CASSAVA AS FEEDSTOCK FOR ALCOHOL PRODUCTION

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Considering the increasing industrial demand for alcohol coupled with an unstable supply of sugarcane molasses, a comparative analysis was made with cassava as an additional feedstock for alcohol production. It is noted that that cassava is expensive to grow and the net profit margin for the farmers is nil at ₱0.80 to ₱1.0/kg farm gate price. As a feedstock for alcohol, it is 2.5 times more expensive than molasses. This is due to (a) the lower fermentable sugars (200-220 kg/ton fresh roots vs 520-570 kg/ton molasses), (b) elaborate pre-fermentation processing required for cassava roots, with only dilution for molasses, and (c) lower amount of alcohol produced per ton (70-110 L/ton vs 300-370 L/ton for molasses). Thus, cropping options for producing cassava were considered.

Cassava grown in large scale, in otherwise underutilized (patch cultivation, seasonal crop) and less favorable agro-environments for agricultural production, would provide benefit in this manner: A minimum of 66 days (man-days, man-animal days) of cash-in labor for crop establishment to harvesting and a money infusion to the village economy through production loans at ₱15,000/ha (cassava monocrop) to ₱18,000/ha (corn + cassava relay). Thus, with increased area planted to the crop, fragile and erosion-prone agro-ecosystems are conserved and developed for higher productivity.

Measures to minimize soil erosion by promoting farmer adoption of soil- and water-conserving (SWC) and soil fertility-amending (SFA) practices are recommended. The adoption of equitable, pro-farmer and profitable cassava-based farming systems for alcohol production is equally emphasized.

Keywords: alcohol from cassava, alcohol from molasses, cassava, corn-cassava relay, cropping systems, erosion-prone environments, feedstock for alcohol, molasses, monocrop, relay cropping

INTRODUCTION

The current feedstock for alcohol production in the Philippines is molasses. This is no surprise as sugarcane is a major crop of the country. On the average, the total molasses yield per year in the country can reach 1M tons. Its high amount of total fermentable sugars (TFS) makes it an ideal substrate for fermentation/distillation into alcohol (Aventino 1976).

The industry demand for alcohol production is increasing, but the supply of molasses is not stable and adequate for the industry. From 1993 to 1998, sugarcane production fluctuated which affected molasses supply (SRA 1999). Big enterprises that demand huge volume of molasses for their alcohol-based enterprises are pressured to look for alternative feedstock to reduce if not to eliminate the threat of inadequate supply in the near future. Large-scale production of cassava could be resorted to as a source of feedstock for alcohol production.

While information or technologies are available, these are yet to be tested, adjusted, optimized and evaluated financially under local conditions. Cassava is about 65% moisture, which makes hauling fresh roots, chipping, then drying very expensive. Pulverizing dried cassava chips into powder is also very energy-expensive. Acid saccharification (acid + heat energy) through high temperature presents not only cost problem but also an environmental setback as the liquid effluent or distillery slop is highly acidic. Advancement in technology, however, has minimized these problems (Uritani 1984). Enzyme saccharification is now optimized and it can be done economically under commercial scale. Presently, the enzyme is largely imported. But there is also the possibility of preparing the enzyme in commercial quantities under local conditions and expertise. The enzyme-mediated saccharification process does not need drying, chipping and pulverizing of cassava roots. Establishing the distillery factory near the farm can also reduce the cost of hauling.
CASSAVA & SUGARCANE MOLASSES AS FEEDSTOCK FOR ALCOHOL PRODUCTION

This study compared cassava with sugarcane molasses as feedstock for fermentation. The study also identified the problems and options for growing cassava in large scale.

Supply. Supply is dependent on farm-level production. Unlike sugarcane farmers, cassava farmers are yet to be fully convinced on the economic advantage of growing high starch-yielding cassava cultivars in large scale. The optimum crop cycle for cassava is 10-12 months (Figure 1); to have a whole-year round supply of cassava for fermentation, the roots have to be stored. This requires chipping and drying which add to the overall cost. In contrast, molasses can be stored in tanks the whole year round without additional processing and therefore readily available without additional cost.

Future Development Possibilities

Road access improves

Price of sugar increases as population increases (demand increases)

Price of rice/corn (as staple food) increases

Oil price increase leads to “domino effect” on cost of production and profit margin for farmers

PRACTICAL FARMER’S RESPONSE

Farmers will have wider crop options. They will grow more profitable crops.

Farmers shall switch to sugarcane production

Farmers shall grow rice/corn giving them better food security

Farmers shall reduce the area devoted to cassava or they shift altogether to less expensive crops to grow

Figure 1. Practical responses of farmers when addressing the situation that cassava is a less competitive crop to grow

Feedstock preparation for fermentation. Preparation of molasses for fermentation requires only dilution or addition of water to adjust the total fermentable sugars (TFS) to optimum concentration. Cassava, on the other hand, requires more elaborate pre-fermentation processing. The pre-fermentation process involves the following steps (PCARR 1983):

From fresh cassava roots:
1. washing/peeling
2. mash preparation
3. dilution of starch
4. pre-liquefaction
5. cooking
6. saccharification.

From dried cassava roots:
1. washing/peeling
2. chipping
3. drying of chips
4. storage of chips
5. mash preparation
6. liquefaction
7. saccharification.

Total fermentable sugars (TFS). Cassava is about 65% moisture. It has only 30% starch (PCARR 1983) which needs to be saccharified into fermentable sugars. On a per ton basis, only 20-22% or about 200-220 kg/ton of fermentable sugars can be obtained from cassava; in contrast, molasses has about 52-58% TFS, ie, it yields about 520-580 kg/ton fermentable sugar (Table 1).

Alcohol produced. Since the TFS in cassava is lower per ton, the alcohol produced per ton is also lower (70-110 L/ton) (PCARR 1983), about 23-30% lower than from molasses (300-370 L/ton). It also costs 2.5 times more to produce alcohol from cassava than molasses even at ₱1.0/kg farm-level cassava procurement price and molasses at ₱2.0/kg.
Profitability comparison

Comparing the profitability between cassava and molasses as feedstock for alcohol production, two cassava production schemes were evaluated. These were cassava monocrop and corn + cassava relay cropping. In monocrop, the planting pattern consisted of cassava cuttings equidistant at 1.0 m between furrows and 0.75 m between hills. This spacing gives a total density of 13,333 plants/ha. At 80% survival to maturity, about 10,000 productive plants are estimated. Assuming each plant yields 2.5 kg of roots, then a yield of 25 tons/ha can be obtained.

The corn-cassava relay cropping data used was based on farmer's practice at Don Manolo Fortich, Bukidnon, Mindanao. Farmers waiting for the 1-year turn around for cassava monoculture experimented on corn + cassava relay. Their technique was to plant corn ahead at 0.75-m furrow spacing. After applying the last dose of fertilizer at 20 days after planting (DAP), they planted cassava stems at 2-row intervals. Thus, the

Bukidnon farmers obtained a minimal yield decline in their corn. They got their usual corn yield as it was planted ahead of the cassava. Since cassava was planted late, excessive shading by corn leaves occurred. However, it was observed that a few days (5-7 days) after the corn was harvested and the stovers were cut to ground, the cassava recovered quickly. To compensate for the slow growth due to shading by corn, harvesting of cassava was delayed by about 2-3 months. Instead of the usual 8-10 months, cassava was harvested after 11-12 months. As expected, under relay cropping, cassava yields were lower than those under monoculture.

Data from conventional sugarcane production was based on De Los Santos (2000). Detailed costs and returns analyses were done. Profitability indicators such as net income, break-even yield, cost to produce 1 ton of cassava and sugarcane were computed. The results are shown in Table 1. After auditing all costs items, the total costs (TC) of production for cassava monocrop amounted to ₱18,053.00/ha. The main cost items included fertilizer, which account for 28.33% of TC, followed by harvesting 17.18% of TC, then land preparation and planting at about same at 16.0% of TC.

The profitability analysis shows that the total costs cannot be recovered at a low yield level, ie, 15,000 tons/ha. At this yield level, the price to produce is more, at ₱1.20/kg, than the price to sell cassava, at farm gate price of ₱1.0/kg. Thus, a negative net return is attained at ₱4,802/ha. It is only at a high yield lever of 30 tons/ha that a modest income of about ₱12,000/ha can be realized, with the cost to produce a kilo being ₱0.60. At medium yield of 20 tons/ha and ₱1.5/kg cassava roots, the farmer earns ₱10,200/ha.

The farm profitability scenario changes under the corn + cassava relay planting pattern. If the total cost of production at ₱25,430/ha is divided between the two crops, the cost of producing cassava (₱12,715/ha) is decreased by 30%. With this scheme the net return even at low yield level of cassava (10,000 t/ha) is already positive (₱2,630). Moreover, the net return increases considerably in both medium and high yield levels when compared with monoculture cassava.

Cassava is asexually propagated, hence, farmers can easily obtain planting materials in subsequent plantings. Land preparation can be done using an animal-drawn plow. If land preparation and planting materials are saved, then the cost of production is reduced by 27% (₱5,000). Then the net return to the farmer increases to about ₱20,000/ha even at medium yield level only.

Comparatively, while it costs more to grow and harvest sugarcane (₱34,220 at low yield level), the estimated net revenue is 23 times more (₱23,540/ha) for sugarcane + molasses yield. At medium yield level, the net revenue for sugarcane (₱32,660/ha) increases 165 times over cassava.

Problems & opportunities

Problems (and opportunities for solutions) in large-scale production of cassava are related to the environment (bio-physical, socio-economic) and the

<table>
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<tr>
<th>PARAMETER</th>
<th>CASSAVA</th>
<th>MOLASSES</th>
<th>M-C</th>
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<tbody>
<tr>
<td>Alcohol yield per ton (L)</td>
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<td>300</td>
<td>200</td>
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<tr>
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<td>Cost before fermentation per ton</td>
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Scenario 1: Alcohol yield from 1.0 ton cassava ranges from 70-110 L. An average of 100 L was used for the estimates (based from 25% starch, 90% hydrolysis, 45% fermentation efficiency). Alcohol yield from 1.0 ton molasses ranges from 280-370 L. An average estimate of 300 L/ton was used (based on information). In general, the cost of material is also the cost of processing.

Table 1. Comparing cassava and molasses in terms of alcohol yield and cost of alcohol production (pre-fermentation).

Note: Actual factory fermentation/distillation costs of alcohol are "cfi" (confidential business information). In general, the cost of material is also the cost of processing.
technical aspects of cassava production (agronomic) and alcohol processing (factory).

**Bio-physical.** Based on known technical requirements, three main factors affect the cost of cassava production. These are (a) hauling/transport, (b) fertilizer and lime requirements, and (c) added cost of conserving the soil, if only to sustain cassava production in the medium (5-10 years) to long term (15-20 years).

1. The high hauling transport cost is due mainly to the distance and difficult field access, which in turn is due to the topography of the land where cassava is being grown, as the more accessible and favorable agro-environments are grown to other, more profitable crops. Due to the weight of cassava (65% moisture), per unit weight of hauling fermentable sugars (starch) is also high.

2. The high fertilizer (+ lime) requirement for a high yield of cassava is because the crop is grown in less fertile soils. Since the soil is acidic, calcium and magnesium have to be applied. The concept involved is not to neutralize the acidity, as this is expensive, but to apply Ca and Mg as fertilizer nutrients. On top of this, organic fertilizer has to be continuously added (Figure 2).

3. Soil conservation is an added cost from whichever line of interpretation one comes from. On one hand, non-adoption of soil conservation measures results in soil erosion or loss of topsoil + nutrients, or productivity. On the other hand, adoption of such measures reduces costs as it results in the avoidance of the need to apply more inorganic fertilizer as the top soil erodes in the absence of timely application of inputs, sufficient weed control, cultivation, drainage, and timely harvesting.

Providing adequate daily supply of quality cassava roots the whole year round to the factory requires monthly or weekly planting of cassava. As shown in cassava planting and harvesting schedules, the optimum planting schedule coincides with the onset of the rainy season, ie, late April to July.

Cassava must be established 3 months before soil conservation.

**Socio-economic.** If cassava is less profitable to grow than sugarcane, developments in the area will prompt farmers to adjust to the situation (Figure 2). With good roads, farmers may opt to plant other crops since marketing these products will be faster, easier and less expensive. Near sugar producing areas (ie, Negros Occidental), millers provide transport subsidy to sugarcane planters to entice them to deliver canes to their mills. With good price of sugar and trucking allowance extended by the millers, farmers may prefer to grow sugarcane instead of cassava.

**Production & processing.** Production of alcohol using cassava as feedstock requires a proper matching of the agronomic aspect of cassava production (farm level) and the processing aspect of alcohol (factory level). The typical requirements for a properly matched system (balanced systems of production) are: whole-year-round stable, adequate and regular (even daily) supply of quality cassava roots for the factory. This requires optimum time of crop establishment with adequate and

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**Figure 2.** The interrelationships of the main cost determinants of cassava production
moisture supply recedes below the crop water requirements for evapotranspiration. This means that cassava establishment is restricted to only a few months of the year (late April to mid-July).

To increase yield to satisfy the need of the industry, delayed harvesting can be employed. Cassava can be harvested up to 2 years because it has biennial characteristics. But roots become more fibrous, although root yield and subsequently starch yield increase. While delaying harvesting to suit the factory is agronomically feasible, it is not farmer-friendly or farmer acceptable, as this means lost income (Correa 1980).

The maturing cassava roots are susceptible to rotting caused by excess soil moisture or waterlogging. Thus, on one hand drying cassava is added labor and/or added cost, but on the other hand it provides rural employment. If the farmers do not realize additional benefits in drying cassava, either they will harvest the cassava roots and sell them fresh, or they will not raise cassava at all. Thus, one option to encourage cassava growing in large scale is for the management to buy fresh cassava roots. This means drying will be done by the factory. For distilleries, excess methane (if there is any) in their distillery slop digesters can be used for drying cassava. Peeling and chipping cassava can be mechanized. Sundrying can be partially done, then, final drying can be done mechanically. This is added cost (investment on machine, sun drying pavement and heat energy), but the quality of drying is assured and farmers are relieved of the burden of drying their produce.

### SUMMARY & CONCLUSION

An analysis of the usage of cassava as an alternative feedstock for alcohol production was done comparing it to sugarcane molasses. Possible problems of large scale cassava production were identified. Cassava yields lower alcohol at 70-110 L/ton compared with sugarcane molasses at 300-370 L/ton. This is due to the lower fermentable sugars (200-220 kg/ton) which in turn is

This requires the digging of drainage canals, which is added work (added cost) and it can promote soil erosion if not properly done.

What is agronomically sound and farmer-friendly is to harvest cassava on time (10-12 months). It means that all the cassava established in late April to Mid-July is to be harvested from January to May. Spoilage of cassava roots occurs fast after uprooting. To store cassava roots, they must first be dried. During dry season, sun-drying could be done. But before it could be sun-dried, root must be peeled off, then, chipped to small pieces to facilitate sun drying. Farmers would need a cassava chipper and sun-drying pavement.
due to the high moisture content (63%) of fresh cassava roots. With cassava + corn relay cropping, farmers can earn as much as ₱20,000/ha from cassava alone.

**Some policy & practical measures**

For a successful large-scale planting of cassava as an alternative feedstock for alcohol production, some practical and policy measures are required. They are as follows:

**Conservation-oriented practice.** The adoption of soil and water conservation-oriented practices should be treated as a matter of necessity in the fragile and erosion-prone agro-ecosystems where cassava propagation is being promoted, eg, the hillsides of Negros Occidental in the Visayas and Isabela Province in Northern Luzon.

**Soil-amending techniques.** There is a need for the adoption of environment-friendly and cost-effective soil acidity- and fertility-amending techniques. Thus, in the short term, the application of dolomitic limestone to supply the calcium and magnesium requirements of cassava may be resorted to as the soil is acidic. It may also be necessary to haul to the farms any animal manure or nutrient-rich residue, eg, digested distillery slops high in potash and containing liberal amounts of N, P, and other nutrients.

In the long term, dependency on chemical fertilizers as source of NPK is not financially viable and ecologically sound. Nitrogen alone is about 30% of the fertilizer budget and 16% the total cost of cassava production.

The promotion of environment-friendly soil fertility-amending practices like in-situ composting and recycling of biomass residues, will not only reduce the cost of cassava production, but increase the net profit margin of farmers and also improve the long-term viability of cassava production in less favorable agro-environment (Mendoza & Samson, 2000).

**Credit & technical assistance.** The adoption of environment-compatible credit and technical assistance policy for cassava production should be pursued. The sad lessons in promoting the massive adoption of crop production technology (eg, Masagana 99 in the 1970’s and KABSAKA in the mid 70’s) should become inputs into any credit and technical assistance.

**Pricing scheme.** The government may develop a flexible and competitive cassava pricing scheme that will assure farmers favorable net profit margins and to encourage them to continue planting cassava. Parity pricing should not only consider the feedstock sourcing for alcohol as in molasses or the importation of cassava elsewhere (eg, Thailand), but also the local cost of cassava production and other crops (corn, sugarcane) that can be grown by farmers.

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