Change of chemical components content in andong and yellow bamboo due to various steam treatment

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Abstract. The purpose of this research is to determine the changes of chemical components content in andong bamboo (Gigantochloa pseudoarundinacea) and yellow bamboo (Bambusa Vulgaris var. striata) due to steam treatment and rinsing with water or sodium hydroxide solution. Samples was taken from culm without bark and node part of the bamboo. The treatments of sample were steam at 126 °C and 0.14 MPa for 1 hour, steam and rinsing with water, and, steam and rinsing with 1% NaOH, respectively. Air-dried samples were then subjected to mill in order to get 40-60 mesh particle size, which was used for chemical components analyses. The results showed that steam and rinsing with water or 1% NaOH solution treatment reduced hemicellulose and extractive contents (dissolved in cold water, hot water, 1% NaOH solution, and ethanol-benzene), whereas alpha-cellulose and lignin were relatively stable. Steam and rinsing treatment generally increased the pH value of bamboo sample. The chemical component change of the bamboo due to the treatments would affect the quality of finish product manufactured especially on its physical and mechanical properties.

1. Introduction
Andong and Yellow bamboo has a great potential in the substitution of wood because it is easily in obtained and it can find in the whole of Indonesia. Bamboo can be developed as a raw material for some composite products such as OSB. The use of bamboo as a raw material in OSB provide some weakness such as low dimension stability and susceptible to termites attack. Innovations that developed to improve the properties of OSB based bamboo is by steaming the strand that modified by rinsing with water and weak alkaline solution (1% NaOH). Previous research showed that treatments mentioned before significantly improve the dimensional stability of OSB prepared from betung bamboo strands produced[1][2][3]. OSB with the best dimensional stability prepared from betung bamboo strand with steam and rinsing with 1% NaOH. Another research showed that steam treatment on wood fiber and wood strands can improve the physical properits, mechanical properties and also dimensional stability of fiberboard and OSB produced[4][5]. Rowell et al.[5] also stated that steam treatment can turn free sugar into furan intermediate and further furan resin that can improve the dimentional stability of products.
The purpose of this research is to determine the changes of chemical components content in andong bamboo (*Gigantochloa pseudorudinacea*) and yellow bamboo (*Bambusa Vulgaris var. striata*) due to steam treatment and rinsing with water or sodium hydroxide solution.

2. Materials and methods

For the present study andong and yellow bamboo were collected from Sukabumi District, West Java, Indonesia. Ethanol-benzene, Sulfuric acid, Sodium hydroxide, NaClO2, acetic acid, distillate water used for determining chemical component of the bamboo.

2.1. Treatment and sample preparation

Strands were steamed at 126 °C for 1 hour at a pressure of 0.14 MPa. Strands then separated into 3 samples. One of them didn’t rinsed, one rinsed with distillate water after steamed and the other one rinsed with 1% NaOH. After that 4 type sample treated and untreated grinded and screened into sawdust with 40-60 mesh size.

2.2. Determining holocellulose

Methods to determine holocellulose is refer to Browning methods[6]. 2.5 grams sample placed into flask then 150 ml distillate water, 1 grams NaClO2, 1 ml acetic acid added respectively. Sample heated at 70 – 80 °C using waterbath. Every 1 hour of reaction time 1 grams NaClO2 and 0.2 ml acetic acid were added until 4 times. After residue become whitish, sample then screened and washed using 500 ml distillate water and 25 ml of 10% acetic acid after that samples were oven dried at 103 ± 2 °C for 24 hours then weighed until constant condition.

2.3. Determining alpha-cellulose

1.5 grams holocellulose samples were placed into erlenmeyer then 75 ml of 17.5% sodium hydroxide were added at 20 °C temperature and stirred until samples completely wetted. Stirrer rinsed with 25 ml of 17.5% sodium hydroxide and the mixture was left to stand for 30 minutes at 25 ± 0.2 °C. 100 ml distillate water were added and the mixture left to stand for another 30 minutes. Samples then screened and rinsed with hot distillate water. After that samples rinsed again with 10% acetic acid 3 times followed by hot distillate water until acid free. samples were oven dried at 103 ± 2 °C for 24 hours then weighed until constant condition.

2.4. Determining klasom and acid soluble lignin

Methods to determine acid insoluble lignin was refer to TAPPI T 222[7]. 1 gram of sample was placed into beaker glass then 15 ml of cold 72% sulfuric acid added gradually in small increments while the samples stirred and macerated with glass rod. Then samples kept in a bath at 2 ± 1 °C during dispersion. After dispersed watch glass used to cover the beaker and the samples kept in a bath at 20 ± 1 °C for 2 hours whiles stirred to ensure complete solution. 300 ml to 400 ml distillate water was placed into a flask followed by samples transfer to the flask. Samples then rinsed and diluted with water to 3% concentration of sulfuric acid until the volume reach 575 ml. the solution then boiled for 4 hour. Hot water added frequently to maintain constant volume. The solution then screened and rinsed with hot water. After that residue samples rinsed again with 10% acetic acid then washed with hot water to get acid free samples. residue samples then oven dried at 103 ± 2 °C for 24 hours then weighed until constant condition to determine acid insoluble lignin and the remaining solvent then tested using UV Spectrophotometry to determine acid soluble lignin.

2.5. Determining cold water solubility extractives

The specimen placed in a 400-mL beaker and 300 mL of distilled water added slowly, make sure the wood or pulp is well wetted initially to avoid tendency to float. Extraction was carried out at 23 ± 2 °C with constant stirring for 48 h. The material transferred to a tared filtering crucible which has been previously dried to a constant weight at 103 ± 2°C, then washed with 200 mL of cold distilled water,
and dried to constant weight at 103 ± 2°C. The heated crucible placed in a tared, loosely-stoppered weighing bottle and cool in a desiccator before weighing.

2.6. Determining hot water solubility extractives
The specimen transferred to a 250-mL Erlenmeyer flask, 100 mL of hot distilled water added and erlenmayer placed in a boiling water bath. The reflux condenser attached and digested for 3 h, making certain the water level of the bath is held above the stock level in the flask. The contents of the flask transferred to a tared filtering crucible which has been previously dried to a constant weight at 103 ± 2°C, then washed with 200 mL of hot water and dried to constant weight at 103 ± 2°C.

2.7. Determining ethanol-benzene solubility extractives
2 grams test specimens weighed in tared alundum or fritted-glass crucible. One specimen dried in an oven at 103 ± 2°C then placed in a loosely stoppered weighing bottle, cooled in a desiccator, and weighed. Then proportion of moister-free sawdust in the air-dried specimens was calculated. The other specimen placed in a Soxhlet extraction apparatus having a tared Soxhlet extraction flask. Small disk of fine-mesh screen wire was set in the top of the crucible to prevent loss of specimen. Extract with 150 mL of ethanol-toluene solution for 6 to 8 h, keeping the liquid boiling briskly. This should provide four to six siphonings per hour. After evaporating the solvent from the extraction flask, dry the flask and contents in an oven for 1 h at 103 ± 2 °C, cool in a dessicator, and weigh. Continue the drying until there is no further loss in weight.

3. Results and discussion

3.1. Holocellulose

![Figure 1. Holocellulose content of andong and yellow bamboo](image)

Holocellulose is total fraction of carbohydrate consist of hemicellulose and alpha-cellulose. Holocellulose content of andong and yellow bamboo under various treatment ranged from 64.77% to 70.04% (figure 1). Kuning bamboo without treatments has the highest holocellulose content while bamboo with steam + 1% NaOH rinse treatment has the lowest content. Statistical analysis showed that interaction between bamboo species and the treatments gave significant influence to holocellulose content of the bamboo. Duncan multiple range test shows that strands with steam+ 1% NaOH treatment is significantly difference with the others bamboo.
The decreasing trends of holocellulose content in both of bamboo allegedly because of the decomposition of hemicellulose while steam treatments. Decomposition of hemicellulose can provide better dimensional stability because hygroscopicity of hemicellulose is higher than cellulose and lignin [8]. Less hemicellulose content means less free hydroxyl group that can bind water.

3.2. Alpha-cellulose

![Figure 2. Alpha-cellulose content of andong and yellow bamboo](image)

The result of this research showed that alpha-cellulose content of andong and yellow bamboo is ranged from 43.99% to 39.10% (figure 2). Andong bamboo with steam treatment has the highest alpha-cellulose content while yellow bamboo with steam treatment has the lowest value. Statistical analysis showed that interaction between bamboo species and the treatments give significant influence to alpha-cellulose content of both of bamboo. While yellow bamboo without treatments are significantly different.

Alpha-cellulose is a parameter to determine purity of cellulose. In this case alpha-cellulose contributed in tensile strength value of betung bamboo so that product manufactured will have good mechanical properties. But on the other side higher alpha-cellulose content indicated that bamboo is susceptible attacked by termites.

3.3. Klason lignin

Klason lignin content of betung bamboo strands is ranged from 28.86% to 26.90% (figure 3). Yellow bamboo without treatments has the highest klason lignin content whereas andong bamboo with steam + 1% NaOH rinse treatment has the lowest content. Statistical analysis showed that bamboo species and treatments give significant influence to klason lignin content of andong and yellow bamboo. Bamboo without treatment is significantly different with the treated bamboo.

Lignin act as adhesive in woods, it bind cellulose fiber so that lignocellulosic materials become hard and stiff. Lignin have less free hydroxyl groups so it become hydrophobic. So it can conclude that materials with higher lignin content provide better dimensional stability.
Figure 3. Klason lignin content of andong and yellow bamboo

3.4. Acid soluble lignin

Figure 4. Acid soluble lignin content of andong and yellow bamboo

The result of this research showed that acid soluble lignin content of andong and yellow bamboo is ranged from 1.31% to 1.41% (figure 4). Andong bamboo with steam + water rinse has the highest acid soluble lignin content while yellow bamboo with steam treatment has the lowest value. Statistical analysis showed that interaction between bamboo species and treatments give significant influence to acid soluble lignin content of both of bamboo.
3.5. Cold water soluble extractives

![Cold water soluble extractives content of andong and yellow bamboo](image)

**Figure 5.** Cold water soluble extractives content of andong and yellow bamboo

Cold water soluble extractives content of andong and yellow bamboo is ranged from 4.79% to 8.11% (Figure 5). Untreated andong bamboo has the highest cold water soluble extractives content whereas andong bamboo with steam + 1% NaOH rinse treatment has the lowest content. Statistical analysis showed that interaction between bamboo species and treatments give significant influence to cold water soluble extractives content. Both of untreated bamboo is significantly different with the treated bamboo.

3.6. Hot water soluble extractives

![Hot water soluble extractives content of andong and yellow bamboo](image)

**Figure 6.** Hot water soluble extractives content of andong and yellow bamboo
Hot water soluble extractives content of andong and yellow bamboo is ranged from 5.03% to 10.03% (Figure 6). Untreated yellow bamboo has the highest hot water soluble extractives content whereas andong bamboo with steam + 1% NaOH rinse treatment has the lowest content. Statistical analysis showed that interaction between bamboo species and treatments give significant influence to hot water soluble extractives content. Duncan multiple range test showed that andong bamboo with steam + 1% NaOH rinse treatment is not significantly different with the other treated andong bamboo but significantly different with untreated andong bamboo and all yellow bamboo. Steam + 1% NaOH rinse treated yellow bamboo is not significantly different with steam+ water rinse treated yellow bamboo and but significantly different with steam treated and untreated yellow bamboo.

3.7. Solubility in 1% NaOH solution

![Figure 7. Solubility in 1% NaOH solution of andong and yellow bamboo](image)

Solubility in 1% NaOH solution of andong and yellow bamboo is ranged from 19.30% to 23.56% (Figure 7). Untreated yellow bamboo has the highest solubility whereas andong bamboo with steam + 1% NaOH rinse treatment has the lowest content. Statistical analysis showed that bamboo species and treatments give significant influence to solubility in 1% NaOH solution. Duncan multiple range test showed that untreated bamboo is not significantly different with steam treated bamboo but significantly different with steam+water rinse and steam+1% NaOH rinse treated bamboo.

3.8. Ethanol-benzene soluble extractives

The result of this research showed that Ethanol-benzene soluble extractives content of andong and yellow bamboo is ranged from 3.64% to 7.41% (Figure 8). Andong bamboo without treatment has the highest ethanol-benzene soluble extractives content while yellow bamboo with steam+ water rinse treatment has the lowest value. Statistical analysis showed that interaction between bamboo species and treatments give significant influence to Ethanol-benzene soluble extractives content of both of bamboo. Duncan multiple range test showed that untreated andong bamboo is significantly different with treated andong bamboo and all yellow bamboo. untreated yellow bamboo is not significantly different with steam treated yellow bamboo and steam+1% NaOH rinse treated andong bamboo but significantly different with steam+water rinse and steam+1% NaOH rinse yellow bamboo.
Figure 8. Ethanol-benzene soluble extractives content of andong and yellow bamboo

The existence of extractives can affect quality of adhesion on finish product. Less extractives content can provide better adhesion on the products. Steam + rinse treated bamboo has the lower extractives content so that can provide better adhesion on finished products.

3.9. pH value

Figure 9. pH value of andong and yellow bamboo

The result of this research showed that pH of andong and yellow bamboo is ranged from 4.68 to 7.37 (Figure 9). Andong bamboo with steam+1% NaOH treatment has the highest pH value while untreated yellow bamboo has the lowest value. Statistical analysis showed that interaction between bamboo species and treatments give significant influence to pH value of both of bamboo. Duncan multiple range test showed that every treatments is significantly different.
The increasing trends of pH value indicates that steam+1% NaOH treated andong bamboo would have better adhesion on finished product using neutral to basic pH curing adhesive such as phenol formaldehyde. While acidic pH curing adhesive is better for untreated bamboo.

4. Conclusions
Treatments given to andong and yellow bamboo resulting chemical component change of both of bamboo that would affect the quality of finish product manufactured especially on its physical and mechanical properties. Treatments also affect the pH value of andong and yellow bamboo that will resulting better adhesion in its constituted product using basic pH curing adhesive.

5. References
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