Analysis and Comparison of Peanut Shell's Cellulose Content

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Abstract

The peanut shell is a waste product of peanut cultivation and is available throughout the year in Sri Lanka. The peanut consists of cellulose and microcrystalline cellulose in its shell, which can be utilized to produce a biodegradable packaging material. As a result, the current research was focused to estimate the ash content, extractives, total solid content, hemicellulose, cellulose and lignin of peanut shells. For that purpose, peanut shell was collected in the Mullaithivu district in the Northern province of Sri Lanka. Further, it was dried in a cabinet dryer, ground using the grinder and sieved into 1mm and 90 µm particle size powders. The composition of the peanut shell was analyzed using standard methods as 'Klason' method for lignin determination and drying methods for other components. Further, the cellulose content was compared with the chemical extraction method which is related to the removal of all the major components except cellulose, and with the literature review which was analyzed by the above standard method. The total solid content of the peanut shell is 92.038 ± 0.0037 % which comprises 4.58 ± 0.0005 % ash, 2.93 ± 0.015 % extractives, 18.1 ± 2.423 % hemicellulose, 32.24 ± 0.081 % lignin and 34.183 ± 0.012 % cellulose. According to the extraction process, the cellulose content was, 32.9 % whereas from the literature review it was 35.7 %. As a by-product, the peanut shell is a valuable source of cellulose that may be utilised to make cellulose-based goods.

Keywords: - Compositional analysis, peanut shell, cellulose content, cellulose-based packaging

I. INTRODUCTION

The extraction of the peanut seed from its pods produces peanut shells as a by-product. It is a common agro-industrial waste product that degrades very slowly in nature. Groundnut shells on the other hand contain a variety of bioactive and functional compounds that are helpful to humans. It is used as a feed, food, fertilizer component and carrier for bio-filters in the commercial world. The bulk of abandoned groundnut shells, on the other hand, are burnt or buried contaminating the environment (Adhikari *et al.*, 2019).

The huge quantity of agro-waste produced by the food industry has been a major source of concern, as it produces massive volumes of inedible residues coming from processed edible crops and grains all over the world (Gonçalves de Moura *et al.*, 2017). Peanut shells contribute to around 20% of the weight of dried peanut pods, meaning that there is a large amount of shell residue after processing. Rising peanut production leads to an accumulation of peanut shells, which are either burnt or buried because they are not utilised. Due to their high content of functional components including cellulose, hemicellulose, and lignin,

groundnut shells may be utilised in a variety of ways (Duc *et al.*, 2019).

Peanut hulls are bulky trash that is produced in enormous quantities. In peanut-producing countries, peanut shells are routinely burnt, discarded or left to decay naturally. Peanut shells are being used for several purposes, including biofuel, compost, chemical and fertiliser transporters, cow and poultry bedding, pet litter, soil conditioners, and so on (Heuzé *et al.*, 2016). Even though its high fibre content makes it inappropriate for monogastric animals, peanut shells are fed to livestock, namely grazing animals and rabbits (Hill, 2002).

II. LITERATURE REVIEW

The nut (79–71%) is surrounded by a shell (21-29%) on the outside of the peanut fruit (Hamm and Hamilton, 2013; Davis and Dean, 2016). Peanut hulls are a by-product of the peanut processing industry. Shelling peanuts is often the second (after washing) step in the peanut processing process. Peanut shells are frequently fractured and contain varying percentages of entire or broken kernels (Hill, 2002).

The microfibrils in peanut shells are organised similarly to those in other cellulosic materials. In a conclusion, employing groundnut shell (shell) as a filler material in polyolefin would pave the way for new ways to transform agro-waste into useful resources for the plastics industry. This contributes to the general need for greater environmental sustainability by reducing municipal solid waste and generating "waste to riches" (Obasi, 2015). The chemical constituents of peanut shells are shown in Figure 01 and described below.

A. Lignin

Lignin is a biological polymer found in plants that serve as a structural support material. During cell wall formation, polysaccharides such as cellulose and hemicellulose are laid down initially, with lignin filling up the gaps between the polysaccharide filaments and binding them all together. This mechanism stiffens cells and protects the carbohydrate against physical and chemical destruction (Mohanty *et al.*, 2000). The uneven binding or insertion of monomers provides natural lignin. The quantity of lignin found in different tissues or cell walls varies a lot. The amount of lignin in various tissues or cell walls varies significantly. Environmental factors such as plant growth, temperature, nutrition, and light have an impact on the chemical composition of lignin. One of the most challenging problems in the field of natural polymers is lignin's chemical structure. Because lignin molecules and their breakdown products have numerous asymmetric centres. They are not formed by a single key-type connection. Between the structural components, there are many carbon-carbon bonds (Huang *et al.*, 2019).

B. Hemicellulose

Hemicellulose is divided into three types based on the primary sugar residue in the backbone: xylenes, mannans and glucans, with xylenes and mannans being the most common. The cellulose, hemicellulose and pectin classes make up the bulk of polysaccharides found in plant cell walls. The stiffness of the cellulose microfibril is enhanced inside a matrix of hemicellulose, regardless of the fact cellulose serves as the rigid, load-bearing component of the cell wall. Hemicelluloses, also known as cross-linking glycan are thought to be involved in the control of wall elongation and modification. Hemicelluloses are non-cellulose, non-pectin cell wall heteropolysaccharides made up of multiple polymers with different monosaccharide and glycosidic linkage compositions, substitution patterns and polymerization degrees. Chemical structure and structural properties are influenced by species, subcellular location, and developmental phases. Between cellulose and hemicellulose, there are likely no chemical connections, but hydrogen bonds and Van Der Waals forces give reciprocal adhesion (Wyman *et al.*, 2005).

C. Cellulose

The most prevalent polymer on the planet is cellulose. It may be used to make high-value chemicals, biofuels, polymer composites and a variety of other products. Biodegradable, durable, non-toxic and thermally stable are the benefits of cellulose (Galiwango *et al.*, 2019). Cellulose has strong film properties and is chemically stable and cellulose derivatives are simple to synthesise. However, due to its insolubility in water and the overwhelming majority of organic solvents, cellulose's use in edible films is limited. These disadvantages can be addressed by derivatization, which enhances not only cellulose's water solubility but also its thermoplastic behaviour (Radovanovi, 2020). Biodegradable, tasteless, odourless, flexible, fairly strong, translucent, impermeable to lipids, water-soluble and relatively transparent to humidity and air, cellulose films have good film-forming characteristics (Kocira *et al.*, 2021).
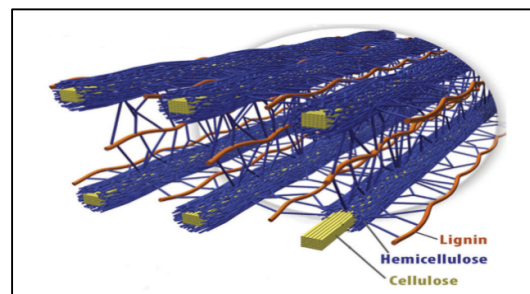

Figure 01: Spatial pattern of lignocellulosic biomass in the cell wall (Source: Brandt et al., 2013)

III. PROBLEM SPECIFICATION

The most prevalent biopolymer in the universe, cellulose, is known for its ultimate tensile strength. Because of its renewable and biodegradable nature, it is an important natural filler. The capacity of the three hydroxyl groups present in the structure of cellulose to form hydrogen bonds is responsible for cellulose's diverse applications due to its improved physical and mechanical

qualities. In recent years, the creation of cellulose-based biological scaffolds has attracted a lot of interest. The removal of hemicellulose and lignin, which form the matrix for cellulose micro fills, is used in the cellulose extraction process. Cellulose has been isolated and characterized from several sources, including maize stalks, rice husks and sugarcane bagasse. But the peanut shell, a readily available and plentiful source, has yet to be documented. Hence, this paper is targeted at the isolation of cellulose from peanut shells.

IV. METHODOLOGY

Peanut shells were gathered from the Murikandy area, Mullaithivu. To eliminate dirt and debris, the shells were cleaned and rinsed with tap water many times. The method described by Punnadiyil, Sreejith and Purushothaman (2016) was used with slight modification. Washed peanut shells were allowed to dry at 60°C for 18 hours using a cabinet dryer (MINI II UF750, Japan). Dried shells were ground using the grinder (Vita-Mix Blender, Absolute 3, Japan) and sieved into less than 90 μm and 1 mm particles. Peanut shell powder was stored in an airtight container for further analysis.

A. Analysis of cellulose content by chemical extraction method

Peanut shell powder of 90 μm particles was taken. The 50g of peanut shell powder was weighed (HR – 250AZ, Japan). In a conical flask, peanut shell powder was placed. The 500 mL of 1.5% NaOH (Jung *et al.*, 2018) was added to that conical flask. The solution with peanut shells was heated in a water bath for 1 hour at 75°C (Yamato – BT200, Japan). The treated solution was washed and filtered until the filtrate was clear. In the oven, it was dried at 60°C for 24 hours (ISUZU- CAP, Japan). The end product is called an "Alkali treated sample" (Oliveira *et al.,* 2015). The 1g of Alkali treated sample was refluxed with 25 mL of HNO_3: Ethanol mixture (1:4) ratio. It was carried out at boiling temperature for one hour. This process is called "Refluxation". It was then rinsed in cold distilled water and filtered via the vacuum pump. The final product was dried at 90°C for one hour with slight modification. The end product was "Cellulose" (Chen *et al*., 2018).

B. Analysis of cellulose content by standard method

For this standard method analysis, 1 mm particle size peanut shell powder was taken.

1) Determination of ash

As defined by Ayeni *et al.* (2015) the weight of an empty crucible was measured (W1). The weight of peanut shell powder was measured with a crucible (W2) in a weighing balance. It was ignited in a muffle furnace for 4 hours at 600°C. The final weight was measured with a crucible (W3).

$$\text{Ash \%} = \frac{(W3-W1)*100}{(W2-W1)}$$

2) Determination of total solids

According to Sluiter *et al.* (2008), the peanut shell powder (1g) was weighed in the moisture can and was kept at 105°C for 4 hours in an oven. The empty moisture can (W3), the initial weight of moisture can with sample (W2) and the final weight of moisture can with sample (W1) were measured.

$$\text{Total Solids \%} = \frac{(W1-W3)}{(W2-W3)}*100$$

3) Determination of extractives

It was done according to Ioelovich (2015), and Li *et al.* (2015) with slight modifications. The thimble was filled with dried peanut shell powder (W1). The weight of the glass used to hold the solvent was measured (W2). The Soxhlet extractor (BUCHI – B811, Japan) was set up for 3 hours for the extraction using 100 mL of ethanol as the extraction solvent. The material was dried at room temperature after extraction. The glass used as the solvent holder was dried for 24 hours in an oven at 80°C to measure the dry weight (W3). The difference in weight between the empty glass and the glass containing extractives was used to calculate the extractive content percentage (w/w).

$$\text{Extractive \%} = \frac{(W3-W2)*100}{W1}$$

4) Determination of hemicellulose

It was described by Ioelovich (2015). Extracted free dried sample (1 g) (W1) was transferred into 500 mL of the Erlenmeyer flask. 150 mL of 0.5 mol/L NaOH was added to the mixture. In a water bath (Yamato – BT200, Japan), the mixture was boiled for 3.5 hours. It was vacuum filtered through and washed until the pH level was neutral. In an oven, the residue was dried for 4 hours at 105°C (ISUZU CAP, Japan) and weight was measured (W2). The hemicellulose concentration (%w/w) of dry biomass is the difference between the sample weight.

$$\text{Hemicellulose \%} = \frac{(W1-W2)*100}{W1}$$

5) Determination of lignin

It was continued as described by Dence (1992) with slight modification. Dried extracted peanut shell powder (0.3 g) was weighed in a 100 mL conical flask and 3 mL of 72% of H_2SO_4 was added. For full hydrolysis, the sample was maintained at $30°C$ for 1 hour with shaking in a water bath (Yamato –BT200, Japan). Following the initial hydrolysis, 84 mL of distilled water was poured. The second phase of hydrolysis was completed in an autoclave (ALP, Japan) at $121°C$ for 1 hour. At room temperature, the slurry was chilled. The vacuum pump was used to filter the residues. By drying the leftovers at $105°C$ and compensating for ash by burning the hydrolyzed sample at $575°C$ in a muffle furnace, the acid-soluble lignin was measured. By measuring the acid hydrolyzed specimens' absorbance at 300 nm, the acid-soluble lignin fraction was measured. The summation of acid-insoluble and acid-soluble lignin was used to compute the lignin content in a peanut shell.

6) Determination of cellulose

This was described by Ioelovich (2015) and Jin et al. (2017). By subtracting extractives, hemicellulose, lignin and ash from the total solids, the cellulose content (%w/w) was determined.

Cellulose % = Total Solids - (extractives % + Ash % + Lignin % + hemicellulose %)

analysis. By the extraction process, the obtained amount of cellulose was 32.9 g/100g. These results vary from the results of Obasi (2015). It's because of some factors which influence the preparation of the sample and processing of the analysis. As well as the ash, extractives, cellulose, hemicellulose, lignin and total solids in the peanut shell powder was measured. The total solid content of peanut shell powder was 92.038 ± 0.0037 g/100g. The ash content of peanut shell powder was 4.585 ± 0.00056 g/100g. Extractives are composed of fats, fatty acids, fatty alcohols, phenols, terpenes, steroids, resin acids, waxes, and a range of other minor organic compounds (Mansor et al., 2019). As a result, the peanut shell has 2.93 ± 0.015 g/100g of extractives. The colour, aroma, and durability of the biomass are all due to the extractives. (Rowell, 2012). Hemicellulose is a sugar-based material that is sometimes referred to by the sugars it contains. Hemicellulose and lignin are a kind of cellulose that contributes to the structural components of plants (Rowell, 2012). The content of hemicellulose and lignin are 18.1 ± 2.423 % and 32.24 ± 0.081 % respectively. These results were approximately the same as the results of Obasi (2015).

VI. CONCLUSION

This research has shown a straightforward method for determining the cellulose content of peanut shells by standard analysis. Comparable results were obtained for the examined raw materials and

Table 01: Compositional analysis of peanut shell

Composition	Value (%) (By extraction)	Value (%) (By standard)	Reported Composition (%) (Obasi, 2015)
Ash	-	4.585 ± 0.0005	5.9
Extractives	-	2.93 ± 0.015	-
Total solids	-	92.038 ± 0.0037	90.5
Lignin	-	32.24 ± 0.081	30.2
Hemicellulose	-	18.1 ± 2.423	18.7
Cellulose	32.9	34.183 ± 0.012	35.7

The values are means of duplicates ± standard deviation for duplicate analysis

V. RESULTS AND DISCUSSION

Lignocellulosic compounds of peanut shells are given below in Table 01.

A plant cell's major structural component is cellulose. The peanut shell has 34.183 ± 0.012 g/100g of cellulose according to the standard

those published in scientific literature. The cellulose, hemicellulose, and lignin content of the peanut shell are all within the range of lignocellulosic components, according to the findings of this study. It has the potential to become a replacement for cellulose-based products due to its high cellulose, hemicellulose, and lignin content. The significance of the

lignocellulosic study is dependent on a result collected from a comparable field and may change somewhat from prior studies due to other factors influencing it, such as specimen preparation and the analysis procedures.

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