

Evaluation of Castor Stems Residue for Cellulose and Lignin Content

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Abstract

Castor is an important crop of arid and semi-arid regions of the country. The castor cultivation in India is increasing year after year. In India, Gujarat and Rajasthan are two major states producing more than 80% of total castor production. The castor seeds are crushed or expelled to get castor oil, which is further used to make many important derivatives for industrial purposes. Castor being more remunerative crop to farmers of arid and semi arid region and the adoption of castor cultivation has improved the livelihood of farmers. Due to non-perishable nature of castor seeds, sometimes farmers store castor for long times growing seasons without any reduction in marketable quality of castor seeds. Cellulose is the major component of castor plant and the paper is composed of cellulose fibers. Paper and pulp industry has found suitability of use of sugarcane bagasse as raw material for paper production. Castor GCH-7 hybrid plants attained an average height of 100-110 cm with 25-30 branches. The diameter of main spike branch and sub-spike branches were ranged between 3.0-5.0 cm and 2.0 to 3.0 cm, respectively. The cellulose content was observed to 45.7%. The present study showed that the cellulose content in castor stem was remarkably higher than the other agro waste, therefore have potential to be used in paper industry, which was around 11% more than sugarcane bagasse, 25% more than rice straw and 50% more than wheat straw. In the present study, the lignin content was found 17.2%. The present study showed that the lignin content in castor stem was less than the other agro waste used in paper industry, which was around 30% less than sugarcane bagasse, 40% less than rice straw while 7% more than wheat straw. The ash content of castor samples was observed to 2.3%.

Highlights

- The cellulose content in GCH-7 castor stem was observed to 45.7% and the lignin content was found 17.2%.
- The present study reveals that castor stem could be a source of cellulose and lignin.

Keywords: Castor seed, cellulose, lignin, paper, pulp, bagasse

The castor oil and its derivatives are highly demanded for its use in a number of industrial applications at present. Castor bean (*Ricinus communis* L) is a non-edible oilseed crop mainly cultivated in arid and semi-arid regions of India. The latest statistics shows that worldwide castor was grown on a total area of

1.68 m ha. Out of total global castor production, India alone produced 2.34 million tonnes of castor, while second and third largest producer countries, China and Brazil produced 0.18 and 0.12 million tones of castor, respectively. The production trend of castor is increasing since starting of commercial castor



cultivation in India. In year 1961, the castor cultivation in India was only in 0.49 mha and 0.10 mt production with a productivity of 224 kg/ha, remarkably over the years of continuous improvement, in year 2011, the castor area reached to 1.25 m ha and production 2.34 mt with about eight times increase in productivity that is 1871 kg/ha (FAO Stat. 2013). In India, Gujarat and Rajasthan are two major states producing more than 80% of total castor production of the country, credited to adoption of newly developed hybrids, creation of irrigation facility and adoption of improved cultivation practices and concerted efforts of farmers and agri-extension machinery. Castor being more remunerative crop of arid and semi arid region, the adoption of castor cultivation has changed the livelihood of farmers. Due to non-perishable nature of castor seeds, sometimes farmers store castor for longer times without any reduction in marketable quality of castor seeds. At the time of final harvesting, most of castor leaves are shed and castor stem remained erected in the field. Some farmers have no use of castor stems except, burning for household purposes. Mostly castor stems are either collected and burnt or mixed well in the soil with the help of rotavator. Mixing of pieces of castor stem showed the infestation of termites in arid and semi-arid regions.

With the advancement of technology and knowledge, to meet out increasing demand, better resource management and to cut down the cost of production, human is continuously in search of new raw materials. The pulp and paper industry is not an exception. Cellulose is the major component of castor plant and the paper is composed of cellulose fibers. Paper and pulp industry has found suitability of use of sugarcane bagasse as raw material for paper production. The residues of castor if used in paper and pulp industry, it would be a further increase in the earning of castor growing farmers besides it will provide raw material to the paper and pulp industry, which is otherwise, dependent of forest, agro-forestry or agri based by products as their raw materials. Crop residues such as sugarcane showed satisfactory outcome in production of paper and pulp, research

regarding non-conventional agricultural residues like castor stems as feed stock is important. In this context, the aim of present research work consists of to determine few key characteristics like lignin and cellulose content to evaluate its potential for paper and pulp industry.

Materials and Methods

Most popular and suitable in castor growing areas of the country, castor hybrid GCH-7 was considered to be evaluated for cellulose and lignin content in their straw. Castor crop residues remaining erected in fields were collected from the Main Castor-Mustard Research Station, Sardarkrushinagar (Gujarat, India). The samples were dried and grinded in mill type grinder and used for analysis for various parameters.

Determination of moisture content: A known quantity of field dried straw was kept in an aluminium box in a ventilated oven at $105\pm 2^{\circ}\text{C}$ for 4 hrs then transferred to a desiccator for cooling to normal. Moisture content was determined as

$$\% \text{ Moisture} = \frac{[\text{Initial wt (g)} - \text{wt of dry sample (g)}]}{\text{wt at initial (g)}} \times 100$$

Determination of cellulose and lignin content: 20.0g sample was treated with 72% Sulphuric acid as per the prescribed method to calculate cellulose and lignin content (AOAC official method 1990).

Determination of ash content: For the determination of inorganic material (ash), 1.0g of sample was placed in pre-weighed porcelain crucible and heated at 300°C for 2 hrs. Ignite it at 500°C for 2 hrs in a muffle furnace. The samples were placed in a desiccator for cooling to normal. The ash content was determined using following formula:

$$\% \text{ Ash} = \frac{\text{wt of ash (g)} \times 100}{\text{wt at initial sample (g)}}$$

Determination of oil content and ricinoleic acid: The oil content in castor seeds was determined from crushed seeds by soxhlet method (AOAC official method 1990). The ricinoleic fatty acid in castor oil was determined through Gas Chromatography (model Thermo Trace Ultra). The fatty acid methyl ester was prepared using 4% methanolic KOH.



Results and Discussion

Oil content and Ricinoleic acid

At present the economic part of castor is seeds, the GCH-7 hybrid produced the seed yield of 3000 kg/ha in four pickings. The seeds were sun dried before dehulled and the oil content was recorded to 50.5%. In different castor genotypes, oil content was ranged 48.0-50.7% in Gujarat conditions (Shah, *et. al.*, 2013). The ricinoleic acid is key fatty acid present in castor oil and used in many direct and indirect reactions and to make many derivatives for industrial uses. Ricinoleic acid (12-hydroxy-9-octadecenoic acid) allows castor oil suitable for trans-esterification to biodiesel also. In the present study, it was found 86.8%. In different castor genotypes the ricinoleic acid content was ranged 84.3 to 87.8% in Gujarat condition (Shah, *et. al.*, 2013). The product of ricinoleic acid per cent and oil yield was 1315 kg/ha, which were of much important for castor export (Table 1).

Table 1. Key valuable parameters of castor crop

Property	Value
Seed Yield (kg/ha)	3000
Oil (%)	50.5
Oil Yield (kg/ha) (A)	1515
Ricinoleic acid% (B)	86.8
Yield of Ricinoleic acid (kg/ha) (Ax B)	1315

Straw yield

Castor GCH-7 hybrid plants attained an average height of 100-110 cm with 25-30 branches. The main spike branch and other sub spike branches were ranged between 3.0-5.0 cm and 2.0 to 3.0 cm, respectively. In Gujarat condition, normally four picking of castor spikes are done. During the present study, after final harvesting of spikes at their physiological maturity, the castor stem residue yield was observed 12000 kg/ha. Leaves are not taken into consideration as it was mostly shed at the time of final harvesting (Table 2).

Table 2. Average properties of castor plant

Characteristics	Value
Plant height (cm)	160
No of branches	6-9
Diameter of Main branch (cm)	3.0-5.0
Diameter of Sub branch (cm)	2.0 to 3.0
Stem residue (kg/ha)	12000

Cellulose content

The castor stems samples were collected and straw was made and analysis report was presented in Table 3. The castor stem were matured fully and apparent dry while seeing. Moisture content in castor stems was found 9.8%. This shows that the materials can be transported economically. The cellulose content in castor dry plant samples was observed to 45.7%. Cellulose and hemicelluloses from these lignocellulosic materials are considered as potent precursors for the second generation biofuels and biobased materials production generated, hence, it is known as bio-refinery processes. The cellulose content in sugarcane bagasse was 40.0%, rice straw 35.0%, wheat straw 30.0%, hard and soft wood stems 40-55%, grasses 25-40% (Sun, 2002 and Saha, 2003). The present study shows that the cellulose content in castor stem was remarkably more than the other agro waste have potential to be used in paper industry, which was around 11% more than sugarcane bagasse, 25% more than rice straw and 50% more than wheat straw.

Lignin content

The lignin content, which is an undesirable characteristic for paper production, which was mostly removed during the process of paper production. Lignin on decay form acid, which turn the paper yellow. In the present study, the lignin content was found 17.2%. The lignin content in sugarcane bagasse was 25.0%, rice straw 12.0%, wheat straw 20.0%, hard and soft wood stems 18.0-35.0% and grasses 10.0-30.0% (Sun 2002 and Saha 2003). The present study showed that the lignin content in castor stem was less than the other above agro waste have potential to be used in paper industry, which was around 30% less

than sugarcane bagasse, 7% more than wheat straw while 40% less than rice straw. The ash content of dry castor stem samples was observed to 2.3% (Table 3).

Table 3. Physical and chemical analysis of castor stem:

Properties	Value (%)
Moisture	9.8
Cellulose	45.7
Lignin	17.2
Ash	2.3

Conclusion

From the present study, the cellulose content in GCH-7 castor stem was observed to 45.7% and the lignin content was found 17.2%. Therefore, it could be concluded that castor which is only natural

source of ricinoleic acid may be tried as a source of raw materials for paper industries due to its high cellulose and low lignin content.

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