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CASSAVA– A RESOURCE FOR BIOETHANOL PRODUCTION

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ABSTRACT

Cassava (*Manihot esculenta* Crantz) is a shrubby perennial crop in the family of Euphorbiaceae. The crop produces edible starch-reserving roots which have long been employed as an important staple food for millions of mankind as well as animal feed. Due to the fact of ease of plantation and low input requirement, cassava is mostly cultivated in marginal land by poor farmers and is sometimes named as the crop of the poor. The distinct attributes of extracted cassava starch, either as native or modified form, are very attractive for a broad range of food and non-food application including paper, textile, pharmaceutical, building materials and adhesives. Cassava starch has a lower cooking temperature, relatively to cereal starches. Cassava roots can be used as the feedstock for bioethanol production. When cassava is used for bioethanol production, different forms including fresh roots, chips and starch can be used. Mostly, roots are transformed readily to a dried form called cassava chips nearby the plantation areas. Ethanol production from cassava involves feed stock preparation, cooking, starch hydrolysis, yeast fermentation and distillation and dehydration. Nowadays, the saccharification and fermentation process were conducted in a single step to reduce processing time and energy consumption.

Key words: Cassava, bioethanol

Introduction:

Cassava (*Manihot esculenta* Crantz,) is one of the leading food and feed plant in the world. It ranks fourth among staple crops with a global production of about 160 milllion tons per year (Lawrence and Moore, 2005).Cassava provides carbohydrates or energy, for more than 2 billion people in the tropics. Cassava is a higher producer of carbohydrate per hectare than the main cereal crops and can be grown at a considerably lower cost. Cassava also grows at a suboptimal conditions; it is tolerant of soil infertility and drought stress and can be stored underground for several months after maturation (Onabolu, 1988, Vlavonou, 1988). The crop is amenable to agronomic as well as genetic improvement, has a high yield potential under good conditions and performs better than other crops under suboptimal conditions.

Over the years cassava has been transformed into a number of products both for domestic use (depending on local customs and preference) and industrial uses. Cassava in the fresh form contains cyanide which is toxic to humans and animals and therefore needs to be processed to reduce the cyanide content to safe level (Eggelston *et al*., 1992). Cassava roots comprise of the peel and bulky storage root with a heavy concentration of carbohydrate of about 80% and only 2-4% crude proteins on dry weight basis (Falade and Akingbala, 2011). Like other roots and tuber crops, cassava has a high water content (65%) which is probably the major limitation in improving the utilization potential. The chemical composition of cassava roots shows that it is a principal source of carbohydrates for the consumers. It is therefore imperative to convert cassava into more utilizable products. Effort in this regard is gradually developing.

Cassava-A bio-fuel crop:

Apart from its traditional role as a food crop, cassava is likely to increase its value by becoming an important bio fuel crop. The high yields of starch and total dry matter in spite of drought conditions and poor soil, together with low agro-chemical requirements, result in an energy input that represents only 5–6% of the final energy content of the total cassava biomass. This translates to an energy profit of 95%, assuming complete utilization of the energy content in the total biomass. The energetic and economic aspects of using cassava as a biofuel crop are well documented. For instance, a direct comparison of bioethanol production from different energy crops was reviewed by Wang, 2002 [Table 1]. A detailed study on the biofuel conversion performance and its related energy input in this crop compared to other energy crops revealed that cassava performed favorably to other crops such as maize, sugarcane and sweet sorghum [Table 1]. Indeed, the annual yield of bioethanol was found to be higher for cassava than for any other crops, including sugarcane.

Cassava starch can be converted readily to ethyl alcohol in a two-stage process involving the hydrolysis of starch slurry into glucose by liquefaction so that dextrin and subsequently fermentable sugar can be obtained. The glucose solution is diluted and converted to ethyl alcohol by the anaerobic action of yeast, ethanol of 95.6% w/w comes out through dehydration which is concentrated to 99.5% w/w (Ramasamy and Paramasamy, 2001; Kosugi *et al*., 2009). Thus cassava-based fuel ethanol is produced and it is usually denatured by small volume of gasoline or other materials added preventing people from drinking it, (Leng *et al*., 2008).

Table 1. Comparison of bioethanol production from different energy crops. (Wang, 2002)

Crops	Yield (tonne ha^{-1} $year^{-1}$)	Conversion rate to Bioethanol (L $tonne^{-1}$)	Bioethanol yield (L ha^{-1} $year^{-1}$)
Sugarcane	70	70	4,900
Cassava	40	150	6,000
Sweet sorghum	35	80	2,800
Maize	5	410	2,050
Wheat	4	390	1,560
Rice	5	450	2,250

Some advantages of biofuel produced from cassava starch are mentioned here under.

- It is not poisonous
- It does not cause air pollution or any environmental hazard
- It does not contribute to the green house effect problem (CO_2 addition to the atmosphere, causing global warming)
- It has a higher octane rating than petrol as fuel. That is, ethanol is an octane booster and anti-knocking agent
- It is an excellent raw material for synthetic chemicals.
- Ethanol provides jobs and economic development to rural areas.
- Ethanol reduces country's dependence on petroleum and it is a source of non – oil revenue for any producing country
- Ethanol is capable of reducing the adverse foreign balance trade.

The ethanol produced is of high quality similar to cereal alcohol (Taiwo, 2006). The cassava chips can be used instead of the tuber in which case the chips are ground, cooked to release the starch etc (Ajibola, 1988). Compared to wheat, corn or sugar cane, cassava ethanol yields amount up to about 200 liters per ton.

Bio ethanol production from Cassava

When cassava is used for bioethanol production, different forms including fresh roots, chips and starch can be used The factory has to make and manage an effective feedstock plan as the feedstock cost can account up to 70%of total ethanol production cost. Types of feedstock used for bioethanol plants depend on many concerns including plant production capacity, plant location, nearby cassava growing areas, amount of feedstock available and processing technology. Ethanol plants that are not close to cassava farms prefer to use dried chips to reduce costs of transportation and storage, while those locating next to cassava fields can use chips and roots. When using both feed stocks, the plants have to somewhat adjust the process in particular feedstock preparation.

According to Nadir *et al* (2009) in order to obtain bioethanol, fermentation has to take place, and the principal feedstocks used in the production of bioethanol includes the followings; sugars, starches and cellulose. The cellulose is hydrolysed by alkali or acids to sugars which enable the microbes to act on the sugars for fermentation to take place in order to yield ethanol. Whereas the sugars are feed stocks that can be freely fermented and transformed to ethanol by the microorganisms. The starch feedstock is first hydrolysed before its subsequent conversion process of producing ethanol (Shanavas *et al*, 2011). But the hydrolysis of starch is by enzymes of malt or moulds. Basically the starch has two types of polysaccharides viz, the amylose which is a linear molecule and amylopectin, a highly branched molecule (Nadir *et al*, 2009).

unlike other feedstocks cassava feedstock can either be used for ethanol production when the fresh root is harvested, the fresh root contains (moisture concentration 70 – 80 %) or when the roots are chipped and sun dried which has only about 10 – 15 % moisture concentration (Ogbonna and Okolib, 2010).According to Ingledew *et al* (2009) the moisture contents of cassava is lowered to about 10 – 15 % by sun drying in order to properly store the dried chip for subsequent use in ethanol production.

Using fresh roots for Ethanol production:

There are four tasks (washing, cassava peel removal, rasping and centrifugal separation) to be carried out when preparing the fresh roots of cassava before to start the conversion process (Ayoola *et al*, 2012). Washing of the fresh roots in order to extract and free the roots from all sorts of impurities. Cassava peel removal decreases the linamarin quantities which produce cyanide, in addition the procedure ensure total extraction of sand from the roots this process reduce the risk of soils that can potentially cause harm to the industrial machines during ethanol production. Rasping is a process used in extracting starch from fibrous cell walls; subsequently water is applied to enable the discharge of starch materials. Centrifugal separation is a process which produces slurry that is of compacted and solid mixture of starch granules that can be used for the conversion.

The efficiency of *S.cerevisiea* depends on the availability of nutrients in the starch slurry, however the starch slurry has very low concentrations of nutrients, in order to obtain good fermentation, nutrients has to be supplied into the starch slurry.

Using dried chips for Ethanol production:

On the other hand the method of ethanol production from dried cassava chips is carried out by starting with scrubbing the chips in order to extract the impurities such as sands, then crushing the chips by pounding it into powdered form followed by applying water to make slurry mixture in preparation for ethanol production (Ingledew *et al*, 2009).

Out of the three common phases deployed in the production of bioethanol from cassava (liquefaction, saccharification and fermentation) liquefaction and saccharification processes are carried out by α-amylase and glucoamylase. Amylolytic enzymes are responsible for hydrolysis of starch (Hai-Juan *et al*, 2010). The fermentation is carried out by microbes such as yeast, (*Saccharomyces cerevisiea*), bacteria and fungi (Ogbonna and Okolib, 2010; Shanavas *et al*, 2011).

Simultaneous saccharification and fermentation process:

Cassava flour (Water & Alpha –amylase enzyme) –Liquifaction (90-95$^{0}{}_{C}$, P^{H} 4-4.5)-Sacchrification (55^{0}C-65$^{0}{}_{C}$) Glucosidase enzymes-Cooling (30-35^{0}C)-Fermenter (Yeast added and Co^{2} out)-Distillation-Ethanol

Nowadays, the production process of bioethanol from starch feedstock is developed to significantly reduce processing time and energy consumption by conducting saccharification and fermentation in a same step; this process is called “Simultaneous Saccharification Fermentation”, or SSF process. In this SSF process, the liquefied slurry is cooled down; afterward glucoamylase and yeast are added together. While glucoamylase produces glucose, yeast can use glucose to produce ethanol immediately. No glucose is accumulated throughout the fermentation period (Rojanaridpiched *et al*, 2003).

Nadir *et al* (2009) stated that under temperature of 90^{0}C in bioreactors about 300g of cassava, 900mL of distilled water, as well as the enzyme α-amylase 0.1% (v/w) are poured into the bioreactor then the mixing was done at 500 rpm for one hour. Afterwards the temperature of the mixture was allowed to cool falling to 50^{0}C; another enzyme glucoamylase of the same amount 0.1% (v/w) was further poured into the mixture and mixed at

250 rpm and the mixture is allowed for two hours, later the temperature of the solution was left to drop down to 35^0C. However the energy cost can be reduced if the techniques of simultaneous saccharification and fermentation (SSF) would be applied in the production of the bioethanol (Shanavas *et al*, 2010; Yingling *et al*, 2010). Because there is no separation of hydrolysis and fermentation phases in the process of ethanol production. The Simultaneous Saccharification and Fermentation (SSF) process has the advantage of producing large quantities of ethanol, the procedure is time efficient and it utilised less energy during the process of ethanol production.

Conclusion:

The demand of cassava has been rising continuously and thereby contributes to agricultural transformation and economic growth in developing countries. In some countries such as Thailand, China and Vietnam, cassava is also used as the energy crop for producing bioethanol, an environmentally friendly, renewable alternative fuel for automobile uses. The promise of using cassava for bioethanol use is supported by its distinct plant agronomic traits.

A short-term and long term plans for root yield and productivity improvement by good cultivation practice and varietal improvement have been presently implemented in some regions. By that with a combination of effective policies and market mechanism, the use of cassava as a food crop, industrial crop and energy crop become sustainable and beneficial to mankind.

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