Characterization of the Physical Properties of Bacillus thuringiensis Corn husk Fibers through Alkalization

Krizzian Hernando[1], Mark Dondy Abayon[1], Jio Vinz Sitjar[1], Marc Jerome Aguirre[1] and Joan Catolico[1]

[1] *Philippine Science High School Western Visayas Campus - Bito-on, Jaro, Iloilo City 5000, Philippines*

Abstract –*Bacillus thurigiensis* (Bt) corn husk bers were characterized for possible usage in textile manufacture. The ber yield, diameter and length were determined and compared to that of native sweet corn husks bers Bt corn husks were subjected to alkalization for 60 minutes at 5 g/L and 10 g/L NaOH concentrations. Fibers subjected to 5 g/L and 10 g/L NaOH concentration treatment had a ber yield of 14.69% and 16.74% respectively. The ber diameter and the ber length was greater in the 5 g/L (817.7 m and 11.7 cm) than in the 10 g/L (723.7 m and 5.3 cm) NaOH concentration treatment. Fiber yield was measured using a standard analytical balance. Measurement showed no signicant dierence between the two corn species. Diameter of bers was also measured using the Laser Diraction method and also no signicant dierence can be observed. The ber length, measured using a Vernier Caliper had a signicant dierence. Bt corn husk bers do not have an observable advantage over native sweet corn.

Introduction. – For the past several years, due to the rapid changes in climate, awareness towards these environmental issues accelerated industries to start utilizing sustainable and renewable resources instead of conventional synthetic materials [1]. For a material to be classied as sustainable, it should be biodegradable or recyclable, made from renewable resources, should in any way not cause any harm to the environment and must be on par with conventional materials in terms of quality and price. Agricultural byproducts are amongst one of the most common renewable resources which are usually secondary or residual products from common drops such as cotton, rice, corn and wheat. Residues such as husks, bagasse, and stalks are usually discarded in most countries. Research regarding these residues are commonly studied in the Philippines since its an agricultural country and majority of the practices within the land include burning of these residues or turning them into fertilizer. Some are also utilized as alternative fuel however proper knowledge and procedures are yet to be released and may even pose a threat to the environment as well as the people. This however can help farmers since it reduces their expenditures in the aspect of farming. These agricultural byproducts are cheap source of cellulosic bers. The composition and structure makes them suitable to be used as composites, textile, and paper manufacturing [2]. Bacillus thuringiensis (Bt) corn is a genetically modied species of corn which includes the Bt protein capable of giving protection from pests. Bt-corn hybrids are dierent from nonBt corn not only only in the genetic code but also in some additional genetic material (Bessin 2010). The Bt protein comes from a soil bacterium, Bacillus thuringiensis, which has the ability to produce protein toxins which are harmful to larvae of the pests [44]. Plant based bers contain cellulosic materials that provides strength and rigidity to the bers. Aside from cellulose, non-cellulosic materials are also present such as pectin which holds the bers together and lignin which acts as a binder for cellulose bers adding strength and stiness to the cell walls [4].

According to the Department of Agriculture (DA), corn is the second most important crop in the Philippines in par with being the second largest agricultural crop grown in the world according [5]. Approximately 14 million Filipinos regard corn as their main source of food. Besides being food for humans, nearly 50% of livestock feeds contain corn. Besides the corn itself, other parts can also be utilized for biofuel from corn oil and as stated beforehand, forage and silage for livestock feeds. The numerous amounts of agricultural byproducts such as cob, husk and silk produced by the massive production of corn, especially the Bt corn, is under-utilized or considered as waste.

These agricultural byproducts can be used as a source of raw material for ber. Majority of the parts besides the corn itself such as the cob, husk and silk is under-utilized and considered as a waste by many. These byproducts can be used as a source of ber for many other uses [6].

Methods. – The conduct of the research experiment is divided in six phases: rst, the collection and Bt corn husks; second, the ber extraction; third, calculating the ber yield; fourth, the calculation of the ber diameter; fth, the measurement of the ber length and; sixth, analysis of the data using statistical tests.

Materials. Bt corn was acquired from a sweet corn vendor near the Jaro Public Market. These Bt corn were from a plantation San Miguel, Iloilo. The husks were transported to the Philippine Science High School - Western Visayas Research Laboratory for storage prior to ber extraction. Chemicals and laboratory equipment such as glasswares and measuring devices were borrowed from the Chemistry Lab of the school. Other basic materials such as distilled water were bought from the local supermarket.

Procedure. To extract the bers three set-ups containing 50 grams of corn husks were placed in a container with a 5 g/L NaOH concentration and another three set-ups containing 50 grams of corn husks were submerged in a one liter distilled water with 10 g/L NaOH concentration placed in a two-liter beaker. These beakers were placed on a hot plate set to 450 for 90 minutes. After alkalization, the bers were rinsed in a beaker lled with 50 mL distilled water for ve times. They were then placed on another beaker containing a 50 mL of a 10% acetic acid solution, and then rinsed again until pH 7 is reached. The pH level was measured using a pH meter. After extraction the bers were air dried for 48 hours, each setup was weighed using a top loading balance. A total of 15 samples were descriptively and inferentially measured. The diameters of the samples were measured using the laser diraction method. Each strand was placed on a cardboard with a 4cmx1cm slit. A 532 nm green laser pointer was situated 30cm from the strand. The distance between the strand and the wall was 4m. As the laser pointer hit the strand, the bright bands were measured from the center of the bright central band to the starting edge of the rst bright band to the left. For each measured distance, the diameter of the ber was solved using the formula

$$\frac{\lambda}{\frac{D_m}{D_w}} \tag{1}$$

where = 532 nm, d_{wall} = 4m since it is the distance between the wall and the strand and dis the distance between the center of the bright band of the laser and the starting edge of the rst bright band to the left. The samples were measured from end to end using a Vernier caliper to get its length. The data acquired were analyzed using the IBM Statistical Package for the Social Science (SPSS) Software. The mean and standard deviation were determined for descriptive analysis. The t-test was used to determine signicant dierences between two independent samples in the study.

Results. – This study specically aimed to extract bers from Bt corn husks and determine and compare the ber yield, diameter, and length of extracted Bt corn husk bers when subjected to alkalization treatment with NaOH concentration of 5 g/L and 10 g/L. Bt corn husks were boiled per each concentration and 150 g of the husks were divided into three setups with 50 g each. The three set-ups were boiled in a 2 L solution of water and NaOH. The solution of NaOH and water followed a concentration of 5 g/L and 10 g/L. The three set-ups were boiled for one hour. Each setup was then rinsed with 100 mL 10% acetic acid solution. After rinsing, the bers were again rinsed with distilled water until pH 7 was reached. The pH was measured using a digital standard pH meter. Fifteen samples that were randomly picked per setup were measured for ber diameter and length.

Fiber Length, Fiber Diameter, Fiber Yield. The ber yield after alkalization is higher in the 10 g/L (16.74%) than in the 5 g/L (14.69%) NaOH concentration. Table 1 shows the data.

Table 1: Fiber Yield

NaOH Conc	Mean Fiber Yield	Std. Dvt.
5g/L	14.69	±5.36859
10g/L	16.74	±2.09001

The fiberr diameter is greater in the 5 g/L (817.7 μm) than in the 10 g/L (723.7 μm) NaOH concentration treatment. See table

Table 2: Fiber Diameter

NaOH Conc	Mean Fiber Diameter(cm)	Std. Dvt.
5g/L	817.7	±156.34684
10g/L	723.7	±83.76536

The ber length is greater in the 5 g/L (11.8067 cm) than in the 10 g/L (5.3333 cm) NaOH concentration treatment.

Table 3: Fiber Length

NaOH Conc	Mean Fiber Diameter(cm)	Std. Dvt.
5g/L	11.8	±2.93873
10g/L	5.3	±1.85831

t-test Results on Fiber Yield, Diameter, and Length. The t-test results shows that there is no signicant difference between the ber yield of Bt corn husks treated with 5 g/L and 10 g/L NaOH concentration as reected by the t(4) = -0.547, p=0.613. Additionally, there is no signicant dierence between the ber diameter of Bt corn husks treated with 5 g/L and 10 g/L NaOH concentration as reected by the t(4) =0.918, p=0.411. However, there is a signicant dierence between the ber length of Bt corn husks treated with 5 g/L and 10 g/L NaOH concentration as reected by the t (4) =3.225, p=0.032. See table.

Table 4: T-test Results

Fiber Property	df	t-value	p-value
Yield	4	-0.547	0.613
Diameter	4	0.918	0.411
Length	4	3.225	0.032

Discussion. – Fibers subjected to 5 g/L and 10 g/L NaOH concentration treatment had a ber yield of 14.69% and 16.74 % respectively. The ber diameter diameter in the 5 g/L is 817.7 m and 723.7 m in the 10 g/L NaOH concentration treatment. The ber length in the 5 g/L is 11.7 cm and 5.3 cm in the 10 g/L NaOH concentration treatment. There is very little dierence with the ber yield of Bt corn husks treated with 5 g/L and 10 g/L NaOH concentration. With the dierence of only 2%, there is no substantial eect in the ber yield of Bt corn husks with 5 g/L and 10 g/L NaOH concentration alkalization treatment. The results of Yilmaz in his study in 2013 regarding the chemical extraction parameters of corn husks showed that corn husks treated with 5 g/L NaOH concentration has higher yield (6%) than the husks treated with 10 g/L NaOH concentration (3%). The results obtained by Yilmaz were lower than the results acquired by the researchers which are 14.69% for the 5 g/L and 16.74% for the 10 g/L NaOH concentration treatment. Similar to the ber yield, there is no signicant dierence in the diameter of bers extracted from Bt corn husks. In the study of Ekhuemelo and Tor in 2013 regarding the assessment of corn stalk and husk characteristics, the corn husk ber diameter is 30.19 m. This value is lower than the ber diameter value acquired by the researchers. The dierence in the results acquired compared to the other studies mentioned above is due to the dierence in the components of Bt and non-Bt corn husks; Bt corn husks have higher content of lignin than non-Bt corn hybrids [7]. Lignin, together with cellulose, is the most important structural component of natural bers. Lignin assists in the water transportation and rigidity of plants by adding strength and stiness to the cell walls [8]. The basic components of bers such as cellulose, hemicelluloses and lignin govern the physical properties of bers [9]. The 5 g/L and 10 g/L NaOH concentrations of alkalization treatments have substantial eect on the ber length. The harshness or higher concentrations of alkalization treatments have aected the extracted ber length negatively. NaOH bounds to cellulose molecules into aqueous solution to a certain extent, and prevents macromolecules from associating, so greater amount of NaOH has harsher eect to the bers [10]. The length of corn husk bers extracted by Yilmaz in his aforementioned study is 15.5 cm for the bers treated with 5 g/L NaOH concentration and 9.3 cm for the bers treated with 10 g/L NaOH concentration. This is consistent with the results acquired by the researchers in which bers treated with higher NaOH concentrations have shorter length. Physical properties of natural bers are important in determining the suitability of bers in dierent industrial materials [9]. The length and diameter of Bt corn husk bers extracted from both 5 g/L and 10 g/L NaOH concentrations are within the range of bers extracted from date palm. The similar physical properties shared by date palm and Bt corn husk bers have potential for a wide range of applications [11,12]. These applications include natural ber composites (NFC) and modern industrial applications such as materials for the automotive industry [11]).Factors that may aect the data acquired by the researchers are the following: dierent models of hot plates used by each setup, the rinsing done separately by the three researchers, and the other factors such as climate, weather conditions and soil quality [13]. Furthermore, various other physical properties were not characterized by the researchers due to the time constraint and lack of budget and expertise. Compared to the industrial properties of ber, bt corn husk bers are on par in terms of basic properties such as ber length. In terms of ber length distribution, bt corn bers are not equal to that of industrial ber. This is due to the processes done in order to retrieve the ber. Fiber length distribution indicates the strength, length and yield of a ber. The higher the value, the higher its potential in the industry. Bt corn husk bers are not equal to industrial bers however it still has potential in the industry due to the fact that it comes from agricultural byproducts. In summary, there is no signicant dierence in the ber yield and diameter of Bt corn husks bers, while there is a signicant dierence in ber length. Bt corn husk bers dier in native corn husk bers due to the abundance of lignin in Bt corn husk bers. Lignin is one of the most important structural components of natural bers. These physical properties of Bt corn husks are within the range of date palm bers. Consequently, Bt corn husk bers have a potential wide range of applications.

Conclusion. – The ber yield and diameter of bers treated with 5 g/L and 10 g/L NaOH concentration have no signicant dierence while there is signicance in ber length. As compared to industrial ber, bt corn husk bers are comparable only in terms of mechanical properties such as length and cannot stand alone as enough evidence for it to be in the same level as industrial bers.

Recommendations. – It is recommended to conduct the boiling of Bt corn husks in 5 g/L and 10 g/L concentration at the same time since factors such as air temperature and humidity has an eect in the boiling time and cooking of Bt corn husks[14]. The use of fully-functional hot plates with similar models is also recommended as this, too, can aect the boiling time and cooking. It is also recommended to use Bt corn husks with the same moisture content, age, and condition. Using dierent NaOH concentrations and cooking time is also recommended since this can aect the physical properties of Bt corn husk bers[15]. Expansion or additional parameters to be acquired is also advised not only to gain more supporting data but also to expand the range of uses of the ber and not limit it to textile industries only.

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