PERSPECTIVES ON THE INTEGRATION OF LIVESTOCK PRODUCTION AND THE SMALL SCALE SUGAR INDUSTRY[1]

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The history of small scale sugar production in Mexico is reviewed together untie the limitations to its development. A system for integrating small scale sugar production and a livestock enterprise is proposed and the advantages of this to the small farmer are discussed. The flexibility of such a system is further demonstrated in an economical comparison of brown sugar production in the traditional manner or in the proposed integral system.

Key words: Review sugar cane, cattle, integrated systems

Introduction

One of the oldest technologies for producing sugar from sugar cane involves the milling of the cane by animal or mechanical power, the evaporation of juice in open pans and cold crystallisation of brown sugar. This technology has become progressively less used in cane producing countries of the Caribbean, but is still very important in India which is the top world sugar producer. In Mexico, although brown sugar supplies less than 1% of national sugar production, small scale sugar milling provides good employment opportunities in remote cane producing regions which produce cane from areas of only 2 or 3 ha, while the large mills require compact areas of greater than 10,000 ha. In addition small-scale milling can generate four times more jobs per capital invested, than a large mill.

In this paper we will discuss: a) the historical background of the small industry to put it into perspective with the sugar industry as a whole; b) the technical and commercial characteristics which limit its development in this traditional way; c) the perspectives offered by the integration of tropical livestock production and sugar cane, in the reutilisation of small mills in technical, organisational and commercial terms.

Historical background

The sugar cane industry started in Mexico when Hernan Cortes introduced sugar cane in the Tuxtlas region in 1521 (Blumenkron 1951). Sometime afterwards, Cortes himself transferred cultivation of the cane to La Hacienda de Tlaltenango, near to Cuernavaca and installed the first known press in Mexico. This region then became

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one of the principal centres of sugar production in Mexico, as can be seen from the numerous remains of presses scattered throughout the region. This tradition has become well known thanks to the many prizes awarded to the presses and mills of San Carlos, Santo Clara, Miacatlan and Casasano , among others at international fairs.

From 1911, the State of Moreles began to decline as the principal sugar producer due to a revolution which had more wide-spread radical and revolutionary effects there, than in the rest of the country and effectively broke the political and economical domination of the groups of plantation owners involved in the sugar industry . From 1920, development within the country began to promote, and depend on modern and more efficient refined sugar factories. As an illustration, before 1911, 60,000 t of brown sugar were produced in Mexico representing 56% of the national sugar production. At the present time only 12,000 t are produced representing 0.5% of sugar production.

Characteristics of the traditional small mills

Various reasons exist as to why the small mills have decreased in importance, but it could be said that they failed to compete with the higher efficiency of the large mills. The traditional method has three technological limitations:

a) Low levels of juice extraction (a maximum of 90% compared with 99% in a sugar factory) which results in sugar being lost in the bagasse which is used as fuel.

b) The use of an open pan evaporating process, whereby 20% of the sugar is lost (compare 2% loss in the factories) and the bagasse is burned wastefully with loss of heat by radiation and by poor distribution of the flue gasses, as compared with the large factory where the bagasse is used efficiently.

c) The low quality of the brown sugar means that it is a perishable product.

However the principal problem of the traditional small mill is that it is a small industry with little capital and without the capacity to control the price of its products compared to the large market for crystallised sugar controlled by monopolies which frequently have direct interests in the sugar factories themselves. Thus, the sugar mills will only have an opportunity when alternative uses for cane favours and strengthens the whole industry.

Due to these circumstances, development of the small-scale industry would be limited were it not for three factors:

a) The necessity to create low cost job opportunities. The small mills generate 4 jobs/million pesos invested which compares favourably with the factories (0.8 jobs/million pesos)

b) The possibility of installing small mills in remote areas with poor lines of communication, and thus unprofitable for the sugar factories.

c) The possibility of increased flexibility in alternative uses of sugar cane which could improve the technological deficiencies of the small mills (extraction, evaporation and perishability).

Integration of livestock and presses

Description of the system:

An attractive alternative for the small mill would be to discover other more flexible uses for the by-products (bagasse, cane tops and scums) and for the surplus cane which is not profitable to use. This would:

1) decrease the commercial risk by diversifying production

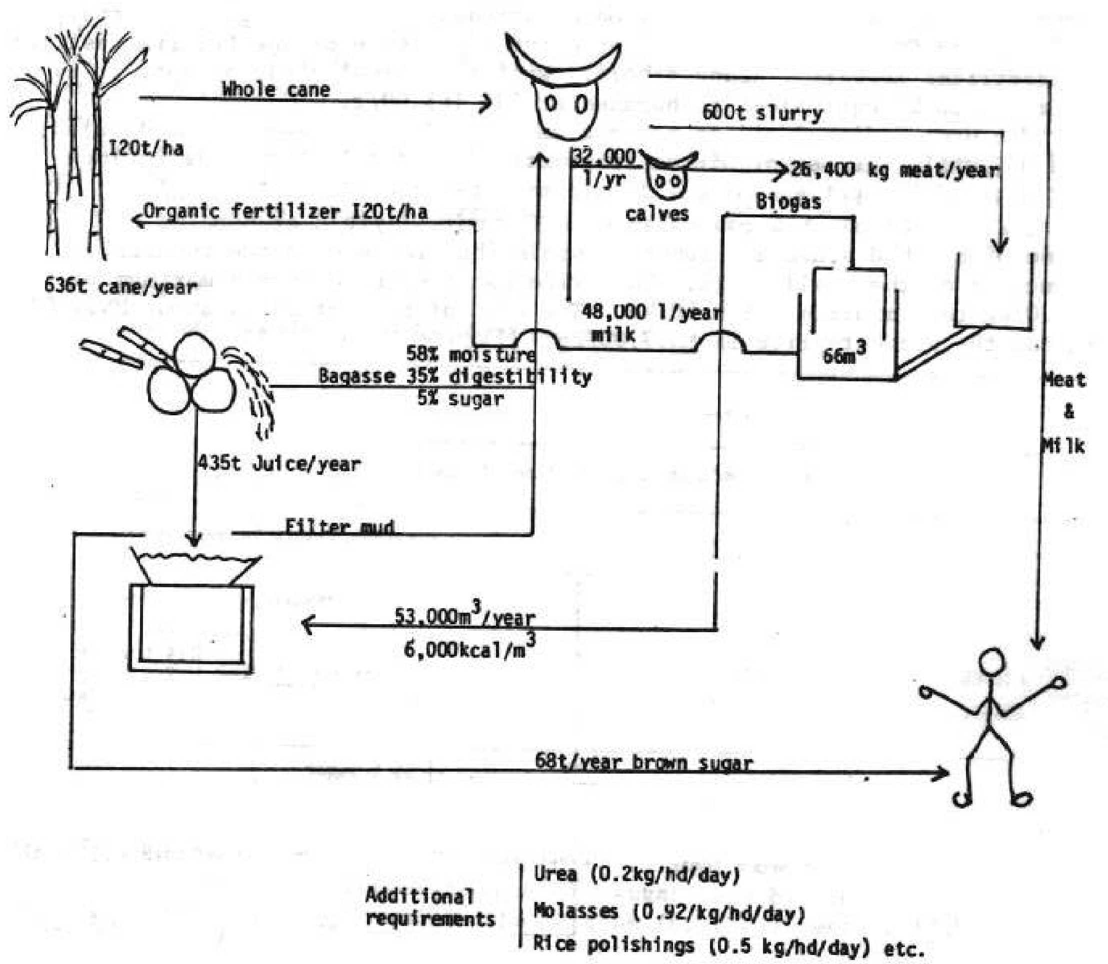
2) bring in an income from the by-products which represent a loss of sugar in the small mills

3) justify in economic terms the substitution of cane bagasse by other more efficient and cheaper fuels, by giving a forage value to bagasse

4) make more productive use of local labour.

To attain these objectives we have designed a system called the Integrated Milling System (Figure 1).

Figure 1
Flow diagram of the integral press



Part of the cane is milled to extract juice and to produce feed. The by-products of this process (bagasse) are fed, together with the rest of the cane, to a dual-purpose herd (meat and milk). The manure from these livestock is fermented in an anaerobic digester to produce biogas and a residue rich in nutrients and organic matter which could be used to condition the soil as organic manure. The gas is used in the evaporation of the juice, at times being supplemented with dried bagasse.

The livestock produce meat and milk. Part of these products can be sold and the other part consumed by the local community.

To free the bagasse from its traditional use as a fuel two alternatives can be considered:

1) To use fuel oil ($MN.8/litre and 11000kcal/litre), which means that the substitution value for fresh bagasse (2000 kcal/kg) is of the order of MN$ 145.00/t

2) To burn the biogas produced by the anaerobic fermentation of animal excrete. The feasibility of this on a national scale has been demonstrated in India and China. In Mexico we have the experience of the Palmira Institute of Electrical Research, among others. With the normal yield of data it is estimated to be equivalent to bagasse at MN$ 165.00/t.

The use of diesel oil to power a small mill can be seen in Miacatalan, Morelos, while the use of biogas is practised in the Livestock Technology Institute of Xoxacotla.

The production of brown sugar with the normal yield at Morelos of 80 kg /tonne of crushed stalk and 106 t of stalks/ha represents the industrial production of the small mills. The price can fluctuate from a maximum of MN$9.0/kg to a minimum MN$ 4.50/kg. The cost of production is about MN$4.00 /kg and the present price is MN$7.00/kg (Figure 2).

Figure 2:
Mass and energy balance in production of brown sugar

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                                                             |   78 t dried bagasse
                                  636 t cane                 | 484 t water
                                       |                     |   73 t water
                                       |
                                      V                                      | 114 t water
                                  Press (73%)------>201 t bagasse            |     9 t sugar
                                      |                                      |   78 t fibre
                                      |
                                      V               |  55 t sugar
                                  435 t juice         | 408 t water
                                      |
                                      V
53 t sugar |   68 t brown sugar<-----Evaporator (70%)------------->364 t water (319 x 10^6 kcal)
           |                          /\
13 t water |                          |
                                      |                  37192 m^3 gas (223 x 10^6 kcal)
                                      -----------------------------  55.35 t bagasse (109 x 10^3 kg)
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Livestock adapted to the tropics usually produce low milk yields. The data of Preston (1977) show that Criollo cows fed on chopped cane, rice polishings, molasses and urea usually produce 5 kg/d in a 200 d lactation with the calf consuming 2.5 kg daily. These calves weaned at 150 kg onto sugar cane could spend the following wet season on higher pastures where they could remain for 150 days after which time they could be ready for sale or could return to the cattle sheds, depending on the availability of feed.

On the other hand it has been found (Preston, personal communication), that it is difficult to manage livestock inside during the rainy season, which in the case of Morelos is when the grass slopes near the sugar cane areas are in maximum production.

In this study Criollo cattle kept on pasture during the rainy season and confined during the dry season, when the cane is green,have been studied. The slurry produced in confinement and fermented in the digester could be used as a fertilizer for the cane. Until now sufficient technical data for the cultivation of cane fertilized with manure are not available although data on nutrient balance indicate that it fulfils the criteria of a fertilizer. Probably it would not be practical to apply slurry further than 1 km from the cattle pens. Energy Balance and Systems Dynamics:

Table 1 presents data on the composition and production of slurry, together with the fertilizer requirements of sugar cane. It can be seen that the slurry from 80 cows is sufficient to fertilize 10 ha of cane.

Table 1:
Composition of slurry as a fertilizer for sugar cane

	Nutrients		
	N	P	K
Composition of slurry, % of DM	4	1.5	3.3
Fertilizer requirement (kg/ha/year)			
First ratoon	100	21-33	83-125
Second ratoon	100-120	21-43	83-166

Slurry production (kg/day): Steers, 10; Cows, 20

Table 2 shows the composition of the sugar cane by-products and these data have been used to formulate the rations for the livestock (Table 3).

Table 2:
Composition of the by-products of sugar cane

	Dry matter %	Protein %DM	Fibre %DM	Carbo-hydrates % DM	Ash %DM
Tops	20-25	5.4	34.5	53.2	5-9
Molasses	83-85	2.5-3.7	-	34-36	9-13
Bagasse	50-53	-	90.0*	4-7	1.5-2.5
Filter mud		12-16	-	10-14	8-12
Juice	12-20	-	-	95-99	-
Slurry	23	27	-	80	-

* Cellulose 65.6%
Hemicellulose 17.5%
Lignin 17%

Table 3:
Animal feeds.

	kg/head/day Fresh	Insoluble DM	Soluble CHO	Protein (kg/hd/d)	Energy (cal/hd/d)	Cost ($/hd/d)
Cows:						
Cane	17	1.6	1.14	0.068	10.96	4.25
By-products	2	1.8	0.07	-	0.48	-
Molasses	0.92	0.46	0.46	-	2.21	1.15
Polishings	0.5	0.03	0.3	0.059	1.6	1.1
Urea	0.2	-	-	0.572	-	1.0
Minerals	0.06	-	-	-	-	0.138
	20.68	3.69	1.97	0.699	15.25	7.638
Calves:						
Milk	2	-	-	0.06	0.5	-
Cane	6	0.5	0.4	0.028	3.84	1.5
By-products	2	1.8	0.07	-	0.48	-
Molasses	0.44	0.22	0.22	-	1.05	0.352
Polishings	0.25	0.015	0.15	0.03	0.8	0.55
Urea	0.05	-	-	0.143	-	0.25
Minerals	0.02	-	-	-	-	0.05
	10.76	2.535	0.84	0.261	6.67	2.702

In summary it can be noted that the normal yield of cane in Morelos is 120 t/ha (106 t of stalk and 14 t of tops) and this could provide basic forage for 80 milking cows, 20 replacement heifers and 60 beef calves utilizing only 4 ha. The remaining 6 ha would be left for the production of brown sugar. Where molasses or cereal grains are fed, a greater quantity of cane would be milled.

This arrangement could be the basis for adapting to fluctuations in the supply and demand for brown sugar, producing extreme price fluctuations. When the price is high a greater proportion of cane could be milled thus maximising sugar production and minimising the amount fed to livestock. When the price of brown sugar is low less could be milled and a maximum fed to the animals, or more than the 60 head from the pasture could be fattened during the dry season.

In reality, the optimum number of livestock will depend on numerous local conditions such as:

a) availability, capacity and organization of the labour force
b) cost of the cattle
c) availability of pasture in the rainy season
d) long term prediction for the price of brown sugar
e) short term stability of the price of the products
f) availability of a cheap energy supply
g) availability of cane by-products
h) regional development policies

To illustrate the dynamic capacity of a small mill integrated with this system, an arbitrary example has been chosen: 100 Criollo cows of which 80% are in production and the replacement rate is 20%, plus fattening of 60 calves (Table 3). This number of cattle would produce sufficient slurry to make the milling system self-sufficient using biogas as a fuel. The nitrogen in the slurry would replace more than 80% of the nitrogen necessary for cane production.

The system would employ approximately ten mill operators and five cattle men plus three cane cutters and ten labourers employed indirectly through payment for the cane whose price is fixed by the factory. Table 4 presents the summary of an economic comparison between the traditional and integrated press systems. The detailed calculations are given in Appendices 1-3. The main point we wish to note is the adaptability of the integral press in the presence of market fluctuations in the price of brown sugar. This can be seen from the respective profits calculated at two prices for brown sugar, MN$ 4,500/T and MN$9,000/t . These indicate that even when the sugar price is halved the integral press could continue in operation with low risk of financial loss.

This type of calculation supports the idea that an integral small mill/ cattle system would be very stable for the small scale farmer with lower financial risk and greater adaptation to local production of meat and milk to supply the protein deficiency of tropical areas. At the same time, energy rich human food (brown sugar) would be produced by employment of surplus labour.

Table 4:
Economic compatison of traditinal and integral systems

	Traditional		Integral	
Cost (MN$tyear)[1]				
Capital costs	365,000		1,256,810	
Running costs	25,918		55,649	
Operating costs	79,970		301,913	
Interest charges	80,094.		275,850	
Totals:	550,982		1,990,222	
	at $4,500/t[2]	$9,000/t	$4,500/t	$9,000/t
Total sales:($/year)	360,000	720,000	1,069,200	1,375,200
Gross profits:($/year)	174,000	534,018	435,788	741,788

[1] All calculations in Mexican Dollar (1US$ = 23.5 MN$)'

[2] Comparative prices for sugar

Conclusions

1) The integration of livestock and small scale mills, appears to have attractive properties for minimising financial risks, generating employment at low cost, utilizing marginal cane areas and simultaneous production of sugar, meat and milk for regional consumption.

2) The integration of livestock and small sugar mill would not only diversify production from these enterprises but could offer new technical alternatives to improve efficiency through utilizing by-products as forage and substituting oil or biogas as a fuel instead of bagasse, according to regional availability.

3) Since the amount of money invested in these small enterprises is less than $US 60,000 (MN$ 1,400,000) and they could be sited in areas of around 10 or 20 ha of cane, this type of enterprise would be very versatile for adapting to a large number of socioeconomic, ecological and commercial situations and it would be of greater interest to tropical regions of poor economic development where labour is readily available, fertile soil scarce and in small areas, and capital not readily available, relative to the other factors of production.

4) Practical, regional demonstrations of this type of system should be tested before widespread application is advocated in tropical regions.

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Appendix 1:
Comparison of capital costs of traditional and integral presses

	Traditional		Integral	
	Investment MN$	Depreciation MN$/year	Investment MN$	Depreciation MN$/year
Mill (2.5 t or 1 t)	100,000	8,182	60,000	4,441
Evaporators	40,000	3,646	15,000	1,363
Pump 1/4 HP	1,000	200	1,000	200
Sugar moulds	2,000	200	1,000	100
Motor (7 or 5 HP)	15,000	3,000	9,500	1,710
Accessories	2,000	200	2,000	300
Construction work[1]	200,000	10,000	300,000	15,000
Chiller	5,000	5,000		
Concrete mixer (100 litres)		500	4,000	250
Cane chopper			15,000	1,000
Motor (25 BP)			21,000	2,400
Mixer (4t)			54,510	4,905
Truck (8t)			171,800	17,180
Trailer			15,000	1,500
Anaerobic digester			70,000	3,500
Silo Hopper (8t)			12,000	1,200
Tank (500 litres)			5,000	500
Cows (100)			500,000	
	365,000	25,918	1,256,810	55,649

[1] Supports and roof of 15 X 15 m, 4 chimneys and ovens, platform for cane (concrete bases for machinery) and for the integral press, a corral for 180 animals.

Appendix 2:
Comparison of operating costs of traditional and integral press systems

	Traditional			Integral		
	MN$/t cane	MN$/t produced	MN$/ year	MN$/t cane	MN$/t produced	MN$/ year
Labour			76,320			120 , 000
Raw material	268	3,350		268	3,350	
Electricity	3.60	63.0		3.60	63.6	
Maintenance (1% capital)			3,650			12,568
Animal feed					54,040	
Interest[1] (18%)	48.24	60.3	80,096	48.24	603	275,850
Totals	319.84	3,473.9	160,064	319.84	4,016.6	342,458

[1] Calculated on capital and operating costs

Appendix 3:
Comparison of gross annual income from traditional and integral systems.

	Traditional	Integral
	$MN	$MN
Milk (48,000 kg x $6/kg)		288,000
Meat (26,400 kg x $18/kg)		475,200
Sugar (68 t x $9000/t)		612,000
(68 t x $4500/t)		306,000
(80 t x $9000/t)	720,000	
(80 t x $4500/t)	360,000	