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Sugarcane as feed
La caña de azúcar como pienso

CONTENTS

Proceedings of an FAO Expert Consultation held in Santo Domingo, Dominican Republic from 7–11 July 1986

Memorias de una consulta de expertos de la FAO en Santo Domingo, República Dominicana 7–11 de Julio de 1986

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INTRODUCTION

Sugarcane is the world's most efficient living collector of solar energy, storing this energy in a huge quantity of biomass in the form of fibre and fermentable sugars.

This crop is of great importance in the agricultural sector and in the general economy of many of the tropical developing countries. It provides employment not only to agricultural labourers in the fields but also to industrial labourers in the sugar factories. It is also an important source of foreign exchange. The tremendous drop in the world market price of sugar which occured in the last years has caused an economic crisis in these countries.

Since sugarcane production has become a second nature in many tropical developing countries it is advisable to explore the numerous alternative uses of sugarcane and its products and by-products.

One of these alternative uses which has shown promising prospects concerns animal feeding. For the last twenty years a tremendous amount of research has been conducted in many countries and specially in the Caribbean region and tropical America. The application of the results obtained could contribute to solving the problems created by the sugar crisis and give a new chance to the animal production sector in the affected countries.

It is in this context that FAO organized an Expert Consultation on the Use of Sugarcane as Feed. This consultation was held in Santo Domingo, Dominican Republic, from 7 to 11 July 1986.

The papers delivered on this occasion are presented in their original language (English or Spanish) followed by a summary in the other language.

INTRODUCCION

La caña de azúcar es el captador vivo de energía solar más eficiente y almacena esa energía en una enorme cantidad de biomasa en forma de fibra y azúcares fermentables.

Es un cultivo de gran importancia para el sector agrícola y para la economía en general de muchos países en desarrollo tropicales. Proporciona empleo no sólo a travajadores agrícolas en los plantaciones sino también a obreros en las fábricas de azúcar. Asimismo, es una importante fuente de divisas. La fuerte baja de los precios internacionales del azúcar registrada en los últimos años ha provocado una crisis económica en esos países.

Teniendo presente que la producción de caña de azúcar se ha convertido en una segunda naturaleza para muchos países en desarrollo tropicales, conviene examinar los numerosos usos posibles de la caña y de sus productos y subproducts.

Un uso que ofrece perspectivas interesantes es la alimentación animal. En los últimos veinte años se ha realizado una cantidad enorme de investigaciones en muchos países, especialmente en la región del Caribe y en la América tropical. La aplicación de los resultados de estas investigaciones podría contribuir a resolver el problema creado por la crisis del azúcar y ofrecer nuevas perspectivas al sector de la producción animal en los países afectados.

Fue dentro de este marco dentro del cual la FAO organizó una Consultación de Expertos sobre la Utilización de la Caña de Azúcar como Pienso. La reunión se celebró en Santo Domingo, República Dominicana del 7 al 11 Julio, 1986.

Los trabajos presentados durante este evento se presentan aquí en la lengua original de sumisión (Inglés o Español) y cada uno acompañado de un resumen en la otra lengua.

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THE ECONOMIC IMPORTANCE OF SUGAR AND SUGAR CANE - PROBLEMS AND PERSPECTIVES

K.S. Mulherin

INTRODUCTION

The world sugar economy is characterized by a combination of complex problems affecting both developing and developed countries whether they export cane or beet sugar. It is faced with recurring supply/demand imbalances reflected in extremely volatile prices on free markets. Over the past five to six years, world free market prices have been severely depressed and in 1985 probably reached all time lows. This situation has of course had most unfavourable repercussions on farm incomes and commodity exports from many countries, particularly developing countries which depend on sugar for a large proportion of their export earnings.

Sugar cane and cane sugar exports are the mainstay of many developing countries principally in Latin America and the Caribbean but also in southern Africa, Asia and the Pacific. Even with the "rock bottom" prices prevailing on export markets in recent years, sugar still accounted in 1984 for US $8 000 million in export income or nearly 10 percent of the total value of agricultural exports of all developing countries, including fishery and forestry products. Again despite the low prices, sugar was second only to coffee as an individual source of export income for developing countries and a larger earner than all cereals, livestock products, forestry and fishery products. This highlights the dependence of developing countries on cane sugar exports and the pressures which they must be under because of the drastic decline in sugar revenues.

To further emphasize the relative weightings and importance of sugar to developing countries it might be added that 70 percent of world sugar output is produced in developing countries and 85 percent of cane sugar. Similarly, developing countries account for 65 percent of total world sugar exports by volume, including 80 percent of cane sugar exports. In global terms cane sugar accounts for about two-thirds of total world sugar exports and beet sugar one-third.

MARKET TRENDS 1960–86

Production

An analysis of world sugar markets over the past 20–25 years indicates that production has more than doubled from 50 to 100 million tons and so has consumption, but that in most years since 1960, world production has in fact exceeded consumption. In the twenty-five years from 1960 to 1985, there have only been eight years with a production deficit caused in each case by a crop failure in one or more major producing countries. In each of the periods in which deficits

occurred - 1962/63, 1971/74 and 1979/80 - prices rose strongly and quickly, but subsequently declined with equal rapidity (Figure 1). It can therefore be taken for granted that production will be sufficient to satisfy demand except in those years which have accrued in the past at about six to seven year intervals when adverse weather in major producing countries causes shortfalls in supply which are significantly above normal. It would appear that producer/exporters operate under the assumption that they will do sufficiently well in the good years around the top of the cycle to carry them over the lean years around the bottom.

A number of other elements must be taken into account in looking in particular at production trends - one has been an increasing tendency, particularly evident since the mid-seventies, of some major developed importing countries, towards protectionism, i.e. to assist producers to reach or maintain a level of output that would not be economically feasible if they were exposed to international prices another has been the tendency for many developing countries to adopt programmes to increase their level of self-sufficiency in sugar or even to attain self-sufficiency. Many of these programmes were conceived during periods of high prices and aimed at saving foreign exchange but in many instances cost was not the primary consideration in their implementation, since it would usually have been much cheaper over time to import sugar.

A third element has been the misreading by countries of the cyclical periods of high prices. All too often there has been a false optimism that these boom periods would last, which led to accelerated increases in production which in turn accentuated the price collapses which inevitably followed. Such considerations undoubtedly influenced the EEC sugar regime when the planning of its production quotas for the second quota period (1975–81) coincided with the 1973/74 sugar price boom.

Technological advances have also played a major role in production increases in both

developing and developed countries. Improved cane varieties, new disease and pest control measures and better farming practices have raised yields appreciably and improved mill technology has also raised sugar extraction ratios in sugar factories.

Finally, the tendency for national policy considerations to obscure the global picture - the separation of supply, which appears to have a life of its own, from demand can be summed-up in one figure - it has been estimated that by 1983/4 world sugar production capacity at factory level was about 120 million tons (compared with 1984 consumption of 94 million tons). Agricultural capacity was of course less but it must be emphasized that both cane and beet sugar have a potential for rapid expansion and there is a large pool of sugar cane which could be used for production of sugar if the price warranted, either by increasing productivity for example through higher fertilizer application, irrigation, or by diverting cane from other uses (e.g. from non-centrifugal sugars in India or from ethanol in Brazil). As evidence of the expansion capacity of sugar production it may be noted that world production rose by 8 million tons or 10 percent between 1980 and 1981 in response to high prices prevailing at the time and in the following year by another 9 million tons, a total increase of 17 million tons or 20 percent in two years.

Consumption

World consumption of sugar also doubled between 1960 and 1965 from 49 million to 99 million tons, but the overall growth rate covers widely divergent trends. In per caput terms world consumption of centrifugal sugar currently fluctuates at about 20 kg per head, i.e. around 38 kg in developed countries and 14 kg in developing countries, which compares with 33 kg and 8 kg respectively in 1960. Per caput consumption continued to grow in both developed and developing countries until the mid-seventies, although at a much faster rate in developing countries, where per caput consumption was low and income and price elasticity of demand

were also high. Thereafter, per caput consumption of developing countries continued to rise strongly, although in the past year or two there have been some indications of a levelling out of demand. This has occurred despite the availability of cheap sugar on world markets and reflects foreign exchange difficulties faced by low income developing countries and the impact of lower oil prices on the incomes of the oil exporting countries.

Since the mid-seventies there has been a declining trend in per caput consumption in developed countries concentrated among net importers of raw sugar, notably the United States, Canada and Japan. In all three, and in the United States in particular, sugar has been subject to increasing competition from a caloric sugar substitute, high fructose corn syrup (HFCS), developed commercially in response to the prevailing high sugar prices of 1973/74. It has proved completely substitutable for sugar in many areas in the bakery, confectionery and soft drinks industries. As a result, its use in the United States has risen from zero in 1970 to nearly 2 million tons by 1980, to an estimated 4.7 million tons in 1985. Over the same period (i.e. from 1970 to 1985) United States sugar consumption has declined from 10.5 million tons to 7.3 million tons.

The gains of HFCS have been made on the basis of price but in developed market economy countries there have also been changes in dietary patterns caused partly by changes in the demographic structure and social habits of the population. There has been a decline in required daily calorie intake and a trend towards low calorie foods which has adversely influenced sugar. As a result new low or non-caloric sweeteners have emerged in recent years, one of which, aspartame, has made dramatic inroads into the sweetener market. Aspartame use in the United States alone has risen from 20 tons in 1980 to 1.2 million tons in 1985. It has no doubt caused some displacement of sugar but has also had an impact on other sweeteners including HFCS and particularly on saccharin.

In developing countries following steady growth in the sixties, there was a surge in per caput consumption from 1975–79 coinciding with the availability of cheap sugar, especially white sugar from the EEC and the general growth in incomes particularly of oil exporting countries. But higher prices in 1979–81 and the economic recession thereafter restrained consumption, at least in low income developing importing countries.

A particularly notable feature in the overall expansion of consumption in developing countries has in fact been the rapid growth in those countries which are traditional net exporters. In these countries, notably India and Brazil, consumption growth is less directly related to income than to the availability of sugar. Sharp rises in the late-seventies and early-eighties in these countries were closely linked to stock accumulations and export limitations under the International Sugar Agreement. As stocks were run down in India for example, consumption declined and in fact with one or two bad crops, India has been temporarily importing sugar. But it should be noted that per caput consumption of sugar is as high in a number of developing exporting countries where sugar is in abundant supply, as in developed countries.

Overall consumption in developing countries has increased substantially over the last twenty-five years from 16 million tons or one-third of world consumption to 50 million tons 53 percent of world consumption in 1985. About half of this growth has been accounted for by imports.

Trade

Despite its overwhelming importance to individual exporting countries, international trade in sugar has always been marginal compared with production and consumption, because of the wide geographical spread of sugar production. While both production and consumption doubled between 1960 and 1985, world trade in sugar rose by only 50 percent. The share of total trade in production actually declined from 36 percent in 1960 to 28 percent in 1984.

However, there have been major structural changes in the pattern of sugar trade. During the sixties developing countries accounted for only about 25 percent of world imports. This share rose rapidly in the seventies to 45 percent and currently is slightly over 50 percent so that net imports of developing countries have in fact in absolute terms almost trebled since 1960. Over the same period the share of imports of developed market economy countries fell, while the share of developed centrally planned economy countries rose from nil to 15 percent.

A great deal of this increase in exports to developing countries has accrued to developed rather than developing countries. In 1984 about 55 percent of developing country imports were drawn from developing countries compared with 45 percent from developed. In 1970 the percentages were 60 and 40 percent respectively. During the period the total share of developing countries in world exports declined from 85 percent in the early 1960s to around 70 percent, reflecting initially expansion by some developed cane sugar exporters, notably Australia, and since the mid-seventies the very substantial exports of white sugar from the EEC. Exports from the Community rose from 0.7 million tons in 1975 to a peak of 5.6 million tons in 1982 and were over 4 million tons in 1984. The Community is in fact the world's leading exporter to the free market.

The decline in developed country imports has occurred since the mid-seventies and is concentrated in the United States, Canada and Japan. In all three countries domestic production has been maintained despite falling consumption and the adjustment has been entirely affected by reducing imports. In the United States, the price and quota mechanism to support domestic producers has provided an umbrella for the growth of competitive sweeteners, in particular HFCS, as low cost sugar producers have been effectively disbarred from competing against them on a price basis. Similarly in Japan the high internal price supported by high duties and a consumption tax on sugar also provided a climate for HFCS expansion which, however, was partially offset in 1982 by the introduction of a surcharge on

imports of raw materials to produce HFCS. To illustrate the impact of these changes, United States imports for example have declined from 4.8 million tons 1970 to 2.3 million tons in 1985 and the approved base quota for 1986 is only 1.5 million tons. It is true of course that countries fortunate enough to have a quota in the United States market receive a price well above the world free market level but on an ever diminishing quantity. Developing countries have been particularly affected by the reduction in United States imports. For example in 1970, some 59 percent of Argentina's total exports went to the United States, 54 percent of Brazil's exports and 100 percent of Philippine exports; in 1984 the percentages were 51 percent, 9 percent and 33 percent.

The developed market, where trade has increased significantly is the USSR, where substantial imports have been drawn from the free market in addition to those from Cuba under prevailing special arrangements. But a major factor in this development has been poor production in the USSR. Imports into the Soviet Union declined significantly in 1985 when there was a good domestic crop so that the Russian market cannot be taken for granted. Furthermore, while cane sugar suppliers have benefited, domestic production shortfalls have been in beet sugar output so that a good share of free market imports have come from white sugar suppliers, namely the EEC.

In 1984 and 1985 there was no growth in world trade despite the “rock-bottom” prices at which sugar could be obtained. This reflected most of the factors already referred to, foreign exchange difficulties of low income developing countries, the continuing drive towards self-sufficiency in many developing countries and further inroads of competitive alternative sweeteners.

It is not the purpose of this paper to review the various international sugar agreements which have attempted to stabilize the world free market for sugar since that has been done in many

publications and reports including the FAO 1985 ESD paper on "Sugar: Major Trade and Stabilization Issues in the Eighties". It is sufficient to say that the 1977 Agreement failed because it lacked the effective supply control measures necessary to support the price range and one major exporter, the EEC was outside it. Exporting countries which had over-reached to the short-lived price surge of 1974/75 again overreached to the ever shorter upsurge of 1980–81 and the result was a massive build-up of exportable surpluses and stocks which led to the disastrous price situation which has prevailed since 1982. The modest recovery which occurred in the second quarter of this year was caused by some improvement in the overall supply demand balance during the present 1985/86 crop year but there are indications that a larger crop could be forthcoming in 1986–87. There were even some early danger signals that the somewhat higher prices of around 7 cents per lb might be causing some producers to think about ressurecting longer term expansion programmes and on the other, that developing importing countries might react adversely to the higher prices.

Medium-term outlook

In a recent review for the world sugar economy, FAO projected production consumption and trade in the medium-term up to 1990. In brief, the projections were based on individual country regressions of historical per caput sugar consumption with income and the deflated retail price of sugar as the explanatory variables. From a base period of 1979–81, sugar consumption in 1990 was projected using specific assumptions about growth rates of income, retail prices and population. Projected consumption was then adjusted to take account of estimated growth in consumption of alternative sweeteners on the assumption that current national policies governing output of alternatives will not change and more importantly, policies which protect domestic sugar output (particularly in the United States and Japan) and which are advantageous to alternative sweeteners, will not change in substance. It was assumed that given the existing factory capacity to process cane and beet and the present proven

agricultural capacity to grow both cane and beet, production would be sufficient to meet any projected level of demand. However, in projecting production, domestic consumption requirements, national programmes and policies economic trends and forecasts - both national and global were taken into account. Furthermore for major exporting countries and regions it was assumed that policies would be adjusted to match production to domestic consumption plus export requirements. The results are summarized in Table 4 - World sugar production, consumption and net trade, 1979–81, 1983 and 1990.

Production was projected at around 110 million tons and consumption at 107–110 million tons on differing price assumptions (constant and 10 percent decline on base period). Given the fact that non-caloric consumption, notably aspartame, has risen much more rapidly than the projections envisaged, it may be wiser to adopt the lower assumption projections but on the other hand, on the assumption of economic recovery in developing countries, demand for sugar could expand much more rapidly than projected. The projections clearly implied that many of the basic issues highlighted in the preceding review would continue, that there would be a notable absence of growth in import demand; the decline in developed country imports would continue and only limited growth would occur in imports into developing countries.

It should be stressed however, that the income assumptions used in the projections were realistically low and indeed even if the economic recovery now being predicted does occur, it will take time to filter through to developing countries. But assuming that a recovery does take place and higher income growth is realized between 1990 and 2000, sugar consumption in developing countries will again resume its strong upward trend. Unless developing importing countries were to increase their combined production levels very substantially between 1990 and 2000 (having already increased them by more than 20 percent between 1980 and 1990), there will be a further growth in developing country imports between 1990 and 2000. A very simple attempt to quantify such growth based on an extrapolation of the 1990 projections

indicates that imports into developing countries could rise by between 3 and 5 million tons in the decade between 1990 and 2000. Regarding developed countries it must be stressed that even in the next decade no further growth may be expected in import demand.

The question arises as to how cane sugar exporters and developing country exporters in particular can gain a larger share of the consumption growth that must take place in developing importing countries in the years ahead. Why, for instance, do developing countries establish high-cost sugar industries when it is undoubtedly cheaper to import? One factor has almost certainly been the instability of world sugar prices. Developing importing countries need to be convinced that it is cheaper on a long-term basis to import sugar from other developing country exporters and this implies a guarantee of stable prices and stable deliveries. Some assurance of price stability through long-term contracts for example, might encourage an increase in imports even in the content of balance of payments problems and long-term growth. Above all, it might discourage uneconomic investment projects sponsored by promoters who can always find in the recent past a high price period which would have had serious balance of payment effects on a large importer, or is able to construct an “average” which appears to justify the investment.

Most developing importing countries lack the refineries needed to convert raw sugar to white for final consumption and therefore it is easier to import white sugar if the price is right. In these circumstances, the EEC by entering the market as a “low price” exporter of white sugar was able to make enormous inroads and sell more than 3 million tons a year to developing countries. Some developing countries including Brazil and Cuba have become significant white sugar exporters and India has traditionally exported white sugar. There are of course costs and problems involved in particular in shipping white sugar but developing exporters of raw sugar world be advised to consider the possibility of increasing their output of white sugar for export. Another alternative could of course be to enter into joint ventures with developing

importing countries to refine raw sugar in the country of destination or even to develop refining capacity in a third country, centrally located in the consuming area (e.g. Korea and Malaysia). Such initiatives would be costly but far less so than setting up new sugar industries in importing countries.

A recent survey by the International Sugar Organization reveals that developing countries apply much higher import duties on sugar than developed countries and contrary to developed countries, apply higher duties on raw sugar imports than on white. In the current climate of balance of payment difficulties it may be inopportune to expect developing importing countries to envisage imports by reducing tariffs but there is clearly scope in the future for preferential tariff concessions for developing country sugar exporters.

These are but a few suggestions which developing country sugar exporters may find of interest. The outlook may not be bright but nor is it without hope. There is a future for sugar but it would be naive to assume that the tendency to produce quantities surplus to market requirements will not persist. It will remain necessary to continue to monitor and regulate production for export. To this end full support should be given to efforts to conclude an effective International Sugar Agreement in which exporting countries agree to discipline their exports and importing countries agree to support such efforts in return for guaranteed supplies at stable and reasonable prices.

Developing countries are well aware of the limitations on producing sugar surplus to market requirements and this consultation is proof of the fact - faced with the realities of the sugar market - sugar cane farmers and millers need alternative outlets. Ethanol is perhaps the best known as is the Brazilian experience where more than 50 million tons of cane, equivalent to 9 million tons of sugar per year are utilized to produce alcohol. A recent report indicates that if no further sugar had been diverted to ethanol production, actual world ending stocks of sugar

would have been larger last year by corresponding amounts which might have resulted in world sugar prices being even lower than they have been. But in the case of Brazil, the decision to produce ethanol was taken independently, although of course linked to the depressed outlook for sugar. In other words the cane was planted specifically to produce ethanol. To divert surplus cane to a viable alternative use is indeed highly desirable. To produce additional cane in a surplus situation may well be another matter.

But it is not the scope of this paper to deal with such questions. The next two speakers are examining alternative uses of sugar cane and of course the main agenda item is the examination of prospects for the utilization of sugar cane for animal feed. I assume that in the discussion of these items, due consideration will be given to the economics involved.

Figure 1 - WORLD SUGAR PRICES, CURRENT AND REAL (1982 = 100): 1960 – 1985

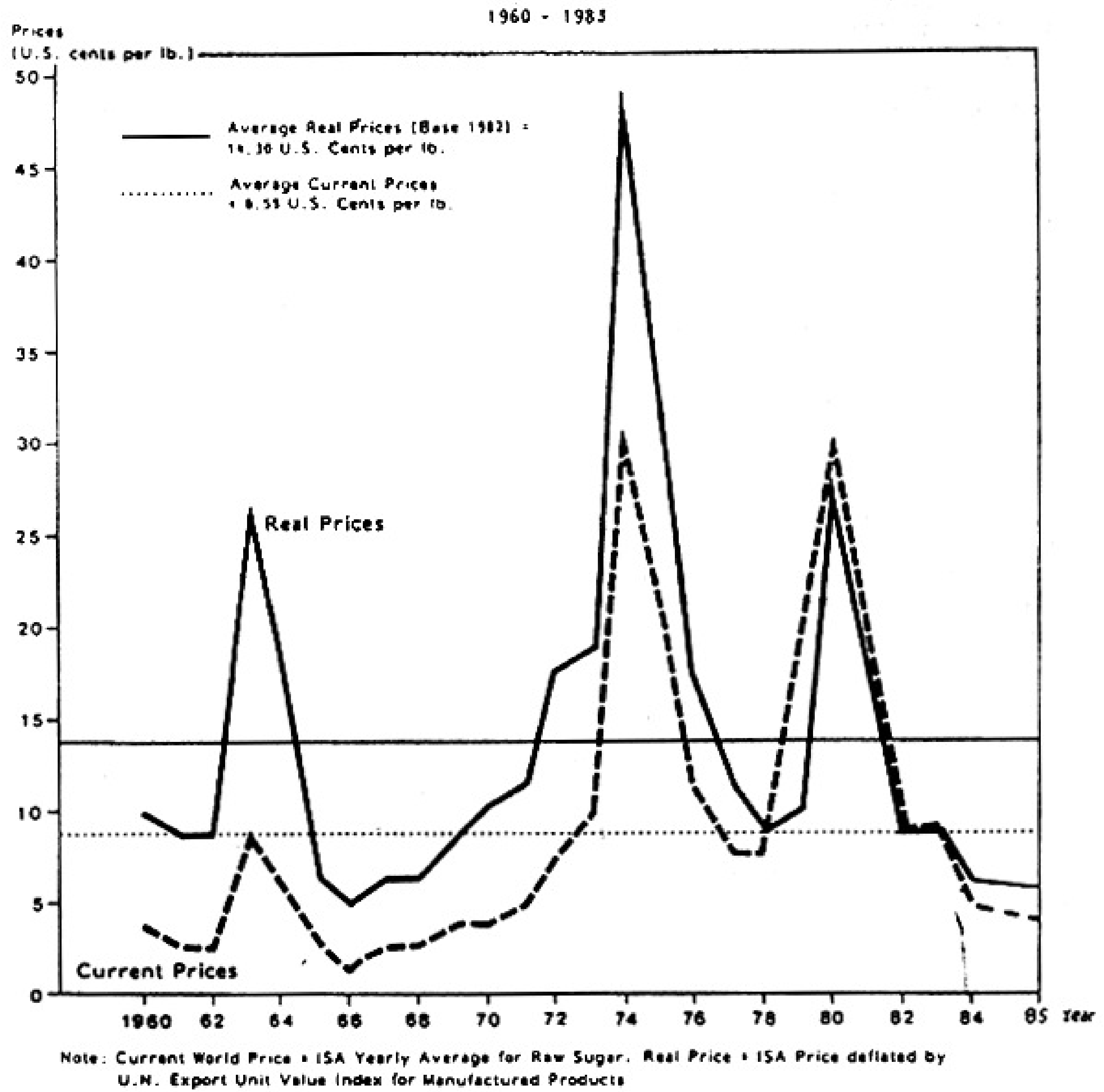

Table 1: Production, exports and relative shares of sugar

	Developing countries			Developed countries			World		

	1983–84	1984–85	1985–86 (Forecast)	1983–84	1984–85	1985–86 (Forecast)	1983–84	1984–85	1985–86
thousand tons									
PRODUCTION									
Beet	6 920	7 859	8 605	35 379	37 024	36 619	42 299	44 883	45 224
Cane	**50 035**	**48 763**	**47 107**	**5 478**	**6 321**	**5 421**	**55 513**	**55 084**	**52 528**
Total	**56 955**	**56 622**	**55 712**	**40 857**	**43 345**	**42 040**	**97 812**	**99 967**	**97 752**
percent									
Relative share									
Beet	16.4	18.6	19.0	83.6	82.4	81.0	100	100	100
Cane	**90.1**	**88.5**	**89.7**	**9.9**	**11.5**	**10.3**	**100**	**100**	**100**
Total	**58.2**	**56.6**	**57.0**	**41.8**	**43.4**	**43.0**	**100**	**100**	**100**
thousand tons									
EXPORTS									
Beet	170	304	459	7 642	6 576	7 992	7 812	6 880	8 451
Cane	**18 880**	**19 151**	**15 960**	**3 267**	**3 663**	**3 637**	**22 147**	**22 814**	**19 597**
Total	**19 050**	**19 455**	**16 419**	**10 909**	**10 239**	**11 629**	**29 959**	**29 694**	**28 048**
percent									
Relative share									
Beet	2.2	4.4	5.4	97.8	95.6	94.6	100	100	100
Cane	**85.2**	**83.9**	**81.4**	**14.8**	**16.1**	**18.6**	**100**	**100**	**100**
Total	**63.6**	**65.5**	**58.5**	**36.4**	**34.5**	**41.5**	**100**	**100**	**100**

Source: Licht, F.O.: International Sugar Report (World Sugar Balances — 22 May 1986).

Table 2 - Production, consumption, trade, stocks and prices of sugar, 1960 to 1985

Calendar Year	Production	Consumption	Closing Stocks	Total trade		World free market			
				Exports	Imports	Net Exports	Net Imports	Current	Real
thousand tons raw value								US ¢/lb	US ¢/lb 1982=100
1960	52 299	49 218	21 400	19 324	19 121	11 500	11 200	3.90	10.09
1961	54 757	53 229	21 300	22 401	21 988	12 000	11 800	2.70	8.84
1962	51 227	53 455	23 851	18 529	18 297	11 671	11 517	2.78	9.11
1963	51 894	54 343	20 867	16 869	16 621	11 727	11 487	8.29	26.84
1964	59 319	54 158	24 564	16 826	16 316	11 379	11 018	5.72	18.16
1965	63 790	57 962	28 226	18 649	18 120	12 208	11 835	2.03	6.29
1966	62 741	59 754	29 355	18 235	15 231	12 340	12 340	1.76	5.47
1967	65 026	61 602	31 395	20 197	19 622	13 761	13 143	1.87	5.80
1968	65 411	64 744	31 030	20 589	19 225	14 306	12 987	1.85	5.74
1969	68 140	66 847	32 345	18 571	18 769	12 989	13 295	3.20	9.29
1970	71 142	70 480	31 586	21 808	21 339	14 035	13 656	3.68	10.08
1971	71 975	72 457	30 644	21 035	20 644	14 534	14 250	4.50	11.68
1972	73 735	73 660	30 109	21 871	21 234	16 657	15 999	7.27	17.36
1973	75 789	76 330	29 343	22 478	22 427	16 544	16 622	9.45	19.16
1974	76 397	77 303	27 895	22 097	21 519	16 240	15 711	29.66	49.32
1975	78 846	74 438	32 065	20 599	20 495	13 351	13 496	20.37	30.15
1976	82 400	79 241	34 251	22 794	21 783	15 549	14 682	11.51	17.04
1977	90 350	82 592	40 615	28 471	26 869	20 760	19 404	8.10	11.00

1978	90 832	86 148	44 734	25 072	24 807	17 490	17 297	7.81	9.24
1979	89 327	89 998	42 992	25 985	25 052	18 270	17 731	9.65	9.90
1980	84 514	88 164	39 311	26 832	26 755	19 418	19 510	28.69	27.16
1981	92 522	88 406	41 134	29 122	28 242	20 628	19 862	16.83	16.66
1982	101 432	91 725	48 803	30 417	29 338	21 636	20 712	8.35	8.35
1983	96 912	93 508	49 071	28 843	27 530	20 532	19 524	8.46	8.79
1984	99 200	96 213	51 673	28 434	27 937	19 210	18 835	5.20	5.59
1985	98 900	97 100	53 400	26 600	26 200	18 600	18 200	4.06	4.40

Source: International Sugar Organization (ISO).

Table 3: US consumption of sugar and other sweeteners 1970 and 1980–85

	1970	1980	1981	1982	1983	1984	1985
	thousand tons						
Sugar (raw value)	**10 547**	**9 330**	**8 860**	**8 310**	**8 085**	**7 756**	**7 271**
HFCS (dry basis, sugar equivalent)	**-**	**1 980**	**2 600**	**2 810**	**3 266**	**3 901**	**4 716**
Other caloric sweeteners(glucose-dextrose)	1 616	2 176	2 221	2 268	2 286	2 304	2 331
Total caloric sweeteners	**12 163**	**13 486**	**13 681**	**13 388**	**13 637**	**13 961**	**14 318**
Non-caloric or low calorie sweeteners							
Aspartame	**-**	**-**	**21**	**105**	**372**	**622**	**1 194**
Saccharin	620	796	835	886	1 011	1 074	651
Total of non-calorie and low calorie sweeteners	**620**	**796**	**856**	**991**	**1 383**	**1 696**	**1 845**

Source: USDA — Outlook and Situation Report (Sugar and Sweetener), March 1986.

Table 4 World sugar production, consumption and net trade: 1979–81, 1983 and 1990

Table 4 World sugar production, consumption and net trade: 1979–81, 1983 and 1990

			1979–81	1983	1990	
			million tons			
1.	**World total**				1	2
	i)	Production	87.1	95.6	110.0	
	ii)	Consumption	88.6	93.6	106.6	110.1
	iii)	Total net imports 3	23.3	23.6	21.9	22.8
2.	**Developed countries**					
	i)	Production	38.2	38.9	41.0	
	ii)	Consumption	46.5	46.0	45.8	11.1
	iii)	Total net imports 3	13.3	13.1	10.8	11.1
3.	**Developing countries**					
	i)	Production	48.9	56.7	69.0	
	ii)	Consumption	42.1	47.6	60.8	63.7
	iii)	Total net imports 3	10.0	10.5	11.1	11.7

1 Based on assumption of constant prices.

2 Based on assumption of 10 percent reduction in prices from base period.

3 Figures derived on the basis of imports minus exports for individualsugar importing countries.

Source: FAO.

Table 5: Value of agricultural exports, including fishery and forestry products

	World		Developed		Developing	
	1983	1984	1983	1984	1983	1984

	million US $					
Sugar, beverage and tropical products	26 832	29 519	4 147	4 289	22 685	25 230
of which:						
Sugar	**10 820**	**10 116**	**2 712**	**2 498**	**8 108**	**7 618**
Coffee	9 145	10 535	303	421	8 842	10 114
Cereals	**35 774**	**37 453**	**29 742**	**31 614**	**6 032**	**5 839**
Livestock products	36 703	34 841	31 844	30 249	4 859	4 592
Raw materials	**12 658**	**13 749**	**5 846**	**6 682**	**6 813**	**7 067**
Fishery products	15 721	15 986	8 968	8 881	6 752	7 105
Forestry products	47 685	50 931	40 152	43 320	7 533	7 612
Others	96 771	102 925	70 613	72 673	26 158	30 251
GRAND TOTAL	**272 144**	**285 404**	**191 312**	**197 708**	**80 832**	**87 696**

Source: FAO (CRO 1985/86)

Table 6: EEC production and exports of sugar: 1975 to 1984

	Production	Total Exports	Of which to developing countries	Annual average[1] white sugar prices
	thousand tons raw value			US ¢ per lb
1975	10 818	702	455	25.3
1977	12 752	2 750	1 917	9.5
1979	13 613	3 621	2 935	11.7
1981	15 476	5 414	3 984	20.4
1982	15 515	5 615	3 848	11.3
1983	12 305	4 910	3 499	11.4
1984	13 271	4 393	3 108	7.7

1 Paris Market.

Source: FAO (ECDC study)

Table 7: US imports of sugar 1970–80–84–85

	1970	**1980**	**1984**	**1985**
	thousand tons raw value			
Total imports	4 758	4 050	3 004	2 273
of which from developing countries share of developing countries	4 401	3 601	2 628	2 082
in total imports (%)	92	89	87	92

Principal developing country suppliers to the USA and their dependence on the US

	1970	**% Dependence**	**1980**	**% Dependence**	**1984**	**% Dependence**
	thousand tons					
Argentina	73	59	141	53	200	51
Brazil	605	54	758	30	323	9
Dominican Republic	659	83	520	66	484	69
Guatemala	63	100	187	89	137	43
Honduras	10	100	88	100	91	100
Peru	413	100	48	82	98	99
Philippines	1 178	100	348	24	378	33

Source: FAO (ECDC study)

Table 8: USSR imports of sugar, 1970, 1980 and 1984

	1970	**1980**	**1984**

	thousand tons raw value		
Total imports	**3 107**	**4 964**	**5 505**
of which special arrangement	3 105	2 726	3 650
free market	2	2 238	1 855
of which developing	0	1 270	811
Re-exports	**1 484**	**164**	**204**

Source: FAO (ECDC study)

IMPORTANCIA ECONOMICA DEL AZUCAR Y DE LA CAÑA PROBLEMAS Y PERSPECTIVAS

por

K. S. Mulherin

En este trabajo se examinan las tendencias de la producción, el consumo, el comercio y los precios del azúcar en los últimos 25 años y se evalúan las perspectivas a plazo medio hasta 1990. Se observa que la oferta y la demanda han experimentado fuertes y constantes desequilibrios, lo cual se ha traducido en precios sumamente variables en los mercados mundiales. Esto ha tenido repercusiones desfavorables en los ingresos agrícolas y de exportación en muchos países, especialmente en los países en desarrollo, que dependen en gran medida de las exportaciones de azúcar. Además, el mercado mundial del azúcar ha experimentado un cambio estructural fundamental desde mediados del decenio de 1970, debido en parte a un menor aumento de los ingresos tanto en los países en desarrollo como en los desarrollados y a cambios en los hábitos alimentarios, lo cual se ha acentuado por el desarrollo de sucedáneos. Las proyecciones a plazo medio de la producción, el consumo y el comercio de azúcar indican que las importaciones sólo crecerán en los países en desarrollo y seguirá siendo necesario controlar y regular la producción para la exportación. Algunos productores de azúcar, especialmente los productores de caña de los países en desarrollo,

necesitan sin duda nuevos mercados, de ahí que deba fomentarse vivamente la búsqueda de nuevos usos para la caña que sean económicamente viables.

ALTERNATIVE USES OF SUGARCANE AND ITS BYPRODUCTS IN AGROINDUSTRIES
by
J.M. Paturau

1. INTRODUCTION

Although world prices for sugar and petroleum products have shown spectacular variations since 1973, the long term outlook is very likely to be a gradual increase in the price of all fossil fuels and stagnation, at best, for the price of sugar.

This gloomy prospect explains, to a large degree, the renewed interest in the byproducts of the sugarcane industry which has developed in the last ten years and which has shown that the optimal use of byproducts can provide a non-negligible support to the sugarcane industry, although it could not, by itself, completely redress the difficult situation sugar is presently experiencing.

The four main byproducts of the sugarcane industry are cane tops, bagasse, filter muds and molasses (Figure 1).

If we accept that the present world production of sugarcane has reached the 60 million tonnes level, then the quantities of these byproducts produced yearly are approximately the following:

Cane tops	200 million tonnes	(fresh weight)
Bagasse	60 million tonnes	(bone dry weight)
Filter muds	5 million tonnes	(air dried weight)
Molasses	16 million tonnes	(at 80 percent DM)

Reliable statistics are not available to show the detailed end uses of these byproducts on a world basis, but although their utilization will be considered later in more detail, as a very rough picture of their trade we can say that at present cane tops and filter muds are largely ignored; that bagasse is used internally mainly as fuel to generate steam in the sugarcane factories and a small fraction to produce pulp and board; and that molasses is exported either as such for animal feed or after transformation as rum, potable alcohol or industrial alcohol.

2. VALUE UPGRADING AND PRICE LEVEL OF BYPRODUCTS

There are many end uses to which the byproducts of the sugarcane industry can be put - probably more than 150. But many of them, under present technological and marketing conditions would be of negligible economic interest. Figure 1 presents about 38 end-products which we consider as potentially important or which have proved, under normal circumstances, of economic interest.

It should be pointed out that, as a general rule, maximum value upgrading goes with more complex processing characterized by capital intensity, sophisticated technical know how and competitive markets. Maximization of profits is not automatically linked with process complexity and depends much more often on advantages local conditions or the proximity of a

remunerative export market.

Although "small" may be rarely "beautiful" when dealing with byproducts, the simpler operations are often the more profitable.

As an example, molasses can simply be exported as such and earn some US$ 25 to 30 per tonne. However, by transforming the molasses into citric acid (worth say US$ 1 600 per tonne) about 330 kg of citric acid worth US$ 528 would be obtained from one tonne of molasses, i.e. about 18 times more than the previous operation. We must point out however that it is generally much easier to find a market for 30 000 tonnes of citric acid (worth US$ 750 000) than it is to find a buyer for 10 000 tonnes of citric acid (worth US$ 16 000 000). The market price of the byproducts of the sugarcane industry varies from country to country with cyclical increases and decreases.

i. **Cane tops have no real market value. They can be compared to fair quality fodder with an average feed value, when fresh, of about 2.8 megajoules of metabolizable energy per kilo of dry matter. However cane tops should be collected and transported from the cane fields to the feedlot and their value to the cane producer could probably be no more than US$ 10 per tonne of fresh cane tops.**

ii. **The price of bagasse is generally related to its fuel value. Thus since 1 tonne of mill-run bagasse can be replaced by 0.173 tonne of fuel oil, worth US$ 80/tonne or again by 0.263 tonne of bituminous coal worth US$55/tonne, it can be said that bagasse is worth between US$ 13.8 and 14.5 per tonne (mill-run weight, 50 percent moisture content) and a figure of US$ 15 can be used as a rounded representative average.**

iii. **Filter muds have no set market value and since they are used almost exclusively as** fertilizer, it is reasonable to utilize their fertilizer value which stands at present at about US$ 10 per tonne of air dried filter muds (30 percent moisture).

iv. Molasses is traded on the international market and its price fluctuates appreciably from year to year. The average FOB price New Orleans for 1985 was US$ 64.33 per tonne (at 79.5° Bx).

3. MAIN UTILIZATION OF BAGASSE

Bagasse is the fibrous residue of the cane stalk left after crushing and extraction of the juice. It consists of fibres, water and relatively small quantities of soluble solids - mostly sugar. The average composition of mill-run bagasse is the following:

Fibre (including ash)	48.0	percent
Moisture	50.0	"
Soluble solids	2.0	"

The fibre consists mainly of cellulose (27 percent), pentosans (30 percent), lignin (20 percent) and ash (3 percent).

The calorific value (CV) of bagasse is given by the formula:

Net CV = 18 309 - 31.1 S - 207.3 W - 196.1 A (expressed in kJ/kg)

where
S = soluble solids % bagasse
W = moisture % bagasse, and
A = ash % bagasse,.

If W = 0, S = 2 and A = 3, then the net CV of bone dry bagasse = 17 659 kJ/kg.

If W = 50, S = 2 and A =1 1/2 then the net CV of mill run bagasse = 7 588 kJ/kg.

Bagasse is used for the generation of steam and power required to operate the sugar factory. A typical factory producing raw sugarcane require, per tonne of cane, about 35 kWh and 450 kg of exhaust steam. Much progress has been achieved lately and, with continuous operation of the pans, crystallizers and centrifuges and an efficient evaporation station, a modern raw sugar factory can now operate with 30 kWh and 300 kg of exhaust steam per tonne of cane. Such a factory can save 50 percent of the bagasse it produces and this bagasse can be used to produce electricity for the grid or saved as raw material for the production of paper, board, furfural, etc.

a) <u>Electricity</u>

The more straightforward solution is to produce electricity from the bagasse saved via a high pressure boiler and condensing turbo-alternator. This solution has found favour in a number of cane producing countries such a Hawaii, Australia, Reunion and Mauritius and with modern equipment some 450 kWh can now be produced per tonne of mill-run bagasse. A typical example of this use is given in Table 1 and if mill-run bagasse is priced at US$ 15 per tonne, electricity can be generated on a year round basis, at a cost of approximately US cents 6 to 8 per kWh, which should prove competitive with the ruling price of electricity in most Third World countries.

To be economical, the generating station must work on a continuous basis, say at least 7 800 hours yearly. This will imply bagasse storage to be able to generate during the intercrop period. Various methods have been tried: dry and wet bulk storage, bale storage and pelleting.

Dry bulk storage has proved uneconomic and is not suitable for large tonnages. Wet bulk storage does not apply and is utilized when bagasse is to be used for pulp production. Pelleting is still being tested in Hawaii and in Mauritius, but appears expensive per tonne of bagasse handled. Thus bale storage, which is presently the most widely used method seem the reasonable choice, although it requires a substantial storage area and can lead to annual losses of 10 percent of more of the bagasse stored.

The generation of electricity from surplus bagasse is undoubtedly the easiest and best utilization of this byproduct for most cane-producing Third World countries. However, as local conditions vary extensively the possibility of utilizing surplus bagasse to produce particle board, paper, furfural, or methane will be briefly considered.

(b) Particle board

The production of particle board from bagasse is a well-proven technology but it has to compete with plywood and fibreboard. Its main difficulty is the high cost of imported synthetic resins which serve as a binder to the bagasse fibres composing the board. Also the board's optimal thickness is about 15 mm and further it cannot be used for outdoor purposes so that its main market is limited to inner partitions and furniture.

In the last few years a process has been developed in the Federal Republic of Germany whereby Portland cement replaces the urea formaldehyde resins, which enables this cement-bonded particle board to be used for exterior walls, roofing, etc. and thus increases significantly its market appeal. Note however that the bagasse utilized should not contain more than 0.5 percent of sugar on a bone dry basis. Otherwise the end product would not be satisfactory. Table 2 gives some indication of the comparative economic data for resin and cement particle boards made of bagasse.

(c) Paper

Good quality wrapping and magazine paper can be produced with a high percentage of depithed bagasse as raw material. The availability of a fair size internal market, sufficient surplus bagasse and fair quality industrial water are the usual constraints, apart from the high capital intensity of paper plants and the necessity to handle polluting effluents.

Up to now the production of newsprint from bagasse has proved difficult and uneconomic, but there are constant advances in technology and bagasse newsprint may become feasible within the next ten years, especially if mixed with a fair percentage of waste paper. Also the production of magazine or note paper on a small scale has been investigated by Western (1979) and the experience gained in India seems to confirm the feasibility of plants producing as little as 15 tonnes of bleached pulp per 24 hours.

The process generally favoured for the production of bagasse pulp is the Kraft process using sodium sulphate. The actual sulphate cooking liquor contains a 4:1 mixture of caustic soda and sodium sulphide. Typical yield on bone dry depithed bagasse, to be expected with the Kraft cooking process is 48 percent for the final bleached slush pulp. Production cost, with depithed and 90 percent dry bagasse at US$ 30/tonne, would be around US$ 340 per tonne of bleached slush pulp. Water requirements would be about 200 m^3 per tonne of pulp. Indicatively, the capital cost for plant and equipment would be about US$ 12 million for a 50 TPD factory.

The production of pulp and paper from bagasse is not advisable as the main use of byproducts by Third World countries, unless very favourable local conditions exist. It is a relatively demanding technology best approached after gaining experience with simpler bagasse processing as called for in electricity generation or particle board manufacture.

(d) Furfural

Furfural is a colourless, inflammable, volatile, aromatic liquid produced from a number of plant materials containing pentosans - in the case of bagasse, 90 percent being xylan. With acid hydrolysis the xylan yields xylose which subsequently loses 3 water molecules to form furfural according to the following simplified equation:

$C_5H_8O_4 + H_2O$ ---- $C5H_{10}O_5$ ---- $C_5H_4O_2 + 3H_2O$

Xylan Xylose Furfural

In practice about 25 tonnes of mill-run bagasse are required to produce 1 tonne of furfural.

Furfural has many industrial uses, one of them being as a selective solvent for the refining of lubricating oils and another as an intermediate in the production of nylon 6.6 and resins used for moulding powders.

Furfural on hydrogenation yields furfuryl alcohol which can produce inexpensive, heat-stable and corrosion-resistant resins. Furfuryl alcohol is also used in the pharmaceutical, fungicide, insecticide and solvent fields. Table 3 gives a summary of production variables of furfural from bagasse.

Capital cost for a 5 000 tonnes/yearly plant, generally considered as the minimal economic capacity, would be about US$ 9 million and the production cost about US$ 450 per tonne of furfural.

It should be noted that about 35 tonnes of steam are required to produce one tonne of furfural, hence the importance of utilizing the lignin rich hydrolysate which is left over from the process

to generate steam in a special boiler. Low pressure steam will be available as surplus and could be used in an adjoining distillery.

Furfuryl alcohol is produced by the catalytic hydrogenation of furfural. Starting from bagasse, a plant to produce 4 500 tonnes yearly of furfuryl alcohol would cost US$ 12 million to US$ 13 million and would require some 150 000 tonnes of mil-run bagasse. The production cost would be about US$ 1 250 per tonne of furfuryl alcohol.

As stated earlier, the production of furfural and/or furfuryl alcohol from bagasse for the production of pulp and paper is relatively complex. The two newcomers to this activity, namely South Africa and the Philippines, have had some initial problems but while the former overcame them and in fact has doubled its initial production capacity, the latter has not been able to find remunerative markets and has been out of production for the last three years.

For the time being, therefore, production of furfural from bagasse should not be given high priority on the list of byproduct industries to be developed by Third World countries.

(e) Methane

Much has been written on the production of methane or biogas and very often sugarcane producers have been under the impression that a good opportunity was being lost in the production of an economic gaseous fuel from their surplus bagasse.

Methane (CH_4) and carbon dioxide are the main gaseous products of the anaerobic methane fermentation of waste and cellulosic materials. Theoretically 1 kg of cellulose would produce 415 litres of methane, but in practice the process is less efficient with a complex three-stage reaction operating in cascade and not always easy to manage.

Cellulose is, normally, easily digested by bacteria. However when it is combined with lignin, as in bagasse, it is degraded only with great difficulty. Hence a biogas digester in the sugar industry should be planned to operate mainly on distillery stillage or feedlot effluents with a small addition of surplus pith, and not on bagasse as the only or main raw material.

It is important, within the digester, to keep the ratio of carbon to nitrogen at about 25:1 and that of carbon to phosphorus at about 150:1. The sludge should be kept slightly alkaline, at about 7.5 pH, and the temperature should be maintained at about 35°C. The retention time would be about 20 days.

Biogas has a calorific value of about 22 000 kJ per kg (which is equivalent to 27 500 kJ per m^3).

A 100 m^3 digester can cost about US$ 50 000, with wide variations according to the sophistication of the arrangement. It could produce some 30 000 m^3 yearly and the production cost can be etimated at about US$ 4 per GJ - while as a reference point tax-free gasoline is at US$ 8 to 10 per GJ.

So while bagasse is not the proper feed for the production of biogas, other byproducts can be considered, especially distillery sludge.

4. FILTER MUDS

The precipitated impurities contained in the cane juice, after removal by filtration, form a cake of varying moisture content called filter muds. This cake contains much of the colloidal organic matter anions that precipitate during clarification, as well as certain non-sugars occluded in these precipitates.

The weight of wet filter muds (80 percent water) averages about 3.4 percent cane.

Filter mud contains, on a dry basis, about 1 percent by weight of phosphate (p_2O_5) and about 1 percent of nitrogen. As a result it has been used, especially since the turn of the century, as a fertilizer. The filter mud also contains a mixture of waxy and fatty lipids in a ratio of 5:2 and refined wax can be extracted by appropriate treatment by solvents. It should be noted, however, that only 386 kg of refined wax, which could be roughly equated to carnauba wax, can be obtained from 1 000 tonnes of cane. The process is not commercially of interest under existing conditions and, as far as we know, only one plant is operating presently in India and on a small scale.

The use of filter muds as animal feed has been tried by a number of sugarcane producer territories but so far has not proved economically rewarding, the main constraints being the magnitude of the drying process involved and the low digestibility of the dried scums.

5. MOLASSES

The exportation of molasses as such is important in international trade and out of a total world production (beet molasses included) of 35.5 million tonnes in 1985–86, some 6.5 million tonnes were exported. The main importing countries, namely USA, Japan, Netherlands and UK, utilize the molasses largely for animal feed.

Molasses is the final effluent obtained in the preparation of sugar by repeated crystallization; it is the residual syrup from which no crystalline sucrose can be obtained by simple means. The yield of molasses is approximately 3.0 percent per tonne of cane but it is influenced by a number of factors and may vary within a wide range (2.2 to 3.7 percent). The specific gravity varies between 1.39 and 1.49, with 1.43 as indicative average.

The composition of molasses varies also within fairly wide limits but, on average, would be as follows:

Water	20%	Other carbohydrates	4%
Sucrose	35%	Nitrogenous compounds	4.5%
Fructose	9%	Non-nitrogenous acids	5%
Glucose	7%	Ash	12%
Other reducing sugars	3%	Others	5%

A very large number of products can be derived from molasses. The question of animal feed from molasses and other byproducts of the sugarcane industry will not be considered in our presentation and we will limit ourselves to describing briefly the main products of molasses fermentation that are of economic importane on an international scale, namely rum, ethyl alcohol, acetic acid, butanol/acetone, citric acid, yeast and monosodium glutamate.

(a) Rum

Rum is the alcoholic distillate from the fermentation of cane juice, syrup or molasses. It has a characteristic taste and aroma. Its production derives from a simplified, but selective, ethylic fermentation and distillation, a number of esters and higher alcohols or “congeners” being present in the end-product.

Rum is generally produced at 76°GL and is diluted with water and sold to th public at 33 to 40°GL. One tonne of molasses would produce about 230 litres of rum (basis 100°GL). Table 4, based on Mauritius data, reasonably representative of Third World conditions, shows how the selling price builds up from producer to retailer. If the producer is also the bottler and wholesaler, the profit is substantial and rum prodution from molasses is, by far, the most

profitable industry in byproducts utilization while being, at the same time, a provider of revenue to the government through excise tax. Yearly consumption of rum is probably more than 480 million litres (1985).

(b) Ethyl alcohol (C_2H_5OH)

Ethyl alcohol is amongst the most important fermentation products and is derived from three types of raw materials:

i. **Sacchrine products - mainly molasses, but also cane juice**

ii. **Starchy products - mainly maize**

iii. **Cellulosic products - mainly waste sulphite pulp liquor.**

It is, however, still largely produced synthetically from ethylene derived from petroleum.

Under Third World conditions, the production cost of ethanol (the common name for ethyl alcohol) from cane molasses in a modern and fair size distillery - of say 60 to 80 000 litres per 24 hours - would depend significantly on the price of molasses:

- **With molasses at US$ 75 per tonne, the cost of ethanol would be US cents 45/litre**
- **With molasses at US$ 50 per tonne, the cost of ethanol would be US cents 36/litre**
- **With molasses at US$ 25 per tonne, the cost of ethanol would be US cents 27/litre**

With fair quality cane molasses some 240 litres of ethanol (100°GL basis) should be obtained

from one tonne. If cane juice is utilized instead of molasses, production would be 72 litres per tonne of cane (which is also approximately 100 litres per tonne of juice).

- With juice at US$ 20 per tonne, the cost of ethanol would be US cents 48/litre
- With juice at US$ 15 per tonne, the cost of ethanol would be US cents 41/litre
- With juice at US$ 10 per tonne, the cost of ethanol would be US cents 34/litre

An initial estimate of the capital cost of a distillery producing industrial alcohol with a normal capacity ranging from 50 000 to 150 000 litres/24 hours would vary between US$ 80 and 140 per daily litre capacity, depending on whether the distillery is annexed to a sugar factory and benefits from the steam generating department or whether it is an independent distillery having to provide its own energy and steam. If the end product is refined potable alcohol (96°GL) or anhydrous (99.8° GL) alcohol, the capital cost would be slightly higher.

One of the main difficulties of large capacity distilleries is the efficient handling of their effluents (also called slops, vinasse or stillage) since 13 litres of slops are produced from every litre of ethanol. The recently developed Swedish process of Biostil, by Alfa Laval, is a great improvement since it reduces the weight of stillage by 60 percent and is thus finding increasing favour among alcohol producers.

However even this reduced tonnage of stillage has to be treated and the two processes generally utilized are either evaporation plus incineration to recuperate the potash in the stillage, or anaerobic digestion. For the treatment of 1 000 tonnes of slops per 24 hours the capital cost for the first method would be about US$ 7 million and the net operating cost US$ 100 000 yearly. For the anaerobic method the capital cost would be about US$ 4 million and the net operating cost US$ 600 000 yearly.

The relatively high cost of gasoline and the recent tendency to decrease atmospheric pollution by progressively replacing leaded gasoline by ethanol extended gasoline has created a significant demand for ethanol, especially when taking into consideration the large-scale Brazilian Alcohol Plan.

However conditions vary from country to country and, for a large number of cane producing countries, present conditions indicate that ethanol is still a relatively expensive product compared to tax—free gasoline. Figure 2 shows how a rough choice would be made, according to the local prices of molasses (or cane juice) and gasoline. It assumes that a vechile running on industrial ethanol would consume 15 percent more volumetrically than when running on gasoline.

(c) Acetic acid (CH_3COOH)

Acetic acid is a colourless liquid with a characteristic pungent odour and a sharp acid taste. Its density is 1 049 g/l. Vinegar is a condiment made from sugary or starchy materials by alcoholic and subsequent acetous fermentation. It contains at least 4 percent of acetic acid.

Acetous fermentation is aerobic and the modern submerged fermentation process requires the thorough airing of the vinegar bacteria - Acetobacter. From 100 litres of absolute alcohol some 950 litres of vinegar with 10 percent acidity can be produced. The capital cost for a 200 000 litres per annum vinegar plant is approximately US$ 500 000 for the main items of equipment. Acetic acid finds large scale utilization in the production of acetic anhydride, cellulose acetate, vinyl acetate, etc.

(d) Butanol-acetone

The butanol-acetone fermentation is a true anaerobic fermentation brought about by various strains of Clostridium acetobutlicum. Maize and molasses are the main raw materials used.

Butanol (C_4H_9OH) is the industrial name given to N-butyl alcohol. It is a colourless liquid with a vinous odour and a density of 810 g/l. It is used, directly or indirectly, in lacquer solvent via its acetate and phtalate salts and also as a plasticizer, hydraulic fluid, and intermediate.

Acetone (CH_3COCH_3) is a colourless, volatile, inflammable liquid with a characteristic odour and a density of 792 g/l. It has a fair number of uses, the main one being as a solvent.

The fermentation process produces a mixture of butanol/acetone/ethanol in the ratio 65:30:5 which is separated by distillation. Approximately 500 kg of molasses would produce 65 kg of butanol, 30 kg of acetone and 5 kg of ethanol.

The economy of teh fermentation proces depends greatly on the cost of molasses and of stream — since extreme sterility is required and steam usage is about half the weight of molasses. It is generally considered that synthetic plants producing butanol from acetaldehyde are more economical than fermentation plants; and this is confirmed by the fact that the production of fermentation butanol does not represent more than 10 percent of the total world production.

(e) Citric acid Citric acid is usually produced in the monohydrate form ($C_6H_8O_7H_2O$), the crystals of which are colourless and odurless, with a sour taste and readily efflorescent in dry air. They have a specific gravity of 1.542.

The fermentation process consists of a complex aerobic cycle and beet molasses has had more success as the main raw material than cane molasses. The mould used is Aspergillus

niger and submerged culture fermentation is now preferred to the surface fermentation previously utilized. Aeration and agitation of the medium are essential and the addition of methanol appears beneficial when using cane molasses. The yield of citric acid is about 65 percent of total sugar used.

A plant to produce 2 500 tonnes of citric acid yearly would probably call for a capital cost of US$ 4 million.

Citric acid is one of the most verstile of the industrial organic acids, finding increasing uses in the food and beverage industries. Since there is no potential threat from any "synthetic" citric acid, the production of fermentation citric acid appears warranted in the larger cane producing countries where molasses is available at a fairly low price, and when the local market for soft drink, confectionery and pharmaceutical preparations is on the increase.

(f) Yeast

Yeasts are complex, protein-rich, living unicellular organisms that have been selected and isolated through research, and two strains are now mainly utilized, namely: Saccharomyces cerevisiae to produce baker's yeast and Torula utilis to produce feed yeast.

The assimilation of glucose in the aerobic biosynthesis of yeast can be approximately illustrated by the formula:

$$C_6H_{12}O_6 + NH_3 \text{ --- } C_6H_7O_3NH_2 + 3H_2O$$

In practice the yield of yeast is much lower than the 80 percent indicated above and does not reach more than about 54 percent (including about 8 percent of ash).

Baker's yeast is normally produced from molasses, grains or potatoes. Feed yeast usually utilizes brewer's or distiller's stillage. These raw materials are not sufficiently rich in assimilable nitrogenous and phosphorus compounds and, usually the addition of inorganic ammonium compounds and phosphoric acid is necessary.

About 4 kg of molasses would be required to produce 1 kg of active dry baker's yeast (92 percent dry matter). Yeast is used in bread production at about 1 percent by weight of flour. On a dry matter basis, it contains about 44 percent protein.

About 4 kg of molasses would also be required to produce 1 kg of feed yeast (92 percent dry matter) which generally contains about 50 percent of crude protein.

In both processes adequate and fine aeration is important and some 15 m^5 per kg of dry yeast are usually required.

Capital cost for a feed yeast plant would be about US$ 500 per annual tonne of yeast production. The production cost would be greatly influenced by the cost of molasses and could be very roughly expressed by the following equation:

$y = 4x + 70$

where y is the price of feed yeast in US dollars per tonne and x is the price in dollars of a tonne of molasses. Thus with molasses at US$ 50/tonne the production cost of feed yeast would be approximately US$ 270 per tonne.

The production of single cell protein (SCP) by microorganisms from hydrocarbons and carbohydrates can be considered as a natural extension of feed yeast production. Its high protein content (65 to 70 percent) and the possibility of using such “waste” substrates as

cellulose, distillery slops and other effluents indicate a favourable commercial outlook.

(g) Monosodium-glutamate ($C_5H_6O_4.NH_2Na.H_2O$)

Monosodium glutamate is an important commercial flavouring intensifier with a world production of about 250 000 tonnes/year. It is currently produced by the aerobic fermentation of molasses but there are also a number of synthetic routes available for its production, especially via acrilonitrile. In the fermentation process which is carried out in well-aerated submerged culture, the bacteria Micrococus glutamicus is utilized with molasses as raw material. About 4 1/2 kg of molasses are required to produce 1 kg of MSG which is worth about US$ 2.50/kg. There are approximately 30 companies producing MSG in the world with an installed capacity of about 325 000 tonnes/year. The larger producers are Japan, Republic of Korea, Taiwan Republic of China and USA.

It would probably be difficult for a small sugar producing country to enter this very competitive and well-supplied market, especially since the fermentation technique required is fairly sophisticated.

(h) Industrial alcohol as cooking fuel

Although this utilization will be of little interest to industrialized countries, bearing in mind the very large number of people who still use wood, or wood charcoal, in open ovens to cook their meals, and the critical problem of deforestation in many parts of the world and especially in Africa, consideration must be given to the efficient utilization of ethanol as cooking fuel.

A possible solution had been proposed by Moundlic (1979) but does not seem to have received the attention it should have attracted. The ethanol cooker envisaged consists of a fuel tank

kept at constant pressure by a small volume of compressed CO_2. This causes the ethanol to flow evenly to a vaporization burner.

The thermal efficiency is about 58 percent while that of an open wood stove varities between 5 and, at best, 10 percent. In some African countries the amount of wood used by a family for cooking is about 4 1/2 tonnes yearly, producing about:

4 500 × 2 530 × 5/100 = 570 000 kcal.

The same heating value would be produced by:

$$\frac{570\ 000}{6\ 650 \times 58/100} = 148 \text{ kg}$$

i.e. about 188 litres of ethanol at 95°GL.

6. CONCLUSIONS

Although schematic and fragmentary, the preceding survey of the current uses of the main byproducts of the sugarcane industry does indicate a few priority choices, generally applicable to conditions obtaining in Third World countries.

i. Surplus bagasse should be used to produce electricity for the grid;

ii. If the electricity supply is already adequate, then surplus bagasse could be used for the production of cement particle board for the local market;

iii. Filter muds should be utilized as low grade fertilizers in the cane fields;

iv. **Molasses should be transformed into rum and potable alcohol, according to the local and export market requirements;**

v. **Any surplus molasses left over could be used either locally for animal feed, or exported as such, depending on the ruling market prices and distance of transport;**

vi. **If there is an excessive use of wood as fuel for cooking which leads to rapid deforestation, a drive should be made to produce industrial ethanol to be used in efficient pressure stoves.**

It should be stressed, as a general conclusion, that the large-scale utilization of byproducts of the sugarcane industry, if efficiently implemented, has the dual and important advantage of generating reasonable profits, not only for the sugar producers themselves but also for the national economy at large, as exemplified by cheap electricity, imports replacement, the efficient use of local fuels and forest preservation.

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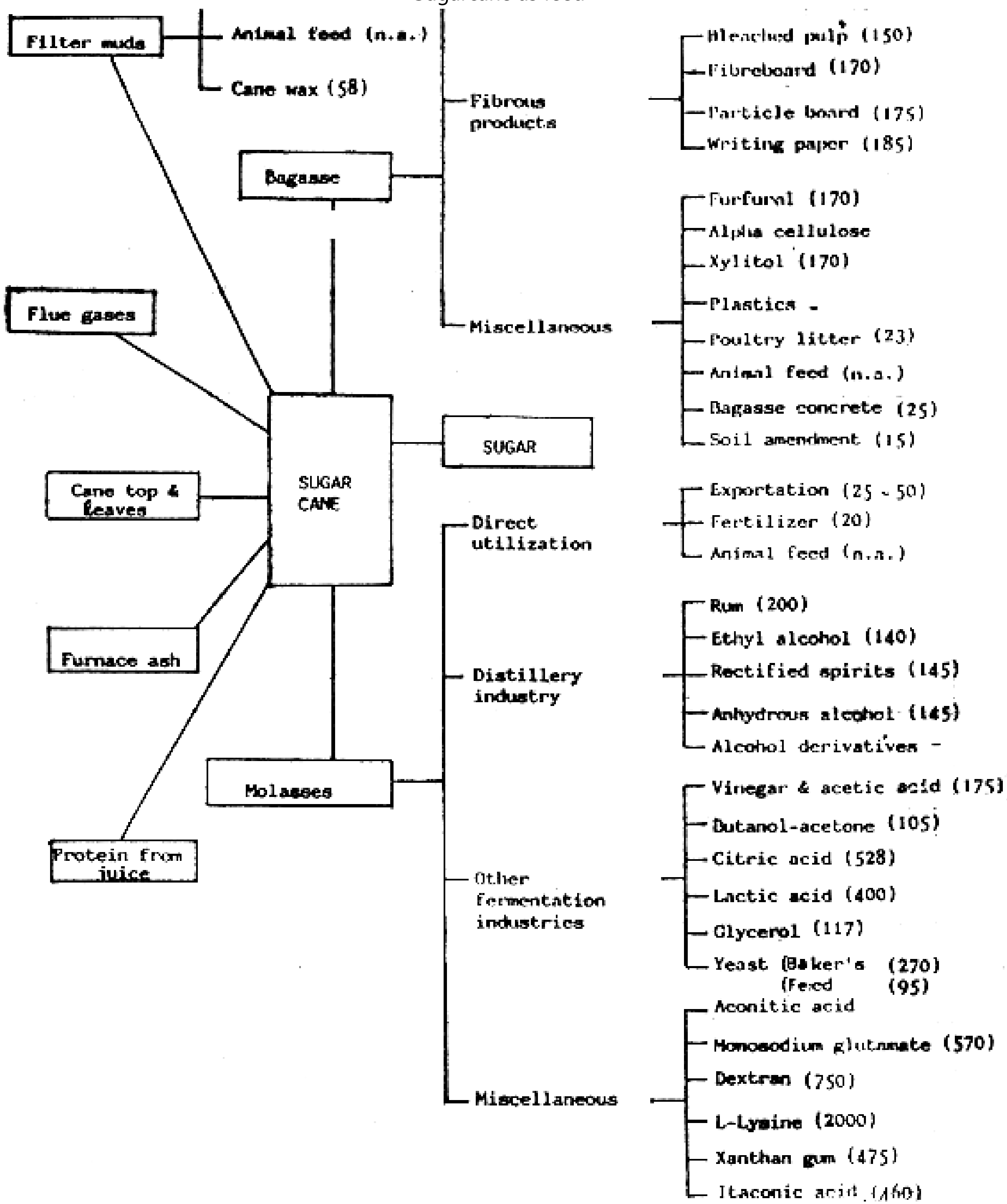
Figure 1: Byproducts of the sugarcane industry


Filter muds
Animal feed (n.a.)
Cane wax (58)
Bagasse
Fibrous products
Bleached pulp* (150)
Fibreboard (170)
Particle board (175)
Writing paper (185)
Miscellaneous
Furfural (170)
Alpha cellulose
Xylitol (170)
Plastics -
Poultry litter (23)
Animal feed (n.a.)
Bagasse concrete (25)
Soil amendment (15)
Flue gases
SUGAR
SUGAR CANE
Cane top & leaves
Furnace ash
Direct utilization
Exportation (25 - 50)
Fertilizer (20)
Animal feed (n.a.)
Distillery industry
Rum (200)
Ethyl alcohol (140)
Rectified spirits (145)
Anhydrous alcohol (145)
Alcohol derivatives -
Molasses
Protein from juice
Other fermentation industries
Vinegar & acetic acid (175)
Butanol-acetone (105)
Citric acid (528)
Lactic acid (400)
Glycerol (117)
Yeast (Baker's (270)
(Feed (95)
Miscellaneous
Aconitic acid
Monosodium glutamate (570)
Dextran (750)
L-Lysine (2000)
Xanthan gum (475)
Itaconic acid (460)

N.B. The figures following each product express the saleable value in US$ of this product obtainable from one tonne of raw material (Adapted from Paturau, 1982)

Figure 2: Price equivalence line for alcohol and gasoline

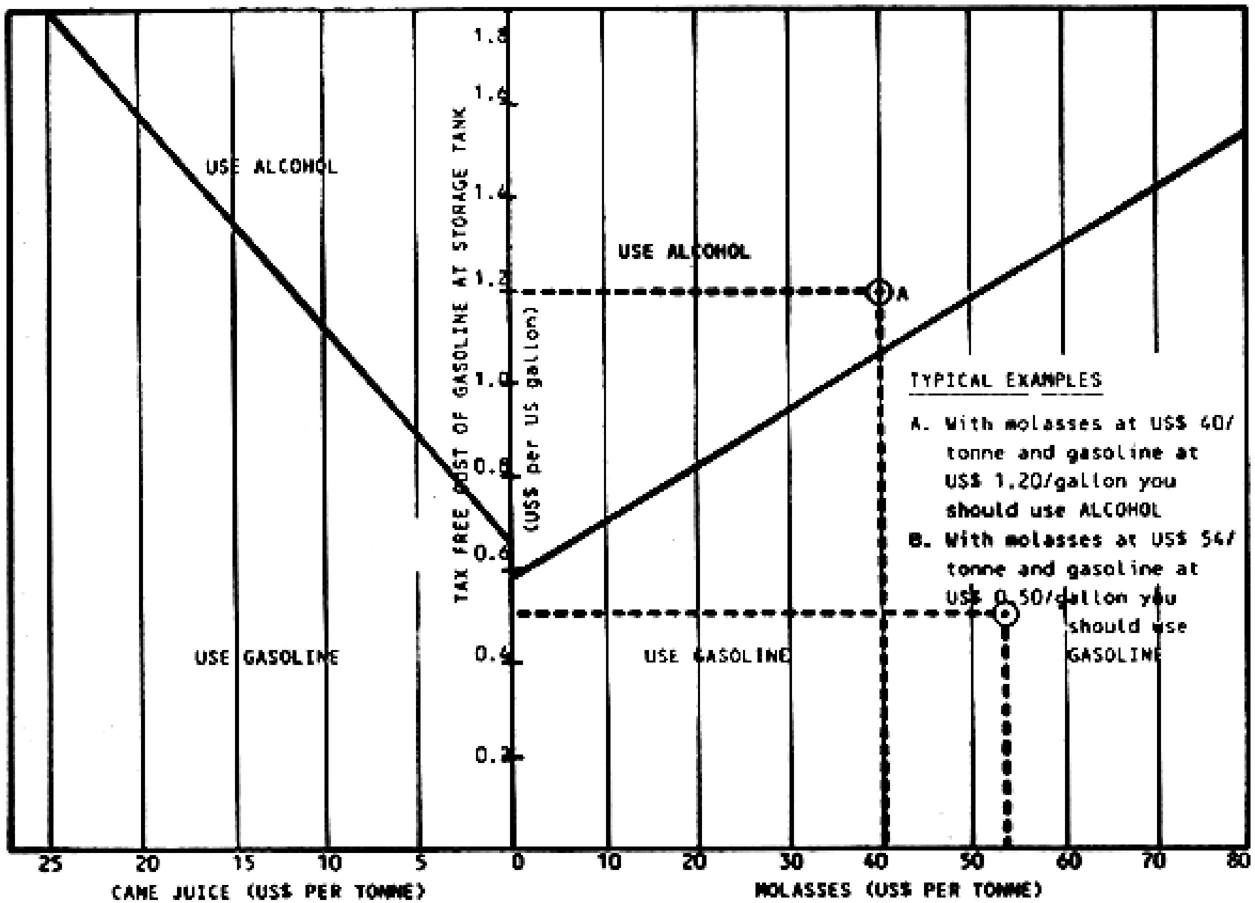


Table 1: Electricity from bagasse

		Best conditions	**Moderate conditions**

1.	Characteristics		
	- Boiler (46 Bar A, 440°C) capacity tonnes steam per hour	90	90
	- Turbo-alternator (condensing at 0.10 Bar A) capacity (MW)	20	20
	- Total capital investment for generating station in working order (US$ million)	9	11
	- Electricity generated yearly (GWh)	150	120
	- Weight of mill-run bagasse utilized (tonnes)	333 000	266 000
	- Acquisition cost of mill-run bagasse (US$ per tonne)	15	20
	- Average transport cost per tonne of bagasse (US$)	4	5
2.	Cost of electricity generated (in US$ cents per kWh)		
	- Depreciation and maintenance (10%)	0.60	0.92
	- Annuity repayment (0.16275 for 10 years at 10% interest)	0.98	1.49
	- Labour and administration (US$ 100 000 yearly)	0.07	0.08
	- Transport cost of bagasse	0.89	1.11
	- Acquisition cost of bagasse	3.33	4.48
	TOTAL GENERATION COST PER kWh	5.87	8.08
		say US cents 6.00/kWh	say US cents 8.00/kWh

Table 2: 50 TPD bagasse particle board plant (per tonne of product)

		Standard resin board plant	**New cement-bonded board plant**
1.	Inputs per tonne of product		

	Mill-run bagasse	3 tonnes	Depithed bagasse (50% H_2O)	450 kg
	Urea-formaldehyde resins	80 kg	)Portland cement	600 kg
	Hardener	8 kg	)	
	Wax	6 kg	Chemicals	25 kg
			Water	250 kg
	Labour	8 man-hours		6 man-hours
	Fuel oil	60 kg		-
	Steam	1 000 kg		1 000 kg
	Electricity	200 kWh		200 kWh
	Depreciation	12% of production cost per tonne of annual production	12% of capital cost per tonne of annual production	
	Repairs, maintenance, administration overheads and other charges	7% of production cost	7% of production cost	
2.	Economics			
	Capital cost	US$ 5.0 million	US$ 9.0 million	
	Production cost	US$ 200 per tonne of board	US$ per tonne of cement board	

Table 3: Furfural from bagasse (Basis 1 tonne furfural)

Consumption		**Production**	

Bagasse (bone dry)	12.5 tonnes	Furfural (99%)	1 tonne
Steam	35.0 tonnes	Acetic acid	550 kg
Water	70.0 tonnes	Hydrolysate residue (bone dry)	6.75 tonnes
Power	875 kWh		
		(This residue has 63% moisture and a net calorific value of 5 442 kJ/kg)	
Labour (3 shifts of 8 hrs)	216 man-hours daily		
Maintenance	10% of production cost	Secondary steam (125°C saturated)	7.5 tonnes
Overheads	10% of production cost		
Depreciation	10% yearly of capital cost		
Marketing (containers, etc.)			

Table 4: Cost structure of rum production and marketing (in Mauritius)

			US$ per litre of rum (40°GL)
1.	MANUFACTURE		
	(i)	Molasses (US$ 25/tonne, 230 litres alcohol at 100°GL equivalent, after dilution, to 575 litres rum at 40°GL)	0.04
	(ii)	Other costs	0.04

	(iii)	Profits	0.10
2.	BOTTLER		
	(iv)	Cost to bottler	0.18
	(v)	Bottling costs (glass bottle, cap, labour, etc.)	0.20
	(vi)	Excise duty (paid to government)	1.40
	(vii)	Profits	0.45
3.	RETAILER		
	(viii)	Cost to retailer	2.23
	(ix)	Profits	0.55
4.	PUBLIC		
	(x)	Retail price to public	US$ 2.78 per litre

USOS ALTERNATIVOS DE LA CAÑA DE AZUCAR Y SUS DERIVADOS EN LAS AGROINDUSTRIAS

por

J.M. Paturau

En los últimos diez años se ha observado un aumento del interés en la plena utilización de los subproductos de la industria de la caña de azúcar como reacción al alza de los precios de los combustibles fósiles y la baja del azúcar.

Se dispone de cantidades suficientes de los cuatro subproductos principales, a saber cogollos, bagazo, cachaza de filtro prensa y melaza, a precios moderados, para poder llevar a cabo importantes actividades agroindustriales.

Se consideran diversas industrias posibles, excepto las de piensos que serán examinadas por

otros oradores, y parece las actividades que ofrecen más interés para los países del Tercer Mundo son las siguientes :

i. **la generación de electricidad con el bagazo excedente para abastecer a la red nacional; si el suministro de electricidad es suficiente, puede utilizarse para fabricar tableros de partículas de bagazo aglomeradas con cemento;**

ii. **la utilización de la cachaza como fertilizante en los cañaverales;**

iii. **la transformación de la melaza en ron o alcohol potable para el mercado nacional y de exportación;**

iv. **si existe un grave problema de deforestación, la producción de alcohol industrial a base de melaza como combustible para cocinar en sustitución de la leña.**

También se consideran otros usos posibles de los subproductos en otras nueve industrias y se indican los principales datos económicos (papel, furfural, metano, alcohol etílico, ácido acético, butanol-acetona, ácido cítrico, levadura, glutamato monosódico).

SUGARCANE AS A SOURCE OF BIOMASS
by

A.G. Alexander

1. INTRODUCTION

Since the early 1980s, the need to diversify the cane sugar industry has become progressively acute (Alexander, 1984a,b, 1985 and 1986a). Substitution of cane with alternative farm commodities is an obvious answer in some circumstances. However, in a large majority of sugar-planting countries, the alternative of internal diversification to multiple products remains a viable option. This alternative is an assertion of the plant's lignocellulose (biomass) components that historically have been both underrecognized and underutilized by sugar interest (Alexander, 1985; Van Dillewijn, 1952; Deere, 1911).

To a large measure, the international effort to diversify sugarcane since the 1974 petroleum “crisis” has been traditional. Greater attention to the usage of bagasse boiler fuel and alcohol from cane fermentable solids has centred on traditional sugarcane, managed with its historic emphasis on sugar (Lipinsky, 1978; Moreira, 1980; Perleman, 1982). A reorientation of cane management to harness its lignocellulose attributes has not generally occurred. Essentially three “total biomass” conditions must be recognized in order to accomplish the biomass reorientation: (a) utilization of the whole cane plant, including tops and trash components formerly discarded; (b) growth-oriented management that aims from the onset to maximize whole cane production; and (c) integration with cane of related tropical grasses to assure a year-round, stabilized supply of lignocellulose to the new biomass-consuming industry. These features are discussed in this paper.

2. TOTAL BIOMASS THEORY

2.1 Total biomass concept

Few, if any, agricultural commodities have the enormous latent potentials to produce biomass that characterize Saccharum species (Alexander, 1973 and 1985; Van Dillewijn, 1952; Alexander et al., 1982). However, even the comparatively constrained biomass yield of conventional, sugar-oriented cane is frequently underappreciated and hence underutilized. Illustrated schematically in Figure 1, the total plant as a botanic entity consists of four major components, all of which contribute materially to total yield potential. Only one of these, the "millable stem", has seriously concerned the historic sugar planter, the refinery manager, and the mill engineers responsible for bagasse disposal. Studies in Puerto Rico have confirmed that the three non-sugar bearing components are both quantitatively significant and technically harvestable (Alexander, 1985, Alexander et al., 1982).

Once the whole cane plant is recognized as an entity of value, it follows that the increased yield of whole cane components becomes a matter of justifiable concern to plantation managers. In essence, the Puerto Rico studies found that growth-oriented management can increase whole cane yield in the order of 250–300 percent, at cost increases in the order of 35–40 percent. Hence, from this plant, the tradeoffs in yield over costs are weighted very heavily in favour of the crop planter, once the inherent value of lignocellulose is established. It is important to add here that at no time does the millable stem component, of historic interest to sugar planters, become any less important than in the past. Hence, sugar and molasses remain as important products of total biomass management. Only now are they seen as contributors to a multiple-products package from an authentic multiple-products commodity (Alexander, 1984a, b and 1985)

2.2 Sugar partitioning for growth

Such favourable tradeoffs in yield over cost are neither artifacts nor an automatic response to be activated by decree. Rather, they are the fruits of conscious effort by field managers to

assist the cane plant to do what it is designed to do best. Even within the cane sugar industry, very few people thoroughly understand the botany of the cane, or recognize more than superficially that growth rather than sugar storage is the age-old objective of Saccharum evolution (Alexander, 1973 and 1985; Van Dillewijn, 1952).

What the cane plant has accomplished botanically over an almost incomprehensible expanse of time is a superior capacity for sucrose production and storage - well appreciated by man - and an equally superior expertise to utilize sugar in support of its own growth processes (Alexander, 1973 and 1985). The latter is not so clearly appreciated but this does not make the botanic fact any less true. Even the most acclaimed "sweet" hybrids of commerce will preferentially utilize their stored sucrose for bud and shoot induction, tissue expansion, and crown expansion when suitable water and nutrient supplies are provided. Assessment of the Puerto Rico studies indicates that sugarcane will apportion roughly 35–40 percent of its stored sucrose for lignocellulose production. In this "partitioning" of its sugar product, the cane plant is something more than a novice. It gives back several-fold increases of lignocellulose, that is, it produces exceedingly well the product of greatest concern to the plant itself (Alexander, 1985; Alexander et al., 1982). Ironically, the mere intervention of human error and the intangibles of a harvest campaign can cause 30 or 40 percent sugar loss with no gain at all of biomass. For truly reliable sugar expenditure we must learn to let this plant "do its thing," and to encourage and assist its natural inclination for growth.

2.3 Allied grasses integration

Whether managed for sugar or as a total biomass resource, sugarcane has the twin characteristics of year-round growth but a harvest capability that is often seasonally constrained. Because lignocellulose industrial consumers must base their operations on feedstock supplies that are both abundant and reliably secure on a 365-day basis, the seasonal

bagasse must be supplemented with some form of stored biomass. Storage of humid bagasse is possible but not very desirable for technical reasons. A better alternative is the stockpiling of solar-dried grasses, particularly certain high-yielding tropical grasses that are generic relatives of Saccharum (Alexander, 1985; Alexander et al., 1982).

In addition to stabilizing the cane bagasse supply, the entry of such grasses offers a series of new benefits not historically enjoyed by cane sugar enterprises. These include:

- **Greater flexibility of feedstock supply**
- **Cleaner and drier feedstock supplies**
- **Opportunities for fire prevention and confinement**
- **Opportunities for interim livestock feed sales**
- **Expansion of the enterprise's agricultural supplier base**
- **Elimination of down-time (“tiempo muerto”)**
- **Increased employment and increased job stability**

The solar-drying of such grasses as a means of water removal is perhaps the happiest feature of their contribution. The issue of hauling water-laden stalks to a distant mill, itself a comparatively poor drying mechanism, is avoided entirely. Dehydrated by the sun to less than 20 percent moisture, these materials are readily compacted into bales that are more economic to haul, more efficiently stored, and more safely stored without hazard of spontaneous combustion.

3. WHOLE CANE PRODUCTION

3.1 Agronomic modifications

From the cane agronomists' point of view, essentially three new features will enter the

management routines for total biomass: (a) greater attention to the conditions of supply and utilization of growth-sustaining resources; (b) involvement of new machinery and practices dictated by greater tonnages of biomass and the needs of integrated grasses; and (c), greater attention to detail in the management of all production resources. Indeed, some phases of biomass cropping, particularly seed and seedbed management, will shift perceptibly in the direction of horticultural-like attention to detail (Alexander, 1985).

In maximizing cane biomass, field managers will give greater attention to the selection of sites, installation of drainage and irrigation systems, and preplant levelling operations than is normally done with conventional sugarcane (Alexander, 1985). Certain soil series and land contours that were marginal for sugar planting might be disqualified altogether for high cane biomass. However, they could still retain excellent suitability for allied grasses biomass in support of the same cane enterprise (Alexander, 1984b 1986a). Specific seedbed preparetion tasks will routinely include thorough ploughing and aeration, subsoiling, surface rotavation, and frequently precision grading with a landplane. Such operations are designed to accommodate the very elaborate upper- and lower-root zone profiles that ideally will proliferate during the first two years of energy cane establishment.

Planting and postplanting tasks essential for maximizing cane biomass are detailed elsewhere (Alexander, 1985). In essence, important emphasis is placed on creating early a "continuous stool" complex, offering much greater numbers of stalks per acre, with attendant early closure of the canopy and efficient utilization of incremental fertilizer and water. There is also an efficient suppression of weed growth through exclusion of light. Having created these conditions for growth and growth-resources utilization, it is in the late-juvenile and adult phases of cane development that the vast growth potentials of Saccharum are finally realized. Particularly in the ratoon crops that produce new top growth almost from the day of harvest, enormous yields are returned for six years or longer, well compensating the added costs and

attention to detail expended in the original crop establishment (Alexander, 1985, 1986a and b).

Harvest of the high-tonnage cane involves several technical issues that are resolved already for the most part (Alexander, 1985 and 1986b; Alexander et al., 1982): (a) harvest of vastly higher tonnages, commonly in excess of 100 tons per acre; (b) harvest of whole cane, including tops, attached trash, and detached trash; (c) clean cane harvest (that minimizes contaminating soil and inorganic extraneous matter); and (d) synchronization of cane and grasses operations for efficient commitment of machinery and human resources. At this moment, effective harvest of high tonnage cane is possible with cutting/windrowing machinery and loading machinery applied in separate operations. Performed on a flat, precision-graded seedbed (Alexander et al., 1982; Alexander, 1986b) with avoidance of mechanical bunching, harvest is completed with minimal incorporation of soil and damage to the cane crown. Alternatively, even cleaner harvests with less seedbed damage are possible where inexpensive labour is still available and employment of labour is itself an important objective of cane production (Alexander, 1985).

Correct synchronization of cane and grasses harvest operations is crucial. It is largely a function of correct planning and execution of the production/harvest campaign. This must begin at the conference table before a given year's planting and ratoon-crops operations are begun. One harvest feature (actualy post-harvest) common to grasses but entirely new for cane producers is the recovery of leafy trash left on the seedbed surface. This component is remarkable and can exceed 20 tons per acre for some varieties (Alexander, 1985; Alexander et al., 1982). Its "harvest" is accomplished on the seedbeds by the same equipment used for grasses conditioning, solar-drying and compacting, and the removal and storage of large bales.

3.2 Potential cane yields

Well within the botanic capability of sugarcane, the potential yields of Saccharum intentionally managed for its total biomass productivity are strikingly greater than those obtained from the traditional sugar commodity. For example, the world average for commercial cane was barely 23 tons per acre/year in 1983 (Table 1), while typical sugar varieties were yielding over 80 tons per acre when managed as a biomass commodity. Varieties noted for their high tonnage as a sugarcanes yielded over 120 tons per acre as biomass resources ("second generation" energy cane, Table 1). Further to this, a significantly greater yield potential remains unfulfilled in sugarcane's tropical habitat. The upper practical limit, that is, under practical farming circumstances given favourable climate, soils and water resources, is thought to be in the neighbourhood of 150–160 tons whole cane per acre year (Table 1). Such productivity in commercial enterprises will require conceptual reorientation in growth management, enterprises will require combination with new varietal genotypes from previously untapped Saccharumgermplasm (Chu, 1979 and 1982; Stevenson, 1985; Irvine and Benda, 1979).

3.3 New uses and yield issues for grasses and cane

The above yield figures for sugarcane, managed as "energy cane", assume that growth processes will operate to accrue lignocellulose on a diurnal basis 365 days per annum. The entry of livestock feed consideration offers an added scenario where such maximum yields are less likely to be attained. For example, dairymen in Puerto Rico prefer to harvest cane at about five or six months of age for use as greenfeed. Mature cane is also used for this purpose and is well accepted by dairy cows, but younger cane is preferred. Experience with energy cane has shown that the combined tonnage from two six-month crops will amount to roughly 70–80 percent of a single 12-month crop (Alexander et al., 1982). Similarly, the combined tonnage from three four-months crops offers further tonnage reduction, in the order of 50–70 percent of a single 12-month crop.

The attendant tradeoffs in biomass enterprise security, economic flexibility, and social/cultural acceptance are nonetheless favourable. This feature is most clearly seen in the concept of allied grasses integration with sugarcane on behalf of biomass consumers, in addition to the traditional sugar consumers. The immediate impact of such species is an added flexibility and stabilization of lignocellulose supply in what still remains as a predominantly 12-month crop of biomass and sugars.

However, since the early 1980s, an unwelcome dimension has superimposed it self on the sugarcane world which has increased the importance and attractiveness of the supplemental grasses. It is international in scope and includes the following features: (a) a persistent deterioration of sugar-planting economics, that is, of low sugar values and inroads of cane sugar substitutes combined with rising costs of production; (b) general recognition that sugar planters must grow something in addition to conventional sugarcane, as a matter of survival rather than choice; (c) recognition of livestock production as a valid alternative to sugar planting in most of the developing tropical world; and, (d) persistently rising costs of commercial protein, fibre, and fats used in cattle feeds and feed blends.

In Puerto Rico's case, the values of imported dry feed components had risen to about US$ 150.00 per ton by 1984 (Table 2). Freight charges alone amounted to US$24.00 per ton (Alexander, 1986a). Ironically, while some US$ 115 million are expendedannually for this purpose in Puerto Rico, the same materials or suitable alternative feed sources can be grown there domestically at less than one-fourth the cost of imported dry feeds.

The supplemental grasses discussed above as integrated lignocellulose backups for cane could figure prominently as livestock feeds in carefully integrated cane and livestock operations. For example, solar-dried grasses could be available or stockpiled as feeds many months before a lignocellulose-products factory could be constructed and made operational

(Alexander, 1986a). Routinely, excess grasses stemming from overproduction or factory down-time would find alternative markets in the livestock industry. Their long-term stability in storage also enables them to wait for favourable market conditions. In essence, such species correctly managed would offer both flexibility and security and added sources of revenue to a biomass-consuming industry operating primarily on an energy cane base (Alexander, 1985 and 1986a).

Two additional benefits of the supplemental grasses deserve mention at this point. First, because such species do not accumulate dry trash and remain non-combustible before harvest, they offer effective fire-breaks for the concurrent energy cane crops. In suitably-planned field design, napier grass can materially limit the spread of fire, even when started maliciously. A second added benefit is a kind of psychological support or assurance for farmers who are encouraged to plant such grasses as industrial lignocellulose feedstocks. Such growers might never wholly understand what products manufacturing from lignocellulose is all about, yet they will always perceive the age-old use of grasses as livestock feed.

4. CANE BIOMASS UTILIZATION

After the petroleum crisis of the mid-1970s, sugarcane often has been depicted as a source of bagasse for boiler fuel and alcohol for motor fuel. This view is perhaps correct in circumstances where sugar and conventional sugarcane management continue to dominate the cane industry thinking. However, it is an overly simplistic view of the potential contributions of cane as a multiple-products commodity. This particularly true where its lignocellulose values are fully appreciated, and where agricultural management is reoriented to maximize total biomass production.

4.1 Biomass hierarchy of values

As a primarily biomass system, sugarcane must be viewed in the context of critical new roles that biomass in general must play as a renewable, domestic resource. Fermentable solids are an important by-product of some biomass systems, including energy cane, and their long-term role in fuel alcohol production seems assured. Opportunities for lignocellulose itself are considerably more complex and less clearly preceived.

A convenient illustration of lignocellulose potentials and opportunities is found in the "hierarchy of values". As presented in Figure 2, the plotted logarithms of lignocellulose sales volume versus value give a straight-line relationship, a hierarchy of industrial utilization opportunities. It is seen that the direct combustion of biomass as a humid boiler fuel is the least-valuable option for a potentially high-value resource. Figure 2 is itself an over simplification. For exampale, entire sub-hierarchies could be plotted for items such as synthesis gas, and little application is seen in the near-term for perfume production from energy cane. However, very real opportunities already exist for the upgrading of humid bagasse to higher-value fuels. Proprietary fuels might include free-flowing powders (for co-combustion withoil), or pelletized products offering chemicals and combustible gases by-products. (Beningson, 1982a and b; Lijinsky and Jenkins, 1982; Anon., 1982a and b; Bouvet and Suzor, 1980; Hasselriis and Bellac, 1980).

An appropriate example of still higher-value opportunities from existing industrial technology is found in the synthesis gas option (Pruett, 1981; Parker, 1978; Wishart, 1978). Consisting of a mixture of hydrogen (H_2) and carbon monoxide (CO), it comprises a kind of chemists' soup from which numerous organic products needed by a modern society can be formed. A product of immediate concern to sugarcane-planting countries is nitrogenous fertilizer (Alexander, 1984 a and 1985).

During most of the present century, the feedstocks for synthesis gas production have been

petroleum and natural gas. However, coal and biomass are equally suitable substrates, a fact of enormous future consequence for both coal-rich temperate countries and "energy poor" tropical societies with established cane industries. By the summary reactions,

1. **$CH_4 + H_2O \rightarrow CO + 3H_2$ (endothermic)**

2. **$n(C\text{-}H) + O_2$ or $H_2O \rightarrow n(CO) + n(H_2)$**
   Biomass
   Coal

the methane component of biogas can be reformed to carbon monoxide plus hydrogen (equation no. 1), or whole biomass can be reformed to the same products in a somewhat more complicated sequence (equation no. 2). Because natural gas bears almost pure methane and is easily managed and inexpensive, it is the preferred feedstock of the current chemical industry. However, the coal and biomass options must evetually assume this role (Pruett, 1981; Parker, 1978).

It is worthwhile mentioning a few of the valuable products that in future will derive from cane biomass. For example, both pure and oxygenated hydrocarbons can be formed from synthesis gas via the Fischer-Tropsch reaction. To future agricultural planners, a great comfort will be found in the fact that nitrogenous fertilizers can be manufactured from domestic biomass feedstocks (Wishart, 1978). Hence, the combination of synthesis gas H^2, with the virtually free N^2 of the atmosphere, provides the essential ammonia feedstock for future N-fertilizers manufacture. Additional products from the synthesis gas resource can include urea, methanol, glycol, glycerol, acetates, ethylene, aromatic compounds, lactides, and various polymers and copolymers. From the aromatics alone, whole families of critical downstream products can be

manufactured from the original cane biomass feedstocks.

4.2 Feeds vs industrial materials feedstocks

Future biomass usage opportunities as depicted in Figure 2 are a convenient background for plant components just beginning to be recognized as industrial raw materials in their own right - not merely as residues from an older farming or forestry commodity. Only a tentative placement of the livestock feeds option on the same hierarchy of values is possible for purposes of this communication. Individual cane-growing regions will preceive the livestock application differently. For some, cattle production is a prime existing reality while others are only beginning to assess this option. Through economic "sensitivity analyses" will be needed in most circumstances. For exampale, the question of cane usage as feed must evaluate the tradeoffs of lower tonnage and loss of sugar versus the very real benefits of no longer having to transport and dewater mature cane in a sugar mill. Similarly, will the cane feed derive from plantings managed as feed from the onset or does feed usage apply merely to the bagasse and molasses byproducts of conventional sugarcane? For Puerto Rican circumstances we are confident that cane to be used as feed ought to be managed as feed from preplanting onward.

For present purposes, it is estimated that energy cane utilized as green-feed for diary cattle would have a final value intermediate between boiler fuel and feedstock for a proprietary industrial fuel (Figure 2). Energy cane management for maximum biomass is assumed, together with harvest intervals of approximately 3–4 and 5–6 months, i.e. three or two greenfeed crops per acre year. Sugarcane cannot express fully its maximum biomass growth capabilities in such shortened time-spains; however, high-growth management is probably justified by the great untapped growth potential of this plant.

5. CONCLUSIONS

Sugarcane is a unique botanic resource whose growth potentials were long underrecognized and underutilized as a monolithic sugar crop. More than ever before, sugarcane is needed today as a multiple-products commodity in the developing tropics. Its management as energy cane is not a substituation or even de-emphasis of sugar. Rather, the plant is encouraged to utilize some of its lignocellulose. contributes to a series of new saleable products from lignocellulose. The accured series value exceeds that of historic sugar plus its molasses and bagasse by-products. Cane utilization as a livestock feed is consistent with energy cane management. Some growth potential is sacrificed but highly favourable tradeoffs emerge. There is added agricultural base flexibility and cash flow to an energy cane enterprise, and elimination of costly transport and milling operations. Equally favourable feed contributions derive from the allied tropical grasses already incorporated into energy cane agriculture.

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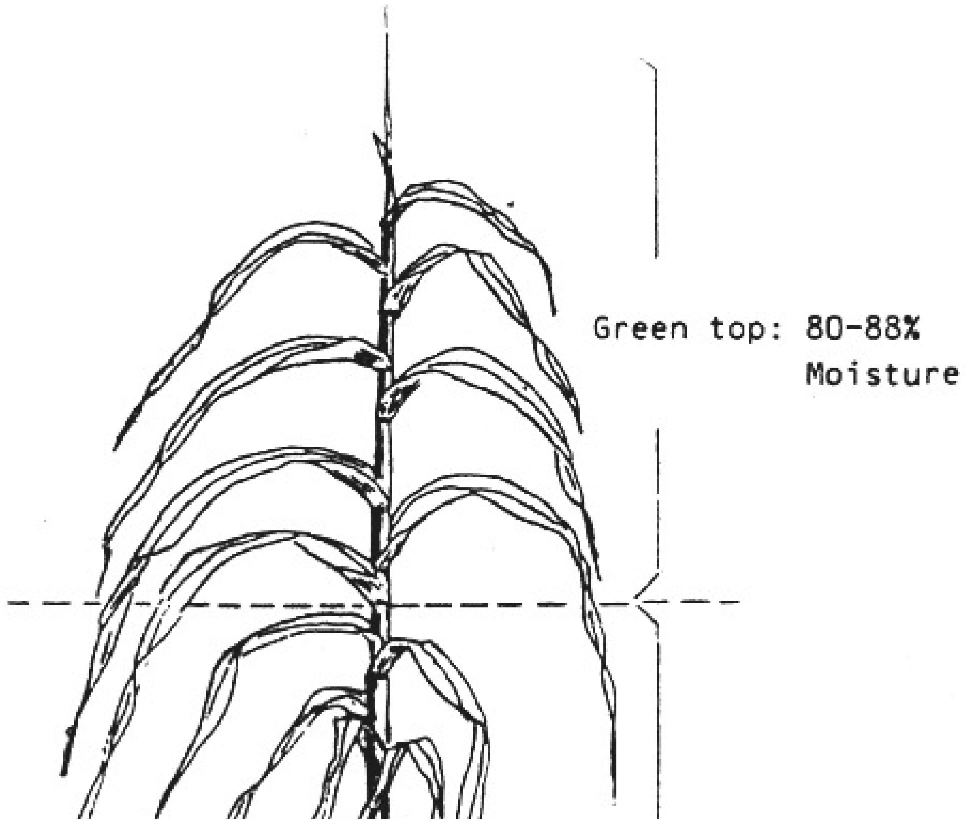
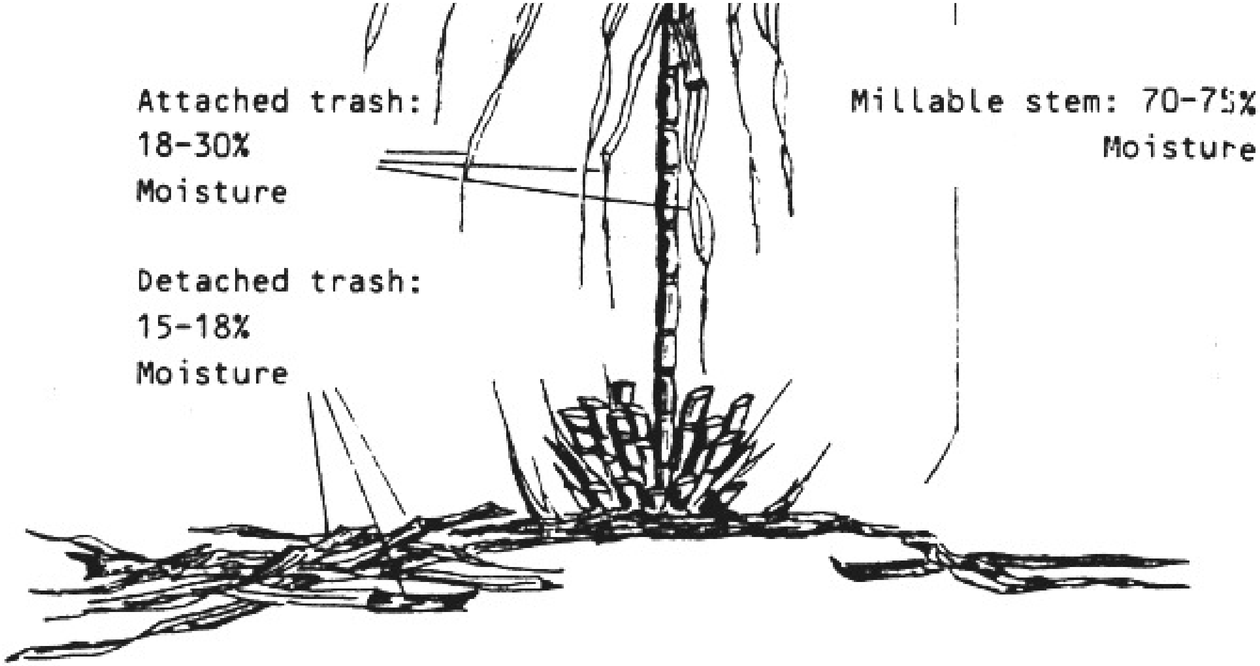
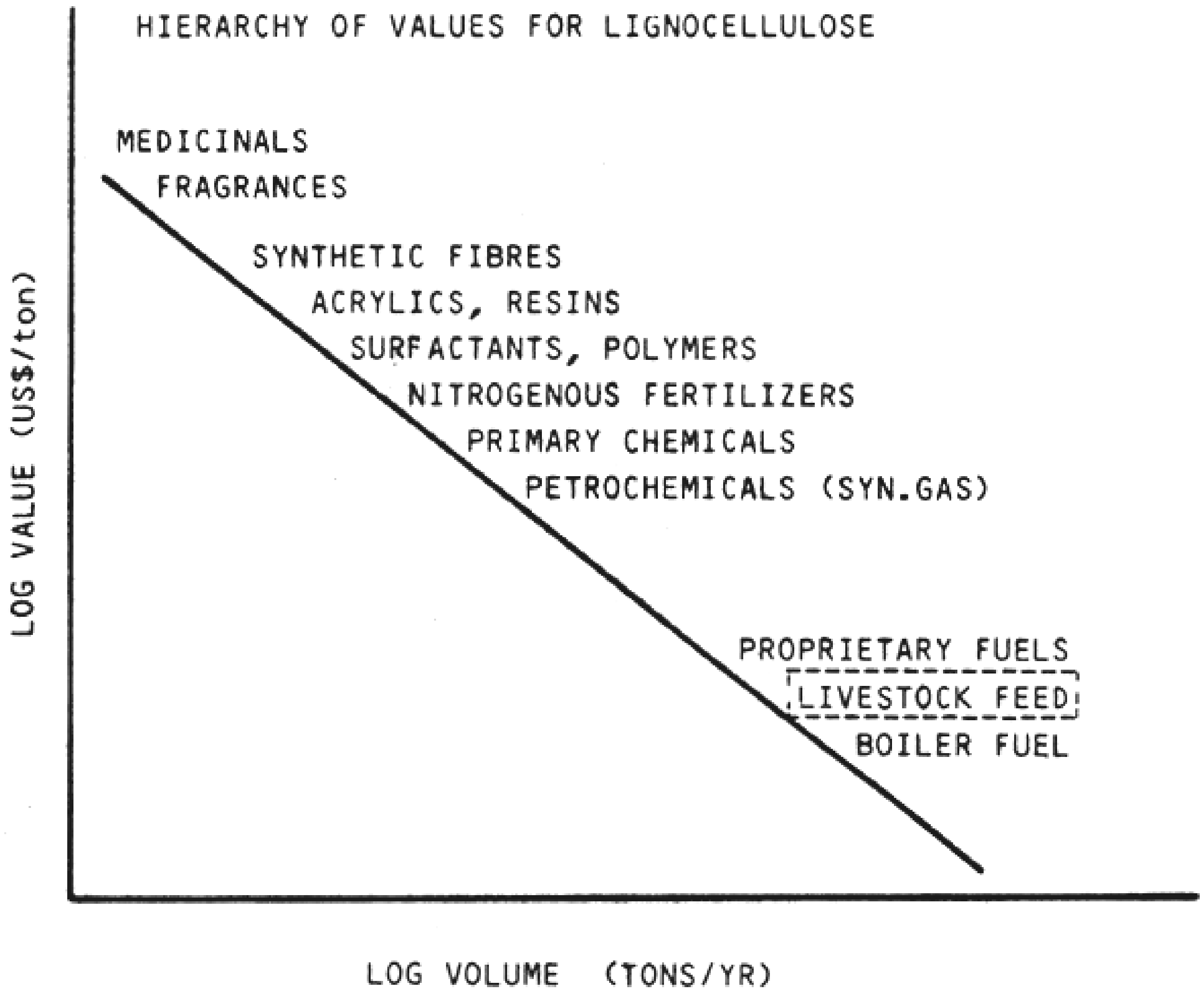
Figure 1





Schematic illustration of the four above-ground components of "whole" sugarcane, as produced for its total biomass lignocellulose in a multiple-products commodity. Reproduced by permission of Elsevier Science Publishers B.V., Amsterdam (Alexander, 1985).

<u>Figure 2</u>



Hierarchy of utilization opportunities for plant Lignocellulose. Adapted from Alexander, 1985.

Table 1.

Average current yield and yield potentials for sugarcane

Parameter	**Green yield1 (Tons/acre year)**

World commercial average (1983)	22.6
Puerto Rico commercial average (1985)	24.0
Energy cane, first generation	83.0
Energy cane, second generation	125.0
Approximate theoretical maximum:	
Subtropics	112.0
Tropics	160.0

1 Source: Alexander, 1986b.

Table 2. Puerto Rico feed imports and costs, 1984[1]

- Materials: Corn, grains, cotton and soybean meal		
- Costs: approximately 115 million (US$) total:		
- Materials	126.00	US$/ton
- Shipping	24.00	"
- Total cost/ton	150.00	"
- Cost of local napier grass, solar-dried, delivered, and size-reduced	28.50[2]	US$/ton

1 Source: Alexander, 1986a

2 Estimated from 1982 production data (Alexander et al., 1982).

LA CAÑA DE AZUCAR COMO FUENTE DE BIOMASA
por
A.G. Alexander

La plantación de caña de azúcar es una reatidad que està intimamente entrelazada con el legado historico de numerosas comunidades rurales del tropico. Las poderosas fuerzas para acelerar la diversificación pueden ser absorbidas e integradas dentro de la infraestructura dedicada a la producción de caña. Cabe señalar, sin embargo, que el enorme potencial de la caña para la producción de biomasa tiene que ser apreciado adecuadamente para poder aportar el nivel de manejo requerido por un cultivo a fines múltiples. Este trabajo incluye análisis y comentarios sobre los requerimientos para la utilización integral de la planta de caña, para reorganizar la producción de caña de modo de maximizar económicamente la total idad de la biomasa producida, y para integrar junto a la caña algunas especies tropicales de alta productividad que le están emparentadas. La producción de biomasa lignocelulósica se propone, a titulo propio, como una meta escencial de manejc. Se estima que el azúcar y la melaza se mantendrán como los principales subproductos comerciales. El estudio identifica nuevos usuarios industriales, como también productos lignocelulósicos de major valor económico; ambos temas son analizados.

SUGARCANE AS ANIMAL FEED: AN OVERVIEW

by

T.R. Preston

INTRODUCTION

There is a long practice in the feeding of sugarcane to all classes of livestock, especially for cattle during the dry season when availability of conventional forage resources is scarce. Nevertheless, the techniques used have been mostly rudimentary and there has been little appreciation of the critical role of supplements as a means of improving the efficiency of utilization of the sugarcane plant as animal feed.

It is only in the last 10–20 years that serious attempts have been made to understand the constraints that limit the expression of the nutritional potential of this feed, especially for ruminants. Our present vastly increased understanding in this area of nutrition stems in large part from research and development done in Cuba in the late 1960s on the feeding of molasses to cattle (Preston and Willis, 1974). The economic crisis affecting sugar producers, which began in the mid-1970s and which continues with little sign of abatement, has also been a major stimulus to the increased activities in the area of alternate uses of the sugarcane crop; and has been one of the major reasons for this Consultation.

FEED BIOMASS FROM SUGARCANE

The potential of sugarcane, and its intrinsic advantages over other tropical grasses, as a converter of solar energy into biomass is the rationale for the concept of "energy cane" (Alexander, 1985). However, sugarcane has other characteristics which make it especially appropriate as a feed reserve for livestock in the tropics, and superior to almost all other forage crops.

Its outstanding characteristics are:

- **Its perennial growth habit.**
- **The quantity and nutritional quality of sugarcane increase with harvest interval, with**

optimum values being reached at a harvest interval of between 12 and 18 months. This is in marked contrast with almost all other tropical forage crops, which deteriorate in yield and quality as the interval between successive cuts is increased. For this reason sugarcane has been called "ensilaje vivo" in many Central American countries.

- **The dry matter content of mature sugarcane averages 30 percent which exceeds that of most other forage grasses (the average for Elephant and King grasses is closer to 17 percent). Thus harvest, transport and processing costs per unit dry matter are less for sugarcane than for most other forages.**

- **It is easy to separate sugarcane into different components (e.g. juice and fibre), which can be exploited to permit flexibility in end-product usage (Preston, 1986).**

- **There is a long tradition in sugarcane agronomy, especially in breeding, pest control and cultural practices. Admittedly this has been mainly directed to enhanced production of sucrose rather than total sugars which is the criterion for animal feed. But the implication of this practice in terms of the loss of potentially promising varieties is one of degree rather than direction, as there is direct compatibility between sucrose yield and feed value.**

- **Sugarcane is widely tolerant of soil and climatic characteristics and by maintaining a canopy of green leaves (or a mulch of dead ones) throughout the year helps to combat erosion, giving it a distinct advantage over competitive forage crops such as cassava and maize.**

SUGARCANE PITH

The stimulus for the research which led to the development of feeding systems based on whole sugarcane was undoubtedly the invention by Tilby and Miller (Lipinsky and Kresovich, 1982) of

the Canadian-designed separator.

The idea of separating the more fibrous rind from the cane stalk, and using it for the manufacture of particle board and paper, led to the possibility of using the residual pith as the basis of animal feed (Pigden, 1972). Sadly this novel approach to sugarcane processing has still not proved to be commercially viable largely because of the high investment and operational costs of the separator and the apparent difficulties in converting the rind into suitable raw material for board and paper manufacture. Furthermore, as the basic diet for ruminants, chopped whole cane proved to have almost the same potential as the pith, and the technology required was both simpler and cheaper (Preston et al., 1976).

TECHNOLOGIES FOR COMMERCIAL USE OF SUGARCANE IN ANIMAL FEEDING

The issues to be considered are not technical but economical, and concern: a) The economics of harvesting, transporting and processing whole cane b) Supplementation.

Harvest, transport and processing

Methods of getting whole sugarcane from the field to the animal range from the entirely manual through combinations of hand cutting and mechanical loading, transport and processing to the use of machines which carry out the entire operation of cutting, chopping and loading direct into forage wagons. Choice of any one or combinations of systems will depend on socio-economic factors such as rates of unor under-employment, minimum wage scales, the nature of the terrain where the cane is grown and transported, costs of machinery and fuel and the economics of converting the processed cane into animal products. Transport of cane stalks by mules and horses is still the dominant system for small scale producers in Colombia; in the Dominican Republic, ox carts predominate at least at the level of field to rail or road. There is

infinite choice, although in many developing countries there is an increasing realization that animal traction is usually the cheapest when distances are short and daily needs are relatively small (e.g. less than 2 tons daily).

Processing can be done by traditional slowly revolving chaff cutters, by high speed disintegrators employing knives and beaters or by the precision chopping chamber of a forage "double chop" harvester; effects on nutritive value due to different methods of processing appear to be negligible (Montpellier and Preston, 1977).

Supplementation

Correct supplementation is the key to animal productivity on sugarcane. The principles are well established and are based on:

- **Satisfying the needs of rumen microbes for fermentable nitrogen (ammonia), trace nutrients (peptides, amino acids, minerals and vitamins) and the physical attributes of an efficient rumen ecosystem (small quantities of readily fermentable fibre).**
- **Sources of protein, glucose precursors and long chain fatty acids able to bypass (or escape) the rumen fermentation so that the end products of fermentative digestion can be balanced according to the needs of the particular production function (Leng and Preston, 1986).**
- **Feeds and/or chemical substances capable of manipulating the rumen fermentation so as to:**
- **Increase propionate relative to the other VFA.**

- **Eliminate (or reduce) protozoal populations in the rumen.**

Optimum levels of rumen ammonia appear to be provided by the equivalent of 30 g urea per kg of sugarcane dry matter (Alvarez and Preston, 1976a) (Figure 1).

Trace nutrients for rumen microbes and the "physical" attributes of a good rumen "ecosystem" are conferred by highly digestible green forages such as sweet potato tops and foliages from legume trees such as leucaena (Meyreles et al., 1979; Hulman and Preston, 1981). Although there have been no comparative studies, suitable amounts seem to be the equivalent of 600 g dry matter per 100 kg liveweight.

Rice polishings have proved to be the best sources of bypass nutrients because of their richness in essential amino acids, starch and lipids (Figure 2). However, other supplements and combinations of supplements have given good results (e.g. cottonseed cake or combinations of maize grain and fishmeal).

The principles are that the active ingredients (amino acids, starch and LCFA) are in a form which permits them to escape to a major degree the degradative action of rumen microbes. Thus cassava root meal (Silvestre et al., 1977) and molasses (Pigden, 1972) which are rapidly degraded by rumen microorganisms (Santana and Hovell, 1979; Encarnacion and Hughes-Jones, 1981) are less effective than maize meal as sources of glucose precursors.

Animal response to supplementation of sugarcane with bypass nutrients is curvilinear, and economically optimum supplementation strategies will depend on cost relationships between product (meat or milk) and supplement, and the dimensions of the biological response curve. For example, the most economic levels of rice polishings have proved to be between 500 and 1 000 g/animal/day.

The interaction between supplements which act in the rumen or in the animal is apparent from the data reported by Alvarez and Preston (1976a) and Ferreiro et al. (1977). Neither urea nor rice polishings was effective when given alone, yet both had dramatic effects on rate of animal performance when given together.

Foliages from legume trees such as Gliricidia sepium, Leucaena and Erythrina glauca, although proven sources of bypass protein (and possibly lipids also) in molasses-based feeding systems (Preston and Botero, 1986) have yet to be evaluated in diets based on whole sugarcane.

MEAT OR MILK

With only moderate levels of supplementation (maximum of 25 percent of the diet dry matter), it is technically feasible to achieve growth and feed conversion rates in cattle only slightly less than the maxima set by the genetic potential of the cattle breeds on test (Pigden, 1972; Meyreles et al., 1979; Preston et al., 1976). Comparable levels of performance have not been reached with milking animals fed sugarcane and the realizable yields are probably less than 50 percent of genetic potential (MacLeod et al., 1976). The reasons are likely to be the higher requirements for both glucose and amino acids for milk synthesis, and the imbalance in the proportions of these nutrients relative to total VFA energy, in the end products of fermentative digestion of cattle fed a basal diet of sugarcane.

However, if the milk production system is"matched with the feed resource" (i.e. the cattle are dual purpose crossbreds), then economical milk production systems can be established with sugarcane as the basal diet (Table 1). In such a system restricted grazing on a legume bank of Leucaena leucocephala permitted economies in the amounts of supplement (rice polishings) needed (Table 1).

ENSILING AND/OR UPGRADING OF SUGARCANE

The growth characteristics of sugarcane are such as to make it unnecessary to ensile this crop, since its nutritive value is highest in the dry season when other forages are in scarce supply, and it can be left in the field as a standing crop until required. A possible advantage from ensiling appeared to be indicated by the finding that young actively growing cane was inferior in feed value to mature cane, apparently because of the higher sugar content of the latter. It was argued that if sugarcane was to be used as the basis of a year-round confinement feeding system, then there could be advantages in certain climatic situations of ensiling cane in the dry season, when its nutritive value was high, and feeding the ensiled material in the wet season when the standing cane was of low nutritive value.

The precautions to be taken in the ensiling of sugarcane were established by Alvarez and Preston (1976c), who showed that when ensiling was performed without additives, a high proportion of the soluble sugars was converted to alcohol, and nutritive value was seriously depressed (Alvarez et al., 1977). Protective measures to ensure development of lactic acid-producing bacteria, rather than yeasts, included incorporation of ammonia (24 g/kg of sugarcane dry matter), or mixtures of urea and cattle faeces allowed to pre-ferment before being incoporated into the chopped sugarcane.

FUTURE RESEARCH

The following topics merit increased research in order to improve the utilization of sugarcane for animal production:

- **The effects of age/maturity on its nutritive value**

- **Upgrading the nutritive value of cane with ammonia and other acids and alkalis.**

- **Supplementation with foliages from forage trees.**

- **Control/elimination of protozoa in ruminants fed sugarcane.**

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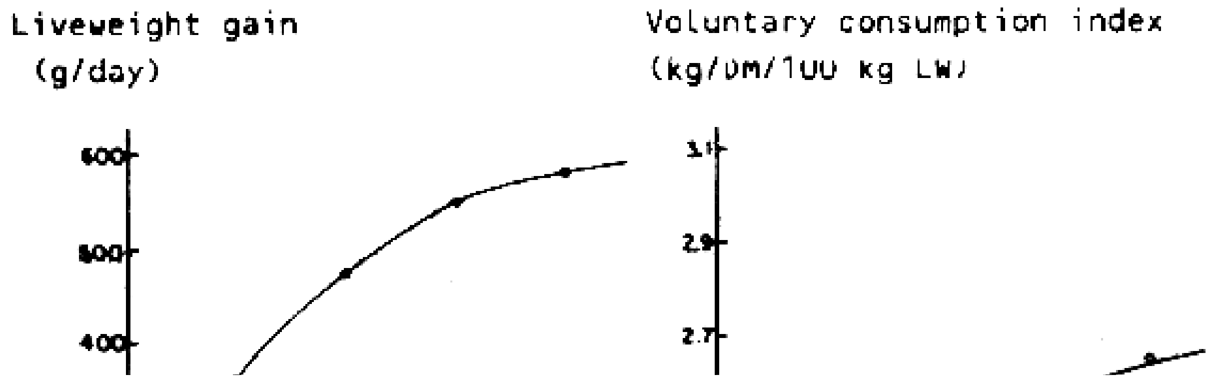
Figure 1: Relation between urea concentration in the diet and Liveweight gain, feed intake and feed conversion.



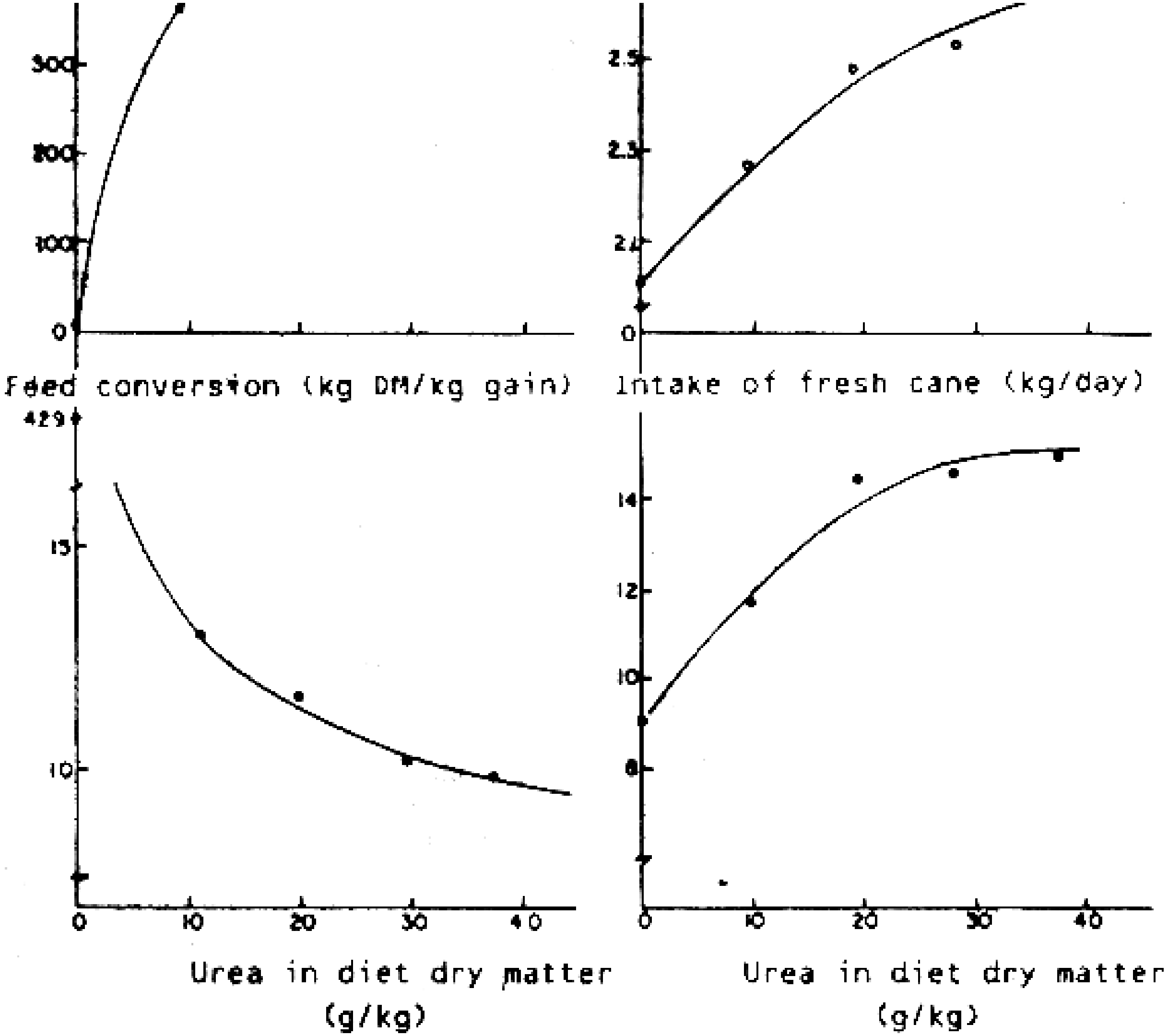
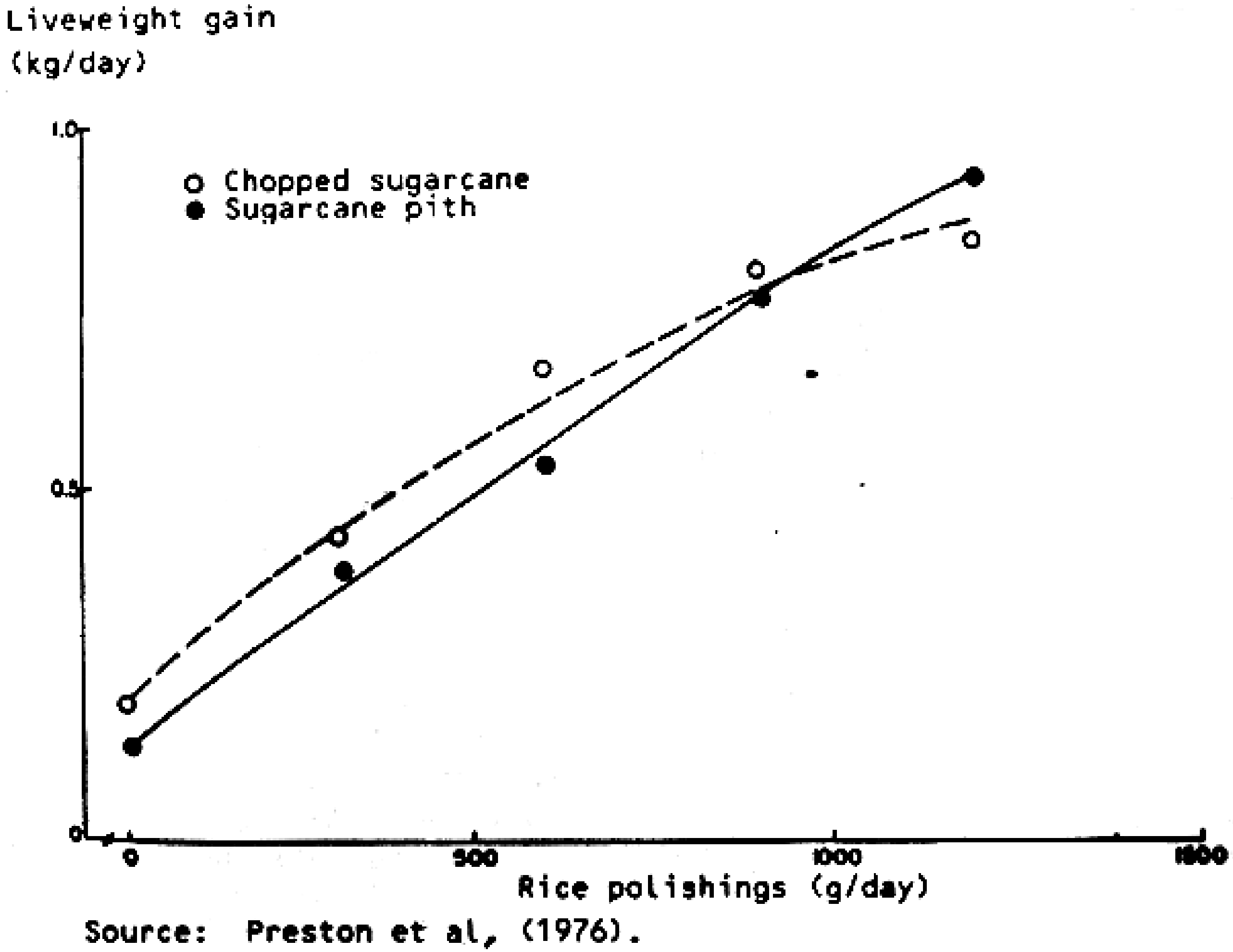


Figure 2: Effects of supplementation with rice polishings (bypass protein, bypass starch and oil) on growth rates of Zebu bulls in Mexico fattened on basal diets of whole sugarcane which had been chopped or derinded by the "Tilby" separator process.



Source: Preston et al, (1976).

Table 1. Milk production and calf growth in dual purpose cows given a basal diet of chopped sugarcane supplemented with rice polishings and restricted grazing on the legume tree Leucaena leucocephala (Alvarez and Preston 1976b; Alvarez et al., 1978)

Alvarez and Preston, 1976b:			
Rice polishings (kg/d)	2	1	-

Leucaena grazing (3 hr/d)	No	Yes	Yes
Milk yield (kg/d)	5.9	6.2	4.6
Calf growth (kg/d)	0.60	0.58	0.63
Weight change of cows (kg/d)	0.34	0.32	-0.23
Alvarez et al. 1978:			
Rice polishings (kg/d)	2	1	0.5
Leucaena grazing (hr/d)	-	3	3
Milk yield (kg/d)	5.1	6.9	6.9
Calf growth (kg/d)	0.50	0.52	0.49
Weight change cows (kg/d)	0.12	0.04	0.02

UTILIZACION DE LA CAÑA DE AZUCAR EN LA ALIMENTACION ANIMAL: SINOPSIS

por

T.R. Preston

La antigua práctica de alimentar al ganado con caña de azúcar se ha racionalizado en los últimos 10–12 años hasta tal punto que actualmente constituye la base de sistemas de producción pecuaria económicamente viables para rumiantes de gran tamaño.

Las características esenciales de los sistemas de alimentación animal a base de caña son las siguientes: utilización de caña madura (el jugo no deberá tener menos de 12–16 grados brix); picadura de toda la cosecha en partículas no más largas de 10–20 mm; y suplementación con urea (10 g de urea/kg de caña fresca).

Cuando es el único elemento de la dieta, este pienso servirá para el mantenimiento del ganado, y cuando se utiliza como suplemento del pasto cabe prever aumentos de peso de hasta 200

g/animal/día.

A fin de lograr mayores niveles de productividad, se requieren suplementos adicionales que ofrezcan un medio más favorable a la actividad microbiana en el rumen y para equilibrar los productos de digestión del rumen (nutrientes sobrepasantes). Para lo primero, son alimentos apropiados la gallinaza y el follaje de cultivos alimentarios (por ejemplo, yuca y batata) y/o árboles leguminosos (por ejemplo, Leucaena, Gliricidia y Erithryna spp) en una proporción del 20 por ciento aproximadamente de la materia seca; para el segundo fin, los suplementos preferidos son los subproductos ricos en lípidos y proteínas de la molienda de cereales (por ejemplo, polidura de arroz) y de la elaboración de semillas oleaginosas (por ejemplo, torta de algodón).

Los niveles recomendados de ambos tipos de suplementos son hasta del 20 por ciento de la materia seca de la dieta.

Las tasas potenciales de productividad correspondiente a las cantidades máximas de suplementos recomendadas son de unos 800 g/día de aumento de peso en vivo en el caso de los toros de engorde y de 6–8 litros de leche/día en las vacas de cruzamiento.

Generalmente no se recomienda el ensilaje de la caña ya que el valor nutritivo de ésta aumenta con la madurez y el comienzo de la estación seca.

Si ha de conservarse, es esencial utilizar aditivos para evitar el desarrollo de levaduras, que convierten a los azúcares en acídos orgánicos y alcohol y reducen su valor nutritivo. Alcalis como el amoníaco y el hidróxido de sodio conservan los azúcares y aumentan la degradabilidad de la fibra.

EXPERIENCIA CON LA CAÑA DE AZUCAR INTEGRAL EN LA ALIMENTACION ANIMAL EN MEXICO

por

F.J. Alvarez Flores

1. IMPORTANCIA DE LA CAÑA DE AZUCAR EN MEXICO

La caña de azúcar es un cultivo ampliamente difundido en México, existen más de 15 regiones cañeras distribuídas en la costa del Pacífico, Area Central, Golfo de México y Area del Caribeña en la Península de Yucatán.

México ha pasado durante los últimos años por diferentes etapas, ya que de ser un país tradicionalmente exportador, se convirtió en la década de los 70 en importador pero en los últimos años llegó nuevamente la autosuficiencia con una cosecha estimada en el último ciclo de 1985/86 en 3.800.000 ton. de azúcar, con los que se logró un superavit estimado en más de 500.000 ton. que no podrán ser exportados debido a la baja internacional de los precios del azúcar, por lo que tendrán que dedicarlas al consumo interno y en esta forma se suma así a los países con problemas de excedentes de dulce.

2. DISPONIBILIDAD DE SUBPRODUCTOS

El uso industrial que se dá a la melaza es en la fabricación de alcoholes, levadura y algunos

ácidos orgánicos. La melaza es el principal subproducto utilizado en la alimentación animal, existe amplia disponibilidad y su uso se ha venido incrementado notablemente sobre todo, en las áreas no muy distantes de los ingenios donde el flete sea costeable; su precio actual es de $ 18,700/ton apróximadamente US$ 30.00/ton. La melaza se ha venido utilizando sobre todo como complemento al ganado en la estación seca cuando el pasto escasea y en menor escala en sistemas intensivos, basados en melaza.

El bagazo y el bagacillo se utilizan principalmente como combustible, y en la industria para la fabricación de papel y en menor escala en la alimentación de ganado.

Las puntas de caña son utilizadas en pequeña escala en las áreas cercanas a las fuentes donde se cultiva principalmente como forraje para ganado.

3. USO DE LA CAÑA DE AZUCAR INTEGRAL

La utilización de la caña de azúcar en México, se ha venido incrementando gradualmente en algunas áreas principalmente como complemento en la época seca en los sistemas de pastoreo, cuando se presenta uno de los principales problemas de la ganadería ocasionado por la falta de forraje.

En el período de 1973 a 1978 se realizó en Chetumal Q. Roo (área caribeña), un programa de investigación tendiente al aprovechamiento de la caña de azúcar integral para la alimentación de ganado. En forma muy resumida se presentan a continuación los principales aspectos estudiados:

3.1 Generalidades

La caña de azúcar es una planta rica en carbohidratos (68 por ciento B.S.) pero pobre en

proteínas (3 por ciento). La disgestibilidad de la caña integral se encuentra alrededor del 60 por ciento, lo que la coloca como un forraje de regular calidad, el cual debe ser suplementado adecuadamente con proteínas sobrepasantes, urea y minerales para mejorar la respuesta animal.

La corteza, parte supuestamente menos digerible no causa efectos negativos sobre el consumo voluntario y comportamiento animal, (Preston et al 1976) pudiendo ser suministrada picada integralmente, no siendo importante el tamaño de picado el que puede variar entre 3–30 mm.

3.2 Efecto de la suplementación proteica

Este efecto ha sido estudiado principalmente con animales que recibían dietas basadas en caña de azúcar en lote seco; la respuesta al suplemento proteico variará de acuerdo al tipo y cantidad de éste (Cuadro 1). Las mejores respuestas encontradas han sido con la pulidura de arroz en la estación seca, este efecto es bien marcado ya que la caña de azúcar es deficiente en proteína y la suplementación exclusiva con NNP (urea) sólo lleva a niveles de mantenimiento o ganancias pobres alrededor de 100 g/día, pero con la adición de pequeñas cantidades del suplemento proteico se obtiene una respuesta significativa en consumo y aumentos de peso.

Con vacas lactantes del tipo "Doble Propósito" se ha reportado que bajo sistemas basados en caña, el óptimo de pulidura de arroz se encuentra alrededor de los niveles de 2 kg/vaca/día para soportar producciones de leche total de 6 a 8 lt diarios, mayores niveles de producción de 9.5 lt/día de leche vendible han sido reportados por Rivera (1977), con la adición de 4 kg de concentrado con 22 por ciento de P.B. Una de las plantas utilizadas con más éxito como suplemento proteico ha sido la Leucaena leucocephala sembrada en áreas compactas; el

pastoreo de 3 horas por día ha sustituído hasta el 75 por ciento de la pulidura de arroz utilizada (Alvarez et al 1978).

3.3 Uso del NNP (urea) en dietas de caña

3.3.1 Efecto del nivel de urea

El alto contenido de azúcares fermentables presentes en la caña madura, permite la sustitución eficiente de la proteína hasta niveles de alrededor de un 70 por ciento por nitrógeno no proteico proveniente de la urea, sin observarse problemas de toxicidad y encontrando respuesta en el comportamiento animal (Alvarez y Preston 1976), éste sin duda es un punto importante debido al alto costo de las proteínas y al relativamente bajo del nitrógeno en forma de urea.

Con vacas lecheras un efecto similar fue reportado por Aranda (1977) cuando se incrementó la urea en la ración de 70 a 210 g/v/d en una dieta basada en caña integral más 3 kg de concentrado proteico logrando un incremento en la producción de leche vendible de 6.3 a 7 lt/vaca/día.

3.3.2 Forma de suministrar la urea

En los primeros trabajos realizados con caña en México, la urea siempre se proporcionó en solución con agua y melaza (22 por ciento de urea).

Posteriormente en un estudio de Alvarez et al (1976), se demostró que la melaza podría ser eliminada de la dieta como vehículo para la urea y que la urea podría ser proporcionada en solución con agua, rociándola sobre la caña sin afectar el comportamiento animal (Cuadro 2).

En las diferentes pruebas reportadas, se encontró un óptimo de 10 g de urea/kg de caña fresca, también se reportaron ventajas en proporcionar la urea en solución con la melaza al 10 por ciento cuando baja la calidad de la caña o el abastecimiento de caña es irregular.

3.4 Efecto de la madurez de la caña

La madurez de la caña es un factor importante a considerar cuando se alimenta ganado, ya que la madurez está relacionada directamente con el contenido de azúcares y éstos con la respuesta animal. Las mejores ganancias en peso vivo que han sido reportadas se relacionan con animales que han sido alimentados con caña madura principalmente en la época seca, (Alvarez y Preston 1976).

3.5 Efecto de la punta de caña

Las puntas de caña también juegan un papel importante en las dietas a base de caña de azúcar, ya que en principio éstas representan de un 20–30 por ciento de la planta entera y tienen un efecto positivo como fibras largas de alta calidad sobre el consumo voluntario y el comportamiento animal sobre todo cuando éstas son verdes y frescas. Este efecto fue estudiado por (Ferreiro y Preston 1976).

Con las mayores proporciones de puntas de caña se obtuvieron las majores ganancias en peso vivo aún cuando la conversión tendió a empeorar (Cuadro 3). Esto muestra el potencial que las puntas podrían tener en la alimentación animal en zonas aledañas a donde se cultiva la caña.

3.6 Suplementación mineral

La caña es deficiente en fósforo y azufre principalmente, por lo que estos elementos deben ser incluídos en la dieta, así como los demás elementos necesarios para evitar una posible

deficiencia; el fósforo puede ser suplido por roca fosfórica, fosfato de calcio o cualquier otra fuente disponible de P. El azufre fue suministrado con éxito en forma de sulfato de amonio al nivel de 1 g/kg de caña fresca; para llenar los requerimientos de azufre; la adición de azufre provocó una mejora del 33 por ciento en el comportamiento y conversión animal, sobre todo en los animales que recibieron niveles moderados de suplementos proteicos (Ferreiro et al 1977).

3.7 Uso de la caña ensilada

Al ensilar la caña picada es conveniente considerar que el resultado será un ensilaje con menores proporciones de azúcares ya que estos serán en gran parte transformados a otros productos que pueden tener un menor valor nutritivo. En el silo de caña se presenta una rápida reducción en el PH por el alto contenido de azúcares solubles, que crean un substrato ideal para el crecimiento de levacuras y consecuentemente un alto contenido de alcohol y poco ácido lactico,lo que afecta la calidad del silo. El uso de aditivos como el amoníaco, urea, hidróxido de sodio, han sido utilizados para reducir las pérdidas del ensilaje y mejorar el comportamiento animal (Alvarez et al 1977).

3.8 Jugo de caña para la engorda de bovinos y cerdos

Los primeros trabajos realizados en México con el jugo de caña para la engorda de bovinos fueron reportados por Sánchez y Preston (1980) quienes encontraron que el jugo de la caña de azúcar como base de una ración de engorda de toros suplementados con fibra, permitían ganancias de 800 a 1.300 g/d tanto en toros que no recibían suplemento proteico y aquellos que recibían 1 kg/día de pasta de girasol. Estos aumentos han sido los más altos reportados en el comportamiento de toros alimentados con caña y sus subproductos en México.

Estos datos fueron confirmados posteriormente por Duarte et al en 1982 quien reportó

ganancias entre 850 y 1.050 g/novillo/ día en animales con una dieta similar y harina de pescado como suplemento proteico. Sin embargo, se encontraron algunos problemas de toxicidad similares a los reportados para las dietas basadas en melaza y las investigaciones en esta área no se han confirmado.

Mena y colaboradores en 1981 utilizaron el jugo de caña para la engorda de cerdos desde un peso de 40 kg, reportando ganancias entre los 614 y 776 g/cerdo/día, logrando substituír totalmente el sorgo, además que reportaron ciertas ventajas económicas y nutricionales, en lo que se refiere a las características de la canal comparada con las dietas tradicionales de granos.

3.9 Limitantes encontradas al uso de caña integral

La principal se relaciona con el bajo contenido de carbohidratos que se observa en la caña inmadura y en la estación de lluvias, lo que reduce la respuesta animal; la utilización durante esta época no ha resultado conveniente, ni práctica, ni económicamente ya que adicionalmente se requieren mayores inversiones en construcciones para mantener animales en confinamiento durante la estación lluviosa del año y además que se dificulta la cosecha de la caña en campo.

El uso de la caña no se ha justificado en la época de lluvias, que es cuando el pasto normalmente crece en abundancia y resulta difícil competir en costos con este sistema. El suministro de caña como complemento al pasto, no mejora el comportamiento animal y solo se logrará incrementar la carga animal (Medellín y Alvarez 1978).

4. USO COMERCIAL DE LA CAÑA DE AZUCAR Y SUBPRODUCTOS EN MEXICO

Actualmente el principal papel que desempeña la caña ha sido como forraje de emergencia durante la estación seca del año al disminuír la disponibilidad y calidad del pasto en los

sistemas de pastoreo. La caña se siembra en pequeñas áreas del rancho, es cortada, picada y suministrada al ganado en el momento que se requira. Es en esta época donde se juega un papel determinante, ya que es cuando alcanza su mayor concentración de azúcares y permanece "almacenada" en el campo para ser utilizada en el momento apropiado. La característica de tener un solo corte al año y no perder su calidad como la mayoría de las gramíneas, la hace ideal para estos sistemas. Su uso en engordes comerciales es restringido debido a que existen sistemas menos costosos.

La principal razón por la que la caña no se ha difundido en mayor escala, se deriva del bajo precio al que se obtiene la melaza y a su facilidad de uso, ya que no requiere procesamientos adicionales, por lo que se ha difundido ampliamente y es común observar depósitos de melaza en muchos ranchos ganaderos, así como algunos cebaderos comerciales que utilizan importantes volúmenes de melaza, sobre todo cerca de los ingenios azucareros.

5. PERSPECTIVAS DEL USO DE LA CAÑA Y SUS SUBPRODUCTOS

Debido a la actual crisis económica resulta cada vez más difícil la importación de granos para la alimentación de ganado, principalmente cerdos y aves, por lo que se espera un futuro promisiorio en el uso de la caña, jugo de caña, melaza y otros subproductos, que podrían desempeñar un papel fundamental como substitutos de los granos, para lo que ya existe la tecnología disponible que podría ser aplicada en forma demostrativa a nivel comercial para ir venciendo gradualmente la resistencia al cambio de los productores.

También la ganadería pasa por una situación difícil, ya que los precios para la carne y la leche se han visto incrementados muy por abajo del índice inflacionario; este fenómeno también ha afectado grandemente el poder adquisitivo de la población, por lo que se observa una drástica depresión en el consumo de estos productos.

Los sistemas que más se han visto afectados son los que dependen de granos y concentrados, que han registrado fuertes incrementos en precios, lo que ha descapitalizado a los productores que dependen de ellos y está sacando del mercado a los menos eficientes.

Por esta razón, las empresas ganaderas que menos dependan de la compra de insumos, serán las menos afectadas, por lo que ésta crisis será un factor favorable en el sentido de que se tendrán que desarrollar sistemas más apropiados para el trópico y sin duda la caña de azúcar y sus subproductos tendrán mucho que aportar en México.

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Cuadro 1: Comportamiento de novillos alimentados con dietas basadas en caña de azucar con y sin varios suplementos comerciales

Suplemento	Ganacia peso (g/d)	Indice 1	No. de pruebas

1 kg. pulidura de arroz	559 – 896	1,90 – 2,60(8)	8
1 kg. maiz molido	296 – 600	2,05 – 2,32	2
1 kg. sorgo	308 – 437	-	1
.5 kg. H algodon	291 – 402	-	1
.4 kg. H sangre	92 – 432	1,90 – 2,01	2
.7 kg. pescado/soya	333 – 669	1,93 – 2,17	1
Sin suplemento	37 – 225	1,46 – 2,19	6

1 Consumo de MS en kg/100 kg de peso vivo

Cuadro 2: Comportamiento de novillos para diferentes metodos de suplementar la urea en dietas de caña (Alvarez et al., 1976) [1]

			Caña + melaza/urea
	Caña/urea	**Separada**	**Mezciada**
No. de animales	10	10	10
Ganancias, g/d	795	801	833
Consumo MS total	6,27	6,95	6,96
Conversión[2]	7,97	8,47	8,25
N × 6.25 en la dieta. % DM	13,05	12,56	13,67
N de urea, %	66,1	56,2	58,4

1 112 dias de prueba y 1 kg pulidura
2 Consumo de MS/ganancias en peso vivo

Cuadro 3: Comportamiento de novillos alimentados con diferentes proporciones de tallo y punta

(Ferreiro y Preston, 1976)

	Puntas: Tallo (Base fresca)					
	0:100	20:80	40:50	60:40	80:20	100:00
No. animales	10	10	10	10	10	10
Ganancia diaria, - g/d	605	614	699	760	789	839
Consumo MS total	4,52	4,66	6,49	6,40	6,76	7,50
1Indice de consumo	1,7	2,2	2,1	2,6	2,3	2,6
2Conversión	7,47	7,59	9,28	8,35	8,57	8,94

1 Consumo de MS/100 kg de peso vivo

2 Consumo de MS/ganancia diaria

EXPERIENCES WITH WHOLE SUGARCANE IN RUMINANT FEEDING IN MEXICO

by

F.J. Alvarez Flores

The use of whole sugarcane and its by-products in animal feeding has increased since 1974. Much work was done in Mexico on the following aspects: types of treatment, digestibility, metabolism, effect of the maturity of the cane, protein supplementation, use of NPN, mineral supplementation, effect of sugarcane tops, use of protein-rich forages, and ensiling. The studies mostly focussed on milk and meat production in double purpose systems.

The liveweight gains in steers fluctuated in the different trials between 300 and 900 g per day, on a diet of whole sugarcane and a moderate supplementation. On commercial farms sugarcane was used as a strategic forage in the dry season, improving the animals productivity and preventing overgrazing of the pastures.

Molasses was in competition with sugarcane because of its low price in Mexico (US$ 27.00/ton) and the facility to use it, specially around the sugar factories where transport costs are low.

Due to the necessity of the livestock holders to reduce external acquisitions, to decrease the costs and to improve efficiency, the use of sugarcane as dry season forage will play an even bigger role in the future.

EXPERIENCES WITH WHOLE SUGARCANE FEEDING IN TRINIDAD AND TOBAGO

by

F.A. Neckles

INTRODUCTION

The Sugarcane Feeds Centre was established in 1976 to demonstrate the technical feasibility and economic viability of cattle production systems utilizing sugarcane as the major ration ingredient. For the first five years, it was jointly sponsored by the Canadian International Development Agency and the Government of the Republic of Trinidad and Tobago. Since October 1981, the latter has been solely responsible for the Centre's funding, operation and technical direction. There are two aspects to the Centre's work. The technical aspect is the interrelationship between animals, soils, crops and feeding. The non-technical aspect is the effort to translate the technical work into wider application - the environmental and economic

factors, and the programmes and policies which facilitate, or hinder, development activity. The experience of sugarcane feeding in Trinidad and Tobago is provided from both aspects.

THE CENTRE'S PRODUCTION SYSTEM

The Centre has a total population of over 750 head of dairy and beef cattle, water buffalo (Bubalus bubalis) sheep and goats, and produces over 300 head annually. Approximately 3 500 animals (the majority Holstein-type week-old calves from the local dairy industry), have been obtained and reared from 1977 to the present time. The animal operations consist of a calf rearing unit, a cattle growth unit with males destined for beef and females for breeding, a small dairy and a small ruminant multiplication and fattening unit with about 40 breeding females. Crop operations are concerned with the growing of sugarcane and Leucaena leucocephala.

Features of the soil on which the Centre is located are lack of structure, impeded drainage, low organic matter and plant nutrient status, low pH (3.5 to 4.5) and high aluminium content. The soil, an acid ultisol, not previously in agricultural use, dries out rapidly in the dry season and quickly puddles in the wet. Three factors made it productive - the use of limestone and inorganic fertilizers at first planting, the establishment of a subsurface drainage system and the use of manure irrigation. This last factor is the most important. The manure washings from the feedlot are collected in ponds and applied to the cultivation through underground mains and a travelling sprinkler gun. The sugarcane cultivar used is B 41227, the main one of the local sugar industry. Total fresh weight yields obtained are in excess of 80 tonnes per hectare on average (Table 1).

Trinidad and Tobago experiences marked dry and wet seasons. In 1985 rainfall at the Centre was approximately 200 cm with 25 cm falling between January and May. Year-round harvesting of sugarcane is undesirable for several reasons. In the wet season brix and dry matter content

are lowered and ability to use equipment is reduced, which increases cost. Trafficking compacts the soil and destroys the cultivations. There is also the prospect of soil contamination of the harvested crop. Daily harvesting is also affected by weather conditions which may lead to insecurity of feed supply.

Since 1983 a Hesston 2 000 corn forage harvester has been modified and used for the in-field harvest of standing sugarcane for silage making. A harvest rate of 4 – 6 tonnes per hour is achieved which depends on the size and shape of field, thrash content, burning or non-burning of the cane and ground conditions. No additives are used at ensiling. The chopped cane is compacted, covered and allowed to ferment. The brix of cane silage is lower (by 33 percent or more) compared to the crop at harvest but is comparable to that of freshly harvested sugarcane in the wet season. Annually six to seven hundred tonnes are ensiled in above ground horizontal silos.

Silage making in 1984 reduced the estimated cost of sugarcane at the feed trough by approximately 30 percent to US cents 14.6 per kg DM through reduction of labour-time and handling. Ensilage makes year-round use of sugarcane for larger scale zero-grazing cattle production more operationally convenient. The cost of sugarcane for animal feeding depends on how efficiently it is grown and the yield obtained. This important point is often overlooked.

FACTORS IMPORTANT TO THE USE OF SUGARCANE

The chemical composition of the whole sugarcane grown at the Centre is given in Table 2. Feeding of sugarcane takes into account sugarcane's high fibre, low crude protein content and energy content (2.7 Mcal per kg DM - Donefer and Latrille, 1979).

In the 1960s and 1970s several workers reviewed the need for the feeding of supplements and

the nutritional issues involved. Based on previous work and the Centre's experiences in maintaining a year-round production-oriented facility certain feeding practices have been developed. These practices are geared toward meeting the needs of animals and sustaining acceptable levels of performance. Factors influencing the feeding strategy are briefly discussed below.

STAGE OF LIFE OF THE ANIMAL

Under the Centre's standard calf rearing system, animals are individually fed limited quantities of milk replacer and a calf starter ad libitum with weaning at 35 days of age. Fresh chopped sugarcane is offered after weaning up to a level of 20 percent of the diet DM. Over the next 35 days of age, ADG consistently averages 0.45 kg. After 70 days of age calves are then reared in groups. Since feeder calves of 170 to 200 kg liveweight typically available to a beef industry are unobtainable, these artificially reared expensive dairy calves have to be brought to this weight as quickly as possible to secure an economic feedlot throughput.

Up until 1981 sugarcane was fed at the level of 40 percent of the diet DM after 70 days of age. From 1982, in various feeding trials, the level has ranged from 5 to 30 percent depending on the other ingredients of the diet. Presently the ADG obtained at the lower levels of sugarcane ranges from 0.70 to 0.90 kg compared to the previously obtained 0.40 to 0.50 kg. As animals grow and develop their ruminant status, increasing levels of sugarcane are included in the diet.

The first lifetime feeding trial utilizing 10-month old calves averaging 160 kg liveweight was started in April 1982 and lasted nearly one year. It compared the effects of energy supplementation using rice at 0, 5 and 10 percent DM levels in 50 percent sugarcane diets. Molasses with a maize-soyabean based supplement containing non-protein nitrogen (NPN) made up the rest of the diet. Average daily gains of 0.42, 0.60 and 0.63 kg were obtained.

Evaluation of feed conversion efficiency, income over feed costs and slaughter data was done. A nutritional model for feeding sugarcane Life Cycle Feeding was proposed by Garcia, Neckles and Benn (1982) based on this and other work. In this model, initially smaller quantities of sugarcane in the diet DM are offered to animals in the lower liveweight ranges which increases to approximately 50 percent of the diet DM for the higher liveweights (see section on dietary fibre, energy and protein levels below).

COMPOSITION OF NON-SUGARCANE INGREDIENTS

Sugarcane has been fed with a wide varety of both energy and protein supplements with varying results. The chemical composition of these non-sugarcane ingredients is important. For economic and national development reasons, supplements utilized with sugarcane have shifted as far as is feasible from the standard soyabean meal and maize which were available only through importation and relatively expensively. Being low fibre, high energy or protein sources, the maize and soyabean were conducive to feeding higher sugarcane levels in the total diet. When replacements were sought few direct substitutions were possible with the exception of broken rice/end bits for maize. Generally the available substitute sources of protein or energy (e.g. poultry byproduct meal (PBM), dried citrus pulp, wet spent brewer's grains, rice polishings, wheat middlings, dried Leucaena forage, etc.) while lower in costs are all of different composition and feeding value of the standards (maize and soyabean meal). Introduction of the local substitutes into the diets generally increases fibre and lowers the energy and/or protein per unit of substitution. Presently NPN is not utilized to any extent in the sugarcane feeding done at the Centre. Previously, it had been fed to growing animals over 150 kg liveweight, contributing about 30 – 35 percent of the total calculated crude protein in the diet. In 1982, urea was fed to calves under 100 kg liveweight and while contributing 20 percent of the total protein resulted in ADG of 0.63, 0.65 and 0.75 kg for sugarcane levels of 40, 30 or 20 percent, respectively. The diets were 20, 30 or 40 percent for broken rice/end bits,

respectively (SFC, 1982). It was considered that NPN use however, depends on the presence of high levels of digestible energy and that this is not generally compatible with use of the substitute energy sources available and high to medium levels of sugarcane in the diet DM.

TOTAL DIETARY FIBRE, PROTEIN AND ENERGY LEVELS

The National Research Council of the USA feeding standards are used in the formulation of diets which are designed to meet the requirements for crude protein and digestible energy for the stage of life and production of the animal. Table 3 is used to illustrate changing sugarcane-molasses levels in the diet of lactating cattle fed by stage of lactation. This example does not contain NPN. Up to 20 percent of the total protein has been supplied by NPN in dairy diets, however.

The feeding strategy makes use of more efficient feed conversion obtained in young growing stock compared to animals approaching mature weights. Diets fed to animals up to 150–200 kg liveweight are designed to be low in ADF and high in energy and protein. This means low levels of sugarcane since byproducts are combined with soyabean meal and maize in the diet. Table 4 shows the diet composition and the results obtained after 56 days of feeding. These results are typical of those obtained with other combinations at lower level sugarcane feeding, i.e. up to 30 percent sugarcane in the diet DM.

In the latter part of the animal's feeding cycle, sugarcane level also exerts influence on the characteristics of the carcass obtained. Between 1980 and 1983 carcass information was collected from animals fed different levels of sugarcans. Table 5 presents a partial summary for the Holstein-type animal. The trend is that finishing animals on high energy, low sugarcane diets resulted in lower dressing out percentages due to increased trimmable fat (the local market discriminates against fat). Rib-eye areas taken after the 12th rib generally increased

with increasing sugarcane level in the diet. This was another factor which led to the emphasis on high growth rates in early life on low sugarcane diets in preference to high grain-low sugarcane “finishing” diets.

The model for utilizing sugarcane in feed for ruminants either for beef or milk production is based on the relationship that as the percentage of sugarcane in the diet is increased, average daily weight gain decreased (Pate, 1981), and milk production of crossbred Holstein of the Centre also decreased according to the relation: $y = -0.13x + 16.35$ ($r=0.92$) (SFC 1983).

THE IMPACT OF THE CENTRE

The Centre has been working with farmers continuously since its inception. Most of the work has been with small producers on 5–8 ha farms established by the State. Farmers have improved their feeding practices, management and animal rearing through contact with the Centre. A study of the Department of Agricultural Extension, University of the West Indies, evaluated seven farms and found that their feeding practices were reversed over the years. Where formerly feeding was in the proportion 68:32 percent bagged concentrate to grass, sugarcane, molasses and byproducts, this was changed to 35:65 percent, respectively, after involvement with the Centre (Dolly and Reid, 1986). The largest producer utilizing sugarcane to feed up to 100 head closed the operation in 1984 due to the inability to market animals and increases in feed prices. Another producer with a beef feedlot as part of a productive dairy enterprise eventually closed the feedlot, again for want of a market.

The Government-owned sugar industry is an important source of foreign exchange, earning US$ 96 million in 1986. Production of raw sugar was approximately 92 000 tonnes from approximately 35 000 ha. Since costs of production are high the industry receives an annual subsidy of approximately US$ 80 million. The subsidy is less sustainable under current

economic conditions and the Company is attempting to increase efficiency of sugar production while diversifying over a ten-year period into production of rice, citrus, coffee, cassava, pigeon peas and other crops on 4 000 ha. Plans are to utilize 1 000 ha for milk and beef production. The Company already owns about 600 head of water buffalo selected and developed over the past 30 years for beef production and a 250 head dairy based on Holstein-type animals. It has not yet committed itself to sugarcane use as a feed but has switched toward feeding of byproducts. The Centre has proposed that a livestock complex integrating sugarcane production, other crop growing and processing, byproduct feed utilization, milk and meat processing, be established as part of the diversification exercise. This will provide economics of scale. Suitable technology should also be supplied for the development of existing small farms.

PROSPECTS FOR THE FUTURE

The philosophy of the Centre is that ruminants should be fed as far as possible from local feed resources which should arise from increased agricultural activity aimed primarily at food for human consumption. With production and processing the quantity and range of byproducts available for animal feed will increase. Integration of production must occur at the farm level and at the sector level as exemplified by the Centre's programmes and at the national level. Proper marketing with fuller utilization of animal carcasses is also necessary. Collaboration between the Centre and another state institution, geared towards swine slaughter and processing has resulted in the successful marketing of chilled beef. The full value of the animal is still to be obtained since all inedible products are rendered. A modern slaughter facility would make fuller use of the animal. Animal production is often discussed in terms of feeding, weight gain, management, etc. and proper marketing is often overlooked. In Trinidad and Tobago the previous policy of unrestricted imports was changed in 1986 and attention is now being given to marketing at the national level. The Centre's role is not only to demonstrate the

use of sugarcaneas a feed but also to influence those who make policy for agricultural development.

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Table 1: Fresh and dry matter whole plant yield, brix and physical composition of sugarcane, January

1986

No. of fields	Tonnes/ha		Brix	DM Physical composition		
	Fresh	DM		Leaf	Stem	Trash
6	88,5	26,6	18,9	17,5	71,3	11,2

Table 2: Chemical composition of sugarcane variety B 41227 on a DM basis

% DM	% Ash	% NDF	% ADF	%CP
27.5	6.5	61.9	40.1	3.3

Table 3: Sugarcane-molasses Levels and calculated composition of diets using mainly local byproduct ingredients fed to lactating cows

Stage of Lactation (weeks)		1–10	11–20	>20
% DM basis-	sugarcane	17	23	28
	molasses	10	17	23
	other ingredients	73	60	48
Calculated composition -				
	% CP	18,0	15,6	13,0
	DE(Mcal/kg DM)	3,3	3,2	3,1
	% ADF	21,3	20,0	20,5

Table 4: Diet composition and performance of growing cattle under 200 kg liveweight in 1986

No. of animals	82	69
Weight range (kg)	60 – 100	100 – 175
Diet composition -		

Sugarcane	7	10
Molasses	12	13
C. pulp/PBM/W. midd.	28	43
Maize/SBM	52	33
Minerals	1	1
Calculated composition		
% CP	16,7	14,5
DE (MCals/kg DM)	3,7	3,6
Cost/kg DM (US Cents)	14,2	12,5
Animal performance		
ADG (kg/day)	0,77	0,92
FCE (kg DMI/kg ADG)	3,6	4,9

Table 5: Liveweight, dressing percentage, rib-eye area of Holstein-type steers related to levels of sugarcane in the diet

Level of cane in diet DM		**Liveweight (kg)**	
%	**Item**	**350 – 400**	**401 – 450**
20	No.	18	8
	Lwt.	387 ± 11	430 ±16
	DP %	51 ± 3	52 ± 2
	RE cm^2	62 ± 14	70 ± 14
30	No.	2	6
	Lwt.	388 ± 11	420 ± 17
	DP %	52 ± 1	53 ± 5

	RE cm^2	70 ± 26	82 ± 29
40	No.	7	5
	Lwt.	377 ± 10	431 ± 10
	DP %	51 ± 3	59 ± 8
	RE cm^2	59 ± 10	78 ± 6
50	No.	7	3
	Lwt.	395 ± 5	426 ± 21
	DP %	55 ± 3	58 ± 1
	RE cm^2	78 ± 14	86 ± 3

EXPERIENCIA EN EL USO DE LA CAÑA INTEGRAL EN ALIMENTACION ANIMAL EN TRINIDAD Y TABAGO

por

F.A. Neckles

El Centro de piensos a base de caña de azúcar, establecido para demostrar la viabilidad técnica y económica de la caña en la producción de carne de vacuno y de leche, mantiene a más de 750 rumiantes (vacas lecheras y de engorde, búfalos de la India, ovejas y cabras) en un sistema intensivo sin pasto. Dos características importantes del sistema de producción de cultivos para el ganado son la utilización de estiércol en el cultivo de la caña y la recolección mecánica durante la estación seca para la producción de ensilaje.

Las estrategias de alimentación animal entrañan la optimización de la proporción de caña en la materia seca de la dieta con arreglo a (i) la etapa de la vida del animal, (ii) la composición de los ingredientes del pienso distintos de la caña de azúcar, (iii) el suministro diario total de fibra,

proteínas y energía en relación con el rendimiento requerido de los animales, (iv) la eficiencia de transformación de los piensos, y (v) las características de la canal. Después de realizar un análisis de la relación costos-rendimientos, la dieta se basó en productos y subproductos locales de la agricultura y las industrias agrarias. El trabajo con los agricultores ha tendido a desarrollar la capacidad de gestión y técnica, que son condiciones importantes para una producción intensiva exitosa. Las importaciones de carne y leche son considerables, pero la limitada capacidad para elaborar y comercializar la producción local dificulta el desarrollo.

Las propuestas relativas a la diversificación de la industria del azúcar ofrecen posibilidades para sistemas de producción agropecuaria en mayor escala cuando puedan movilizarse los recursos técnicos, financieros, de comercialización y de otro tipo necesarios. Se promueve la alimentación del ganado a base de caña en el marco de un esfuerzo de producción agrícola integrada.

CASE STUDY - PROSPECTS FOR RECONVERSION OF SUGARCANE INTO ANIMAL FEEDS IN THE PHILIPPINES

E.T. Baconawa

I. INTRODUCTION

The Philippine sugar industry, the country's oldest and leading export earner, is a very important sector of the economy. Average sugarcane production over the past five years was 23 million metric tons which yielded 2 243 700 metric tons of sugar from about 411 000 ha planted to sugarcane (Philippine Sugar Commission, 1985).

Over the years, the industry has kept the country self-sufficient in sugar with a large surplus for export. Moreover, the industry provides jobs for close to a million sugar workers and supports a big dependent sector estimated at 4.5 million people. In 1984, the contribution of the sugar industry to the GVA in the agriculture sector accounted for about 8 percent and its contribution to the GDP accounted for 2.0 percent. Sugar export accounts for an average of 6 percent of total export earnings (National Economic and Development Authority, 1985).

Today, roughly 10 percent of Philippine sugar is exported to the USA, and 40 percent to the world free market. The remaining 50 percent is for domestic use (National Economic and Development Authority, 1985).

Annual production of cane tops and molasses, estimated at 4.70 million metric tons and 916 000 metric tons, respectively, provides a substantial supply of feed materials for the livestock industry. Annual bagasse production output at 6.45 million metric tons provides fuel for the sugar mills and is a potential feed for livestock.

However, since the oil crisis in the early 1970s, the sugar industry has faced several reversals, the most serious of which occurred during the early 1980s when sugar prices plummetted from US 27 cents a pound in 1980 to US 3.5 cents a pound in 1983.

Faced with multifarious problems such as surplus production, low productivity, prohibitive costs of inputs like fertilizers, high costs of wages and capital, and low export market prices,

the industry faces a seemingly irreversible crisis. Since the start of the crisis, 3 out of 42 sugar mills have closed and many are moribund. Many planters have become bankrupt and their sugarlands have been foreclosed by the banks. As a result, over 200 000 sugar workers have lost their jobs. Today, the living conditions and the peace and order situation in the sugar-producing areas, especially in Western and Central Visayas, have greatly deteriorated.

II. IMPORTANT BYPRODUCTS OF THE PHILIPPINE SUGAR INDUSTRY AND ALTERNATIVE USES

Sugarcane molasses

Annual molasses production output has averaged about 916 000 metric tons. Of this, about 67 percent is exported, 17 percent is used by the distilleries, and 16 percent is for animal feed, etc. (National Economic and Development Authority, 1985).

Sugarcane bagasse

Bagasse production output averaged 6.45 million metric tons from 1980 to 1985. For many years, bagasse has been used mainly as fuel by sugar mills during milling seasons, but there is plenty of bagasse available that cannot be used as fuel. A small amount is used as feed, the surplus bagasse being left just to rot around the sugar mills (Rojas, 1985).

Sugarcane tops

During the past five years, estimated yearly cane top production output has been 4.7 million metric tons, with an average production of 11.5 tons per hectare.

Around sugar-producing areas, small farmers collect cane tops during milling seasons as feed for their cattle, carabaos, horses, goats and sheep. Among medium and large livestock raisers, the cane tops are chopped and fed to animals or ensiled for use during off-milling seasons.

III. PRESENT USES OF WHOLE SUGARCANE AND BYPRODUCTS FOR ANIMAL FEEDING

Whole sugarcane

Since the start of the sugar crisis, some sugar planters and millers began diversifying into other crops and integrating livestock. This has been the practice since the early 1960s when sugar prices were fluctuating. But the use of whole sugarcane as feed began in the early 1980s, and this is now common in Luzon and Visayas.

In Dasmarinas, Cavite, some 50 km south of Manila, Monterey Farms, a large livestock company with about 18 000 beef and dairy cattle and some 50 000 pigs in different parts of the country, have been feeding chopped whole sugarcane to feeders and dairy cattle. Over 600 crossbred dairy cows (Brahman × Holstein-Friesian) are fed whole sugarcane about half of the year from a 40-hectare sugarcane plantation. A hectare of 10–12 month-old sugarcane fertilized by animal manure produces 75–80 metric tons of whole sugarcane which is fed to the cattle. The cane field is allowed to ratoon once or twice.

A few years ago, the farm ensiled whole sugarcane and is still using the silage today. During summer, 60 percent of the bulk feed for dairy animals consists of chopped whole sugarcane, the other 40 percent consists of chopped napier grass. The combined volume of sugarcane and napier being fed to the dairy cows is 15–20 kg/animal. In addition, 10–15 kg of fresh brewer's grains are given to the milking animal.

Average production of the crossbred dairy cows is 8.5 kg of milk/day during a lactation period of about 260 days. Among selected cows, average milk production is 15 litres. Here, the male

calves are raised for fattening purposes along with culled animals. Monterey Farms dairy project has been in operation for two years. So far the project is successful with an assured market for fresh milk at Magnolia Dairy Plant, the biggest ice-cream and liquid milk plant in the country.

At Canlubang Sugar Estate, Canlubang, Laguna, 50 km south of Manila, the sugar estate, one of the biggest planters and millers, is feeding chopped whole sugarcane to 200 crossbred Brahman and STa. Gertrudis calves and yearlings, with 5–10 kg fresh brewer's grains purchased from Beer Hausen's Brewery, some 20 km away, as supplement. These animals are raised for sale to feeders and breeders when they reach 120 kg liveweight or above.

Sugarcane tops

This is a very popular feed among small livestock raisers who have their farms around the vicinity of sugarcane plantations. During milling seasons, sugarcane planters allow small farmers to collect cane tops from the fields to feed their cattle, carabaos, goats and sheep.

Semi-commercial and commercial scale feeding of cane tops to cattle and carabaos is commonly practised in Western and Central Visayas, particularly in the Island of Negros (Negros Occidental and Negros Oriental) which is predominantly a sugarcane area. In this island alone, some 50 sugar planters are using cane tops as feed for their feeder and breeder cattle and carabaos, estimated at 7 500 cattle and 500 carabaos.

Sugarcane molasses

Molasses for animal feeding is commonly used by feedmillers who incorporate it in the compound feed for poultry, swine, cattle, goats and horses. The Bureau of Animal Industry, the government agency authorized by law to supervise feedmillers and feed dealers, recommends

the use of 4–5 percent molasses in the compound feed for various livestock species. At cattle feedlots, molasses is given freely to animals as a lick. Among work-horse owners in cities and towns, it is also a common practice to incorporate molasses in the feed for horses. During summer, when forage and pastures are scarce, rice straw is generally fed to cattle, carabaos, horses and goats. To make rice straw palatable and smell sweet to the animals, molasses is added to the straw at the rate of 8–10 percent of the weight of the straw (Baconawa, 1985).

Filter cake

Several attempts have been made to use some amounts of filter cake in feeding cattle and carabaos. However, the use of filter cake or mud press has not yet become popular with the farmers.

Sugarcane bagasse

Likewise, attempts have been made to use sugarcane bagasse for feeding animals, but the cost of treating or fermenting bagasse to make it suitable for feed has been the biggest problem.

IV. PERSPECTIVES FOR USE OF SUGARCANE BYPRODUCTS IN ANIMAL FEEDING VERSUS OTHER ALTERNATIVES

The serious problems attendant to the importation of yellow corn, soybean, fishmeal, and meat and bone meal for feed, and the foreign exchange requirements of importing feed ingredients have greatly affected small and medium livestock raisers in the countryside. Today, backyard poultry and pig raisers using compound feed have practically disappeared from the scene.

Use of whole sugarcane for feed

Feeding of chopped whole sugarcane is likely to become popular among livestock raisers feeding animals in confinement. The example of Monterey Farms who are feeding feeder cattle in three big farms where sugarcane has been planted not for milling purposes, but for feeding to cattle, has become an eye-opener to farmers, who are constantly faced with shortage of forage during summer.

Animal raisers are realizing that among graminae, the sugarcane plant is the most efficient as far as storing food energy is concerned. It does not need harvesting every 45 days like napier, guinea grass, etc. which have to be harvested while the leaves are young and succulent. In the case of sugarcane, the plant can store the nutrients in the cane up to a year or over. If allowed to grow up to 10–12 months in the field, it will yield more tonnage. Sugarcane may be harvested as it is needed for feed, and by chopping the whole sugarcane finely, it practically all becomes edible as feed. Being rich in sucrose content, sugarcane has a very high energy value compared to cultivated grasses like napier, guinea, etc.

As animal raisers continue to look for non-conventional feeds for livestock, Don Bosco Technical School for Boys in Victorias, Negros Occidental and Don Bosco Technical School in Canlubang, Laguna have institutionalized the fabrication of a sugarcane chopper. This is a useful factor in the efficient use of sugarcane as forage.

Sugarcane bagasse

The experimental feeding trial using treated cane bagasse for animal feeding at the Bureau of Animal Industry Non-Conventional Feed Development Project in Quezon City, Metro Manila some three years ago proved technically feasible. The use of chemicals for treating bagasse is expensive, but the use of enzyme or yeast has great promise. The scarcity of feedstuffs today may hasten the full use of fermented bagasse for feeding, both to monogastrics and

ruminants. The use of bagasse with molasses will increase the use of molasses.

A Japanese buyer representing Nippon Hi-Cel Co. Ltd. is interested in setting up a fermentation plant in the Philippines to process cane bagasse into feed. The buyer could pay US$ 100 per ton of bagasse. If realized, this venture will absorb all unused bagasse (Daily Bulletin, 1986).

Sugarcane molasses

The introduction of the urea-molasses block as a "lick" for ruminants in the country is likely to increase the use of molasses. Many farmers, using rice straw, corn cobs, etc. for feed, use molasses to increase the energy value and palatability of the feedstuffs.

Filter cake

The use of filter cake as a soil conditioner has become routine among sugar planters. Its use in the feed for cattle and carabaos has been tried by farmers but it has not become popular. The cost of transport from the mill to the farm is high. Even if the planters want to use the filter cake, they have to buy it from the millers.

5. CONCLUSIONS AND RECOMMENDATIONS

A number of cattle raisers have already introduced sugarcane as forage for their cattle, instead of just depending on cogon (Imperata cylindrica Linn.) and other natural grasses. This appears to be the beginning of a breakthrough in the use of whole sugarcane. In Masbate, a cattle rancher has established a sugarcane plantation to feed and fatten his cattle during summer when fresh cogon and other grasses are scarce. Among smallholder farmers in Batangas province, feeding manually separated sugarcane to pigs when compound feed is scarce is another step toward the use of sugarcane as feed to monogastrics.

There is a great potential of feedstuffs available in the form of cane tops, bagasse and molasses. With the use of fermentation technology, the tremendous supply of these feedstuffs could feed millions of livestock in the country, cut down feed imports, and increase meat and milk production.

If the sugar industry is to recover from and survive the present crisis, it has to undertake some radical steps, mainly aimed to 1) reduce total land area planted to sugarcane, removing marginal areas, effecting production efficiency, and limiting production to demand for domestic and foreign export; 2) conduct sustained studies on costs and returns on growing and feeding sugarcane and its byproducts; 3) formulate least cost feed rations for various livestock species and classes with sugarcane and its byproducts 4) conduct research on crop diversification to determine the crops most suitable for inter-cropping, multi-cropping, crop rotation, etc.; 5) stimulate studies on integration of various livestock species most suitable for the use of sugarcane and 6) conduct continuing workshops on the results of such studies, and train technicians and farmers on the use of suitable and cheap feeding systems and feed formulations, using sugarcane and its byproducts as components.

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PERSPECTIVAS PARA LA UTILIZACION DE LA CAÑA DE AZUCAR COMO PIENSO EN FILIPINAS

por

E.T. Baconawa

La industria azucarera, que siempre ha sido el principal sector de exportación, es un elemento vital de la economía de Filipinas. Proporciona emleo casi a un millón de personas y tiene un importante sector dependiente de 4,5 millones de personas.

Los cogollos de caña y la melaza, cuya producción media anual se estima en 2, 72 millones y 900 000 toneladas, respectivamente, representan una enorme cantidad potencial de piensos para la industria pecuaria.

Después de la crisis del petróleo de comienzos del decenio de 1970, esta industria ha sufrido various retrocesos, el más grave de los cuales en los primeros años ochenta, cuando los precios del azúcar se hundieron, pasando de 27 centavos de dólar EE.UU. por libra en 1980 a 3,5 centavos en 1983.

Algunas fábricas de azúcar han cerrado, muchos propietarios de plantaciones y fabricantes de azúcar están registrando pérdidas, más de 100 000 hectáreas de plantaciones han sido sometidas a procedimiento de embargo por los bancos y más de 200 000 trabajadores han perdido su empleo en este sector. En consecuencia, las condiciones de vida y la paz social en las zonas productoras se ha deteriorado mucho.

Para que la industria azucarera pueda recuperarse de esta crisis y sobrevivir a ella, se han de

tomar medidas radicales, sobre todo con el fin de (1) reducir la superficie total dedicada a este cultivo, suprimiendo tierras marginales, lo cual permitiría aumentar la eficiencia y ajustar la producción a la demanda interna y de exportación; (2) realizar constantes estudios de los costos y los rendimientos del cultivo y la utilización de la caña de azúcar y sus subproductos como pienso; (3) preparar raciones de bajo costo para distintas especies y clases de ganado a base de caña de azúcar y sus subproductos; (4) realizar investigaciones sobre la diversificación de cultivos con el fin de determinar cuáles son los más apropiados para un régimen de cultivos intercalados, cultivos múltiples, rotación de cultívos, etc.; (5) promover la realización de estudios sobre la integración de diversas especies de ganado apropiadas para la industria del azúcar; y (6) celebrar periódicamente reuniones de trabajo sobre los resultados de tales estudios y capacitar a técnicos y a agricultores en la aplicación de sistemas de alimentación adecuados y baratos y en preparaciones de piensos, utilizando la caña de azúcar y sus subproductos como componentes.

CASE STUDY - BRAZIL SUGARCANE AS FEED

E.L. Caielli

1. Sugarcane production in Brazil

Sugarcane is grown on approximately 3.8 million hectares of land which represents only 0.76 percent of Brazil's arable land consisting of about 500 million hectares. The land actually used

is only 5.9 percent of these values. From this area, 125 million tons of cane were harvested in the 1985/86 season. Sugar and alcohol production were respectively 7.8 million tons and 11.9 billion litres. Of the total sugar production only 1.8 million tons are sold outside the country.

Sugarcane cultivation represents the third working force of the country with 1 700 000 employees. Since 1979 alcohol production has represented an investment of Brazilian capital equivalent to US$ 6 billion and has represented an economy of US$ 9 billion.

The harvesting plan for 1986/87 has established a production target of 8.5 million tons of sugar and about 11.7 billion litres of alcohol. Alcohol production is dependent upon political decisions. Two factors have disturbed alcohol producers: the return of oil prices to the level of 1973 and a long, dry season that reduced production and influenced this year's yield. Some views were that it was necessary to stop the National Alcohol Programme. However, on 27 February, during a visit of the President of Brazil to Ribeirao Preto, State of Sao Paulo, it was confirmed that the Programme would continue. It is commonly agreed that some changes should be made but the reduction in yield will give them time to decide.

2. Sugarcane by-products

The 125 million tons sugarcane harvest in the 85/86 season gave 17 million tons of tops, 31 million tons of bagasse, 5 million tons of filter cake, about 5 million tons of molasses, 75 billion tons of stillage and 140 thousand tons of dried yeast.

Sugarcane tops are, in almost their totality, left in the field. In special situations they are used for feeding animals.

Fifty percent of the bagasse produced is burned for steam production. Some is burned for the production of electricity. From the remaining bagasse, about 100 thousand tons are used in the

paper industry and about 140 thousand tons in furfural production which has a very large industrial application. Small amounts are used as a crop mulch and for animal feeding. In 1985 the southeast area had an unusual drought during the months of October to December, so emergency feeding for the animals on pastures consisted in low quality roughages (including bagasse) with the addition of urea plus oil cake proteins to cover the lack of green forages.

Filter cake has a very large variation in its chemical composition so it is difficult to recommend it for any specific use. Its final use is as fertilizer in sugarcane crops.

From 1979 to 1985 molasses has almost disappeared as an animal feed being partly exported and partly transformed into alcohol.

Stillage no longer causes problems for producers and consumers. Actually it is almost entirely used as a fertilizer, at least as a good source of K and water, increasing the sugarcane yield from 8 to 10 percent. After fermenting a batch of sugarcane juice, using the Mellet-Boinot process, some yeast milk is taken off giving about 40 g of dry matter per litre of alcohol.

3. The use of sugarcane and byproducts in animal feeding

The real amount of whole sugarcane given to domestic animals in the country is not known but it has certainly been widely used as green chopped forage in the majority of low production (less than 10 kg/cow/day) milking farms. A recent survey (1983) in a very representative area of milk production, the county of Campinas, in the State of Sao Paulo, showed that 70 percent of the farms have sugarcane as green stock. They cover 1.3 ha in an average area of 123 ha. The amount given, per animal, per day, on average is 14 kg (from 9.9 to 17.6). Whole sugarcane in some cases is given with cotton seed meal or soybean meal, raising protein levels to 11–12 percent (dry basis) which gives a daily gain of 0.7 to 0.8 kg. Lower gains have been obtained

when urea, sulphur and rice polishings are given instead of oil cake protein.

Sugarcane tops in spite of their large availability are not commonly used and in fact are only used in very specific situations. One of the factors that limits their use is the collecting cost from the field after harvesting the sugarcane. Left on the soil when manually cut the mineral matter increases if the sugarcane tops are not properly managed. The common practice of burning the crop reduces production and the time available to transport them from the field without changing their composition. Burned sugarcane tops, plus soybean straw without pods are two kinds of residues found together in some areas of the State of Sao Paulo. Consumption of 6.6 kg dry matter composed of 2.6 kg of burned sugarcane tops and 4.0 kg of soybean straw is enough to maintain the liveweight of 350 kg steers during the dry season.

Raw bagasse has been introduced in many situations as emergency feed. Diets including 30 percent of raw bagasse (± 50 percent dry matter) given to Nelore cattle and buffaloes were consumed in growing amounts in relation to time. Treatments with ammonia, sodium hydroxide and steam cooking have actually been tested in several places with variable results. Of these treatments, steam cooking seems to be the one that has a more promising application in the future. Currently more than 5 000 head of cattle are fed with one type of steam treatment representing about 50 percent of the daily dry matter consumption. There are still several questions to be answered before the release of the technique. Some of the equipment used for steam treatment does not have good control of temperature and time, so it is very difficult to know what are the real working conditions. It is well known that small variations in these parameters can change considerably the digestibility and probably the consumption of the steam treated bagasse.

Molasses was largely used before 1975 and it seems that, if no big changes occur in the oil price, it will again be available for animal feeding.

Dried yeast tested as a protein source for ruminants, totally substituted cotton seed and soybean meal for beef and dairy cattle. Consumption of up to 4 kg/animal/day was not detrimental to the animals. The possibility to take off 40 percent of dried yeast, without affecting alcohol production, opened a new set of opportunities for the utilization of this source of protein. The strategy towards yeast production in relation to alcohol will be decided by international prices and Brazilian internal policy. The "Usina Santa Luiza", one of the alcohol producers in the State of Sao Paulo, has a daily production of 4 tons of dried yeast, which, over the entire sugarcane harvesting season, gives about 800 tons (1983). The producers mentioned export of 250 tons to UK in 1983 and about 1 000 tons in 1984.

Stillage as it comes after distillation (2 to 7 percent of dry matter) has also been used as a palatability agent for low quality forages. Corn husks and cobs 50 percent (W/W) and stillage 50 percent (W/W) had a 10 percent increase in nutritive value compared to the first one alone. Stillage has been used in mixtures with low quality forages and ensiled. Some mixtures balanced in nutrients can constitute a complete ration.

Concentrated syrup (± 48 percent of dry matter, pH = 4.5) has a detrimental effect on the animals when representing more than 7 percent of the total diet dry matter.

Two research projects dealing with sugarcane are presently in operation. One is the use of steam exploded bagasse in rations for beef and dairy cattle. The other is the establishment of an integrated system of sugarcane utilization, starting with direct fermentation in the plant without tops, distillation of the biomass and the residue given as a partial ration to the animals in the feedlot, faeces and urine producing biogas, biogas used to produce heat for distillation (or for any other kind of use) and the final residue returned to the field as fertilizer.

The use of steam exploded bagasse at temperatures of 200–210°C, pressure toward 18 kg/cm^2

for 5 minutes has given promising results in terms of nutritive value measured in the laboratory and in short feeding trials with sheep and steers. Small feedlots receiving diets with 50 percent dry matter from steam treated bagasse for more than 100 days, have shown a constant drop in dry matter intake in relation to time. It was suspected that the furfural produced in the process was partially retained in the mass. Levels, in terms of free furfural in the filtrate, varied from 0.14 to 0.35 percent, the potential value varied from 0.42 to 0.66 percent and the potential furfural level in the solids varied from 0.37 to 7.59 percent. The representativeness of these figures is not yet known, but what is surprising is the large variability of the potential furfural in the solid, despite physical conditions being the same. This year it is planned to go deeper into the analyses of chemical residues produced during the process. Analyses of the fibre portion that represents 91.6 percent in the dry matter expressed as Neutral Detergent Fibre in the raw bagasse, drops to 67.2 percent in steamed bagasse.

Hemicellulose in the first case is 29.1 percent and in the second only 10 percent. Steamed bagasse mixed with corn ground grain, urea, ammonium sulphate and several other ingredients, in such a way to give more or less 30 percent of dry matter was ensiled in small plastic silos. "In vitro" dry matter digestibility and "in situ" nylon bag technique gave higher figures when compared to non-fermented steamed bagasse. This year testing will be done with animals.

The integrated sugarcane system project has just begun. Some of the initial problems in relation to the sugar level in the mass and transportation of the material have been solved. The residue left after distillation had an increase in the protein level from 1.25 to 6.8 percent. The nutritive value will be better evaluated this year when routine work will be started.

4. Perspectives

At this point it is important to find out what is happening in the country now and what kind of strategies are under way. With this in mind a profile can be drawn of the type of residues available in the near future. It is well known that Brazil has a huge sugar-alcohol industry. Its survival is very dependent upon the efficiency of utilization of the sugarcane yielded and a better use of the residues produced. It was recently said that the new alcohol distillery will be a chemical industry using renewable sources of carbon. It will be based on the conversion of starchy and cellulosic materials to single sugars which will be transformed biologically to several chemical feedstocks now produced by petrochemistry.

The first and main factor that affects production is sugarcane and sugar yield per unit of area. Recent varieties produced 20 percent more than the older ones. The variety SP 70–1143 produces 21.1 tons of sugar per ha against 17.4 of the NA 56–79. The extension of the harvesting season and the payment for the amount of sugar in the harvested sugarcane are two new strategies that will increase productivity and total production.

At the industrial level new technologies have been applied and many others are under way in different sugar mills or distilleries. The Bagatex Industry installed in the “Usina Santa Lydia” in Ribeirao Preto - Sao Paulo, developed a project to reduce bagasse moisture from 50 to 20 percent and actually more than 20 new installations will be working this year. The stillage production with new techniques can be reduced from 13–16 1/per litre of alcohol to 3–4 1. Recycling stillage is now largely used. Centrifuged stillage gives a product very similar to the yeast produced in the fermentation bath.

Many other new developments have been tested on a small scale, such as: a) the use of a bacteria Zymomonas mobilis instead of Saccharomyces; b) use of immobilized enzymes; c) extraction of K, lactic and succinic acid and glycerine from stillage; d) reduction of water in distilled alcohol with absorption agents like Silicalitas ZSM-5 and ZSM-11; e) extraction of

hemicellulose by-products specially D-Xylose and f) saccharification of cellulose with the yeast Pachysolen tannophilus.

One question that can be raised is, if these technologies will change the relation in many cases of product to byproduct or residue? What will remain for animal feeding will be the result of the new technologies applied. We can guess that whole sugarcane will still be largely used with the addition of some source of nitrogen. Sugarcane tops, if available, will only be used in very specific situations. The situation of molasses, a strategic byproduct, will be uncertain. Low moisture stillage (free of K), or centrifuged stillage, probably would substitute molasses and probably there will be plenty of yeast produced in different ways.

ESTUDIO MONOGRAFICO: LA CAÑA DE AZUCAR COMO PIENSO EN BRASIL
por
E.L. Caïelli

La zafra de 1985/86 produjo 125 milliones de toneladas de caña de azücar, 7,8 de azücar, 5 de melaza y 12 billones de Litros de alcohol.

La caña entera es empleada como forraje en lecherias y en unidades de engorde. El uso del cógollo es limitado en el periodo de sequia. El bagazo fresco se ha empleado en periodos criticos. La melaza era muy utilizada antes del 1975 y podria ser empleada de nuevo si el precio de petróleo se mantiene bajo. La producción de levadura como subproducto del alcohol ha brindado una fuente importante de proteina para los animales.

El proyecto más importante que se está desarollando ahora es el tratamiento del bagazo con el vapor a una temperatura de 200–210°C y una presión de 18 kg/cm^2 durante 5 minutos. En ensayos con bovinos de engorde se ha notado una disminución constante del consumo de

materia seca que podria ser debido al contenido de furfural.

En el futuro la utilización de la caña de azúcar y sus derivados en la alimentación animal en Brasil será dependiente de las nuevas tecnologías utilizadas en la industria azucarera particularmente dentro del marco del programa de producción de alcohol.

SUGARCANE TOPS AS ANIMAL FEED

by

M.R. Naseeven

1. WHAT IS SUGARCANE TOP (SCT)?

It is generally known to be a major byproduct of the sugarcane industry which is left in the field after cane harvest. It is, however, rarely realized that the 'top' has been removed from the cane at a very 'arbitrary' point. This results in important variations in the composition - especially for neutral detergent solubles or nitrogen-free extractives. Sugarcane millers have widely different opinions as to the optimum topping point, but the consensus is that it should be the highest fully formed node. SCT, therefore, consists of 3 distinct parts - the green leaves (blades), the bundle leaf sheath and variable amounts of immature cane.

2. Sugarcane top production

SCT production varies considerably with variety, age at harvest, growing conditions and management practices. Data available for Natal are shown in Table 1. The relative yield of SCT in Natal is much lower than values reported for Mauritius and Hawaii (Table 2) where SCT represents 16 – 18 percent of the aerial biomass respectively. Based on a conservative figure of 5 tonnes of dry matter (DM) per hectare, Mauritius produces around 390 000 tonnes of DM from SCT annually (equivalent to 1.5 million tonnes of fresh SCT at 26 percent DM). Assuming SCT loss by burning at 5 percent and unavailability due to flowering at 10 percent, 1.3 million tonnes of SCT are therefore produced annually.

The SCT produced per hectare (21 tonnes) is theoretically enough to provide forage for 1 livestock unit (LU) over a year (1 LU = 500 kg). The present ruminant population in Mauritius represents only 15 000 LU while the SCT produced is sufficient for 78 000 LU. The dependence of Mauritius on sugar for currency earnings and the guaranteed prices obtained do not justify the feeding of whole cane to ruminants at this stage.

3. LIVESTOCK PRODUCTION SYSTEMS IN MAURITIUS AND UTILIZATION OF SCT2 FOR RUMINANTS

In Mauritius, livestock depend heavily on SCT, especially in winter when the productivity of most other species is at its lowest. The most difficult months for fodder availability are November, December, January, May and June. Figure 2 illustrates the availability-deficit picture.

Three distinct groups of livestock producers can be identified in Mauritius: (i) Small cowkeepers owning 1 – 4 head per family; (ii) Medium-scale entrepreneurs having 10 to 100 head of cattle, mostly self-owned; (iii) Large-scale breeders - having over 100 head, generally private companies or subsidiaries of sugar estates and Government farms.

The small cowkeepers utilize SCT massively in winter but have so far thought very little about preserving it. In the intercrop season they cover relatively long distances to collect fodder from crown lands, forest reserves, river sides and mountain slopes. They own the majority of the cattle in the country (70 percent), 100 percent of the goats and produce most of the local fresh milk. This group should, therefore, be a major target for new SCT utilization technology although the response may be relatively less being a traditionally low input - low output system.

The medium-scale entrepreneurs are a new generation who find self-employment in livestock rearing and are keen to adopt new technologies. SCT is used massively in winter but, during periods of fodder shortage, they purchase either poor quality fodder from the humid uplands or use dried grass cut from mountain sides - some grazing is practised for beef stock while dairy animals are zero-grazed. Molasses/urea and protein supplements are major inputs in the system.

The large-scale breeders on the other hand have little choice. They improve marginal lands for grazing part of the stock in summer but rely heavily on sugarcane tops both in the harvest and the intercrop season. The larger the farms, the more they depend on SCT for year-round feeding. The system is heavily mechanized and molasses/urea forms an important constituent of the year-round ration.

Land for fodder cultivation is not available in Mauritius (and many Caribbean countries). Figure 1 clearly shows that SCT is, therefore, not only essential for the livestock industry in Mauritius, but forms the basis of feeding for any major expansion and development of the livestock sector.

4. CONSTRAINTS LIMITING THE USE OF SCT

4.1 The seasonal availability:

Various methods of preservation for SCT have been tried ranging from small plastic bag silos, below ground trench silos, above ground low cost silos (1 – 4 tonnes), small concrete silos (2 – 6 tonnes), and large concrete silos (100 – 4 000 tonnes).

Large concrete silos have been successfully used in Mauritius for the past 10 years but small concrete silos for the medium and small livestock breeders are more recent achievements. Loss of ensiled materials is very low (5 percent) and the quality of the preserved materials is very good. The quality of the silage made with SCT and molasses from 1 to 5 percent of cane tops (fresh) and 1 percent ammonium sulphate compares very well with norms set for temperate crops silage (Deville et al., 1979). The recent technology of preserving cane tops with NH_3 produced in situ from urea has also been successfully applied in small concrete silos (1 – 4 tonnes) at small cowkeepers' sites. The resulting preserved materials have been well received by both the livestock and the farmers. The rate of urea application has been 4 – 5 percent of SCT dry matter. An aggressive demonstration programme funded by the UNDP is in progress to make 50 silos (5 – 6 tonnes) to disseminate the technology and another 100 will be built this year with grants from USAID. The results from low cost above ground silos (chipped material was heaped on the ground, trodden upon with addition of urea and covered with pieces of plastic and soil) have given variable recoveries and were susceptible to rapid spoilage especially during periods of heavy rainfall.

4.2 The relatively low nutritive value of the SCT on its own: or rather the lack of knowledge on the best ways to use SCT. This is extensively covered in another section.

4.3 The labour intensive collection of the cane tops in the field:

Collection of cane tops for small cowkeepers is easily achieved because of the abundant family labour available but for larger units, this is a costly and labour intensive item (1 tonne of SCT may be collected by 1 female worker daily = Rs 50/t). Baling of SCT has been tried in South Africa and Australia and this year a round baler is working in Mauritius. This partially solves the problem of collection and presents the material in a compacted form for easy storage.

4.4 The restricted access to cane fields:

Although SCT is considered free (at present), large scale collection on private lands requires the permission of the land owners. Some planters practise trash conservation and view the excessive removal of SCT from the fields as a loss of soil nutrients and impose some sort of quotas. The issue of leaving livestock breeders a more liberal access to private cane fields needs to be resolved by mutual cooperation by the people concerned - an exchange of SCT with manure being just an example. In the long term as demand increases, a price will probably have to be paid.

4.5 Transport of SCT over long distances:

This involves additional costs and is accentuated by the bulkiness of the collected material (half the weight of cane a lorry normally carries) and competition with the priority of carrying cane for sugar production.

4.6 The increasing use of burning:

Burning is practised to ease harvest, especially with cane having trashing problems. In Mauritius it is estimated that only 5 to 10 percent of the cane fields are burnt prior to harvest. Although some losses of dry matter occur, the burnt cane tops are still a valuable feed for feeding livestock directly and processed (Pate and Coleman, 1975) or for silage making. The

severity of losses to SCT due to burning depend on the initial 'greenness' of the leaves, the amount of dry trash and strippings, their humidity and the prevalence of winds. Generally the bundle leaf sheath is recovered with variable proportions of partially burnt leaf blades.

4.7 <u>The construction of silos for preserving SCT</u>

This involves capital costs which the small farmer does not readily possess. The need for credit facilities and 'package' approach is discussed in the last section.

4.8 <u>Other factors</u>

Flowered tassels of sugarcane are not normally utilized for feeding livestock by small breeders. Some varieties, e.g. S17, flower precociously and profusely, hence limiting SCT availability for small cowkeepers. However, under large scale collection, a large part of it is collected with the SCT and is chipped. The specific nutritive value of flowered tassels is not known.

The use of chemical cane ripeners (e.g. polaris) on a large scale to increase cane sucrose content is practised by the MSIRI in Mauritius and many cane producing countries. Their effect on the nutritive value of SCT has not yet been determined.

5. <u>COMPOSITION AND NUTRITIVE VALUE OF SCT</u>

Classical analytical techniques have been extensively used to estimate the nutritive value of SCT based on chemical composition. Table 3 presents data from a wide geographical area. The mean values presented do not include cases which exert an artificial difference in the normal composition of SCT.

Table 3 also summarizes data for digestibility coefficients of the components of SCT. Dry

matter digestibility (DMD) is low (54 percent) while crude protein digestibility is much lower (39 percent). Thus only 23 g of digestible crude protein are available per kg of SCT dry matter. The total digestible nutrients calculated from the mean values is 510 g/kg of SCT (DM).

The composition of organic structural components of SCT is shown in Table 4. The neutral detergent solubles (NDS) are almost completely digested (98 percent) while the in vitro coefficient of digestibility of the fibre has been found to be 50.2 percent (Kevelenge et al., 1983a). Using a correction of 12.9 percent for endogenous and bacterial matter as a percentage of intake (Kevelenge et al., 1983a) the apparent dry matter digestibility is calculated to be 54.0 percent. This figure is similar to the in vivo DM digestibility presented in Table 3.

Large variations exist in the literature for the nylon bag degradability of SCT. Some are real differences while part is due to the basal rations used. It appears, however, that most of the difference is due to the use of non-standard procedures - especially fineness of grinding. Hughes-Jones and Peralta (1981) found that only 18.2 percent of SCT dry matter disappeared from nylon bags after 48 hours in bulls fed a basal diet of sugarcane and molasses ad lib while removal of the molasses increased it to 31.8 percent. In this case the SCT was passed twice through a hammer mill without a screen to simulate animal mastication. In Mauritius the degradation of SCT in nylon bags in the rumen of cattle fed a basal diet of poor quality fodder was found to be 43 percent after 48 hours. The SCT was oven dried at 100°C and ground through a 2.5 mm screen (Naseeven, unpublished data). San Martin et al (1983a,b) have demonstrated the rapid drop in the degradability of SCT in the presence of high levels of starch. Similar results were obtained by Ma Poon (1981) with increasing levels of molasses in the basal diets. These illustrate the need for a judicious choice of supplements (and levels) on SCT diets.

Energy

The gross energy of SCT is 15.9 MJ per kg DM and the coefficient of digestibility with sheep being 52.4, the digestible energy (DE) is calculated as 8.3, and ME = 6.9 MJ/kg DM (Kevelenge et al., 1983b). This value is much lower than values of 10 MJ/kg ME normally obtained for good quality fodder.

Minerals

The average mineral composition of SCT (percent on DM basis) is as follows: Ash:9.6; Ca:0.43; P:0.15; Na:0.05; K:2.31.

Sheep fed only sugarcane tops were found to be in positive balance for major minerals with the exception of phosphorus (Kevelenge et al., 1983c).

The nutritive value of SCT fed alone

There are few reports where sugarcane tops have been fed alone to ruminants. Information available shows that SCT is a highly palatable forage with good voluntary consumption indices (Table 5). However, animals either lose condition or just maintain themselves or at best have very low levels of production.

Similar results are reported from the Philippines (Roxas, 1985) and Pakistan (Amanat Ali and Amanullah Cheema, undated). Kevelenge et al. (1983b) calculated the ME intake of sheep (42.6kg) fed only SCT to be 6.0 MJ/d and compared it to ARC (1965) data which requires 5.48 – 6.65 MJ/d for maintenance of sheep between 30 – 40 kg liveweight. In Mauritius it is known that ruminants are fed exclusively on cane tops for most of the harvest season. Based on island-wide analyses, it has been estimated that SCT can provide for maintenance and 2 – 4 litres of milk (Sansoucy, 1972).

The reasons why ruminants fed only SCT in Mauritius are able to achieve low-moderate levels of production are two-fold: firstly a high selection is exerted by the small cowkeepers who peel the cane tops keeping the succulent central portion only. Secondly, the animals in turn select the succulent bundle leaf sheath and eat very little green leaf - a luxury they can afford because of the amount fed (up to 90 kg/head/d). It is known that the bundle leaf sheath and the young cane inside have a higher amount of sugars and it was found that the rate of degradability of the bundle leaf sheath was relatively higher although the potential degradability was similar to green leaves (Boodoo, unpublished).

Similar results were obtained (Naseeven, unpublished data) when the components of different varieties were studied using the nylon bag. The degradability of the bundle leaf sheath was 50 percent higher than that of the green leaf blade after 48 hours of incubation in the rumen of cattle (Table 6). If the rate of digestion proceeds faster, it would be expected that animals would be able to consume more feed and nutrients. This probably explains the Mauritian performances.

A study carried out by FAO in Mauritius in 1971 showed that village cows prduced 1 500 kg milk without supplementation of traditional concentrates. However, although the fodder was predominantly cane tops during the harvest season, other highly nutritive fodder species were utilized in summer.

6. IMPROVING THE VALUE OF SUGARCANE TOPS FOR RUMINANT FEEDING

There are basically three approaches:

- **The first one, already discussed, is a selection of the succulent bundle leaf sheath - obviously not practical for large units and overall SCT utilization;**

- **The second one, and the most complex, is the optimum combination of products and byproducts for supplementation at the best economic levels to achieve the maximum of returns;**

- **The third is treatment action directly on the SCT to increase its DMD by physical, chemical, as well as biological means.**

6.1 Supplementation of sugarcane top-based diets

With the low amount of digestible crude protein obtainable from SCT (23 g/kg DM), it is logical that the first supplement should be a nitrogen source. Pate et al. (1971) obtained average daily liveweight gains (ADG) of 0.52 kg by supplementing SCT with 1 kg cotton seed meal/hd/day while animals just maintained weight without the supplement. Ferreiro and Preston (1976) obtained ADG of 0.84 kg when zebu bulls were fed 1 kg rice polishings with SCT. In Mauritius, feeding of SCT silage together with 1 kg copra cake, 0.2 kg fish meal, 0.5 kg rice bran and molasses/urea 3 percent fed at 3 percent of liveweight gave ADG of 0.57 – 0.67 kg (Deville et al. 1978). Tuazon (1974) obtained lower ADG of 0.41 kg by feeding SCT silage (60 percent of DM), molasses (20 percent of DM) and copra meal (20 percent of DM).

However, these growth rates are well below the genetic potential of these animals which indicates that nutrients are still limiting. Luz Meyreles and Preston (1982) and Luz Meyreles et al. (1982) have fed growing bulls ad libitum SCT and ad libitum molasses but with different sources of nitrogen: urea, poultry litter and wheat bran (see Figure 1). Leaving aside the 1.01 peak (the experiment was of short duration and with a small number of animals), it is safe to conclude that the addition of molasses worsens a situation where N was already limiting and the supply from 1 kg bran is not sufficient for high production. Further addition of nitrogen is seen to result in corresponding increases in performance. The effects of nitrogen/SCT are

confounded by the presence of ad libitum molasses in the system. Referring to the high liveweight gain, the authors say 'better performance due to combining the supplements was obtained with a slightly reduced intake of molasses, but a higher intake of forage'. It is very unfortunate that this question was not followed closely.

Recent findings in Mauritius on a commercial farm show that SCT silage at 15 kg + molasses/urea 4 percent at 1.5 percent LW (7 kg) and brewer's grain 14 kg + CSC 1 kg in rations for finishing beef cattle give ADG of over 1.4 kg. This represents a total DM intake of 13.7 kg or 3 percent of LW for a 450 kg animal. These data which are actual production figures from the largest livestock fattening enterprise in Mauritius indicate that the 1.01 kg ADG reported by Meyreles and Preston (1982) was possibly not a chance occurrence. The common factor is the lower level of molasses. According to the manager, the level of urea in the molasses was brought down from 6 to 4 percent without any adverse effects on performance. This is plausible in view of the large amount of N entering the system (1 030 g DCP/hd/d). In view of the generally poor performance obtained on diets based on both molasses and canetops Brewer's grains appear to have a very positive effect.

Following the work of Ma Poon (1981) it would appear that molasses levels up to 1.5 percent of LW could be used advantageously without affecting the energy contributed by the SCT, but it has been current practice to limit molasses to 1.0 percent of LW to be safe.

6.2 Supplementing for milk production

A UNDP-funded pilot project to demonstrate the use of Cotton Seed Cake for milking cows fed predominantly on SCT in the harvest season has given the following preliminary results (Boodoo, unpublished data):

Cows on fodder + cowfeed	(29 cows)	12.6	kg milk/day
Cows on fodder + 250 kg CSC	(34 ")	12.5	"
Cows in FAO - No concentrates	(980 ")	5.0	"
Cows in FAO - Concentrates	(- ")	8.0	"

It is therefore clearly demonstrated that cowkeepers can increase their milk production from 5 litres average daily yields (FAO, 1971) to 13 litres with the supplementation of protein supplements.

Concentrates being relatively expensive to provide all the nitrogen requirement, current research is looking into the use of molasses blocks with high urea levels to supplement part of the nitrogen. This is expected to bring further reduction in the cost of production.

6.3 SCT treatment

Apart from the judicious use of appropriate supplements with SCT rations, attempts have been made to treat SCT for improving its nutritive value especially with alkali. The data in Table 7 show that ammonia/urea treatment did not improve DM digestibility as previously believed and as exhaustively reported for cereal straws. There is no explanation to this difference in behaviour of SCT and this is probably the only report on the subject. However, the advantage of the urea treatment is an increase in the crude protein content to levels optimal for microbial degradation.

6.4 Physical factors

Ferreiro and Preston (1977) found that fine chopping of SCT decreased the voluntary intake while coarse chopping 5 – 15 cm significantly increased it. This aspect has not been

investigated further. It could be important in the design for better chipping equipment and improvement of feed intake.

7. Improving the overall use of SCT from field to animal silage

The high seasonal peak availability (Figure 2) pattern of SCT poses a problem for its year-round utilization. As far as large sugar estate farms are concerned, it is now an established practice to fill the silos of 100 to 4 000 tonnes during periods of availability. The material is chipped and sprayed with molasses partially diluted with water at the rate of 1 to 5 percent of fresh SCT followed by trampling. The silos are subsequently sealed by PVC or butyl sheeting.

An attempt to make a communal trench silo for village cowkeepers in 1968 failed completely. It was surprising that although faced with a major crisis of fodder shortage during the off-harvest period, the small cowkeepers were not interested in communal silos. The main reason was the availability of scrub lands, river sides, crown reserves and forest land from where it was possible to get a daily fodder requirement with the family labour - although it meant walking long distances. The other factor was the psychological aspect - farmers are very sentimental about their cows and are reluctant to feed them with feeds they judge 'unfit' for the cows.

However, times have changed - with the increasing number of livestock, an increasing awareness of silage technology and increasing pressure on the scrub lands, today many small farmers are very keen in preserving cane tops. Since the small cowkeepers are the owners of most of the ruminant livestock in Mauritius, any plan to increase SCT utilization through silage making must make them the main target.

Extension services play an important role in the education process and sensibilize farmers to the new technology. Afterwards elite farmers keenly interested and in great need of silage are

selected for pilot silos to be used as a demonstration for other cowkeepers in the village. Apart from technical advice, a national silage programme requires credit facilities for the initial silo construction, basic equipment for chipping, additives (molasses and urea) for improving preservation and feed supplements to ensure improved animal performance on the silage. It is only through an integrated approach that chances for success exist. The medium to large farms could be encouraged to increase their storage capacity with soft loans and subsidies on silage making equipment and materials used in the construction of silos.

A longer term approach should, however, involve a higher degree of integration with the cane milling industry. As sugarcane is considered a precious crop, the SCT could also be harvested and carried to the factory where an additional chain + knives would do the chipping and offer the chipped material for sale on a weight basis. Any excess could be ensiled for sale during the intercrop season. Alternatively the Government could encourage entrepreneurs to offer chipping services directly in the field or at the farms. Contractors could even propose the complete filling of the silo on a weight basis.

It has been estimated that for a small cowkeeper owning 2 head of cattle and requiring about 5 tonnes of silage for feeding them for 3 months the cost of ensiling would be about 185 Rs/tonne. It would only be 155 Rs/t for a 2 000 t silo (1 US$ = 12.9 Rs). In both cases, these values are lower than the cost of producing planted fodder.

8. CONCLUSIONS

SCT is abundantly available and by tackling the major constraints limiting its use priority-wise, more fodder will be made available during the off-harvest ‘difficult’ months. The first priority is preservation.

The problem of relatively low nutritive value of SCT is rather a lack of knowledge of judicious supplementing to exploit the most out of the ration. Research is desperately needed to find other forms of cheap 'ideal supplements'.

SCT does not behave like cereal straws. It has good voluntary intakes and does not appear to respond to ammonia treatment. This deserves the attention of research workers for elucidation.

In countries like Mauritius, instead of planting graminaceous species, the limited land should rather be exploited with high yielding legumes while SCT and molasses are exploited for energy. An integrated approach to encourage farmers and parallel services to move to SCT preservation is a major step towards the increase in livestock numbers and production.

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Figure 1 : Performance of bulls fed ad lib sugarcane tops

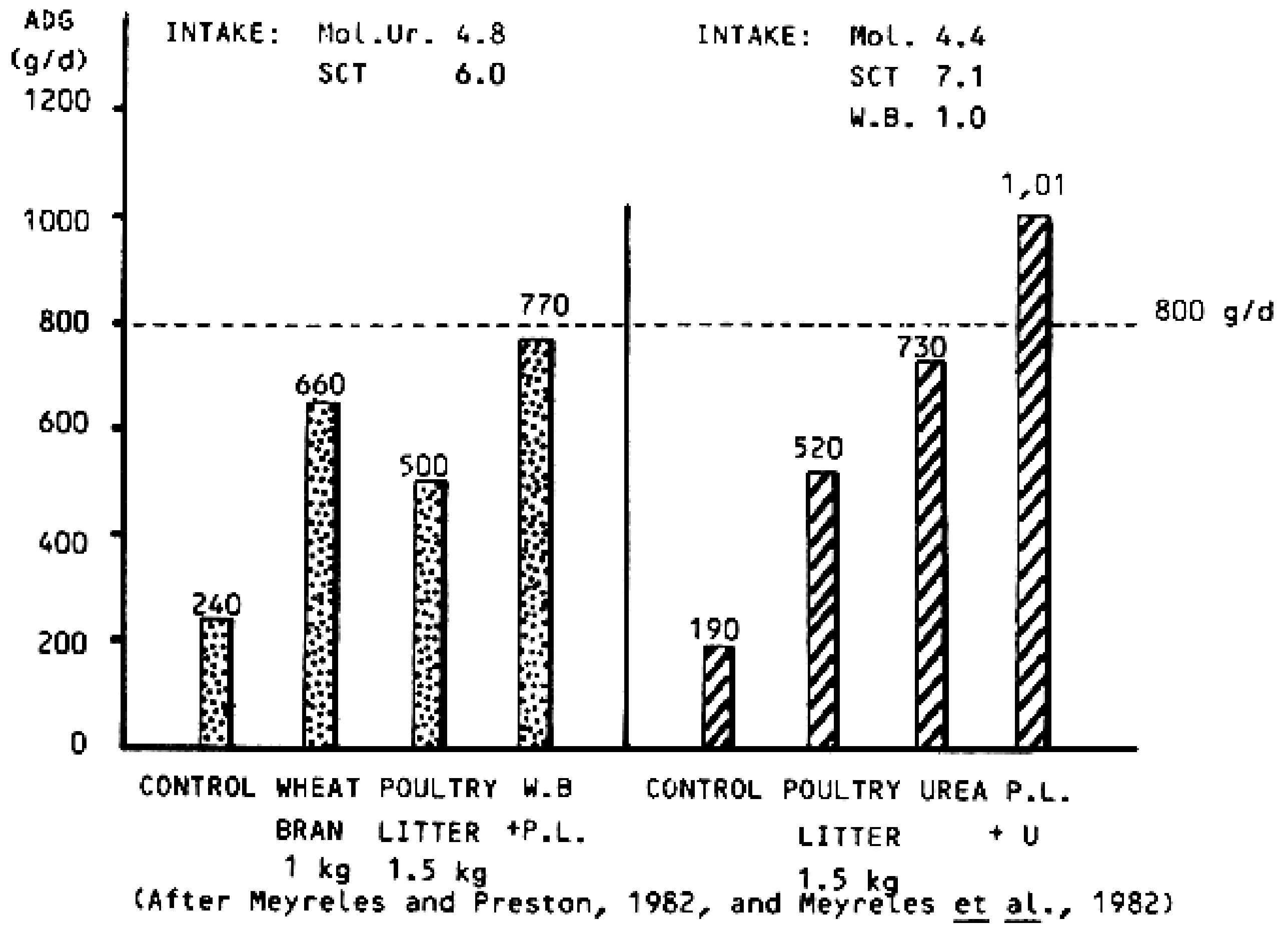

Figure 2 : Theoretical availability/deficit of fodder and their seasonality

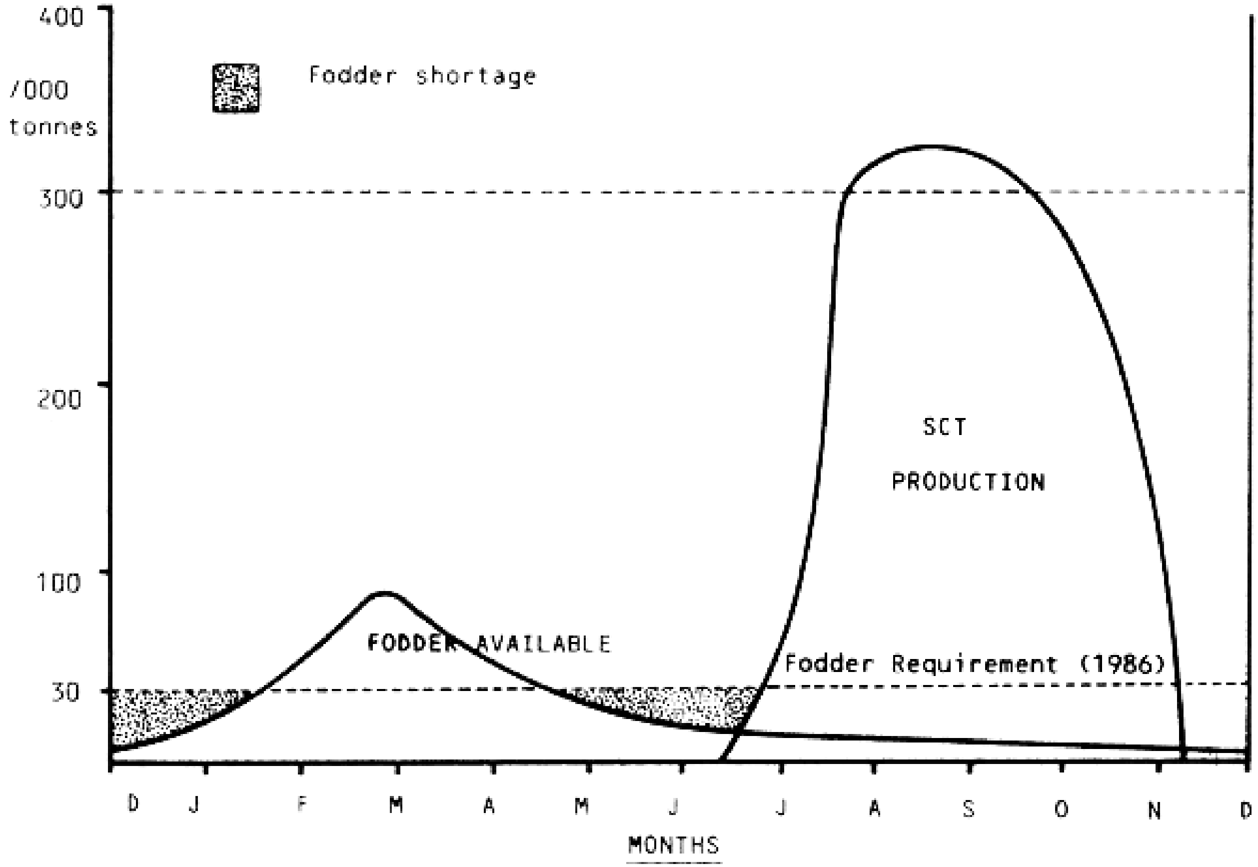

Table 1: Yields of sugarcane aerial biomass over 12 years in Natal (1940–52)

	Green wt. (tonne/ha	DM%	Dry Wt. (Tonne/ha
Millable cane	83.4	32	26.8
Sugarcane tops	21	26	5.45
Trash	12.6	85	10.6

Source: Barnes, 1974.

Table 2: Comparison of relative aerial biomass yields - % dry matter (DM)

%	Natal	Hawaii	Mauritius

Millage cane (DM)	62.4	56.2	59.3
Sugarcane tops (DM)	12.6	18.1	16.3
Trash (DM)	24.9	25.6	24.3
Tops/cane ratio			
(Dry matter basis)	20.2	32.2	27.5

Table 3: Chemical composition and digestibility coefficient of sugarcane tops

	Chemical	**composition**	**Digestibility**	**coefficients**
	means, %	**SD ±**	**Sheep**	**Cattle**
Dry matter	29.0	2.3	54.3	53.9
Organic matter	91.5	-	56.2	55.1
Ash	8.5	2.1	-	-
Crude protein	5.9	0.7	37.7	41.1
Crude fibre	33.5	2.1	56.5	54.1
Ether Extract	1.7	0.3	-	56.2
Nitrogen-Free-Extract	50.3	3.9	56.6	57.8
Sources	Calculated from various sources		Kevelenge et al., 1983b	Sanchez Nunes et al. 1974

Table 4: Composition of organic structural components in sugarcane tops

% in DM			
OM	90.4	93.7	92.1
NDF	63.3	67.0	65.15
NDS	36.7	33.0	34.85

ADF	43.1	37.7	40.4
ADL	5.0	4.6	4.8
Cellulose	38.1	33.1	35.6
Hemicellulose	20.2	29.3	24.8

Source: Kevelenge et al.,1983b
Godoy and Elliott, 1981

Table 5: Feeding sugarcane tops only to ruminants

Species	Live wt.	VCI[1] kg	ADG (L)	Source
Steers	330 kg	1.78	0.000	Pate et al., (1971)
Steers	347 kg	1.68	-0.164	
Sheep	42.6 kg	2.02	-0.010	Kevelenge et al.
				(1983b)

1 Voluntary intake: kg DM/100 kg LW

Table 6: Relative degradation rate of sugarcane tops and different components after 48 hours

Varieties	M 2173	M 13/56	$\bar{x}$
Whole canetop	41.5	43.9	42.7
Bundle Leaf sheath	51.6	52.4	52.0
Green Leaf blade	35.4	35.4	35.4

Table 7: Nylon bag degradability (48 hours) of sugarcane tops (SCT) Var. 13/56 treated by different methods for 34 days

Treatment	DM%			DM	±	Crude
	Initial	Final	pH	degraded	SD	Protein
SCT control	22	21.3	4	49.9	1.6	
SCT + urea	24.2	21.9	8.6	48.4	1.7	
SCT + molasses	26.3	25.4	4	60.1	2.4	6.6
SCT + molasses +						
	25.4	23.4	7.8	52.4	2.4	10.1
urea						

Source: Naseeven, 1986 - unpublished data

UTILIZACION DE LOS COGOLLOS DE CAÑA COMO PIENSO

por

R. Naseeven

Se producen actualmente por hectárea alrededor de 15 – 18 toneladas de cogollos de caña fresca (5 – 6 toneladas de materia seca), lo cual representa suficiente forraje para una cabeza de ganado (500 kilos de peso en vivo) durante un año.

La producción mundial de cogollos de caña se calcula en 60 millones de toneladas. En Mauricio se producen 1 – 3 millones de toneladas, de las cuale sólo el 15 por ciento se utilizan en sistemas de alimentación animal. Es pos ble cuadruplicar el número de rumiantes que se alimente con cogollos, melaza suplementos nitrogenados, y la utilización de la caña integral no se justific mientras no se utilice la cantidad máxima de subproductos posible. Una de la principales limitaciones a un mayor uso de las puntas de caña es su disponibi lidad estacional lo cual entraña costos adicionales de almacenamiento y conse vación durante casi seis meses. También son consideraciones importantes el acceso a tierras privadas para la recolección en

gran escala, los aspectos logísticos o los elevados costos de transporte, especialmente de material voluminoso. Aunque la quema reduce la cantidad de cogollos frescos disponibi el material quemado puede utilizarse directamente o ensilarse. En Mauricio, ganado depende mucho de los cogollos de caña fresca, los cuales representan mayor parte del pienso utilizado en el invierno, cuando la productividad de mayor parte de las especies tropicales es baja. Sin embargo, su valor nutrit vo es bastante reducido lo cual entraña una producción baja, si bien su cons es bien aceptado. Se examinan los resultados de investigaciones sobre el va nutritivo de los cogollos frescos, los tratamientos y las combinaciones óptir y se indican los sectores en los que es posible mejorar de manera fundamenta nuestros conocimientos relativos a la utilización del mencionado producto. miras a mejorar la producción pecuaria potenciando al máximo la utilización cogollos de caña, se propone un enfoque integrado que entraña actividades de investigación y extensión, crédito, y otros servicios (transporte, picado, ve ta de la melaza, urea y telones de plástico), y se examinan brevemente los aspectos económicos.

SUGARCANE PITH (SUGAR-FITH) AS ANIMAL FEED

by

E. Donefer

INTRODUCTION

In the early 1960s, two Canadians (R. Miller and T. Tilby) invented a procedure for "sugarcane

separation", the subsequent development of which has had a marked influence on concepts of feeding the sugarcane plant to livestock, and which may ultimately modify the operation of the conventional sugar factory. Over the past 18 years, trials with cattle and sheep based on feeding cane separation products have been conducted in many countries, primarily in the Caribbean region. Claims and counterclaims have been published about the technical and economic feasibility of livestock feeds produced by the cane separation process, and to date there has not been an adaptation of the technology to commercial livestock production systems.

Is this lack of adoption due to problems of equipment design, to the nutritive value of the feeds or to a lack of economic feasibility of intensive livestock production systems in cane-growing countries of the tropics and subtropics? This paper will attempt to review the development of cane separation as related to livestock feeds, clarify some of the misconceptions which have arisen and comment as to future perspectives.

SUGARCANE SEPARATION TECHNOLOGY

There were two basic objectives in developing the cane separation technology, which were based on observations in the Caribbean of conventional sugar factories. It appeared that a disproportionate amount of energy was required to crush the sugarcane stalks prior to sugar extraction and that also the bagasse product resulting from crushing did not provide the sugarcane fibres in a form for optimum by-product utilization. It was proposed, therefore, to develop a system which minimized sugar factory energy requirements, reducing factory requirements for burning bagasse as a fuel with the resultant increased availability of sugarcane rind fibres providing an increased potential for producing high quality board products for construction purposes. Conventional bagasse does not make a strong fibre board, because it contains a mixture of long rind fibres and short internal fibres and pith. It is

common in some countries to depith the bagasse mechanically, use the long fibres for paper or board manufacture and the pith residue for livestock feed, but this is not always cost-effective as it adds an additional processing step to the conventional factory operation, and the quality of the depithed bagasse product is very variable. The new procedure would eliminate bagasse as a sugar factory by-product.

Development of the sugarcane separation technology was based on two simple physical properties of the sugarcane stalk (stem). The first is that it is easier and requires less energy to split the stalk longitudinally than to crush it. The first step in a cane separator is the passing of the stalks at high speed over a splitter blade, dividing it down the middle into two halves (Figure 2). The second step involves the derinding of the stalk or the separation of the outer rind layer from the inner sugar-containing pith. The hard properties of the rind and soft characteristic of the inner stalk make it possible to accomplish the derinding by passing the split stalk between two special rollers. These rollers have a gap between them to allow the stalk to pass through, the outside roller moving clockwise at about six times the speed of the inner roller which is moving counterclockwise. The result of the speed and rotation differences is that the inner roller holds back the stalk allowing the outer roller to scrape and separate the soft pith from the rind. The separated rind can actually be passed through a second set of similar acting rollers which will separate the outside wax layer from the rind fibres, if cane wax is desired as a by-product.

New terminology was required to describe the product of cane separation and the commercial term "Comfith" was used by the company which developed the cane separator (Canadian Cane Equipment Ltd.) to designate the inner stalk components which consisted of fibre vascular bundles and pith, the latter in association with the naturally occurring liquid sucrose. Requiring a non-commercial term in technical publications, the term sugar-fith was introduced, the fith thus referring to the two quite different types of fibre components (fibre vascular bundles and

pith) (Donefer et al., 1975). Thus the "pith" referred to in the title of this paper as the product of cane separation actually contains the sugars in addition to fibrous products, and herein will be referred to as sugar-fith. With the sugar removed the resultant product is termed fith (or commonly, pith). There has been no consistent use of cane feed terminology in the literature resulting sometimes in confusion as to the actual nature and composition of the feed being described. Figure 1 compares common and international names and numbers of sugarcane-derived feeds (Donefer and Latrille, 1980).

It is important to emphasize that the development of the separation process was designed for application to sugar factory operations and that possible uses for animal feed was a later development. The sugar-fith (or Comfith) produced in the modified sugar factory would thus be subject to sugar extraction procedures, so that there are four resulting products of the cane separation technology: rind, fith, sugar and molasses (a fifth being wax if desired). From an animal feed perspective, two feeds are possible, fith with sugar (sugar fith) or without sugar.

LIVESTOCK FEEDS FROM SEPARATED CANE

Essentially all experimental work has been based on sugar-fith, with its promise of a highly digestible energy content combined with the high yield potential of the sugarcane plant.

In 1964, Canadian Cane Equipment Ltd. established a pilot plant on the Island of St. Kitts in the Caribbean in association with the local sugar factory, where a factory-scale separator was constructed. The company became interested in identifying all potential commercial products, so, in conjunction with the Department of Animal Science of McGill University, preliminary feeding trials, limited to a total of 12 cattle and covering a 90-day period, were conducted in St. kitts in 1968. Daily weight gains averaging 0.7 kg were obtained for a group of cattle fed supplemented sugar-fith, and in addition, digestibility trials were conducted with sheep fed

rations of sugar-fith or fith (MSc. thesis, James, 1969).

The encouraging results from the preliminary observations in St. Kitts led to an extended experimental programme conducted in Barbados in conjunction with the Animal Nutrition Laboratory of the Barbados Ministry of Agriculture. The “Barbados Comfith Project”, initiated in late 1969 and continuing for a 4-year period, was funded by the Canadian International Development Agency (CIDA) in conjunction with the Barbados Government. This project involved the feeding of a ration predominating in sugar-fith, with cattle growth trials conducted primarily for beef production but with parallel studies with lactating cattle, sheep and swine (Donefer et al., 1975).

A major accomplishment of the Barbados project was the demonstration that high levels of animal production (cattle growth averaging 0.9 kg/day) could result from a ration containing a major proportion of sugar-fith and cane tops (together up to 80 percent of ration dry matter).

An event which had an important influence on future canefeed developments was a CIDA-sponsored seminar held in Barbados in January 1973 for representatives of Commonwealth Caribbean Countries, the major purpose of which was to present the initial results from the Barbados Comfith Project. Dr. T.R. Preston was an invited speaker at the seminar and his interest in the new separation technology was initiated. In addition to reporting the sugar-fith results presented at the seminar in various publications, Dr. Preston was able to obtain prototype cane separators for feeding trials conducted under his supervision in Mexico (Chetumal) and later in Mauritius and the Dominican Republic.

Although there have been widespread traditional practices of feeding unsupplemented sugarcane to livestock particularly under emergency conditions (i.e. drought), this usually resulted in survival or maintenance conditions for the animals. Prior to the 1970s there have

also been sporadic research reports from Brazil, the USA and Mexico of feeding trials where sugarcane was a ration ingredient.

The Barbados Comfith Project thus did more than present preliminary livestock production results based on the cane separation technology; it restimulated interest in the tropical world as to the potential for using the whole sugarcane plant (as an alternative to sugar production) as a feed for intensive livestock production. The important principle demonstrated was the necessity of supplementing the energy-rich, sugarcane feed with sources of protein, minerals and vitamins to meet nutritional requirements for increased levels of production.

The next developments in the use of derinded cane (sugar-fith) were related to results of trials conducted in Chetumal, Mexico by Preston et al. (1976). Using a cane separator obtained from Barbados, their cattle rations compared two types of processed cane, sugar-fith and chopped cane, each at increasing levels of supplementation with rice polishings. They concluded that the results of the 400-head feeding trial showed no significant difference in animal performance between derinded and chopped cane. In a later report, Preston and Leng (1978) stated that "following the results of the Chetumal trials the much heralded, sophisticated and expensive 'separation' technology was discarded in favour of simple chopping with machines costing less than one twentieth of the price".

The company which originally developed the separation technology, Canadian Cane Equipment Ltd., went bankrupt in mid-1974, and their patents on cane separation reverted to the Canadian Government, who had provided the company substantial development grants. Several companies have since been licensed by the Canadian Government to pursue commercial development of the equipment, but to date a sustained strategy has not been obvious.

It is with much interest and speculation on the part of those of us who have been involved in

the technical research and development of cane separation technology as to why there has not been more success in its commercial adoption, particularly since many of us continue to believe that it represents a revolutionary process which could have a profound positive effect on both the sugar industry and livestock production in the humid tropics. I would suggest that the companies involved appeared to be more interested in short term profits and quick recovery of development costs rather than in the logical technical and commercial development. All cane separators manufactured have been prototypes with minimal apparent attempt to incorporate engineering principles necessary for sustained use of equipment at factory or farm level. Separator prototypes should not have been sold to far-reaching project sites (Mexico, Mauritius) without guarantees by the company for maintaining the equipment in proper condition, for there is evidence that the separators used in Mexico and Mauritius were not working properly and therefore may not have been producing a high quality and uniform feedstuff. Also, the cost charged for the prototype separators had little relationship to what the price of machines factory-produced in large quantities would have been. In addition, the equipment developers, Canadian Cane Equipment Ltd., as executing agency for the Canadian International Development Agency for the Barbados Comfith Project should have been more closely monitored by the Canadian Government agency to guarantee that commercial equipment development procedures were being carried out by the company.

An additional factor discouraging separator development was the very high prices being received for sugar, particularly in the mid-1970s. The Caribbean sugar industry was little interested in innovations which might have affected its current sales and was particularly negative about diverting any part of the sugar crop to livestock feed production. It is thus ironic that the very low sugar prices experienced in the 1980s have caused sugar factories in several countries to close and others to attempt to determine if crop and product diversification might allow profitable utilization of valuable agricultural resources.

SUGAR-FITH VERSUS CHOPPED CANE

Although the separator-produced sugar-fith contained only the internal stalk fibres and sugar, initial feeding trials in Barbados demonstrated the advantage of adding sugarcane tops to the ration due to increased voluntary intake (Donefer et al., 1975). Therefore, when comparisons were made between sugar-fith plus cane tops and chopped whole cane, the only apparent difference between the two feeds would be the rind layer removed by the separator in the case of the former. The Chetumal results (Preston et al., 1976) indicated "no significant difference in animal performance between derinded and chopped whole cane" and in a comparision of studies conducted in many countries in the Caribbean region the average cattle liveweight gains (g/day) were 755 and 736 for derinded and whole cane respectively (Preston and Leng, 1978). Perhaps more important than this slight difference was the large variability observed in the different studies, ranging from a -28 to +17 percent change in liveweight gain due to derinding. One explanation for this variation might be related to the large differences in the composition of sugarcane known to be related to season of harvest and harvesting procedure (particularly if the cane field was burnt prior to harvest to reduce the trash content).

To contrast possible options, the cane used in the Barbados Comfith project might be considered in optimum condition as it was from unburned fields but with the stalks "hand cleaned" prior to separation. A 12-month continuous sheep digestibility trial (Donefer and James, 1978) indicated a mean dry matter digestibility (%) of 69.7 ± 2.1 (SD) and mean voluntary intake (expressed as a percent of 3 kg DM intake/100 kg body weight) of 77.3 ± 8.1 (SD). The lowest values were found in the "wet season" when cane is known to be at its lowest sucrose content.

Comparison between sugar-fith and chopped cane conducted at the Sugarcane Feeds Centre (SFC)[1] in Trinidad is particularly revealing as to the effect of cane variables on animal

performance results.

Cattle feeding trials at the SFC have been sustained over many years involving a 500-head capacity feedlot with the chopped whole sugarcane plant as the primary ration ingredient. Table 1 summarizes cattle growth responses to whole cane harvested during the 1981 dry season in Trinidad, with an average daily gain of 0.72 kg being observed for 197 steers (Donefer et al., 1982, 1983). Immediately following the dry season, a group of 120 of the steers were fed rations comparing whole and derinded cane, with a marked growth depression (p<.001) observed for the whole cane-fed cattle (0.46 kg/day) but with no change for the cattle fed derinded cane (0.73 kg/day).

Table 2 summarizes the chemical composition of the cane and the most obvious difference between the dry and wet season harvested whole cane is the 3-fold increase in ash content, due to soil contamination under wet season harvesting conditions in Trinidad. In this climatic situation the advantage of the sugar-fith is the fact that in its preparation soil contaminated leaves (trash) have been removed prior to derinding, whereas this is not the case for the whole cane which is chopped in the condition in which it is harvested. Since climatic conditions in relation to dry season (length and extent) vary within countries and considerably between the sugarcane-growing tropical countries, these data illustrate the large effect that this variation might have on livestock feed quality and thus the applicability of results from one area to another. It also emphasizes that the results of feeding trials conducted with minimal number of animals, for short feeding periods and only covering one season, must be regarded as preliminary, to be confirmed in extended studies at experimental as well as commercial prototype levels.

[1]The Sugarcane Feeds Centre was initiated in 1976 as a joint project of the Government of Canada and the Government of Trinidad and Tobago, with McGill University acting as

executing agency for the period 1976–81.

ECONOMIC ASPECTS OF CANE SEPARATION

Until there are commercially available cane separators, it is not possible to comment on the actual cost of production of livestock feeds based on derinded cane. The success of a system based on feeding a product such as sugar-fith is also very much dependent on the utilization of the sugarcane ring for hard board production purposes; it is indeed suggested that the construction material potential of sugarcane is more valuable than the price received for its sugar content. Separators would always be more costly than choppers, but the animal feed potential of the process must be considered as a by-product of board manufacture.

At present, there is work in Jamaica on the development of an integrated sugarcane system based on sugarcane separation technology (Holmes, 1983). Under Dr. I. Sangster, Director of the Jamaican Sugar Industry Research Institute (SIRI) - Factory Technology Division, a pilot plant is in operation where a cane separator is used to produce the three major separation products, sugar (or sugar syrup), board, and livestock feed. In this system, the sugar is removed from the fith so that the sugar-free fith is primarily a low energy forage very similar in its chemical and feeding properties to conventional bagasse pith or bagacillo. Effective use of this product, not the topic of this paper, requires proper energy and other nutrient supplementation and possible use of chemical or physical treatment procedures to distrupt the ligno-cellulose structure and thus increase energy availability to ruminant species.

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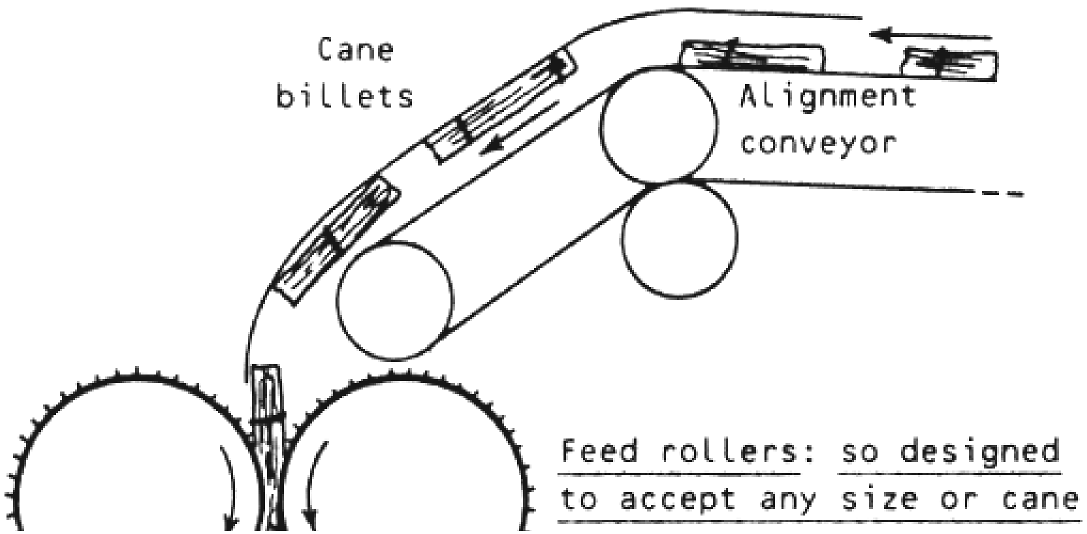
Figure 1: International and common names for sugarcane-derived feeds

Int. feed name	Int. feed no.	Common names
aerial part	(2-04-689)	whole plant
— top of aerial part	(2-13-568)	cane tops
— stems or stalks	(2-13-248)	cane stalks
(B) — pith (stalks wo rind)	(2-13-564)	derinded stalks, sugar-fith, Comfith
— rind	(2-20-761)	rind
(A) — bagasse or pulp	(2-09-909)	bagasse
— pulp, sifted	(1-04-700)	bagasse pith, bagacillo
— molasses	(4-04-696)	cane, blackstrap or final molasses
— molasses, dehy.	(4-04-695)	dry (dehy.) molasses
— sugar, raw	(4-13-569)	raw sugar
— sugar, brown	(4-13-578)	brown sugar
— sugar	(4-04-701)	white (refined) sugar

Figure 2: The cane separation process (Holmes, 1983)



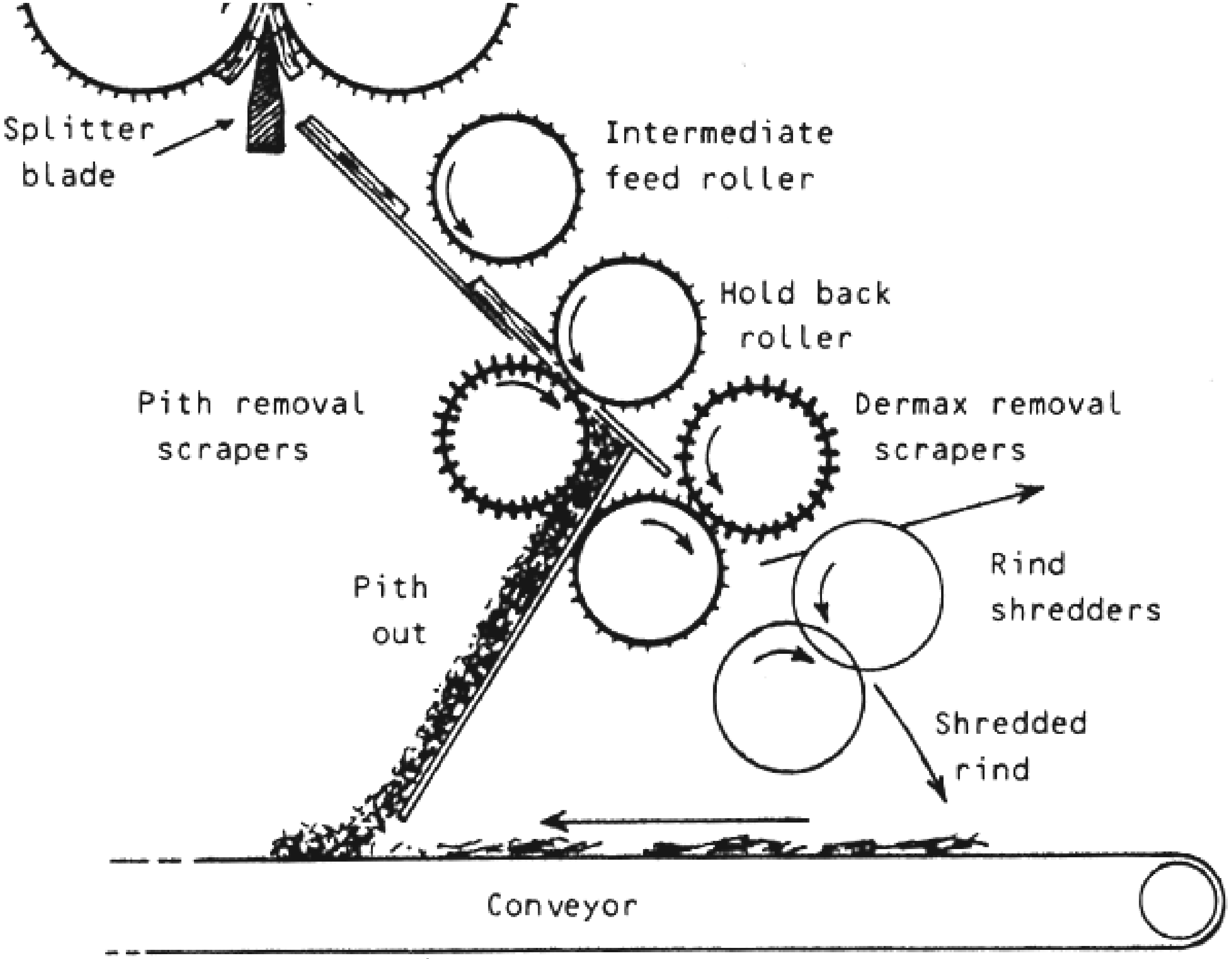


Table 1. Sugarcane Feeds Centre: cattle feeding trial (1981) - Summary of results

Sugarcane Season Days	Whole Dry 55	Whole Wet 84	Derinded Wet 84
Steers, no.	197	80	40
Weight, initial, kg	201	243	246
final, kg	240	282	307

ADG, kg	0.72	0.46	0.73
DM intake, % LW			
Cane	1.55 (61)	1.60 (60)	1.89 (64)
Supplement	1.00 (39)	1.07 (40)	1.08 (36)
Total	2.55 (100)	2.67 (100)	2.97 (100)
Feed:Gain	7.9	15.2	11.6

Table 2. Sugarcane Feeds Centre: summary of chemical analysis of cane, % DM

Sugarcane Season	Whole Dry	Whole Wet	Derinded Wet
Crude protein	1.9	3.2	2.3
ADF	40.8	43.3	26.3
NDF	60.9	61.5	44.1
Ash	3.9	12.4	3.5
DM	34.3	31.2	
Brix	17.7	16.5	
		15.0 (last month)	

UTILIZACION DE LA CAÑA DESCORTEZADA COMO PIENSO

por

E. Donefer

El equipo técnico de separación de la caña rompe el tallo y separa la corteza exterior de la médula contenedora del azúcar y los hacecillos vasculares de fibra. Se desarrolló este proceso a fin de reducir las necesidades de energía de las fábricas de azúcar eliminando el

desmenuzamiento y a fin de utilizar las fibras de la corteza en la fabricación de tableros de partículas muy resistentes. Ensayos realizados en San Cristóbal y Barbados demostraron que el componente de médula contenedora de azúcar podía representar una parte importante de la ración de un rumiante, lográndose un aumento de peso de 900 g/día como promedio. Ensayos ulteriores en muchos países en los que se compararon los resultados de la alimentación con caña descortezada y con caña integral picada indicaron sólo pequeñas diferencias en cuanto al aumento de peso del ganado, por lo cual se prefirió el equipo picador menos costoso. Estudios realizados en Trinidad (Centro de piensos a base de caña de azúcar) dieron resultados mucho mejores para la caña descortezada que para la caña picada (730 frente a 460 g/día) debido a la contaminación del suelo que limitaba la utilización de la caña integral en la estación de las lluvias.

La tecnología de separación de la caña sirvió para estimular el interés mundial en la utilización de este cultivo en la alimentación del ganado y no en la producción industrial de azúcar.

Las perspectivas en cuanto a la adopción de la technología de separación de la caña dependen de la disponibilidad en el mercado de equipo de separación eficiente y parece viable cuando los tableros de corteza son el principal producto y los piensos un subproducto poco costoso. La separación industrial producirá corteza y azúcar, y la médula a la que se ha extraído el azúcar podrá utilizarse como forraje de baja calidad (de composición análoga al bagazo o bagacillo) en la alimentación de los rumiantes, sea en forma no tratada o tratada (con álcalis o al vapor).

BAGAZO COMO ALIMENTO PARA RUMIANTES
por
P.C. Martín

Los subproductos fibrosos de la caña de azúcar adquieren una gran importancia como alimentos para rumiantes. El bagazo integral y su componente más fino, el bagacillo, pueden constituír el 28 por ciento de la caña en su conjunto. Desde años atrás (Beames, 1961, Kirk, Peacock, Davis, 1962) se ha utilizado el bagazo en las raciones para rumiantes. Sin embargo, su baja digestibilidad y contenido de nitrógeno, limitaron su uso a servir de relleno en los concentrados o en muy bajos niveles de inclusión en las raciones. De esta forma, el aporte de nutrimientos del bagazo resulta insignificante. Ello, a pesar de que el contenido en carbohidratos potencialmente digestibles por el rumiante es alto (más del 70 por ciento). Sin embargo, el alto porcentaje de lignina (más del 20 por ciento) y el bajo contenido en nitrógeno limitan el aporte de energía de este subproducto.

Con vistas a transformar esta limitación en el valor nutritivo del bagazo y del bagacillo, se han ensayado diferentes variantes:

- **Predigestión por medios químicos y físicos.**
- **Mezclado con carbohidratos de fácil fermentación y nitrógeno no proteico.**

1. EFECTO DE LA PREDIGESTION POR MEDIOS QUIMICOS Y FISICOS

Inicialmente se compararon 2 reactivos químicos: el hidróxido de sodio y el hidróxido de calcio. El primero es señalado por la literatura desde inicios de siglo como un agente capaz de elevar la digestibilidad de residuos lignocelulósicos (Beckman, 1921) y el segundo, aunque se trata de

una base débil y de poca solubilidad, presenta la ventaja de hacerse disponible en Cuba y otros países que no producen el hidróxido de sodio. Los resultados de esta primera prueba (Cuadro 1) indicaron que el $Ca(OH)_2$ no ofrece posibilidades para lograr un aumento de digestibilidad apreciable, evidenciando el hidróxido de sodio su superioridad con este fin.

Una posibilidad que brindan las fábricas de azúcar es tener disponible presión de vapor, la cual ha sido probada como medio de predigestión del bagazo y del bagacillo. En el Cuadro 2 se muestran los resultados. Estos resultados coinciden con los anteriores, es decir, la digestibilidad aumenta con el nivel de hidróxido de sodio empleado. Sin embargo quedaron descartados bajos niveles de presión para lograr un incremento adecuado de digestibilidad.

Para descartar el efecto combinado de ambos factores, se realizó una prueba con 3 niveles de hidroóxido de sodio y tratamiento con 3 presiones (Cuadro 3).

Se concluyó que el efecto del nivel de hidróxido de sodio es más importante que el nivel de presión. No obstante, a medida que el nivel de NaOH se incrementa, la aplicación de 4–6 atm resulta eficiente para situar la digestibilidad de estos materiales en un valor cercano al de los pastos de mediana a buena calidad (60 por ciento).

El objectivo de beneficiar con los tratamientos de predigestión estos subproductos de la caña de azúcar es el de elevar la energía que para el rumiante se hace disponible a partir de ellos. Con esta finalidad se realizaron pruebas donde queda claramente establecido que el nivel de NaOH modifica significativamente los ácidos grasos volátiles disponibles a partir de bagazo y bagacillo (Cuadro 4).

Cuando se comparan estos valores, que son reflejo de la energía disponible para el rumiante, con los que caracterizan los pastos tropicales fertilizados y regados se observa que niveles

entre 6 y 8 por ciento de NaOH son suficientes para obtener un aporte energético similar al reportado por Reyes y Sutherland (1969) para gramíneas cultivadas y cortadas a intervalos entre 36 y 45 días de edad.

Este efecto sobre la digestibilidad y su expresión material, la producción de AGV totales, se debe a una profunda modificación de la composición química de los materiales lignocelulósicos tratados con hidróxido de sodio. En el Cuadro 5 se presentan algunos resultados de como influye en la composición química el nivel de NaOH y la presión, siendo significativa la disminución en el contenido de lignina y el aumento de los solubles, fundamentalmente. Por otra parte el efecto de la presión no fue significativo dentro de cada nivel de NaOH.

En base a estos resultados se diseñó una tecnología nacional para la fabricación de alimentos para la ganadería vacuna. En unos casos se empleó la variante de utilizar las mezclas de bagacillo/melaza urea y en otros se fabrica el bagacillo predigerido.

2. EFECTO DE LA MEZCLA CON FUENTES DE CARBOHIDRATOS DE FACIL FERMENTACION Y NITROGENO NO PROTEICO

De esta forma se formularon 2 alimentos, los cuales son utilizados comercialmente en todo el país. El primero, similar al CAMOLA, sin emplear predigestión y con una relación bagacillo: melaza/urea de 64:36, el segundo incorpora la tecnología de la predigestión y mantiene una relación bagacillo: melaza/urea de 85:15.

A partir de lo anterior es fácil sugerir que la predigestión no sólo es un medio para aumentar la digestibilidad del bagazo, sino para preparar fórmulas con similar valor nutritivo, empleando significati- vamente menos melaza, subproducto este último por el cual compite toda la industria fermentativa.

Vacas Lecheras

Para la confirmación a escala comercial del valor de estos dos alimentos se realizó una prueba en 4 lecherías con un total de 734 vacas F_1 Holstein x Cebú y se consideró la comparación entre 2 períodos consumiendo melaza/bagacillo/urea (A y B); un período con bagacillo predigerido (C) y un período con ensilaje de gramíneas (D). Los resultados fundamentales se muestran en la Figura 1.

La tendencia general fue a mejorar la producción de leche cuando los animales consumieron el bagacillo predigerido, manteniéndose la producción entre 5 y 7 litros con el bagacillo sin predigerir y entre 6,5 y 7,0 con el predigerido. Ambos tuvieron un comportamiento similar al ensilaje pero con la tendencia a ser menor la producción con la mezcla preparada con bagacillo sin predigerir. Como se puede observar los días de lactancia no favorecieron de forma ostensible a ninguno de los tratamientos.

Cuando los promedios de litros por vaca por día obtenidos en cada una de los períodos fueron los que aparecen en la figura, el comportamiento de los grupos de alta producción de esas mismas lecherías (1–100 días de lactancia) fue como se muestra en el Cuadro 6.

De nuevo se observó la tendencia favorable al bagacillo predigerido y al ensilaje superior al bagacillo sin predigerir. No obstante, con cualquiera de las mezclas de bagacillo empleados en función del potencial de los animales se alcanzaron entre 7 y 13 litros de leche aproximadamente. El resto del sistema fue común, y consistió en 4 horas de pastoreo y 0.45 kg de concentrado por litro de leche a partir del 5to.

A partir de estos resultados se generalizó la comercialización de estos dos productos y ya en su primer año los resultados se vieron confirmados y permitían concluír que la mezcla de

bagacillo predigerido es superior a la mezcla de bagacillo sin predigerir; que la primera sostiene niveles de rendimiento entre 9 y 14 litros en comparación con 6–10 litros la segunda y que ambas constituyen una posibilidad real de aumentar la producción bajo condiciones de alta carga y en las etapas de sequía cuando los pastos reducen su producción y es necesario reducir el horario de pastoreo.

Otra forma de utilización del bagacillo predigerido es como materia prima para la elaboración de concentrados completos. Este enfoque de trabajo ha sido desarrollado por el grupo de Puerto Rico desde finales de los años 60 obteniendo como resultado la posibilidad de disminuir el maíz de 64 a 18 por ciento en piensos para vacas lecheras (Randel, 1969; Randel, Carrero, Valencia, 1970). En Cuba utilizando bagacillo predigerido hemos obtenido los siguientes resultados. En el Cuadro 7 se muestra el comportamiento del rendimiento lechero antes de suministrarse un pienso preparado a base de bagacillo predigerido (30 por ciento) suplementando al pastoreo y en el período en que éste fue suministrado. Este trabajo se aplicó comercialmente en 30 vaquerías y más de 3.600 vacas en ordeño, obteniéndose un incremento en la producción del 8 por ciento. Las medias de rendimiento de las vaquerías oscilaron entre 3,9 y 10,7 antes de ser suplementadas y entre 4,8 y 11,3 después de ser suplementadas.

Novillas Lecheras y Terneros

Actualmente en Cuba la utilización del bagacillo predigerido mezclado con melaza y urea está dirigido a la alimentación de vacas lecheras y ganado en desarrollo. Para la confirmación práctica de los resultados en estas categorías se realizaron varias pruebas. Sobre un rebaño de 600 novillas Holstein que tenías acceso durante 4 horas al pasto natural, se realizó un muestreo de 2 grupos: uno suplementado hasta el momento de la inseminación y otro sin suplementar (Cuadro 8).

Como se observa, la suplementación ejerció un efecto muy significativo tanto en ganancia diaria como en el porcentaje de gestación y en el índice de repetición, siendo igual el porcentaje de inseminadas lo cual es un reflejo de que aún sin suplementación se logró una buena presentación del celo. El suplemento suministrado en la prueba fue de baja calidad (sólo 2,2 Mcal EM/kg de MS y 9 por ciento de P.B.), sin embargo, tanto su contenido en proteína natural como en fósforo fundamentalmente, fueron suficientes para que se evidenciaran las diferencias que se reportan.

Para probar la posibilidad de uso en terneros sometidos a crianza artificial, se tomaron 236 animales de diferentes edades y se sometieron a control. Se evidenció que la edad al inicio del consumo de bagacillo predigerido/melaza/urea no ejerció un efecto de significación oscilando la ganacia diaria entre 500 y 600 g/d. Si bien a las edades más tempranas el consumo de predigerido es de poca significación, en relación con los aportes del concentrado y la leche, el aporte del mismo va creciendo al aumentar la edad y desarrollarse tanto anatómicamente como fisiológicamente el rumen.

En esa misma instalación comercial fue comparado el sistema heno/leche/concentrado con el sistema bagacillo predigerido/leche/ concentrado. La Figura 2 muestra los resultados por sexo y son indicativos de que las ganacias mínimas se obtuvieron en machos y se situaron en 450 g/d, mientras las hembras crecieron a un ritmo de 650 g/d. En ambos sexos el comportamiento con bagacillo predigerido fue superior al heno, cuando éste no fue molido, lo cual no es práctica frecuente.

3. CONSIDERACIONES GENERALES

Experimentación con otros tratamientos físicos y químicos (radiaciones, amoníaco, etc) se ha realizado en los últimos 10 años con resultados variables. No obstante, ninguno de estos

programas de investigaciones ha tenido una salida comercializable hasta el momento. Algunos de ellos, como el tratamiento con amoníaco, resultan promisorios. Sin embargo, es necesario esperar más información sobre sus posibilidades de implementación tecnológica. La experiencia anterior permite establecer que por distintas vías la disponibilidad de energía del bagazo y delo bagacillo de caña para ser utilizado como alimentos, puede ser elevada hasta cerca de 60 por ciento de digestibilidad. Una vez en ese punto las formas de utilización en el animal no deben diferir a las obtenidas en condiciones comerciales en Cuba donde desde hace años, más de 600,000 animales consumen estas mezclas en el período seco.

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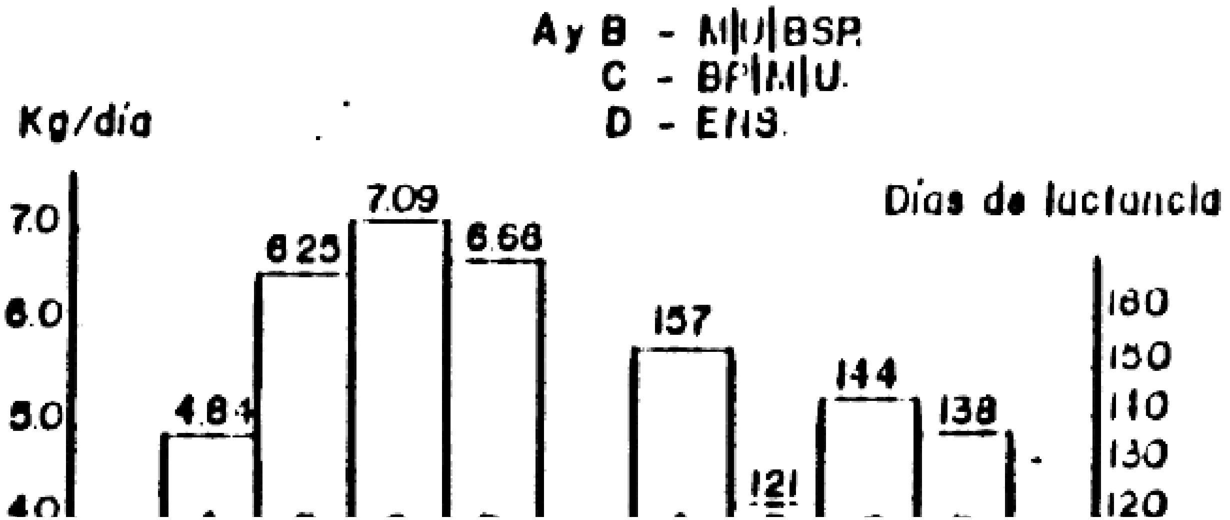
Figure 1: Rendimiento Lechero y dias de Lactancia segû sistema de alimentación en cuatro vaquerias



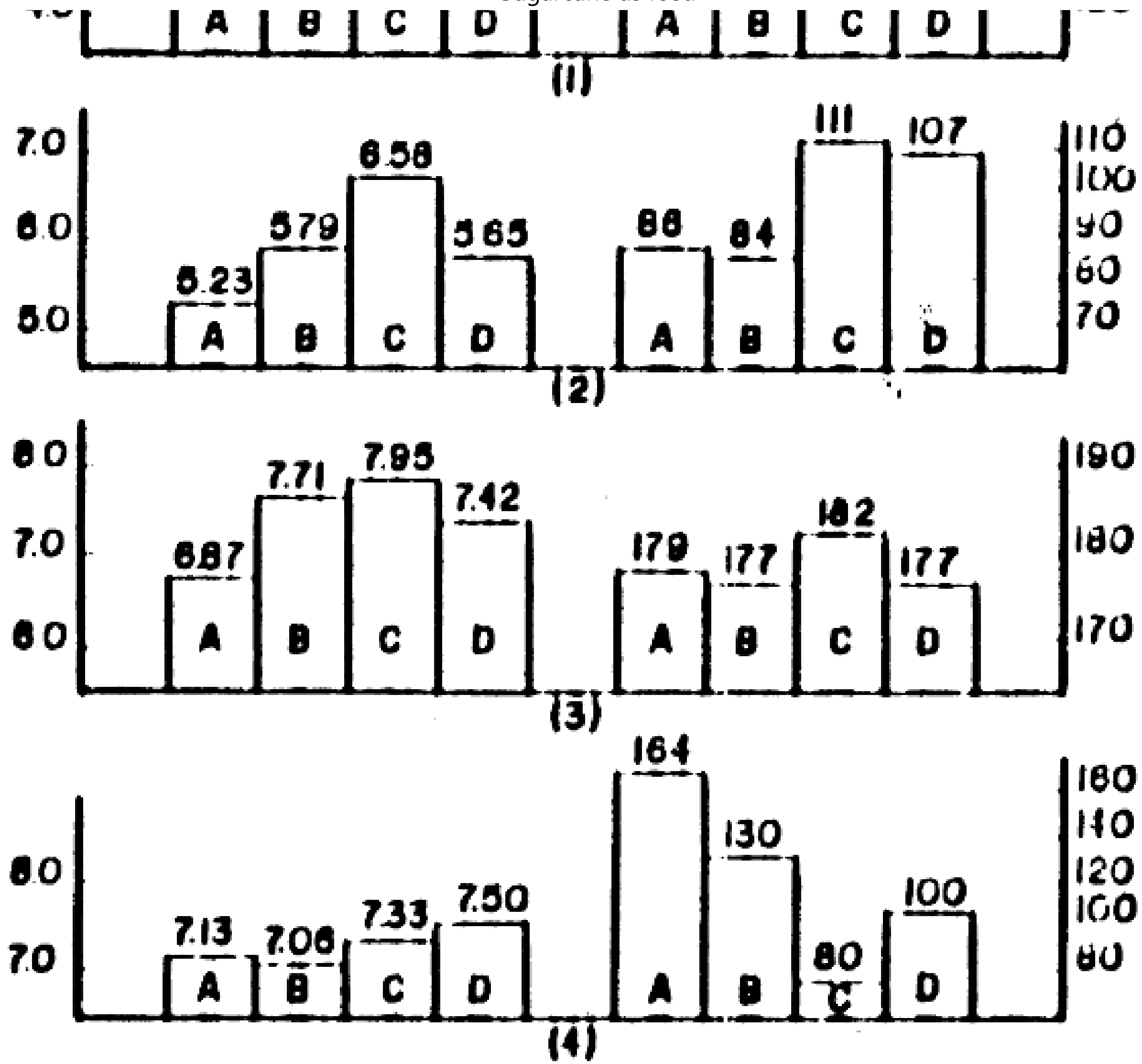
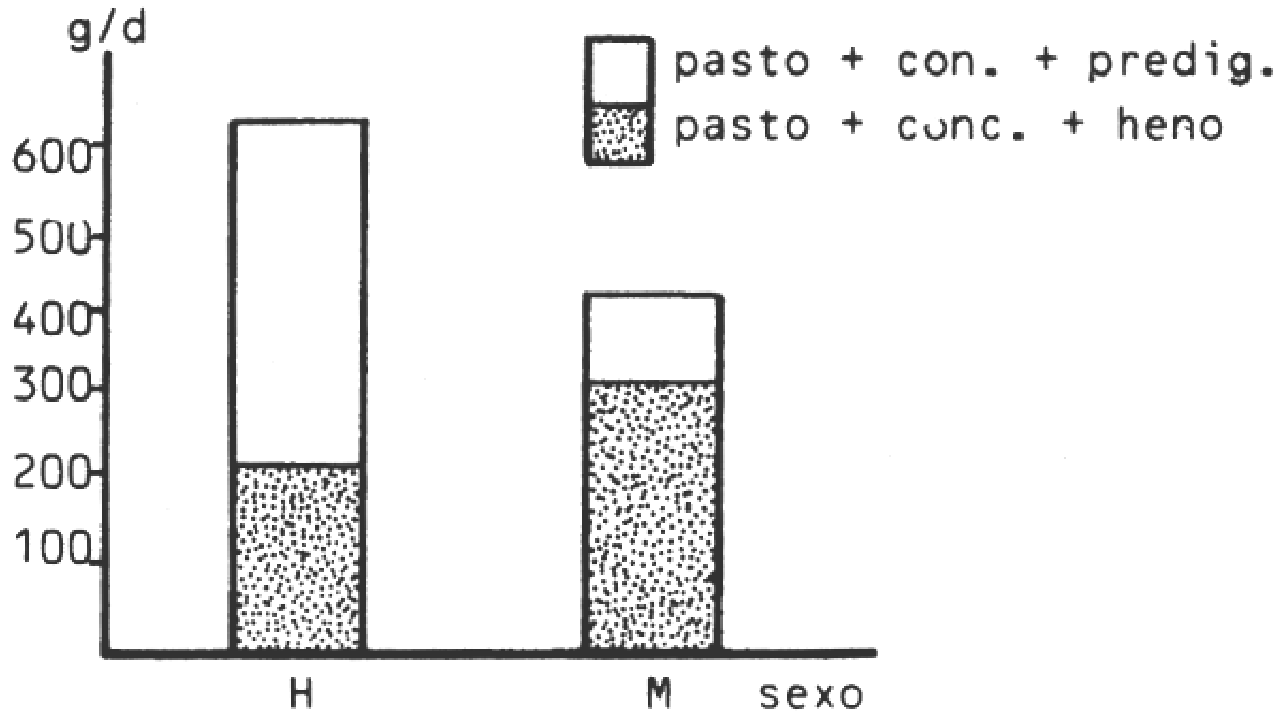


Figure 2: Efecto del sexo sobre el comportamiento de terneros en 2 sistemas de alimentación



Cuadro 1: Efecto del NaOH ó $Ca(OH)_2$ sobre la digestibilidad in situ -de la materia seca (Martin, Cribeiro, Cabello, Elias, 1974).

Tratamiento	Digestibilidad in situ MS %	
	Bagazo	Bagacillo
Testigo sin tratar	9,2	3,8
3% NaOH	25,9	33,3
6% NaOH	46,6	59,0
14% NaOH	77,0	78,8
8% $Ca(OH)_2$	40,5	10,7
16% $Ca(OH)_2$	44,0	43,1

Cuadro 2: Efecto del NaOH ó la presión sobre la digestibilidad in vitro de la materia seca (Martin

Cuadro 2: Efecto del NaOH o la presión sobre la digestibilidad in vitro de la materia seca (Martin, Cribeiro, Cabello, Elias, 1974)

Tratamiento	Digestibilidad in vitro MS %	
	Bagazo	Bagacillo
Testigo	11,4	20,5
4% NaOH	32,5	48,6
5% NaOH	37,7	53,6
6% NaOH	57,0	57,2
8% NaOH	63,3	66,9
12% NaOH	77,2	78,4
4 atm 15 min	28,3	21,4
4 atm 30 min	30,1	21,2
6 atm 15 min	24,9	35,4
6 atm 30 min	44,9	60,0

Cuadro 3: Efecto de la combinación NaOH-presión sobre la digestibilidad in vitro de la materia seca (Martin, 1976).

Tratamiento	Digestibilidad in vitro MS%	
	Bagazo	Bagacillo
Testigo	11,4	24,0
4% NaOH - 2 atm	35,2	56,9
4% NaOH - 4 atm	44,1	57,9
4% NaOH - 6 atm	45,5	60,1
5% NaOH - 2 atm	46,9	61,4

5% NaOH - 4 atm	52,1	64,5
5% NaOH - 6 atm	56,9	67,6
6% NaOH - 2 atm	58,2	67,0
6% NaOH - 4 atm	59,1	67,4
6% NaOH - 6 atm	61,7	72,7

Cuadro 4: Efecto del NaOH sobre la producción in vitro de AGV-totales (Martin, Cabello, Elias, 1977)

Tratamiento	**AGV - Totales, meq/g MS**	
	Bagazo	**Bagacillo**
Testigo	1,37	1,81
4% NaOH	2,35	2,75
5% NaOH	2,92	3,25
6% NaOH	3,73	3,57
8% NaOH	4,74	3,92
12% NaOH	5,60	4,63

Cuadro 5: Efecto del NaOH y la presión sobre la composición quimica - (Martin, 1976)

% NaOH	**0**	**4**			**5**			**6**		
Presión, atm	0	2	4	6	2	4	6	2	4	6
Solubles	5,8	20,3	20,2	17,5	18,5	18,5	27,0	26,5	31,4	29,1
Lignina	22,6	11,5	12,2	13,0	8,0	11,4	10,6	10,7	10,7	14,8
Cenizas	5,3	9,1	8,6	7,7	8,6	8,2	9,8	10,2	10,6	9,8

Cuadro 6: Comportamiento de los grupos de alta producción en lecherias bajo diferentes periodos de

alimentación[1].

kg/vaca/dia	A	B	C	D
Vaqueria 1	8,4	8,1	9,9	8,9
Vaqueria 2	7,4	7,2	7,4	7,8
Vaqueria 3	11,2	11,5	12,8	13,7
Vaqueria 4	10,2	8,5	8,9	8,8

[1] A y B: Bagacillo sin predigerir/melaza/urea; C: bagacillopredigerido; D: ensilaje.

Cuadro 7: Efecto de la suplementación con concentrado a partir de sub-productos de la caña de azúcar en la producción de leche

Granja	Lts/vaca anterior	Lts/vaca suplement.	No. de lecherias	No. de vacas
SC	10,69	11,27	5	550
FI	8,68	9,52	6	475
VE	9,78	10,07	7	630
SE	7,30	7,63	6	897
CA	3,90	4,78	6	1 068

Cuadro 8: Comportamiento de novillas Holstein consumiendo bagacillo - predigerido.

Medida	No suplementadas	Suplementadas
Ganancia de Peso Vivo, kg/dia	0,295	0,586
% de inseminadas	85	85
% de gestadas	66	82
% de repitentes	35	23

BAGASSE FOR RUMINANT FEEDING
by
P.C.Martin

Treatment of bagasse and bagacillo with pressure and NaOH has been tried and its effect on composition and nutritive value studied. Two feeds are formulated for commercial use in Cuba based on treated or non-treated bagacillo together with molasses urea and minerals. They are used for feeding young bulls, heifers and milk cows. Treatment of bagasse and bagacillo improved its chemical composition, diminishing by 14 units its lignine percentage and augmenting by 40 units its digestibility. Also treatment augments 2.2 times the production of total VFA per gram of dry matter. The mixture of bagacillo/molasses/urea as basic diet can support in growing cattle a daily liveweight gain of 400–600 grams and 8–10 litres of milk per cow per day. When the diet was based on treated bagacillo/molasses/urea, the daily milk production rose by 8%. Neither the composition of the milk nor the animal health were affected by this feeding system.

It is suggested that the implementation of technologies in favour of bagasse permits producing feeds capable of diminishing the effects of drought and guaranteeing a medium level of animal production.

SUGARCANE IN ANIMAL FEEDING IN JAMAICA

by

P.G. Jennings

INTRODUCTION

The Jamaican sugar industry, despite significant contraction during the last two decades, continues to be the major agricultural sub-sector of the Jamaican economy. Export earnings from the sugar industry in 1985 were of the order of US$70 million which represented approximately ten percent of total export earnings or 56 percent of earnings from agricultural exports. The decline in the industry since the peak year of 1965 might be seen from the reduction in total land area devoted to sugarcane production from 60 700 ha to 37 000 ha in 1985, the latter representing approximately seven percent of the country's arable land. Despite its waning fortunes the industry remains an important stabilizing factor in the Jamaican economy directly employing some 50 000 persons with a further estimated 200 000 dependents (i.e. one-eighth of the Jamaican population is supported by the industry).

The industry has been affected by a lack of any sustained capital development over the last decade as lands have been reallocated to more economically attractive enterprises. It has been conceded by sugar interests, however, that of the present 37 000 ha planted to sugarcane approximately 20 percent still represents marginally productive land which might find more economic alternative usage (Shaw, 1986). With existing technology it would still be possible to meet current market requirements of approximately 225 000 tonnes sugar even with this further reduced acreage by increasing yields of cane to 80 tonnes per hectare. Livestock production from the marginal sugar lands has long been suggested as an option in the diversification of the industry.

CURRENT LEVELS OF OUTPUT AND UTILIZATION AS FEED

The total quantity of sugarcane milled at the nine factories in operation during the 1985 crop was 2.2 million tonnes which was converted to approximately 206 000 tonnes of sugar, 78 000 tonnes of molasses and 336 000 tonnes of bagasse. (Falloon, SIRI, personal communication).

Bagasse: With the decline in the industry, bagasse has become virtually unavailable as a feed material as most of it is used in situ for fuelling factory boilers. The feeding of bagasse, as poultry litter, still continues, however, particularly among small beef producers in combination with other low cost feed materials such as wet brewer's grains and molasses.

Molasses: The availability of molasses to the farmer has drastically declined in recent years. However, it continues to be the most widely used sugarcane byproduct in livestock feeding, largely through its use in the compound feed industry, which in 1985 has accounted for approximately 22 percent of the total output of molasses. Much of the remainder have been used in alcohol production, direct export of molasses having declined substantially during the last ten years.

Cane tops: The practice of cane burning on most estates has reduced the availability of sugarcane tops as a feed source. Nevertheless cane tops remain an important dry-season fodder for small livestock farmers in close proximity to cane farmer's holdings. It is unlikely, however, that any significant technology could be developed around the use of cane tops due mainly to the problems of collection and transportation of this material from the fields. Even on larger farms where burning is not carried out, cane tops have an important role as a soil conditioner which virtually precludes their availability locally, as a feed source.

Other byproducts: Recent developments involving the testing of the cane separation

technology by the Sugar Industry Research Institute (SIRI) in conjunction with CIDA indicate that this process has potential to contribute significantly to the livestock industry. The finely divided pith remaining after juice extraction has been tested at Bodles as a ruminant feed in conjunction with the Faculty of Agriculture, McGill University. This pilot project is being expanded to a semi-commercial operation with assistance from the West German Organization for Technical Cooperation (GTZ).

RECENT DEVELOPMENTS IN THE USE OF SUGARCANE AND BYPRODUCTS AS FEEDS

Whole cane and tops, have been an important traditional dry season feed for ruminants in Jamaica, particularly by farmers operating within or adjacent to cane-growing areas. Research on sugarcane feeding, however, is relatively recent with much of the effort commencing during the late-1960/early 1970 period. Large-scale commercial feeding of whole cane or byproducts, except for molasses used in the feed manufacturing industry, has been slow in development.

Research investigations

Much of the research into sugarcane feeding has been conducted at the Ministry of Agriculture's Bodies Agricultural Station and has largely been confined to studies with beef cattle. Archibald and Osuji (1981) have, however, described a study of chopped whole cane as feed for dairy cattle on a commercial farm.

The earlier work with beef cattle at Bodles has been reported by Dixon (1978). This work assessed the value of derinded sugarcane (‘sugar fith’) or chopped whole cane in conjunction with hay or cane tops, supplemented with protein and minerals, as feed for fattening cattle. Both feeds supported similar levels of average daily gain of the order of 1 kg per day and it was suggested that the added cost of producing ‘sugar fifth’ made its use less economical

than that of chopped whole cane.

Molasses at levels well above conventional inclusion rates in commercial feed mixes has also been studied as a feed component along with other locally produced ingredients in feed mixes for finishing meat goats (Johnson, 1983). In four rations, inclusion rates of molasses ranged between 35 and 50 percent. It is significant that the researcher reported no adverse effects on the keeping quality of the rations, although at the higher levels of molasses inclusion, a low incidence of fungal growth was noted on the bottom of the jute sacks containing these mixes. The observations on keeping quality have important implications for increasing the use of molasses in the feed milling industry as an energy substitute for imported corn.

The most recent investigations involving the feeding of sugar cane derivatives have been based upon the evaluation of sugarcane pith after juice extraction in the cane separation process referred to earlier. The untreated pith has been compared with hay as the roughage (at 27 percent inclusion) in complete feeds for performance testing of dairy bulls (Gordon and McDonald, 1984, unpublished). Tables 1 and 2 display respectively the composition of the rations compared and the performance of the animals. The investigators reported no difference between hay-based or sugar pith-based rations or between rations based on home-mixed or commercial concentrate with animals gaining on average 1.1 kg per head per day.

Recent commercial developments

The application of research findings on the value of sugarcane as feed by the livestock industry has been slow. Recently, however, a commercial feedlot project based on sugarcane feeding was initiated, the success of which could have an important bearing on the expansion of the livestock industry based on an increased use of sugarcane as feed. This project was initially developed in 1983 to fatten 1300 head of cattle annually for the local butcher trade

using a high-forage feedlot system based on the feeding of whole cane either freshly chopped or as silage. The ensiling process is based on the 'Ag-Bag' system whereby up to 150 tonnes of silage are ensiled in individual plastic containers. The project was established on a former sugar estate and had 140 ha of sugarcane available at the outset. Weaners are supplied from the farm's breeding herd augmented by purchases from other farms. Animals are introduced at 200 kg liveweight and finished at 400 kg. Initially, animals were offered a complete diet based on sugarcane which comprised approximately 86 percent of total ration (fresh weight). Target average daily gain was 0.78 kg per head at an estimated cost of J$2.52 (US$0.46) per kilogram of gain. Average daily gains of up to 1 kg per head have been reported. There has been, however, very wide variation in liveweight gains, due mainly to inclement weather conditions which affected the feeding conditions in most pens. At present, forage sorghum and milo are being introduced as alternative forages of higher feeding value which would reduce the fattening period and allow a higher annual turnover of animals.

THE POTENTIAL FOR INCREASING THE USE OF SUGARCANE AS FEED

The livestock sector has been targeted for sustained increases over the next ten years in the current national drive for food self-sufficiency. A major plank of the policy of self-sufficiency in livestock products is a shift from the current dependence on imported feed ingredients to an industry based upon maximum use of locally produced feeding materials. In 1985 over 100 000 tonnes of corn and 47 000 tonnes of soya were imported at a total cost of approximately US$22 million.

The dairy industry represents the area of greatest priority in the self-sufficiency programme for the livestock industry and it is probably in this area that the greatest potential exists for increasing the use of sugarcane as feed. Current annual production of milk, at approximately 45 million litres, represents only about 11 percent of estimated requirements. This production

is from approximately 19 000 ha and any meaningful increases in production in the short run would require almost a quadrupling of pasture land, assuming current levels of productivity.

As previously indicated, approximately 7 400 ha of current sugar lands at minimum could be diversified without reducing the capacity to meet existing market requirements. Assuming a carrying capacity of 10 animal units per hectare this resource offers the potential for trebling the present dairy cattle population. Even at the present relatively depressed economics of dairying the net returns per hectare from milk production based on feeding of whole cane at 10 cow units per hectare would outstrip current returns from sugar.

Much of the previous research work on sugarcane feeding has been confined to studies on beef cattle. The viability of any expansion in the dairy industry based on sugarcane feeding will require further research on the year-round feeding of cane and particularly on a thorough evaluation of sugarcane silage supplemented with other indigenous materials for milk production.

With respect to other livestock enterprises the feasibility of sugarcane feeding as an alternative to sugar production is less attractive than dairying. At present lending rates, new investments in other types of ruminant production are less likely unless geared toward the export trade. There is, however, still great scope for increasing the levels of utilization of sugarcane byproducts such as bagasse and molasses. The feasibility of animal feeds developed from the cane separation process will need to be rigorously assessed if this is to compete with charcoal which is viewed as an alternate option for the dehydrated pith.

CONCLUSION

The sugar industry is uniquely equipped to contribute to the development of the Jamaican

livestock industry in that much of the logistical problems associated with utilizing other indigenous sources of feed are absent. Additionally, a large body of research data on its potential as animal feed is available within the region and awaits commercial application. Within the sugar industry the technology exists for sustaining or even increasing current levels of production while reallocating substantial land areas to alternative agricultural enterprises.

The harnessing of this potential in the development of the livestock industry will require reorientation in national priorities to ensure that this industry contributes maximally to national development.

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Table 1: Formulation of complete diets including juice extracted pith, Bodies 1984

Ingredients	Diet 1	Diet 2	Diet 3	Diet 4
Commercial mix	-	73	-	73
Wheat middlings	40	-	40	-
Soya Meat	20	-	20	-
Molasses	10	-	10	-
Oil	2	-	2	-
Minerals	1	-	1	-
Sugar pith	27	27	-	-
Pangola hay	-	-	27	27

Source: Gordon and McDonald (1984) Unpublished

Table 2: Performance of bulls fed pith or hay based diets

	Over 134–day trial			
Parameter	**D1**	**D2**	**D3**	**D4**
Ave. D.M.I. (kg)	7.3	7.3	7.4	7.4
Ave. daily gain (kg)	1.10	1.15	1.09	1.06
F.C.E. (kg/kg)	6.64	6.35	6.79	6.98

Source: Gordon and McDonald (1984) Unpublished

ESTUDIO MONOGRAFICO: UTILIZACION DE LA CAÑA DE AZUCAR COMO PIENSO EN JAMAICA

por

P.G. Jennings

La industria del azúcar sigue siendo el subsector agrícola predominante en la economía de Jamaica, ya que en 1985 aportó más de 70 millones de dólares en concepto de ingresos de exportación y dio empleo a 50 000 personas.

Aunque desde hace tiempo se considera que la producción comercial pecuaria representa una alternativa viable al azúcar en los cañaverales marginales, ha habido pocas novedades en este sector. Sin embargo, tradicionalmente la caña ha aportado una contribución a la producciópecuaria. Aproximadamente el 22 por ciento de la producción total de melaza, que es el principal producto utilizado por la industria ganadera, se utiliza en la fabricación de piensos compuestos. La disponibilidad de otros subproductos como el bagazo y los cogollos de caña está limitada por la contracción de la industria. Estudios experimentales de la técnica de separación de la caña realizados recientemente han demostrado también la viabilidad técnica de utilizar la médula a la que se ha extraído el jugo como componente de piensos completos para rumiantes.

Se dispone de una base considerable de datos sobre la alimentación animal a base de caña procedentes de otras investigaciones llevadas a cabo en Jamaica y en la región. Sin embargo, su aplicación comercial ha sido lenta.

La tendencia actual de los países a la autosuficiencia alimentaria da nuevo relieve al gran potencial de expansión de la industria ganadera basada en la alimentación durante todo el año a base de caña mediante una redistribución de las tierras que actualmente se utilizan de manera poco rentable para la producción de azúcar.

UTILIZACION DEL JUGO DE LA CAÑA DE AZUCAR PARA LA ALIMENTACION ANIMAL: SINOPSIS

por

A. Mena

La crisis económica mundial y muy especialmente de América Latina y el Caribe, exige la necesidad de aprovechar en una forma más amplia y con mayor eficiencia el uso de recursos nativos que tiene cada país.

La caña de azúcar es el principal cultivo agrícoloa de la República Dominicana y de otros países tropicales. Sin embargo, la industria azucarera tradicional padece de enormes problemas actualmente debido a la sobreproducción mundial de azúcar respecto a la demanda. En consecuencia, los precios del producto en términos reales son los más bajos en mucho tiempo. Las perspectivas para que esta situación se mejore no son tan alentadoras, especialmente en los paises tradicionalmente exportadores de azúcar al mercado mundial.

Una solución pudiera ser el sustituír la caña por otro cultivo que rinda productos de mayor demanda en el mercado, tal como la Palma Africana. Sin embargo, no debe olvidarse que la caña es el rey de los cultivos tropicales, produciendo más biomasa por unidad de superficie y con mayor eficiencia en cuanto a la captura de energía solar con respecto a cualquier otra planta. Además, tiene la ventaja de ser perenne, adaptable casi a cualquier suelo, resistente a las plagas, no provoca erosión y necesita pocos insumos de origen fósil.

Lo que se necesita es buscar una mayor diversificación en el uso de la caña de azúcar, utilizándose la misma para otros propósitos además de la elaboración de azúcar, que será en el futuro únicamente para llenar las necesidades de consumo interno de cada país.

Preston (1980) planteó un modelo generalizado para el aprovechamiento de la caña de azúcar por el proceso de fraccionamiento tradicional a través de un trapiche sencillo, con el fin de usar el jugo en la alimentación de animales de alta demanda nutricional (ej. cerdos, aves y ruminantes en la fase de crecimiento precoz y/o lactancia) y la fibra (incluyendo el jugo residual) como combustible. Luego se agregó otra alternativa de usar el bagazo junto con el cogollo como alimento de rumiantes mayores en menor demanda nutricional (hembras de levante y vacas) y/o para rumiantes menores con alta capacidad selectiva (cabras y ovejas), con la finalidad de que ellos pudieran aprovechar la médula, más rica en azúcares, dejando la fibra dura de la corteza para usarse como combustible y/o cama para las aves.

Extracción del jugo de caña

Para extraer el jugo se prensa el tallo de la caña en un molino o trapiche, que es una máquina compuesta de tres rolos superpuestos configurados en forma horizontal o vertical. Los trapiches se mueven con motores eléctricos o de gasolina (o petróleo); también se utiliza el tiro animal.

El uso de trapiches es una tecnología muy sencilla que ha sido utilizada desde hace muchos años para la obtención de panela o piloncillo principalmente en las zonas menos desarrolladas. A nivel de pequeño productor lo aplicable es el uso del trapiche vertical tirado por animales (caballos, bueyes e incluso vacas). En la República Dominicana hay talleres que fabrican trapiches, además se importan de Brasil y Colombia. En algunos países tropicales se dispone

de trapiches que han permanecido sin uso en fincas, por generaciones.

La eficiencia de extracción se mide en términos del peso de la caña que se recupera en jugo. En promedio, esta cifra es de alrededor del 50 por ciento y cambia según la variedad de la caña utilizada, el ajuste del trapiche y otros diversos factores como el clima, manejo, etc.

En la industria azucarera la eficiencia de extracción se mide en términos diferentes, por ejemplo el porcentaje de azúcar total que se extrae y/o el porcentaje de la caña que se convierte en azúcar cruda. Algunos datos comparativos se presentan en la Figura 1. Obviamente, la extracción de azúcar es menor en el trapiche, que produce panela o alimento animal, que en el sistema del ingenio. Sin embargo, requiere menos inversión con muy bajos costos operativos.

Conservación de jugo de caña

El jugo de caña se fermante en un lapso de 10–12 horas, dependiendo de la temperatura; cuando ésto sucede los animales no consumen jugo. Sin embargo, existen aditivos en el mercado que permiten la conservación del jugo. Bobadilla y Preston (1981), demostraron que el jugo se puede conservar con formalina (formaldehido al 30 por ciento) usando niveles desde 0,01 hasta 0,06 y conservando hasta 72 horas. Duarte (1981) evaluó niveles de Hidróxido de Amonio (Amoníaco NH_3), logrando período de conservación de 6 días a partir del nivel de 1,5 por ciento (v/v). Santana y Jiménez (1985), utilizaron Benzoato de Sodio (0.15 por ciento), logrando conservar el jugo por un período de 7 días, lo que sería muy importante para productores que poseen poca mano de obra, ya que la conservación le permitiría maximizar la mano de obra, además de que el Benzoato de Sodio se puede adquirir con facilidad en el mercado.

Alimentación de novillos con jugo de caña

No se ha difundido a escala comercial el uso de jugo de caña en la ceba de novillos, sin embargo, los trabajos de investigación realizados en este renglón muestran al parecer que es posible en dietas basadas en jugo de caña lograr niveles de comportamiento animal en el trópico comparables con aquellos obtenidos en condiciones óptimas de alimentación y manejo de países templados (ver Cuadro 1). En cuanto al uso de jugo en animales en producción de leche, hay alguna tendencia a su utilización por los productores, sobre todo en los últimos meses cuando se ha incrementado el precio de la melaza, disminuyéndose el uso de ésta e incrementándose el de la caña directamente en la alimentación de rumiantes.

Alimentación de cerdos

La primera fase de las investigaciones se hizo en México, en la Estación Experimental de la Facultad de Medicina Veterinaria y Zootecnia de la Universidad de Yucatán, con el propósito de comprobar la hipótesis que fuera factible para engordar cerdos en una dieta cuya fuente de carbohidratos era jugo de caña. El ensayo se realizó con tres grupos de cerdos de peso inicial de 40, 50 y 60 kg. La dieta básica era jugo de caña fresco complementado con un suplemento proteico en base a torta de soya. Este suplemento se dió en cantidades suficientes para cubrir las necesidades de proteína según las recomendaciones del NRC (1979). El jugo fue extraído de la caña de azúcar dos veces al día y se ofreció a voluntad. El cuarto grupo recibió una dieta testigo en base a grano de sorgo y torta de soya.

Los resultados de este ensayo se presentan en el Cuadro 2. No hubo diferencias significativas entre los tres tratamientos con jugo y todos tendieron a ser mejores que el testigo, especialmente con respecto a la conversión alimenticia.

La segunda fase del programa se llevó a cabo en la República Dominicana, en el Centro de Investigaciones Pecuarias (CENIP) y en fincas privadas, con la finalidad de validar la tecnología y aplicarla en el sector comercial. Los resultados indicaron un nivel de comportamiento animal similar, y en algunos casos superior en comparación con animales recibiendo dietas tradicionales; sobre todo en animales en crecimiento y engorde, lo que ha permitido el uso a nivel comercial por muchos productores.

La mayor experiencia en el uso de jugo de caña es lógicamente en animales en las fases de crecimiento y engorde. El Cuadro 3 muestra los consumos promedio determinados por medio de un gran número de trabajos de investigación realizados en Estaciones Experimentales y Fincas de Productores. El consumo de jugo dependerá de factores como variedad de caña, época del año, cantidad de suplemento proteico ofrecido a los animales.

El Cuadro 4 muestra el comportamiento de cerdos alimentados con jugo fresco y conservado. Encontrándose diferencias significativas entre tratamientos, lográndose mayor ganancias en el tratamiento donde se usó jugo conservado.

También se ha estudiado el uso de jugo de caña en reproductoras (véase el Cuadro 5) lográndose mayor tasa de concepción y lechones más pesados al nacimiento y al destete.

El jugo de caña se compone casi en su totalidad de carbohidratos en forma de azúcares. Por lo tanto, se requiere el uso de suplementos proteicos que puedan suplir las necesidades de proteína en las diferentes etapas de producción.

Generalmente, los productores compran un suplemento comercial con un 40 por ciento de proteína, constituído fundamentalmente por torta de soya, que es caro (representa entre 40 y 50 por ciento del costo total de la ración) y tiene que ser importada. Por lo tanto, el actual

enfoque de la investigación es sustituír la torta de soya con fuentes locales de proteína, especialmente los follajes de cultivos y de leguminosas. Se ha logrado cierto éxito con el uso de hojas secas de yuca, de batata y de leucaena, sustituyendo hasta 30 por ciento del aporte proteico, sin afectar la tasa de comportamiento del animal. Las perspectivas en este campo son muy promisorias, pero se necesita más investigación antes de poder hacer recomendaciones concretas.

La otra alternativa es la de reducir los niveles de proteína en las raciones de cerdos para el mercado, con la finalidad de producir animales con mayor cantidad de grasa, lo cual también constituye un serio problema en los países en vías de desarrollo, ya que se ven en la necesidad de hacer grandes importaciones de grasa. El Cuadro 6 muestra resultados de experimentos donde los cerdos recibieron niveles de proteína inferior a los recomendados por los Estándares Alimenticios.

Al parecer es factible desde el punto de vista biológico reducir los nivels de proteína en las raciones de cerdos en finalización, pero es más atractivo si tomamos en cuenta la parte económica, ya que el suplemento en todos los casos es el componente más costoso.

Alimentación de aves

Hasta el presente en esta área se ha considerado que son los patos las aves que más se ajustan a una dieta líquida como el jugo. Sin embargo, en dietas de pollos de engorde se ha logrado sustituír un 40 por ciento de la ración diluyendo el jugo con agua y hasta un 60 por ciento al suministrar el jugo puro a voluntad en bebederos (Mena 1986, datos ineditos). Al iniciarse esta observación los 20 pollos tenían 5 semanas de edad y un peso de 1,106 kg. Al final tenian un peso de 2,060 kg (ganancia: 46 g/dia). El consumo diario era de 491 g de jugo fresco y 79 g de suplemento proteico (40 por ciento PC) sea un consumo total de 169 g de

MS/dia. La tasa se conversion era de 3.67. Estos resultados indican que es factible la sustitución de granos por jugo de caña, aunque ameritan investigación. La sustitución de granos por jugo de caña es el enfoque que se está dando actualmente a los trabajos de investigación, dadas las posibilidades de desarrollar esta alternativa para el uso del jugo de caña en esta especie.

USO DEL BAGAZO

El bagazo que queda después de la extracción del jugo de caña es rico en azúcares y el 50 por ciento está constituído por médula que bien puede ser utilizada en la alimentación de rumiantes. En este orden, las primeras observaciones llevadas a cabo con caprinos indican que estos animales pueden seleccionar la parte medular del bagazo, pero también los bueyes pueden consumirlo directamente. Esta es, por lo tanto, una de las líneas que se deben desarrollar a la mayor brevedad dado que el bagazo constituye el cuello de botella del jugo de caña como alimento de monogástricos, aunque conocemos que hay varias alternativas que algunos productores aplican con mucho éxito.

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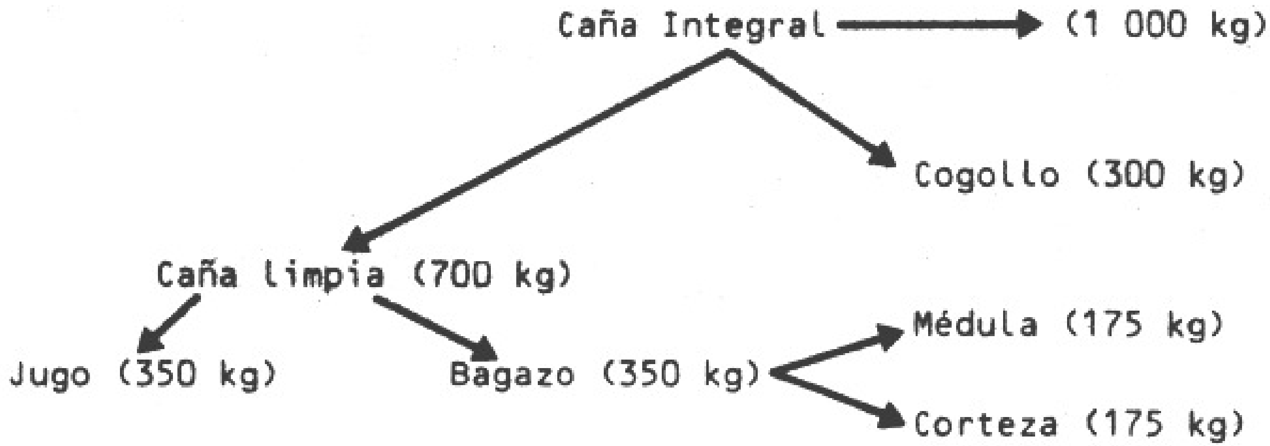
Figura 1: Fraccionamiento de la caña de azúcar



Cuadro 1: Sumario de trabajos usando jugo de caña y melaza como dieta básica en ceba de novillos

Peso inicial (kg)	Peso final (kg)	Ganancia (kg/d)	Consumo en base fresca (kg/d)				Total MS (kg/d)	Conversión
			Melaza	Jugo	Forraje	Suplem.		
279	300	0,252	3,95	-	9,90	NS	5,44	21,54[a]
266	304	0,545	4,00	-	10,00	S	6,42	11,78[a]
261	309	0,795	-	22,70	9,80	NS	5,85	7,42[a]
279	361	1,315	-	31,90	10,90	S	8,43	6,44[a]
182,5	277,5	1,035	-	18,5	4,2	S	4,7	4,60[b]
182	257	0,850	-	18,8	4,45	NS	4,35	5,27[b]

a
b Las cifras de la misma columna con diferentes superindices difierensignificativamente a p>0,05.

Cuadro 2: Comportamiento de cerdos en finalización, alimentados con jugo de caña fresco y suplemento proteico

	Tratamientos			Testigo
	40	**50**	**60**	
No. de animales	8	8	8	8
Peso vivo (kg)				
Inicial	37,6	49,3	58,9	41,8
Final	90,8	91,2	91,9	90,9
Ganancia (kg/dia)	0,614	0,729	0,776	0,590
Consumo (kg/dia)				
Jugo fresco	10,9	11,5	13,1	-
Suplemento1	0,77	0,81	0,96	-
Balanceado comercial	-	-	-	3,80
Consumo total de MS (kg/dia)	2,25	2,35	2,63	3,24
Conversión	3,55	3,30	3,42	5,49

Fuente: Mena (1981)

1 Composición del suplemento: torta de soya + minerales + vitaminas

Cuadro 3: Niveles de jugo y suplemento proteico (40% proteina) ofrecido a animales en diferentes etapas

Peso vivo (kg)	Consumo jugo (kg/a/d)	Suplemento proteico
10 – 30	3,8	0,600
30 – 60	9,5	0,700
60 – 100	10,8	0,975
Reproductora	8	0,680

Cuadro 4: Comportamiento de cerdos en crecimiento alimentados con una dieta básica de jugo de

caña fresco y conservado con benzoato de sodio

	Tratamientos	
	Jugo fresco	**Jugo conservado**
Peso vivo (kg)		
Inicial	31,9	33,2
Final	61,2	67,8
Ganancia (kg/dia)	0,601	0,707
Consumo (kg/dia)		
Jugo	11,0	10,9
Suplemento	0,678	0,678
Consumo total de MS (kg/dia)	2,70	2,40
Conversión	4,16	3,33

Fuente: Santana y Jiménez (1985)

Cuadro 5: Resultados con cerdas preñadas y lactantes alimentadas con diferentes fuentes alimenticias

Alimentos	No. de servi-cios	Tasa de concep-ción (%)	No. de crias nacidas	Peso de los lechones at nacer
Jugo de caña	25	92,0	8,28	1,47
Balanceado comercial	14	85,7	10,09	1,38

Fuente: Estrella, Mena y Uen (1984)

Cuadro 6: Niveles bajos de suplemento proteico en cerdos en finalización

	Suplementos proteicos, 40% PC (g/dia)

	454	681	908
No. de animales	12	12	12
Peso vivo (kg)			
Inicial	76,3	76,8	77,8
Final	105,2	105,8	106,6
Ganancia (kg/dia)	0,838	0,840	0,830
Consumo (kg/dia)			
Jugo	3,57	3,0	2,75
Suplemento	0,408	0,613	0,818
Consumo total de MS	3,98	3,61	3,57
Conversión	4,75	4,51	4,27

Fuente: Estrella, Uen y Mena (1986)

SUGARCANE JUICE AS ANIMAL FEED: AN OVERVIEW

by

A. Mena

Since sugarcane is the highest biomass producer, it could be envisaged to use it as a multipurpose crop, with an important role in animal production. The fractionation in a "trapiche" (traditional mill) in juice and fibre is the most recent development, using the juice as animal feed and the fibre for other purposes. The use of the trapiche is a long known technology for the production of panela (brown sugar). The extraction efficiency, expressed in the weight of juice produced from cane is about 50%.

No commercial cattle fattening enterprise uses the sugarcane juice yet but research has pointed out that results similar to cereals can be obtained.

Sugarcane juice as a substitute for cereals is used in the feeding of pigs on a commercial scale obtaining growth rate similar to diets based on imported cereals. But a protein supplement is necessary to satisfy the animal requirements. This supplement consists mainly of soya, which is imported, but it is envisaged to use protein from local sources (leaves). Results from experiments have shown that 30% of this imported component could be replaced by leaf protein. Furthermore it seems that the protein levels can be reduced at the end of the fattening period.

The conservation of sugarcane juice is another important factor. Since the juice ferments within 10–12 hours, it could be important occasionally to conserve it with 0.15% Sodium Benzoate. This will help to maximize the efficiency of labour on small farms.

Little is known about the use of sugarcane juice in poultry feeding but the first observations seem promising.

The bagasse coming from the trapiche still contains large quantities of sugar and it could be used in feeding sheep, goats and oxen, but more research is required.

In general it seems apparent that sugarcane juice offers a major potential as a substitute for cereals in pig feeding.

USO DE JUGO DE CAÑA PARA CERDOS EN UNA FINCA DE MEDIANO PRODUCTOR EN LA REPUBLICA DOMINICANA

por

G.M. Fernández

1. EL SISTEMA TRADICIONAL DE PRODUCCION PORCINA EN LA REPUBLICA DOMINICANA

La explotación porcina se llevó a cabo en la República Dominicana hasta 1978, utilizando una tecnología muy sencilla en la cría y ceba de cerdos criollos, muy rústicos pero de bajo valor genético y por consecuencia una pobre conversión de alimento en carne y grasa mal distribuidos, restando mérito a los animales que se traducía en precios más bajos para mercados exigentes.

Lo anteriormente expuesto no quiere decir el que no se importaran cerdos de pura sangre, principalmente verracos (padrotes), pero no se seguía un patrón científico en los cruzamientos y con excepción de algunas empresas de importancia los descendientes degeneraban rápidamente. En un pasado relativamente remoto, hasta la década de los años 1930 a 1939, la manteca constituía prácticamente la única fuente de grasa para cocinar. En aquel período habían criadores más o menos especializados y de cierta importancia. Unos soltaban las cerdas madres en potreros con palmas real (Roystonea hispaniolana), otros las encerraban en pocilgas y las alimentaban junto a los lechones con los desperdicios de cosechas y de la casa. Unos y otros, algún tiempo después del destete, encerraban los cerditos para cebarlos con maíz, fruta de palma real, yuca, batata y aguacates; los tres últimos aprovechando los excedentes en las épocas de recolección, prefiriendo desarrollar la capa para producir manteca o grasa.

Con la instalación de la primera fábrica de aceite de maní en el país la producción de cerdos

pasó por una crisis y paulatinamente los productores comerciales desaparecieron. La industria del cerdo se redujo al ámbito familiar (tanto que se le llegó a llamar "alcancía de pobre") con reducido número de animales y con una tecnología más sencilla que la anterior en los cruzamientos y la alimentación, dándosele preferencia a la obtención de carne en lugar de la manteca o grasa, es decir, objetivos contrarios a los perseguidos anteriormente. En 1978 se detectó la fiebre porcina africana en el país y el Gobierno dispuso la eliminación total de la población porcina para poder conjurar el problema y replobar de nuevo con animales de pura sangre de alto nivel genético.

Ya no era posible criar estos cerdos con los sistemas tradicionales del pasado y por tanto se hacía necesario confinarlos y buscar unas raciones alimenticias balanceadas a base de maíz, sorgo y harina de soya, coco, maní, ricas en proteínas.

Para agravar la situación, habían y persisten aún dos circunstancias fundamentales que encarecen la producción de cerdos.

1. **La balanza comercial del país es deficitaria y se hizo necesario dejar flotar el dólar para que el peso dominicano buscara su paridad real, la cotización se ha mantenido en los últimos meses a los tres pesos por un dólar.**

2. **Nuestro país no es autosuficiente en la producción de granos para preparar las raciones y por lo tanto tenemos que importar los déficits, lo cual se traduce en un costo muy alto para producir un kilo de cerdo, y a la vez influye en la cotización del dólar.**

Los hechos descritos más arriba nos obligaron a buscar soluciones que resultaran más económicas y evitaran en lo posible las costosas importaciones de granos para preparar las raciones alimenticias para los cerdos. En lo inmediato, nada nos ofrecía mejor perspectiva que

la caña de azúcar, cultivada con mucho éxito desde que Colón la trajo en su segundo viaje desde las Islas Canarias y que en el presente constituye nuestra más importante agroindustria.

2. LA PRODUCCION PORCINA BASADA EN LA CAÑA DE AZUCAR

De Felicio y Spers (1973) llevaron a cabo estudios en Brasil para reemplazar parcial o totalmente el maíz por jugo de caña fresco en raciones para cerdos.

Preston (1980) planteó la alternativa de fraccionar la caña de azúcar en jugo y fibra, procesando el tallo en un trapiche con la finalidad de utilizar el jugo en la alimentación de cerdos.

Mena, A. (1981) realizó con éxitos investigaciones para sustituír paracial o totalmente el maíz o sorgho por jugo de caña de azúcar en la dieta para cerdos.

Fermín D. (1983) concluyó en el Central Romana trabajos investigativos utilizando el jugo de caña de azúcar y raciones con diferentes niveles de melaza ofrecida ad libitum en la alimentación de cerdos. Los resultados han sido tan alagueños que esta tecnología ha tomado el lugar de la anterior para desarrollar una importante empresa porcina.

Estimulado por la necesidad de profundizar estudios, mi hijo (Fernández, R. 1985) desarrolló su tesis para optar por el título de Ingeniero Agrónomo en la Universidad Central del Este (UCE) sobre una Evaluación de Jugo de Caña de Azúcar más Concentrado Proteico versus alimento balanceado comercial en cerdos en crecimiento y engorde. El experimento se llevó a cabo en mi Hacienda Villa Gilda, ubicada en el centro de una zona productora de caña de azúcar en el poblado de Guerra, paraje Enjaguador, al nordeste de Santo Domingo a unos 35 km de distancia.

El estudio tuvo una duración de 98 días, comprendidos del 20 de Febrero al 28 de Mayo de 1984. En este experimento (Cuadro 1), al igual que los otros, se determinó que es muy factible el uso de jugo de caña de azúcar como fuente principal de energía (maíz, sorgo, etc.) en raciones para cerdos desde 16 kilogramos de peso vivo hasta el sacrificio (90–100 kilos) por resultar muy económico para el productor, a la vez de evitar la importación de granos con dólares escasos y caros, pero se recomienda la caña de azúcar en zonas cañeras tradicionales y donde ésta esté cerca, - hasta 8 kilómetros del criadero para permitir el transporte en carretas tiradas por bueyes.

Explotaciones de esta naturaleza, también tienen la ventaja de contribuír a la diversificación del uso de la caña de azúcar, cuyo futuro se perfila muy incierto en los mercados internacionales.

3. <u>EXPERIENCIA A NIVEL COMERCIAL</u>

En conocimiento de los resultados positivos de las investigaciones descritas en los párrafos anteriores, decidimos establecer una empresa mediana para la ceba de cerdos utilizando el jugo de caña de azúcar. Lo estamos haciendo en partidas de 120 animales en ciclos variables desde 80 a 90 días. Hasta la fecha hemos cebado 940 cerdos que han ido al matadero desde 90 kilos hasta 110 kilos de peso vivo. De esta cantidad hemos comprado 600 cerdos a distintos productores y 340 han sido producidos por nosotros.

Parte de los cerditos los estamos produciendo y estos comienzan a beber jugo de caña de azúcar desde los 10 días de nacidos. La otra parte de cerditos los compramos a criadores particulares, pero estos últimos, la experiencia nos ha enseñado que deben tener un peso vivo de 35 a 40 kilogramos. En este caso, el tiempo para llevarlos a los 90 a 100 kilos es menor de los 80 a 90 días.

En promedio, hasta ahora la pequeña empresa ha sido exitosa, porque:

1. **Mi hacienda está ubicada en el centro de una zona tradicionalmente productora de caña de azúcar, lo que nos garantiza un abastecimiento seguro durante todo el año.**

2. **La caña, a diferencia de los granos o alimentos balanceados no requiere almacenamiento, ya que el almacén es el campo y su traslado del campo a la finca es fácil, barato y en las cantidades que se requieren.**

3. **Se ha demostrado durante un largo período que el cultivo de la caña prospera bien en la zona y su cultivo es muy conocido por los campesinos. El cultivo de la caña de azúcar tiene la ventaja sobre el maíz y el sorgo de que es prácticamente permanente, renovándose cada 6 u 8 años, mientras que el maíz y el sorgo son cultivos de ciclos cortos de 3 a 4 meses y hay que renovarlos cosecha tras cosecha, lo que conlleva costos más elevados en preparación de terrenos, etc.**

4. **En estos momentos estamos comprando la caña de azúcar a razón de RD$20.00 la tonelada corta puesta en la finca contra RD$ 25.00 el CEA. También compramos la caña a la vista o sea parada en el campo, lo cual nos resulta más económica, teniendo dos o tres pesos por tonelada y a veces más. Nosotros no tenemos caña y la compramos a unos 26 pequeños colonos alrededor de la hacienda. Con este sistema de compra se benefician los colonos por que no tienen que vender su caña al CEA y esperar varios meses para cobrarla.**

5. **El jugo lo extraemos con un trapiche de fabricación local, accionado por un motor eléctrico de 5 H.P., y acoplado a un reductor, siendo la extracción de 50 por ciento, es decir, que de una tonelada de caña limpia obtenemos 1,000 libras de jugo y 1,000 libras de bagazo. Si el**

costo de RD$20.00 de la tonelada de caña lo sumamos a RD$6.05 por concepto de electricidad y RD$29.65 por tonelada molida de caña (ver Fernándes, R. 1985), o sea por cada 1,000 libras de jugo, lo que le da un costo de 0.03 centavos la libra de jugo. En trabajos realizados se ha demostrado que approximadamente 4 libras de jugo sustituyen una libra de maíz, el cual en los momentos actuales su costo promedio es de 0.25 centavos la libra.

Si consideramos el promedio de 4–5 libras de jugo por una de maíz obtendríamos la sustitución a 0.15 centavos, sin tomar en cuenta el monto que representa el cogollo y el bagazo.

6. **El bagazo que en cierto modo constituye para muchos productores un problema botarlo, para el caso nuestro utilizamos una gran parte de este en la alimentación (como fuente de fibras y carbohidratos) en los ovejos y novillas en crecimiento.**

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Cuadro 1: Comparación del jugo de caña con balanceado comercial.

	Tratamientos	
	Balanceado Comercial	**Jugo de Caña**
Número animales Peso vivo, kg	14	14
Peso inicial	16 ± 2.35	16.2 ± 2.10
Peso final	73 ± 9.63	91 ± 9.97
Ganancia kg/d	0.579 ± 0.092	0.775 ± .103
Tiempo en días	98 ± 00	97 ± 2.67

COMMERCIAL FEEDING OF PIGS WITH SUGARCANE JUICE IN THE DOMINICAN REPUBLIC

by

G.M. Fernandez

Until 1978 the traditional pig production in the Dominican Republic was based on locally available feeds from agricultural production.

However, after the detection of the African Swine Fever in that vear it was decided to eliminate all the pigs and to introduce after a quarantine period imported high producing breeds. These

breeds however could not survive or produce under the traditional system with the local medium quality feeds and so feeds had to be imported. As these feeds have to be paid in hard currency this posed many problems.

For this reason and also because of the low price of sugar, sugarcane juice as a substitute for cereals has been tried in the Dominican Republic with much success. This system was then introduced on a medium scale commercial farm.

Piglets of 40 kg were fed on a diet based on juice plus a protein supplement (soya based). In around 90 days pigs were finished at 90–100 kg liveweight.

This feeding system saves 15 centavos per day per pig compared to commercial concentrate. Since then around 900 pigs have been fattened in this system with satisfactory results. The farmer does not grow the cane himself but purchases it from about 25 small growers in the neighbourhood.
