IMPROVING PRODUCTIVITY IN SUGAR MILLS BY INTEGRATING CO-PRODUCTS UTILISATION

By

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Abstract

This paper shows an 'incentive program' for workers, through one model of development, using mainly co-products of sugarcane; used in different ways in 'Granja Teresita', 25 kilometres from the mill. The mill has a plant to hydrolyse bagasse in two batch reactors by a physical process (using steam at 1.4 MPa) and areas for composting residuals (90 days, without enzymatic process), and sell the production to the ranch. For cattle and goats, we use the cane tops with molasses, hydrolysed bagasse, wet fibre cane 'cush – cush' separated in clarifier filters, and other agriculture residuals of the region. For pigs, invert 'B' molasses and some locally produced complements are used. For sustainable agriculture, organic fertiliser (compost), made from sugar mill products (vacuum filter mud, bagasse, ashes, etc), and worm compost, produced locally, are used with lamb manure. A range of crops is grown including corn and sorghum and horticultural crops, and there is also an aquaculture industry.

Introduction

In order to increase the productivity in the MOTZORONGO sugar group, which includes two mills (El Refugio (syrup) and Motzorongo (sugar & molasses)), the administration has promoted a program based on compensation of workers, giving a box that includes several products obtained by cane diversification processes , with several agro-products which are shown in Figure 1.

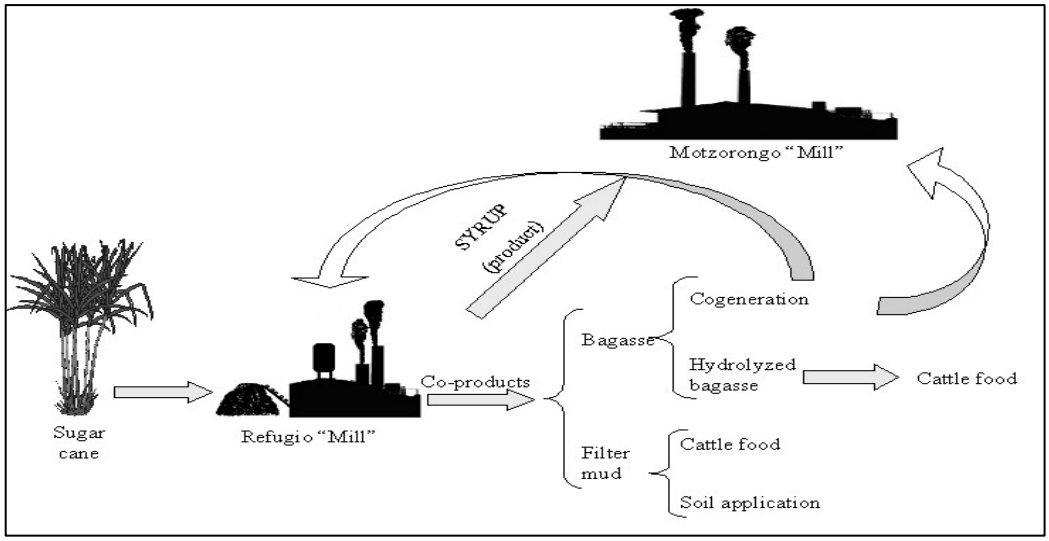

Fig. 1—Co-products development into the mills.

Work development

El Refugio Mill

Hydrolysed bagasse production

In the El Refugio Mill, there are two reactors (1.5 m diameter and 4 m high – see Figure 2) fed for 40 min with steam at 1.7 MPa and 573 K; the nominal capacity of each is 750 kg per batch. The total capacity of the plant is 2000 tonnes per crop. The composition of hydrolysed bagasse is presented in Table 1.

Fig. 2—Bagasse hydrolysed reactors.

Table 1—Analysis of hydrolysed bagasse.

Humidity	68.29%
Dry matter	31.71%
Phosphorus	0.005%
Ashes	3.80%
Crude protein	1.34%
Crude fibre	63.17%
Crude grease	0.004%

Central Motzorongo, S.A. de C.V.

The mill is dedicated to the production of raw and standard sugar, with a daily grinding capacity of 8500 tonnes of cane and a total crop of 1 280 000 tonnes. The co-products produced are shown in Figure 3.

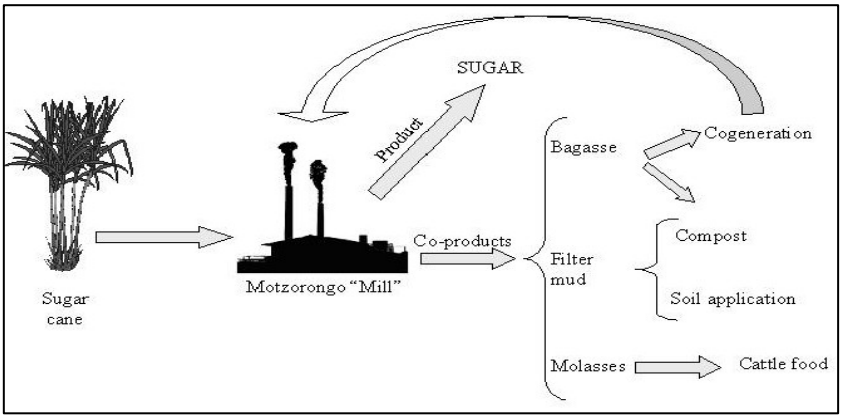

Fig. 3—Co-products development in Motzorongo.

Compost

The production of organic fertiliser 'compost' is 3000 tonnes, using 20 000 t of filter mud and 4500 t of bagasse. The materials are sent to special areas forming long piles, and are maintained for 15 days to separate the excess water; after that, the components are mixed weekly and air is introduced for the micro organisms that degrade the organic material (fungus and bacteria) (Figure 4). The chemical composition of the compost is presented in Table 2.

Fig. 4—Compost production process.

Table 2—Chemical composition of 'COMPOMOTZ'.

Nitrogen	2.50%
Phosphorus	0.60%
Potassium	1.20%
Calcium	1.40%
Magnesium	0.24%
Iron	1.20%
Organic Mater	54%
Acids. Humic & fulvics	2%
pH	6.8
C/N Relationship	12:1
Humidity	20–30 %

Teresita farm

The farm is located about 25 km from El Refugio, and has a total area of 112 ha; 20 ha for sugarcane, leaving the remaining 92 ha for cattle and fruit production, including 3.50 ha for banana

(musa ssp), mango (manguifera indica L), and noni (morinda citrifolia) and 2.50 ha for short-cycle vegetables. The other 86 ha are used as pasture and corrals for cattle and sheep, fish tanks and pig breeding places. The farm buys molasses and compost from Motzorongo, hydrolysed bagasse and mud from El Refugio (it only pays the freight of the last) and sells the products to both mills. A flow chart of the incentive program is presented in Figure 5.

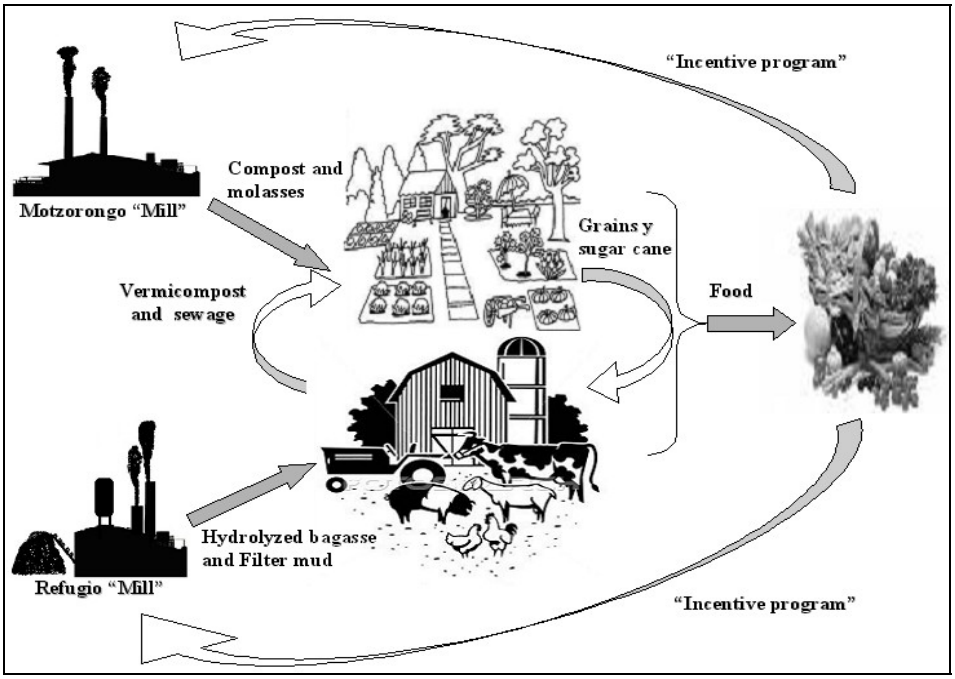

Fig. 5—Incentive program.

Cattle food

To make balanced diets for the animals, sugarcane (juice and tops) and co-products from the milling process (molasses, hydrolysed bagasse and dry filter mud), as well as cheese whey and other products from the regional agriculture are used.

Cattle

Grazing is the basic feed, complemented with sugarcane co-products. The cattle are classified as milking cows, empty cows, calves, and stud bulls.

Milking cows

They are given a supplement of 5 kg of concentrate after milking to complement their feed from grazing. The production cost per litre is no more than $1.50 (feeding) and it is sold for $7.00/L. With this regime, there is a reduction from 220 to 120 days from giving birth to getting pregnant again. This way, the productive and reproductive parameters are higher. The composition of food for milking cows is shown in Table 3.

Table 3—Components for a tonne of food for milking cows.

InputS	Quantity		Cost ($)
	(%)	kg	
Cane tops	20%	200	100.00
Hydrolysed Bagasse	50%	500	200.00
Molasses	17%	170	170.00
Crushed corn	8%	80	280.00
Urea	3%	30	135.00
Dry filter mud	2%	20	5.00
TOTAL COST			$890.00 – U$65.93
COST / kg			$0.89 – U$0.07

NOTE: Exchange rate used is $13.50 Mexican Pesos/US$dollar.

The cost of sugarcane is only for manpower. The cost of feeding each cow is $4.45 per day. The cows given this supplement increased their milk production by 3 L/day. That is a daily gain of $21.00.

Empty cows

These are cows that are pregnant or empty in preparation to enter into the milk production of the farm. Composition of the supplement given to empty cows is presented in Table 4.

Table 4—Ingredients of a tonne of food for empty cows.

Inputs	Quantity		Cost ($)
	(%)	Kg	
Molasses	96	960	960.00
Dry mud	2	20	5.00
Urea	2	20	90.00
Total cost			$1055.00 U$78.15
Cost / kg			$1.06 – U$ 0.08

The daily cost for feeding one cow is $5.30.

Calves

It is more expensive to nurse a calf with only its mother's milk than to give food as a supplement; with it, the milk feeding can be reduced up to 50%. The composition of the supplement for calves is shown in Table 5.

Table 5—Ingredients for a tonne of food for calves.

Inputs	Quantity		Cost ($)
	(%)	Kg	
Hydrolysed bagasse	65	650	260.00
Molasses	20	200	200.00
Dry filter mud	2	20	5.00
Crushed corn	6	60	210.00
Soybean and blood meal	5	50	350.00
Urea	2	20	90.00
Total cost			$ 1115.00 – U$ 82.59
Cost / kg			$ 1.12 – U$ 0.08

Feeding them only with milk will cost $28.00 daily to gain 1 kg of weight; using a diet of 2 L of milk plus 2 kg of supplement will cost $16.24 per day.

Sheep

Their feeding should be by grazing, but seeking the highest rate of reproduction, it is convenient to give supplement and chopped sugarcane with urea, which produces good results at low cost. The ingredients in the supplement for sheep are presented in Table 6.

Table 6—Ingredients for a tonne of food for sheep.

Inputs	Quantity		Cost ($)
	(%)	Kg	
Bagasse	87	870	261.00
Molasses	10	100	100.00
Urea	3	30	35.00
Total cost			$ 396.00 – u$ 29.33
COST / kg			$ 0.40 – U$ 0.03

This bagasse is the one that remains after the juice extraction process that is also used to feed the sheep. The price of this is calculated as $0.30 pesos, which is the milling cost.

Pigs

To prepare the diets for pigs, cane juice, cheese whey from the farm and a concentrated feeding supplement are used. The composition of the supplement given to feeding sows and breeding stud is given in Table 7.

Table 7—Ingredients of the ration for sows just after giving birth and breeding stud.

Inputs	Content	kg of inputs	Cost ($)
Cheese whey	43.75%	3.5	1.05
Cane juice	43.75%	3.5	2.45
Concentrate	12.5%	1.0	4.50
Total Cost of the ration (daily consumption per animal)			$ 8.00 – U$ 0.59

This ration is given to the pig for the first 25 days. Feeding with the traditional diet costs $27.00 (6 kg per day) and, with the use of byproducts, we lower the cost to $8.00, which represents a saving of $19.00 per animal.

Pregnant sows

The composition of the supplement for pregnant sows is given in Table 8.

Table 8—Supplement for pregnant sows.

Inputs	Content	kg of inputs	Cost ($)
Cheese whey	43.75 %	3.5	1.05
Cane juice	31.25 %	2.5	1.75
Concentrate	25.00 %	2.0	9.00
Total cost of the ration (daily consumption per animal)			$11.80 – U$0.87

Traditional feeding has a cost of $27.00 (6 kg per day) and, adding cane co-products, we lower the price to $11.80, which represents savings of $15.20 per animal.

Fattening piglets (30 days)

The ingredients given to piglets to fatten them are presented in Table 9.

Table 9—Ingredients for fattening piglets.

Inputs	Content	kg of inputs	Cost ($)
Cheese whey	50%	1.5	$0.45
Cane juice	30%	0.9	$0.63
Concentrate	20%	0.6	$3.60
Total Cost of the ration (daily consumption per animal)			$4.68 – U$0.35

This portion is for piglets to be sold roasted Cuban style. Traditional feeding has a cost of $12.00 (2 kg daily) and, with the addition of cane co-products, we lower the cost to $4.80, which represents a saving of $7.20 per animal.

Fattening pigs

The ingredients used for fattening pigs are given in Table 10.

Table 10—Ingredients for ration for fattening pigs.

Inputs	Content	kg of inputs	Cost ($)
Cheese whey	50 %	3.0	0.90
Cane juice	30 %	1.9	1.33
Concentrate	20 %	1.2	5.40
Total cost of the ration (daily consumption per animal)			$7.63 – U$0.57

The traditional food ration has a cost of $31.50 (7 kg/day) and, with the addition of cane co-products, is reduced to $7.63, saving $23.87 per head.

Sustainable agriculture

Fruits and vegetables are fertilised with organic fertiliser bought from CM and produced by the same farm from manure (worm compost) and residuals from a biodigester for the production of methane gas. To control pests and diseases, natural traps and bio products are used.

Growing vegetables

Plot preparation

The soil is loosened with a pick and shovel to a depth of 30 cm and compost is added to give good conditions for plant development.

Lime is added.

Buying plants

The plants that are used have been handled and selected previously for their optimum growing and maturing properties and the size of their fruits. The plants are bought by a filial firm, VITROMOTZ.

Sowing

At transplanting, the roots are disinfected with a solution of 'Bordalese broth' and are inoculated with mycorrhizae to stimulate root development to improve the growing of the plant.

Fertilisation

During the first 10 days of development, foliar applications are made with liquid fertiliser, which gives nutrients and salts needed for an optimum growing and production of a good number of flowers and fruits. As a supplement, the crops are fertilised monthly.

Biological control of pests

To control pests, biological methods from plant extracts and infusions, such as garlic, onion, cempasuchil, basil, peppers, rue, chamomille and neem are used. Chemical insecticides are not used.

Diseases

When there are fungus problems such as smut, control is effected by applying a solution made of cupper sulfate and lime, called 'Bordalese broth'. It is made with 1 kg of copper sulfate and 1 kg of hydratated lime dissolved in 100 litres of water.

Fertigation

Water from the fish ponds is used for irrigation so that all the nutrients and organic matter are used.

Costs and Profits

The costs and profits of growing vegetables are presented in Table 11.

Table 11—Costs and profits for vegetables in lots of 100 m^2.

Vegetable	Production cost ($)	Production value ($)	Margin
Tomatoes (*Lycopersicum esculentum*)	2062.00	3000.00	$938.00 – U$69.48
Cucumber (*Cucumis sativus* L.)	946.00	1600.00	$654.00 – U$48.44
Pumpkin (*Cucúrbita mixta*)	377.00	1,080.00	$703.00 – U$52.07
Radish (*Raphanus sativus*)	392.00	800.00	$408.00 – U$30.22

Price

Not having intermediaries, all products are sold at the regional market price, which makes the production more profitable.

Analysis of cost-benefit

It is important to emphasise that the biggest profit is for the environment by not using agrochemicals, insecticides, herbicides and pesticides. It favours not only the direct health of consumers, but it also protects land, streams, and aquifers. There is some reduction in yields, but this is justified because it spares the depreciation of the biological capital.

Biogas production

As part of an environmental plan for the pigs and cattle, Teresita Farm has a biodigester, Hindu type, of continuous flow, that permits the use of manure and other organic wastes. The volume of the biodigester is 3 m3 and it is fed daily with 35 kg of fresh manure, mixed with 70 litres of hot water at 45oC.

With the biodigester, methane gas is produced for use at the farm, and its residue is used as fertiliser for the vegetables and to feed the fish. A schematic diagram of the biodigester is presented in Figure 6.

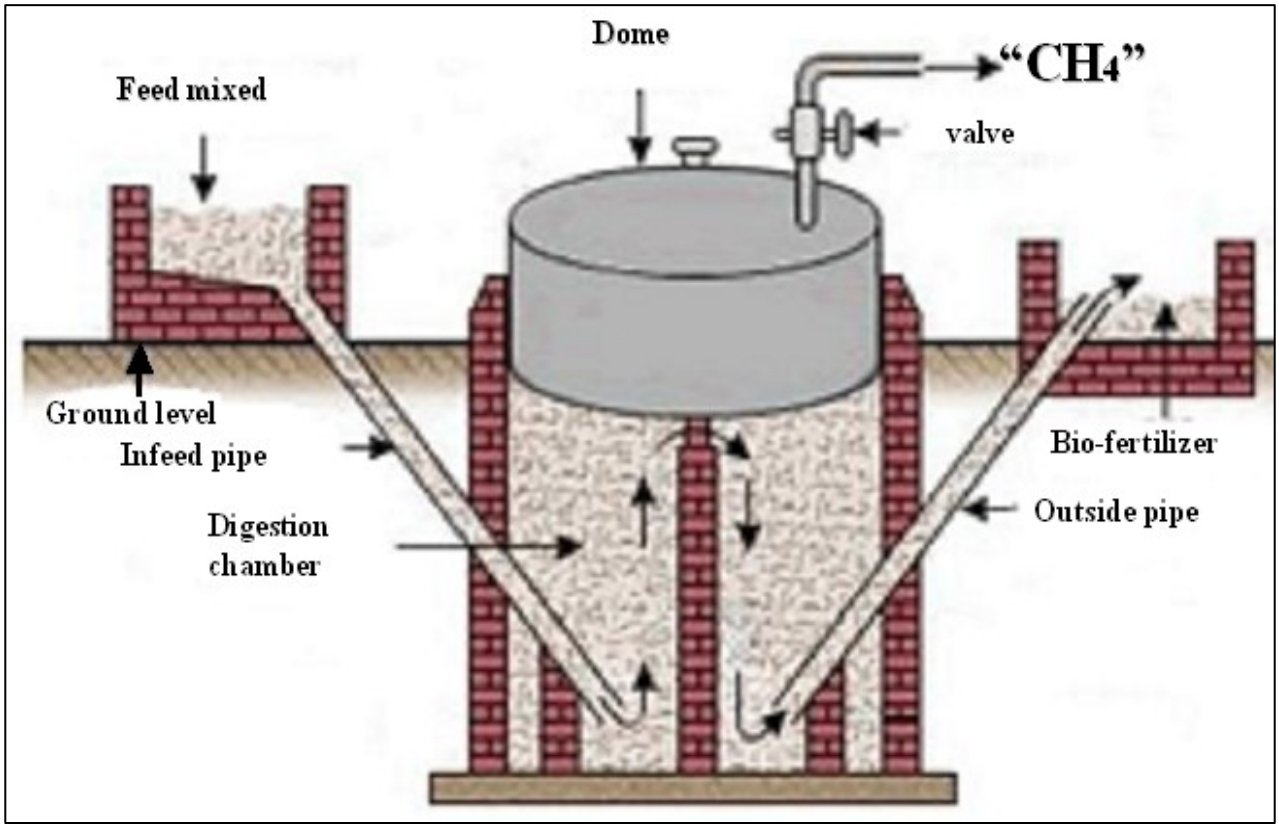

Fig. 6—Biodigester.

Fish pond

The farm has 4 ponds with a capacity of 2000 fish each. The biofertiliser from the digester is used to initiate the production of algae and this begins a trophic chain to feed the fish.

The residual water is used to irrigate vegetables, giving very good results, due to the fact that this water has a good load of nutrients.

Economical impact

It is possible to deduce from Tables 12 and 13 that, during a crisis period in the Mexican sugar industry, both mills produced good financial results.

Table 12—Economical Results Central Motzorongo mill 2005–2008.

INGENIO: CENTRAL MOTZORONGO, S.A. DE C.V.				
Results 2005 – 2008 (thousand of pesos $)				
C O N C E P T	YEAR			
	2005	2006	2007	2008
INCOME	1 141 371	1 171 757	1 110 305	986 569
Sales cost	1 030 095	1 008 431	1 038 229	901 930
Profit (Losses)	111 276	163 326	72 076	84 639
Operational expenses	47 033	54 952	58 324	68 544
Profit (Losses) operation	64 243	108 374	13 752	16 095
PRODUCTION DATA				
Cane grinding tonnes	1 270 426	1 089 368	1 176 626	1 338 529
Sugar produced tonnes	136 753	123 647	127 574	150 285
Molasses tonnes	49 802	38 440	40 713	65 466

Table13—Economical Results El Refugio mill 2005–2008.

INGENIO EL REFUGIO, S.A. DE C.V.				
RESULTS 2005 – 2008 (THOUSAND OF PESOS $)				
C O N C E P T	**YEAR**			
	2005	**2006**	**2007**	**2008**
INCOMES	286 641	268 901	286 828	270 986
Sales cost	249 518	224 964	265 807	240 238
Profit (Losses)	37 123	43 937	21 021	30 748
Operational costs	14 799	15 174	16 812	21 798
Profit (losses) operation	22 324	28 763	4209	8950
PRODUCTION DATA				
Cane grinding tonnes	426 510	343 374	383 343	448 016
Sugar produced tonnes	46 143	39 267	40 786	49 866
Molasses tonnes	17 734	12 512	13 049	22 971

Conclusions

Co-products of the cane provide an alternative to increase the productivity of the factories, to improve the development of new areas of interest, and to promote parallel businesses and receive greater profits.

AMÉLIORATION DE PRODUCTIVITE DANS LES USINES SUCRIERES AVEC L'INTEGRATION DE L'UTILISATION DE CO-PRODUITS

Par

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MOTS-CLÉS: Productivité, Bagasse Hydrolysée, Compost; Production de Biogaz et 'Mélasse Riche En Sucre'.

Résumé

CETTE COMMUNICATION décrit un programme incitatif pour les travailleurs par le biais d'un modèle de développement, en ayant recours principalement les co-produits de la canne à sucre; utilisés de différentes façons à 25 kilomètres de l'usine de 'Granja Teresita'. L'usine a une unité pour l'hydrolyse de la bagasse de la canne à sucre dans deux réacteurs individuels, à l'aide d'un procédé physique (utilisant la vapeur à 1.4 MPa) et les aires de compostage de résidus (90 jours, sans procédé enzymatique). La production est vendue à la ferme. Pour les bovins et caprins, la partie supérieure de la canne est utilisée avec la mélasse, la bagasse hydrolysée, la fibre humide provenant des décanteurs et d'autres résidus agricoles de la région. Pour les porcins, la mélasse 'B' invertie et d'autres compléments locaux sont utilisés. Pour l'agriculture durable, les engrais organiques (compost), produits à partir des sous-produits de l'usine (boues, bagasse, cendres, etc...) et vermi compost, produit localement, sont utilisés avec du fumier d'agneau. Toutes une gamme d'espèces est cultivée comprenant le maïs et le sorgho et d'autres espèces horticoles, et il y a également une industrie aquacole.

MEJORANDO LA PRODUCTIVIDAD EN EL CENTRAL AZUCARERO MEDIANTE LA INTEGRACIÓN DE COPRODUCÍOS

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PALABRAS CLAVE: Productividad, Bagazo Hidrolizado, Compost, Biogás, Mieles Ricas Invertidas.

Resumen

EL ARTÍCULO muestra un 'Programa Incentivo' para trabajadores, a través de un modelo de desarrollo, empleando fundamentalmente coproducíos de la caña de azúcar, utilizados en diferentes modos en la Granja teresita, a 25 kilómetros del Central. El Central posee una planta de hidrolizar bagazo en dos reactores batch mediante un proceso físico (con vapor a 1,4MPa) y áreas para composteado de residuales (90 días sin proceso enzimático) y vende la producción al rancho. Para vacunos y caprinos, empleamos las 'puntas' de caña con melazas, bagazo hidrolizado, fibra húmeda de caña 'cush-cush' separadas en los filtros clarificadores y otros residuales agrícolas de la región.

Para cerdos utilizamos mieles B invertidas y complementos producidos localmente. Para agricultura sostenible se aprovechan fertilizantes orgánicos (compost) fabricados a partir de productos del Central (tortas de los filtros al vacío, bagazo, cenizas, etc.) y compost de lombrices, producido localmente, junto con excretas de ovejas. Se cosechan un conjunto de cultivos incluyendo maíz, sorgo y hortalizas, también existe una industria acuícola.