Optimization Production and Characterization of Bacterial Cellulose from Corn Husk

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Optimization Production and Characterization of Bacterial Cellulose from Corn Husk

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Abstract

Cornhusks are agricultural wastes with low economic value and will cause environmental pollution if not appropriately handled. Cornhusk waste can be processed as raw material in bacterial cellulose (nata) because it contains 44% cellulose. This study aims to optimize bacterial cellulose production from corn husks and determine the effect of corn husk mass and fermentation duration on the characteristics of the nata that produced. The primary process in producing bacterial cellulose from corn husks is fermentation by *Acetobacter xylinum*. The nata characterization is carried out, which includes thickness, yield, crude fiber content, and moisture content, as well as statistical analysis to determine whether there is a significant effect of variations in corn husk mass and fermentation duration on bacterial cellulose produced. Based on the results of optimizing the production of nata from corn husks, the optimal mass of corn husks is 50 grams with a fermentation duration of 14 days. Based on the characterization and data analysis results, that variation in the mass of cornhusks and fermentation duration had a significant effect on fiber content, yield, and tensile strength of bacterial cellulose from corn husks. On the other hand, variations in the mass of corn husks and duration of fermentation did not significantly affect the moisture content and thickness of bacterial cellulose from cornhusks.

Keywords: cornhusk; fermentation; nata; optimization

1. Introduction

The most abundant natural polymer in the world is cellulose. Cellulose obtained from the synthetic process of acetic acid bacteria is commonly known as bacterial cellulose [1, 2]. Bacterial cellulose is a nanomaterial produced by various strains of Acetobacter species and Pseudomonas, Achrobacter, Alcaligene, Aerobacter, Azotobacter strains [3]. Bacterial cellulose or natural hydrogels have better properties than hydrogels produced from synthetic polymers. For instance, bacterial cellulose shows high water content (98-99%), good liquid absorption, wet strength, and high chemical purity and can be safely sterilized without changing its structure and properties in the slightest [4].

Bacterial Cellulose (BC) has always attracted the interest of scientists because it has a high level of purity, has biodegradability, biocompatibility, and ease of polymerization [5], [6]. Bacterial Cellulose (BC) can be applied to engineering skin tissue and bone, barrier technology and electricity, electrochemistry, and sensing applications [7]–[11]. Although BC has excellent potential, its high production costs limit its industrial-scale applications.

Kurniawan et al. [12], created new bacterial cellulose from chayote fruit and bamboo shoots. The BC has excellent mechanical properties such as tensile strength, elongation and water absorption capacity. On the other hand, there have been efforts to evaluate the possibility of utilizing other agricultural wastes for carbon sources in bacterial cellulose production, including corn products, coffee cherry husk (CCH), date fruits, and banana peel. The findings were parallel with research evidence that

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steep corn liquor is rich in nutrition, which supplied organic content during BC production, such as carbon and nitrogen [5], [13].

Sulistiyana [14] also has researched that light yellow corn extract can be used as an ingredient for making nata de corn with the optimum condition for 14 days of fermentation. The characterization of nata de corn from light yellow corn substrate includes the yield of 46.82%, the water content of 93.13%, and fiber content of 1.31%. This value has met the quality standards of nata according to SNI No. 01-4317-1996. Among the substrates that have been widely used in previous studies, the use of agricultural waste biomass can be an alternative instead of having to use food ingredients that will disrupt food security.

That is why, active research investigating the cost-effectiveness of BC synthesis from different waste products is ongoing and needs to be elaborated currently. Many agricultural wastes are rich in carbon and nitrogen content; therefore, utilizing it as a substrate can produce high concentrations of microbial cellulose by optimizing the culture conditions [15].

Therefore, one of the agricultural waste biomass that can be used is corn husks. Corn husk is an abundant agricultural waste and is widely used as a raw material for handicrafts, bio-ethanol production, pulp alternatives, etc. Corn husk is the part of the plant that protects the corn kernels, is bright green when young, and dries on the trees as it ages. Communities commonly use corn husk waste as animal feed, but its utilization is under-utilized. Corn husks still have little economic value.

In the present work, it is necessary to determine whether corn husks can be used as raw material to manufacture bacterial cellulose and to determine the optimal conditions required for the production of bacterial cellulose in terms of the results of the characterization of its physical and chemical properties.

2. Materials and Method

2.1 Materials

Corn husk (obtained from the traditional market Landungsari-Malang), *Acetobacter xylinum* starter in liquid medium of coconut water (from Laboratory of Process Engineering, Agricultural Industry Technology Study Program, UNITRI), pro analysis urea, pro analysis glucose, glacial acetic acid (Merck 100%), and aquadest. Characterization tests were done at Laboratory of Chemistry - UNITRI and Laboratory of Animal Husbandry - UMM.

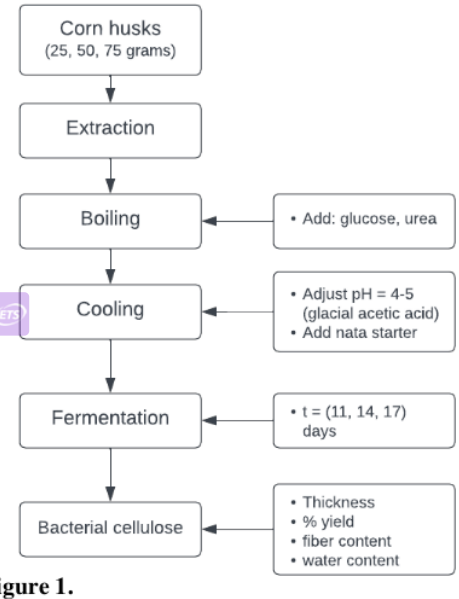

Figure 1.
Research flowchart

2.2 Bacterial Cellulose Production from Corn Husk Extract

Raw materials (cornhusks) weighed as much as 25, 50, and 75 grams and then blended with 1 liter of distilled water. Hot maceration was done after boiled then filtered to get the corn husk extract. Glucose added as much as 100 grams and 4 grams of

urea, then stirred while brought to a boil. The mixture was then adjusted to pH 4 by adding glacial acetic acid. If pH 4 has been reached, a mixture of 250-300 ml each poured into a sterile plastic box container and then added 20 ml of nata starter for every 100 ml of the mixture. All of them stored for fermentation at room temperature with variation of fermentation duration (11, 14, and 17 days). The same procedures were applied for each corn husk mass variation. Bacterial cellulose/nata were harvested and cleaned using running water and sterilized by soaking it in hot water.

2.3 Characterization of Bacterial Cellulose from Corn Husk

The next step is to characterize the physical properties (thickness and %yield) and chemical properties (fiber and water content analysis). The most optimal conditions determined using a statistical analysis called the ANOVA test from the results of the characterization of each bacterial cellulose from mass variations of corn husk and fermentation duration.

3. Result and Discussion

3.1 Optimization of Cornhusk Bacterial Cellulose Production

Based on Figure 2, it appears that the longer the fermentation duration, the wet weight of bacterial cellulose also increased. The wet weight of nata for 11 days to 14 days of fermentation significantly increased, while between 14 days and 17 days, there was not much difference.

Then for variables in the mass of raw materials (25, 50, and 75 grams), when compared to each fermentation duration, all of them have the same curve pattern; specifically, the wet weight of nata has increased for the mass of raw materials 25 grams to 50 grams, and subsequently reduction for the mass of raw materials 75 grams. The optimal condition for producing bacterial cellulose from cornhusks was 50 grams and 14 days for fermentation duration.

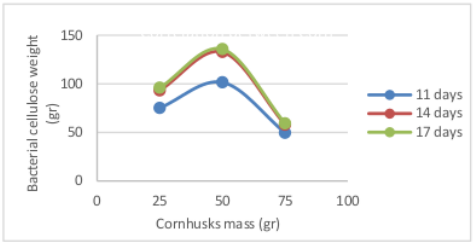

Figure 2. The correlation between cornhusk mass and fermentation duration to the bacterial cellulose weight

Duration of the fermentation affected the formation of nata or bacterial cellulose. Meanwhile, too long fermentation caused *Acetobacter xylinum* bacteria went to the death phase due to lack of nutrients and depletion, causing cells to lose a lot of energy reserves. According to Putriana and Aminah [16], fermentation duration caused bacteria growth slowed down due to reduced sugar levels and the emergence of acid as metabolite of fermentation process. Incubation time in the manufacture of nata used consists of over 6-12 days, 14 days, 16 days, and 21 days.

3.2 Characterization and Results of Statistical Analysis

The data on the characterization of bacterial cellulose from cornhusks with the variable in the cornhusks mass and the fermentation duration, including fiber content, moisture content, yield, and thickness are summarized in Table 1.

The factorial ANOVA test was carried out to test whether there were differences in the average for the mass of corn-husk (25 gr, 50 gr, and 75 gr), the duration of fermentation (11 days, 14 days, and 17 days), and interactions between corn-husk mass and fermentation duration on the

variables measured (fiber content, moisture content, yield, and thickness).

Table 1. Bacterial Cellulose Characterization Results Data

No	Cornhusk mass (gr)	Fermentation Duration (days)	Fiber Content (%)	Moisture content (%)	Yield (%)	Average Thickness (cm)
1	25	11	52.39	98.62	30.05	0.50
		14	49.18	98.64	37.27	0.65
		17	13.69	94.29	38.36	0.63
2	50	11	47.75	98.44	40.59	0.67
		14	36.45	97.97	53.08	0.87
		17	14.26	93.97	54.25	0.85
3	75	11	58.60	98.89	19.83	0.34
		14	55.88	98.90	23.12	0.44
		17	15.69	95.93	23.69	0.41

If the ANOVA factorial analysis results show a significant difference, then a further test (if the treatment being compared is more than 2), namely the Tukey test, then a different notation will be given if the two treatments are in different subsets, which means that the two are significantly different. Meanwhile, the same notation will be given if they are in the same subset, which is not significantly different.

The highest average thickness score in treatment A2B2 (mass of cornhusks 50 gr, fermentation duration 14 days) was 0.8750, and the lowest average thickness score in treatment A3B1 (mass of cornhusks 75 gr, fermentation duration 11 days) of 0.3400. To see whether the difference in the mean between the treatment groups was significant or not, a factorial ANOVA analysis was carried out.

Table 2. The Anova Factorial Analysis Results of Average Thickness Parameter

Treatment	Average	Notation	Average A	Average B
A1B1 (mass 25gr, 11 days fermentation)	0.5000	a	A1 (massa 25 gr) = 0.5938 ab	B1 (fermentasi 11 hari) = 0.5033 a
A1B2 (mass 25gr, 14 days fermentation)	0.6500	a		
A1B3 (mass 25gr, 17 days fermentation)	0.6313	a		
A2B1 (mass 50gr, 11 days fermentation)	0.6700	a	A2 (massa 50 gr) = 0.8604 b	B2 (fermentasi 14 hari) = 0.6542 a
A2B2 (mass 50gr, 14 days fermentation)	0.8750	b		
A2B3 (mass 50gr, 17 days fermentation)	0.8563	b		
A3B1 (mass 75gr, 11 days fermentation)	0.3400	a	A3 (massa 75 gr) = 0.3961 a	B3 (fermentasi 17 hari) = 0.6333 a
A3B2 (mass 75gr, 14 days fermentation)	0.4375	a		
A3B3 (mass 75gr, 17 days fermentation)	0.4125	a		
F (p-value)				
Nata	6.014 (0.022)*			
Concentration	0.986 (0.410)			
Nata * Concentration	0.050 (0.994)			

*: significant with α 5%

From the results of the ANOVA factorial test, table 2 shows that:

a) There is a significant average difference based on treatment factor A (mass of cornhusks) on the variable mean thickness number measured, it can be seen from the p-value which is smaller than (0.022 < 0.050). The highest average thickness of the 50 g corn husk mass was significantly different from the 75 g corn husk mass, but the 50 g corn husk mass was not significantly different from the 25 g corn husk mass.

b) There is an insignificant average difference based on treatment factor B (fermentation duration) to the measured average thickness number variable, it can be seen from the p-value which is greater than (0.410 > 0.050). The average thickness of the average number of fermentation duration was not significantly different from the

average number is not too much different.

c) There is an insignificant average difference based on the interaction of treatment factors A (mass of corn husk) and B (fermentation duration) on the variable number of average thicknesses measured, it can be seen from the p-value which is greater than (0.994 > 0.050). The average thickness score on the interaction of corn husk mass treatment and fermentation duration was not significantly different, as seen from the average number between treatments which was not much different.

The conclusions from the results of the factorial ANOVA test for all characterization parameters are:

a) The treatment of cornhusk mass and fermentation duration and their interactions had a significant effect on fiber content, with the significance value of the ANOVA test results being significant (p<0.05)

b) Fermentation duration had a significant effect on water content with the significance value of the ANOVA test results being significant (p <0.05). While the treatment of cornhusk mass and its interaction with fermentation duration did not significantly affect the water content with the significance value of the ANOVA test results was not significant (p>0.05).

c) Treatment of cornhusk mass and fermentation duration and their interactions have a significant effect on the yield, with the significance value of the ANOVA test results being significant (p<0.05)

d) The treatment of cornhusk mass has a significant effect on water content with the significance value of the ANOVA test results being significant (p <0.05). While the fermentation duration treatment and its interaction with the mass of cornhusk did not significantly affect the water content, the significance value of the ANOVA test results was not significant (p> 0.05).

4. Conclusion

The optimal corn-husk mass was 50 grams with fermentation duration of 14 days. Both corn-husk mass and fermentation duration significantly affect fiber content and yield, but didn;t affect significantly the moisture content and thickness of bacterial cellulose from corn-husk. The benefit of this research is to provide innovative raw materials for making bacterial cellulose by utilizing agricultural waste biomass. Also provides an overview of the optimal conditions in the manufacture of bacterial cellulose from corn husks.

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