SEPARATION — A PROCESS TO PRODUCE HIGH QUALITY SUGARS AND HIGH VALUE CO-PRODUCTS FROM SUGAR CANE

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ABSTRACT

A process for the separation of the sugarcane stalk into its various components has been developed. The process offers a system whereby one or more co-products may be produced simultaneously.

The high quality fibers of the rind are separated from the pith and are utilized in the production of high value structural composite board panels. The high purity juice from the separated pithy core of the cane stalk is extracted and used for the manufacture of refined sugar, amorphous sugar and alcohol. The pith complete with all of the sugars may be used as an animal feed.

The possibility of future sugar cane variety selections being made on the basis of fiber quality and fermentable sugars rather than on sucrose alone offers much potential.

INTRODUCTION

It has been the dream of the sugar industry to develop a by-product or co-product that could share equally with the major product—sugar—in the cost of growing and processing the sugar cane crop of the world.

The interest in by-product has always been in direct ratio to the price obtained for raw sugar by the mills. Since the price has fluctuated drastically over the years there has been no sustained effort to develop the by-products as is a feature of agro-industry in the more developed countries of the world; a feature which could help to stabilize the income of growers and processor alike.

It has not been the lack of research work on by-products that has hampered their commercial development but the absence of developmental capital and entrepreneurial skills available to take the research results and translate them into economically viable operations. This situation of borderline economic returns, coupled with the traditional conservatism of the sugar industry, has hampered the necessary investment in by-product processing leaving us today, with few exceptions, with an industry totally dependent on sugar sales with only minor income from its by-products.

In the above context it can be seen that the breakthrough in the processing of sugar cane, known as the "Separation Process", whereby the hard outer rind of
the sugar cane stalk (containing the high quality fibers and low purity juice) is separated from the soft pithy core (containing the high purity juice — uncontaminated with soil, etc.) producing for the first time two basic components of nearly equal value, is a great step forward.

The advantages of separating the sugar cane stalk into its various components has been known for over fifty years. Deerr in Hawaii and Geerlig in Java and others in Louisiana (Agee and Halligan) and the West Indies (Payew) had mechanically separated cane stalks in the laboratory and analyzed the various components. This basic work demonstrated very clearly that the sugars in the stalk were heavily concentrated in the inner core of the sugar cane while the longer and tougher fibers were to be found in the outer rind.

Cobb later carried out a microscopic examination of a stalk cut across the center of an internode. This examination showed that the cane stalk consisted of two basic components:

1. a core of soft tissue interspersed with fibers, these being most frequent around the periphery of the stalk; and

2. a hard outer rind which in itself consisted of two components:
   a. a layer of thick walled fiber cells; and
   b. a thick epidermis or cuticle covered very often with a layer of wax which made it impervious to water. The function of the cuticle would appear to be, to control the evaporation of water from the stalk and to protect the soft core from mechanical damage.

The thick walled cells of the outer rind provide rigidity and strength to the stalk. The thick-walled cells gradually pass into the thin-walled cells of the parenchyma of the core which serve to store the high purity sugar containing juices of the cane.

The internal fibro-vascular bundles interspersed in the core consist of the wood vessels, sieve tubes and companion cells surrounded by thick walled fibers.

The question arises as to why, with the above knowledge, did it take over fifty years to commercialized the separation process. This can be due to several reasons: firstly, there was no technology developed at that time that could transform the high quality fiber of the rind into a useful and valuable product. Since all the fiber was destined for the furnace there appeared to be no economic advantage to separate it into its various components; secondly, the engineering ability and materials to design and construct a ‘separator’ were not available; 3rd the trend in sugar cane processing was for expanding the capacity of mills and the gradual mechanization of agricultural practices.

It therefore appeared that any process to treat the cane stalk individually was not feasible. It is also ironic that the mechanization process, which led to the expansion of the sugar industry and to a reduction in process costs, also led to the production of lower quality by-products. This was caused mainly by the inclusion
of extraneous matter in the field cane — such as tops and soil — which ended up in the bagasse, mud and molasses produced, thus reducing their value in further processing.

SEPARATION — A NEW TECHNOLOGY

It is very significant that the necessary mechanical development that led to the production of a commercially viable separation process came about due to the search for a method of obtaining the high quality fibers present in the outer rind of the sugar cane stalk rather than as a method aimed at taking advantage of the high purity juices present in the core of the stalk for sugar production.

A lesson learned, in the over ten years development period, has been the fact that the separation process can only be seen to commercially viable provided advantage is taken of the production of the high quality fiber for subsequent processing into high value products.

In the 1960's the inventors of the new technology, S.E. Tilby and R.B. Miller of Alberta, Canada developed the necessary machinery and mechanical systems for separating the high quality fibers without in any way damaging them in the removal process. The development work, which started some sixteen years ago and which has cost several million dollars, took place in the West Indian island of Antigua, St. Kitts (Laurie6) and Barbados (Laurie7).

OBSERVATIONS

The processes and apparatus which make up what has become known as the “Tilby Separation System” are subject of world wide patents, Tilby14. A brief outline, taken from the patent literature, is given below:

Field cane, containing mainly cane stalks along with other extraneous matter such as tops, trash, rocks, soil, etc., is partially dry cleaned to remove rocks, stumps and other heavy extraneous matter; the stalks are then aligned and chopped into approximately 35 cm billets. The billets are further dry cleaned to remove residual soil, trash and tops. The clean billets are stored in a bin from which they are metered at a pre-set rate to the separator.

The billets are aligned and fed vertically to the rubber feed rolls which grip the billet forcing it into the edge of the splitter blade causing it to be split longitudinally into two equal parts. Each half is carried by the intermediate feed rolls to the depthing section of the Separator. This section consists of a hold-back roll which grips the rind side of the split billet, and the cutter which mills away the soft interior of the billet. This is followed by the milling away of the epidermis materials from the outer side of the rind strip.

The milling away of the interior pith, known as “Comfith”, and the epidermis material, known as “Dermax”, is controlled so that the milling depth is uniform thus producing strips of sugar cane rind, known as “Comrind”, having a generally uniform thickness and containing substantially undisturbed unitized or laterally interconnected rind fibers.
The two milled components of the process can therefore be defined as:

1. Comfith — the interior portion of the cane stalk, consisting of mechanically shortened internal fibro-vascular bundles and pith cells attached to or inter-mixed with them, having the appearance of wet sawdust; and

2. Dermax — the epidermal cover of the cane stalk together with the cuticle wax and an intentionally limited amount of fiber, removed in the form of small particles.

Dermax

Dermax is approximately 2% of the weight of the cane stalk. (Table 1). An average quantitative analysis of Dermax is shown in Table 2. It is obvious that the hard cuticle wax on the outside of the cane stalk ends up in the Dermax from which it can be extracted by using conventional solvent extraction techniques.

The removal of the Dermax during the Separation Process and its elimination from further processing in the sugar factory would appear to have many advantages. Since it contains over 90% of the coloring matter and chlorophyl, which normally finds itself in the juice from a conventional mill, it is obvious that the juice extracted from the Comfith would be significantly lower in color, thereby holding out the possibility of decolorizing techniques being used on the Comfith juice in
order to directly produce a refined sugar rather than a raw sugar.

The fact that the Dermax, which contains just under 60% of the silica (the Comrind contains another 30%) is eliminated from the juice processing should significantly reduce the scaling of heating surfaces which is normally a major constraint to the continuous processing of sugar cane over long periods in conventional sugar factories.

In the fiber processing industry, the removal of the Dermax has some important advantages. In the processing of bagasses for pulp and paper it has proven to be extremely difficult to completely eliminate the Dermax during the refining and pulping process, in which case flakes of this varnish-like material appear as transparent spots on low quality bagasse paper.

The bond between the Dermax or cuticle layer of the rind fiber is considerably weakened during drying of the fibers and if these fibers are bonded together to form composition panel boards without first removing the Dermax then the internal bond strength of the panel is considerably reduced. The effect of a layer of cuticle wax can also be to reduce the internal bond strength.

Comrind

The Comrind is approximately 18% by weight of the stalk but it contains over 45% of the total fiber in the stalk. It is generally shredded into strips about 0.32 cms wide on leaving the Separator, as it is in this form that it can be most easily washed free from sugars and further processed into fiber based products. A typical analysis of Comrind is shown in Table 3.

### TABLE 3. Typical analysis of comrind

<table>
<thead>
<tr>
<th>Determination</th>
<th>Comrind</th>
<th>Original Cane</th>
</tr>
</thead>
<tbody>
<tr>
<td>% by weight</td>
<td>18.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Dry matter</td>
<td>41.0</td>
<td>30.0</td>
</tr>
<tr>
<td>Moisture</td>
<td>58.0</td>
<td>70.0</td>
</tr>
<tr>
<td>Pol</td>
<td>4.7</td>
<td>14.0</td>
</tr>
<tr>
<td>Fiber</td>
<td>33.2</td>
<td>13.0</td>
</tr>
<tr>
<td>Ash</td>
<td>0.7</td>
<td>0.5</td>
</tr>
<tr>
<td>Reducing Sugars</td>
<td>0.4</td>
<td>0.2</td>
</tr>
</tbody>
</table>

The sugars in the rind are usually in the form of a low purity juice, averaging less than 70.0 apparent purity. The sugar in the rind as a percentage of the sugar in the cane averages around 6% and is comparable with the sugar lost in bagasse in the Pol Balance of a conventional mill. Where no attempt is made to recover the sugar in the Dermax of the Comrind then the loss in sugar of approximately 7% is
equivalent to a pol extraction of 39% — providing all of the sugar can be recovered from the Comfith.

In order to further process the rind it would generally be necessary to remove most of the sugars and other hot water soluble. The economic feasibility of recovering this sugar from the low purity juice extracted will depend to a large extent on the value of the sugar at the time.

**Comrind as a replacement for wood**

After extraction of residual sugars and hot water solubles, the chemical composition of Comrind is shown to be very similar to that of both hard wood soft wood species, because of the close similarity to wood, Comrind can replace wood fibers for nearly all purposes in which wood has to be disintegrated into fibers or bundles of fibers; for example in the manufacture of particle board, fiber board or pulp and paper.

Research on the use of bagasse for the production of fiber board or particle board has shown that bagasses fiber may be substituted for wood but the resulting product is considered to be of inferior quality to that made from wood. However because of the great difference in the quality of the fiber in Comrind as compared to that of bagasse, tests carried out on boards produced from Comrind fibers, have shown that the quality of particle board is equal to that of wood based particle board.

In addition to particle-type boards, since the Comrind fiber strips are considerably longer than bagasses fiber and have been removed from the cane stalk without in any way damaging or dis-arranging the fiber bundles, a new type of structural particle board can be produced from Comrind which is equal in quality and value to exterior grade structural plywood.

**Production of Composition Panel Board from Comrind**

The basic research and development work relative to the production of various board composites, utilizing Comrind as a raw material, has been carried out by Messrs Interca Systems Inc., of Windsor, Ontario, Canada in association with Helmut G. Moeltner & Associates Ltd. and Reichold Chemicals (Canada) Ltd. with the further support of several engineering and manufacturing groups in the composition board field.

The results of this research and development is that many board composites such as Hardboard, MFD Board, Particle Board, Waferboard, Complyboard and Comply Lumber have been produced with Comrind as the raw materials. As in the case of wood based panel products many variations are feasible and those listed above are only a few of the potential products capable of using Comrind as a raw material.

Over ten years ago a special type of particleboard — Waferboard — was developed in Canada and the U.S.A.; this board is manufactured with large size flakes
of wood which are bonded with a phenolic glue. The properties of these boards, being between Particleboard and Plywood makes Waferboard suitable for uses similar to Plywood and a material suitable for building purposes including external applications.

The research program has shown that Caneboard, with a density of 64-70 Kg/m$^3$, has mechanical properties as good as or better than wood Waferboard; thus Caneboard can be considered an equal substitute for wood based Waferboard translating further into an equal substitute for wood based sheathing grade plywood.

As the Plywood industry struggles with poor peeler of reduced diameter, low quality veneers, higher harvesting and conversion costs and both near term and far term resource depletion, Caneboard would appear to be the ideal substitute to satisfy the spiralling need for structural panels.

The demand for forest product is expected to increase until, by the end of this century, the annual harvest will about equal the annual growth. This expectation dictates not only the efficient use of the forest resources but further dictates the need to find a resource such as sugar cane which renews itself on an annual basis.

**Specific Product Description**

Caneboard is an engineered Panelboard made from narrow and relatively long strand-type particles of Comrind. In the manufacturing process these particles, which can be thought of as small pieces of veneer panels.

The high strength of Caneboard panels comes mainly from the long strand like particles in the same way Plywood owes its strength to cross laminated veneers. However, because the panel is formed by random placing of the Comrind strands, unlike Plywood there is equal strength in all directions. Phenolic resin binder combines with the strands to augment directional strength and to provide internal strength, rigidity and water resistance.

Caneboard panels do not warp or check, and panels are knot- and defect-free. They are easily cut and machined and provide a good base for painting and other finished.

While the physical properties and quality in general of Plywood and lumber depends largely on the specie and/or quality of the raw material wood, Caneboard is an engineered product whereby the product and its quality is under direct and positive control on the basis of board composition and/or manufacturing methods. Special properties can be built into a Caneboard by changing the inherent structure of the board, the density, the resin content or the particle geometry.

**Production of Pulp and Paper from Comrind**

Comrind fiber, due to its low pitch cell content, has good properties for
<table>
<thead>
<tr>
<th>Identification</th>
<th>9-point</th>
<th>50/50</th>
<th>70/30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheet Wt., (8½x11), m.f.g.</td>
<td>7.30</td>
<td>7.60</td>
<td>7.49</td>
</tr>
<tr>
<td>Ream Wt., (24x36-500) m.f.</td>
<td>74.3</td>
<td>77.4</td>
<td>76.3</td>
</tr>
<tr>
<td>Ream Wt., lb/1000 sq ft, m.f.</td>
<td>26.0</td>
<td>25.5</td>
<td>25.0</td>
</tr>
<tr>
<td>Caliper, mils</td>
<td>10.8</td>
<td>9.2</td>
<td>9.1</td>
</tr>
<tr>
<td>Apparent Density, g/cc</td>
<td>2.27</td>
<td>0.539</td>
<td>0.537</td>
</tr>
<tr>
<td>Bulk Density, cc/g</td>
<td>49.9</td>
<td>65.6</td>
<td>86.0</td>
</tr>
<tr>
<td>Mullen, Points</td>
<td>67.2</td>
<td>143</td>
<td>128</td>
</tr>
<tr>
<td>Tear, g/sheet, M.D.</td>
<td>180</td>
<td>211</td>
<td>167</td>
</tr>
<tr>
<td>%</td>
<td>154</td>
<td>163</td>
<td>127</td>
</tr>
<tr>
<td>Tensile, kg/15mm M.D.</td>
<td>11.5</td>
<td>9.7</td>
<td>12.7</td>
</tr>
<tr>
<td>%</td>
<td>180</td>
<td>211</td>
<td>167</td>
</tr>
<tr>
<td>Stretch, %</td>
<td>1.6</td>
<td>3.1</td>
<td>1.6</td>
</tr>
<tr>
<td>%</td>
<td>134</td>
<td>163</td>
<td>127</td>
</tr>
<tr>
<td>Ring Crush, lb</td>
<td>5.8</td>
<td>36.2</td>
<td>47.4</td>
</tr>
<tr>
<td>%</td>
<td>216</td>
<td>285</td>
<td>26.2</td>
</tr>
<tr>
<td>CMT (conical) lb/10 flutes (A)</td>
<td>4.4</td>
<td>44</td>
<td>86.2</td>
</tr>
<tr>
<td>%</td>
<td>56.2</td>
<td>56.2</td>
<td>56.2</td>
</tr>
<tr>
<td>Smoothness, Sheffield</td>
<td>305</td>
<td>395</td>
<td>382</td>
</tr>
<tr>
<td>Porosity, Gurley, Sec/100ml</td>
<td>381</td>
<td>381</td>
<td>381</td>
</tr>
<tr>
<td>Brightness, Photobright</td>
<td>26.5</td>
<td>26.5</td>
<td>26.5</td>
</tr>
<tr>
<td>Wire Side</td>
<td>6.4</td>
<td>13.5</td>
<td>20.9</td>
</tr>
<tr>
<td>(a) 9-point Standard paper for corrugated sheet and product</td>
<td>(b) 9-point made from 50%/Concaved 50% card paper</td>
<td>(c) 9-point paper made from 70% Kraft and 30% kraft paper</td>
<td></td>
</tr>
</tbody>
</table>
producing 9-point corrugating medium form blends of Comrind fiber and waste corrugated kraft cuttings were extremely promising. Board were made in which 50% and 70% of the total finish was composed of Comrind.

The stock in each run drained freely and there was no picking in the sheet in the presses or driers as might be expected in the presence of pitch cells in the pulp.

Tests on the finished board resulted in crush values of 64 and 74 C.M.T. on the 50/50 and 70/30 Comrind/waste, respectively. These tests are much superior to the minimum crush requirements for an acceptable 9-point board and the results are compared with commercial board in Table 4.

Comfith

Comfith consists of some 80% of the sugar cane stalk and contains over 90% of the sugar in the stalk. A typical analysis of Comfith is shown in Table 5.

### TABLE 5. Typical of Comfith

<table>
<thead>
<tr>
<th>Determination</th>
<th>Comfith</th>
<th>Original Cane</th>
</tr>
</thead>
<tbody>
<tr>
<td>% by weight</td>
<td>80.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Dry matter</td>
<td>28.0</td>
<td>30.0</td>
</tr>
<tr>
<td>Moisture</td>
<td>72.0</td>
<td>70.0</td>
</tr>
<tr>
<td>Pol</td>
<td>16.3</td>
<td>14.0</td>
</tr>
<tr>
<td>Fiber</td>
<td>8.3</td>
<td>13.0</td>
</tr>
<tr>
<td>Ash</td>
<td>0.4</td>
<td>0.5</td>
</tr>
<tr>
<td>Reducing Sugars</td>
<td>0.13</td>
<td>0.2</td>
</tr>
</tbody>
</table>

**Sugar Production**

The Comfith leaving the Separator is in a highly disintegrated form and has an appearance similar to wet sawdust. A determination of the Preparation Index of Comfith has shown that cell rupture is over 92%. This indicates that extraction of the juice from the pith cells can be easily carried out by conventional milling, diffusion or pressing. The inventor of the Separator has recently developed a system specifically designed for very high extraction of sugar from Comfith, known as the "Tilby Multiple Ram Hydraulic Press", in which Pol Extractions in excess of 98% are claimed. Laboratory trials on the milling of Comfith have indicated the necessity of pre-compressing the feed before it enters the mill in a similar manner to the feeding of well prepared cane from a shredder of disintegrator. In laboratory milling trials Pol Extractions in the region of 70% were obtained in a single pass through a three roll mill and close of 80% with a pass through a second mill without the addition of any imbibition water.

Since the Comrind contains some 45% of the fiber in the cane and since the
capacity of a mill is best rated in the tons fiber per hour it can process, then it is obvious that the tons of juice per hour produced in a given mill can be nearly doubled by installing a Separator in front of the mill. It follows therefore that the horse power of the milling plant — on the basis of tons sugar produced — would be considerably less than that necessary when crushing whole cane stalks in the same mill.

Since any extraneous matter coming to the mill from the field in the sugar cane is removed, either in the cane cleaning plant or during the Separation Process in the Dermax, then the Comfith is essentially free from soil and sand particles. The serious problem therefore of abrasion that faces conventional mills processing mechanically harvested cane, is completely eliminated.

**Juice Treatment**

If one uses a conventional imbibition rate of 200% on fiber the total amount of water used in the extraction of sugar from Comfith would be significantly less than that used when processing whole cane stalks since, as in Table 6 Comfith only contains 51% of the fiber in the original cane. This results in a mixed juice going to be processed at 16-17° Brix depending on the quality of the original cane. The elimination of the extractable solubles present in the Dermax and the Comrind results in a mixed juice from Comfith of some 6 – 8 units of apparent purity higher than the apparent purity of mixed juice obtained from the same cane extracted in a conventional mill or diffuser.

The clarification of this high purity juice is relatively simple and laboratory tests have indicated a lime requirement of about 10% of that required for conventional mixed juice. In fact clarification by heat alone, without the addition of lime or flocculant, has been shown to be possible with certain varieties of sugar cane. Over the years, hundreds of clarifying agents have been used but most of these have been rejected in favor of lime because of its lower cost; however, with this high purity juice the possibility will have to be examined using some of the more expensive clarificants which, due to the very small amount of clarifying agent needed in this juice, would provide the necessary technical advantage while still being economically feasible.

Again by reason of its high purity and low color, sophisticated methods of juice purification, such as ion exchange and dialysis, may well be economically feasible leading to the production of a water-white clarified juice which may be evaporated to produce a liquid sugar for industrial use without the production of any molasses. If this is technically feasible, and laboratory tests have indicated a strong possibility that it is, then the economics of this process would be extremely attractive.

Since all of the sand and soil normally found in mechanically harvested cane are eliminated in the Separation System, and since the Comfith juice is high in purity and requires very little lime, the quantity of mud precipitated during clarification is drastically reduced. This means less clarifier and mud filter capacity would be required and the Pol in Mud % Pol in Cane should be less than half that
normally found when processing whole cane. This should lead to an increased Boiling House Recovery.

**TABLE 6. Distribution of pol and fiber in various separated components**

<table>
<thead>
<tr>
<th>Pol Balance</th>
<th>Fiber Balance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pol in Comfith % Pol in Cane 93</td>
<td>Fiber in Comfith % Fiber in Cane 51</td>
</tr>
<tr>
<td>Pol in Comrind % Pol in Cane 6</td>
<td>Fiber in Comrind % Fiber in Cane 46</td>
</tr>
<tr>
<td>Pol in Dermax % Pol in Cane 1</td>
<td>Fiber in Dermax % Fiber in Cane 3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ash Balance</th>
<th>Reducing Sugars Balance</th>
</tr>
</thead>
<tbody>
<tr>
<td>*Ash in Comfith % Ash in Cane 64</td>
<td>R.S. in Comfith % R.S. in Cane 50</td>
</tr>
<tr>
<td>Ash in Comrind % Ash in Cane 24</td>
<td>R.S. in Comrind % R.S. in Cane 36</td>
</tr>
<tr>
<td>Ash in Dermax % Ash in Cane 12</td>
<td>R.S. in Dermax % R.S. in Cane 14</td>
</tr>
</tbody>
</table>

*Most of this Ash is insoluble and located in the fiber.*

**Evaporation and Crystallization**

The evaporation of Comfith clarified juice is expected to be carried out with considerably reduced scaling of the heating surfaces due to the elimination of the silica in the Dermax and the Comrind and the reduction in the amount of lime used for the clarification process.

Referring to Table 6, it has been shown that if no attempt is made to recover the sugars in the Comrind and the Dermax then the overall Pol Extraction would certainly be less than that achieved in a modern conventional mill or diffusion plant. However, it is in the Boiling House that the advantages of the Separation Process for sugar production would be realized.

Due to the considerably lower ash content of the clarified juice from Comfith as compared with conventional juices, the production of molasses may be as low as 50% of that obtained in a conventional sugar factory, as predicted from laboratory analyses. Therefore it is to be expected that the Boiling House Recovery will considerably exceed that of a conventional sugar factory and that an overall recovery would equal or exceed the most efficient conventional sugar factory. The corollary of the low molasses production per ton of sugar produced is that the steam requirement in the Boiling House should be significantly lowered since the number of "C" strikes, which are large consumers of steam, would be less than in a normal Boiling House.

With good juice clarification, followed by some syrup purification — for example by the Taladura process — it may be possible, due to the low inherent
color in the original Comfit juice, to further decolorize the syrup using conventional activated carbon to produce a water-white syrup from which a standard white granulated sugar could be boiled. As mentioned for the juice purification, due to the low ash content of the clarified juice, the use of ion exchange columns for further de-ashing and decolorizing may well be economically feasible.

Amorphous Sugar

The production of crude sugar provides a livelihood for millions of people in the underdeveloped parts of the world. However, due to the 'technological transfer' from the more sophisticated countries, these people are led to believe that they need refined granulated sugar or at least a 'plantation white' sugar as part of their development. This trend is a threat to the market for crude sugars which are actually of a higher nutritive value than refined sugar.

Laurie has been able to demonstrate at the Pilot Plant stage in Barbados that with a good quality cane the high purity Comfit juice following simple clarification techniques may — because of its high purity and low ash content — be directly evaporated to dryness producing a soft light colored amorphous sugar of excellent flavor. The yield of this sugar is significantly higher than that normally obtained from a given quantity of cane since all of sugars and non-sugars that normally end up in the molasses are included in the amorphous sugar produced. Due to its high purity the storage characteristics of the amorphous sugar should be considerably better than the normal crude sugars thus eliminating the chief objection to this project.

This process holds out great promise for use on a small scale to replace the crude sugars such as Gur, Khandsari, Panella, etc., produced at the village level. Also since amorphous sugar contains most of the protein, minerals and vitamins that were in the original juice has great potential on the "Health Food" market.

Alcohol

Sugar cane juice or molasses for use as a fuel for automobiles is probably the most significant development in the sugar industry in the latter half of the present decade. The energy crisis, caused by the spiralling cost of oil, has spurred activity in many areas in the search for an alternative source of energy that may be easily renewable. Since sugar cane is known to be the most efficient converter of solar energy of all plants the use of sugar cane biomass as a renewable alternative source of energy appears to be the most logical development. There are three major ways of converting sugar cane biomass to usable energy.

1) The burning of the biomass in specially constructed furnaces designed to handle high moisture fuels. The heat energy thus produced would be converted into steam and electricity.

2) The use of the biomass material as a major feed ingredient for working animals with the waste products being utilized for the production of biogas and fertilizers.
3) The production of liquid gaseous fuels of high calorific value either as the major product or as a co-product of processing the biomass material.

The first two systems mentioned above are likely to be relatively inefficient but may have limited application on a small scale at the village level. In the third system the most obvious method would be to use the sugar cane as a raw material for the production of liquid fuel by converting the fermentable sugars in the cane to alcohol.

Since it is generally accepted that some 65-70% of the cost producing alcohol comes from the cost of the raw material used, assuming a reasonably efficient milling and distillation unit and a sugar cane cost of around US$15 per ton, then anhydrous alcohol capable of being mixed with gasoline would cost approximately US$0.34-0.37 per liter.

In order to significantly reduce this cost other high value products must be produced simultaneously. Since sugar cane consists primarily of solubles 12-15% (mainly sugars), fiber 10-14% and water 72-77%, then it is obvious that it is the fiber or non-fermentable components of the cane that must be utilized to produce the high value products mentioned above. However, the bagasse produced in the conventional processing of cane has not been developed into high value products. With the advent of the new Separation Technology there is the possibility of producing high value composite board panels as a co-product. It would therefore appear that for the first time, in a fully integrated panel board/alcohol plant, the cost of alcohol could be significantly reduced.

In a recent feasibility study carried out for a Central American Corporation it was shown that alcohol could be produced at US$0.16 per liter – provided the board panels produced could be sold at 80% of the value of competing Plywood. The board plant part of the fully integrated complex would then give a return of 30% on capital invested. It would therefore appear that in order to economically produce alcohol for fuel from sugar cane it is essential to produce a high value co-product simultaneously.

Animal Feeds

The use of the whole sugar cane plant including the tops, leaves and stalk for feeding ruminant animals has aroused world wide interest and holds out great promise for the large scale production of milk, beef and mutton in the underdeveloped tropical world. This is because of the very high yields of digestible dry matter obtained with sugar cane, which has been shown to be able to carry from three to five times the number of animal units per hectare of cultivated land as compared with conventional tropical grasses such as Pangola, Bermuda, Elephant Grass, etc.

By removing the rind from the cane stalks and using the Comfith as a high energy feed base the feed has been significantly improved by reducing its fiber level from around 13% to about 8%. Research work, carried out in Barbados (Intersane System Ins, Laurie91 in the early 1970's and more recently in the Do-
minican Republic by Prestone et al., has shown that with proper supplementation of the correct proteins Comfith is capable of very high levels of animal production. However, as with the production of alcohol and sugar, it is essential that a use be found for the Comrind produced by the Separator.

In countries that have existing board plants, the possibility of setting up large scale feedlots near the source of supply of cane and the board plant, holds out exciting possibilities. In a reasonably large scale feedlot of 15,000 – 25,000 head capacity, with a market prepared to purchase the Comrind at US$25 per ton, the price for Comfith – when subsidized by selling the Comrind – would actually be lower than the price of the original cane; in which case this system of animal production would appear to be economically feasible.

VARIETY SELECTION

The breeding and selection of varieties of sugar cane have been based primarily on selection criteria such as yield of sucrose per hectare, with other factors such as low fiber, erectness for mechanical harvesting, resistance to disease and insect attack, etc, being given more or less weight, depending on the problems of the particular area in which the cane is to be grown.

With the advent of the Separation Process, whereby Comrind fiber appears to be at least equal value with the sugar content, the breeders will now be faced with a complete new set of selection criteria whereby the quantity and quality of the Comrind fiber assumes great importance.

For the purpose of alcohol and animal feed, it is the yield of total sugars or fermentable material – and not just the more exacting requirements of high sucrose – that would be of importance. For example, in the past, many varieties which yielded high tonnages of cane stalk have been rejected because they produced low purity juice.

It is not unreasonable to project that in the not too distant future different varieties of sugarcane will be grown with different end uses in mind and that with this specific selection criteria, the potential to significantly increase yields of fiber products, alcohol and livestock per hectare is feasible.

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SEPARACION — UN PROCEDIMIENTO PARA PRODUCIR AZUCAR DE ALTA, Y CO-PRODUCTOS DE ALTO VALOR DE LA CAÑA DE AZUCAR

C. Keith Laurie

RESUMEN

Un procedimiento para la separación del tronco de la caña de azúcar en varios componentes se ha desarrollado. El procedimiento ofrece un sistema donde uno ó más co-productos se podrían producir simultáneamente.

Las fibras de alta calidad de la corteza se separan de la medula y se utilizan en la producción de láminas de tabla compuesta de alto valor estructural. El jugo de alta puerza se separa del corazón tuétanico del tronco de la caña y se extrae y se usa en la manufactura de azúcar refinado, azúcar amorfo y alcohol. El meollo completo con todo su azúcar se podría usar como comida de animales.
La posibilidad de que futuras selecciones de variedad de caña de azúcar se harán a base de la calidad de la fibra y de azúcar fermentable en vez de la sucrosa sola sería probablemente el cambio más grande que se podría ver en la industria de caña de azúcar en este siglo.