

Cassava – a promising raw material for Bio-Ethanol

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India is the world's third-largest consumer and net importer of crude oil and petroleum products after the United States and China. India's petroleum product demand reached nearly 4.4 million barrels per day, far above the country's roughly 1 million barrels per day of total liquid production. Unless alternative fuels based on indigenously-produced renewable feedstock are developed to substitute or supplement petro-based fuels, India's energy security will remain vulnerable.

Biofuels are the most promising alternative options to conventional fuels, as they can be produced locally, and can substitute diesel or gasoline to meet the transportation sector's energy requirements. Biofuels could have positive implications for national energy security, local air quality and GHG mitigation, employment generation and rural development.

Biofuel is the product of blending a fossil fuel with a certain percentage of ethanol. This ethanol is generally extracted from crops, oilseeds and waste, and mixed in a ratio that doesn't affect the properties of the fossil fuel while reducing the amount of greenhouse gases it emits when combusted.

Types of Bio Ethanol

Bioethanol and biodiesel in India can be produced from various sources. Depending on the raw material, a biofuel is called 1G, 2G and 3G, where 'G' stands for 'generation'.

The source of 1G – the first generation of biofuels – include edible sources like molasses, sugar-containing materials like sugarcane, sugar beet and sorghum, starch-containing materials like corn, cassava and rotten potatoes, and edible oil seeds.

2G biofuels use non-edible sources like non-edible oilseeds (e.g. *Jatropha curcas*), used cooking oil, agriculture residue such as rice straw, cotton stalk, corn cobs, saw dust, bagasse, etc.

3G biofuels are drawn from industrial waste, municipal solid waste, etc. 2G and 3G biofuels are recognised as being more advanced.

The National Policy on Biofuels 2018 ensures the availability of biofuels to meet the demand of 20 per cent ethanol produced from molasses, sugarcane juices etc. To meet this target India has to produce 1,016 crore litres of ethanol for blending programmes apart from 334 crore litres for other uses as part of the EBP (Ethanol Blanding Petrol) target by 2025. But the current ethanol production capacity is 426 crore litres from sugarcane-based distilleries and 258 crore litres from grain-based distilleries. To meet the target of 1,350 crore litres, production has to be increased to 760 crore litres from molasses and 740 crore litres from grain-based distilleries.

This necessitates the search for alternative feedstock because of huge gap between the available ethanol and its projected demand in the transportation sector.

Cassava

Cassava is a drought-tolerant crop that can be grown in areas with uncertain rainfall patterns which usually results in unsuccessful cultivation of many other crops. Recently, the world cassava production stands at 291 million tonnes with leading countries like Nigeria, Congo DR, Thailand, Indonesia ranked 1st, 2nd, 3rd and 4th respectively with production in the Africa (177 millionmt) regarded as the world largest cassava growing region and unarguably Nigeria remained the highest producer of cassava in the world with about 59 million tonnes.

cassava with its high starch content and ability to grow under low management conditions has been globally recognised as a potential candidate for bioethanol production.

There are a number of comparative advantages for cassava as a biofuel crop vis-à-vis sugarcane. Its starch with its unique physico-chemical and functional properties finds extensive applications in the food and industrial sectors. The agricultural residues of cassava such as peels, stems and leaves are potential feedstock for 2G bioethanol production.

Cassava Conversion Factor

Because of the high starch content cassava is a high yielding ethanol crop. However, a distinction has to be made between yields from dried cassava chips and fresh cassava roots. For one kilogram of cassava chips, approximately two kilograms of fresh cassava roots are required.

One litre of ethanol can be produced from:

- 5 - 6 kg of fresh roots (containing 30% starch)
- 3 kg of cassava chips (14% moisture content)

On a per tonne cassava basis:

- 1 tonne of fresh cassava roots yields 150 litres of ethanol
- 1 tonne of dry cassava chips yields 333 litres of ethanol

Cassava Vs other Starch Crops

Sugarcane can be directly used to create ethanol with a conversion factor between 12.5 and 14.3 kg of sugarcane/L of ethanol.

Molasses a by-product of sugar production from sugarcane that contains around 50% sugars which can be fermented by yeast to ethanol. One mt of sugarcane is capable of producing approximately 106 kg of sugar and 46 kg of molasses. A typical molasses-to-ethanol conversion

rate is 4 kg of molasses/ L ethanol. However, this number can vary based on production practices and sugar content of the molasses.

Key Process Difference

It is important to have a basic understanding of the biochemistry involved in the conversion of a feedstock into bioethanol. Molasses is a sugar feedstock. As such, it can be directly fermented into ethanol using yeast enzymes which convert its sugars into alcohol. However, cassava is a starch feedstock, and as such, it requires an additional step, saccharification, which uses enzymes to convert the starch into sugars which can then be fermented.

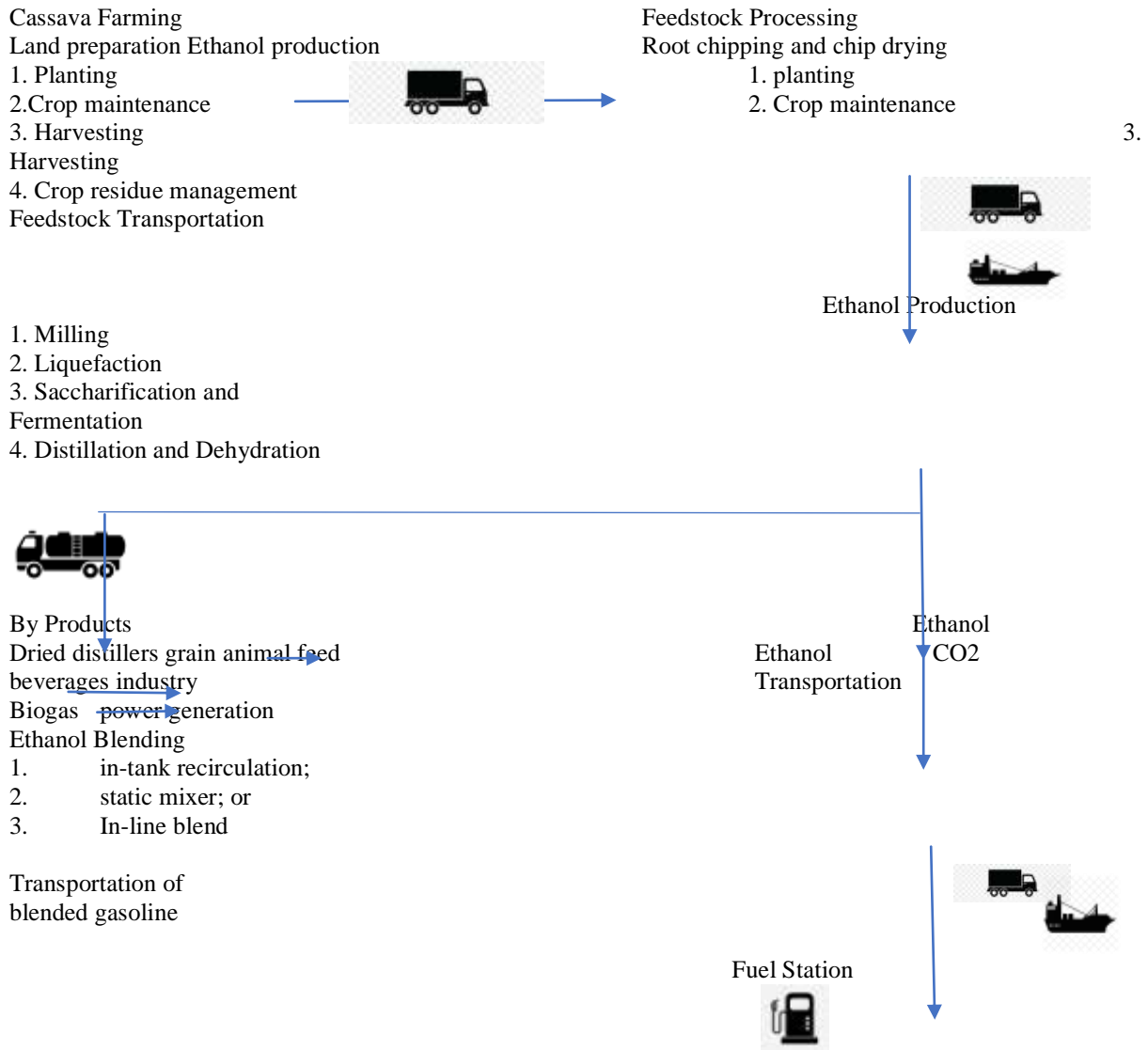
The process of producing ethanol from cassava is almost the same as for starchy crops like corn and wheat. However, there are also some differences in the processing. The ethanol yield is determined by the efficiencies of several consecutive processing steps along the production chain. These factors differ from crop to crop. There is not a single crop performing best at all these steps. Cassava is performing average to good on all steps, resulting in an excellent overall efficiency

Comparison of ethanol yield from different crops				
Crop	Yield	Conversion Rate to sugar/starch	Conversion rate to Ethanol	Overall Ethanol Yiled
	tonnes/ha/year	L/Tonne)	l/Tonne	Kg/Ha/Year
Cassava	20	25	150	3000
Sugarcane	70	12.5	70	4900
Corn	5	69	410	2050
Wheat	4	66	390	1560

Above shows that under optimal conditions the ethanol yield of cassava (in kg/ha/a) is the substantial. Moreover, a cassava ethanol plants requires less complex processing equipment resulting in lower investments. This is due to the unique characteristics of cassava starch and the low amounts of impurities which makes the extraction of starch from the root, relatively easy.

Cassava based Ethanol Value Chain

The Cassava-based ethanol value chain consists of five phases: cassava farming; cassava chips processing; ethanol production; ethanol distribution and blending; and ethanol use.



**Global Perspective –
 Leading countries based on biofuel production in 2019**

