binder is prepared simultaneously. Binder is as important as residual sources because it keeps fibers together and gives paper the most strength it requires. For preparing the binder aloe vera pulp and corn flour is used. Skin of the aloe vera leaf is removed and transparent part is blended with the corn flour. Aloe vera presents good anti-microbial activity providing longer life to paper and preventing fungal and bacterial growth in paper. Corn flour is a starch and provides the stickiness to paper and is good natural binder.
7. Blending: All the bleached substances along with the prepared binder and warm water are blended together using mixer to obtain smooth and thick pulp.
8. Beating: After blending, the pulp which is obtained undergoes beating to obtain uniformity and consistency in the pulp.
9. Spreading: Pulp is transferred to muslin cloth for removing excess of water. Then, the same is spread in even manner on laminated material for drying. Flat plastic material could be substitute laminated material. These materials make it easier to detach the paper after drying.
10. Drying: Pulp is allowed to semi-dry naturally under the sun.
11. Pressing: Before paper dries completely it is pressed using small roller and then again allowed to dry completely. Pressing is required to obtain flat and straight paper.
12. Estimating the paper quality: After the paper dries completely bursting strength, moisture content and bursting factor are measured and calculated with the following formulae:

$$B. F = (B.S * 1000) / G.S.$$

RESULT

Sr. No.	Objectives	Raw Material	Result	Bursting strength (kg/cm ²)	Gram per square meter	Bursting factor	Moisture content (%)	Remark
1.	Making paper using Radish leaves.	Radish leaves, corn flour, baking soda, water.	 Dry.	0.5	350	1.4286	3.2	Dry and brittle paper. New source is used in experiment 2.
2.	Making paper from lily leaves and cabbage.	Lily leaves, baking soda, corn flour, water.	 Brittle but smooth.	0.6	228	2.6316	3.45	For better results, new sources are tried in experiment 3.
3.	Making paper from lime and orange pulp and fibres.	Lime and orange pulp and fibres, corn flour, water, baking soda.	 Fungal growth.	-	-	-	-	Paper making is modified by using new source in experiment 4.
4.	Making paper from cabbage.	Cabbage, corn flour, Baking soda, water.	 Smooth but poor strength.	0.2	200	1	2.5	To check natural binding no corn flour is used in experiment 5.
5.	Making paper from cabbage.	Cabbage, baking soda, water.	 Smooth but brittle.	0.35	200	1.75	4.1	Resulted paper was brittle therefore sources were kept same and other binders are tried in making paper.
6.	Making paper from cabbage.	Lily leaves, Aloe Vera pulp, hydrogen peroxide, baking soda, water.	 Rough and dry.	0.4	350	1.1429	2.2	To achieve better quality of paper process is modified and 2 binders are used in experiment 7.

7.	Making paper from lily leaves and cabbage leaves.	Lily leaves hydrogen peroxide, baking soda, water, aloe vera pulp, corn flour.	 Smooth, less tear strength.	0.73	500	1.46	4	To increase the tear strength, 2 sources and 2 binders are used in experiment 8.
8.	Making paper using lily as main source and small quantity of cabbage.	Aloe Vera pulp, Cabbage, Lily leaves, hydrogen peroxide, water, baking soda, corn flour.	 Smooth, better tear strength.	0.75	450	1.6667	2.9	Obtained good quality of paper. Combination of different source are tried to improve paper quality.
9.	Making paper using lily leaves as main source and cabbage and radish leaves in lesser quantity.	Aloe Vera pulp, Corn flour, Lily leaves, cabbage leaves, hydrogen peroxide, baking soda, water.	 Hard, shapeless, brittle, rough and poor quality.	0.65	390	1.6667	3.1	Very bad quality of paper obtained. Different quantities of combination of sources are changed in experiment 10.
10.	Making paper from lily leaves and using cabbage and radish leaves in less quantity and checking life of pulp.	Aloe Vera pulp, corn flour, lily leaves, cabbage leaves, hydrogen peroxide, baking soda, water.	 Fungus growth within 3 days.	-	-	-	-	Observed fungus growth on paper pulp in 3 days. New sources used in experiment 11.
11.	Making paper using lily leaves as main source and cabbage and potato pulp in less quantity.	Aloe Vera, potato starch, lily leaves, cabbage leaves, baking soda, water.	 Foul smelling.	0.5	192	2.6042	2.6	Foul smelling and dark paper obtained. New source is used in experiment 12.

12.	Making paper using lily leaves, cabbage waste, and rice starch and guava pulp.	Aloe Vera, baking soda, cabbage waste, guava pulp, water, rice starch, lily leaves.	 Rough, hard, brittle	0.2	780	0.2564	3.45	Rough, dry and brittle paper obtained. New combination of sources are tried in experiment 13
13.	Making paper using lily leaves, cotton and cabbage leaves.	Aloe Vera, baking soda, corn flour, lily leaves, cabbage leaves, water and hydrogen peroxide.	 Partially writable, Smooth, brittle.	(thin): 1.1 (thick): 2.8	200 320	5.5 8.75	3.8 4.00	Partially writable and smooth. Same sources with different amounts will be tried in next experiment.
14.	Making paper using lily leaves, cabbage and cotton.	Aloe Vera, baking soda, corn flour, lily leaves, cabbage leaves, water, cotton and hydrogen peroxide.	 Writable, smooth	6.2	800	7.75	5.00	Writable, smooth but thick. Same sources are used in experiment with changes in its concentration
15.	Making paper from lily leaves, cotton and cabbage	Aloe Vera, baking soda, corn flour, lily leaves, cabbage leaves, water, cotton and hydrogen peroxide.	 Writable, smooth, brittle.	0.9	312	2.885	2.5	Writable, smooth, but brittle. Same sources with different concentrations will be used in next experiment.
16.	Making paper from lily leaves, cotton and cabbage	Aloe Vera, baking soda, corn flour, lily leaves, cabbage leaves, water, cotton and hydrogen peroxide.	 Thin, smooth, writable and brittle.	2.2	210	3.492	2.26	Thin, smooth, writable and brittle.

CONCLUSION

Paper making process is easier to carry out at lab scale. It involves simple steps like collecting sources and materials, cutting, boiling, blending, beating, drying and measuring bursting strength and moisture content. There are various resources like lime, orange pulp, radish leaves, cabbage leaves, and guava pulp which are used to make the paper and fortunately, these resources are available abundantly without any difficulty. Also, other raw material apart from residuals are very economical. The paper obtained is environmental friendly, chemical free and rapidly degradable. However, there are various drawbacks which are observed in the results obtained. They are:

- Paper which is obtained becomes brittle and dry over the period of 3-4 months.
- Paper is not conveniently writable and do not have water resistance.
- It releases foul odor in the working area while making a paper.
- Paper obtained also smells bad immediately after drying.
- Paper making requires sources with better cellulose content to be of a desired quality.

To estimate the quality of paper bursting strength and gram per square meter (GSM) are measured which gave the value of bursting factor through the formula:

$$B. F = (B.S * 1000) / G.S.M$$

In most of the experiments lily leaves are incorporated as it gives better shelf life to paper with better bursting strength. Various combination of sources was used- orange and lime pulp, cabbage and lily leaves, cabbage, radish leaves and lily leaves. In experiment where orange and lime pulp were used, both fungal and bacterial growth were observed within a month of its production. Fungal growth comprised of *Penicillium* spp. and *Aspergillus Niger* while bacterial growth comprised of the *Bacillus* spp. However, after the microbial growth was observed aloe vera was instilled as a natural anti-microbial agent. This increased life of paper and no paper produced after that developed the microbial growth. In later experiments, cotton was inculcated along with cabbage and lily leaves which produced desirable results with highest bursting strength and preferred smoothness. In addition, natural binders like corn flour, rice starch and potato starch were used from which corn starch produced the best results. Thus, corn flour is used in most of the experiments. In the experiments where cotton was incorporated along with cabbage and lily leaves and where corn flour is used had the highest bursting factor. Therefore, it can be concluded that experiments that used cabbage and lily leaves along with cotton, corn flour, aloe vera and hydrogen peroxide was produced the finest results making the paper writable, smooth and strong.

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