Sweet Sorghum Co-Product Optimization

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Abstract:
This presentation deals with alternate technologies to treat waste streams in sweet sorghum bio-refineries to produce higher valued co-products. These products have established commercial markets and in some instances have a negative carbon footprint for a project. Several waste streams in an ethanol bio-refinery will be examined and alternative processes or treatment methods suggested which will produce high quality end-products for worldwide markets and add a significant income value to a project. The waste steams which will be examined are the field trash when harvesting sweet sorghum, vinasse from the distillery, ash from boilers and what to do with surplus bagasse.

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1. Introduction

This presentation is about co-product development in a sweet sorghum bio-refinery producing alcohols. Alternate conversion techniques for four (4) product and process streams, field trash, vinasse, bagasse and power generation, are presented. The products produced by these alternative techniques greatly improve the profitability of a sweet sorghum bio-refinery.

2. Alternate Processing Techniques

2.1 Processing Field Trash

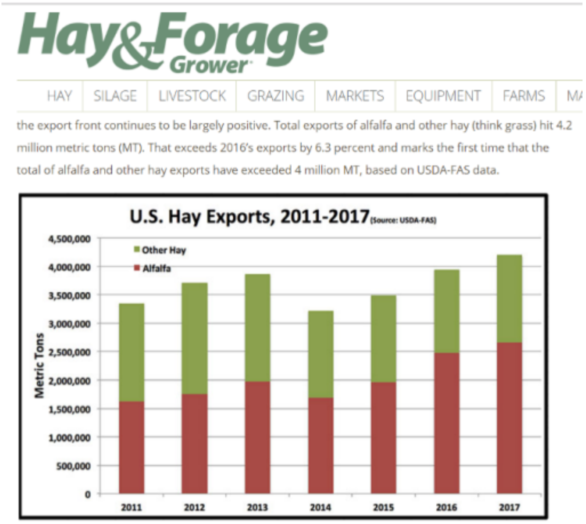
Field trash is the biomass left in the field when harvesting sweet sorghum with a sugar cane harvester. Approximately 15% to 20% (Data from USDA Trials in LA at the St. Gabriel Experimental Station, R. Ricaud, B. Cochran, A. Arceneaux and G. Newton 1979,) of the total biomass produced by sweet sorghum is field trash and it contains between 16-18% (Data from Vincent Screw Press via private communication) of the total sugars produced by the plant. Field trash is a sweet feed and that is why we see cattle grazing in harvested sugar cane fields. Traditionally, in the sugar industry, field trash is left in the field and is burnt. Of late, the sugar industry has been baling the field trash to burn it in their boilers to produce additional electric energy.

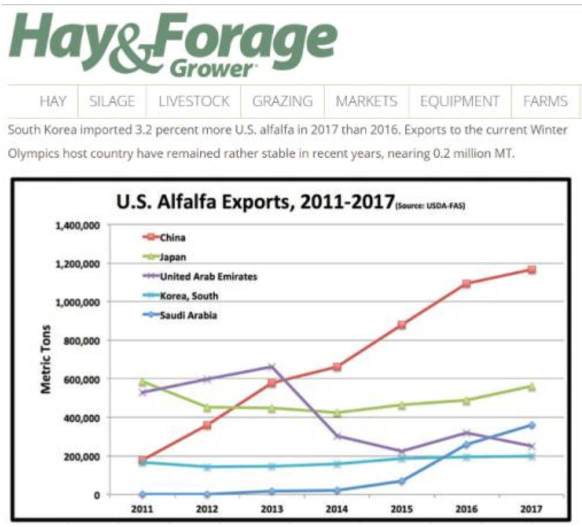
Fig 1 Baling Field Trash

Alternative uses of field trash are as follows:

2.1.1 Hay as Animal Feed

There is a huge international market for hay products as shown in figure 2. The farm gate price of baled hay is as high as $115/ton.





2.1.2 Feedstock for BioChar production

Using the pyrolysis process will convert any biomass into biochar. BioChar is a valuable soil amendment product and animal and human food supplement. As a soil amendment product it has these properties:

- Enhances soil biological activity by 40%
- Improves nutrient retention in soils. 50% increase in Cation exchange capacity
- Increases water retention capacity up to 18%
- Increase soil organic matter

Currently biochar sells for $1.00 to $1.25/pound. Figure # shows a 300 kg/hr pyrolysis system for the production of biochar.

(Picture courtesy Pro-Natura)
Fig 3 Pro-Natura Biochar System

2.1.3 Feedstock for 2nd generation Synthetic biofuel production

Alphakat and EcoKat, a German/Mexican company, builds a bio-refinery which uses any biomass to produce a synthetic transportation diesel product. Field trash is an ideal product for this process as both the cellulose material and the remaining sugars will be converted in the diesel product. The biomass is blended with a catalyst and lime and is metered into a 300ºC oil bath. A "turbine" processes this mixture of hot oil and biomass and in three (3) minutes diesel fuel, meeting all ASTM standards, is produced. (Table 1 shows data by EkoKat, Mexico)

In non-oil producing countries, which have high transportation fuel costs, this is an ideal technology. Figure 4 shows a 2,000 liters/hour Alphakat Diesel Plant.

2.1.4 Feedstock for Syngas and Electric Energy Production

The field trash is also an ideal material, because of its low moisture content of between 12% and 14%, for a pyrolysis gasifier system producing electricity. Fluidized bed gasifiers are the best for this application as they are not sensitive to the ash content of the biomass. Traditionally, steam and power plants are used to convert biomass into electric energy. These plants are very expensive, about $3.5to $4M/MW, and have a long lead-time, two to three years, to be built. Gasifier plants on the other hand can be installed in six to nine months at a cost of less than $3M/MW. The other benefit of using a gasifier system is the production of biochar whose benefits have been described earlier. Figure 5 depicts a typical gasifier system.

Table 1 ASTM Standards

Fuel Specification - Diesel Fuel

Property	Test method	Measurement	Minimum	Maximum
Appearance	Visual	Optical	Tan/clear	clear
Color	ASTM D1500-02		0	2.5
Cetane Index	ASTM 976-91	ppm	47	none
Caloric Value	ASTM 2015	kJ/L	36,800	none
Sulfur Content	ASTM 4294-02	ppm	0	Content in Feedstock
Flash point	ASTM 93-02	° C	60	none
Density	ASTM 1298-99	kg/l @ 15° C	0.80	0.875
Kinematic Viscosity	ASTM 445-03	cSt @40° C	1.6	5.8
Distillation	ASTM 86	90% Recovery, °C	0	370

Fig 4 Alphakat 2,000 liter/hour synthetic diesel plant

(Picture courtesy PowerMax of China)
Fig5 PowerMax Gasifier System

2.2 Bagasse

2.2.1 Bagasse Boilers

Traditionally, bagasse, which has a high moisture content of up to 55%, is burnt in biomass boilers to produce process steam and electricity required by the sugar mill or ethanol plant. The bagasse value for use in a steam plant is approximately $25/ton.

2.2.2 Panel Board Plant

Some years ago sugar mills in Louisiana sold their surplus bagasse to a local manufacturing plant making panel boards. It is our understanding, from a private source, that this plant is no longer in operation.

2.2.3 Bulk Cattle Feed

Bagasse is an ideal cattle feed product and can be delivered in bulk to local cattle feedlots. This is only an option if feed lots are in close proximity of the bio-refinery. The bagasse can also be packaged in bulb bags similar to peat moss and marketed to cattle feed lots.

2.2.4 Ensilaging Bagasse

Studies have been carried out in China comparing sweet sorghum silage to corn silage and they showed similar results in weight gain and milk production. (Qi Xei, Chinese Academy of Science) The silage can then also be processed into pelletized animal feed products by adding the required nutrients to the bagasse as required by each animal group.

2.3 Ash from Boilers and Gasifiers

Ash from biomass boilers can be used as a fertilizer if its chemical composition is suitable. It is also mixed with cement as it produces a stronger concrete. Ash from a pyrolysis system has a much higher value than ash from a biomass boiler. It is a great soil amendment product as well as an animal and human food supplement.

Using a gasifier system over a steam boiler in a bio-refinery has many technical and commercial advantages such as lower investment costs, faster installed times, high valued biochar and the flexibility to increase the system capacity in incremental steps as low as 0.2MW and as high as 2MW.

2.4 Vinasse

Vinasse is the waste fluid from the distillation process of an ethanol plant. In round numbers, to produce 1 gallon of ethanol requires 10 gallons of fermented juice called beer. Thus 9 gallons of beer turns into vinasse which is a highly toxic product with very high BOD and COD values. The following comparative vinasse data was published by Dr. Baez-Smith.

Anaerobic Digestion

Comparative Vinasse Composition

Components		Raw Material	
	Molasses	Cassava	Sorghum
pH	4.4	3.5	4.5
	mg/l	mg/l	mg/l
BOD	25,800	31,400	46,000
COD	48,000	81,100	79,900
Total Solids	68,000	44,500	34,100
Soluble Solids	57,100	40,400	n.a.
Fixed Solids	48,400	4,100	n.a.
Suspended solids	38,700	n.a.	n.a.
Organic matter	19,500	37,100	n.a.
Carbohydrates	8,000	20,100	3,400
Total Nitrogen	820	650	800
Total phosphorus (as phosphates)	480	380	100
Ash	10,700	10,500	6,100

Source: Barreto de Menezes, T. J., Etanol, o Combustible do Brasil (Ethanol, Brazil's fuel, in Portuguese language), 1980, Editora agronomica Ceres Ltda, Sao Paulo, Brasil

n.a. means not available

2.4.1 Organic Fertilizer

Anaerobic digestion is currently the technology used to neutralize vinasse so it can be returned to the fields as irrigation water. In Europe, as per Vogelbusch, alcohol plants have extracted the solids in vinasse, which are about 6% to 8%, using centrifuges and then produced an organic fertilizer by composting these solids.

2.4.2 Pig Feed

Pigs love to feed on vinasse. It will have to be cooled before feeding pigs. Again, pig feedlots need to be close to a bio-refinery to take advantage of this animal feed option.

2.4.5 Chemical boilers

Vinasse can also be fired in chemical boilers to produce steam and electricity. A Spanish company, Tomsa Distil, delivers such systems.

2.4.6 Composting – Organic Fertilizers

Mixing the solids from vinasse with bagasse, adding some biochar and then composting this mixture will produce a high valued organic fertilizer or potting soil. In Canada a potting soil with N-P-K of 1-1-1 retails for $3,600CAD/ton. This makes biochar a very valuable co-product from the production of ethanol.

3. Conclusions

The above presentation clearly shows that there are many process options for a sweet sorghum bio-refinery which will produce very profitable co-products. Of course, in each case economic studies have to be carried out to determine which process is most profitable for a specific project. All waste streams in a sweet sorghum bio-refinery can be converted into profitable co-products.