REVIEW: CORN COB WASTE POTENTIAL IN COMMERCIAL PRODUCTS

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ABSTRAK

**ULASAN: POTENSI TONGKOL JAGUNG UNTUK APLIKASI PADA PRODUK KOMERSIAL.** Kegiatan pasca panen hasil pertanian sering menyebabkan limbah pertanian. Salah satu limbah pertanian yang meningkat setiap tahunnya adalah limbah tongkol jagung. Tongkol jagung memiliki kandungan selulosa yang cukup tinggi sehingga memiliki potensi untuk dapat dijadikan sebagai bahan dasar pembuatan serat alami /natural fiber untuk kemudian dapat dijadikan sebagai bahan pembuatan produk-produk komersial. Penelitian ini bertujuan untuk mengulas beberapa potensi tongkol jagung untuk produk komersial. Metode penelitian yang digunakan adalah studi literatur dengan menelusuri sumber-sumber tulisan yang pernah dibuat sebelumnya Dalam penelitian ini, akan diuraikan mengenai metode pemrosesan tongkol jagung untuk pembuatan serat alami serta produk-produk komersial yang dapat dibuat menggunakan limbah tongkol jagung. Dari sumber-sumber sebelumnya yang telah ditelusuri dalam pemanfaatan limbah tongkol jagung, didapatkan 4 produk hasil dari limbah tersebut. Hasil yang didapatkan berupa hidrogel nano berbasis radiasi sinar gamma, karbon aktif dengan proses karbonasi, bioetanol menggunakan proses SSF dan pemanfaatan selulosa tongkol jagung sebagai kampas rem yang berkualitas baik..

Kata kunci: Limbah, tongkol jagung, potensi, produk

ABSTRACT

**REVIEW: CORN COB POTENTIAL FOR APPLICATIONS IN COMMERCIAL PRODUCTS**. Post-harvest activities of agricultural products often generate wastes. One of the agricultural wastes that increase every year is corn cobs, which have a high cellulose content and can potentially be used as raw materials for making natural fibers. Therefore, this study aims to examine the several potential commercial products from corn cobs. The method used is a literature study by tracing the sources of previous writings. Furthermore, how to process corn cobs waste for the manufacture of natural fibers and commercial products will be discussed. From the previously traced sources in the utilization of corn cobs waste, 4 products were obtained. The results are nano hydrogels based on gamma radiation, activated carbon with a carbonation process, bioethanol using the SSF process, and the use of corn cob cellulose as good-quality brake lining.

Keywords: Waste, corn cobs, potential, product

INTRODUCTION

Indonesia is an agrarian country with a variety of agricultural products ranging from rice, cassava, corn, and other important crops that are important in the national industry. In Indonesia, corn is the main food commodity after rice which has a strategic role in agricultural and economic development. The extension of this commodity contributes to the supply of food and industrial raw materials. In fact, the development of corn on a wider scale with higher production has the potential to increase farmers' incomes and the regional economy [1]. However, the long-term impact that needs to be considered in increasing agricultural capacity, especially in corn farming, is the post-harvest waste in the form of husks and corn cobs. The waste in terms of productivity per hectare occupies the lowest place compared to other agricultural wastes. However, because the corn area is quite large and the plant has a relatively short lifespan with 75-120 days after planting, harvests can be obtained several times a year. Therefore, the production yield and total waste are quite balanced with other agricultural wastes except for rice [2].

The corn cob is the part of the plant where the kernels are attached. Currently, the waste is often used as animal feed by the community, but its utilization has not been optimal. This indicates the waste utilization still has a low economic value and will cause environmental pollution when the combustion process is carried out. Corn cobs are one of the most widely available lignocellulosic wastes in Indonesia. Lignocellulosic waste is agricultural garbage that contains cellulose, hemicellulose, and lignin. The cellulose component is a carbon source that can be used by micro-organisms as a substrate in the fermentation process to produce high-value products [3]. Also, the cellulose content in corn cobs is quite large, which causes the waste to have the potential to be used as a natural fiber, and hence more valuable.

Natural fibers are those that come from plants or animals and tend to look like threads. To get the shape of the fiber, it takes several processing steps depending on the character of the basic material. Examples of fiber from plants include cotton, banana midrib, water hyacinth, and corn cobs. Meanwhile, animal fibers include wool, silk, and bird feathers.

The results of the chemical analysis of corn cobs contain hemicellulose (30.91%), alpha-cellulose (26.81%), lignin (15.52%), carbon (39.80%), nitrogen (2.12%), and water (8.38%). From the results of the content analysis obtained, it can be concluded that corn cobs contain a large amount of cellulose which can be used for manufacturing natural fibers [4].

Cellulose is an organic compound with the formula (C6H10O5)n which is the main component of lignocellulose. Furthermore, it is a polysaccharide consisting of linear (elongated, unbranched) chains with several hundred to thousands of linked D-glucose units [5]. The utilization of cellulose is preceded by hydrolyzing it into glucose. However, this process is difficult because the cellulose polymers accumulate together and form very strong long fibers [5].

Hemicellulose is a group of polysaccharides containing many different sugar monomers. These monomers may consist of pentoses (xylose, rhamnose, and arabinose), hexoses (glucose, mannose, and galactose), uronic acid, and acetyl groups. Like cellulose, hemicellulose needs to be hydrolyzed to xylose for utilization [5].

Lignin is a complex structure found in the primary cell wall, as a support for the lignocellulosic structure. The constituent unit is a phenylpropane polymer consisting of guayacyl, syringyl, and p-hydroxyphenyl linked by ether bonds (C-O-C), and/or C-C bonds [3]. Furthermore, lignin is one of the main factors that complicate the enzymes degradation of lignocellulose. Also, lignin is the main barrier to accessing cellulose and hemicellulose, therefore, hydrophobic interactions of lignin with enzyme molecules cause bonds that reduce the ability of the enzymes to hydrolyze cellulose [5].

Processing of natural fiber from corn cobs requires special treatment at the beginning of the process, such as the hydrolysis process, which opens the lignocellulose structure. This should be conducted to allow the cellulose becomes more accessible to enzymes that break down polysaccharide polymers into monomers. [5].

Hence, this study is carried out to identify the potential of corn cobs as raw materials for making commercial products. Furthermore, readers are expected to understand the several stages of processing the identification of potential corn cobs waste. The waste treatment process includes the use of cellulose-based nano hydrogel technology from corn cobs with gamma irradiation, the process of making activated carbon from corn cobs, using X-Ray Diffraction (XRD) to analyze the samples, and the process of making bioethanol.

Method

Literature study is a way to solve problems by tracing previously written sources. This study also uses a literature study method which was performed to examine the main points of corn cobs discussions such as the components, the results, and processes of the obtained waste products. A search was conducted using literature from journals. At the journal article search stage, 16 pieces of literature were obtained with a period from 2006 to 2019 using the keywords "corncob waste", "corncob waste potential using irradiation", "making natural fiber from corncob waste".

Results and Discussion

**Cellulose-based nano hydrogel technology from corn cobs with gamma irradiation**

Cellulose in corn cobs can be used as raw material for hydrogels. These hydrogels are three-dimensional polymer networks with cross-links, which are capable of expanding or retaining water. Considering their properties, hydrogels are used for drug carriers, tissue engineering, separations, and as support materials in biomedical and agricultural applications. The hydrogels can be synthesized from synthetic or natural polymers. Synthetic polymers such as polyhydroxy ethyl methacrylate (pHEMA), polyacrylamide, and polyvinyl alcohol are derived from petroleum derivatives, hence the resulting hydrogel is difficult to decompose in nature. Therefore, efforts to reduce the use of hydrogels made from synthetic polymers should be carried out by developing natural polymers that are environmentally friendly (biodegradable), non-toxic, and abundant [6].

The process of forming a three-dimensional network (cross-linking) on hydrogels can be carried out using chemical cross-linking and gamma irradiation methods. These two methods each have advantages and disadvantages. The several advantages of using gamma irradiation compared to conventional methods are that the process can be quickly carried out, does not require a catalyst, crosslinkers and initiators are not required during polymerization, and there are no residues in the process. Furthermore, the setting of the irradiation dose absorbed by the material can be varied to increase the hydrogel's ability to absorb water.

The water absorption capacity of the hydrogel can also be improved by reducing the cellulose particles to nanocellulose. The nanocellulose based hydrogels have higher absorption and swelling rate compared to micro-cellulose. This is because the smaller particles have an important characteristic of a large surface area to volume ratio. Therefore, more atoms are available to interact with other atoms or ions. The processing of corn cobs waste into nano hydrogels needs to be accomplished to obtain products with a high swelling ability and gel fraction, as well as good mechanical strength, hence they can be optimized in various fields [6].

**Nano hydrogel preparation**

The first stage is a proximate analysis of corn cobs. The extraction of cellulose began with a delignification process to degrade lignin to obtain pure cellulose. This process was carried out for 3 kg of corn cob powder using an 8% 25 liter NaOH solution using an autoclave. Furthermore, the temperature was raised to 110oC and then held for 30 mins at a pressure of 1.5 bar. The corn cobs became blackish-brown due to the delignification process. The bleaching process was subsequently carried out using a 20-liter NaClO solution at room temperature for 1 hour. After which the bleach was rinsed with running water several times until it reaches neutrality. The corn cobs cellulose was then vacuumed to reduce the moisture content. Subsequently, the resulting cellulose was stored in a cold room (4oC) [6].

The preparation of nanocellulose by the wet grinding process was carried out using an ultrafine grinder with cellulose and aquadest ratio of 1:10 (2% of dry weight). The resulting nano cellulose solution was dissolved with PEG (4% wt/vol) and NaOH (8% wt/vol) solutions. The treatment tested was the ratio of nano cellulose solution to the PEG/NaOH solvent, namely 1:2 called sample C2 and 1:4 called C4. The solution was stored in a cold room (4oC) for 1 day, and the sample solution was filtered by vacuum filtration and dried in an oven for 6 hours at 60°C. The dry sample is a control sample without the influence of gamma-ray irradiation which is then stored for further analysis [6].

The nano hydrogel crosslinking process was carried out using the gamma irradiation technique. The advantages of the cross-linking method using gamma irradiation compared to conventional methods include that the process can be carried out quickly, no catalyst needed, crosslinking and initiator are not required during polymerization, and there are no residues in the process [14]. The test treatments were unfiltered (G1) and filtered nano-cellulose with vacuum filtration (G3). The nano cellulose was subsequently irradiated at a dose of 20 kGy with gamma rays at a dose rate of 5.4 kGy/hour. After this process, the solution was filtered by vacuum filtration and dried in an oven for 6 hours at 60oC. The dry samples are those with the influence of gamma irradiation which are then stored for analysis [6].

One of the important parameters of a hydrogel is the ratio of the expanding weight to the dry hydrogel. The nano hydrogel has a higher expansion ratio when irradiated. From these data, it can be concluded that the expansion ratio of C2 control nano hydrogel with a 1:2 ratio of cellulose to solvent has a lower expansion ability than control C4 nano hydrogel with a 1:4 ratio of cellulose to solvent. Meanwhile, C4 has a higher solution concentration, hence the swelling ability and cross-linking formed will increase [15].

The dose used for the irradiation method greatly affects the characteristics of the hydrogel produced. The nano hydrogel with the gamma-ray irradiation method has a high swelling ratio value above 200%. The radiation method utilizes a high-energy ray such as gamma which results in the formation of a three-dimensional cross-linked hydrogel network. The molecular structure of nano-cellulose which is sensitive to radiation exposure forms free radicals, and at the end of the free radical reaction process forms a hydrogel with an interpenetrating network (IPN) which allows the entry of organic or inorganic substances. This shows that when the tissue is in contact with water or a dilute solution, it will absorb water and solutes hence, the nano hydrogel can swell.

**The Process of Making Activated Carbon from Corn Cobs**

Samples of corn cobs that have been cleaned were then put into a kiln for the carbonization process at a temperature of 600°C for 1 hour. Carbonization is an indoor cooking process or a kiln in the absence of oxygen and other chemicals. After the charcoal is formed, the next process is to refine the charcoal to a size of 100 mesh. This is done and the adsorbate absorption process by the adsorbent is faster because the smaller the particle size, the larger the surface area of the adsorbent hence, more metal will be absorbed on the surface [7].

Corn cobs carbon activation aims to remove impurities contained in the pores of the activated carbon by breaking the hydrocarbon bonds or by oxidizing the compounds found on the surface of the adsorbent. The absorption will be higher when the carbon is activated both chemically (with chemical activators) and physically (by heating at high temperatures). In this study, 50 grams of carbon were activated with 500 mL of 4 M hydrochloric acid by soaking for 24 hours. The high concentration of acid solution activator used in the activation process facilitated the process of dissolving impurities on the carbon surface, hence, the pores of the activated carbon opened and expanded the surface [8][13].

**Corncob Sample Analysis Using X-Ray Diffraction (XRD)**

To support the results of the Chesson-Datta analysis, XRD analysis was carried out which aims to determine the degree of crystallinity of cellulose. This is because in this case, cellulose has a crystal structure that is opposite to hemicellulose and lignin which are amorphous materials. Furthermore, XRD analysis used the best data from Chesson data analysis using 5% HCl FeCl3 solvent at 60°C for 240 mins. The XRD analysis data of corn cobs powder before and after sonication can be seen in Figures 1 and 2 below:



Figure 1. XRD graph without sonication. [16]

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Figure 2. XRD graph with sonication. [16]

Comparison of graphs in Figures 1 and 2 shows that both diffractograms have a steep valley at 2θ about 18° to 19° where this steep valley shows an amorphous structure. Furthermore, both diffractograms have sharp peaks at 2θ around 22° to 23° which at the two peaks indicate the crystalline structure of cellulose [11]. In Figures 1 and 2, it can be seen that there is no significant change in the two diffractograms. This indicates that the crystal structure of cellulose does not change before and after the delignification process using ultrasonic wave radiation, but after the delignification process, there are changes in the intensity of the crystalline and amorphous structures. The crystalline structure indicates the cellulose content, while the amorphous indicates lignin and hemicellulose. From the XRD diffractogram in Figures 1 and 2, the degree of crystallinity can be calculated by the Segal method as in Eq (1) [16].

  (1)

With:

CrI : Degree of Crystallinity

I002 : Intensity of the crystalline portion (at 2θ = 22° to 23°)

IAM : Intensity of the amorphous part (at 2θ = 18° to 19°)

The calculations using the Segal method showed that the degree of corn cobs crystallinity before processing was 11.09%. After the delignification process using ultrasonic radiation waves, the degree of crystallinity increased to 44.70%. This increase is due to the release of lignin and hemicellulose groups on corn cobs after the sonication process using HCl and FeCl3 solvents [16].

**Potential and Process for Making Bioethanol from Corncob Waste using the Simultaneous Saccharification and Fermentation (SSF) Process**

Before entering the stage of the fermentation process for making bioethanol, the research team first carried out a preliminary process, namely grinding corn cobs solid waste with a uniform size of -20,+40 mesh [10]. Then the delignification process was carried out using 10% NaOH solution for 28 hours and washed with distilled water to pH neutral. This study was conducted to see the effect of the corn cobs delignification process and to determine the effect of enzyme concentration and fermentation time on the levels of bioethanol produced.

The operating conditions followed the optimum conditions of previous studies, namely fermentation at pH 5, enzyme incubation time of 4 days, and corn cob size of -20,+40 mesh. After the crude cellulase enzyme was obtained, the bioethanol production process was carried out using the simultaneous saccharification and fermentation (SFS) method with Saccharomyces Cerevisiae inoculum and cellulase at variations in enzyme concentrations of 3%, 5%, 7%, 9%, and 11% substrates, and time variations fermentation for 3, 4, and 5 days. After going through the SFS process, part of the solution was taken to test for glucose levels and the rest was purified using a rotary evaporator. Subsequently, the bioethanol content was calculated using an alcoholmeter [10].

Bioethanol and final glucose levels obtained in this study can be seen that the highest 8% bioethanol content was obtained at a variation of 72 hours’ fermentation time and 11% enzyme concentration. Meanwhile, the lowest final glucose level was 855 mg/mL with variations in fermentation time being 72 hours and enzyme concentration being 3% [10].

**Corn Cobs for Other Types of Fiber**

Non-asbestos brake pads have a good braking system when working to slow down vehicle speed compared to those that contain asbestos. In general, brake lining friction materials have three constituents, namely binders, fiber materials, and fillers [12]. The fiber acts as a support for the strength of the composite structure, and the load that is initially received by the matrix is then transmitted to the fiber. Therefore, the fiber should have a higher tensile strength and elasticity than the matrix. Fiber generally consists of two types, namely natural and synthetic. Corn cobs can be used as a natural fiber to increase the friction coefficient and increase the mechanical strength of the material.

Several tests are needed to determine the feasibility of non-asbestos brake linings from corn cobs fiber. The tests include the brake lining surface characterization test using a zoom stereo microscope, hardness testing using the Brinell Hardness Tester, and wear testing using the Ogoshi High-Speed Universal Wear Testing Machine. The test uses comparison in the form of Indoparts brand brake linings which are widely used in the market. From the three tests, the most optimal composition that approximates the hardness and wear test of Indoparts brand non-asbestos brakes is the composition of 30% corn cob powder, 30% brass powder, and 20% MgO and polyester resin [12].

CONCLUSION

Corn cobs have a high cellulose content, hence they have the potential to be used as a raw material for making natural fibers which can then be used as materials for making commercial products such as nano hydrogels, activated carbon, bioethanol, and brake linings. In the process of utilizing corn cobs, a process is needed that aims to change the characteristics of the lignocellulosic components to obtain good quality natural fibers. Furthermore, nuclear technology can be applied to corn cobs waste treatment processes, such as hydrogel manufacturing. Therefore, with good natural fibers as raw materials, high-quality commercial products such as nano hydrogel, activated carbon, bioethanol, and brake linings can be produced.

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