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Production of Pulp Through Groundnut Shell: A Bio-Waste Source

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Abstract

In recent years, the growing shortage of wood from forest has been directed in the search of alternatives for producing fiber plant materials. In many countries, the extensive use of biomass yielding plant has been a far best solution whereas in India the generation of the biomass yielding plant has shortage of cellulosic needs for the materials. In certain agricultural plants the production of high biomass fiber content is found and among them groundnut shell is served as alternative resource. In the current study, the analysis of the yield by changing the concentration of the sulfides in preparation of the pulp from the waste groundnut shell is undertaken. The Kraft and soda process has helped in analyzing the yield and energy consumption done by the material in production of pulp quality. Variations in the concentration ratio of the pulp would represent the fragmentation of the paper. At 10% concentration, the pulp quality obtained is dark brown in color, while at 40% it is slightly wheatish in color. The effective change in the concentration of the Na_2S, NaOH has effectively provided the pulp with different proportions.

Keywords: Groundnut Shell, Bio-Waste, Kraft & Soda Process, Pulp, Yield, Fiber Plant Material

1. Introduction

Groundnut shell is nutritious leguminous crop which is obtained mainly from the seeds and oil worldwide. It has provided a leftover product after removal of the groundnut seed from its pod. The slow degradation has provided the bioactive and functional components through which the beneficial for mankind has commercially managed the feedstock, food and fillers in the fertilizers. Environmental pollution has set up new technologies which could manage zero-waste production with the waste product into feed, paper and bioenergy as well as industrial measures [15]. There are different measures which have been undertaken by the researchers where they integrate on the trials, feedstock for bio-ethanol production and particle board component as well as adding groundnut shell usage in the wastewater treatment as well as using the insulation board and metal casting along with the activated carbon. However, the current challenges that are preserved in the environment by reducing the energy, water and chemical requirements is attained while making pulp. The Pulp and Paper industry has repeatedly derived the use of fibers from wood to produce paper. However, it has raised deforestation and poses to environmental degradation. The Paper making process is focused on the number of stages of Soda and Kraft process. It includes the raw material to pulp by mechanical and chemical method. Pulping reduces the lignocellulosic material which helps in generating higher yield. The parameters that are undertaken to strength the tensile strength and elongation are optimized through it. The review summarizes that the wide range of the potential application of groundnut shell to paper production would help in the evaluation of the bio-products [2].

2. Review

Y N Ramgopal has presented that in recent years, with the growing shortage of wood from the forest, the search for alternative fiber producing plant material has been initiated in many countries of the world [22]. The generation of fast-growing high biomass yielding plants is thought to be one of the solutions to meet the shortage of cellulosic material. However, 14 certain agricultural plants producing higher biomass are found to be suitable substitutes for certain fiber-based industries. Among them ground nut shells may serve partly as an alternative resource. In this project we produced pulp from waste ground nut shells using Kraft's process and Soda process and analyzed both processes based on their yield and energy consumption. Tejas Suryawanshi (2017) has presented that India is the second largest producer of groundnuts. Groundnut shells which remain as a waste after the separation of groundnut seeds are mostly dumped or burned. They can be used as a renewable source of energy. Fossil fuels are nonrenewable sources of energy which need

an alternative. In present study ground nut shells were collected from Mirewadi village in Maharashtra. They were cleaned, dried, powdered and used for biofuel production. The pure culture of Saccharomyces cerevisiae was used for fermentation of the hydrolysate with an addition of peptone as protein source. MIC of alcohol and glucose for S.cerevisiae was carried out. Aliquots were removed at different time intervals and subjected to distillation. Distilled samples were subjected to glucose and ethanol estimation by DNSA and Dichromate method respectively. The yield of alcohol was found to be highest on the 4th day of fermentation. Cellulose was extracted from groundnut shell powder. Muffle furnace was used to make ash of groundnut shells and used to check its applications to increase crop yield.

Upendra Kadre (2018) has presented that in recent years, with the growing shortage of wood from the forest, the search for alternative fiber producing plant material has been made in many countries of the world [21]. Among them ground nut shells may serve partly as an alternative resource. In this project we produced pulp from waste ground nut shells using Kraft's process. We also analyzed both processes based on their yield and energy consumption. It is also a project from waste material (groundnut shells). Karthikeyan S (2019) has presented that in recent years, with the growing shortage of wood from the forest, the search for alternative fiber producing plant material has been initiated in many countries of the world. The generation of fast-growing high biomass yielding plants is thought to be one of the solutions to the shortage of cellulosic material. However, certain agricultural plants producing high biomass are found to be suitable substitutes. Among them ground nutshell may serve partly as an alternative resource. In this study we extracted cellulosic fiber from ground nutshell by kraft's process and we compared other source of cellulosic fibrous materials. In application we produced paper from ground nutshell. This is going to be more effective and alterative for cellulosic fiber in future. Pham Anh Duc (2019) has presented that groundnut shells account for approximately 20% of the dried peanut pod by weight, meaning there is a significant amount of shell residual left after groundnut processing [15]. Increased groundnut production leads to the accumulation of these groundnut shells which is not utilized, thus either burnt or buried. As Groundnut shells are rich in many functional compounds and composed of cellulose, hemicellulose and lignin, it can be utilized in multiple ways. This review highlights potential applications of ground nut shells for commercial and industrial purposes. Groundnut shells can be converted in various bio-products such as biodiesel, bioethanol, nano-sheet and has applications in enzyme and hydrogen production, dye and heavy metal degradation etc. An efficient management strategy is required to convert this otherwise considered waste into valuable bio-products to achieve zero waste production system.

P Musekiwa (2020) has presented that paper production through chemical pulping has been identified as one of the ideal avenues of exploring the uses of groundnut shells as they are rich in cellulose [14]. Ideally, cellulose can be used to synthesize fibers that can be converted into useful paper products. In this study, chemical pulping was the chosen process for liberating the fibers as it is effective in dissolving lignin embedded within the cellulose. In addition, the fibers produced have superior physical properties compared to mechanical pulping. It is imperative that optimal conditions are identified for the chemical treatment process, in order to ensure that energy and chemical consumption are minimized. All these measures are aimed at reducing production costs and make chemical pulping economically viable, as compared to the mechanical pulping process which is less costly. Response surface methodology (RSM) was used in this study to evaluate the effect of three independent variables (cooking time, temperature, and sulphidity) on pulp yield and kappa number. These parameters are critical in the chemical pulping process and the optimal conditions obtained were 180 min, 100 C and 23.6 wt.%, respectively. At the optimal conditions, the pulp yield was 64.39wt% with a kappa number of 19.5. The results showed that all parameters investigated, had a statistically significant effect on the production of pulp. The increased cooking time was efficient in ensuring complete impregnation of the groundnut shells with chemicals for pulping and ensuring that the dissolution of lignin is not selective and does not result in dead spots inherently compromising the quality of the pulp. On the other hand, lower temperatures limited the peeling effect due to hydrolysis of carbohydrates which increased pulp yield due to a higher cellulose retention. Consequently, this contributed towards obtaining pulp that is well cooked, has a low bleach consumption and a higher quality.

Vallabh C Chiplunkar (2022) presented that in previous years, there is shortage of wood from forest, so for the production of the paper there is need to find an alternative fiber producing material is initiated in world. The generation of fast-growing biomass yielding plants is one of the solutions to meet up the requirement of cellulosic material. However, certain agriculture plants produce cellulose in large amounts so they are suitable substitute for fiber-based industries. Among various types of options groundnut shells serve as an alternative resource. Nigam Mohit (2014) presented that this paper covers the scenario of Indian Paper Industry and different processes for the production of paper. In this study wood is take as raw material which is converted into pulp and primary form of Paper. Generally two (Mechanical and Chemical) pulping processes are used for manufacturing of pulp from wood. In the manufacturing process of pulp and paper firstly wood chips are cooked in digester and then washing, screening, bleaching operations are carried out and then forming, pressing, drying operations used for paper manufacturing.

Honghi Tran (2016) presented that the kraft chemical recovery process is a mature, effective technology that provides for recycling of the pulping chemicals, efficient generation of steam and electrical power from the fuel value of the black liquor, and effective disposal of dissolved wood substances. The process now faces significant challenges with respect to air emissions, effluent discharge, and the

need for improved energy recovery and utilization. Means for dealing with these issues are available but they can costly. New technology may result in significant energy benefits. Manuel Javier Feria (2011) presented that pulp and paper making by kraft and refining processes and a OD(EP)DP bleaching sequence. The same species has been suggested as an energy crop and, in fact, this species used shows a high gross heating value; besides, this variety of Leucaena has appropriate characteristics for pulp and paper making. The holocellulose content was higher than Eucalyptus globulus, and ash and lignin contents were comparable to other 18 varieties of Leucaena. Pulps with a kappa number between 17 and 18, and 21.4 cP viscosity were obtained using an active alkali concentration of 31%. Also, paper sheets showed good strength properties, comparable or even greater than those obtained with Eucalyptus or others varieties of Leucaena at comparable refining degrees, between 30 and 40 ºSR. The pulp was successfully bleached in all cases with a kappa number below 1.5 in the EP stage and a value of brightness higher than 90%.

Drake Mboowa (2021) presented that the demand for paper and pulp derived products to full fill consumer needs is increasing considerably globally. This work provides a critical overview of the various traditional pulping methods and describes the recent improvements in pulping processes. A comparison of different pulping techniques has shown that the mechanical pulping process produces high pulp yields per unit volume of wood of poor quality (low strength, bonding, fiber morphology, etc.) as compared to chemical pulping methods. The use of semi-chemical pulping is reported as an effective way of overcoming the disadvantages of the mechanical pulping process. Recent modifications of the pulping processes that have happened in the last decade have been discussed and shown to be driven by the desire to save energy and reduce chemical requirements while maximizing pulp yields and quality. With the emergence of bio-based nanotechnology, post-pretreatment of Kraft and sulfite pulps for making nanocellulose and lignin containing nanocellulose with improved fiber characteristics of fiber size, crystallinity, chemical composition, and fiber surface functionality has been discussed. Furthermore, challenges and prospects of the improvements in pulping processes are highlighted.

3. Pulp Production Methodology

3.1. Raw Material

Usually, the waste from the groundnut shell has basically involved pectin, lignin, cellulose and hemicelluloses. The groundnut shell consists of lignin as per the previous studies where single monomer has managed the pulping process evidently. It consists of the cross-linked phenolic polymer comprises of three constituent p-hydroxyphenyl (4-hydroxyphenyl, P), guaiacyl (4hydroxy-3-methoxyphenyl, G), and syringyl (4-hydroxy-3,5-dimethoxyphenyl, S). This has no repeating structure which gives rise to complex polymer of aromatic alcohols and monolignols. However, the lignin in softwood is composed of the guaiacyl units and few phenylpropane of phydroxyl [10].

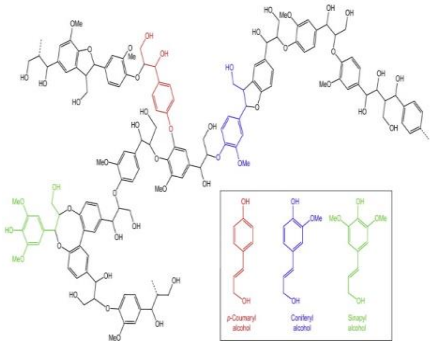

Figure 1: Lignin Fibers

3.2. Method of Pulping

Because of producing pulp from groundnut shell, it has been evident that the Soda and Kraft method has been bound to provide the quality of pulp after the process based on efficiency. This mainly takes place to separate the cellulose of lignin fibers through chemical or mechanical processes [8]. The process of production of pulp using the groundnut shell which consists of lignocelluloses fibrous material is defining pulping process. This is usually prepared by chemically separation of the cellulose from the groundnut shell pods [15].

3.3. Preparation of Pulping

Initially, the groundnut shells are chipped for pulp and then crushed, clean and dried. This has mostly regulated on the getting the good quality of pulp by crushing the groundnut shell evenly and uniform pattern [2].

3.3.1. Mechanical Pulping

To gather the different forms of the pulp, we have eventually treated the groundnut shell through mechanical pulping where silicon carbide and aluminum oxide are used to make stone pulp from groundnut shell. It has then refined the plates with Refiner mechanical pulp and thermomechanical pulp by decreasing the fibers. It has certainly used products which will help in strengthening the less print paperboards [2].

3.3.2. Thermo-Mechanical Pulping

With this method, the mechanical refining of the waste in the groundnut shell has taken place. It has added steam treatment through digestor that helps in removing the moisture content around 20% by exerting mechanical force. This action helps in separating the lignin fibers to pulp and then cleaning on the clumps of fiber reprocess. It has given rise to the high yield fibers from the groundnut shell as it's easy to remove lignin from them [22].

3.3.3. Chemical Pulping

Chemical pulping on the other hand would help in breaking down the cellulosic intent present in the groundnut shell. It would degrade the cellulose fibers and provide a much stronger pulp than the mechanical pulping in terms of the product characteristics [22].

4. Materials and Chemicals

4.1. Why Using Groundnut Shell?

Groundnut shell is considered agro-waste rich in lignin constituent in the environment. It undergoes slow degradation and offers a wide range of biomass applications. It can be converted into a bio-product which will result in zero waste production [22]. Chemicals Required: Sodium Carbonate (Na_2CO_3), Sodium Hydroxide (NaOH), Sodium Sulphide (Na_2S).

5. Lab-Scale Procedure of Production of Pulp

5.1. Preparing Raw Material & Cooking Process

Initially the groundnut shell is taken and washed several times to remove dust and soil particles present on it. It is cut into long pieces to separate them for the drying and pulping process and remaining for cooking process. The dried shells are obtained at 900C after 25 minutes of water content reduction.

5.2. Kraft Pulping Process

The name of this process is taken after a German term “Kraft”, means "strong". It is also known as kraft’s pulping or the sulphate process which is a prime method to produce pulp from generally wood (groundnut shells in our case). The kraft’s process involves treating wood chips with white liquor (cooking liquor) which is a solution of NaOH, Na2SO4, and Na2CO3 [17]. For this experiment, a total solution concentration of 14% by weight of these three compounds combined with the percentages of- 30% of NaOH, 12.5% of Na_2SO_4, and 7.5% of Na_2CO_3.

Figure 2: Cooking Liquor Prepared

For a 500ml basis of liquor solution, the combined weight of the three chemicals is 140 grams. Following that, the weights of compounds are computed as: 42 grams of NaOH, 17.5 grams of Na_2SO_4, and 10.5 grams of Na_2CO_3.

5.3. Soda Pulping Process

Soda pulping is a chemical process that uses NaOH as the cooking chemical to produce pulp. The soda process produces pulp with lower tear strength than the other chemical pulping processes (sulfite and kraft), but it has limited application for easily pulped materials such as straw and some hardwoods [7].

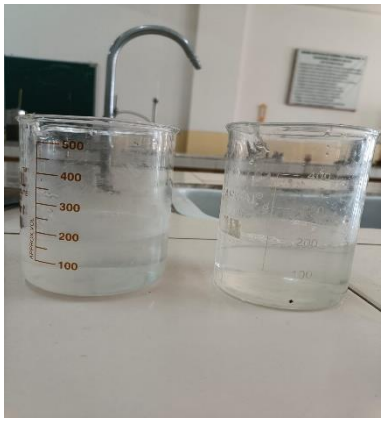

Figure 3: Cooking Liquor for Kraft’s and Soda Processes

A 20% by weight solution of NaOH is used as the cooking liquor in this experiment. 20% of 500 milliliters by weight yields 200 grams of NaOH. 200 grams of NaOH is mixed in water to create 1000ml of cooking liquor.

5.4. Digesting

Batches of 5 grams and 10 grams of raw material (groundnut shells) are added separately to 400ml of the prepared cooking fluid in three different beakers. The next step is to cook these solutions in the digester for roughly four and a half hours at 90C.

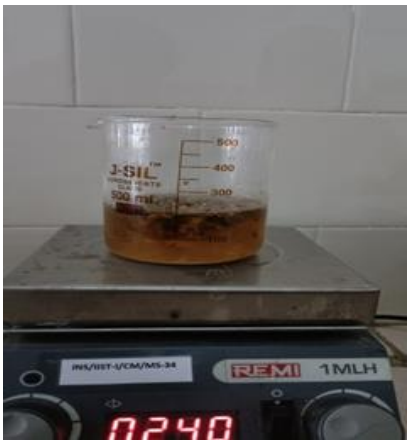

Figure 4: Digesting Process

The linkages between the lignin molecules are broken down by the combination of heat action and the powerful basic cooking liquid. The broken lignin molecules dissolve in the cooking liquor, turning it into a dark brown hue known as "black liquor," while the cellulose stays unaltered and is present in the cooking medium as brown stock along with traces of lignin. Heat is insufficient during the soda pulping process because the cooking liquor is relatively weaker than it is during the Kraft process. So, it is heated for one more hour to increase the effectiveness of heat [21].

5.5. Filtration and Washing of Pulp

Brown stock and black liquor are the byproducts of digestion. Pulp and lignin, in minuscule proportions, are present in brown stock. The combination was continuously filtered through cloth to produce waste black liquid, which contained salvageable cooking ingredients [4]. The pulp and cooking chemicals are separated by pulp washing properly. Before pulp is dried, bleached, and made into paper, chemicals and byproducts of lignin breakdown must be eliminated. To lower the lignin content, it is rinsed many times with 1000 ml of water. Finally, the filtered product must be produced in such a way that there are fewer lignin traces.

5.6. Bleaching

Bleaching is done to the pulp to create white paper. Bleaching aims to eliminate trace amounts of lignin that remain after digestion [12]. After being filtered and cleaned, pulp is dissolved in 200ml of water. 5 grams of bleaching powder are added to this mixture to get pulp suitable for making white paper by removing the brown tint.

5.7. Drying

To determine the yield in the procedures, drying is used. The entire water in the bleached pulp must be removed to calculate the yield. The bleached pulp is dried in a hot air oven for one hour at a temperature of 100°C to eliminate the water content [10].

6. Results

The pulp produced by Kraft's and soda pulping techniques produced the following outcomes:

- For breaking the lignin molecules, Kraft's method needed heating at 90°C for around 4 hours and 30 minutes. To get good results, however, the soda pulping procedure required an extra hour of heating.
- For breaking the lignin molecules, Kraft's cooking liquor is more potent and efficient. Because the cooking liquor is rather weak, there were traces of lignin in the pulp produced by soda pulping.
- The less lignin content in pulp obtained from Kraft's process resulted in a lighter brownish color while the pulp from soda process was comparatively darker.
- We experimented to produce pulp from both the processes with difference in the amounts of raw material to note the variation in product based on yield. The following tables show the figures for yields obtained [22].

For Kraft's Pulping process

Groundnut Shells (in grams)	Pulp Obtained (in grams)
5 grams	1.7 grams
10 grams	3.4 grams

Table 1: Pulp Obtained from feed (Kraft Process)

Figure 5: Pulp Yield from Kraft's Process

For Soda Pulping process

Groundnut Shells (in grams)	Pulp Obtained (in grams)
5 grams	1.2 grams
10 grams	2.9 grams

Table 2: Pulp obtained from feed (Soda Process)

Figure 6: Pulp Yield from Soda Process

7. Conclusion

The following are the conclusions reached after experimenting with and observing both techniques.

• In Kraft's method, which worked well enough to break lignin bonds, a solution of three chemicals in correspondingly smaller amounts was used as cooking liquor. To get satisfying results, however, soda pulping required a significant amount of a single chemical as a cooking chemical. Therefore, for better lignin bond breakage, Kraft's method is beneficial.

• The soda pulping procedure needed an additional hour of heating to produce results that were close to what was anticipated. Kraft's method achieved effective results and is more favorable in terms of heat demand.

• In comparison to the soda process, Kraft's method produces pulp that uses less bleaching chemical. Considering this, soda process pulp may be used to produce low-grade pulp whereas Kraft's process pulp can be used to produce high-grade pulp.

• Lastly, it should be noted that, in terms of yield, Kraft's method has generated considerably more pulp for a given amount of raw material employed. As a result, Kraft's method is beneficial in every aspect considered [22].

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