A Study On Production Of Pulp From Groundnut Shells

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Abstract

Paper production through chemical pulping has been identified as an ideal avenue for exploring the use of groundnut shells, as they are rich in cellulose. This cellulose can be used to synthesize fibers that can be converted into useful paper products. In this study, chemical pulping was chosen to liberate the fibers because it is effective in dissolving lignin embedded within the cellulose. In addition, the fibers produced exhibit superior physical properties compared to those obtained through mechanical pulping. It is imperative to identify optimal conditions for the chemical treatment process in order to minimize energy and chemical consumption. These measures aim to reduce production costs and make chemical pulping economically viable when compared with mechanical pulping, which is generally less costly. Response Surface Methodology (RSM) was used in this study to evaluate the effects of three independent variables—cooking time, temperature, and sulphidity—on pulp yield and kappa number. These parameters are critical in the chemical pulping process. The optimal conditions obtained were a cooking time of 180 minutes, a temperature of 100 °C, and a sulphidity of 23.6 wt.%. Under these conditions, the pulp yield was 64.39 wt.% with a kappa number of 19.5. The results showed that all the parameters investigated had a statistically significant effect on pulp production. Increased cooking time ensured complete impregnation of the groundnut shells with pulping chemicals, enabling uniform lignin dissolution and preventing dead spots that could compromise pulp quality. Conversely, lower temperatures limited the peeling effect caused by carbohydrate hydrolysis, thereby increasing pulp yield due to higher cellulose retention. Consequently, this contributed to the production of well-cooked pulp with lower bleaching chemical consumption and improved quality. In recent years, the growing shortage of forest-derived wood has prompted many countries to search for alternative fiber-producing plant materials. The development of fast-growing, high-biomass-yielding plants is considered one solution to address the shortage of cellulose resources. Certain agricultural residues with high biomass have been identified as suitable substitutes, among which groundnut shells may serve as a partial alternative resource. In this study, cellulose fibers were extracted from groundnut shells using the Kraft process and compared with other cellulose fiber sources. Paper was successfully produced from groundnut shell pulp, demonstrating that it is a promising and effective alternative source of cellulose fibers for future applications.

Key words: Kraft's process, Cellulose fibre, extraction, paper, Chemical engineering, Chemical synthesis, Materials characterization, Natural product chemistry, Groundnut shells, Chemical pulping, Response surface modelling, Low temperature, Lignin.

I. INTRODUCTION

Paper is a versatile material with many uses. It is prepared mainly by using cellulose pulp derived from wood and then drying them into flexible sheets. The most common use is for writing and printing; it is also widely used as a packaging material and even as a food ingredient particularly in Asian cultures. Paper and the pulp paper making process is an ancient process which was developed in China. Groundnut is also of value as rotation crop. As it is the plant, it improves soil nutrients, due to the presence of atmospheric nitrogen fixing bacteria in its root nodules. Thus, all parts of groundnut plant are fully useful. Groundnut shell has great potential for commercial use. Groundnut shell is used as a fuel, filler in cattle feed, hard particleboard, activated carbon, etc. The groundnut shell fibre possess good physical strength properties. The higher peasant content together with gums of some species of groundnut plant may be a suitable source for producing paper.

Figure 1. Groundnut

Groundnuts (Arachis hypogaea), also known as peanuts. Mention their widespread cultivation and consumption globally. **Botanical Characteristics**: Description of the plant's appearance, including its growth habits, leaves, flowers, and fruiting structures. Explanation of its unique reproductive process of pegging, where the flowers are self-pollinating and develop into pods underground. Environmental requirements: soil type, temperature, rainfall, and sunlight. Planting techniques, including seed selection, spacing, and planting depth. Irrigation, fertilization, pest, and disease control. Harvesting methods and post-harvest handling. Analysis of groundnuts' nutritional content, including macronutrients (carbohydrates, proteins, fats), vitamins (especially B vitamins), minerals (such as magnesium, phosphorus, and potassium), and phytochemicals. Emphasis on their high protein and healthy fat content, making them a valuable dietary source. Global production and trade statistics. Importance in agriculture for smallholder farmers and as a cash crop in various regions. It is the fourth largest oil seed produced in world and India is the second largest producer of groundnut after china. A complete seed of groundnut is called as pod and outer layer of groundnut is called shell. Almost every part of groundnut is of commercial value. Groundnut seeds are nutritionally rich due to the presence of oil, protein, minerals, vitamins etc. As a result, it is often described as ‘Poor man’s Badam’. There is versatility with respect to the groundnut seed consumption, since it is consumed in raw or roasted or salted or sweetened states in Indian food preparations.

Industrial uses: food processing, culinary applications, oil extraction, and animal feed. Discussion of the potential health benefits associated with groundnut consumption, such as heart health due to their monounsaturated fat content, protein content aiding muscle repair and growth, and rich source of antioxidants like resveratrol. Mention of studies linking groundnuts to reduced risk of chronic diseases like diabetes and certain cancers. Cultural and Culinary. Exploration of groundnuts' role in various cuisines around the world, from Savory dishes to confectionery. Cultural traditions and rituals associated with groundnuts in different societies. Recap of the importance of groundnuts as a versatile crop with significant nutritional and economic value. Potential for further research into their health benefits and sustainable cultivation practices. The following are this herb's taxonomic details:

Kingdom : ***Plantae*** **Division :** ***Magnoliophyte*** **Class :** ***Magnoliopsida***
Order : ***Fabales*** **Family :** ***Fabaceae*** **Genus :** ***Arachis***
Species : ***Arachis hypogaea***

Bio-active Compounds Present in Groundnut Shell

The groundnut shell contains several bioactive components, one of which is phenolic compounds. Phenolic compounds are known for their antioxidant properties and potential health benefits. These compounds include flavonoids, phenolic acids, and tannins. Additionally, groundnut shells contain other bioactive compounds such as lignin, which may have various biological activities including antimicrobial and anticancer properties Groundnut botanically known as Arachishypogaea belongs to leguminous family. It is the fourth largest oil seed produced in world and India is the second largest producer of groundnut after china. A complete seed of groundnut is called as pod and outer layer of groundnut is called shell. Almost every part of groundnut is of commercial value. Groundnut seeds are nutritionally rich due to the presence of oil, protein, minerals, vitamins etc. As a result, it is often described as 'Poor man's Badam'. There is versatility with respect to the groundnut seed consumption, since it is consumed in raw or roasted or salted or sweetened states in Indian food preparations.

II. PROPERTIES OF GROUNDNUT SHELLS:

2.1 PHYSICAL PROPERTIES:

Groundnut shell having the following physical properties:

- Chemical composition
- Groundnut shells are made of cellulose, hemicellulose, and lignin. They also contain silica, iron oxides, alumina, and calcium oxide.
- Density
- The solid density of groundnut shells is between 0.27–0.30 g cm−3, and their average bulk density is between 0.066–0.077 g cm−3.
- Porosity
- Groundnut shells are highly porous and can absorb around 198% of water in 72 hours.
- Microstructure
- Groundnut shells are made of microfibers with highly porous borders.

2.2 CHEMICAL PROPERTIES :

- Groundnut shell powder is a ligno cellulose material that is made up of cellulose (44.8%), hemicellulose (5.6%), and lignin (36.1%), and also contains proteins (5.4%), minerals, pectin, and tannins. The surface of groundnut shell powder contains several polar functional groups, including hydroxyl, methoxy, and carboxyl groups.
- Groundnut shells are also high in the following minerals:
- Sodium (42.00 mg/100 g)
- Potassium (705.11 mg/100 g)
- Magnesium (3.98.00 mg/100 g)
- Calcium (2.28 mg/100 g)
- Iron (6.97 mg/100 g)
- Zinc (3.20 mg/100 g)
- Phosphorus (10.55 mg/100 g)

2.3 MECHANICAL PROPERTIES:

- Groundnut shell powder (GSP) has mechanical properties such as tensile strength, impact strength, and flexural property.
- The mechanical properties of GSP can be improved by treating it with alkali or acetylation.
- For example, alkaline treatment of GSP can improve the mechanical properties of recycled high density polyethylene composites.
- Acetylation treatment can enhance the photochemical and mechanical properties of groundnut shell fiber, making it suitable for composite processing.
- GSP is a lignocellulose material made up of cellulose (44.8%), hemicellulose (5.6%), and lignin (36.1%).
- It can be used in automobiles, railway coach, and military applications.
- Other mechanical properties of GSP include Density, Microhardness, and Inter-laminar shear strength (ILSS).
- GSP can also be used as a source of fuel for cooking, heating, and electricity generation. It can also be used as a component of animal feed, especially for ruminants like cattle and sheep.

Species	Cellulose (wt%)	Hemicellulose (wt%)	Lignin (wt%)	Ash (wt%)
Pine (softwood)	40-45	25-30	26-34	-
Maple (hardwood)	45-50	22-30	22-30	-
Banana	63-64	19	5	-
Coir	32-43	0.15-0.25	40-45	-
Sisal	63-64	12	10-14	-
Jute	61-71.5	12-20.4	11.8-13	2
Kenaf	31-39	21.5	15-19	-
Hemp	70.2-74.4	17.9-22.4	3.7-5.7	-
Bagasse	40-46	24.5-29	12.5-20	1.5-2.4
Groundnut shell	35.7	18.7	30.2	5.9
Rice husk	31.3	24.3	14.3	23.5
Pineapple	81	-	12.7	-

Figure 2 .Groundnut shell - properties of fibres

III. AIM AND OBJECTIVE OF THE STUDY

Aim: To investigate the feasibility and effectiveness of producing pulp from groundnut shells as an alternative raw material for paper and packaging industries, focusing on optimizing pulping conditions and evaluating the quality of the resulting pulp.

Objective:

Raw Material Characterization: Assessing the chemical composition and fiber content of groundnut shells to determine their suitability for pulping.

Pulping Methods: Exploring various pulping processes (e.g., chemical, mechanical, and combined methods) to identify the most effective technique for groundnut shells.

Optimization Parameters: Studying variables such as temperature, time, chemical concentration, and pressure to maximize pulp yield and quality.

Pulp Quality Evaluation: Testing physical and mechanical properties of the produced pulp, including tensile strength, burst index, tear resistance, and fiber morphology.

Comparative Analysis: Comparing the pulp from groundnut shells with conventional pulps (e.g., wood, bamboo, bagasse) in terms of quality and cost-effectiveness.

Environmental and Economic Aspects: Assessing the environmental impact and potential economic benefits of utilizing groundnut shells, a common agricultural waste, for pulp production.

Application Potential: Evaluating the end-use suitability of groundnut shell pulp in products such as paper, cardboard, or biodegradable packaging materials.

IV. PULPING

Pulping is the process of production of Pulp using wood material which is a ligno cellulose fibrous material. It is prepared by chemically or mechanically separating cellulose fibres from wood, fibre crops or waste paper.

Raw Materials

Generally, woods are two types. Hard woods and Soft woods. Wood from conifers (e.g. pine) is called softwood, and the wood from dicotyledons (usually broad -leaved trees, e.g. oak) is called hardwood. Hard woods are not necessarily hard, and softwoods are not necessarily soft. Thewell-known balsa (a hardwood) is actually softer than any commercial softwood. Conversely, some soft woods (e.g.yew) are harder than many hardwoods. These woods contain basically three materials in them. They are:

1. Cellulose 2. Hemi cellulose 3. Lignin and 4. Pectin

The cellulose present in wood is mostly in the form of fibres. The cellulose fibres are obtained as pulp after pulping process. Cellulose fibre is a long chain of single monomer C6H10O5.

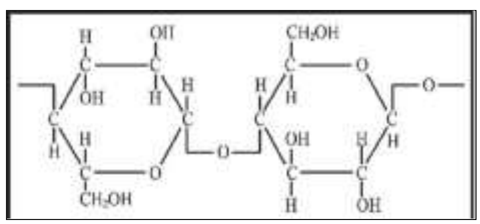

Figure 3. Cellulose

Methods of Pulping

Many processes came into existence for production of pulp from wood materials in past 2 decades. These methods work different because of the feed they take in, based on the quality of pulp obtained after the process and also based on their efficiencies.

Preparation for Pulping

Wood chipping is the act and industry of chipping wood for pulp, but also for other processed wood products and mulch. Only the heartwood and sapwood are useful for making pulp. Bark contains relatively few useful fibers and is removed and used as fuel to provide steam for use in the pulp mill. Most pulping processes require that the wood be chipped and screened to provide uniform sized chips.

Mechanical pulping:

Manufactured grindstones with embedded silicon carbide or aluminium oxide can be used to grind small wood logs called "bolts" to make stone pulp (SGW). If the wood is steamed prior to grinding it is known as pressure ground wood pulp (PGW). Most modern mills use chips rather than logs and ridged metal discs called refiner plates instead of grindstones. If the chips are just ground up with the plates, the pulp is called refiner mechanical pulp (RMP) and if the chips are steamed while being refined the pulp is called the thermo mechanical pulp (TMP). Steam treatment significantly reduces the total energy needed to make the pulp and decreases the damage (cutting) to fibres. Mechanical pulps are used for products that require less strength, such as news print paperboards.

Thermo mechanical pulping:

Thermo mechanical pulp is pulp produced by processing wood chips using heat and a mechanical refining movement. It is a two-stage process where the logs are first stripped of their bark and converted into small chips. These chips have a moisture content of around 25-30% and a mechanical force is applied to the wood chips in a crushing or grinding action which generates heat and water vapour and softens the lignin thus separating the individual fibres. The pulp is then screened and cleaned; any clumps of fibre are reprocessed. This process gives a high yield of fibre from the timber (around 95%) and as the lignin has not been removed, the fibres are hard and rigid.

Chemical pulping:

Chemical pulp is produced by combining small pieces of groundnut shells and chemicals in large vessels known as digesters where heat and the chemicals break down the lignin, without seriously degrading the cellulose fibres. Chemical pulp is used for materials that need to be stronger or combined with mechanical pulps to produce different characteristics.

V. MATERIALS AND CHEMICALS

Cellulose and lignin are important components of plant cell walls, and their presence and proportions can vary among different plant materials. Here's a comparison of cellulose and lignin content in walnut, peanut, banana, and wood:

Walnut:
Walnut shells, which are the hard outer coverings of the walnut fruit, contain cellulose and lignin. However, the cellulose content in walnut shells is relatively low compared to other plant materials.
Lignin content in walnut shells is relatively higher, providing strength and rigidity to the shells.

Peanut:
Peanut shells, or peanut hulls, are the outer coverings of peanuts. They contain cellulose and lignin, similar to walnut shells. The cellulose content in peanut shells is relatively higher compared to walnut shells, making them a potentially suitable raw material for paper pulp production. Lignin content in peanut shells is present but needs to be removed or modified during the pulping process for paper production.

Banana:
Banana stems and leaves are rich in cellulose, making them a potential source of cellulose fibers. The cellulose content in banana fibers is relatively high, making them suitable for paper and textile production. However, lignin content in banana fibers is relatively low compared to other plant materials, which may affect their strength and durability.

Wood:
Wood is composed mainly of cellulose and lignin. Cellulose is the primary component of wood cell walls, providing strength and rigidity. Lignin, on the other hand, acts as a binding material and gives wood its characteristic hardness and resistance to decay. The proportions of cellulose and lignin in wood can vary depending on the tree species, age of the wood, and specific parts of the tree (e.g., heartwood vs. sapwood).

Overall, while walnut and peanut shells contain cellulose and lignin, their cellulose content may be relatively lower compared to other plant materials such as banana fibers or wood. However, peanut shells, with their higher cellulose content, can be a suitable source for paper pulp production.

There are several reasons why peanut shells may be chosen as a raw material for pulp production:

i. **Abundance and availability:** Peanut shells are readily available as a byproduct of peanut processing. They are generated in large quantities as agricultural waste, making them a potentially abundant and easily accessible source of raw material for pulp production.
ii. **Sustainability:** Utilizing peanut shells as a raw material for pulp production can contribute to sustainable practices. By using an agricultural waste product, it helps to reduce waste and promote resource efficiency. It provides an alternative to traditional wood-based pulping, which involves cutting down trees.
iii. **Similar composition**: Peanut shells contain cellulose, which is a key component required for paper production. Cellulose is the primary structural material in plants and is responsible for providing strength and rigidity. Peanut shells contain a significant amount of cellulose, making them a potential source for pulp production.
iv. **Economic considerations:** Peanut shells, being a waste product, may be available at a lower cost compared to traditional wood sources. Utilizing peanut shells as a raw material for pulp production can offer cost advantages, especially if they are locally sourced.
v. **Potential for value addition:** By converting peanut shells into pulp, which can then be used for paper production, value can be added to an otherwise underutilized waste material. This can create economic opportunities and contribute to a circular economy approach.

Why Ground nut Shell?

Groundnut is also of value as rotation crop. As it is the plant, it improves soil nutrients, due to the presence of atmospheric nitrogen fixing bacteria in its root nodules while the dry plant parts are used as fodder. Thus, all parts of groundnut plant are fully useful. Groundnut shell has great potential for commercial use. Groundnut shell is used as a fuel, filler in cattle feed, hard particleboard, cork substitute, activated carbon, etc. De-hulled groundnut husk is used in production of hard boards. The groundnut shell fibres possess good physical strength. The higher pentosan content together with gums and mucilage in the sheath of certain species of groundnut plant may be a suitable source for producing paper. Although, reports are available on utilization of groundnut shell fibre for textile, pulp and paper making, but no reports are available developments of paper using groundnut shell fibre.

Chemicals

1. Sodium carbonate (Na_2CO_3)
2. Sodium Hydroxide (NaOH)
3. Sodium Sulphide (Na_2S)
4. Sodium Hypochlorite (NaOCl)

Sodium carbonate

Sodium carbonate, Na_2CO_3 is a sodium salt of carbonic acid. It most commonly occurs as a crystalline heptahydrate, which readily efflorescence to form a white powder, the mono-hydrate. Sodium carbonate is domestically well known for its everyday use as a water softener. It can be extracted from the ashes of many plants. It is synthetically produced in large quantities from salt (sodium chloride) and limestone in a process known as the Solvable process.

Sodium Hydroxide

Sodium hydroxide, also known as lye or caustic soda, has the molecular formula NaOH and is highly caustic metallic base. It is a white solid available in pellets, flakes, granules, and as a 50% saturated solution. Sodium hydroxide is soluble in water, ethanol and methanol. This alkali is deliquescent and readily absorbs moisture and carbon dioxide in air. Sodium hydroxide is used in many industries, mostly as a strong chemical base in the manufacture of pulp and paper, textiles, drinking water, soap sand detergents and as a drain clean.er. Worldwide production in 2004 was approximately 60 million tonnes, while demand was 51 million tonnes. Although molten sodium hydroxide possesses properties similar to those of the other forms, its high temperature comparatively limits its applications

Sodium Sulphide

Sodium sulphide is the chemical compound with the formula Na2S, or more commonly its hydrate $Na_2S·9H_2O$. Both are colourless water-soluble salts that give strongly alkaline solutions. When exposed to moist air, Na_2S and its hydrates emit hydrogen sulphide, which smells like rotten eggs. Some commercial samples are specified as Na2S·xH2O, where a weight percentage of Na2S is specified. Commonly available grades have around 60% Na2S by weight, which means that x is around 3. Such technical grades of sodium sulphide have a yellow appearance owing to the presence of poly sulphide. These grades of sodium sulphide are marketed as 'sodium sulphide flakes'. Although the solid is yellow, solutions of it are colourless.

Sodium Hypochlorite (NaOCl)

Sodium hypochlorite is a chemical compound with the chemical formula NaClO or NaOCl . It may also be called sodium hypochlorite acid salt. The anhydrous 10 sodium hypochlorite compound is unstable at room temperature. It may decompose explosively. The common name of sodium hypochlorite solution is bleach solution or "chlorine bleach". It is widely used in textile mills. Sodium hypochlorite is a chemical compound commonly used as a bleaching agent in the paper industry. It helps to remove color and impurities from the pulp.

VI. EXPERIMENTAL PROCEDURE FOR PRODUCTION OF PULP

Preparation of raw material

Initially Groundnut Shells are taken and washed several times with water to remove dust and soil particles present on it.Later it is cut into long pieces. They are crushed to remove water content and later dried at 80ºC for about 30 minutes to further reduce the water content.

Kraft's Pulping

For cooking liquor to be prepared chemicals must be taken in right proportions so that effective cooking would happen. Kraft pulping consists of following chemicals-NaOH, Na2SO4, and Na2CO3. These three chemicals must combine to give total of 12.5% by weight solution. In this 12.5% of solution, according to Kraft's pulping solids analysis says-

-58.6% is NaOH,

-27.1% is Na2SO4, and

-14.3% is Na2CO3

If we take basis as 1000 ml solution of cooking liquor, then 12.5% by weight gives 125grams which is the total weight of all three chemicals required. Compositions of solids are given by wt%. If we calculate the individual weight of chemicals required, they would give the following.

NaOH weight=0.586×125=73.25grams.

Na2SO4 weight=0.271×125=33.875grams.

Na2CO3 weight=0.143×125=17.875grams.

Digesting:

Once the cooking liquor is prepared 400ml of it is taken separately in a 100ml beaker to which 5 grams of raw material (dried banana stem) is added and the level is marked. The reason for marking the level is described below. Industrially, steam is used for heating purpose. There are two reasons for selecting steam as heating source:

1. Firstly, it would serve as the heating medium for the digester.

2. Secondly, once the steam exchanges heat with the cooking liquor and the raw material the water present in the cooking liquor evaporates due to increase in temperature difference. Then the initial concentration of the cooking liquor is not maintained which would result in weak cooking. So, if steam is used, it condenses into the cooking liquor after exchanging heat, there by maintaining the concentration of the cooking liquor. Here, we do not use steam as heating source. If heat is continuously supplied the water present in the cooking liquor evaporates there by initial

concentration of the cooking liquor is verified. To bring back the concentration to initial we add water up to the marked level in the beaker. This is taken care of throughout the process of digesting. The heat is supplied by means of hot plate for about 4hr 30min at a temperature of 90ºC. At the same time stirring is done continuously throughout the process. In the process of digestion, the strong basic cooking liquor and the action of heat combine and help breaking the bonds in lignin molecules. The broken lignin molecules dissolve in cooking liquor there by turning it into dark brown colour called as Black liquor and cellulose remaining unaltered is present in the cooking medium as brown stock along with the traces of lignin.

Soda Pulping

In this process, 20% by weight solution of NaOH is required as cooking liquor. If we take 1000ml as basis 20% by weight gives 200grams of NaOH. These 200 grams of NaOH is dissolved in water and makeup to 1000ml to give required concentration of cooking liquor. Once the cooking liquor is prepared, 5 grams of raw material is taken in 400ml of cooking liquor in 1000ml beaker and the level is marked. The reason for the marking the level is already described above in Kraft’s process. The same reason applies here too. And water must be added continuously to maintain the initial concentration of the cooking liquor and this process must be repeated entire boiling time. Next, it is heated to about 90˚C (boiling) for 4hr 30min with continuous stirring. But the heat is not enough as the cooking liquor is weak basic compared to Kraft process. So, it is heated for one more hour to increase the effectiveness of heat and cooking liquor in breaking the lignin molecules and dissolving in the cooking liquor.

Figure 4 . Soda Pulping

Filtration and washing of pulp

After digesting, brown stock and black liquor are formed. Brown stock contains pulp (cellulose and hemi-cellulose) and small amounts of lignin (reason for brown colour). And the black liquor contains the dissolved lignin and cooking chemicals that are unconverted and can be recovered. The mixture filtered using cloth to obtain black liquor as waste that contains cooking chemicals that can be recovered. One time filtration doesn't remove the lignin traces completely. So, once the filtration is done it is again washed with water to let lignin and chemicals associated with the brown stock to dissolve in it. And, this mixture is again filtered with the cloth and this process is repeated. It is washed several times with 1000ml of water to reduce the lignin content (about 5 times). Finally, the obtained product from the filtration must be in such a way that lignin traces must be less in amounts.

Bleaching

Once filtration and washing are completed the washed pulp is dissolved in 200ml of water to which 5grams bleaching powder is added to completely remove the brown colour to obtain white paper grade pulp

Figure 5. Bleaching

Filtration:

Filtration is done to find the yield in the process. To removed entire water content in the bleaching cellulose.

Drying

Drying is done to find the yield in both the processes. To find the yield entire water in the bleached pulp must be removed. To remove entire water content in the bleached pulp, it is dried at a temperature of 100ºC for one hour in hot air oven.

PAPER FROM PULP

Once the pulp is ready, it is then used to make paper in a process that is quite similar (in the basic actions) to the process first used by the ancient Chinese more than 1,900 years ago. We spray the pulp mixture onto a flat and smooth surface to make a layered mat. The mat of pulp is then heated to remove water and then dry it out.

Finally, we compressed it into one continuous roll of paper. When the paper has the desired thickness, it may be coloured or coated with special chemicals to give it a special texture, extra strength, or water resistance. We got a packaging paper from it.

VII. RESULTS AND DISCUSSIONS

Firstly, describing about the heat required for digesting, Kraft process required only 4hr 30min for breaking lignin molecules. But soda process required more heat for digestion and yet could not obtain effective digestion as groundnut shell material is still present as it is in the beginning on the water cooking liquor surface. Secondly, Kraft's process consists of strong cooking liquor

which can break the lignin more effectively. Whereas soda process consist of weak cooking liquor. Because of this reason we can find the traces lignin is more in Soda process than Kraft process.

Figure 6. Comparison of pulp obtained from Kraft process and Soda process

At the same pulp obtained after bleaching is also compared. The pulp obtained after bleaching is observed and found that Kraft pulp is whiter in colour compared to soda process, as bleaching agent required breaking the traces of lignin is more in soda process than Kraft process.

Process	Groundnut shells taken (grams)	Pulp Produced (grams)
Kraft's Process	5	1.735
Soda Process	5	1.273

IX. CONCLUSION

In this study, peanut shells were procured from a local market at a very low cost, where they are generally regarded as agricultural waste, and were utilized as the raw material for pulp production. Through chemical processing carried out in the laboratory, 8.875 g of pulp was successfully obtained from 20 g of peanut shells. The produced pulp was further processed at a regional paper manufacturing unit, resulting in the successful production of paper. This outcome demonstrates the technical feasibility of using peanut shells as a viable raw material for paper production.

The high yield of cellulosic fibers obtained from peanut shells indicates their strong potential as an alternative to conventional wood-based pulp sources. Utilizing peanut shells for pulp production offers multiple advantages, including reduced dependence on wood resources, thereby helping to mitigate deforestation and environmental degradation. The use of agricultural waste materials also supports sustainable resource utilization and promotes environmentally responsible manufacturing practices.

Additionally, peanut shells are often underutilized or disposed of with minimal economic value. Converting this waste into pulp for paper production adds significant value and contributes to the development of a circular economy. The physicochemical properties of peanut shells, which are comparable to those of hardwood and bamboo, further support their suitability for paper manufacturing with acceptable quality and performance.

Paper production from agricultural waste materials such as peanut shells aligns closely with several United Nations Sustainable Development Goals (SDGs). It supports **SDG 12 (Responsible Consumption and Production)** by reducing reliance on virgin raw materials and minimizing waste. It contributes to **Climate Action (SDG 13)** by lowering greenhouse gas emissions and preserving forests that function as carbon sinks. Furthermore, by reducing deforestation, it indirectly supports **SDG 14 (Life Below Water)** and **SDG 15 (Life on Land)** through the protection of ecosystems and biodiversity. The process also encourages **SDG 9 (Industry, Innovation, and Infrastructure)** by promoting innovative and sustainable industrial practices, and **SDG 17 (Partnerships for the Goals)** through collaboration between academic institutions, industries, and local communities.

Overall, this study highlights the potential of peanut shells as an economical, sustainable, and environmentally friendly alternative raw material for pulp and paper production. Further research and development are recommended to optimize processing conditions, improve pulp quality, and assess large-scale industrial feasibility.

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To Study The Effect Of Potassium Bisulphite As Food Preservation

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Abstract

Food preservation is an important aspect of food science that aims to prevent food spoilage, enhance shelf life, and ensure food safety. Spoilage of food materials mainly occurs due to the growth of microorganisms such as bacteria, yeast, and moulds, along with enzymatic reactions and environmental factors like temperature and moisture. To control these spoilage processes, chemical preservatives are widely used in food products. Potassium bisulphite is a commonly permitted chemical preservative, especially suitable for colourless food items such as fruit juices, squashes, jams, and chutneys. In the present study, the effect of potassium bisulphite as a food preservative has been investigated using fruit jam as the test sample. The preservative efficiency was analyzed under different conditions, including variation in potassium bisulphite concentration, sugar concentration, temperature, and storage duration. The observations were based on changes in colour, odour, texture, and overall quality of the jam over a period of time. The results revealed that potassium bisulphite effectively inhibits microbial growth by releasing sulphur dioxide, thereby delaying spoilage and extending shelf life. Lower temperatures and higher concentrations of potassium bisulphite were found to enhance preservation efficiency. This study highlights the importance of controlled use of chemical preservatives and appropriate storage conditions for maintaining food quality and reducing food wastage.

Key words: Food preservation, Potassium bisulphite, Chemical preservatives, Sulphur dioxide, Microbial spoilage, Shelf life, Fruit jam, Storage temperature, Food safety

I. INTRODUCTION

Food is a basic necessity of life, but most food materials are highly perishable in nature. Fresh fruits, vegetables, and processed food products are easily spoiled due to microbial activity, enzymatic reactions, oxidation, and unfavorable environmental conditions. Food spoilage not only leads to economic loss but also poses serious health risks to consumers. Therefore, preserving food to maintain its quality, safety, and nutritional value is of great importance. Food preservation refers to the process of treating and handling food in such a way as to stop or slow down spoilage, thereby extending its shelf life. Various methods of food preservation are practiced, including physical methods such as refrigeration, freezing, drying, and canning, as well as chemical methods involving the use of preservatives. Among these, chemical preservatives are widely used because they are effective even in small quantities and are easy to apply. A chemical preservative is a substance added to food to prevent or delay spoilage caused by microorganisms. In India, only a few preservatives are approved for food use to ensure consumer safety. Benzoic acid (or sodium benzoate) and potassium bisulphite are two commonly permitted chemical preservatives. Potassium bisulphite is particularly useful for preserving colourless food products. When added to food containing natural acids, it releases sulphur dioxide, which acts as a strong antimicrobial agent by inhibiting the growth of bacteria, yeasts, and moulds.

Potassium bisulphite is not suitable for coloured food items because sulphur dioxide has bleaching properties that can destroy natural and artificial colours. However, its advantage lies in the fact that it does not leave harmful residues in food when used within permissible limits. The preservative action of potassium bisulphite depends on several factors such as its concentration, temperature of storage, acidity of the food, and duration of storage. The present study is designed to examine the effect of potassium bisulphite as a food preservative by studying its role under different experimental conditions. Fruit jam has been selected as the model food system due to its high sugar content and susceptibility to microbial spoilage. By varying the concentration of potassium bisulphite, sugar content, temperature, and storage time, the effectiveness of this preservative has been systematically analyzed. This study helps in understanding the practical application, benefits, and limitations of potassium bisulphite in food preservation and emphasizes the importance of safe preservative usage in food industries.

II. AIM AND OBJECTIVES OF THE STUDY

Aim

To investigate the effectiveness of potassium bisulphite ($KHSO_3$) as a food preservative by analyzing its impact on microbial growth, shelf life, and quality parameters such as colour, texture, and taste in selected food items.

Objectives

• To evaluate the antimicrobial activity of potassium bisulphite against common spoilage microorganisms.

• To assess the preservative's effect on the shelf life of perishable food products such as fruit juices, dried fruits, and vegetables.

• To determine the optimal concentration of potassium bisulphite that ensures food safety while maintaining nutritional and sensory quality.

• To compare the effectiveness of potassium bisulphite with other commonly used preservatives.

• To identify any potential health or safety concerns related to the use of potassium bisulphite in food preservation.

• To explore regulatory standards and permissible limits for the use of potassium bisulphite in different food products.

III. MATERIAL REQUIRED

APPARATUS

• Beaker
• Conical flasks (100 mL)
• Glass bottles
• Glass rod
• Balance scale
• Knife
• Pestle and mortar
• Peeler

CHEMICALS

- Sugar
- Potassium bisulphite
- Fresh fruits

IV. THEORY

Food materials undergo natural deterioration due to the combined effects of microbial activity, enzymatic reactions, temperature, time, and moisture. Microorganisms such as bacteria, yeasts, and moulds grow rapidly in food materials under favourable conditions, leading to spoilage, unpleasant odour, change in texture, and loss of nutritional value. As a result, preserved food becomes unfit for consumption.

These undesirable changes can be minimized or delayed by the addition of chemical preservatives in small and safe quantities. Potassium bisulphite is one such chemical preservative commonly used for the preservation of colourless food products like fruit juices, squashes, jams, and chutneys. When potassium bisulphite reacts with acids present in food, it releases sulphur dioxide (SO_2), which acts as an effective antimicrobial agent. Sulphur dioxide inhibits the growth of bacteria, yeasts, and moulds by interfering with their metabolic activities.

The effectiveness of potassium bisulphite as a preservative depends on several factors such as its concentration, storage temperature, acidity of the food, and duration of storage. If used in appropriate amounts and under controlled conditions, potassium bisulphite helps to extend the shelf life of food without leaving harmful residues. However, excessive use may affect taste and may not be safe for consumption, hence regulated limits are followed.

4.1 OTHER METHODS OF FOOD PRESERVATION

Refrigeration

Refrigeration is one of the most commonly used methods of food preservation. It involves storing food at low temperatures to slow down the growth of spoilage microorganisms and enzymatic reactions. Refrigeration is effective for short-term storage of fruits, vegetables, dairy products, and meat. However, it does not completely stop spoilage and is unsuitable for long-term preservation.

Fermentation

Fermentation involves the action of beneficial microorganisms such as bacteria and yeast, which convert sugars into acids, alcohol, or gases. This process creates an environment that inhibits the growth of harmful microorganisms. Fermented foods such as yogurt, cheese, pickles, sauerkraut, kimchi, and sourdough bread have improved flavour, enhanced nutritional value, and longer shelf life.

Canning

Canning involves heating food to destroy microorganisms and then sealing it in airtight containers to prevent recontamination. This method is widely used for preserving fruits, vegetables, soups, and meats. High-acid foods can be preserved using boiling water bath canning, while low-acid foods require pressure canning. Proper sealing and processing are essential to avoid spoilage.

Drying or Dehydration

Drying removes moisture from food, thereby preventing the growth of microorganisms that require water for survival. Foods can be dried naturally under the sun or using mechanical dehydrators. Dried fruits, vegetables, herbs, and meat products such as jerky can be stored for long periods and are lightweight and easy to transport.

4.2 BENEFITS OF FOOD PRESERVATION

Preventing Food Spoilage

Food preservation methods inhibit the growth of spoilage-causing microorganisms, helping to maintain food safety and quality.

Extending Shelf Life

Preservation slows down natural decay processes, thereby increasing the shelf life of perishable food items and reducing food wastage.

Availability of Seasonal Produce

Preservation allows fruits and vegetables to be consumed throughout the year, regardless of their seasonal availability.

Convenience

Preserved foods can be stored for long durations without immediate consumption or continuous refrigeration, making them convenient for daily use.

Cost Savings

Food preservation enables bulk purchasing and storage of seasonal produce at lower cost, leading to economic benefits.

Food Security

Preservation plays a vital role in ensuring food availability during emergencies, natural disasters, or periods of food scarcity.

Nutritional Retention

Proper preservation techniques help retain essential nutrients such as vitamins and minerals, ensuring the nutritional value of food during storage.

V. PROCEDURE

- Take fresh fruits, wash them thoroughly with water and peel off their outer cover.
- Grind it to a paste in the mortar with a pestle.
- Mix with sugar and colouring matter.
- The material so obtained is fruit jam. It may be used to study the effect of concentration of sugar and $KHSO3$, temperature and time.

(A) Effect of Concentration of Sugar

1. Take three wide-mouthed reagent bottles and label them as **I, II, and III**.
2. Place **100 g of fruit jam** into each bottle.
3. Add **5.0 g, 10.0 g, and 15.0 g of sugar** to bottles **I, II, and III**, respectively.
4. Add **0.5 g of potassium bisulphite ($KHSO_3$)** to each bottle.
5. Mix the contents thoroughly using a **glass rod** to ensure uniform mixing.
6. Close the bottles properly and keep them undisturbed at **room temperature** for **one week**.
7. Observe and record the changes occurring in the jam **daily**, such as colour change, odour, texture, and signs of spoilage.

Observation:

Bottle No.	Wt. of Jam	Wt. of Sugar	Wt. of $KHSO_3$	Observation (Days)				
				1	2	3	4	5
I	100 gm	5 gm	0.5 gm	No Change	No Change	No Change	Few Change	Few More Change
II	100 gm	10 gm	0.5 gm	No Change	No Change	Few Change	Some Change	Few More Change
III	100 gm	15 gm	0.5 gm	No Change	Few Change	Few Change	Some Change	Few More Change

Table 1 . Effect of Concentration of Sugar

Result (Effect of Concentration of Sugar)

It was observed that an increase in the concentration of sugar led to faster spoilage of the jam. Higher sugar concentration promoted fermentation and microbial activity, resulting in quicker deterioration of quality.

(B) Effect of Concentration of Potassium Bisulphite ($KHSO_3$)

1. Take three clean, dry bottles and label them as **I, II, and III**.
2. Place **100 g of fruit jam** into each bottle.
3. Add **5.0 g of sugar** to each bottle.
4. Add **1.0 g, 2.0 g, and 3.0 g of potassium bisulphite ($KHSO_3$)** to bottles **I, II, and III**, respectively.
5. Mix the contents thoroughly using a **glass rod** to ensure uniform distribution.
6. Keep all the bottles at **room temperature** for several days and **observe the changes daily**, noting variations in colour, odour, texture, and spoilage rate.

Observation:

Bottle No.	Wt. of Jam	Wt. of Sugar	Wt. of $KHSO_3$	Observation (Days)				
				1	2	3	4	5
I	100 gm	5.0 gm	1.0 gm	No Change	No Change	No Change	Few Change	Some Change
II	100 gm	5.0 gm	2.0 gm	No Change	No Change	No Change	No Change	Few Change
III	100 gm	5.0 gm	3.0 gm	No Change	No Change	No Change	No Change	No Change

Table 2 . Effect of Concentration of Potassium Bisulphite ($KHSO_3$)

Result (Effect of Concentration of Potassium Bisulphite)

It was observed that an increase in the concentration of potassium bisulphite increased the duration of preservation of the jam by effectively inhibiting microbial growth.

(C) Effect of Temperature

1. Take 100 g of fruit jam in three clean bottles and label them as I, II, and III.
2. Add 10.0 g of sugar and 1.0 g of potassium bisulphite ($KHSO_3$) to each bottle.
3. Mix the contents thoroughly using a glass rod to ensure uniform mixing.
4. Keep Bottle I in a refrigerator at 0°C, Bottle II at room temperature (25°C), and Bottle III in a thermostat at 50°C.
5. Observe and record the changes in the jam daily for several days, noting variations in colour, odour, texture, and spoilage.

Observation:

Bottle No.	Observation (Days)		
	7	14	21
I	No Change	****	****
II	No Change	Taste Change	****
III	No Change	No Change	Unpleasant Smell Develops

Table 2 . Effect of Temperature

Result

It was observed that with an increase in the number of days, the quality of the jam gradually deteriorated, showing changes in colour, odour, texture, and overall acceptability.

VI. CONCLUSION

The present study was carried out to investigate the effectiveness of **potassium bisulphite ($KHSO_3$)** as a food preservative under different conditions of **concentration, temperature, and storage time**. From the experimental observations, it was evident that both sugar concentration and potassium bisulphite concentration play a significant role in the preservation of fruit jam.

An increase in the concentration of sugar was found to accelerate the rate of spoilage, indicating that higher sugar levels alone do not necessarily enhance preservation and may promote fermentation. In contrast, higher concentrations of potassium bisulphite effectively inhibited microbial growth and significantly increased the duration of preservation, proving its efficiency as a chemical preservative.

Temperature was observed to have a major influence on the preservation process. Lower temperatures, such as refrigeration, slowed down microbial activity and fermentation, thereby extending the shelf life of the jam. On the other hand, higher temperatures accelerated spoilage and led to rapid deterioration of food quality.

The duration of storage also affected the quality of the preserved jam. With an increase in storage time, gradual deterioration in colour, texture, and overall quality was observed, even in the presence of potassium bisulphite, indicating that no preservation method can completely prevent spoilage indefinitely.

In conclusion, potassium bisulphite is an effective food preservative when used in **appropriate concentrations** and stored under **controlled temperature conditions**. However, its preservative action is limited by factors such as time and storage environment. Further studies on optimizing preservation conditions and exploring safer alternative preservatives can contribute to improved food preservation techniques and reduced food wastage.

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