# THE UTILIZATION OF SUGAR CANE BY-PRODUCTS AS SUBSTITUTES FOR CEREAL IN ANIMAL FEED

by

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## 1. INTRODUCTION

From the point of view of biomass (Leng and Preston, 1976), the tropical regions are potentially the most productive in the world, and numerous plants are available that have great potential in animal feeding.

A very clear example is sugar cane, a crop that has been traditionally oriented for sugar production and has played a very important role in the economy of many countries. In this respect, Preston and Hagelberg (1967) consider that sugar cane (including both sugar and molasses) is capable of producing a greater quantity of available carbohydrates than any other tropical crop. Nevertheless, its use in animal feeding has been very limited in comparison to cereal grains, which compete with humans.

## 2. PRODUCTS DERIVED FROM SUGAR CANE

The by-products of the sugar industry can be grouped according to source; those that originate from harvesting: tops, leaves and straw, and those that are obtained from the industrial process: bagasse, molasses and filter mud.

During harvesting and processing of sugar, for each ton of sugar cane cut it is possible to obtain approximately 120 kg of sugar, 38 kg molasses, 36 kg of filter mud and 250 kg of bagasse, 60 kg of straw and 100 kg of tops.

Harvest residues can be used directly as forage, specially during dry periods when pastures are limited. These by-products are concentrated in specific areas, i.e. the sugar cane producing regions.

In addition to residues obtained from harvesting and by-products from processing of sugar, sugar cane juice may be used as a substitute for grains, as well as high-test molasses, which is a concentrated form of partially inverted cane juice which avoids crystallization of sucrose, and the use of sugar cane itself in ruminant feeding.

Chemical composition of sugar cane products and by-products

The principal value of sugar cane is as a source of energy, mainly soluble carbohydrates of high digestibility. Its protein content is very low. (Table 1.)

## 3. CATTLE FEEDING

### 3.1 Use of harvest residues

In the Dominican Republic, harvest residues were used for silage. The chopped residue was mixed with chicken manure, filter mud and molasses (Table 2.) Water was added to these mixtures to reach a level of 60 to 70 percent moisture.

Feeding an average of 22 kg of silage per head daily was enough to maintain the animal's weight and to sustain reproductive activity. This practice, however, was recently discontinued because the harvesting costs were very high due to recent increases in the cost of petroleum products.

### 3.2 Use of chopped cane

#### 3.2.1 Fattening steers

The average daily consumption for a lot of 1 200 steers of a commercial herd fed under an intensive confinement feeding programme oscillates between 15 and 20 kg of chopped cane per head. In addition, they are fed 9 kg of a mixture of molasses/urea-chicken manure with free access to a mineral supplement. Cattle are selected for this feeding programme at about 10 months of age at an average weight between 200 and 225 kg and are fed for a period of 8 to 10 months until they reach a liveweight between 380 and 400 kg. During the feeding period, average daily gains of approximately 750 g per head are obtained. Before being slaughtered, the animals reach a weight of 450 kg.

#### 3.2.2 Confinement of replacement heifers

In this programme, crossbred Holstein or Brown Swiss heifers consume between 13 and 16 kg of chopped cane and 5 kg of the molasses-urea-chicken manure mixture. As soon as the heifers reach 300 to 320 kg liveweight, they are passed on to a programme where they are artificially inseminated with Holstein or Brown Swiss semen.

In a commercial herd with 1 800 heifers of the Romana Red breed and commercial crosses, conception rate was 84%.

## 3.3 The use of molasses/urea in milk production

Most of the investigators who work with animals on good quality pasture have not encountered a significant positive response in either milk production or weight gain with animals that have been supplemented with molasses/urea, sugar cane and grains. What has usually been reported, when these materials are used, is a substitution of pasture for these supplements, increasing carrying capacity, which is uneconomical.

This lack of response, could be related to the rumen microorganisms, which may use the easily fermentable energy sources with the suppression of cellulose digestive activity.

Under similar circumstances, to supplement animals with protein only of low solubility has resulted in relatively low increases in milk production and has required from 0.2 to 0.7 kg of concentrate for every additional litre of milk which, under most conditions, is not economical. The best responses among milk cows to concentrate supplementation have occurred at the beginning and at the peak of the lactation period.

The response to supplementation after these periods is much less, all of which concurs with the common knowledge that this is a period of maximum nutritional need. When pastures are short, or too mature, a positive response to an energy supplement frequently occurs, it being often necessary to add fermentable nitrogen (urea) to improve microbial synthesis, since it increases voluntary intake of low quality forage and its digestibility.

In those cases, where high levels of productivity are programmed, it will be necessary to add protein supplements. The response would depend on such factors as the genetic potential of the animal, the climate and the total ration.

Alvarez et al., (1979) report results in a commercial operation on lactating cows on pasture of Bermuda Cross No. 1 that were in regular condition. (Table 3.)

## 3.4 Use of sugar cane and urea for milk production

As in the case with molasses/urea a positive response is not to be expected in either meat or milk production when the cane is fed to animals that have continuous access to pasture of good quality. From this point of view, sugar cane, just like molasses; should be used as a pasture supplement during critical periods. Under such circumstances, supplementation has maintained weight and milk production and has helped to avoid overgrazing of pastures.

## 3.5 Cane juice

Sanchez and Preston (1980) reported the first research work with cattle using sugar cane juice as a basic element in comparison with molasses and Estrella Africana forage, fed at a level of 3 percent of liveweight per animal - plus 1 kg of sunflower meal and 50 g/an/d of a commercial mineral mix. (Table 4.)

There were very high responses, both in voluntary intake and weight gains that were attributable to both the molasses and cane juice diets and to the presence or absence of sunflower meal. Sunflower meal improved the results of the molasses by 116 percent of the cane juice by 65 percent. The use of cane juice as a substitute for molasses tripled the rate of gain when sunflower meal was included in the ration. An extremely high rate of growth was found in the case of the basic ration using cane juice. The results from a basal diet using cane juice without protein supplement were very much higher than would be normally anticipated with a diet of molasses without supplement, and what was specially surprising was that the results from unsupplemented cane juice were superior to those of the ration of molasses with supplementation. The rate of gain of 1.3 kg/an/d which was obtained with the supplemented cane juice ration, is comparable to the results reported in temperate climates with steers receiving rations based on cereal grains (Preston and Willis, 1974).

# 4. MONOGASTRIC FEEDING

## 4.1 Use of molasses in pig feeding

Molasses is the principal by-product in the sugar industry and has been used as an animal feed for a long time.

Two major problems have arisen as limiting factors in the use of high levels of this by-product. First, quantities in excess of 30 percent in pig feed produce laxative-like effects in all ages, especially in piglets and growing pigs. On the other hand, increasing the level of molasses dilutes the concentration of energy in the diet, which results in lowered weight gain per animal (Buitrago et al., 1978). Iwanaga and Otagaki (1979) demonstrated that tolerance of molasses increases in pigs of greater weight and age. This was supported by the work of Fermín and Piña (1974) when they used levels between 30 and 50 percent of molasses in the diet of growing and fattening pigs, without finding serious problems of diarrhoea and without affecting animal performance. Recently Fermín (1983) included 50 percent molasses in the diet of growing and fattening pigs, slowly varying or increasing those levels, depending on the weight gain of the animals, without any digestive troubles.

The problems produced by the high level of molasses have been attributed to osmotic effects caused by the great quantity of potassium ions in the final molasses. Obando et al.(1969) and Ly and Velázquez (1969) suggested the possibility that part of the laxative-like effect caused by the final molasses in pigs is due to insufficient intestinal saccharase used for the complete hydrolization of sucrose present in the molasses.

One of the problems that limits the use of high levels of molasses is the difficulty of mixing quantities in excess of 20 percent, in addition to the problems of storage and handling of this type of diet, when using automatic feeders. High levels of molasses would have to be mixed daily and be offered in special troughs.

Therefore, the majority of investigators agree that the most practical level of molasses used should be between 15 and 20 percent of the diet.

## 4.2 Sugar in pig feeding

We consider that sugar is an excellent source of energy, but in view of its manufacturing cost and its direct competition with human use, it is impossible to use high levels in pig feed. Also more economic alternatives exist such as high-test molasses and sugar cane juice.

## 4.3 High-test molasses in pig and poultry feeding

High-test molasses is prepared from sugar cane juice, which has been clarified, later concentrated and partially hydrolized to avoid the crystallization of sucrose. In this process, sugar is not extracted and therefore high-test molasses has a greater concentration of sugars and lower concentration of minerals with respect to molasses.

High-test molasses can completely substitute grains in pig feed (Velázquez et al., 1970; Ly and Velázquez et al., 1972; Dieguez, 1974; Marrero and Ly, 1976. Even in the poultry industry, primarily for smaller units and as an integral part of mixed production systems, high-test molasses can be an important substitute for grains presently imported by developing countries.

## 4.4 Sugar cane juice for pigs

Pigs present certain advantages over other species such as ruminants and poultry in that there is a greater flexibility in the use of sugar cane juice as a source of energy in their diet. Pigs are more efficient compared to ruminants in the conversion of simple sugar in animal meat and fat. Furthermore pigs are less affected by laxative effects produced by brown sugar and molasses than poultry.

Mena (1981) in an investigation carried out in Mexico indicated the feasibility of using sugar cane juice as a total substitute for grains in growing and fattening pigs. Mena (1983) continued the evaluation of sugar cane juice in the Dominican Republic at the Centre for Livestock Investigation. He and his colleagues carried out a series of research in different stages of the pig's life cycle (Table 6).

Interesting results were obtained from lactating and pregnant sows that received sugar cane juice during the entire reproductive and lactating period, (Table 7) and piglets had a greater birth weight.

This feeding system has great application in sugar cane producing regions. The best alternative would be to integrate the production of sugar cane with pig production.

A characteristic of sugar cane juice is the complete lack of fibre. Therefore, pig rations based on sugar cane juice allow protein supplementation with fibre levels that would not be accepted in conventional cereal-based diets. There exists a wide range of protein rich forages, some of which are harvest by-products, for example, cassava and sweet potato leaves. Other sources are legumes, such as Gliricidia, Leucaena, Syratro and Stylosanthes.

### 4.5 Poultry feeding

Sugar cane derivates for poultry feed have had less application due to problems in the industrial setting. However, if one considers the smaller rural operation, high-test molasses and sugar cane juice can completely replace cereals in poultry feed. This allows the use of foliage protein sources, which in addition to protein would supply carotenoid pigments, which are imported by developing countries.

## 5. CONCLUSIONS AND RECOMMENDATIONS

Depressed prices of sugar have made it necessary to diversify the use of sugar cane in sugar producing countries. Today technology exists which can play a decisive role in this diversification.

Infrastructure and technology of sugar factories can be successfully used for livestock feeding with the production of high-test molasses which can substitute cereal grains as an energy source in the animal diet. This would help to solve not only part of the sugar industry's difficulties, but also animal production problems in developing countries.

An advantageous alternative is sugar cane juice, which can be used in small and large production systems and has great application in sugar cane growing regions, where no transportation is required.

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Table 1: Chemical composition of sugar cane

| | PERCENTAGE | | | |
|---|---|---|---|---|
| | Dry Matter | Crude Protein | Calcium | Phosphorus |
| Harvest residue | | | | |
| Tops | 30.5 | 3.9 | 1.23 | 0.13 |
| Leaves and straw | 64.4 | 3.2 | 0.44 | 0.07 |
| Industrialization process | | | | |
| Bagasse | 46.40 | 2.70 | 0.15 | 0.12 |
| Final molasses | 70-75 | 3.75 | 0.84 | 0.03 |
| Cachaza | 19 | 10.2 | 2.63 | 1.3 |
| Products | | | | |
| Sugar cane | 34.3 | 2.6 | 0.45 | 0.03 |
| Sugar cane juice | 18-20 | 0.4 | 1.9 | 2.3 |
| High-test molasses | 82-85 | - | 0.12-0.18 | 0.9-0.12 |

Fermin (1984) and Caballo (1980)

**Table 2:** Nutritive composition of harvest residues silage

| | PERCENTAGE | |
|---|---|---|
| | IN FRESH MATTER BASIS | DRY MATTER BASIS |
| Harvest residues | 20 | 37.46 |
| Filter mud | 15 | 8.29 |
| Molasses | 15 | 31.39 |
| Poultry manure | 10 | 22.86 |
| Water | 40 | 0 |
| TOTAL | 100 | 100 |
| Nutrients | | |
| Dry matter | 34.97 | 100 |
| Crude protein | 3.49 | 9.97 |
| Calcium | 0.48 | 1.37 |
| Phosphorus | 0.19 | 0.54 |

Fermin (1984)

Table 3: Milk production of grazing cows with and without supplementation of molasses/urea.

| | With 1.3 kg/cow/day | Without molasses |
|---|---|---|
| No. of cows | 14 | 14 |
| Milk production (l/day) | | |
| a) 10 days before | 3.97 | 4.12 |
| b) 74 " observation | 3.15 | 3.05 |
| Milk taken by calf (kg/d) | 2.03 | 2.10 |
| Total milk (milked + calf) | 5.18 | 5.15 |
| Liveweight change (l/day) | 0.087 | 0.02 |

Alvarez *et al.*, (1979)

Table 4: Mean values for liveweight gain, feed intake and conversion of crossbred bulls fed basal diets of cane juice or molasses.

| | MOLASSES | | CANE JUICE | | SD% (prob) |
|---|---|---|---|---|---|
| | No Supplement | 1 kg/d Sunflower meal | No Supplement | 1 kg/d Sunflower meal | SD% (prob) |
| Liveweight, kg. | | | | | |
| Initial | 279 | 266 | 261 | 279 | |
| Final | 300 | 304 | 309 | 361 | |
| Daily gain | 0.252 | 0.545 | 0.795 | 1.315 | ± 17(P .001) |
| Feed intake kg/d | | | | | |
| Juice/molasses | | | | | |
| Fresh | 3.95 | 4.00 | 22.69 | 31.92 | |
| DM | 2.96 | 3.00 | 3.40 | 4.79 | ± 12(P .001) |
| (Sugars) | (2.17) | (2.20) | (3.06) | (4.31) | |
| Forage (DM) | 2.48 | 2.52 | 2.45 | 2.74 | |
| Supplement (DM) | - | 0.90 | - | 0.90 | |
| Total (DM) | 5.44 | 6.42 | 5.85 | 8.43 | ± 22(P .001) |
| Feed conversion | 21.54 | 11.78 | 7.42 | 6.44 | ± 57(P .001) |

Sánchez and Preston (1980)

**Table 5: Mean values for animal performance parameters of bulls fed a sugar cane juice diet.**

| | Fresh juice with fish meal | PRESERVED JUICE | | |
|---|---|---|---|---|
| | | + Fish | - Fish | SD $\pm$ (P) |
| Liveweight kg | | | | |
| Initial | 179 | 186 | 182 | |
| Final | 275 | 280 | 257 | |
| Daily gain | 1.05 | 1.02 | 0.85 | $\pm$.12 (.42) |
| Feed intake kg\|d | | | | |
| Fresh juice | 17.20 | 19.7 | 18.8 | $\pm$2.4 (.5) |
| Leucaena | 4.10 | 4.25 | 4.45 | |
| Fish meal | 0.40 | 0.40 | - | |
| Minerals | 0.06 | 0.06 | 0.06 | |
| Total DM | 4.50 | 4.90 | 4.35 | $\pm$10 (.18) |
| Conversion DM | 4.28 | 4.63 | 5.27 | $\pm$69 (.5) |

Duarte _et al._, (1982)

Table 6: Animal performance of pigs fed sugar cane juice.

| Initial weight | Final weight | Gain | Intake | Conversion | Author |
|---|---|---|---|---|---|
| kg | kg | g/d | kg/DM/D | Feed | |
| 48.6 | 87.9 | 706 | 2.41 | 3.40 | - Mena et al., (1981) |
| 26.8 | 54.6 | 555 | 1.86 | 3.35 | - Mena et al., (1982) |
| 38.6 | 100 | 991 | 3.29 | 3.66 | - Fermin (1983) |
| 27.6 | 61.5 | 576 | 1.90 | 3.29 | - González (1983) |
| 16.2 | 93 | 781 | 2.51 | 3.40 | - Fernández (1984) |
| 11.4 | 28 | 350 | 1.20 | 3.41 | - Cadena (1984) |
| 32.0 | 61.4 | 601 | 2.70 | 4.16 | - Santana et al. (1985) |
| 60.9 | 102 | 800 | 2.95 | 3.69 | - Abreu (1984) |

Table 7: Reproductive performance of sows fed sugar cane juice and commercial concentrate feed.

| Feed | No. of services | Conception rate % | No. of piglets per litter | Birth weight kg |
|---|---|---|---|---|
| Sugar cane juice | 25 | 92.0 | 8.28 | 1.47 |
| Commercial | 14 | 85.7 | 10.09 | 1.38 |

Mena *et al.*, (1984)