UTILIZACION DEL JUGO DE CAÑA Y LA UREA COMO COMPLEMENTO EN LA ALIMENTACION DE VACAS DE LECHE EN COLOMBIA

por

B.E. Vélez White

El presente trabajo tiene como origen la crisis crónica en que se encuentra el precio de azúcar y por consiguiente los productos que utilizan la caña como materia prima para su elaboración como la panela. Durante 25 años hemos trabajado una tierra con 200 hectáreas dedicadas al cultivo de caña panelera, 50 por ciento de pendiente ondulada y 50 por ciento plana, la una mecanizada con bueyes, mulas y caballos, la otra con tractores; los rendimientos han llegado a 100 toneladas/ha/año, mediante la introducción de variedades, sistemas de cultivo y corte, fertilización y manejo general del plantel. El clima está caracterizado en el cuadro 1.

Cuadro 1: El Clima

Clasificación ecológica:	Bosque muy húmedo premontano
Altura sobre el nivel del mar:	Desde 1 300 hasta 1 450 mt
Precipitación promedio anual:	2 450 mm/10 años
Humedad relativa:	Media anual 88 %
Temperatura promedio:	22°C.

Colombia no es una excepción a la crisis del azúcar y la mayoría de los trapiches se han ido cerrando o sea que permanecer en el mercado significa un logro. El manejo de mercado de la panela ha sido un factor clave de permanencia y se ha basado en la calidad. Pese a todo esto la situación económica ha sido mala, los pasivos mayores y las utilidades mínimas y aún negativas casi todos estos años.

Buscando alternativas se decidió a partir de 1980 diversificar dos lotes de tierra dedicados hasta ese entonces a la ceba de ganado, a una actividad más intensiva como la lechería. Como se hicieron dos hatos distintos y se les ha dado distinto manejo les llamaremos “A” y “B”. El hato “A” se inició con ganado Holstein Americano puro y el “B” con Holstein Americano mestizo.

Se implementaron 2 salas de ordeño mecánico con capacidad de 80 vacas/hora, comederos individualizados y estercoleros.

El hato “A” tenía suplementación comercial (Cuadro 2 y 3) y el “B” pastoreo sin suplementar, (Cuadro 4)

Cuadro 2: Fórmula suplemento comercial

Componentes	Kilos
Sorgo	400
Melaza	150
Palmiste	70
Cebada	100
Harina de carne	20
Harina de pescado	30
Torta de Algodón	50
Sal	10
Premezcla vitaminas y minerales	3
Carbonato de calcio	10
Harina de hueso	20
Harina de arroz	137
	1 000

Cuadro 3: Dosificación concentrado comercial

Producción Litros/día	Identificación Color cinta	Kilos concentrado/ día
Menos de 10	Amarillo	2.0
10 – 15	Verde	3.0
15 – 20	Azúl	4.0
20 – 25	Rojo	6.0
Más de 25	Café	8.0
Valor kilo concentrado		Valor kilo miel
$43.05 US 0.22		$42 US 0.21

Bosque muy húmedo premontano
Epoca de prefloración

Cuadro 4: Análisis bromatológico Axonophus Micay

Materia seca:	21.46
Proteína:	11.74
Fibra:	20.76
Grasa:	2.14
Carbohidratos:	30.93
Cenizas:	12.38
Calcio:	0.31
Fósforo:	0.28

A partir de enero de 1985 ambos se suplementaron con miel. La composición química de diferentes tipos de guarapo está descrita en el Cuadro 5:

Cuadro 5: Análisis químico del jugo de la caña

Muestras	Humedad	Materia Seca	Cenizas	Fibra	Proteina	P.	Ca.
Guarapo evaporado	44.50	55.50	0.81	-	0.25	0.038	0.036
Cachaza medio codida	73.77	26.23	3.35	0.41	2.27	0.25	0.20
Miel de secadora	14.74	85.26	0.84	-	0.30	0.034	0.035
Guarapo sin des -cachazar	78.88	21.22	0.82	-	0.104	0.041	0.033
Ripio de guarapo	68.15	31.85	5.02	13.26	4.17	0.10	0.058
Guarapo crudo	76.25	23.75	0.93	-	0.19	0.064	0.017

Nota: Resultados con base en 100% de materia seca Factor de conversión para la proteina 6.25

El manipuleo se hace en canecas y baldes, los comederos son separados para cada vaca. El valor de estas mieles se determinó en la siguiente formula. (Cuadro 6).

Cuadro 6: Precio kilo caña (fórmula)

P:	Rendimiento de caña a panela
V:	Precio venta panela
F:	Flete $
E:	Empaque $
U:	Unidad (cartón 20 kilos)
K:	Valor kilo caña $

K:	$\frac{P\ (V-F-E)}{U}$
Actual: \$4.98 =	$\frac{9.5\ (1.150 - 56 - 45.65)}{100 \times 20}$
Precio kilo miel	
Rendimiento de	
caña a miel:	13.5%
Valor \$ kilo miel:	4.98 × 100 = \$36.89 US 0.19

La disolución en agua es instantánea, a la miel se le añadió un suplemento proteico (Cuadro 7):

Cuadro 7: Fórmula de suplemento proteico - mineral

Urea:	150	Gramos
Harina de hueso:	200	Gramos
Torta de algodón:	300	Gramos
Harina de maíz:	350	Gramos
	1 000	

Ambos productos se dosificaron de la siguiente forma (Cuadros 8 y 9).

Cuadro 8: Dosificación miel urea hato "A"

Producción Litros/día	Identificación Color cinta	Gramos concentrado Proteico-día	Gramos Urea/día	Kilos miel/ día

Menos de 9	Amarilla	0	0	1.8
9 – 13	Verde	900	135	2.8
13 – 17	Azúl	1 200	180	3.8
17 – 21	Rojo	1 600	240	4.8
Más de 21	Café	2 000	300	6.0
Valor kilo	concentrado proteico	Valor kilo miel		
$52	US 0.26	$36.89 US 0.19		

Cuadro 9: Dosificación miel urea hato "B"

Producción Litros/día	Identificación Color cinta	Gramos concentrado Proteico/día	Gramos Urea/día	Kilos miel/ día
Menos de 8	Amarilla	0	0	1.40
8 – 10	Verde	700	105	2.20
10 – 14	Azúl	1 000	150	3.00
14 – 18	Roja	1 300	195	4.00
Mas de 18	Café	1 700	225	5.00
Valor kilo	concentrado proteico	Valor kilo miel		
£52	US 0.26	$36.89 US 0.19		
Dilución de la miel en el agua 80% H_20.				
La miel es muy palatable, el concentrado no.				

En el segundo semestre del 85 se observó los siguientes resultados en cada hato.

Hato “A”	- De 14 litros promedio la producción rebajó 1.5 litros a 12.5 litros promedio.
	- La grasa aumentó de 3.30 a 3.85 en promedio.
	- El estado físico de los animales se mantuvo
	constante.
	- La reproducción no fué intervenida, siguió
	normal.
Hato “B”	- De 10 litros pasa a 12.5 litros promedio.
	- La grasa aumentó de 3.10 a 3.75.
	- Los animales acumularon mucho músculo y grasa,
	aumentaron significativamente de peso.
	- La reproducción mejoró radicalmente.
	- El pelo mejoró sustancialmente el brillo.
	- El consumo de drogas disminuyó apreciablemente.

Sería viable suplementar con miel más urea, ganados que tengan alguna aptitud para acumular músculos y grasa con eficiencia, aunque la producción de leche sea menor; Fleckvieh Simental ó Rock Butten ó ganados de carne tipo Angus.

SUPPLEMENTATION OF MILK COWS WITH SUGARCANE JUICE AND UREA

by

B.E. Velez

This paper describes a family farm with 200 ha sugarcane land and 200 ha pasture for beef cattle, in the western mountain area of Colombia with an annual rainfall of 2 500 mm.

With the drop of the world market prices of sugar it was decided to intensify the cattle production and to start milk production.

Two groups of 100 cows were formed. Group A consists of purebred Holsteins, Group B of crossbred Holsteins. A received concentrate supplementation while B only had pasture. In 1985 the supplementation of the cattle was changed. Both groups now received a bit of concentrate and sugarcane juice mixed with urea.

In Group A average milk yield dropped from 14 kg/d to 12.5 kg/d but the fat content rose from 3.30 to 3.85%.

In Group B the milk yield rose from 10 kg to 12 kg, the fat content from 3.10 to 3.75% while their condition and fertility improved considerably.

INTEGRATION OF SUGARCANE AND MILK PRODUCTION IN WESTERN INDIA
by
D.V. Rangnekar

1. INTRODUCTION

Sugar production has emerged as one of the major agroindustries in the rural areas of India

during the last few decades. It has made a considerable impact on the economy of farmers, particularly in irrigated areas. The impact has been much more in States like Maharashtra, Gujarat and Karnataka in the Western Region since many of the factories are cooperatives and the producer receives full benefit from sugar production. The dairy industry has developed more recently but is more extensively spread, since it is not restricted to irrigated areas only. These two industries integrate very well and are complementary to each other, particularly in the States of Maharashtra and Gujarat where farmers' cooperatives are fairly strong.

2. Sugar production and use of byproducts in India

2.1 In India sugar production is undertaken practically throughout the country and there are well-established factories in 18 out of 26 States. According to reports for the last crushing season, there were 338 factories in operation which crushed about 60 million tonnes of cane, produced 6.1 million tonnes of sugar and 2.5 million tonnes of molasses.

Thus the average recovery of sugar percent cane ranged between 10.0 to 10.3 during the last two seasons and molasses percent cane around 4.2. The major sugar producing States in the country are Maharashtra, Uttar Pradesh, Tamil Nadu, Karnataka, Gujarat and Andhra Pradesh considering total sugar production and area under sugarcane.

2.2 Average bagasse production is about 30 percent of the sugarcane crushed and about 90 percent of bagasse produced is used as fuel. There are many factories which do not have surplus bagasse either because the boilers are inefficient or the supply of sugarcane is inadequate or irregular. The major use of surplus bagasse is for paper making. However, large quantities of bagasse are either thrown away or taken away for use as fuel or for compost making. In a number of factories surplus bagasse becomes a disposal problem. The price of bagasse ranges between Rs. 0 to 400 per tonne with an average of about Rs. 100 per tonne.

This wide range is essentially due to changes in production. Some of the factories are now thinking in terms of using bagasse for feeding cattle in view of increasing shortages of good roughages and increasing interest in milk production by farmers.

2.3 Molasses is a very peculiar commodity. The overall country picture shows a shortage of molasses. However, in areas like Western Maharashtra, there is a surplus and much is wasted. Its use and prices are controlled by the Government and one has to get Government permission for purchase, storage and use of molasses. It is a very low priced item and hence various industries, including the cattle feed industry, are very keen to get as much molasses allocated by the Government as possible. It is used in foundries, paint industries, distilleries for power alcohol, acetone and potable alcoholic drinks, besides the cattle feed industry which has a fairly low share of available molasses. It is currently priced at Rs. 60 per tonne (compared to Rs. 1 200 per tonne of grain). The recent report of the Compound Livestock Feed Manufacture's Association (Annual Report for 1985) shows total feed production (cattle and poultry) to be about 2.0 million tonnes and the molasses requirement to be about 250 000 tonnes per year which is less than 10 percent of the total molasses production of about 2.5 million tonnes. However, the feed industry has great difficulty in obtaining allocations of the desired quantity of molasses. The industry has been making strong representations to the Government to increase the price of molasses.

2.4 In most of the sugarcane producing areas the tops are the sole green material available to dairy animals particularly between February to April when it is relatively dry. The average quantity of tops available are about one third of the cane harvested. These are mostly fed as green to the animals or sometimes dried and stored and fed like cereal straws (in Western Maharashtra). However, in some areas like South Gujarat tops are used as fuel and now attempts are being made, by organizations like ours, to convince the farmers on the use of tops for feeding animals and to ensile them for storage.

2.5 Press mud has found considerable use as a soil conditioner. It is acidic, rich in minerals and contains organic matter, since bagasse is added to the material in the process of pressing out the juice. In most parts of Western India the soils are alkaline and are fast becoming more saline and alkaline. Press mud has been found to be useful to correct this problem. Some factories sell and some allocate press mud free to the farmer members.

2.6 Other uses of byproducts which are under consideration by a number of factories are:

a. **Production of yeast from molasses**
b. **Mushroom cultivation on bagasse**
c. **Briquetting of bagasse for use as fuel**
d. **Use of sugarcane bagasse and molasses as animal feed.**

2.7 Some of the features characterizing the sugar industry are:

a. **a large captive market, ever-increasing demand within the country and a fair market price;**

b. **possibilities of substantial export and export incentive offered by the Government;**

c. **good support to industry from the government, particularly in the cooperative sector, in view of the significant contribution in terms of output, employment generation and foreign exchange earning by this industry;**

d. **sugarcane is used for production of Jaugary (Gur) and brown raw sugar (Khandsari) in India besides white sugar. These two products are used as a sweetening agent like sugar throughout the country. In some of the states like Uttar Pradesh, Punjab, Karnataka, Haryana more than 60 percent of sugarcane is used for the preparation of these two products;**

e. since the last few years attempts have been made to introduce sugar beet particularly in North India. A recent study indicates that sugar beet is a financially viable and attractive activity from the point of view of farmers as a complementary crop to sugarcane. However critical assessment is suggested before launching a large programme of introducing sugar beet (Gurdev Singh et al., 1985).

f. another feature which is worth noting is the emergence of a farmers' cooperative for sugar production.

3. Problems faced by the sugar industry in India

In view of fairly strict Government control on sugar and its byproducts, the industry faces some problems while receiving a certain amount of protection from the Government. The factory has to make available a fairly large share of its produce at a controlled rate for marketing through Government channels (levy sugar). It can sell a specific quantity in the free market as and when the government announces the release quota, which limits the profitability of the factory. Sometimes there is compulsion for export and by and large the international market price is lower than the local market price. The price of molasses, is fixed by the government at a very low level (Rs. 60/ton) thus reducing the income of the industry.

The average production of sugar and recovery of sugar is fairly low in many States and is detrimental to the industry as a whole. In many States recovery is between 8 to 9 percent as against about 11 percent in Maharashtra. In many States sugarcane production is very low, i.e. around 40 tonnes per hectare as against 100 tonnes per hectare or more in some States like Maharashtra, Andhra Pradesh etc. Variation in rainfall has a tremendous effect on this industry like any other agroindustry.

However the major factor affecting the profitability of the sugar industry is the increasing cost of inputs coupled with limitations regarding sale of products described above. The cost of labour, irrigation, transport, seed material and chemicals has gone up considerably during the last few years. Hence the farmers have to consider maximizing the use of land by integrating sugarcane production with other operations.

4. Suggested approach for maximizing benefits from sugar production

4.1 In a developing country like India with a large human population and limitation of land, irrigation facilities and purchasing power of an average person, a different approach is needed to obtain full benefit from any agricultural production system. An approach which will maximize use of all natural resources such as land and water, and in addition human labour and products of the system, needs to be taken. A change in the organizational pattern of the industry has to be considered so that farmers benefit fully from the profits of value addition in the product due to processing. Thus integration of farming systems, cooperativization and full use of byproducts are suggested. Adoption of this approach has considerably improved the socio-economic status of farmers in Western India. A systems approach needs to be taken which will consider agroclimatic conditions, natural resources, farmers' aptitude, organizational support, Government policies and other related aspects.

4.2 Emergence of cooperatives in sugar production

As a result of the emergence of cooperative units in Western and Southern India, the industry has played a very significant role in the economic and social progress of the farmers. In States like Maharashtra, Gujarat, Karnataka and Andhra Pradesh the majority of factories are in the cooperative sector, while in the States of Uttar Pradesh, Bihar etc. most of the factories are in the private sector. The cooperative sugar factory has enabled the farmers to come together

and made them realize their ability in organizing themselves for sugar production and overall development. The unique feature of the sugar cooperatives in these States lies in the fact that they have used part of the profit for the overall development of the area, the people and water resources, providing educational and health facilities, helping the farmers in diversifying into horticulture, poultry and animal production, arranging loans on easy terms etc. The factories employ professionals who help to organize and plan cultivation, harvesting, crushing and processing of sugarcane and marketing. The farmer does not have to bother about any of these aspects and he can concentrate on cultivation and also think of diversifying. Many factories have started distilleries for alcohol or acetone production from molasses and a few have put up papermaking units based on sugarcane bagasse. Preparation of cattle feed from bagasse is a relatively new area of interest.

4.3 Integration of sugar and milk production in Maharashtra State

Diversification, development programmes and integration with milk production by the sugar cooperatives in Maharashtra with a view to increasing the farmer's income and optimize use of land and human labour are worth studying. Some cooperatives established distilleries for making power alcohol and potable alcoholic drinks from molasses and paper units using bagasse. Some have established large poultry farms since Bombay provides an excellent outlet for eggs and chicken. The Bhartiya Agro Industries Foundation which initiated a large cattle development programme during 1969–70 in Western India was able to convince the cooperatives that dairy cattle keeping could integrate very well with sugarcane production and would be an excellent source of additional employment and income to the farmers as well as to the landless labourers working in that area. It would provide work and income for womenfolk - who generally look after cattle or buffaloes. Starting with a few centres for crossbreeding covering a few thousand animals in 1969–70 the BAIF has during the last few years been operating more than 50 centres covering 100 000 cattle in the sugar belt. About 50 000

crossbreds have been produced through these centres with farmers. The amount of milk generated increased so rapidly that separate cooperatives have been formed in different districts and dairy cattle keeping, which was never a traditional vocation in this area, has become an important part of the farming system. The cattle utilize byproducts like sugarcane tops efficiently and provide valuable manure and males for farm operations and carting.

A large number of farmers have installed a cowdung biogas plant which provides fuel as well as good quality manure. Manure is valuable since it helps to maintain soil texture and quality which otherwise deteriorate rapidly in the sugarcane area because of heavy doses of fertilizers and irrigation. The farmers produce good quality fodder crops as rotational crops or catch crops or inter crops since good milch cattle are now available to them. Generally lucerne is sown as a rotational crop for sugarcane in order to restore the fertility of the plots.

While the sugarcane is in a growing stage catch crops of maize or sorghum are grown by the farmers. Most of the farmers sow leguminous trees like sesbania and more recently leucaena on the bunds between the sugarcane plots as wind breaks and a source of fuel and fodder. An attempt has been made to illustrate this integration in Figure 1. Another interesting feature which has attracted the farmers towards animal production and particularly milk production is ready cash availability through milk; while payments are generally made for sugarcane at 6-monthly intervals and full payment is received only after 12–14 months, payment for milk is made every day or at least once a week by the cooperative.

4.4 Utilization of sugar and its byproducts for animal feeding

4.4.1 Whole sugarcane is not commonly fed to animals or cultivated as a fodder crop since it fetches a fairly high price for sugar production. However, under certain conditions, such as excessive production of cane and delay in harvesting, rejection of the cane by the factory, non-

availability of irrigation and non-availability of fodder crops, whole sugarcane is sometimes fed to the animals. The average chemical composition observed after analysing a number of samples of whole sugarcane of the CO-740 variety is summarized in Table 1. Feeding trials conducted on crossbred cattle producing 10 to 12 litres of milk indicate that whole sugarcane can easily replace conventional fodder crops like sorghum with an average intake of 20.5 kg per day and dry matter digestibility ranging between 56 to 57 percent (Rangnekar & Joshi, 1978). Ensiling of sugarcane was tried along with 0.5 percent urea. A product with pH of 3.6, crude protein content of 6.25 percent and good acceptability by animals could be obtained. Some trials were also conducted cultivating sugarcane as a fodder crop and it was found that by harvesting sugarcane at shorter intervals, a more leafy material and fairly high yields (about 200 tonnes per hectare) could be obtained. Feeding trials comparing sugarcane harvested at 6 and 12 months showed that dry matter intake is significantly better for 6 months' cane and crude protein is higher (Badve et al., 1979) (Table 1). Derinding of sugarcane was not tried since it involves fairly high investments. However, use of a softer variety of sugarcane available in Maharashtra State (called Pundya) has indicated that intake with this variety could be fairly high. However, the yields are low.

4.4.2 Sugarcane tops, as indicated earlier, are utilized in many areas as green fodder during the harvesting season. The average chemical composition of sugarcane tops of the CO-740 variety is summarized in Table 2. Trials conducted on ensiling of sugarcane tops with urea produced encouraging results and good quality silage could be obtained. Ensiling of tops for preservation is now being popularized.

4.3 Sugarcane bagasse is available in large quantities with well established sugar factories since this is a material available at low cost and at one point of production. The possibilities of its use attracted attention particularly during the severe drought in 1974–75 in Maharashtra and Gujarat States. Thousands of animals were maintained in these States on sugarcane

bagasse supplemented with molasses, urea, minerals and a concentrate mixture. Encouraged by experience it was thought worthwhile to study the processing of bagasse to improve its palatability and digestibility and to supplement it to increase energy, protein and mineral value so that a cheaper alternate feed could be made available to the small farmer and landless labourer. Trials were conducted with bagasse subjected to steam treatment using pressure of 5, 7 and 9 kg per cm^2 for 30, 60 and 90 minutes (Table 3). It was found that the digestibility improved considerably with the treatment. However, the important change was in colour, smell and palatability of bagasse, making it an acceptable material (Rangnekar et al., 1982, 1986a). The process has been tried at several places in Maharashtra and Gujarat and ultimately a spherical rotating digester has been designed to process bagasse since a number of factories were interested in preparing low cost feed from treated bagasse. Trials have been conducted with complete feed prepared with treated bagasse as a major component. Purebred Jersey averaging 11 to 12 litres and crossbred cattle averaging 8 to 9 litres could be easily maintained on this complete feed. Moreover the cost of feeding the animals was lowered considerably (Rangnekar et al., 1986b).

4.4.4 With regard to use of molasses, there are two centres where some interesting applied research has been undertaken in India which resulted in the recommendation of two products from molasses for cattle feeding. At the Punjab Agricultural University, Ludhiana, preparation of Uromol was undertaken and it was successfully demonstrated that this could replace concentrates to some extent. The Uromol involves mixing of urea and molasses and cooking for 60 minutes. The mixture can be used as such or with bran mixture oil cakes or other supplements as per the requirement (Rana and Lengar, 1982). Another interesting product has been developed by the National Dairy Development Board, Anand which has resulted in development of a molasses brick. This essentially contains molasses, urea, minerals, rice bran and a protein supplement and the mixture is solidified and made into brick form. NDDB has

developed the process with the advice of Dr. Leng from Australia and a unit for making bricks has been developed. This has been tried in some of the Operation Flood areas with good results. The results show a considerable economy in feeding of milch buffaloes particularly those on a straw diet (Kunju, 1986). The feeding of molasses bricks is reported to increase the intake of straw and replace a concentrate mixture to some extent.

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Figure 1: Integration of sugar and milk production for optimizing Land use

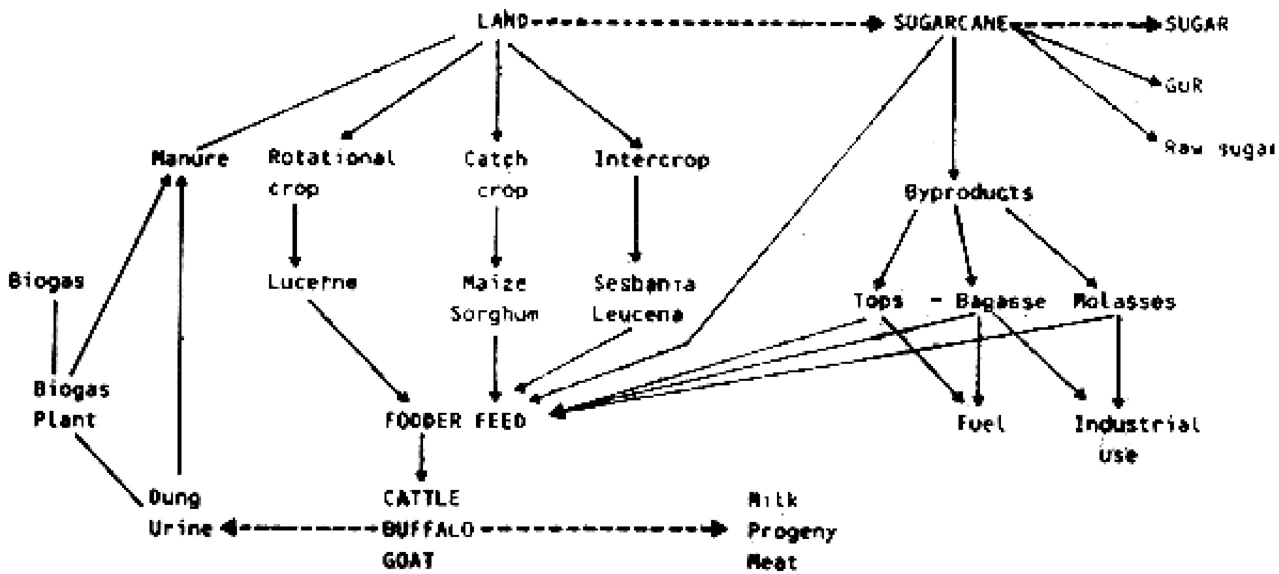

Table 1: Some observations on whole sugarcane

1. Chemical composition of mature (18 m) whole sugarcane; var. CO-740 (% dry basis) (average of

several observations)

DM	CP	CF	EE	Ash
30.0	2.3	30.1	1.3	6.2

2. Chemical composition of sugarcane harvested at two stages (6 & 12 months) (var. CO-740) (% dry basis)

	CP	CF	EE	Ash	NFE
6 months	3.4	21.7	1.4	5.4	68.1
12 months	1.8	23.8	1.1	6.8	66.4

3. Average digestibility coefficients & intake of whole sugarcane (CO-740) harvested at 6 and 12 months age (% dry basis)

	DM	OM	EE	CF	NFE	(Dig).Energy)
6 months	56.9	61.6	39.8	56.2	65.3	2450
12 months	57.8	59.7	17.2	58.1	62.4	2446

Table 2: Studies on sugarcane tops

1. Chemical composition of sugarcane tops (average of several observations - % dry basis)

CP	CF	EE	Ash	NFE
6.2	30.9	1.5	8.5	52.9

2. Chemical composition and digestibility studies with silage of sugarcane top + 0.5% urea (% dry basis)

	DM	CP	CF	EE	Ash	NFE	pH	Lactic

acid

Composition	30	8.1	31.7	1.8	6.1	53.2	4.7	5.2
Digestibility Coefficients	48.4	56.3	60.0	36.7	-	44.7	-	-

Table 3: IVTDMD and cell wall digestibility of steam-treated sugarcane bagasse, paddy straw and sorghum straw

	Treatment		Sugarcane bagasse[1]		Paddy straw[2]		Sorghum straw[3]	
Pressure (kg cm^{-2})	**Period (min)**	**IVTDMD**	**CWC digestibility**	**IVTDMD**	**CWC digestibility**	**IVTDMD**	**CWC digestibility**	
Untreated		34.5[a]	30.8[a]	49.2	26.0	38.2[a]	13.8[a]	
5	30	42.5[a]	40.1[b]	58.8	36.0	54.0[b]	28.9[b]	
7	30	51.1[c]	34.9[c]	61.6	39.7	54.3[b]	27.1[bc]	
9	30	54.5[c]	30.1[a]	67.0	30.4	53.9[b]	22.9[c]	
5	60	50.6[bc]	34.5[c]	60.5	26.8	50.3[b]	21.6[c]	
7	60	50.5[bc]	32.4[d]	63.5	26.2	50.7[b]	22.1[c]	
9	60	56.6[c]	26.2[c]	62.5	26.1	52.1[b]	17.9[d]	
SE		2.70	0.46	-	-	1.69	1.70	
LS		8.10	1.42	-	-	5.61	5.26	

1 Mean of 10 observations.

2 Mean of 2 observations.

3 Mean of 6 observations.

abcd: Values in a column with different superscripts differ ($p < 0.5$)

INTEGRACION DE LA PRODUCCION DE CAÑA DE AZUCAR Y DE LECHE EN LA INDIA OCCIDENTAL

por

D.V. Rangnekar

La producción de caña de azúcar es una de las agroindustrias más importanres en las zonas rurales de la India. Ha tenido un enorme impacto en la situación socioeconómica de la población de algunas zonas en que la industria está organizada. La producción de azúcar en los últimos cinco años ha sido de 6 a 8,4 millones de toneladas, con una tasa de recuperación media del 10 por ciento aproximadamente. La industria del azúcar se está diversificando y tratando de utilizar debidamente los subproductos. Sin embargo, las posibilidades de mejorar su utilización son grandes.

La industria del azúcar en la India se caracteriza por una demanda nacional cada vez mayor, por sus posibilidades de exportación y por el surgimiento de cooperativas. Sin embargo, los bajos rendimientos obtenidos en algunas zonas, la fluctuación de los precios, el control ejercido sobre la venta de azúcar, los bajos precios fijados para la melaza y la periodicidad de las sequías influyen negativamente en la economía de esta industria.

Un elemento positivo es el surgimiento de cooperativas de agricultores en la India occidental y meridional, que permiten a éstos beneficiarse plenamente de la industria e invertir parte de las utilidades en su desarrollo, diversificación e integración en la producción animal. Las cooperativas reciben bastante apoyo del Gobierno. Merece estudiarse el impacto que ha tenido en el estado de Maharashtra, ya que la mayoría de las fábricas funcionan en régimen cooperativo. Las cooperativas han colaborado con la Fundación de Industrias Agrarias de Bhartiya en la integración de la producción del azúcar y la leche con excelentes resultados.

Se describen brevemente algunas interesantes investigaciones aplicadas sobre los subproductos.

Para países en desarrollo como la India, se sugiere la aplicación de un método de sistemas que potencie al máximo la utilización de los recursos, permita elegir a los candidatos apropiados para la integración, las technologías y las estructuras orgánicas (como cooperativas) a fin de que los productores puedan beneficiarse plenamente.

LA INTEGRACION DE LA PRODUCCION ANIMAL EN LA EMPRESA AZUCARERA COMERCIAL

por

Angel M. Piña

INTRODUCCION

El ingenio Central Romana es una empresa que se dedica básicamente a la producción azucarera ubicada en la región Este de la República Dominicana. La ganadería nace en esta empresa en vista de la necesidad de producir un animal para el arrimo de la caña a las estaciones de carga, de donde el ferrocarril levanta la cañ para llevarla al ingenio.

A través de los años nuestra ganadería se ha diversificado, de tal manera que ya no solo

producimos y mantenemos a la boyada, sino que también producimos ganado especializado (cría y ceba), ganado de leche, ganado porcino y crianza equina, así como también la industrialización de carne mediante un moderno matadero con fábrica de embutidos.

Como empresa azucarera el ingenio Central Romana genera una serie de subproductos con potencial para ser convertido a través de sistemas de producción animal en carne y leche.

La región Este de la República Dominicana tiene condiciones excelentes para la explotación animal. Estos subproductos podrían ser utilizados para liberar las presiones existentes sobre la tenencia de tierra de un país pequeño, pudiendo producirse más sin demandar nuevas áreas y también estos subproductos podrían servir para nivelar la producción de carne y leche a través del año, ya que la producción de pasto en la zona tiene períodos de alta y baja, así como también un valor nutritivo deficiente, especialmente en energía, proteína y minerales.

La lluvia tiene un efecto directo sobre la producción de pastos; como puede notarse durante los meses de Diciembre, Enero, Febrero, Marzo y Abril, la disponibilidad de pastos es baja, afectando en esa misma forma la producción de carne y leche.

Preocupado por los inconvenientes en la producción animal, antes expuestos y en razón de la disponibilidad de algunos subproductos, el ingenio Central Romana ha incursionado en los siguientes programas.

1. <u>USO DE MELAZA EN ALIMENTACION</u>

La melaza de la industria azucarera, es el subproducto que mayor uso se le ha dado en el ingenio Central Romana para la alimentación de sus animales. Su utilización ha variado desde 5 hasta 50 por ciento en las raciones de vacas de cría de carne y lecheras, novillos de engorde y cerdos. Se pueden mencionar los programas siguientes:

1.1 Suplemento a Crianza de Ganado de Carne en Pastoreo

La suplementación de melaza, ha sido enfocada en dos aspectos: en primer lugar la necesidad de suplir energía y otros nutrientes al ganado en la época seca del año en que los pastos son deficientes. En segundo lugar la suplementación de melazas enriquecidas a vacas reproductoras en su período pre y post partum, resulta necesaria aún en condiciones de abundante pasto. Esto se debe a que los pastos disponibles son mayormente gramíneas que se desarrollan en suelos marginales con su consecuente deficiencia en proteínas y minerales.

En este programa se utilizan mezclas de melaza-urea ácido fosfórico-vitaminas que se suministran a solas o mezcladas con gallinaza, cáscara de maní o tusa de maíz, tomando como base la disponibilidad de pastos, la etapa de producción de las diferentes clases de bovinos y su valor genético. Por ejemplo, las novillas primerizas ocupan el primer lugar en el orden prioritario de suplementación y en tal sentido se les suministran de 1.0 – 1.5 kg de melaza enriquecida y una cantidad de gallinaza, desde el 7mo mes de la preñez hasta terminado el período de monta (120 días).

1.2 Melaza para la Mejora de Ganado de Carne

Tradicionalmente la ceba o engorde de novillos en la República Dominicana se ha hecho en potreros, utilizando un área de alrededor de 0,625 ha por animal. Indudablemente que este sistema requiere de grandes extensiones de terreno y mayor tiempo para que el animal obtenga el peso deseado para el sacrificio (425–450 kg).

Consciente de que las áreas dedicadas a las explotaciones ganaderas tienden a disminuir, mientras que la demanda por la carne roja aumenta, es necesario recurrir a sistemas de producción que nos permitan producir más carne en menos tierra. En tal sentido, el ingenio

Central Romana ha utilizado la melaza para incrementar la concentración energética de las dietas de los animales en pastoreo y de esta manera aumentar la carga animal de la finca.

Al suministrar de 4–5 kg de este subproducto por animal por día se pudo reducir el área por animal en un 25 por ciento, lo que nos indica que las áreas donde pastoreaban 100 animales pueden ahora pastar, utilizando este recurso, 125–130 cabezas.

La melaza la utilizamos también en programas de ceba intensiva, es decir en confinamiento total, donde los animales permanecen encerrados con dietas donde la melaza y el pasto constituyen las fuentes principales de energía, obteniendo 600–700 gramos de aumento por cabeza por día, con un consumo de melaza de unos 5 kg.

1.3 <u>La Melaza para Vacas Lecheras</u>

En el ingenio Central Romana se opera una lechería con vacas mestizas de las razas Holstein y Pardo Suizo, con ganado de carne producido por la empresa. Las novillas de reemplazo son producidas en la misma operación. La producción de estas vacas oscila entre 8–10 litros de leche por día en dos ordeños.

La melaza ha sido un ingrediente energético básico, utilizado en varios programas dentro del área lechera:

a. **Componente de una mezcla suplemento con 50 por ciento de melaza, ofreciendo 20 kg diarios a las vacas en ordeño.**

b. **Parte de un ensilaje (5–10 por ciento) para ayudar a preservarlo y a la vez aumentar el valor energético del mismo. Las vacas consumen 25–30 kg.**

c. **Suplemento a vacas secas y novillas de reemplazo en pastoreo, en cantidades de 1–2 kg por día.**

1.4 Sustituto de Granos para Alimentación de Cerdos

Cerdos de 40–100 kg fueron alimentados con dietas en las que se sustituyó gradualmente el maíz por melaza a los niveles de 30, 40 y 50 por ciento. El programa de alimentación y comportamiento de los cerdos están descritos en los Cuadros 1 y 2.

Indiscutiblemente que estos resultados muestran la posibilidad de sustituír económicamente parte del maíz por melaza hasta 50 por ciento, sin alterar significativamente el cebado de los cerdos.

2. USO DE BAGAZO

El valor alimenticio del bagazo, como es de todos conocidos, es muy pobre, especialmente si no se le somete a algún tipo de tratamiento tendiente a aumentar su digestibilidad. Originalmente el ingenio Central Romana utilizó bagazo como fuente de fibra para controlar problemas de meteorismo en programas de ceba intensiva de novillos en la que aparentemente las dietas estaban deficientes de fibra.

Otro uso ha sido en períodos extremos de sequía, cuando la carestía de pasto es tal que se hace necesario el uso o suplemento de fibra a los animales, como parte de una mezcla con melaza y otros.

Hemos utilizado gallinaza proveniente de operaciones avícolas que usan el bagazo como cama. Cabe mencionar que este tipo de gallinaza resulta más difícil de incorporar en mezclas.

El uso más efectivo que hemos logrado en producción animal en nuestras operaciones, es como cama para los establos de caballos y en la operación porcina para la protección de los cerditos en las parideras y los recién destetados.

3. USO DE LA CACHAZA

Unas 100 mil toneladas de cachaza son producidas anualmente por el ingenio del Central Romana. Regularmente este subproducto representa un problema, ya que la factoría tiene que acarrearlo o deshacerse de él, resultando en un costo sustancial. En el ingenio Central Romana se han implementado varios programas en busca de aprovechar este recurso.

3.1 Cachaza como parte de un Alimento Balanceado

La cachaza muestra el análisis siguiente: materia seca: 21 por ciento; proteína cruda: 8.50 por ciento; fósforo: 1.42 por ciento; calcio: 2.60 por ciento; pH: 7.40 por ciento.

Se ha fabricado alimento balanceado para bovinos con 50, 25 y 15 por ciento de cachaza. El consumo de este alimento fue aceptable por los animales, así como el comportamiento de los mismos. Sin embargo, por la composición (humedad) y naturaleza de la cachaza se hizo difícil el manejo de la misma, ya que por su alta humedad y pH, existe un medio ideal para la multiplicación de hongos, así como el hecho de que el peso de los sacos de alimento era muy instable, de manera que 100 kg de la mezcla en la mañana, se convertían en 70–80 kg en la tarde. Lógicamente que a niveles bajos este problema se reduce sustancialmente.

3.2 Aditivos para Ensilaje

Un ensilaje utilizando barbojo de caña con una humedad de alrededor de 50 por ciento, se prepara incorporando un 15 por ciento de cachaza para subir la humedad al standard de 65 por

ciento, así mejorar la capacidad de compactación de la mezcla, su valor nutritivo y bajar el costo de producción.

3.3 Para mejorar los Suelos de los Potreros

El programa de cachaza para mejorar los suelos de los potreros del departamento de ganadería, es muy prometedor. Por lo regular este material se utiliza en aquellas áreas de potreros que estén cerca del ingenio azucarero y la razón de esto es que el costo de transportación es sumamente alto para un material que contiene 80 por ciento de agua. Los suelos donde es aplicada la cachaza son pedregosos o rocosos, así como superficiales, en tal sentido su uso es muy limitado o su potencial de producción de pasto es sumamente reducido, comparado con otras áreas.

Este abono orgánico es una enmienda al suelo que restituye las características físico-químicas indispensables para la producción de un pasto mejorado. Generalmente la hierba sembrada es la Estrella o Bermuda (Cynodon Spp) pero cualquier pasto mejorado es capáz de responder a esta práctica. Se ha observado que aquellas áreas que fueron regadas con cachaza han aumentado su capacidad de producción de pasto o forraje de 3 a 4 veces cuando se le relaciona con áreas no tratadas o mejoradas.

4. USO DE BARBOJO

La industria azucarera nacional produce anualmente unos 2–3 millones de toneladas de barbojo, de los cuales solo un 20 por ciento se quema para fines de renovación de los cultivos de la caña.

El ingenio Central Romana por espacio de 5 años utilizó unas mil toneladas de barbojo como fuente de un ensilaje que mezclado con melaza, cachaza, gallinaza y agua añadida, constituyen

la dieta principal de un grupo de novillas que se confinan por 5–6 meses del año.

El ensilaje está compuesto de: barbojo 20 por ciento, cachaza 15 por ciento, melaza 15 por ciento, gallinaza 10 por ciento, agua 40 por ciento.

El análisis es el siguiente: materia seca: 35 por ciento, proteína cruda: 10 por ciento, calcio: 1.37 por ciento, fósforo: 0.54 por ciento.

Las novillas de unos 300 kg consumían unos 23 kg de este ensilaje por día. El aumento de peso de las novillas no fue significativo, pero cabe recalcar que se mantuvieron en condiciones satisfactorias y muestra de ello es que 75 por ciento de ellas mostraron celo normal y se obtuvo una preñez de 81.5 por ciento en un período de 45 días de inseminación artificial.

Otro programa que hemos ensayado es el barbojo mezclado con melaza/urea, para los bueyes durante el tiempo muerto. Durante la cosecha de la caña, los bueyes se mantienen en los campos de caña comiendo las puntas verdes de la caña consechada durante el día, estos bueyes solo van a los potreros si tienen algún problema que les impida el tiro de la caña; algunos trabajan hasta siete meses sin descansar.

El barbojo con melaza/urea mantuvo el peso de los bueyes y obtuvieron un ligero aumento de peso. Los bueyes más jóvenes lógicamente presentaron un comportamiento más pobre, pero satisfactorio.

5. USO DE LA CAÑA DE AZUCAR PARA RUMIANTES

El cultivo de la caña permite ser cosechado en diferentes estados de madurez sin que su valor nutritivo sea alterado significativamente, como ocurre con la mayoría de las gramíneas tradicionales. Esta condición permite que un campo determinado sea cosechado fresco

durante un período de tiempo prolongado.

Las experiencias del ingenio Central Romana indican que la caña de azúcar produce bajo condiciones de secano y en suelos pobres, mucha más materia seca que el pasto Estrella Africana. Una hectárea de caña produce 26 toneladas de materia seca por año, mientras que el pasto Estrella solo produce 6 toneladas.

Nuestra experiencia en la alimentación de la caña de azúcar a nivel comercial ha sido la de suplir caña fresca picada diariamente a los animales. La caña picada es suministrada a libre consumo del ganado, en corrales de alimentación en confinamiento. En todos los casos se les suple adicionalmente cantidades limitadas de una mezcla en proporciones iguales de gallinaza con melaza-urea, debido principalmente al escaso contenido de proteínas de esta gramínea.

Hemos realizado los siguientes programas:

5.1 <u>Confinamiento de Machos Comerciales</u>

Los niveles de consumo diario para un lote de 1,200 novillos que se encuentran en un programa de ceba intensiva, oscila entre 16 y 20 kilos de caña limpia picada (sin hojas ni puntas) por cabeza. Adicionalmente se les suministran 9 kg de la mezcla melaza-urea-gallinaza y todo el tiempo tienen disponibles un suplemento mineral.

Los animales son seleccionados alrededor de los 10 meses de edad con un peso promedio de 180 kg permaneciendo en este programa de 8–9 meses, cuando alcanzan de 350–375 kilos de peso vivo. Durante esta etapa de crecimiento se obtiene una ganancia diaria de alrededor de 750 gramos por cabeza.

Antes de ir al matadero, los animales son llevados a un peso de 450 kilos, en un programa de

acabado con una dieta de subproductos y granos, por un período de 90–120 días (Cuadro 3).

5.2 <u>Confinamiento de Hembras Lecheras de Reemplazos</u>

En este programa se han mantenido éxitosamente, hembras mestizas de las razas Holstein y Pardo Suizo, comiendo todos los días alrededor de 14–16 kg de caña picada y 12 libras de la mezcla melaza-gallinaza.

A medida que las novillas alcanzan los 300–320 kilogramos de peso viso, se van promoviendo a un programa donde son inseminadas artificialmente con semen de las razas Holstein y Pardo Suizo.

5.3 <u>Confinamiento de Novillas de Ganado de Carne</u>

1,800 hembras de 24 meses de edad, de la raza Romana Red y cruces comerciales, están siendo alimentadas con 16 kg de caña picada y 5 kg de una mezcla mitad melaza enriquecida con 3 por ciento de urea y la otra mitad de gallinaza.

El confinamiento se hace en corrales de alambre, provistos de comederos móviles, sin fondo y un bebedero de 30 pies de diámetro, por un período de cuatro meses, mientras dure el período de encaste, que va desde el lero de Abril hasta el 31 de Julio de cada año. Las novillas son palpadas 60 días después de concluído el encaste y los resultados revelan una preñez superior al 80 por ciento.

5.4 <u>Bueyes Confinados con Caña de Azúcar Picada y Melaza/Urea</u>

Durante los últimos dos años hemos confinado unos 5 mil bueyes durante el período de tiempo muerto. La alimentación se realiza con caña picada integral suplementada con melaza/urea. El

consumo estimado de caña es de unos 23 kg de caña - una cantidad limitada de melaza/urea de 1,5 kg/cabeza/día. El comportamiento de los bueyes ha sido satisfactorio.

6. ALIMENTACION DE CERDOS CON GUARAPO DE CAÑA

La parte energética de la ración, que tradicionalmente se ha suplido utilizando granos, es uno de los factores que más limitan la producción porcina en nuestra área. La alta concentración energética en el guarapo de caña lo convierte en un producto con potencial para la alimentación de cerdos.

Después de realizar algunos ensayos el ingenio Central Romana ha iniciado gradualmente la sustitución de granos por jugo de caña. En la actualidad estamos alimentando cerdos desde los 40 kg con guarapo de caña y un suplemento proteico que se va ajustando a las necesidades del cerdo a medida que aumenta de peso.

El aumento de peso de los cerdos entre los 40 y los 100 kg de peso vivo, es de 800 a 900 gramos diarios, con un consumo de unos 12 kg de guarapo y 1.0 kg de concentrado proteico (40 por ciento P.C.). La edad de los animales al mercado es de 165±10 días. De acuerdo a comparaciones entre dietas con jugo y dietas tradicionales en estos rangos de peso no se encontraron diferencias significativas.

En el presente estamos incursionando en la alimentación de guarapo a las cerdas madres. Suministrándoles unos 7 kg de guarapo a las cerdas preñadas en los últimos 30 días antes del parto, ayuda al desarrollo fetal. Los cerditos nacen más fuertes, la lactación es más abundante y las cerdas no muestran pérdidas de peso excesivo.

Cuadro 1: Programa de Alimentación

	Testigo (Maíz)	Melaza

Peso vivo kg.	40–50	50–70	70–100	40–50	50–70	70–100
Proteína, %	16	14	13	16	14	13
Fórmulas						
Maíz, %	74	87	90	38	32	25
Concentrado, 42% PC%	26	13	10	32	28	25
Melazas, 5	0	0	0	30	40	50
	100	100	100	100	100	100

Cuadro 2: Comportamiento de los cerdos alimentado con melaza

Grupo Promedio/Cerdo	Testigo (Maiz)	Melaza
Peso inicial, kg.	40	40
Peso final	102	101
Ganancia diaria, kg.	,85	,84
Consumo alimento/Dia, kg.	3,3	3,7
Conversion	3,86	4,40

Cuadro 3: Margenes de composicion en dietas para el terminado de novillos

Ingredientes	Porcentaje En la Dieta
Melaza-Urea	40–45
Gallinaza	20–30
Afrecho (Arroz-Trigo)	20–30
Cascara de Mani	10–12

INTEGRATING LIVESTOCK PRODUCTION IN A COMMERCIAL SUGAR ESTATE

by

A. Piña

The Romana sugar estate uses its by-products from sugar production for animal production systems.

The molasses is used at levels of 5 to 50% in rations for beef cattle, milk cows, pigs and horses. The results are satisfying. The work done at Central Romana has shown that molasses can substitute up to 50% of corn in rations for fattening pigs without changing their performance. Bagasse is used as roughage in times of scarcity of pasture, and is also a good litter for horses and piglets. The filter mud can be used only in a limited quantity as animal feed. Pastures with stony and superficial soils improved in productivity after applications of 500–600 m3 of filtermud per acre. This practice was limited to pastures close to the sugar factory.

The trash, mixed with filtermud, molasses and poultry litter as part of a silage, gave good results in maintaining animals during periods of scarcity.

The eastern part of the Dominican Republic has excellent conditions for the production of sugarcane. The cane can be harvested in different stages of maturity without a significant change in nutritive value. Diets based on sugarcane, given to beef cattle, oxen, milk cows and pigs, have demonstrated the great potential of these grasses for animal production.

Finally sugarcane juice as a substitute for cereals in pig feeding presents big potential, given to pigs who reach 100 kg liveweight in a period of about 165 days.

MOLASSES AS ANIMAL FEED: AN OVERVIEW
by
T.R. Preston

INTRODUCTION

Research at the Cuban Institute of Animal Science in the late 1960s led to the development of molasses-based feeding systems for both cattle and pigs, which have been applied on a widespread scale, in many tropical countries (Preston and Leng, 1986).

Molasses had been used previously in animal feeds, but always at relatively low levels (usually less than 20 percent of the diet). The Cuban research was the first to show that molasses could seriously be considered as an alternative to cereal grains as a means of intensifying animal production in the tropics.

DEFINITIONS

Molasses is a term applied to a variety of by-product feeds derived from sugar-rich crops. To avoid confusion, the different kinds of molasses that are produced by the sugarcane industry are listed in Table 1. The Spanish names are used in the case of products derived from the "panela" industry as there are no English equivalents.

From the nutritional standpoint, the major differences in the various "molasses" by-products are in the amount of soluble ash as a proportion of the total dry matter. In this respect, final molasses stands apart from the rest with an ash content between 10 and 15 percent of the dry

matter. As is to be expected from the method of manufacture, “B” molasses is in a position intermediate between final and high-test molasses. The “cachaza” and “melote” from “panela” production resemble the raw cane juice and cane syrup, respectively; they differ in their higher content of impurities, mostly as protein and mineral matter complexed with “tannins” from the bark extracts used to clarify the juice.

The concentration of soluble ash in the molasses derived from industrial manufacture of crystalline sugar, and the impurities in “cachaza” and “melote”, are the factors which apparently determine the degree to which these feeds can be incorporated in the diets of monogastric animals. All the different types of molasses can be fed safely to ruminants, even at high levels (> 70 percent of the dry matter).

MOLASSES AS A FEED FOR RUMINANTS

It is important to distinguish between low and high level usage of all types of molasses. At low levels (<20 percent of the diet dry matter), the effect of the soluble carbohydrates in the molasses tends to be complementary rather than competitive and there appears to be little or no depression in the degree to which the basal feed resource is fermented. Beyond a concentration of 20 percent in the diet dry matter, there is increasing competition for substrate by the rumen microorganisms, with the result that the basal diet is used less and less efficiently according to the amount of molasses that is fed.

When molasses accounts for more than 50 percent of the diet, the digestibility of all types of feeds that accompany the molasses is depressed often to the point of only half the value recorded when molasses is not given (Encarnación and Hughes-Jones, 1981). These effects are obviously undesirable if the accompanying feed is composed mainly of cell wall carbohydrate: however, if the feed is rich in protein, starch or lipids-which can be digested by

gastric enzymes in the small intestine-then depressing the extent to which these nutrients are fermented in the rumen becomes an advantage to the host animal.

Final molasses as a supplement

It is frequently claimed that small amounts of molasses in a roughage-based diet stimulate rumen fermentation. However, this appears to be unlikely in view of recent evidence that sources of digestible cell walls, rather than soluble carbohydrate, are the most appropriate supplements for this purpose (e.g. Gutierrez and Elliott, 1984; Silva and Orskov, 1985).

The most appropriate role for small amounts of molasses in ruminant diets is as a vehicle for other nutrients (e.g. urea and minerals). A drought feeding strategy based on the use of liquid molasses supplements containing from 8 to 10 percent urea is now an established practice in Australia (Nicol et al., 1984) and has been introduced sucessfully in Africa (Preston and Leng, 1986).

The incorporation of urea and other nutrients in molasses-based (multi-nutritional) blocks promises to be an even more attractive technology, especially for smallholder-village farmers, for supplementation of locally available crop residues which are of low digestibility and also deficient in fermentable nitrogen (Leng and Preston, 1984; Sansoucy et al., 1986).

Final molasses as the basis of the diet

The Cuban research in the late 1960s had, as its objective, the development of livestock feeding systems in which molasses was the principal ingredient. At the outset it was decided that molasses should be fed in its original liquid state in order to reduce processing costs and to facilitate transport and storage. The successful development of the high molasses-fattening system for cattle (Preston et al., 1967a) exemplifies the application of the basic principles of

ruminant digestion and metabolism on low-N, high-CHO feeds, namely:

- **optimization of rumen fermentation by supplying fermentable-N (urea) and some high quality green forage;**
- **balancing the nutrients available for metabolism, by providing bypass nutrients.**

The original system utilized forages such as Elephant grass, pangola grass and often sugarcane tops as the roughage source. Forage was restricted (0.8 kg dry matter/100 kg liveweight) to encourage the animal to consume high levels of molasses. The urea level was set at 2.5 percent of the fresh weight of the molasses to provide a ratio of fermentable nitrogen to carbohydrate close to the theoretical requirements of efficiently growing rumen microorganisms. Sulphur supplementation was not required as sulphur dioxide is used in clarification of cane juice and residual sulphur is concentrated in the molasses. In the first widespread commercial application of the feeding system, fishmeal (Peruvian) was the bypass protein supplement. The dramatic effect of this supplement in raising animal productivity on a molasses-based diet is shown in Figure 1. The data in Tables 2 and 3 summarize the results obtained when the molasses fattening programme was commercialized in large scale feedlots and under conditions of restricted grazing on State farms.

Subsequent developments in the use of molasses-based diets have been directed to the use of:

- **high protein forages which supplied much, and sometimes all, of the bypass protein as well as the roughage characteristics (Figure 3, Tables 1 and 5);**
- **Supplementation with poultry litter (Figure 2).**

There is evidence that on molasses-based diets, poultry litter influences the pattern of VFA formation by increasing the proportions of propionate and decreasing the butyrate (Fernandez and Hughes-Jones, 1981; Marrufo, 1984). This would be a partial explanation of the improved growth rates and feed conversions associated with the use of poultry litter in molasses-based diets (Figure 2) see also Meyreles, 1984 and Herrera, 1984).

OTHER TYPES OF MOLASSES

High-test molasses

High-test molasses differs from final molasses in that it is the concentrated sugarcane juice, from which no sugar has been extracted, but which has been clarified and filtered (to remove impurities) and partially inverted (conversion of sucrose to its constituent reducing sugars, glucose and fructose), to prevent crystallization of the sucrose. It is thus richer in total sugars and has a much lower content of soluble ash than final molasses, which as the name implies is the residual solubles of the cane juice after most of the sucrose has been extracted. High-test molasses is not laxative and gives rise to faeces which have normal consistency.

The successful feeding of pigs with liquid diets in which high-test molasses was the only source of carbohydrate, and contributed up to 70 percent of the ration dry matter, was first reported from Cuba (Preston et al., 1968). High-test molasses supported similar rates of liveweight gain as final molasses in one experiment with fattening steers in Cuba (Preston et al., 1967b).

“Cachaza” and “melote” (sugarcane scums)

“Cachaza” is the flocculated matter and associated cane juice removed from the boiling cane juice during the artisanal production of “panela”. Its composition is similar to that of cane juice

differing only in the higher percentage of protein and minerals and other substances (including tannins) present in the bark extracts added to aid the flocculation process. It may be fed fresh but usually it is concentrated to about 60 percent solids so as to give a stable product which can be stored (the fresh "cachaza" begins to ferment after 24 h). The concentrated product is called "melote" in Latin America.

There seem to be no reports in the scientific literature concerning the nutritive value of "cachaza" or "melote" in animal feeds; however, they are widely used at least in Latin America as a feed for pigs and for the mules that traditionally transport the feed for pigs and for the mules that traditionally transport the sugarcane from the fields. Practical observations are that they satisfactorily replace cereal grains in the diet of finishing pigs but cause diarrhoea in younger pigs and are not suitable for lactating sows (T.R. Preston, unpublished observations).

In Colombia, steers given free access to "melote"/urea (2.5 percent urea), and restricted quantities of rice polishings, poultry litter, sugarcane tops and foliage from the legume tree, Gliricidia sepium, had average liveweight gains of 800 g/d (T.R. Preston and R. Botero, unpublished data).

METABOLIC DISEASES ON MOLASSES-FEEDING SYSTEMS

Three metabolic diseases may occur in cattle and sheep fed diets in which molasses is used as a supplement (as a vehicle for urea) or as the basis of the diet. These are: urea toxicity, molasses toxicity and bloat.

Urea toxicity

With ad libitum feeding of molasses/urea mixtures, urea intakes may reach as high as 300 g/d (e.g. in a 500 kg dairy cow consuming 10 kg/d of the molasses/urea mixture). Even in these

cases, there is rarely any risk of urea toxicity since the sugars in molasses and ammonia from urea are quickly used in microbial cell growth. Animals which have never previously consumed urea can be safely permitted free access to mixtures of molasses containing up to 3 percent urea without fear of toxicity. The principle underlying the use of molasses with 8–10 percent urea is that the high urea concentration inhibits consumption of the mixture (Figure 4). Toxicity will only occur if the urea is not uniformly mixed or if the mixture has a high water content which may encourage the animal to "drink" rather than "lick" the mixture.

Molasses toxicity

This used to be the most serious problem associated with ad libitum molasses feeding. For example, in the first year following the introduction of the molasses/urea fattening system in Cuba, mortality and emergency slaughter rates in a 10 000 head feedlot increased from 0.1 percent and 0.4 percent (when a forage-based diet was fed) to 1 percent and 3 percent respectively, when the diet was changed to high levels of molasses/urea (see Table 2).

Cattle suffering from molasses toxicity salivate, stand apart in a "dejected" posture, usually with their head lowered; and frequently are found "leaning" against the fence or feed trough. Invariably, eye-sight is affected and often the animal is blind. When disturbed they have an unsteady and uncoordinated gait and this led the "cowboys" in Cuba to refer to the affected animal as "borracho" (i.e. drunk!!).

The nervous symptoms and blindness, that were a feature of molasses toxicity, indicated damage to the brain and it was subsequently shown (Verdura and Zamora, 1970) that the clinical syndrome was indistinguishable from that of cerebro-cortical necrosis (CCN) also known as polioencephalomalacia (Edwin et al., 1979). The necrosis in the brain is readily seen and this allows rapid diagnosis. The cause of the necrosis is likely to be a decrease in the

energy supply to the brain either because of an absolute deficiency of alimentary thiamine, binding of thiamine analogues produced in the rumen and/or through the action of thiaminase in the rumen (Edwin et al., 1979); or a deficiency of glucose (Losada and Preston, 1973).

Treatment and prevention

In high-molasses feeding systems, it is usual to restrict the supply of forage (either to stimulate molasses intake or because of the greater cost of forage compared with molasses). Inadequacies in the forage supply, either in quantity or "quality", appear to be the main causative factors of molasses toxicity. Thus, the incidence of molasses toxicity was less when wheat or barley straw, rather than sorghum forage or maize silage, were used as the forage sources in molasses-based feedlots (T.R. Preston, unpublished data). Furthermore, there have been no reports of toxicity when high protein forages (e.g. leucaena, and cassava and sweet potato leaves) have been used. Equally, the feeding of palatable forage with a high protein content appears to be the best cure for affected animals. The recent developments in the molasses feeding system have emphasized the technical and economic advantages of giving high protein forages, especially from leguminous trees like leucaena, gliricidia and erythrina, as a combined source of both "roughage" and "bypass" protein (Preston and Botero, 1986). Such procedures are also likely to offer the most cost-effective solution for molasses toxicity. The above discussion emphasizes the critical role of management in any feeding system where economic constraints dictate a less than optimum degree of supplementation.

Bloat

Bloat, which is the retention in the rumen of gas, either free or entrapped in foam, occurs in almost all feeding systems. It is more frequent in the diet of other carbohydrate sources which have little or no fibre but which are highly digestible, such as raw sugar (MacLeod et al., 1968)

and maize grain (Fermin et al., 1984).

PRACTICAL FEEDING SYSTEMS FOR MONOGASTRIC ANIMALS USING MOLASSES (FINAL, HIGH-TEST AND "MELOTE")

Two approaches are possible:

Molasses as a component of traditional feeds

Including molasses in conventional cereal grain-based feeds is established technology, but has limited economic significance in developing countries because of the relatively small proportion (5 to 10 percent of the feed) of molasses than can be accepted by most mixing systems in conventional feed mills.

Molasses as the basis of new feeding systems

Final and "B" molasses have been the basis of commercial pig diets in Cuba since the late 1960s (Perez, 1986). The molasses is fed in liquid form, partially diluted with water and is combined with a protein supplement usually of saccharomyces, yeast and fishmeal.

The most widescale example of molasses usage is as a component of a "soup" prepared by boiling urban organic refuse (mostly food and vegetable wastes) and using this enriched with "B" molasses as the only feed for pigs (Perez, 1986).

Although technically feasible (e.g. Perez et al., 1968), there has been no commercial application of molasses feeding as the basis of diets for poultry, mainly because of management difficulties caused by the viscous nature of the molasses.

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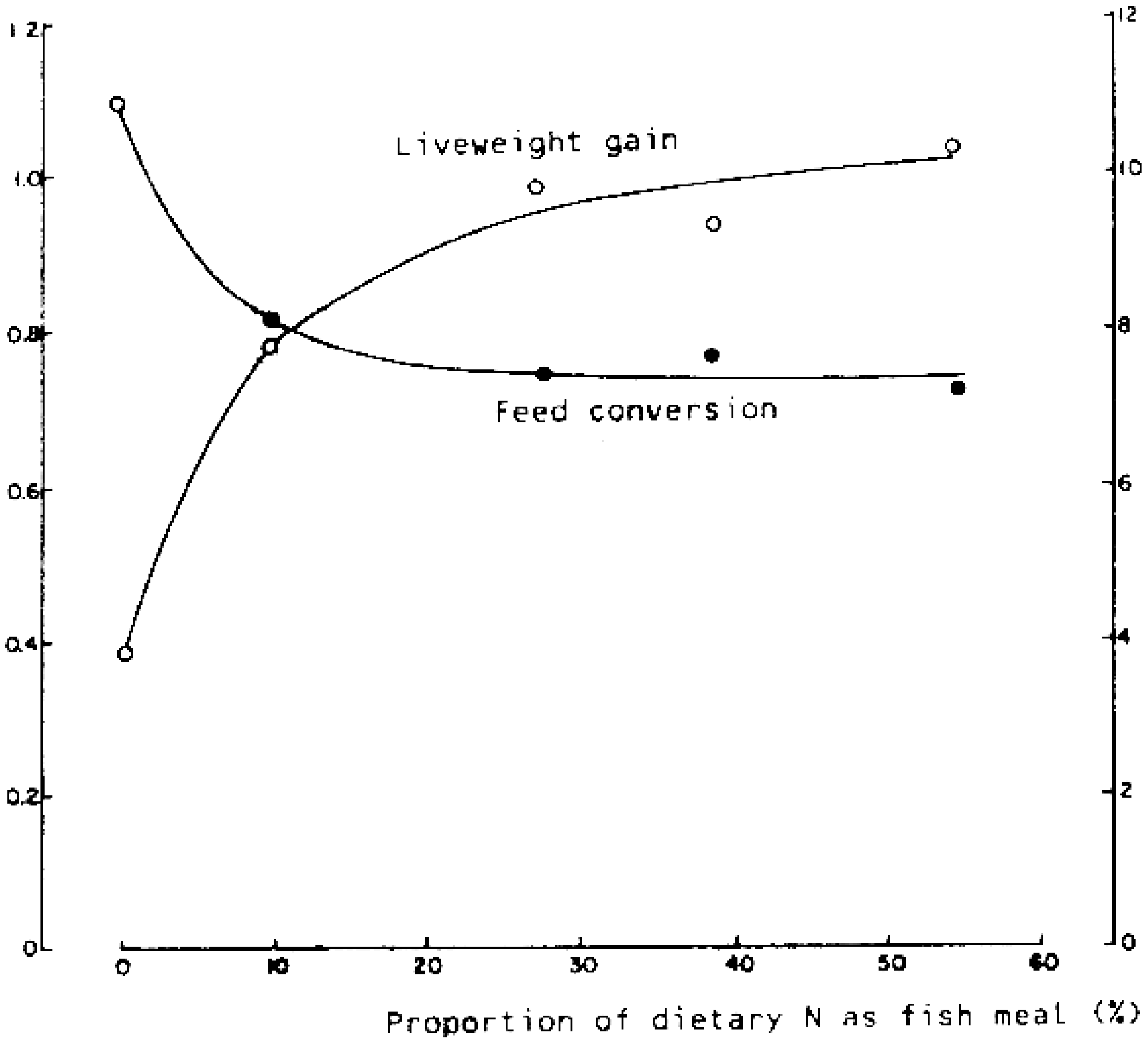
Figure 1: Addition of fish meal to a basal diet of ad libitum molasses/urea and restricted forage dramatically improves growth rate and feed conversion of cattle in Cuba.



Source: Preston and Willis (1974).

Figure 2: In a cattle fattening diet based on ad libitum molasses, sugarcane tops and wheat bran (1 kg/day), urea was a more effective source of fermentable-N than poultry litter. Poultry

litter stimulated growth rate when added to the diet (with urea), which was apparently adequate in fermentable-N.

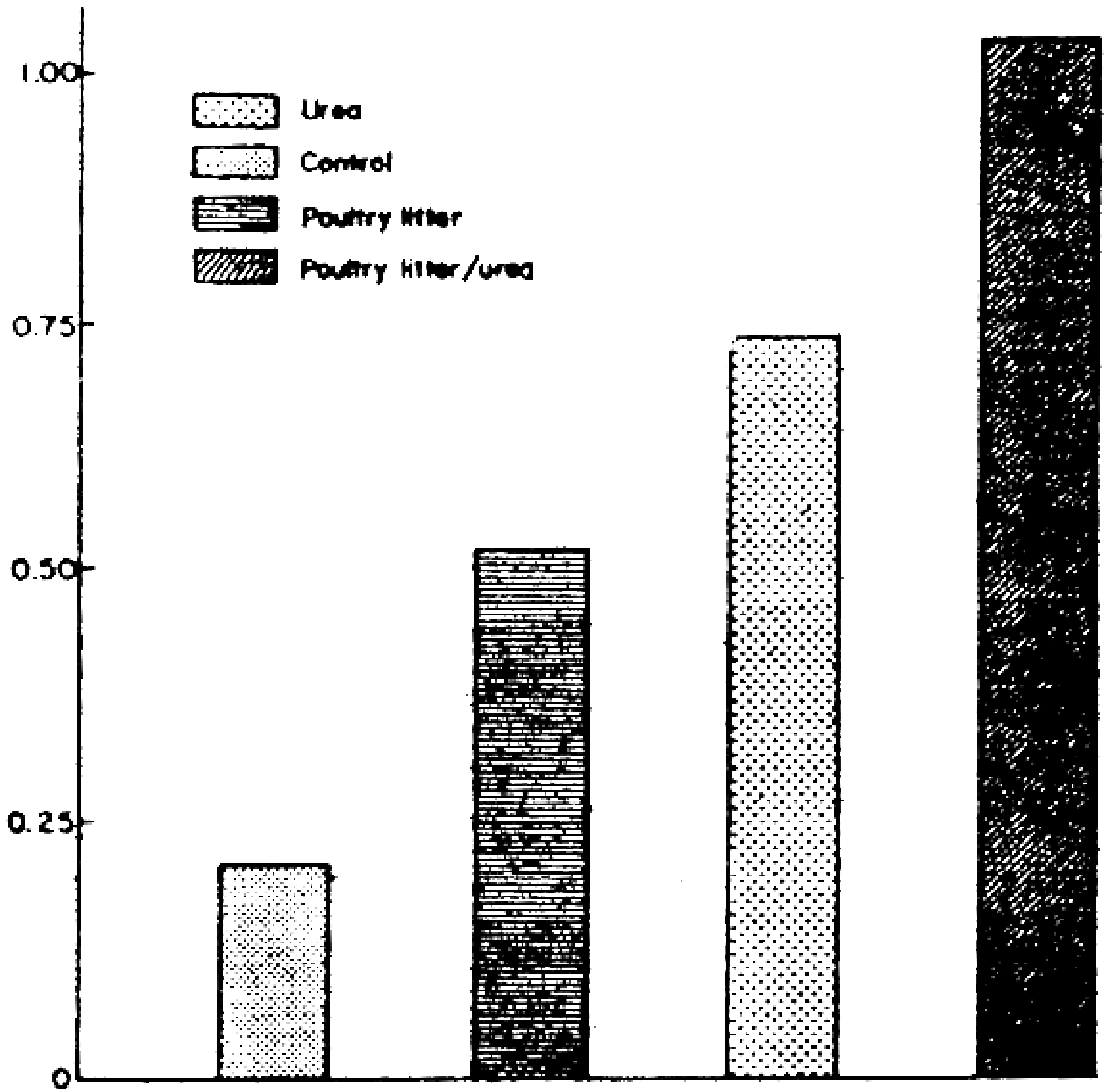


Figure 3: Contrasting effects of legume and grass as the roughage supplement in a diet based on ad libitum molasses/urea with or without supplements of wheat bran (1 kg/day) and/or poultry litter (1.5 kg/day).

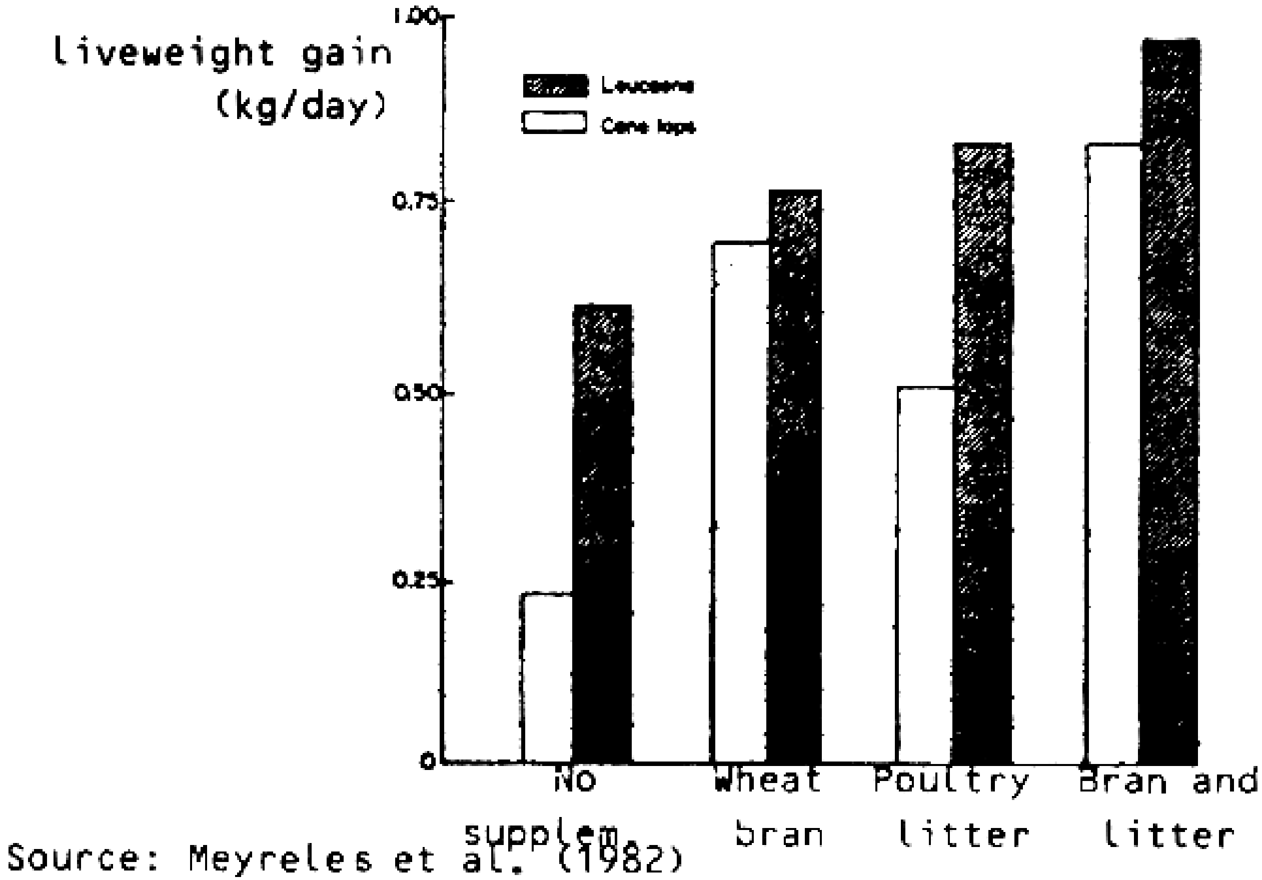
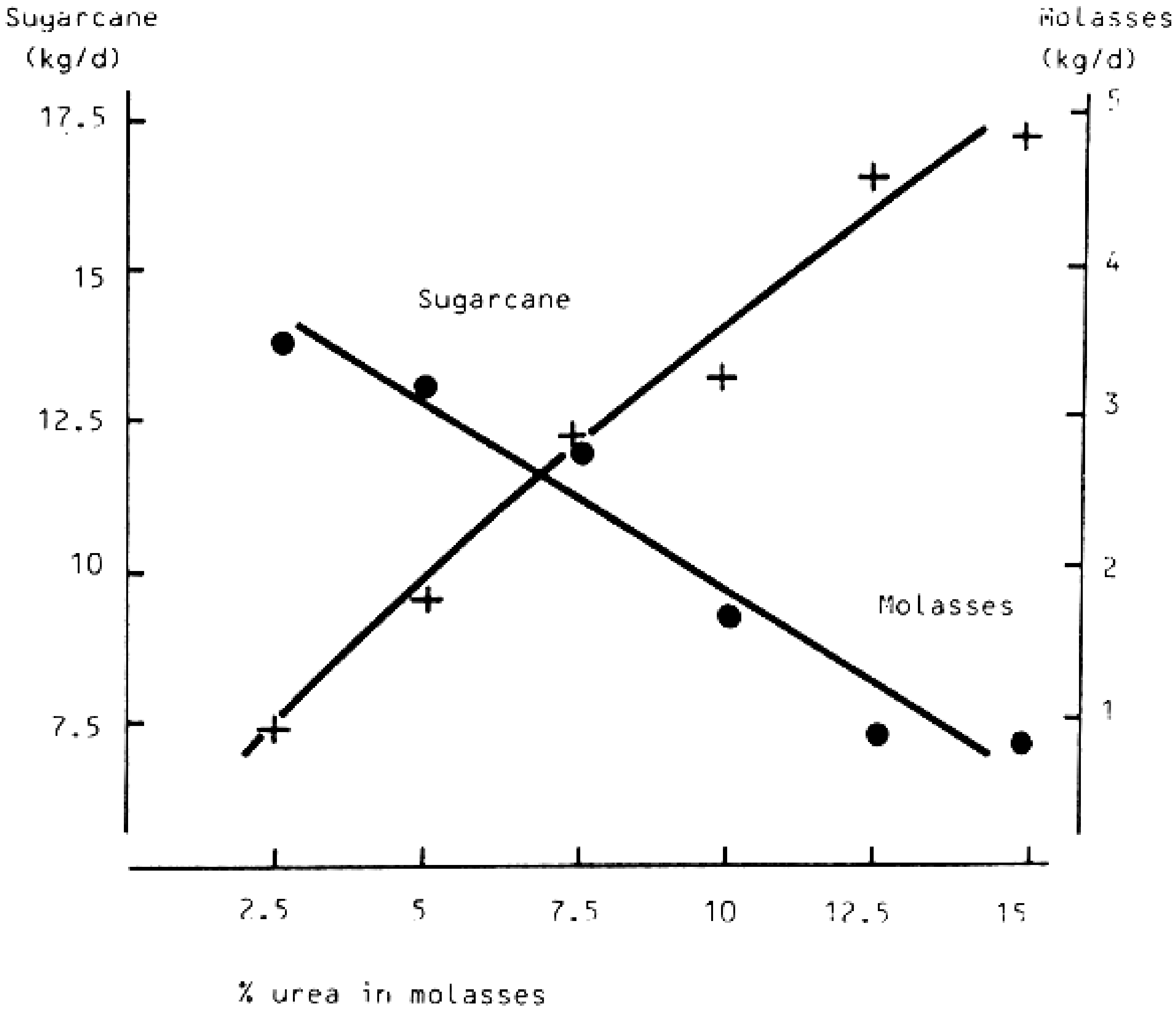


Figure 4: Intakes of steers (250 kg) given free access to chopped sugarcane and molasses with different concentrations of urea.



Source: Silvestre et al., 1977.

Table 1. Sugar-rich by-products derived from the processing of sugarcane

Process	Name	Approximate composition (% fresh basis)			
		Sucrose	Reducing sugars	Ash	Dry matter
Crystalline “B” molasses(i)			5–8	80–90	

sugar					
(Industrial)	Final molasses(ii)	33–37	15–19	10–15	80–90
	Cane syrup(iii)	45–55	5–10	1–2	55–60
	High-test(iv)	25–30	40–50	2–3	80–90
Panela	Cachaza(v)	15–20	3–5	0.5–1.0	18–25
	Melote(vi)	50–55	45–50	5–10	55–60

(i) Concentrated soluble residue following the secondcentrifugation to remove the "B" sugar
(ii) Concentrated soluble residue after the last centrifugationto remove the "C" sugar; also known as "C" and blackstrapmolasses
(iii) The clarified cane juice concentrated to the point where thesucrose is almost ready to crystallize
(iv) The concentrated cane syrup that has been partially inverted toavoid crystallization
(v) A mixture of "scums" and cane juice that is "skimmed off" theboiling juice following addition of a flocculating agent(usually extracts from the bark of resin-rich trees) whichcauses coagulation of the protein and mineral matter
(vi) Cachaza which has been concentrated to a point that preventssubsequent fermentation

Table 2. Economic data from a commercial cattle feedlot (10 000 head) in Cuba during the years when a change was made from an ad libitum forage (Pangola grass) plus concentrate diet to one based on ad libitum molasses/urea and restricted forage and fish meal. The high losses for emergency slaughter and mortality in the first year of high molasses feeding were due to molasses toxicity (Cerebro-cortical necrosis, see Preston and Willis 1974).

Forage		Molasses-based	
	1969	**1970**	**1971**
Total liveweight gain (kg/day)	3 724	8 295	13 797

Liveweight gain (kg/head/day)	0.43	0.88	0.89
Feed conversion (DM)	15	11	10
Deaths (%)	0.1	1.0	0.21
Emergency slaughter (%)	0.4	3.0	1.3

Source: Muñ et at. (1970)

Table 3. Performance of bulls fattened commercially in Cuba on ad libitum molasses/urea, fish meal and restricted grazing (3 hours/day). Results are for 11 units each with 400 animals.

	Liveweight gain (kg/day)		Conversion	
		Molasses	Fish meal (kg/kg)	Urea
Worst	0.74	14.7	0.54	0.47
Mean	0.83	9.1	0.45	0.29
Best	1.04	5.9	0.32	0.19

Source: Morciego et al. (1970).

Table 4. Leucaena foliage was as effective as groundnut meal in supporting high growth rates in young Friesian bulls fed a diet based on molasses/urea. The Leucaena replaced both the forage (native grass) and the groundnut meal, and thus served as a combined source of protein and roughage.

	Leucaena (% LW/day)			Groundnut cake (g/day)	
	2	3.5	5	500	1300
Liveweight gain (g/day)	790	740	847	597	742
Feed conversion (kg/kg gain)	9.2	12.2	9.7	10.5	10.4
Molasses (% of diet)	79	68	62	73	53

Table 5. The foliages of cassava or sweet potato were used as the roughage supplement in a molasses-urea diet for fattening bulls in the presence or absence of soyabean meal. With cassava supplementation there were no benefits from additional protein indicating that it was a better source of bypass protein than sweet potato foliage.

Forage	**Sweet potato**		**Cassava**	
Soyabean meal (g/day)	**0**	**400**	**0**	**400**
Liveweight gain (kg/day)	0.65	0.85	0.85	0.87
Molasses (kg/day)	5	6	6	6
Forage (kg/day)	13	13	10	10

Source: Ffoulkes and Preston (1978).

UTILIZACION DE LA MELAZA COMO PIENSO: SINOPSIS

por

T.R. Preston

En los países productores de caña, la melaza es el nombre genérico que se da a una serie de productos y subproductos con gran contenido de azúcar, que van desde la melaza de mejor calidad, pasando por las clases "A" y "B" hasta la melaza "C" o "final", que se producen en las etapas sucesivas del proceso actual de fabricación del azúcar.

En la producción de azúcar no centrifugado (denominado panela y gur en América Latina y el subcontinente indio, respectivamente), los subproductos son la cachaza apartada del jugo hirviente después de haber añadido un agente de floculación para eliminar la materia proteínica y mineral contaminante. En América Latina, la cachaza puede concentrarse para producir un producto parecido a la melaza denominado "melote".

Puede utilizarse todo tipo de melaza en la dieta de los rumiantes. La suplementación es

decisiva para lograr niveles altos de productividad, y debe proporcionar (i) los nutrientes complementarios necesarios para la actividad de los microorganismos del rumen, (ii) los estímulos físicos necesarios para lograr un funcionamiento adecuado del rumen, (iii) nutrientes sobrepasantes para equilibrar los productos de digestión del rumen, con arreglo a las necesidades del animal. En la práctica, estas necesidades pueden satisfacerse con menor costo añadiendo urea en la melaza (25 g urea/kg melaza) y suministrando cantidades limitadas de un forraje con alto contenido de proteínas (por ejemplo las hojas de un árbol leguminoso), que puede ser al mismo tiempo una fuente de nutrientes para el rumen y para el animal.

Los productos de fermentación de la melaza en el rumen padecen un desequilibrio particularmente acusado de precursores de glucosa (baja proporción de propionato y alta de butitato) que pueden ser un factor inductor de desórdenes metabólicos (toxicidad de la melaza) que provoquen necrosis cerebral y la falta de idoneidad de una dieta a base de melaza para la producción de leche. La alimentación con gallinaza aumenta la productividad animal y la eficiencia de los piensos en las dietas a base de melaza, al parecer porque cambia la estructura de los ácidos grasos volátiles hacia proporciones más elevadas de propionato.

En el caso de los cerdos y las aves, las tasas de rendimiento (y la humedad de los excrementos) están en función directa de la proporción de sacarosa y/o azúcares reductores en la melaza. Los mejores resultados se obtienen con melaza rica y los peores con las melazas finales.

Se utilizan comercialmente sistemas de alimentación a base de melaza con los cerdos, pero no con las aves de corral.

EL USO DE LAS MIELES DE CAÑA DE AZUCAR EN MONOGRASTRICOS
por
R. Pérez

1. INTRODUCCION

El uso de las mieles en sistemas alimenticios para monogástricos en Cuba requiere de una pequeña introducción.

Hace 20 años se comenzó a estudiar la posible sustitución por miel de una parte de la dieta nacional para aves y cerdos, basada en materias primas importadas. En aquel momento, a principios de la década del 60, la palabra “miel” realmente significaba la miel C o final, el producto que se obtenía conjuntamente con el azúcar C, después de purgar la segunda y última masa en la fabricación de azúcar cruda. Era un producto que se exportaba, que se destilaba para hacer alcohol y ron y se utilizaba en pequeña escala en la alimentación vacuna.

Actualmente, en nuestro país, la palabra “miel” ha dejado de ser un término “específico”, referido solamente a la miel C, y ha pasado a ser un término “genérico” que comprende tanto la miel C como las mieles intermedias, A y B (Figura 1).

Razón fundamental para este cambio han sido los resultados obtenidos en las investigaciones sobre la utilización de las mieles intermedias, netamente superiores a los de la miel final, mediante la integración de sistemas de producción animal con la industria azucarera.

2. INVESTIGACIONES

2.1 <u>Pollos de ceba y ponedoras</u>

Cuando en Cuba se comenzó a estudiar el uso de la miel en los piensos avícolas, se partió de dos ideas contradictorias: añadir un elemento líquido, la miel, a una masa seca, el resto de la dieta, y que el producto siguiera siendo un pienso seco.

Inicialmente se probaron (Pérez et al 1968) dos niveles de incorporación de miel rica, 12 y 24 por ciento, en dietas para pollos basadas en sorgo. Se encontró que aunque el peso vivo fue mayor con el uso de las mieles, la conversión alimenticia fue menor con los cereales (Cuadro 1).

Por esa época también se estudió (Pérez 1968) la incorporación de miel rica y miel final a niveles desde 6 hasta 24 por ciento en dietas para ponedoras; los resultados fueron adversos al uso de las mieles, tanto en huevos vendibles, como en la conversión alimenticia.

En todos los casos de incorporación se produjeron problemas en el mezclaje de las mieles con el pienso seco y con la humedad de las heces cuando se suminitró a pollos criados en el piso.

Se determinó suministrar a los pollos de ceba dietas completamente líquidas, que en aquel momento en nuestro país se comenzaban a usar en la ceba de reses y de cerdos (Preston y Willis 1970). Se previó que criando los pollos en baterías se podría solucionar el problema de las heces húmedas y se razonaba, que si los pollos pueden tomar agua, también se pudieran ingerir los demás nutrientes en forma líquida.

Una pequeña prueba con dietas basadas en los dos tipos de mieles disponibles en aquel momento, la rica y la final (C), y con dos diluciones diferentes, suministradas a pollos de 21 días de edad, arrojó que la miel rica y un suplemento proteico basado en harina de pescado y levadura sacharomyces pudiera producir un pollo criado sobre alambre de 1, 6 kg en 63 días.

Aunque los resultados obtenidos con la miel rica en dietas líquidas para pollos fueron alentadores, la miel rica seguía siendo la materia prima de nuestro renglón fundamental de exportación, el azúcar. Se había demostrado en cerdos (Velázquez et al 1969) que las diferencias entre los dos tipos de miel podían ser virtualmente eliminadas añadiendo azúcar a la miel final, y se determinó comprobar esta hipótesis en pollos.

Se probaron cinco niveles de incorporación de azúcar crudo a la miel final y tres dietas basadas en azúcar, miel final o miel rica. La dieta basada en 54 por ciento de miel rica produjo un peso final de 1, 5 kg, significativamente más alto que cualquiera de las combinaciones de miel final-azúcar; en adición, la conversión alimenticia fue de un 15 a un 18 por ciento mejor que las combinaciones con la miel final (Cuadro 2).

2.2 Pavos

Se experimentó el uso de la miel rica en dietas líquidas para cebar pavos a partir de las 18 semanas donde una dieta de maíz fue comparada con tres dietas de miel rica y un suplemento proteico, ofrecido por separado o mezclados, para proporcionar un nivel de 16 por ciento de proteína, con un 12 o 24 por ciento de agua adicional.

No hubo diferencias en la ganancia (Cuadro 3) que puedieran ser atribuibles a los tratamientos, pero si con respecto a la conversión alimenticia, siendo las dos dietas de miel y suplemento mezcladas con 12 y 24 por ciento de agua, mejores que el testigo de cereal y que la dieta con miel y suplemento, ofrecidas por separado.

Se estudió la posibilidad de introducir una dieta líquida basada en la miel rica, la miel A o la miel final a una edad más temprana de 6 semanas (Valarezo y Pérez 1972a) y el efecto de suministrar en forma restringida distintas contidades de suplemento proteico separado de la

miel rica, (Valarezo y Pérez 1972b). Se concluyó que era factible reemplazar cereales por miel rica con una cantidad restringida de proteína.

2.3 Patos y Gansos

Las aves acuáticas parecen que son las especies más idóneas para vivir en los países productores de caña de azúcar; la miel puede constituír hasta un 60 por ciento del total de su alimento.

Pérez y San Sebastián (1970) compararon tres tipos de miel (Cuadro 4) con maíz como principal fuente energética en dietas de ceba de patos; obtuvieron la misma conversión entre la dieta de maíz y una basada en miel rica.

De nuevo, surgió el propósito de añadir azúcar a la miel final para mejorar su comportamiento y se comparó una dieta en 52 por ciento de MS de miel final y 15 por ciento de azúcar con una dieta basada en 65 por ciento MS de miel rica, encontrando la de la miel rica 11 por ciento más eficiente (Pérez y del Cristo 1971).

Por ser tan fácil cebar patos con dietas basadas en miel, Valdivie y Pérez (1974) sugirieron la posibilidad de utilizar también la miel rica en los gansos. Obtuvieron resultados más pobres con la miel rica que con cereales, lo cual era opuesto a los resultados experimentales obtenidos en las otras especies.

2.4 Cerdos

Es curioso que la mayoría de los trabajos investigativos en Cuba sobre el uso de las mieles en cerdos no han utilizado una dieta testigo basada en cereal (Velázquez et al 1969; Velázquez y Preston 1970). Esta curiosidad responde a una realidad y es, que el sistema alimenticio estatal

en cerdos siempre fue basado en el uso mínimo de pienso seco importado, con la mayor utilización posible de los desperdicios y la miel final (Velázquez 1976).

Las investigaciones acerca de la sustitución completa de cereal por miel final en la categoría de ceba han señalado un comportamiento biológico inferior, siempre. Tanto Castro y Elías (1978) como Ly y Castro (1984) obtuvieron (Cuadro 5) una conversión alimenticia de un 25 por ciento inferior con la miel final comparada con una dieta de cereales, sin embargo, estos últimos autores observaban que con la dieta de miel rica, aunque la ganancia fue significativamente inferior, la conversión no difirió de la dieta de cereales.

Igual que con las aves también las investigaciones con los cerdos han sido enfocados a añadir algo a la miel final para que dejara de “ser” miel final y así mejorar las ganancias y las conversiones.

Pero los efectos nocivos de la miel final son, al parecer muy fuertes, así cuando Marrero y Ly (1976) mezclaron sólo un 15 por ciento de miel final con miel rica, notaron una disminución de aproximadamente 100 gramos en la ganancia diaria con casi un 18 por ciento de empeoramiento en la conversión, mientras niveles superiores de miel final produjeron conversiones 15 por ciento inferiores a la dieta testigo de miel rica (Cuadro 6).

Durante la década de 1970 a 1980, se continuó investigando sobre formas de mejorar el uso de la miel final en cerdos, y casi siempre desde la óptica de mejorar el comportamiento de la miel final, no considerando el problema en una forma integral con la inclusión del proceso dentro del ingenio azucarero.

Posteriormente comenzaron a publicarse los trabajos (Ly 1984; Ly y Castro 1984) relacionados con los índices digestivos y el patrón de ingestión de dietas basadas en cereal, miel rica o final

en cerdos, revelando diferencias en la digestibilidad del nitrógeno y de la energía de entre un 7 y un 10 por ciento inferiores en dietas de miel final comparadas con cereal. Se observó que en dietas de miel final, comparado con cereal, aunque los cerdos pasaban más tiempo frente al comedero (25,8 v 13,3 minutos) realmente consumieron significativamente menos alimentos (926 v 1765 g MS) y más agua. Se detectó con las dietas de miel final un menor tiempo de tránsito, boca-recto, de solamente 4 horas, comparado con 28 horas en la dieta de cereal.

Hasta la zafra 1981–1982, las empresas porcinas solo habían utilizado la miel final, aunque los resultados experimentales con los distintos tipos de mieles intermedias comenzaron a demostrar una superioridad de estas mieles sobre la miel final. Era evidente que, tanto la miel rica, como las mieles intermedias A y B, podían producir ganancias diarias de 100 a 150 gramos más y conversiones alimenticias aproximadamente de un 15 por ciento mejores a cualquier dieta basada en la miel final (Cuadro 7).

3. LA MIEL B

3.1 Comienzo del uso de la Miel B

El sistema alimenticio utilizado para la ceba de los cerdos en las granjas estatales cubanas está basado en una mazcla de desperdicios procesados y miel final de caña, en una proporción aproximada de 60:40 en MS. A esta mezcla que se distribuye en forma mecanizada, se adiciona diariamente, en forma manual, 0,8 kg de pienso seco importado por cerdo (ver Cuadro 8).

Este sistema permite que los cerdos reciban aproximadamente la tercera parte de sus necesidades nutritivas en el pienso seco y las dos terceras partes en la mezcla de desperdicios procesados y miel final, conocido como pienso líquido terminado (PLT).

Los cerdos jóvenes llegan a los cebaderos a la edad de 100 días con un promedio de 25 kg; el

sistema tecnológico de producción contempla 147 días para alcanzar los 90 kg, o sea, deben aumentar un total de 65 kg para una ganancia media diaria de 442 gramos.

Durante la zafra 1981–1982, en un cebadero porcino mecanizado de 17,000 cabezas se sustituyó completamente la miel final por miel B, como una forma de extender a la escala de producción los resultados experimentales e inmediatamente se notó que los cerdos consumían la ración de pienso líquido con más rapidez, sin dejar como antes residuos en el comedero, que las excretas eran más duras y se dejó de producir el "estado diarreico" observado con dietas de altos contenidos de miel final. Al consumir los alimentos más rapidamente y eliminarse el "estado diarreico" los cerdos se mantuvieron más limpios, necesitando mucho menos agua para mantener la higiene en los corrales.

Paralelamente con el trabajo de sustituír la miel final por la miel B, se sometió un total de 220 cerdos a dos tratamientos en un experimento controlado durante 93 días; a la mitad se le suministró la dieta nacional de ceba basada en la miel final. Los resultados (ver Cuadro 9), arrojáron una diferencia de 12 kg a favor de los cerdos que consumieron la miel B, o sea, que aumentaron 128 g más por día en relación a los animales alimentados a base de miel final.

3.2 Valoración de la miel B

Al analizar los factores económicos de una posible extracción de otras mieles azucareras en sustitución de la miel final para la alimentación de los cerdos, se ha escogido la miel B, que es el residuo de la segunda templa de azúcar, donde se ha extraído un 82 por ciento del total de la sacarosa disponible (Figura 1). Aunque la miel C y el azúcar C representan el 100 por ciento de la sacarosa disponible, esta azúcar C no es un azúcar comercial, requiriendo grandes cantidades de energía para su cristalización, su licuación y reprocesamiento. Con la miel B los cerdos pueden utilizar su potencial genético de crecimiento ya que el factor limitante de la miel

final no está presente; además de las otras mieles es la que contiene menor cantidad de azúcar comercialmente recuperable.

El hecho de sustituír la miel final por la miel B mejora la conversión, no solamente de la miel, sino de todos los componentes de la dieta en aproximadamente un 15 por ciento. De 5,3 t de materia seca por t de aumento en el sistema alimenticio basado en la miel final, se ha estimado solamente 4,5 con la miel B. En el Cuadro 10 se ofrece un análisis comparativo de la conversión de los tres componentes alimenticios utilizados: miel, desperdicios y pienso por tonelada de aumento de carne de cerdo en pie con las variantes de la miel final o la miel B.

Por ser el object principal de cualquier sistema de producción animal minimizar los costos alimenticios, se ha preparado una comparación (Cuadro 11) de los costos durante los últimos 5 años de los alimentos necesarios para producir tonelada de carne de cerdo en pie, utilizando el sistema alimenticio basado en la miel final, o utilizando la variante de sustituír la miel final por la miel B, a la que se ha calculado el costo por su contenido en azúcar y en miel final (Cuadro 12).

Se han utilizado los precios internacionales del azúcar, la miel final y los otros componentes de los piensos, (Cuadro 13) la composición promedio de la dieta nacional y la conversión de alimentos en carne de la categoría de ceba con dietas basadas en miel B o miel final (Cuadro 10).

Los resultados demuestran que el cambio de la miel final por la miel B permite un aumento de un 15 por ciento de la producción de carne; que el aumento de 100 g de la ganancia diaria implica un incremento de un 20 por ciento en la utilización de las instalaciones de ceba, con las consiguientes disminuciones de los costos por amortizaciones, salarios y otros gastos materiales, y que, además, el costo de los alimentos disminuyó con excepción del año de

precio alto del azúcar.

4. SITUACION ACTUAL

4.1 Porcino

El sistema alimenticio se basa en dietas líquidas donde el nivel de miel final varia desde un 30 a 35 por ciento MS en la dieta de ceba hasta un 60 por ciento MS en la dieta de mantenimiento de las cerdas gestadas.

Al comienzo de la zafra azucarera 1985–1986 se sustituyó toda la miel C por miel B en la mayor empresa productora de cerdos del país. El peso promedio de entrega de los cerdos cebados ha comenzado a reflejar este cambio, después de solo 6 semanas, con un aumento de 1,9 y 2,8 kg en Abril y mayo de 1986, sobre los pesos promedio que se obtenían el año anterior cebando con la miel final. En igual manera, el indicador de “cría x parto”ha aumentado desde 9,0 a 9,2 mientras la “efectividad económica” que fue 75 por ciento en Mayo de 1985, ha mejorado, obteniendo un 82 por ciento en Mayo de 1986.

Adicionalmente, se ha comenzado en pequeña escala, la producción porcina aledaña a los centrales azucareros y se experimenta con una dieta líquida basada en la mezcla de 65 por ciento de miel B con 35 por ciento de crema torula, obtenida esta última, mediante la fermentación de la miel final. Los resultados preliminares señalan que esta dieta puede garantizar una ganancia de aproximadamente 550 a 600 gramos con una conversión alimenticia de 4.50 en MS.

De acuerdo a estos resultados se ha trazado un plan nacional para sustituír unas 200,000 toneladas de miel final utilizadas en la actividad porcina, por igual cantidad de miel B.

4.2 Gansos

Recientemente se ha comenzado la explotación comercial de esta ave acuática en áreas aledañas a los ingenios azucareros donde se inician con un pienso seco hasta los 10 días, seguido por dietas líquidas basadas en 70 a 80 por ciento MS de miel B o Sirope-off, con un mínimo de alimentos proteicos que varian desde desperdicios de pescado o pescado entero ensilado en miel, hasta una simple mezcla de gallinaza, cachaza y bagacillo suministrados en partes iguales con la miel B.

Un aspecto muy interesante relacionado con la crianza de esta ave es la correspondencia tan estrecha que existe entre la zafra azucarera y la "zafra de gansos", coincidiendo la etapa de engorde con la presencia de toda una serie de sub-productos energéticos de la industria azucarera, tales como el bagacillo, la cachaza, el sirope-off y la miel B.

4.3 Pienso seco comercial

No se incluye miel final en el pienso avícola. Para los piensos secos de porcinos se incluye un nivel de 6,5 por ciento BH en las categorías de "crecimiento" y "reproductor" mientras para los piensos de bovino se utiliza un nivel de 15 por ciento BH.

Aunque no se incluye miel final en el pienso avícola se piensa iniciar estudios sobre la utilización de la miel B que es una miel mucho menos viscosa y por lo tanto de dosificación más fácil.

5. PERSPECTIVAS

De acuerdo a la experiencia en el uso de las mieles intermedias azucareras, especialmente la miel B en dietas líquidas para la alimentación de algunas especies de monogástricos, tales

como cerdos, y aves acuáticas, como patos y gansos, resulta previsible la integracón de sistemas de producción animal con los centrales azucareros.

Esta integración estaría justificada por el hecho de que los animales obtendrían la mayor parte, o la totalidad de los alimentos de la fábrica de caña de azúcar y de sus áreas de plantaciones, mediante el suministro de:

- **Miel B, o sea miel procedente de la segunda masa, como principal fuente de carbohidratos para el mantenimiento y la ceba de los rebaños. Puede constituír del 60 por ciento al 80 por ciento del total de materia seca en la dieta; y,**
- **La producción local de la proteína necesaria mediante:**
- **la fermentación de rediduos agrícolas o industriales;**
- **la siembra de oleaginosas en rotación con la caña de azúcar; y,**
- **el ensilaje con miel de los desperdicios de pescado que de produzcan en las cercanías.**

Estas perspectivas de integración de la producción de caña de azúcar con la producción animal son válidas, desde luego, para todos los países productores de caña de azúcar.

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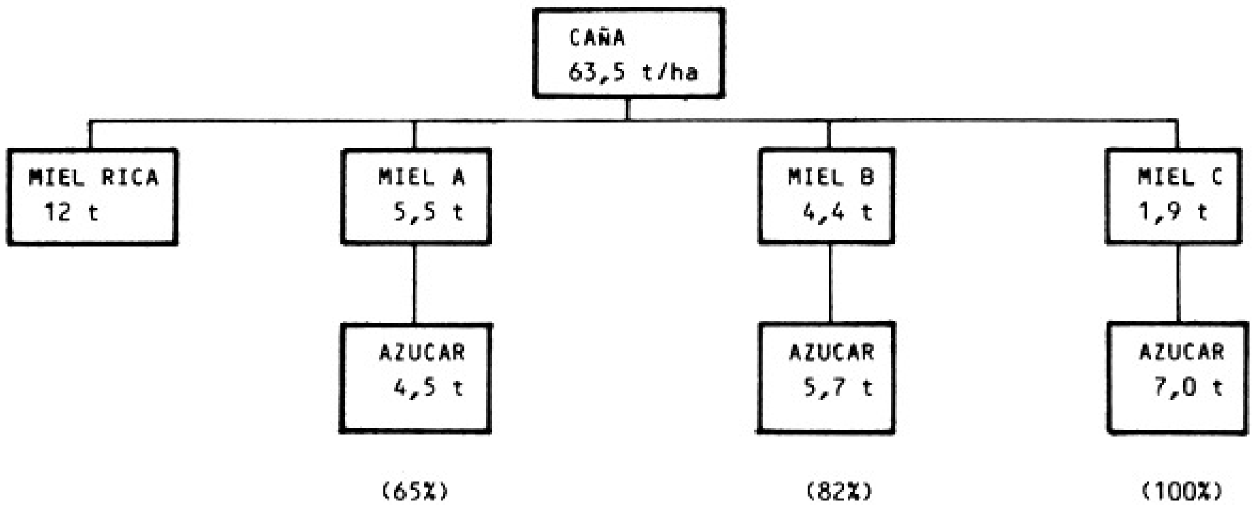
Figure 1: Extracción de azucar y varios tipos de miel



Cuadro 1: La sustitución de cereales por azúcar o miel rica para pollos de asar

		44%	12%	24%

	Cereal	Azúcar	M.Rica	M.Rica
Ganancia, g	1 537	1 497	1 551	1 616
Consumo, g MS	3 699	4 036	4 020	4 090
Conversión, en MS	2,45	2,73	2,64	2,54

Cuadro 2: Peso vivo, consumo y conversión en broilers alimentados con dietas Liquidas basadas en miel rica o mezcla de miel final y azúcar[1]

Azúcar % de MS	Peso vivo, g	Consumo, de MS	Conversion, en MS
0	1 106	3 945	3,57
9,5	1 321	4 395	3,33
18,3	1 391	4 417	3,17
27,3	1 412	4 609	3,26
37,4	1 414	4 310	3,05
44,1	1 488	4 307	2,89
52,2	1 417	4 836	3,10
54,0 (m. rica)	1 549	4 686	3,02

1 Pérez y Preston (1970)

Cuadro 3: Efecto de sustituir el grano por miel rica y un suplemento proteico en pavos [1]

		Miel rica y suplemento proteico:		
	Maiz	ofrecido por separado	mezclado con 12% agua	mezclado con 24% agua
Peso inicial, kg	5,88	5,81	5,82	5,83
Aumento total, kg	2,98	2,79	2,82	2,95
Consumo MS, kg	17,8	17,8	12,4	12,7

Conversión en MS	6,48	7,14	4,98	4,74

1 Valarezo yPérez (1970)

Cuadro 4: Sobre el comportamiento de patos Pekin Blanco, 9 semanas

		Tipo de miel		
	Maiz	**Rica**	**A**	**Final**
Peso vivo, g	2 035	1 844	1 707	1 530
Consumo, kg MS	10,45	9,17	10,12	10,72
Conversión en MS	5,02	5,00	5,93	6,99

Cuedro 5: Sustitución de cereal por miel en dietas para cerdos en ceba

Dieta	% MS en dieta	Peso vivo, kg	Ganancia, g/dia	Conversión, kg MS/kg aumento
Cereal	73	38 – 71	797	3,94[1]
M.final	63	"	536	4,95
Cereal	89	60 – 90	791	3,96[2]
M. Rica	80	"	693	4,04
M.Final	82	"	540	5.00

1 Castro y Elias (1978)
2 Ly y Castro (1984)

Cuedro 6: Ganancia, consumo y conversión alimenticia en cerdos [1]

Miel rica, % MS Miel final, "	75 0	60 15	45 30	30 45	15 60

Ganancia, g/d	655	559	532	507	519
Consumo, kg MS/d	2,66	2,41	2,67	2,54	2,56
Conversión en MS	4,09	4,32	5,12	5,06	4,99

1 Marrero y Ly 1976

Cuadro 7: Comportamiento de cerdos alimentados con dietas en distintos tipos de mieles

Tipo de miel	% MS en dieta	Etapa del crecimiento	Ganancia diaria, g	Conversión en MS
Rica	71	30–80	609	3,80[1]
	74	30–90	644	3,60[2]
	75	32–91	655	4,09[3]
A	70	30–60	671	3,90[4]
	69	25–90	638	5,20[5]
	69	25–90	558	4,10[6]
B	69	25–90	715	4,50[5]
	70	25–85	530	4,40[6]
Final	62	30–90	520	5,30[2]
	60	32–90	519	4,99[3]
	70	25–71	414	5,60[6]
	35	25–85	450	5,50[7]

1 Velázquez y Preston (1970)
2 Velázquez et al (1972)
3 Marrero y Ly (1976)
4 Pérez (1975)

5 Figueroa et al 1983

6 Cervantes et al 1984

7 Experiencia personal de La autora entre1971–1979; 80 mil cerdos de ceba.

Cuadro 8: Composición promedio de La dieta nacional de ceba porcina, 25–90 kg

	Kg BH-[1]/dia	% MS	KG MS	% MS en dieta
Desperdicios	4,5	20	0,9	37
Miel final	1,0	80	0,8	33
Pienso seco	0,8	90	0,7	30
			2,4	100

1 BH (base húmedo)

Cuadro 9: La sustitución de La Miel C por Miel B en La ceba comercial de cerdos[1]

	Miel B	Miel C
Peso inicial, kg	47,5	46.4
Peso final, kg	99,8	86,8
Aumento, kg	52,3	40,4
Ganancia diaria, kg	562	434

1 Pérez et al (1982)

Cuadro 10: Análisis de la conversión de alimentos por toneLada de aumento de ceba con Las variantes de la Miel final o Miel B

Componentes de la dieta, % MS	Tipo de miel	Conversión	t de pienso por t de aumento	

			MS	BH
Miel, 33%	Final	5,3	1,75	2,19
	B	4,5	1,48	1,85
Desperdicios 37%	Final	5,3	1,96	9,80
	B	4,5	1,66	8,30
Pienso seco, 30%	Final	5,3	1,59	1,77
	B	4,5	1,35	1,50

Cuadro 11: Comparación de los costos de las dietas con miel C o con miel B, USD/t

Años	Miel C	Miel B	Diferencia a favor de la miel B
1981	599	634	(35)1
1982	440	440	-
1983	498	488	10
1984	475	434	41
1985	400	364	36

1 Azúcar 353 USD/t

Cuadro 12: Costo de alimentos por t de peso vivo de aumento de ceba, US$/t

	Dieta de ceba con miel B				Dieta de ceba con miel C			
	Miel B	Desperdicios	Pienso	Total	Miel C	Desperdicios	Pienso	Total
1981	276	83	275	634	177	98	324	599
1982	139	83	218	440	85	98	257	440
1983	150	83	255	488	99	98	301	498
1984	111	83	240	434	94	98	283	475

1985	93	83	188	364	81	98	221	400

Cuadro 13: Costo de los alimentos utilizados, USD/t

	1981	1982	1983	1984	1985
Azúcar crudo	353	184	188	113	89
Miel C	81	39	45	43	37
Maiz1	164	124	154	148	115
Soya1	241	209	216	195	156
Pienso2	183	145	170	160	125
Miel B3	149	75	81	60	50
Desperdicios4	10	10	10	10	10

1 Conversión a CIF
2 Un pienso 75–25 (Maiz-Soya) con aproximadamente 16% de proteina
3 Se calculó 250 kg azúcar cruda/t Miel B
4 Pesos cubanos

THE USE OF MOLASSES FOR MONOGASTRICS
by
R. Perez

The research made in the last 20 years in Cuba, on the use of all kinds of molasses (Final, A, B, High-test) in feeding systems to fatten pigs, broilers, ducks, geese or turkeys, has proven that it is possible to substitute all cereal grains by these by-products of the sugar industry.

The results were worse with final molasses. Substituting this final molasses in liquid feeds for

monogastrics by B or high-test molasses gave an improvement of performance of 15 and 25% respectively.

Recent studies have concluded that it could be economically advantageous, both for the Cuban sugar industry as for its livestock production, to sacrifice some crude sugar in order to produce molasses with characteristics which permit taking maximum advantage of the genetical potential for growth of the animals.

It is suggested for raw sugar producing countries to develop liquid feeding systems based on B molasses as an energy source for fattening pigs and ducks and geese.

APLICACION COMERCIAL DE LA MELAZA COMO ALIMENTO PARA RUMIANTES
por
A. Elías

En muchos países tropicales, el pasto es la principal fuente de alimento para el ganado. Sin embargo, el uso de fertilizantes y el riego es limitado lo que produce un descenso en el valor nutritivo del pasto, especialmente en el contenido de proteína y se hace más crítico en la época poco lluviosa. Esto se refleja en los bajos rendimientos de la vaca lechera y en la ganancia diaria de peso vivo de los animales en crecimiento con una respuesta satisfactoria a la suplementación con concentrados o subproductos industriales o agrícolas.

Por otra parte, es evidente que los animales domésticos pueden ocasionalmente competir con la población humana por los granos de cereales y otros alimentos. Es por ello, que los animales deberán usar como fuente de alimentos aquellos materiales que no pueden ser consumidos por el ser humano.

En aquellos países donde existe tecnología azucarera es posible disponer de una abundante cantidad de materias primas alimentarias en forma de caña de azúcar y sus subproductos, entre ellos, la melaza con muy bajo contenido en proteína y fósforo. Hay muchas posibilidades de utilizar la urea para suplementar a estos alimentos. Este ha sido uno de los programas que se ha desarrollado en el Instituto de Ciencia Animal (ICA) de la República de Cuba.

1. ALTOS NIVELES DE MELAZA Y UREA PARA LA CEBA DE TOROS

La suplementación líquida de melaza con 3 por ciento de urea es común en nuestro país. En dietas experimentales de concentrados (conteniendo 1,7 por ciento urea) or forrajes ad lib., suplementadas con melaza con 3 por ciento de urea, también ad lib. el consumo de melaza fue relativamente bajo (2,9 – 3,1 kg/día; 30–36 por ciento de la energía metabolizable consumida). La ingestión de urea fue 180 y 90 g/animal/día y la ganancia diaria fue 0,90 y 0,60 kg/día en los sistemas respectivos (Preston et al 1967). Según estos resultados fue evidente que para incrementar el consumo de melaza era necesario restringir otros componentes dietéticos.

En trabajos preliminares (Elías y Preston, 1966, datos no publicados) se encontró que al reducir el forraje seco en dietas de concentrado solamente, los resultados fueron pobres y hubo timpanismo e intoxicación con melaza. Estos problemas se evitaron cuando una pequeña cantidad de forraje de alta calidad se incluyó en la dieta (Elías et al 1968). En este sistema de alimentación los animales tenían acceso libre a una solución acuosa de melaza (14 por ciento de sólidos solubles) que contenía 0,67 por ciento de urea y 0,11 por ciento de C1Na y a un

suplemento mineral rico en fósforo y sodio. También recibían 1,5 kg de forraje fresco y 200 g de un concentrado con 30 por ciento de proteína (P2) 0 400 g con 15 por ciento de proteína y 50 por ciento de maíz (P4) por cada 100 kg de peso vivo/día. Los animales fueron cebados desde un rango de peso vivo de 200 hasta 400 kg. La major ganancia de peso fue de 0,83 kg/día y los animales consumieron 70 a 80 por ciento de la materia seca dietética en forma de melaza, 240 g de urea y 30 g de $SO_4(NH_4)_2$ (ver Cuadro 1).

La proporción de la proteína verdadera fue 10–20 por ciento del nitrógeno total dietético consumido. Las características de los canales se muestran en el Cuadro 2.

En el sistema de alimentación con altos niveles de melaza y urea, la calidad del forraje es importante, debido a que el comportamiento de los animales se empeora cuando solamente tienen disponible forraje maduro o de baja calidad. Martín et al (1968a) no encontraron diferencias en la digestibilidad de la MS o la retención del N entre maíz, napier, sorgo o alfalfa, cuando estos forrajes se suministraron inmaduros. Pero, cuando el forraje es suministrado más maduro, el comportamiento de los animales fue mejor con maíz que con napier (Martín et al 1968b).

Aunque la selección de 1,5 kg de forraje/100 kg de PV fue arbitraria, Preston et al (1968) no encontraron diferencias significativas en el comportamiento de los animales, cuando el nivel de forraje lo incrementaron a 3 kg. Sin embargo, en una investigación más amplia, Elías et al (1969) usaron diferentes niveles de forraje (1,5, 2,5, 3,5 y 4,5 kg/100 kg de PV) y encontraron una tendencia para aumentar el consumo diario de la MS y disminuír el consumo de Energía Metabolisable con el incremento del nivel de forraje (ver cuadro 3). El nivel de forraje no afectó la ganancia diaria en peso vivo o cualquier medida de la canal pero la tasa de la conversión alimentaria fue significativamente mejor con 1, 5 kg de forraje comparado con los otros tres niveles. La ventaja en la restricción del forraje no solamente está relacionada con la conversión

alimentaria. Una menor cantidad de forraje debe ser cortada y transportada diariamente y esto pueder ser un factor considerable en la organización de un lote seco (cebadero) grande, especialmente durante la época lluviosa de las áreas tropicales cuando las condiciones del terreno hace muy difícil la organización de la cosecha del forraje.

2. UTILIZACION Y NIVEL DEL SUPLEMENTO PROTEICO EN DIETAS ALTAS EN MELAZA Y UREA

En estas dietas, el objectivo es mejorar la utilización del nitrogéno no proteico (NNP) a través de mantener un equilibrio entre esto y la proteína, sin afectar el comportamiento productivo de los animales. Consecuentemente, las diferencias en el comportamiento animal en dietas con diferentes fuentes proteicas pueden ser en parte debidas a los diferentes grados de escape a la degradación ruminal de la proteína dietética. Elías y Preston (1969a) sugirieron que la eficiencia de la utilización del N parece depender de la presencia de proteína verdadera insoluble, la cual puede pasar al abomaso con poca modificación y así complementar las deficiencias cuantitativas y cualitativas de las proteínas microbianas sintetizadas de la urea.

Preston (1969) y Preston y Willis (1970) basados en las consideraciones teóricas de Hungate (1966) consignaron que las limitaciones energéticas de la síntesis microbiana aneróbica permite una síntesis de menos de 50 por ciento del requerimiento protéico de los animales de un crecimiento rápido y Preston (1972) sugirió un régimen de alimentación que consiste en suministrar de 500 a 300 g/día de harina de pescado según el momento de la ceba para suplir 30 por ciento del N dietético y garantizar una ganancia diaria de 1 kg. Sin embargo, Elías y Preston (1969b) encontraron que el N proteíco como porcentaje del N total del contenido ruminal de animales cuyas dietas aproximadamente conforman 10 por ciento del N total en forma de proteína verdadera, fue de 80 a 90 por ciento. Esto es similar a los valores encontrados en el rumen de animales alimentados con concentrados y sin NNP. Además, Veitía (1973) al revisar la literatura y con más de 23.000 animales alimentados intensivamente con

esta dieta, encontró que los animales recibieron un promedio de 20 por ciento más de proteína cruda de la requerida según NRC (1979). Veitía (1973) no halló diferencias significativas para ganancia diaria y conversión alimentaria cuando incrementó los niveles de harina de pescado de 100 a 400 g/día en la ceba de Cebú comercial con miel/urea. Es posible que la ausencia de respuesta al incremento de harina de pescado se debió al potencial de crecimiento más bajo del Brahman con respecto a otras razas usadas en Cuba para la producción de carne. Sin embargo, en otro experimento, Veitía y Elías (1973 datos no publicados) no encontraron diferencias significativas en ganancias de peso vivo cuando los toros Holstein x Cebú fueron alimentados con alrededor de 100 por ciento de los requerimientos proteicos (Cuadro 4).

La posibilidad de sustituír harina de pescado con diferentes proporciones de maíz:trigo (ver Cuadro 5) fue estudiada por Elías y Delgado (1976). En este experimento se obtuvieron ganancias de 0,91 kg con solamente 120 g de harina de pescado y ésta sustituída con 575 g de mezcla de cereales sin afectar el comportamiento de los animales. La contribución de la proteína verdadera no fue superior a 9 por ciento del nitrógeno dietético tanto en la harina de pescado como en las proporciones de cereales.

Elías (1971) estudió el efecto de la suplementación de la melaza con vitaminas del complejo B y minerales trazas y demostró que la melaza no contiene las vitaminas para la máxima utilización del amonio por las bacterias ruminales. También es deficiente en algunos elementos trazas. Esto podría confirmar el papel importante que desempeña el forraje de buena calidad en este sistema de alimentación.

3. ADAPTACION DE LOS ANIMALES A LAS DIETAS ALTAS EN MELAZA Y UREA

Los animales deben ser adaptados gradualmente a las dietas altas en melaza y urea. Así, cuando los animales fueron cambiados abruptamente del pasto a la melaza y urea (a diferentes

diluciones: 14, 25, 55 y 75º Brix) suministradas ad lib, y con cantidades restringidas de forraje, no hubo problemas con las melazas diluídas, pero ocurrienron tres muertes y síntomas severos de toxicidad en otros 10 animales con las diluciones más concentradas. Si los animales fueron adaptados gradualmente (en un período de 10 días), entonces se obtuvo un incremento en la ganancia diaria de peso vivo, una mejor conversión alimentaria y mayor deposición de grasa excesiva en la canal cuando se incrementó la concentración de melaza (Preston et al 1968). Cuando los terneros Holstein destetados a una edad temprana se cambiaron abruptamente de dieta de concentrados a una dieta alta en melaza/urea, el comportamiento de los animales fue muy pobre. Sin embargo, con otro sistema de cambio (Elías y Preston 1969b) basado en forraje fresco ad lib. durante una o dos semanas y luego forraje restringido (3 kg/100 kg PV) y en la semana siguiente una solución de melaza y urea, el pH ruminal se incrementó y se estableció una microflora y microfauna diversa. El comportamiento de los animales fue satisfactorio durante el período de cambio. Asimismo, la consiguiente tasa de crecimiento de más de 1 kg/día confirma la eficiencia de este sistema. Es evidente que el tipo de población microbiana ruminal que se establece es capaz de ayudar a los animales en el uso de la melaza y urea, con un efecto mayor en la síntesis microbiana y en el comportamiento de los animales. Esto fue sugerido y confirmado por Elías (1971).

4. LA MELAZA Y UREA COMO SUPLEMENTO AL PASTO

En dietas a base de pastos y forrajes frescos o conservados, la fuente principal de energía para los microorganismos del rumen así como el animal hospedero proviene de la degradación de los carbohidratos estructurales insolubles (celulosa y hemicelulosa) que forman una gran parte de los constituyentes celulares de los forrajes. De aquí que su valor nutritivo dependa, en gran medida, de su consumo y digestibilidad. Elías (1983) realizó un amplio análisis de los factores que afectan la digestibilidad de estos alimentos.

La ingestión de nitrógeno ha mostrado ser uno de los factores principales que influyen en el consumo y digestibilidad de los forrajes de baja calidad. La mejora en la utilización de estos forrajes se obtiene con proteína natural y NNP o ambos (Cuadro 6). La eficiencia en la utilización de la urea está dada por su nivel en la dieta, así como por la presencia de carbohidratos de fácil fermentación y de proteína verdadera.

El incremento energético en la dieta mejora la utilización de la urea, pero esto disminuye la utilización del material fibroso, producto de la inhibición de la celulolisis ruminal o por un mecanismo de represión enzimática (celulasa). Sin embargo, se ha señalado que pequeñas cantidades de almidón, grano o melaza incrementa la digestión de la celulosa y que la adición de pequeñas cantidades de sacarosa aumenta la formación de proteína microbiana en el rumen. Este efecto positivo de pequeñas cantidades de carbohidratos de fácil fermentación para la utilización de la urea y materiales fibrosos de baja calidad hay que tenerlo en cuenta para no caer en la concepción errónea de la necesidad de alta proporción de carbohidratos de fácil fermentación para la utilización del NNP y que este último no debe pasar de 30 por ciento del nitrógeno total.

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Cuadro 1: Efecto de la suplementacion con almidón (P_4), o sin almidón (P_2) en el comportamiento de toros Brahman cebados con una dieta alta en melaza y urea (Elias et al, 1968)

	Suplemento	
Indicador	**P_2 (30% PC) 200 g/100 kg PV**	**P_4 (15% PC) 400 g/100 kg PV**
No de toros	22	20
Peso inicial, kg	236	252
Peso final, kg	355	386
Ganancia diaria en PV, kg	0,72	0,83

Consumo diario de materia seca, kg		
Forraje de maiz	1,10	1,19
Melaza	5,28	5,11
Urea	0,26	0,24
Minerales	0,06	0,06
EM como melaza, %	80,9	71,4[1]
Conversión, Mcal EM/kg ganacia	25,2	24,5

1 P 0.001

Cuadro 2: Caracteristicas de las canales de toros cebados con melaza y urea ad libitum

	Suplemento	
Indicador	**P_2**	**P_4**
No. de toros	22	20
Peso final, kg	355	386
Canal fria, kg	203	218
Rendimiento, %	57	56,2
Carne comestible total, %	73,2	72,6
Grasa excesiva, %	8,7	9,2
Hueso, %	18,1	18,1

Cuadro 3: Comportamiento de toros Brahman con cuatro niveles de forraje fresco (Elias et al, 1969)

	Nivel de forraje, kg/100 kg de PV			
Indicador	**1,5**	**2,5**	**3,5**	**4,5**

No. de animales	10	12	11	12
Peso inicial, kg	191	195	196	196
Peso final, kg	380	387	383	387
Ganancia diaria, kg	0,79	0,77	0,81	0,80
EM concentración[a], Mcal/kg	2,60	2,57	2,55	2,54[3]
Consumo de alimento				
MS kg/dia	6,78	7,39	7,65	7,89[2]
EM[6], Kcal/kg	61,8	65,3	67,6	68,8[1]
EM como melaza, %	75,5	72,7	68,5	64,4[3]
Conversión[c], Mcal/kg	22,3	24,9	24,4	25,3

1 P 0,10;
2 P 0,05;
3 P 0,001;
a - EM en la MS dietëtica;
b - consumo de EM como proporcióndel promedio de PV
c - EM consumida/ganancia diaria.

Cuadro 4: Efecto del nivel de proteina en la ganancia de peso en toros Holstein X Cebú cabados con dietas de melaza-urea

	Nivel de proteina (NRC req. %)		
Indicador	**80**	**100**	**120**
Peso inicial, kg	202	204	203
Peso final, kg	401	400	401

Ganancia diaria, kg	0,74	0,82	0,87
Consumo de melaza,kg/dia	4,9	5,4	5,3

Cuadro 5: Efecto de la suplementación con proporciones de maiz:trigo en el comportamiento de toros en ceba con dietas de melaza-urea (Elias y Delgado, 1976)

		Proporciones maiz:trigo		Harina de pescado
Indicador	**100:0**	**40:60**	**100:0**	
No. de toros	12	12	12	12
Peso inicial, kg	298	294	297	293
Peso final, kg	402	398	401	405
Ganancia diaria, kg	1,00	1,02	1,02	0,92
Consumo de alim.				
(base fresca), kg/dia[1]				
Melaza	7,52	7,66	7,50	7,20
Cereales	640	652	638	-
Harina de pescado	-	-	-	137
MS total, kg/dia[1]	8,99	9,17	9,02	8,36
Prot. cruda, g/dia[1]	935	968	961	935
EM, Mcal/dia[1]	26,35	26,83	26,34	24,11

1 Ajustado para el mismo peso inicial de 296 kg

Cuadro 6: Efecto de la suplementación con melaza + urea y diferentes fuentes de proteinas sobre la ganancia de peso vivo de toros en pasto de baja calidad

	Pasto	**Melaza + urea**

Indicador	solo	Pescado	Soya	Girasol	Algodón
Peso inicial,					
kg [1]	299	301	301	302	299
Peso final, kg	360[a]	416[b]	416[b]	413[b]	421[b]
Ganancia diaria,					
kg.	0,37[a]	0,78[b]	0,77[b]	0,75[b]	0,78

1 Ajustado para el mismo peso inicial de 300 kg.
ab Las cifras de la misma fila con differentes superindices difieren significativamente a P 0,05.

COMMERCIAL APPLICATION OF MOLASSES FEEDING TO RUMINANTS IN CUBA
by
A. Elias

Feeding of liquid molasses mixed with 3% urea as a supplement is widely spread in Cuba. In experimental diets with good quality forage, the intake of molasses and urea was around 3 kg/day (30–36% of the ME intake) and 90 g/day respectively giving a growth of 0.6 kg/day in fattening bulls. When the forage or pasture is of low quality (<5% CP) molasses supplements without urea give weight losses while a supplement based on molasses with urea and a protein source (urea: protein = 75:25) gave liveweight gains of 500 and 750 g/d for yearlings and bulls respectively.

The use of a high proportion of molasses/urea in feeding fattening cattle has been developed in Cuba since 1967. In this system the animals get 70 – 80% of their dry matter as molasses, the proportion of true protein being only 10 – 20% of the total ingested nitrogen and the

animals grow between 800 and 1 000 g/day, under experimental conditions, depending on the source of true protein. In this system the animals received around 3 kg fresh forage/100 kg liveweight when in the stable or restricted grazing. The animals have to adapt gradually to this feeding system to prevent digestive problems or intoxication caused by high molasses intake.

EXPERIENCES IN THE DEVELOPMENT OF MOLASSES-BASED FEEDING SYSTEMS IN AFRICA

by

K. Hübl

1. LIVESTOCK PRODUCTION IN AFRICA

This paper will concentrate on the tropical part of Africa commonly called sub-Saharan Africa and more particularly on the experience gained in West Africa.

1.1 Livestock production systems

Two major cattle breeds have populated sub-Saharan Africa: zebu cattle brought by nomads from Asia who settled in the tsetse-free rangelands, and humpless cattle (Bos tauru) introduced via North Africa. The latter started to develop from West Africa's coastal regions especially the highlands of Guinea, Futa Djallon, from where two famous livestock breeds

originate: the N'Dama cattle and the Djallonké sheep.

Several livestock production systems have developed according to ecological conditions and as a result of coexistence of animal and plant production within the main farming systems.

In the semi-arid zones, pastoral range-livestock systems still predominate, although the number of real nomads is constantly declining with a trend toward shorter migration distances, agro-pastoral activities and settlement of at least part of the family keeping the milking animals and young calves. Ruminants play by far a predominant role and milk is the main product.

In areas of higher humidity and crop growing potential, crop-livestock systems have developed. Trypanosomiasis is a major problem where cropping areas are placed within bush and tree savannah. If the area is totally cleared and used for crop production, the tsetse flies disappear. Under these conditions more intensive feeding systems based mainly on crop residues become possible. Quite often the nutritional bottleneck occurs during the rainy season and vegetation period when livestock are enclosed in order to prevent crop damage.

In the African highlands the crop-livestock production system is characterized by a high density of the livestock and human populations (Jahnke, 1982). Animal traction is well established and cow milk and sheep production play an important role.

In addition to the above structures which have logically developed on the basis of tradition, environment and socio-economic conditions, more intensive and modern production systems such as ranching and intensive dairy, pig and poultry production units have been introduced to most of the sub-Saharan countries. A great number of them have failed because of supply, management and marketing problems which had been underestimated by ambitious promoters. Many others have shown rather promising results and they are those which give hope for the

future. However, it must be remembered that these units request a similar management level to those in other parts of the world.

1.2 Animal health problems

Unlike Asia and Latin America, the African continent has almost all the known animal diseases causing tremendous losses. Because of their mobility and frequent contacts with other animals, different soils and watering facilities, nomadic livestock are continuously exposed to various diseases. Outbreaks of epizootic diseases remain inevitable unless an efficient vaccination cover is established and maintained but unfortunately this is not yet the case.

A wide range of ecto-, endo- and blood parasites threaten the stock. Blood parasites develop through the occurrence of biting and sucking insects, tsetse flies transmitting animal trypanosomiasis which prevails in most of the sub-Saharan countries. These diseases, together with nutritional problems, are mainly responsible for the low productivity and moderate growth rates of African livestock.

2. MOLASSES FEEDING IN WEST AFRICA

2.1 Introduction and first trial in Nigeria

In August 1971, in a first meeting in Rome with FAO officials and representatives from the sugar industry, the idea was born to launch a cane-molasses fattening operation at the Mokwa Cattle Ranch (MCR) in northern Nigeria. At the MCR conditions for such a project were almost ideal:

7 000 ha of partly cleared land, cattle corrals and holding facilities, building, workshop, office and storage infrastructure, presence of five internationally recruited development experts, their

well-trained Nigerian counterparts and over 100 workers and herders having at their disposal more than 1 000 head of fattening cattle.

In agreement with the Federal Government of Nigeria and FAO, Dr. T.R. Preston visited Nigeria in the second half of 1972. Based on his experiences from Cuba, a detailed workplan for a big feeding trial using cane molasses was immediately conceived and elaborated. Shortly after, some 600 young zebu bulls were procured and passed through quarantine treatment.

By November 1972, these fattening animals were already divided in three equal groups and fed cane molasses transported from the Bacita Sugar Complex situated some 75 km south of MCR. Molasses intake was rationed only for about 3 weeks after which the animals were given molasses ad libitum.

The fattening stock belonged to the Sokoto Gudali breed. The average starting weight was around 195 kg and the ages varied from 1.5 to 3 years. They were kept in open corrals allowing 4 to 5 m^2 space per head. In addition to free water and molasses intake each bull was offered 2–3 kg (DM) of roughage and about 2 kg of whole cotton seed including some 30 g of mineral salt per day. The roughage consisted of grass silage, Panicum hay or 3–4 hours' limited grazing on natural pasture (mainly Andropogon).

Apart from the three different sources of roughage on which the three fattening groups were based all other feedstuffs were identical. After an adaptation period of 4–5 weeks where some molasses toxicity occurred (majority successfully treated) the animals fully consumed the different feeds showing considerable weight gains with an intake of 6–7 kg liquid cane molasses per day.

The weight gains shown in Table 1 were obtained despite a temporary (19 days) breakdown in

the supply of cotton seed.

2.2 Mokwa feedlot

Following the promising results of the successfully completed molasses-based feeding trial (April 1973) the Mokwa Cattle Ranch which had started nine years previously, rapidly developed (Neumayer and Húbl, 1974). Within one year the cattle stock was raised to over 3 000 head permitting an annual throughput of more than 4 500 animals. All animals were kept on zero-grazing and ad libitum molasses. More than 15 tons of liquid cane molasses was transported daily from Bacita to Mokwa.

The average weight gains rose from 150–200 to over 700 g/day and all finished bulls were slaughtered and processed in the project's own refrigerated abattoir. Up to 120/day carcasses were transported to the capital of Nigeria, while most of the fifth quarters were sold locally.

Table 2 shows tremendous change in fattening performances. In this table molasses-based feedlot performances are compared with the fattening conditions in Mokwa before the introduction of the intensive molasses fattening method.

From February to March 1974 the international expert team was removed and full responsibility was placed in the hands of the well-trained Nigerian counterparts. The motivated feedlot management did very well for about one year until the oil-producing country decided to subsidize imported beef to an extent that cattl carcasses in the south were sold cheaper than live animals in the north. The project had little chance to survive this development in the Nigerian beef industry and the feedlot, including the very successfully run refrigerated abattoir, was closed after the last of almost 4 000 fattening bulls had been slaughtered.

From the Mokwa experience, the following conclusions can be made:

- **Introducing and starting a molasses-based feeding system in a well equipped and efficiently managed cattle fattening station can be done quickly.**

- **Losses through molasses toxicity can be kept at a very low level if consumption is increased gradually during the first two or three weeks and if the stock is under continuous observation by experienced herdsmen.**

- **Transportation and distribution of liquid cane molasses require little equipment and very little manpower. One driver can supply up to 4 000 fattening bulls.**

- **Water or fuel tankers have to be modified for molasses transport: springs have to be reinforced and outlet diameters enlarged.**

- **Because of seasonal shortages and to face temporary supply difficulties, storing of molasses within the feedlot is highly advisable. It can be easily stored in simple earth holes covered by a water-tight roof.**

- **Ad libitum molasses feeding requires a minimum of about 1 percent of the animal's bodyweight of palatable roughage (DM). A wide range of forages, including limited grazing on low-value pasture, is suitable.**

- **Whole cotton seed and dried brewers' grain as a protein source have proven the most efficient, but cotton seed has better roughage characteristics than brewers' grain and oil cakes.**

- **Under free marketing conditions, molasses-based cattle fattening can be run economically if the total animal losses do not exceed 5–6 percent.**

- **Cane molasses contain very little phosphorus and this must be considered in the composition of the ration.**

2.3 Ferkessedougou feedlot

The feedlot and sugar complex is situated 600 km north of the capital and port, Abidjan, in the Côte d'Ivoire. The country is highly deficient in meat and imports more than 100 000 head of zebu cattle per year, an important part of these animals passing through Ferkessedougou on their way down to the coast.

In 1976 a molasses-based feedlot was started close by the sugar complex of Ferkessedougou. Under a statal development agency (SODEPRA) and financed by the West German Technical (GTZ) and Financial (KfW) Cooperation, the target was an annual throughput of 10 000 head of cattle to be slaughtered in Ferke (Domdey, 1983).

From 1976 to mid-1980, some 18 000 head of cattle passed through the feedlot producing more than 1 000 tons of liveweight gain in more than 2 million fattening days. Performances resulted in an ADG of 456 g against about 700 g in the Mokwa Cattle Ranch.

As in Nigeria, molasses was given ad libitum. Although the feed composition had to be changed quite often due to temporary shortage of certain items the following ration (Table 3) is typical for most of the time from 1976 up to the present as the feedlot is still running.

While the infrastructure and the regular supply of purchased and farm-produced feed were better than in Mokwa, the project in Ferke had great difficulty with lean cattle quality at purchase. Zebu bulls, originating from the northern range, suffered particularly from parasites and they also had great difficulty to withstand the high rainfall of northern Côte d'Ivoire (1200–1300 mm p.a.). Under these conditions only about 90 percent of the incoming fattening bulls

reached a normal slaughter weight. The other 10 percent had to undergo emergency slaughter or died (about 2 percent). All slaughtering was carried out in the project's own refrigerated abattoir, most of the products being transported and sold in the bigger towns of southern Côte d'Ivoire: Bouaké, Yamossoukro, Abidjan.

Experiences and results from the Ferke feedlot lead to the following conclusions:

- **Low quality fattening cattle (mostly chronically sick) are a serious handicap for satisfactory fattening performances.**
- **Animal health conditions in northern Côte d'Ivoire must be among the worst in the world.**
- **Under high rainfall the fattening of zebu cattle on an earthen floor is difficult to manage, trypanotolerant Bos taurus cattle (i.e. N'dama) withstanding these conditions much better.**
- **On the other hand, the trodden mud is an excellent manure. Correctly applied on forage crops, one treated hectare supplies enough roughage for more than 10 fattening bulls throughout the year.**
- **The adjacent abattoir is technically an advantage to the fattening unit as it allows immediate slaughtering whenever necessary. But the high standard of hygiene which is practised does not (yet) pay in West Africa so that the abattoir is economically a burden to the feedlot.**
- **The Ferke feedlot is built around a small hill on which the water storage tank is placed and cheap molasses storage is built into its slope. Supplies to large tankers and distribution with tractor-driven trailers can be done by gravity by just opening a tap.**

- Some fattening pens have been modified for the collection of liquid manure. This material goes into an attached biogas digester. The gas produced is burnt in an 18 KVA gas generator. The concrete floor is economically justified because of biogas production, but also because of better growth rates during the rainy season as the formation of mud is no longer possible.

3. PROSPECTS AND DEVELOPMENT ALTERNATIVES

If molasses is produced at great distances from the nearest sea port and if molasses fermentation into yeast or alcohol is not intended or feasible, a molasses-based feeding operation on fattening cattle, growing sheep or other domestic animals is still advisable. However, large industrial-type feedlots in the African context seem to be difficult to manage creating marketing problems on both sides which involve a great deal of risk.

If the transportation problem can be resolved, i.e. by an effective extension service operation (as in Nigeria and Côte d'Ivoire), smaller and medium-sized fattening units seem to have less problems and more chance for long-term development.

Based on his experiences over the last few years, the author considers that the molasses-based feeding system practised in small or bigger fattening units using purchased fattening animals does not seem to be the ultimate stage in development. Many of the problems and difficulties of the production system which have been described can be resolved or overcome if feeder bulls are replaced by dual-purpose crossbred cattle and molasses by farm-produced sugarcane and other forage crops within the flexible and efficient frame of a family-type production unit.

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Table 1. Performance data

	Herd 1 (silage)	**Herd 2 (restricted grazing)**	**Herd 3 (Hay)**
Fattening period (days)	169	167	169
Total weight gain (kg)	96.635	98.21	119.13
Average daily gain (kg)	0.572	0.588	0.705

Table 2. Comparison of performances before and after introduction of molasses

1.	Rainy season1	a) natural pasture	0.300 kg average
			daily gain
		b) artificial pasture	0.500 " "
2.	Dry season1	a) natural pasture	0.000 " "
		b) artificial pasture	0.100 " "
3.	Feedlot (whole yr.)2	a) maize silage and cotton seed	0.300 " "
		b) molasses, grass silage or hay, cotton seed or dried brewers' grain	0.700 " "

1 before introduction of molasses

2 after introduction of molasses

Table 3. Composition of ration at Ferkessedougou feedlot

Feedstuff	kg	DM kg	Dig. protein kg
Molasses	4.5	3.6	-
Roughage (grass or silage)	8.0	2.0	0.200
Cotton seed	1.0	0.9	0.150
Cotton seed cake	0.5	0.45	0.200
Total		6.95	0.550

ENSAYOS DE DESARROLLO DE SISTEMAS DE ALIMENTACTION DEL GANADO A BASE DE MELAZA EN AFRICA
por
K. Huebl

Africa subsahariana se enfrenta con una serie de problemas. El rápido crecimiento de la población y el estancamiento o la disminución de la producción alimentaria están provocando un deterioro de la situación económica y social. Además, la repetición de períodos de sequía parece agravar la situación general.

El sistema de la ganadería tradicional evoluciona bastante lentamente, mientras que se observa una clara tendencia a la integración de la producción ganadera y agrícola. Los animales domésticos padecen una amplia gama de enfermedades que afectan a su productividad.

La alimentación del ganado con melaza ad libitum fue introducida en Africa occidental por el consultor de la FAO Dr. T.R. Preston. En 1972 se inició con éxito una operación en el Rancho Mokwa en Nigeria. Con arreglo a los conocimientos y la experiencia adquiridos, se estableció otra segunda granja de engorde de ganado vacuno con dietas a base de melaza en Ferkessedougou, en Côte d'Ivoire septentrional.

Se describen y analizan la situación inicial, el ganado utilizado, la zénica de alimentación y los problemas con que se tropezó.

Por último, se intenta ofrecer una perspectiva de los futuros sistemas de alimentación del ganado a base de melaza.

MOLASSES AS A DROUGHT FEED
by
H. Menbere

1. INTRODUCTION

Ethiopia has the largest livestock population in Africa, with approximately 27 million head of cattle, including around 6 million draught oxen, 24 million sheep, 18 million goats, 7 million equines, 1 million camels and 52 million poultry. The greatest concentration occurs in the

highlands where 70 percent of the human population live. Livestock and livestock products contribute 35 percent of the agricultural output and additionally supply the power to cultivate virtually all of Ethiopia's 6 million ha of land cropped annually. Livestock (mainly donkeys) also contribute substantially to rural transport needs. Exports of livestock products are presently limited to hides and skins, but a great potential exists and maximum effort is being exerted for exports of beef, mutton and live animals, especially to the Middle East. Livestock is the second largest earner of foreign exchange after coffee.

Since the mid-1970s, rural development has been organized within a socialist framework. However, collective farming through cooperatives and state farms accounts for less than 10 percent of the total cultivated area. Over 85 percent of agricultural output is still produced by individual subsistence smallholders who have farming rights over the land they till. Out of the total land area 55 percent are grasslands or permanent pastures. In the highland area animals are part of a mixed subsistence farming complex, while in the lowland area animals are kept by pastoralists. Only a very small proportion is commercially owned by state farms, cooperatives or private individuals.

Livestock productivity, in general, is low throughout the country. Cows calve about every second year and cattle take four to five years to reach maturity. All types of animals suffer nutritional stress for much of the year because of the high cropping and grazing intensity. There are few opportunities for increased offtake under the present production systems and nutritional interventions, such as forage development or supplementation (or a combination of the two) which would be necessary to increase per head and animal production. Cattle, sheep and goats frequently walk long distances to water/graze and are housed or gathered at night, either with their owners or in simple shelters and barns made out of thorn bushes.

Substantial areas are used for communal grazing. These commons are typically dominated by

unpalatable and low productivity grass types. Severe overgrazing and erosion are evident in almost every part of the country.

2. FEED SUPPLIES

2.1 Crop residues: cereals, pulses and other crops

These are the main sources of roughage for small-scale and commercial fatteners operating around crop farming areas. Cereal straws from teff, barley and wheat are the largest component of the livestock diets. The residues are stacked after threshing and fed during the dry season, as are pulse crop residues. Maize, sorghum and millet stovers are important residues in the lower altitude zones. Teff is widely grown in the highlands and barley replaces wheat at higher altitudes, where pulses increase in importance.

Ethiopia's annual crop of about 4.6 million ha of cereals produces 6.5 million tonnes residue, and 0.8 million ha of pulses provide 0.4 million tonnes of haulms. Nutritive values of teff straw are equivalent to medium quality hay, whereas other cereal residues are only of poor to fair quality. However, pulse haulms are high quality roughage (5–8 percent crude protein).

2.2 Byproducts from the Ethiopian sugar industry

On the average about 15 000 ha of cane are harvested each year with a yield of 110 tonnes cane/ha (FAO Production Yearbook 1985). Sugar mills are found at Wonji/Shewa and Metahara and are organized and run by the Ethiopian Sugar Corporation (ESC).

2.2.1 Molasses

Present molasses production is more than 70 000 tonnes per annum (Table 1) and molasses

production is expected to reach 92 000 tonnes by 1991–92. The expansion will take place in 1988–89 (Wonji/Shewa) and 1989–90 (Metahara).

The major part of molasses produced by the Sugar Estate is presently exported to Europe and USA through Djibouti and all the molasses from Metahara are exported (Table 2). Railway wagons are used as transport for exports.

A part of the molasses produced in sold on the local market to distilleries and for cattle fattening (Table 3)

Comparison, for each year, of the figures of production and export + local sales shows immediately that there is an important quantity of molasses which is neither used locally nor exported. Residual molasses could be available for additional livestock feed. The average excess for 1980, 81 and 82, is around 15 000 tonnes/year. This excess molasses is in fact dumped in ground pits existing in the Sugar Estates and used for road maintenance and the rest dumped down the river (Awash).

Explanation of this situation is not the lack of export possibilities. ESC always finds international buyers but the Ethiopian railways cannot for the moment insure the transport of molasses. The surplus molasses will increase with the expansion programme and will reach 65 000 tonnes in 1991–92. However, the Government has started plans to convert all surplus molasses into ethanol including, presumably, the 50 000 tonnes which were to be exported.

The most recent group to examine alternative use for molasses was an FAO team that visited Ethiopia in late 1984 to plan an emergency programme for livestock survival during the current drought. The team adovocated (and we all do) that all molasses should be used as livestock feed, both in times of drought and during normal seasons. Five thousand tonnes of molasses

would fatten less than 10 000 head per annum. This is less than the number currently fattened by the Ministry of State Farms Development for export. Ethanol production conflicts with existing operations and future plans for cattle fattening in Ethiopia particularly if rations are to rely on molasses for the energy available for weight gain.

There are substantial economic data and research results to support the argument that molasses should be used as a livestock feed, irrespective of the season. The FAO team that visited Ethiopia in late 1984 concluded that in times of severe drought, priority should be given to the use of molasses to assist with the survival of breeding cattle and that in normal years, fattening and feedlot finishing would be the most profitable alternative.

2.2.2 Cane tops, trash and bagasse

Ethiopia's cane field produces 540 000 tonnes of cane tops and 270 000 tonnes of trash each year (380 000 tonnes of dry matter) and the factories produce about 476 000 tonnes (235 000 tonnes of dry matter) of bagasse. Some of the cane tops are collected by local peasants and fed to livestock without any charge. Usually most of the cane tops and trash are burnt to facilitate subsequent irrigation and cultivation of the ratoon crop. The three existing factories use most of the bagasse as boiler fuel. In any given year a minimum of 300 000 tonnes of dry matter in the form of cane tops and trash has been produced within the three sugar estates. This means that at the rate of 3 to 4 kg average dry matter intake per head per day for 90 days it will be sufficient to feed more than one million cattle. This is assuming efficient recovery of tops and trash but shows the enormous potential for productive utilization of available resources that are presently wasted.

3. Molasses as cattle feed

3.1 Background

Feeding practices in almost all fattening programmes in our country depend on liberal feeding of wheat bran, and middlings and noug cake supplemented with straw (and more recently sugarcane tops). Molasses is fed in limited quantities (less than 3 kg/day). Urea in most cases is not used. Average performance rate is between 500 and 600 per day. These feeding practices must change and are being changed because of the following major reasons:

- **There is a shortage of wheat bran and middlings due to competition for existing supplies to livestock which make more efficient use of the resource (poultry, pigs and milking cows).**
- **Total production of wheat bran and wheat middlings that is physically available within the country does not increase by more than 30 000 tonnes annually.**
- **The only other concentrated energy resource available locally which can serve as the basis of a cattle fattening diet is molasses. The average production of molasses is some 70 000 tonnes.**
- **Drought has put further pressure on feed supplies.**
- **The pressing need to earn foreign currency and the rising price of good quality beef makes it imperative to expand the fattening programme using more and more molasses.**
- **To reduce the cost of fattening by making greater use of presently under-utilized feed resources (molasses).**

The use of molasses for cattle fattening has been developed in many countries under

conditions resembling in some respects those presently prevailing in Ethiopia. Namely, shortage of foreign exchange, lack of conventional concentrate feeds, and the need to expand meat production to provide protein for the population. A high molasses feeding system proved economically successful since rates of animal performance and efficiency of feed utilization were almost doubled compared with the traditional method. In view of the export potential of molasses and foreign exchange cost associated with urea, the use of molasses/urea (blocks or liquid) must be associated with livestock production systems which either provide export earnings (finished beef animals) or provide substitutes for imports (dairy production).

3.2 Feeding and management systems on state farms

3.2.1 Beef cattle feedlots (at Wonji and Kuriftu) have started to feed ad libitum molasses with 500g/day of poultry litter, one kg/day of protein-rich oil cake (noug, cotton) and sugarcane tops or straw at the rate of approximately 1 kg dry matter per 100 kg liveweight per day. A mixed supplement of wheat bran and wheat middlings with oil seed cake is being replaced by oil cake and poultry litter. The supply of poultry litter is from the State Poultry Farm not too far from the feedlots (Debre Zeit). The ad libitum feeding of molasses is reached by providing steadily increasing quantities of molasses; it usually takes three weeks to reach ad libitum feeding.

3.2.2 Beef holding areas (Netle, Alemtena): These areas have water points and advantage was taken to situate cattle around the water troughs and to feed them molasses ad libitum. Oil barrels cut down the middle and concrete troughs made from drain pipes (60 cm diameter) are used to mix the molasses, 1 kg oil cake, and 500 g of poultry litter per head per day. Straw is fed on the ground (or on a rack) at daily quantities between 1 and 4 kg/head depending on the holding area grazing capacity (native pasture). Grazing time is between 3 and 7 hours per day and confined throughout the rest of the day and night (with adequate space) with easy access to the troughs. This system of feeding is also adapted to fattening of goats and sheep. The

amount of oil seed cake and poultry litter is 150 kg and 50 g per head per day respectively. Molasses is sometimes sprinkled over the daily hay allowance at the rate of about 0.5 kg/head/day.

3.3 Storage and transport of molasses

A system of mixing aqueous urea and molasses in standard oil tankers has been developed and is giving satisfactory results. The important points to note are that water should be added first to the tanker in amounts equivalent to 5 percent based on the weight of the final mixture. The system of introducing the water is to use a hose pipe and to measure the rate of flow with a watch. The approximate amount of water is then added to the tanker on a time basis. This is quicker and perfectly reliable for the purposes required. The urea (in amounts equal to 2.5 percent of the total weight of the mixture) can be added at the same time as the water. Care must be taken to ensure that there are no lumps in the urea. Lumps of urea can be easily broken with a spade or similar instrument. The urea and water must be put in the tanker at least some 10 km away from the sugar factory so that the urea will go into solution as the tanker is driven to the factory. At the factory the required amount of molasses (92.5 percent of the total weight of the mixture) is added. As molasses has a higher density (1.45) than fuel oil the loaded weight of the tanker is achieved when it is approximately two thirds full. The space that is left above the above the molasses together with the baffler inside the tanker ensure that the molasses and aqueous urea are completely mixed before the tanker arrives at its destination. The above system of transporting and mixing of urea was used during the drought feeding programme and to feedlots and holding areas of the State Farms.

Storage of molasses on farm sites is a simple earth pit on a hill side. Tankers can unload and the molasses could flow out by gravity on tankers pulled by horses or tractors.

4. RECOMMENDATIONS AND CONCLUSION

Changes in feed availability and in the nature of the ingredients fed can be causal factors of the metabolic disturbances associated with high level feeding of molasses. Inevitably when a change is made from restricted feeding of molasses to ad libitum feeding, there will be a relatively high incidence of metabolic disturbances. The three metabolic disturbances that can occur are molasses toxicity (drunkenness), urea toxicity and bloat. The important step is to establish the feedlot on the ad libitum molasses system; then provide on a continuous basis both the molasses and the other supplements (e.g. oil seed cake and poultry litter) and measure the results in terms of animal performance, economics and disease incidence.

The economic advantages of using high levels of molasses/urea are considerable apart from the fact that the use of high levels will enable the wheat bran/middlings presently used in the fattening ration to be allocated for other more appropriate purposes such as feeding of dairy cows, poultry and pigs. There is, therefore, a very strong incentive for a programme of research which will increase the understanding of the factor causing molasses toxicity; and to development of feeding and management systems in which the economic losses due to this disease are minimized to the point that they are more compensated by the greater rate and economy of fattening.

Therefore, the following feeding trials should be the developmental research areas to be studied: the base of research areas will be on indigenous cattle, crop residues and agroindustrial byproducts available in Ethiopia.

- **Evaluation of roughage sources and the interactions between these and supplementation with poultry litter and with the level of feeding of the molasses (e.g. restricted versus ad libitum feeding).**

- **Investigation concerning the use of cane tops as roughage source. This will include studies on the method of harvesting and processing (e.g. use of fresh green or burnt tops).**

- **Studies on the use of poultry litter and poultry excreta partly as additives for improving the rumen ecosystem and as a partial replacement for urea.**

- **Determination of response course to different protein supplements including levels with the use of molasses/urea blocks.**

The list of research areas is not comprehensive nor does it indicate the exact orders of priority. It is certain that considerable research will be needed both at the operational level and laboratory in order to optimize the use of molasses in livestock feeding systems in Ethiopia.

In order to understand and implement strategic feeding systems the Ministry of State Farms Development and the International Livestock Centre for Africa (ILCA) have commenced collaborative programmes on development research and training since the beginning of this year (1986). This point of collaborative effort should be stressed because the result will not have application only to Ethiopia but to other African countries already contemplating a greater utilization of their own national feed resources.

Table 1: Molasses production (tonnes)

Year	1984 – 85	1983 – 84	1982 – 83
Wonji	11 917	14 358	11 547
Shewa	13 988	15 158	12 565
Metahara	44 856	43 727	40 629
	70 761	73 243	64 741

Table 2: Molasses exports for the last five years

Year	1984 – 85[1]	1983 – 84[1]	1982 – 83	1981 – 82
From ESC tonnes	35 000	28 000	41 000	29 000
Sale prices US$/tonne		50.0	47.8	61.9

Table 3: Local use of molasses

Year	1984 – 85[1]	1983 – 84[1]	1982 – 83	1981 – 82
Distilleries				
	16 000	15 000	18 303	14 771
(tonnes)				
Cattle fattening				
	15 000	9 800	821	724
(tonnes)				

1 On estimate available from Ethiopian Sugar Corporation(ESC), 1984.

Table 4: Tonnage foreseen as being available for livestock (tonnes)

Total molasses production 1991–2	91 000
Tonnage to be used for alcohol production and baker's yeast	66 000
Residual	25 000
Tonnage required by the beverage industry	21 000
Tonnage available for livestock	5 000

UTILIZACION DE LA MELAZA COMO PIENSO EN PERIODOS DE SEQUIA

por
Hiwot Menbere

El ganado y los productos ganaderos representan el 35 por ciento de la producción agrícola de Etiopía, además de proporcionar energía de tiro para la producción agrícola y el transporte. Aunque las exportaciones de productos pecuarios se limita actualmente a cueros y pieles, se reconoce el beneficio potencial de la exportación de animales vivos y carne de vacuno y de carnero, y se están haciendo grandes esfuerzos en este sector.

Los residuos de cosecha constituyen la principal fuente de forraje para los animales, y también se dispone localmente de subproductos de la industria azucarera, por ejemplo melaza, cogollos de caña, bagazo y paja. Una pequeña parte de la melaza producida por el Ethiopian Sugar Estate (Ingenio azucarero etíope) se vende localmente a destilerías y para el engorde de ganado, mientras que la mayor parte se exporta. En general, todo parece indicar que el sector ganadero no utiliza plenamente los recursos de piensos disponibles.

Por consiguiente, es necesario realizar investigaciones sobre la utilización óptima de los recursos de piensos. La atención deberá concentrarse en la utilización de esos subproductos industriales por el ganado autóctono. Ello supondrá una evaluación de las fuentes de forrajes bastos y sus interacciones y suplementación con melaza/urea; investigaciones sobre la utilización de los cogollos de caña como forraje y de la gallinaza como aditivos y sustitutivos parciales de la urea; y la determinación de la respuesta de los animales a los diversos suplementos proteínicos.

A este respecto, el Ministerio de Desarrollo de Granjas Estatales de Etiopía y el Centro Internacional para la Ganadería en Africa (ILCA) han iniciado un programa cooperativo de investigaciones y capacitación en desarrollo a comienzos de 1986.

MOLASSES-UREA BLOCKS AS A MULTINUTRIENT SUPPLEMENT FOR RUMINANTS

by
R. Sansoucy, G. Aarts and R.A. Leng

1. INTRODUCTION - THE NEED FOR SUPPLEMENTATION

Ruminant diets in most developing countries are based on fibrous feeds: mainly mature pastures (particularly at the end of the dry season) and crop residues (e.g. wheat and rice straw, maize and sorghum stovers). These feeds are imbalanced as they are deficient in protein, minerals and vitamins and since they are highly lignified their digestibility is low. Both these characteristics keep intake and productivity low.

The principles for improving the use of these poor quality roughages by ruminants have been discussed by Preston and Leng (1984). They basically include:

- satisfying the requirements of the rumen microorganisms to ensure efficient fermentation of fibre and increased production of microbial protein relative to volatile fatty acids.
- balancing the products of fermentative digestion with dietary nutrients (mainly through the use of bypass protein) to meet the needs of growth, milk, meat and wool production.

In practice this can be achieved by supplying, in order of priority:

1. **A supplement of fermentable nitrogen and minerals.**

2. **A small amount (10 to 20 percent) of good quality forage, preferably a legume or grass cut at an early stage.**

3. **A small amount of a supplement containing materials that by-pass the rumen: these include protein meal (e.g. toasted soya cake, solvent extracted groundnut cake) or starch based supplements (e.g. maize and sorghum).**

This strategy is applicable in developing countries, e.g. in the Sahelian region of Africa, where ruminants are fed on pastures throughout the year with limited access to supplementary crop residues, or in Asia where they are fed mainly on rice straw and their diets are low in true protein for prolonged periods.

Mixtures of liquid molasses and urea, which provide fermentable nitrogen and are a good source of minerals, have been used for many years by ranchers in Australia and Southern Africa. Mineral licks (sometimes including urea) have also been extensively used in various parts of the world. However, small farmers have rarely benefitted from these supplements usually because of difficulties of handling these in small quantities. Molasses in the liquid form is difficult to transport (requiring expensive tanker trucks), to store (requiring tanks), to handle (it is highly viscous) and to distribute to animals (troughs or other receptacles being needed). Mineral licks which are usually imported are highly expensive and their cost/benefit ratio is often questionable.

By-pass nutrients, with the exception of legume leaves, come generally from rather expensive feeds which are either in demand for human nutrition (cereals) or exported for foreign

exchange (oil cakes). However, because recent research has generally shown that their inclusion at a low rate in the diets is efficient, they should be economical to use in many situations.

2. BLOCK FORMULATION

The objective of the blocks is to provide the small farmer with a supplement for his ruminants which will improve the efficiency of use of the basal diet at an acceptable cost. The concept of using a molasses-urea block to provide nutrients is not new: about 25 years ago they were being used in Australia (Beames, 1963). However, the improvement in knowledge now indicates their strategic place in feeding strategies aimed at improving cattle production by the small farmer (Leng and Preston 1983).

The "solidification" of molasses is a way of solving the difficulties encountered in distributing and feeding molasses and also allows for the incorporation of various other ingredients.

Attempts have been made in many countries to manufacture solid blocks with a high molasses content, but their development has not been very successful. However, recent work in India under the leadership of Prof. R.A. Leng of the University of New England has revived interest in such blocks. Trials are under way, with the technical assistance of FAO, in several countries: Burkina Faso, Bhutan, Egypt, India, Iran, Mali, Mauritius, Pakistan, the Philippines, Senegal and Sudan. More than 30 other countries have shown their interest in this technology.

The blocks can be made from a variety of components depending on their availability locally, nutritive value, price, existing facilities for their use and their influence on the quality of blocks. They can also include specific components.

- Molasses provides fermentable substrate and various minerals and trace elements (but low

amounts of phosphorus). Because of its pleasant taste and smell, it makes the block very attractive and palatable to animals. The degree Brix of the molasses should be as high as possible, and preferably higher than 85, to ensure solidification.

- **Urea, which provides fermentable nitrogen, is the major component of the block. Campling et al. (1962) have shown that its continuous supply to cattle may increase the intake of straw by about 40 percent and its digestibility by 8 units (or 20 percent. The intake of urea must be limited to avoid toxicity problems but sufficient to maintain ammonia levels in the rumen consistently above 200 mg N/1 for growth of microorganisms and high rates of degradation of fibre. Blocks are an excellent way of controlling intake and allow continual access.**

- **Wheat or rice bran has a multiple purpose in the blocks. It provides some key nutrients including fat, protein and phosphorus, it acts as an absorbent for the moisture contained in molasses and gives structure to the block. It may be replaced by other fibrous materials such as dry and fine bagasse or groundnut hulls which are finely ground but some loss of nutritive value occurs.**

- **Minerals may be added where appropriate. Common salt is generally added because this is often deficient in the diet and it is inexpensive. Calcium is supplied by molasses and by the gelling agent, calcium oxide or cement. Although phosphorus is deficient, there is no evidence that its addition is beneficial where animals are at below maintenance when grazing on dry mature pastures or fed low-quality forage (Cohen 1980; Van Niekerk and Jacobs 1984). Mineral requirements are reduced at maintenance or survival levels. Deficiencies will generally become a problem only when production is increased, particularly when a bypass protein supplement is given and in these cases phosphorus should be included in that supplement.**

- **A gelling agent or binder is necessary in order to solidify the blocks. Although the mechanism of gelling is unknown, various products have been tried successfully: magnesium oxide, bentonite, calcium oxide, calcium hydroxide and cement.**

  The use of cement has raised some questions, from various nutritionists and extension workers, about possible negative effects on animals. In fact, research on the use of cement or its by-product, cement kiln dust, as a mineral supplement in Canada (Bush et al. 1985; Nicholson, personal communication), Italy (Galvano et al. 1982), USSR (Karadzhyan and Evoyan 1984) and USA have not shown such adverse effects at levels of 1 to 3 percent of the total diet dry matter. Nevertheless, USDA has restricted the use of cement kiln dust since it could cause a deposit of heavy metals in animal tissue (Oltjen, personal communication).

- **Various chemicals or drugs for the control of parasites or for manipulation of rumen fermentation (e.g. anti-protozoal agents, ionophores) can be added to the molasses blocks which can be an excellent carrier for these products.**

Recent work (Van Houtert and Leng, 1986) has shown that the addition of small amounts of rumen-insoluble calcium salts of long chain fatty acids could further increase the efficiency of the use of fibrous residues.

Finally, the formulae may vary according to the process adopted in manufacturing the block (Table 1).

3. THE MANUFACTURE OF MOLASSES-UREA BLOCKS

Different processes have been tried and can be grouped in three categories:

3.1 The “hot” process

This is the process which was first recommended in Australia. The molasses (60 percent) and urea (10 percent) were cooked with magnesium oxide (5 percent), calcium carbonate (4 percent) and bentonite (1 percent) at a temperature of 100–120°C for about 10 minutes. The content was brought to a temperature of about 70°C and then cottonseed meal (20 percent) was added while stirring. The mixture was left to cool slowly which enhanced solidification (George Kunju, 1981, unpublished data). It settled after some hours. The cooking was done in a double-jacketed rotating boiler with circulating water and steam.

3.2 The “warm” process

The molasses (55 percent) was heated to bring the temperature to about 40° – 50°C and the urea without water (7.5 percent) is dissolved in the molasses, (Choo, 1985). The gelling agent was calcium oxide (10 percent). The rest was made up of common salt (5 percent) and bran (22.5 percent).

The inconvenience of these processes, particularly the “hot” one, is the necessity for providing energy for heating. However, if it is possible to use the hot molasses as it leaves the sugar factory or if an excess of steam is available, the cost of energy may be acceptable. The advantages are the reduction of time for setting and the final product is not hygroscopic.

3.3 The “cold” process

It has been noted that, in tropical conditions, it was not necessary to heat the molasses in order to obtain a good block when 10 percent of calcium oxide was used as a gelling agent (Barker, 1984, personal communication). This observation is of primary importance when blocks are manufactured in a unit separate from the sugar factory as was the case in Senegal.

The “cold” process has been recently described in detail (Sansoucy, 1986). A horizontal paddle mixer, with double axes, is used to mix, in the following order of introduction, molasses (50 percent), urea (10 percent), salt (5 percent), calcium oxide (10 percent) and bran (25 percent). The mixture is then poured into moulds (plastic mason's pails or a frame made of four boards 2.5 m × 0.2 m). After about 15 hours, blocks may be removed from the mould and they may be transported by truck after 2 days.

Calcium oxide may be replaced by cement, but when cement is used it is important to mix it previously with about 40 percent of its weight in water, and common salt to be included in the block. This ensures its binding action, as the water in molasses does not seem to be available for the cement. The quality of the cement is of primary importance. Mixing the salt with cement accelerates hardening.

The disadvantage of the “cold” process is that it needs some time to set and the final product is somewhat hygroscopic. The advantages are the saving in energy, and the simplicity and ease of manufacture.

Independent of the process, the hardness of the block is affected by the nature and proportion of the various ingredients. High levels of molasses and urea tend to decrease solidification. The concentration of gelling agents and bran is highly important in the hardness of the final product. For example if the urea percentage is as high as 20 percent, molasses should be reduced to 40–45 percent and the gelling agent needs to be increased. Quick lime produces harder blocks than cement.

4. FEEDING MOLASSES-UREA BLOCKS TO RUMINANTS

4.1 Factors affecting the intake of blocks

The hardness of the block will affect its rate of intake. If it is soft, it may be rapidly consumed with the risk of toxicity. On the other hand if it is too hard its intake may be highly limited.

High levels of urea may reduce intake of the block as well as of straw, urea being unpalatable (Table 2).

The level of inanition or imbalance in minerals which lead to pica may result in excessive consumption in a short time also leading to urea poisoning. This has been noticed in at least one case in Senegal. Precautions should be taken to avoid this problem of over-consumption in drought prone countries particularly towards the end of the dry season when feed is scarce. The block should be introduced progressively, and it should be clear that the block, as it is presently formulated, cannot constitute the only feed and a minimum of roughage is necessary.

Where there is a bulk of dry feed the risk of toxicity from overconsumption is not apparent (Leng and Preston, 1983). In India, several thousand buffaloes in village herds have been fed blocks containing 15 percent urea without problems (George Kunju, 1986a and 1986b) and there is some indication that buffaloes learn to regulate their intake.

Finally, the intake of block obviously varies with the type of animals (Table 3).

4.2 Effects of blocks on intake of basal diet

Feeding blocks usually results in a stimulation of intake of the basal diet. With a basal diet of straw without any supplementary concentrate, the increase of straw consumption due to molasses urea blocks is between 25 and 30 percent. When some high protein concentrate is also given with the basal diet, the increase of straw consumption is less and varies between 5 and 10 percent (Table 4).

4.3 Effects of intake of blocks on digestibility of straw and some parameters of digestion

The digestibility of straw dry matter in dacron bags measured after 24 hours in the rumen of lambs (Sudana and Leng, 1986) increased from 42.7 to 44.2 percent when 100 g of molasses urea block was consumed, and to 48.8 percent by an additional supply of 150 g cottonseed meal.

Ammonia concentration in the rumen of lambs receiving molasses urea blocks increases to levels which are much higher than those generally recommended for optimal microbial development (60 to 100 mg NH3/1 of rumen fluid). This concentration increases with the urea content of the block (Table 5) and when a by-pass protein is added (Table 6). Krebs and Leng (1984) showed that the digestibility of straw in sheep increased even up to 250 mg NH_3 - N/1.

The total volatile fatty acids in rumen fluid is increased when lambs consume the blocks with or without additional by-pass protein (Table 6). There is a small but significant shift towards a higher propionate and butyrate production, and a lower acetate production.

4.4 Effects of blocks on ruminant growth

Dry mature pasture or straw given alone are unbalanced in nutrients to provide for an active and efficient rumen and to ensure an efficient utilization of the nutrients absorbed. Feed intake and the nutrients absorbed from such diets are insufficient to ensure even maintenance requirements and animals lose weight if they do not receive any nitrogen and mineral supplement. Molasses-urea blocks added to such an unbalanced diet allow for maintenance requirements because they ensure an efficient fermentative digestion (Table 7). When some by-pass protein is added (e.g. cottonseed meal, noug cake) there is a synergistic effect which further improves considerably the average daily gain of ruminants and they become much

more efficient in using the available nutrients. In addition total nutrients are often increased because feed intake is increased.

Compared to urea supplied by spraying on straw, urea from blocks give superior results (Table 8). It is assumed that part of the response may be due to the small amount of supplementary energy supplied by the molasses but also by a stimulatory effect of other ingredients in the blocks on the rumen ecosystem (Preston and Leng, 1986).

4.5 Effects of blocks on milk production

The use of multinutrient blocks has allowed for a substantial reduction in concentrate in the diet of buffalo cows fed on rice straw. The fat corrected milk yield was not diminished by replacing part of the concentrate with block. But the amount of straw in the diet and thus the profit per animal per day were greatly increased (Table 9).

Considerable commercial experience has now been acquired in the use of blocks for supplementing dairy buffaloes fed rice straw under village conditions in India (George Kunju, 1986b). Reducing the amount of concentrate given to buffalo cows from 5 to 3.5 or 4 to 2.5 kg/day, and distributing blocks, did not reduce milk production but increased fat percentage by about 10 percent and reduced the cost of feeding. In other observations the addition of blocks to the diet increased milk production by about 10 to 25 percent and fat content of milk by 13 to 40 percent. In one village where the initial production level was lower the increase was even greater.

Subsequent trials were conducted in Ethiopia with crossbred cows given meadow hay of low quality with two levels of noug cake (Table 10). They showed that milk yield was increased by 28 percent when feeding 2 rather than 1 kg of noug cake in the absence of blocks. However,

there was no difference between the two levels of noug cake when the cows had access to blocks (containing 10 percent urea). It was then possible to save 1 kg nough cake by providing blocks without lowering milk production.

5. <u>CONCLUSIONS</u>

Molasses-urea blocks appear to be a simple way of improving the efficiency of utilization of fibrous feeds by ruminants. These feeds constitute the bulk of the diets of ruminants of small farmers in most developing countries.

The ingredients required are usually available locally at a reasonable price. Their nature and proportion may vary according to the process used for the solidification and the purpose for which these blocks are to be used.

Manufacture is easy and simple and different processes exist which may be used according to local conditions.

Molasses-urea blocks have proven to be an excellent tool for the improvement of ruminant feeding. They create an efficient rumen ecosystem which favours the growth of young animals and milk production but they may also affect conception rates and the size of a newborn animal.

The development of molasses-urea blocks should be encouraged in all developing countries which have a sugar industry and where small farmers feed their livestock on crop residues, communal pastures or agroindustrial byproducts, as a means to make better use of available feed resources at the small farmer level.

One of their greatest advantages resides in the versatility bestowed by the solid state and their

ease of packaging which allows them to be easily transported and used by small farmers.

The main role of molasses-urea blocks is as a cheap, relatively safe and practical way of supplying in order of priority urea and sulphur for rumen microbes, trace minerals and macro elements for the rumen microbes and the animal in small amounts of highly critical nutrients such as amino acids B-vitamins and perhaps other growth factors.

In the future the widespread use of such blocks will give the scientist access to small-holder cattle for administration of drugs, microbial manipulators or even growth promotants.

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Table 1. Examples of formulae according to manufacturing process:

Ingredients	Process			
	Hot	Warm	Cold	
Molasses	60	55	50	50
Urea	10	7.5	10	10
Common salt	-	5	5	5
MgO	5	-	-	-
CO3Ca	4	-	-	-
Bentonite	1	-	-	-
CaO	-	10	5	-
Cement	-	-	5	10
Cottonseed meal or bran	20	22.5	25	25

Table 2. Effect of urea content on intake of block and straw by lambs

Urea content of block, %	10	15	20
Block intake	136	112	18*
g/lamb/day			
Straw intake	441	550	326
g/lamb/day			

*** 4 out of 5 lambs did not lick and of their block**

Source: After El Fouly and Lenc 1986

Table 3. Intake of blocks for different types of animals fed a basal diet of straw

Type of animals	Animal weight	Block intake per 100 kg LW	Authors
Lambs	22	400	Sudana and Leng 1986
Calves	66	250	Van Wageningen and Premasiri 1986, personal communication
Young buffaloes	100	380	Leng 1983
Jersey bulls	300	185	Gedrge Kunju 1986b
Jersey bulls	350	150	" " "
Zebu heifers	280	110	Diallo and Ngoma 1985

Table 5. Ammonia concentration in the rumen of lambs fed oaten chaff with or without molasses urea blocks containing different proportions of urea

Diet (*)		Oaten chaff alone	OC + B 10% Urea	OC + B 15% Urea	OC + B 20% Urea
Rumen ammonia: (mg N/L)	mean	23	131	210	317
	range	8–66	93–209	131–305	285–342

(*) OC = Oaten chaff;B = Block; U = Urea.

Source : Krebs and Leng 1984

Table 6. Mean. ammonia concentration, VFA concentration and molar proportions in the rumen fluid of Lambs fed on wheat straw plus mineral mixture (A), or supplemented with molasses urea block (B) or molasses urea block plus 150 g cottonseed meal (C)

Diet	Ammonia conc.	Total VFA	Individual VFA (molar %)

Diet	(mg NH3 N/L)	(mmoL/L)	Acetate	Propionate	Butyrate
A	26a	63a	78a	17a	4.3a
B	262b	84b	70b	22b	7.5b
C	352c	82b	69b	21b	8.2b

Source: Sudana and Leng 1986

a,b,c: Values within the same column with the same superscript are not significantly different.

Table 4. Effect of block on intake of straw

Type of animals	Animal weight, kg	Increase of straw intake, %	Authors
STRAW WITHOUT CONCENTRATE			
Lambs	22	26	Sudana and Leng 1986
Jersey bulls	300	29.5	George Kunju 1986b
Dairy buffaloes	-	24	" " "
Young buffaloes	100	23	Leng 1983
STRAW WITH HIGH PROTEIN MEAL SUPPLEMENTS			
Lambs	22 (1)	8	Sudana and Leng 1986
Jersey bulls	350 (2)	6	George Kunju 1986b
Crossbred cows	- (3)	10)	Preston, Leng and Nuwanyapka,
" "	- (4)	5)	unpublished data, quoted by
		)	Preston and Leng 1986

(1) with 150 g cottonseed meal

(2) with 1 kg concentrate

(3) with 1 kg noug cake (Guizotia abyssinica)

(4) with 2 kg noug cake

Table 7. Effects of blocks (+B) on growth of young ruminants

Type of	Weight	Basal diet	Growth,	g/d	Authors
animals	kg		no B	+B	
Lambs	22	S	-53	10	Sudana and Leng 1986
Lambs	22	S + CSM	38	90	Sudana and Leng 1986
Jersey	350	S + 1 kg C	220	700	George Kunju 1986b
bulls					
Oken	-	S + 2 kg Ga	220	570	ILCA, quoted by
(5–6 years)					Preston and Leng 1986

C = Concentrates;
CSM = Cottonseed meal;
Ga = Guizotia abyssinica/(noug cake)
S = Straw

Table 8. Compared effects of urea sprayed on straw or blocks on growth

Type of animals	Weight kg	Basal diet	Growth, Urea	g/d Block	Authors
Lambs	22	wheat straw	-59	10	Sudana and Leng 1986
Oxen	-	wheat straw	-190	-70	ILCA, quoted by
					Preston and Leng 1986

Table 9. Effects of blocks on milk production

Diet	Dry matter intake, kg/d	S. dry matter intake, kg/d	Fat correct. milk, kg/d	Profit rupees/d
	11.7	4.8	7.4	5.5

S + 7.75 kg C				
S + 7.75 kg C	11.4	4.9	8.1	7.3
+ Block				
S + 6 kg C	11.0	5.8	7.0	6.9
+ Block				
S + 4.6 kg C	10.5	6.0	7.2	7.8
+ Block				
+ .450 kg CSM				

S = Straw;
C = Concentrate;
CSM = Cottonseed meal

Source: George Kunju, P.J., Tripathy, A. and Leng, R.A. Unpublished data, quoted by Leng 1983.

Table 10: The effect of providing blocks (700 g/cow/day) and two Levels of noug cake on milk yield and Liveweight change of crossbred cows fed a basal diet of low quality hay

	1 kg noug /day		**2 kg noug /day**	
	no block	**with block**	**no block**	**with block**
Milk yield, kg/d	4.2	5.4	5.2	5.4
Liveweight, kg	395	396	336	371
Liveweight change, kg/d	-0.64	-0.39	-0.27	-0.27

Source: Preston, T.R., Leng, R.A. and Nuwanyapka, A. quoted by Preston and Leng 1986.

BLOQUES DE MELAZA Y UREA COMO SUPLEMENTO MULTINUTRIENTE PARA

RUMIANTES
por
R. Sansoucy, G. Aarts y R.A. Leng

Pastos de mala calidad y residuos fibrosos constituyen la dieta básica de los rumiantes en la mayor parte de los países en desarrollo. Es una dieta desequilibrada, sobre todo en nitrógeno y minerales, y ha de ser suplementada para mejorar su eficiencia. Los nuevos tipos de bloques de melaza-urea, parecen ser un medio excelente para aumentar la productividad animal en esas condiciones.

Pueden utilizarse diversos ingredientes para la preparación de los bloques. Generalmente contienen alrededor del 50 por ciento de melaza y del 10 al 20 por ciento de urea. Se necesita un agente cuajante para la solidificación del producto final. Otros ingredientes pueden variar con arreglo a su disponibilidad y precios y al destino que se pretenda dar al bloque.

Existen tecnologías sencillas para su fabricación. La elaboración en caliente es aplicable cuando los bloques se preparan en la fábrica de azúcar o cuando se dispone de una fuente de energía barata. La elaboración en frío es más conveniente en otras situaciones.

Su consumo puede variar con arreglo a su dureza y al contenido de urea, pero el riesgo de intoxicación por urea es muy bajo.

Los principales efectos que se derivan de administrar estos bloques a los rumiantes pueden resumirse como sigue:

- **aumenta el consumo de la dieta básica (paja u otros piensos fibrosos);**
- **aumentan las concentraciones de amoníaco y de ácidos grasos volátiles en el fluido del**

rumen;

- mejora la digestibilidad de la paja;
- aumenta la ganancia media de peso por día. Se mejoran aús los resultados incluyendo proteínas sobrepasantes. La utilización de estos bloques es mejor que la pulverización de urea sobre la paja;
- aumenta la producción de leche y su contenido de grasa, economiza el concentrado requerido para suplementar la dieta.

CASE STUDY - ZIMBABWE SUGERCANE AS FEED
by
T.Madonko

1.INTRODUCTION

This case study on sugarcane as feed is based on a drought relief exercise carried out during the 1983/84 drought situtation in Zimbabwe. The southern part of the country which, traditionally, carries the bulk of the beef herd, was the worst effected. It should be noted here that the drought came at the same time as the introduction of veterinary controls which meant

that the cattle could not be moved to the north where there was some grazing. The only alternative was to feed the cattle where they were. Soon after the ministerial approval of the drought relief national herd rescue programme, a total of 120 000 head of cattle were purchased by the Cold Storage Commission (CSC) from various drought stricken commercial producers as well as from communal farmers.

Due to the lack of grazing, it was evident that any survival of the cattle which had been purchased was only possible through pen feeding. However, the aim here was not to finish the cattle for slaughter but only to enable them to survive until the next rains then eight months away. Two basic feed formulae were arrived at to solve the situation:

a. **survival feed**
b. **maintenance feed**

Generally, maize is the traditional energy source in all our feed formulae in Zimbabwe. However, because of the drought, all available maize had to be reserved for human consumption and as a result an alternative had to be found.

2. THE FEEDING OF CATTLE ON BAGASSE AND MOLASSES

Triangle Sugar Estates comprises 13 000 ha of irrigated cane fields. The factory operates two sugar mills which crush a total of 2 million tonnes per year, producing 220 000 tonnes of sugar. The main byproducts obtainable from the mill are bagasse and molasses.

Included in the factory complex is the ethanol plant which produces petrol blend, utilizing 90 percent of the molasses. Bagasse is also used as fuel for the boilers and approximately 60 percent is committed for this purpose. These parameters of quantity had to be considered carefully in determining the numbers of cattle to be survival fed and the composition of the

feed formula.

The analysis of the two sugarcane byproducts used is as follows:

	Prot.	**TDN**	**Cal.**	**Phos.**	**Fibre**	**Fat**	**Ash**
Molasses	3.50	70	-	0.40	-	0.1	9.0
Bagasse	1.00	43	0.07	0.03	35	0.4	4.0

Based on the nutritive value of these byproducts two feed formulae were established:

a) Survival feed composition

Wet bagasse	50%
Molasses	16%
Maize	34%
Analysis	
Dry matter	67%
Crude protein	6.25%
TDN	46%

The recommended daily distribution was as follows:

3 kg/hd/day for	+/- 300 kg livemass
5 kg/hd/day for	+/- 450 kg livemass
7 kg/hd/day for	Mature cows in calf

b) Maintenance feed formulation

Bagasse	20%
Molasses	45%
Soya oil cake	5.5%
MCP	0.5%
Maize offal	25%
Urea	2%
Limestone	1%

The TDN on this formula was calculated at 60 percent. However, to provide a maintenance function only, this feed was given to animals of weights described above to a maximum of 5 kg/head/day. After the animals had finished the feed, some additional semi-wet bagasse was added into the troughs to provide a filler.

3. THE USE OF CANE TOPS

Due to difficulty in handling as well as the non-availability of effective mechanization in collecting the cane tops on the veld, it was virtually impossible to utilize them on a large scale. The use of cane tops was eventually left to small scale survival feeders who had to collect them manually off the veld. Here again, a number of variations had to be applied in feed mixing:

- **80 percent cane tops, 1 percent urea, 15 percent molasses, 4 percent maintenance feed formulation (see paragraph 2 b)**
- **75 percent cane tops, 2 percent urea, 18 percent molasses, 5 percent chicken litter**
- **70 percent cane tops, 20 percent molasses, 10 percent protein cake**

- **80 percent cane tops, 20 percent molasses**

In most cases, the cane tops had to be chopped to about 12–15 cm pieces using a threader and in some cases, this was done manually.

4. OBSERVATIONS AND CONCLUSIONS

- **Molasses, especially in our case (Zimbabwe), where maize is required for human consumption, is a very valuable stock feed.**
- **Under drought conditions, molasses can be used to induce animals to consume coarse fibres which would assist them to survive.**
- **Bagasse, as a sugarcane byproduct, requires minimal blending with some appropriate supplement to be converted into a valuable feed under drought conditions.**
- **Use of cane tops on a large scale is restricted by low levels of mechanization.**
- **In cases where transportation of feed with high molasses content is involved, substantial losses are incurred due to compaction especially where the molasses exceeds 15 percent.**
- **Wherever possible, the use of jute bags must be avoided. To minimize loss only poly-propylene bags should be used in conjunction with molasses, as they can easily be recycled.**
- **Where no feed troughs are available, bagasse and molasses based feeds can be fed on the ground without substantial loss as, on drying, it quickly forms a hard surface.**

ESTUDIO MONOGRAFICO SOBRE ZIMBABWE

por

T. Madonko

La parte sur de Zimbabwe, que es la zona productora de carne de vacuno más importante del país, fue gravemente afectada por una sequía en 1982/84. Durante ese período, el transporte de animales desde el sur hasta las zonas septentrionales menos afectadas de Zimbabwe no fue posible por razones veterinarias.

La Comisión de almacenamiento en frigorífico elaboró un plan nacional de salvación de la cabaña que afectó a 120 000 cabezas de diversas razas pertenecientes diferentes granjeros comunales comerciales.

Los únicos piensos disponibles eran los subproductos de la industria zucarera. Se preparó un pienso de supervivencia compuesto de bagazo, maía y nerales, y otro pienso de mantenimiento compuesto de bagazo, melaza, torta de ja, residuos, urea y minerales.

Se ensayó la utilización de cogollos de caña, pero debido a dificultades recolección se dejaron para los pequeños agricultores.

CONSTRAINTS TO THE EFFICIENT UTILIZATION OF SUGARCANE AND ITS BYPRODUCTS

AS DIETS FOR PRODUCTION OF LARGE RUMINANTS

by

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INTRODUCTION

Land for production of forage to feed to cattle is almost always of limited availability in developing countries in the tropics. Whether land can be spared for such use depends largely on population pressures and the need to produce food staples for human consumption. High human population densities are almost always associated with soils of high actual or potential productivity, high rainfall or adequate water for irrigation systems where up to three crops per year can be harvested. Livestock have been integrated into these systems and are usually multipurpose and provide draught power in addition to milk, meat, hides and dung for fuel and fertilizer. The animals are largely supported on the crop residues and byproducts of agroindustries.

With increasing urbanization, the demand for and the value of animal products increase. This together with increasing crop yields increases pressure on land use and allows the development of specialized animal production systems aimed largely at producing food for people in the cities. These systems are usually based on forage production and the feeding of high levels of concentrates. The use of land for cattle production is inefficient in terms of biomass produced and therefore a very high level productivity per hectare is necessary to justify such systems. Crops to be fed to cattle must therefore yield a high biomass or provide essential dietary components that are more economic to grow than to obtain from other sources (e.g. byproducts).

Sugarcane, with its high efficiency of solar capture, more than any other crop fits the concept

of maximizing unit area yield of fermentable carbohydrate. Leguminous crops (forages and trees) fit the latter requirement since they provide fermentable N and bypass protein to balance diets based on sugarcane and/or agroindustrial byproducts and crop residues.

One of the major consequences of the fossil fuel crisis is that biomass for fuel is now competitive with biomass for feeding ruminants. This has led to the concept of fractionating plants into relatively digestible (say soluble sugars and high digestibility leaves) and relatively indigestible lignified components (i.e. straws or fibrous residues from extraction processes). Sugarcane is ideal since it has both high biomass yields and it is relatively easily fractionated into highly digestible (sugar) and less digestible fibrous components (fibre or bagasse).

SUGARCANE, BYPRODUCTS AND RESIDUES AS CATTLE FEED

The principal forms of sugarcane or its byproducts that can be used as a basis of a diet include whole chopped cane, chopped stalk or chopped tops (fibre and sugar are usually about 50:50), sugarcane pith (after removal of rind) and molasses. The principal fermentable carbohydrate source in all these materials is sucrose with some other sugars (glucose and fructose), and except for molasses, this is mixed with relatively low digestible fibre. Bagasse is also available but it has a very low digestibility (about 35 percent) and is more suited to being used as a fuel than a feed. All products of the sugarcane plant are low in total N and protein.

Feeding systems based on sugarcane and its byproducts

The objective of designing a diet based on such products must be to optimize animal productivity rather than to meet requirements for maximum production. In this context then the criteria must be to:

1. **establish an efficent rumen ecosystem in order to: a) optimize microbial growth yield in**

order to obtain a high microbial protein relative to energy in the products of fermentative digestion; b) where fibre is a high percentage of the diet it is essential to maximize the digestibility of fibre within the rumen.

2. balance the absorbed nutrients with dietary nutrients to meet the requirements for a particular productive purpose. This includes supplementation with: a) bypass protein to provide essential amino acids; b) bypass starch to provide extra glucose, and c) fat to provide long chain fatty acids for body tissue synthesis and for synthesis of milk fat.

ESTABLISHMENT OF AN EFFICIENT RUMEN ECOSYSTEM

In this context an efficient rumen is characterized as one in which there are: a) high rates of microbial protein synthesized in relation to VFA produced; b) the rate of digestibility of the components of the feed is high; and c) the balance of propionate relative to acetate and butyrate is high.

Protein to energy ratio

This is the amount of microbial protein available for digestion in the intestines relative to energy absorbed as VFAs (g protein/MJ VFA energy).

Microbial cells in the rumen are synthesized largely from the fermentable carbohydrate source and therefore there is an inverse relationship between microbial cells and VFA produced (Figure 1). There are many factors that influence microbial cell yield (YATP, g cells per mole ATP available) in the rumen (Leng and Nolan, 1984); the most important with the diets discussed here are: a) availability of substrates for microbial growth; b) bacterial N turnover in the rumen, and c) high turnover rate of rumen contents since this decreases the maintenance energy requirements of microorganisms (M-ATP (Leng, 1982).

Availabilities of fermentable substrate and ammonia for microbial growth are the primary limitations to fermentation in the rumen.

Supplementation with fermentable-N

The low N content of sugarcane and its byproducts is a clear indication of a need to supply fermentable-N. This is usually done as urea, but fermentable N can be supplied by other N sources such as chicken litter or high protein forages. Normally about 30gN are required for every kilo of fermentable carbohydrate in the diet. Because a large proportion of the fermentable carbohydrate is rapidly fermented, urea must be mixed through the feed so that ammonia becomes available when the sugars are being fermented. The effect of adding urea on liveweight gain and intake in cattle on a molasses based diet is shown in Figure 2.

The need for other microbial activators

Recognition that microbial growth in the rumen is stimulated by peptides and amino acids (Maeng et al., 1976) has suggested that the effects of supplementation with a relatively insoluble protein may increase the efficiency of microbial growth. The effects of peptides and amino acids on microbial growth in the rumen on sugar based diets has not been studied. However, indirect evidence has been obtained which suggests that improved efficiency of utilization of feed by ruminants on a molasses based diet occurs if poultry litter is included in the diet.

In a cattle fattening diet based on ad libitum molasses sugarcane tops and wheat bran (1 kg/d), urea was a more effective source of fermentable-N than poultry litter. However, poultry litter stimulated growth rate when added to a diet apparently adequate in fermentable-N given as urea (Meyreles and Preston, 1982) (Figure 3). Consequently it appears that there are a number

of microbial precursors all of which may increase microbial growth or activity in the rumen.

Maintaining a high rumen outflow rate

Isaacson et al. (1975) concluded from studies using continuous culture of rumen microorganisms in vitro that increases in the turnover rate of the contents of the flask increased the efficiency of growth of the microbes, i.e. more microbial cells were synthesized per mole of carbohydrate fermented or per mole of ATP available from fermentation.

Rumen volume and outflow rate on sugar based diets are highly correlated, and influenced by the proportion of fibre relative to sugar in a diet as fibre is generally only digested to a small extent and is only needed to maintain rumen motility. The reasons for, and the amount of fibre needed in sugar based diets are not fully understood. Fibre is approximately 50 percent of the dry matter of sugarcane. It is only slowly digested and its long retention time in the rumen may represent a constraint to intake through distension of the rumen.

Preston and Willis (1974) recommend that on molasses based diets for cattle about 8 g/kg bodyweight should be provided as a ‘good quality’ forage to allow high intake of molasses. Forage quality here probably refers to the slow physical breakdown of fibre in the rumen. For instance sugarcane-stem fibre which is rapidly broken down to small particles is not a good fibre to include in a molasses based diet; sugarcane tops which have longer fibres are better, but neither appear to be as effective as straws in maintaining a high intake of molasses when this is freely available.

Lack of forage in a molasses based diet reduces rumen outflow rate and may lead to the establishment of sludge fermentation (Rowe et al., 1979a, b). Providing a long forage with sugar based diets is an important management strategy. If the fibre source also provides fermentable N and bypass protein and lipid as is the case with legumes, these are major advantages.

Reducing the turnover of microorganisms in the rumen

All sugar diets tend to support high populations of protozoa. On molasses based diets the protozoal species are usually the small ciliates (entodiniomorphs) whereas on sugarcane based diets the larger ciliates (holotrichs) tend to predominate. These protozoa are able to establish large population densities on these diets because of their ability to rapidly assimilate soluble sugars. These give protozoa a competitive advantage over bacteria. Protozoa appear to depend on engulfment of bacteria for their amino acid requirements (Coleman, 1975). Protozoa are retained preferentially in the rumen (Weller and Pilgrim, 1974; Bird and Leng, 1985) and their turnover, which is slow, is largely due to death and fermentation of their components in the rumen (Leng, 1982). The pool size, and half life in the rumen of protozoa on a number of sugar based diets are shown in Table 1. According to Leng (1984), there is a positive relationship between protozoal pool size and growth rate.

The conclusions that can be drawn from these data are that protozoa are likely to reduce the microbial protein available for digestion in the intestines and therefore increase the need for dietary protein which escapes rumen fermentation. Data in Table 2 indicate that the absence of protozoa (the defaunated state) is associated with higher flow of both microbial and dietary protien to the intestines. If protozoa could be removed from the rumen of cattle on sugar based diets the outcome should be decreased requirement for dietary protien which is often the most expensive component in a molasses based diet. The result of the experiments of bird and Leng (1978) confirm this conclusion where defaunated animals grew about 50 percent faster than control animals when fed on low protein-molasses based diets (Table 3).

To create optimum rumen conditions for the utilization of sugar or sugar/fibre based diets it is necessary to: a) provide fermentable N to optimize rumen ammonia concentration; b) provide other unknown co-factors for the rumen microbial ecosystem (e.g. relatively insoluble proteins to provide amino acids and peptides, and chicken litter to provide others); c) provide a good quality forage to maintain a high outflow rate of digesta from the rumen and to stimulate mixing of rumen contents, and d) manipulate the rumen microbes to obtain a high protein/energy ratio in the products of fermentative digestion - essentially to defaunate the rumen.

MANIPULATION OF DIET

Different physiological states in cattle have different demands for both the quantity and balance of nutrients required. Growth places a lower demand for nutrients on the animal than milk production. Pregnancy appears to be less demanding than both growth and milk production., although just prior to calving, feed requirements may be 75 percent higher than at maintenance. However, recent studies from Australia suggest that even on diets of low digestibility forage (e.g. 45 percent) merely supplementing with urea is sufficient to produce viable offspring (Stephenson et al., 1981; Lindsay et al., 1982). Therefore on molasses based diets there appears to be no need for dietary protein supplements during pregnancy.

Requirements for bypass protein for growth

For high rates of growth and to support late pregnancy and moderate to high milk production the demand for essential amino acids is higher than can be provided by an optimized rumen fermentation and therefore supplements of bypass protein should be given to maximize intake and production. The effects of supplementation of cattle on molasses based diets with fishmeal are shown in Figure 4.

Mechanism of action of bypass protein

Although the effects of fishmeal have been assumed to be due to an increased availability of essential amino acids, fishmeal is also a source of lipids, Ca and P and other essential macro and micro minerals, and in addition, because of its insolubility, it could supply a slow rate of release of proteins within the rumen which may stimulate microbial growth.

There are undoubtedly factors in fishmeal that stimulate the efficiency of microbial growth. However, these factors are unlikely to stimulate microbial growth efficiency by more than say 10 percent. The effects of fishmeal supplements on protein availability to the animal from both an increased efficiency of microbial growth and from fishmeal bypassing the rumen can be roughly calculated taking an example of a steer consuming 4 kg of fermentable carbohydrate (as molasses) supplemented with urea and 0.5 kg of fishmeal (i.e. 300 g true protein). At an average efficiency of Y-ATP of 14 in the rumen (Leng, 1982), the amount of microbial protein synthesized could be 800 g/day and the VFA energy absorbed would be 34 MJ/d. Three hundred grammes of bypass protein would give a total protein available for digestion in the intestines of 1 100 g/d. If the effects of supplementation were largely occurring through stimulation of microbial growth in the rumen, then at uppermost we could perhaps expect to increase microbial protein production by 80 g/d.

Protein fermentation results in a low microbial growth yield of approximately half that of a similar quantity of carbohydrate fermented (Leng and Nolan, 1984) and 300 g of protein fermented would yield about 30 g microbial protein. Thus if fishmeal is largely used intraruminally the net effect is an increase in microbial protein yield to 910 g/d and in the VFA produced to about 36 MJ/d. Similarly if 66 percent of the protein escaped rumen fermentation (i.e. 200 g/d) and there was an increase in microbial growth efficiency of 10 percent (80 g/d) the net effect could be 80 g of extra microbial protein and 200 g of dietary protein entering the

intestines. This latter case is the most likely scenario when feeding fishmeal to cattle on molasses based diets. The data are summarized in Table 4.

Fishmeal also provides long chain fatty acids which may be equally important on these low fat diets since a high proportion of tissue fat probably arises from dietary long chain fatty acids (Thornton and Tume, 1984) as does approximately half the fat of milk (Annison and Linzell, 1964; Linzell, 1968).

Milk production on sugar based diets

Attempts to establish feeding systems for milk production on molasses or sugarcane based diets have generally resulted in animals losing weight and milk yield rapidly dropping to low levels. The effects of replacing maize grain with molasses on milk yield of cows is shown in Figure 5. These data suggest marked difficulties in meeting the requirements for milk production on sugar based diets.

Milk production has a high demand for glucose for lactose synthesis, and for glucose to supply about half the NADPH (see Moore and Christie, 1981) which are the co-factors involved in synthesis of the C4 to C16 fatty acids from acetate (Linzell, 1968). Long chain fatty acids of dietary origin appear to supply C16-C18 fatty acids.

It is well recognized that a bypass protein is required to meet the needs of milk protein synthesis. There is thus a demand for critical nutrients in milk production and long chain fatty acids and glucose are required in higher proportions than in any other productive functions. Kronfeld (1982) has suggested that maximum efficiency of milk production occurs when lipid in the diet supplies 15 percent of the metabolizable energy of a diet.

Sugarcane and its byproducts, particularly molasses, are low in fat, and this may be a primary

limitation to milk production. The lactating animal on a high sugar based diet may attempt to overcome the low dietary fat availability by synthesizing more palmitate and stearate from acetate and butyrate but this again places a major drain on the glucose economy of the animal because of the need for NADPH and the need to synthesize glycerol from glucose for lipid synthesis. The synthesis of milk fat as a constraint to production on diets based on agroindustrial byproducts or sugar based feeds does not seem to have been recognized and therefore the theoretical aspects are discussed in more detail here.

Relationship between glucose oxidation and fat synthesis from acetate

The interrelationships are illustrated in Figure 6. The synthesis of palmitate from acetyl CoA is shown below.

8 Acetyl-S-CoA + 14NADPH + $14H^{+}$ + ATP + H20
→ Palmitic acid + 8 CoA + 14 NADP + 7 ADP.

The NADPH is formed largely via the phosphogluconate pathway from glucose in which 1 mole of glucose-6-phosphate is oxidized to C02 with reduction of NADP.

Glucose-6-P04 + 12 NADP + 7 H20
→ 6 C02 + 12 NADPH + 12 H^{+} + P_1.

Thus, for every 8 mole of acetate converted to 1 mole palmitic acid, 14 moles of NADPH need to be provided by the oxidation of 1.17 moles of glucose via the phosphogluconate pathway. In addition 1 mole of glycerol-phosphate from glucose is needed to easterify three moles of palmitic acid. The reaction for the synthesis of tripalmitin is as follows:

24 acetyl-S-CoA + 42 NADPH → 3 palmitic acid + 42 NADP
3.5 glucose → C02 + 42 NADPH
0.5 glucose → 1 glycerol
3 palmitic acid + glyucerol-phosphate → tripalmitin + Pi

Thus 4 moles of glucose are needed to synthesize 1 mole of tripalmitin or 89 g of glucose are oxidized in the formation of 100 g of fat.

There is evidence that about one third to one half of the NADPH for long chain fatty acid synthesis may arise in mammary tissue through other reactions than the phosphogluconate pathway (e.g. dehydrogenation of isocitrate to 2-oxoglutarate). The relative contribution of this pathway has not been quantified.

The question arises, how much NADPH needs to be formed in the phosphogluconate pathway and how much arises from the alternative pathways, and how much milk fat is actually synthesized de novo in cattle on these high sugar and low fat diets. The low efficiency of utilization of molasses dry matter for bodyweight gain or milk production is evidence for this being an important constraint to production (Preston and Leng, 1985).

Feeding a low fat diet to potentially high yielding cows in early lactation necessitates fat to be mobilized from body reserves to provide some of the palmitic and all the stearic acid of milk fat, unless these can be synthesized from acetate. As 60-85 percent of glucose is taken up by the udder during peak lactation(Annison and Linzell, 1964), it appears that a low fat diet imposes a dual constraint since, besides being low in fat, these sugar based diets are characterized by the low glucogenic energy (i.e. propionate) in the VFA produced (Table 5).

EVIDENCE FOR CONSTRAINTS TO RUMINANT PRODUCTIVITY DUE TO AVAILABILITY OF

GLUCOSE

The need to manipulate or supplement diets in order to ensure adequate amounts of glucose and/or glucogenic compounds was proposed by Leng and Preston (1976). As this thesis is being disputed (ARC, 1980; Orskov, 1980) it is necessary to present the evidence which justifies the need to take account of the glucogenic potential of a diet.

Molasses Fattening systems for cattle on molasses based diets supplemented with bypass protein supported levels of growth comparable with those on grain based diets (Preston et al., 1967). Molasses-fed animals had a poorer feed efficiency and a lower carcass fat content (Preston and Willis, 1974). In contrast it was impossible to support even moderate levels of milk production on a molasses based diet (Figure 5). The milk yield was closely related to rumen propionate proportions and the diet was extremely low in fat (Clark et al., 1972).

Sugarcane Rice polishings with a large proportion of broken rice grains and oil (12 percent) was a better supplement than cassava root meal for growth of cattle on sugarcane based diets (Preston and Leng, 1980). The starch in rice polishings almost quantitatively escaped rumen fermentation (Elliott et al., 1978), whereas the starch of cassava root meal was fermented rapidly in the rumen (Santana and Hovell, 1979). Glucose entry rates were higher in cattle fed sugarcane based diets when rice polishings rather than cassava root meal was the supplement (Ravelo et al., 1978). On these diets rice polishings provided considerable fat in addition to bypass protein.

Supplementary maize grain with good rumen escape characteristics and with a relatively high content of oil improved feed conversion efficiency in cattle fed sugarcane pith whereas the same amount of molasses energy which would be completely fermented in the rumen (and containing no fat) depressed feed conversion efficiency (Donefer cited by Pigden, 1972).

Forage Thomson (1978) found that the efficiency of utilization of ME for tissue synthesis in sheep was higher for concentrate/forage combinations of maize and clover than for barley and rye grass even though the metabolizability of the DM (ME/DM) was the same on all diets. One explanation is the proportionately greater post-ruminal digestion of maize/clover DM than with barley/grass (Table 6). Also maize contains twice the content of oil found in barley.

Evidence from infusion of metabolites

Economides and Leng (Leng, 1982) examined the interaction between dietary bypass protein (fishmeal) and abomasally infused glucose in lambs fed a basal diet of sugar/oaten chaff supplemented with urea. Feed intake and growth rates were increased by supplements of bypass protein. Glucose had no effect on feed intake but increased liveweight gain and feed conversion efficiency (Table 7).

Supporting evidence for the thesis put forward is provided by Orskov et al., (1979) where sheep nourished by infusion of VFA into the rumen and infusion of casein into the abomasum without any long chain fatty acids in their diet increased their nitrogen retention as the proportion of propionic acid in the infused VFA was increased (Figure 7).

In the very early studies of Blaxter and his colleagues (Blaxter, 1962), there was apparently a positive linear relationship between the molar proportions of propionate in rumen VFA and the efficiency of utilization of metabolizable energy above maintenance for fattening. As these animals were mature they were laying down mostly fat.

It is relevant to compare Blaxter's data with the results obtained by Orskov et al., (1979) with young lambs nourished by infusion of VFA into the rumen and casein into the abomasum (Figure 8). These data clearly show that N-balance, reflecting protein deposition, was

stimulated in young animals as the proportion of glucogenic energy increased.

There is obviously less need for glucogenic energy when the body tissues synthesized are high in protein rather than fat. The highly efficient use of both dietary energy and protein at the highest level of glucogenic energy (i.e. where the data of Blaxter and Orskov and their colleagues coincide) is clearly the optimum balance of nutrients.

The need for glucogenic compounds in the end-products of digestion was clearly shown by Tyrell et al., (1979) (Figure 9). Acetic acid infused into the rumen of animals receiving a basal diet of lucerne hay of low glucogenic potential was less efficiently utilized for tissue synthesis than when the infusion of acetate was given with a basal diet of high potential for providing glucose (i.e. high maize grain content). Again the oil from maize may have had a significant effect in reducing the need for long chain fatty acid synthesis and thus sparing glucose from oxidation.

The superior nutritive value of propionic acid compared with acetic acid, observed in the original work of Armstrong and Blaxter (1957a, b) and Armstrong et al., (1958) and the absence of differences between these two fatty acids in the experiments of Orskov and Allen (1962) can also be explained in terms of the glucogenic potential of the basal diet. The diet used by Armstrong et al., (1958) was dried grass (low glucogenic potential) whereas Orskov and Allen (1962) gave the different VFA mixtures to animals fed mainly on barley grain (high glucogenic potential).

In conclusion, on sugar based diets the imbalances in nutrient availability from fermentative and intestinal digestion for productive purpose appear to be: a) a low protein to VFA energy ratio; b) a low glucogenic energy/total VFA energy, and c) a low ratio of long chain fatty acids relative to VFA. For optimizing growth on diets based on sugarcane products a supplement

containing bypass protein and fat is likely to be sufficient to support maximum growth rate. However, the much greater demand for the “essential” nutrients for milk production and the very high demand for glucose for lactose and glycerol synthesis and glucose for oxidation and the generation of NADPH places special emphasis on the need for supplements containing bypass protein, long chain fatty acids and starch (to provide post-ruminal glucose).

Rice polishings containing broken rice relatively rich in bypass protein, bypass starch and fat appear to be an ideal supplement to sugar based low protein diets. The response to supplementation with rice polishings of a diet for cattle on sugarcane is shown in Figure 10.

There is obviously a great need to carry out further research to isolate the effects of supplements and then to develop and compound supplements to provide the necessary nutrients.

The theoretical need for bypass starch is a concept that requires further testing. Problems in feeding bypass starch are likely to arise since absorbed glucose tends to reduce gluconeogenesis from propionate in maintenance fed animals. This is, however, unlikely to occur in animals constrained by their glucose economy which are defined here as animals on a low fat diet with a low proportion of propionate in the rumen VFA.

Sugarcane byproducts - low in sugar

Two byproducts, cane tops and bagasse are available which are low in sugar but have a high content of (low digestibility) fibre. They are also low in fat and when they are fermented in the rumen the VFA profile is extremely low in propionic acids. The use of these as diets for producing ruminants has not been successful. The above discussion relates to these feeds in a number of ways and possible approaches to increasing productivity can be developed by application of the principles we have outlined (Table 8).

CONCLUSIONS

The utilization of crop byproducts high in sugar for cattle is dependent on establishing an efficient rumen ecosystem by providing microbial growth factors not provided in the diet (i.e. urea, peptides, amino acids, etc.) and balancing the products of fermentative digestion with essential amino acids and glucose from materials that escape rumen fermentation.

Supplementation with a source of long chain fatty acids is essential and may considerably affect the amount of glucose actually needed by the animals.

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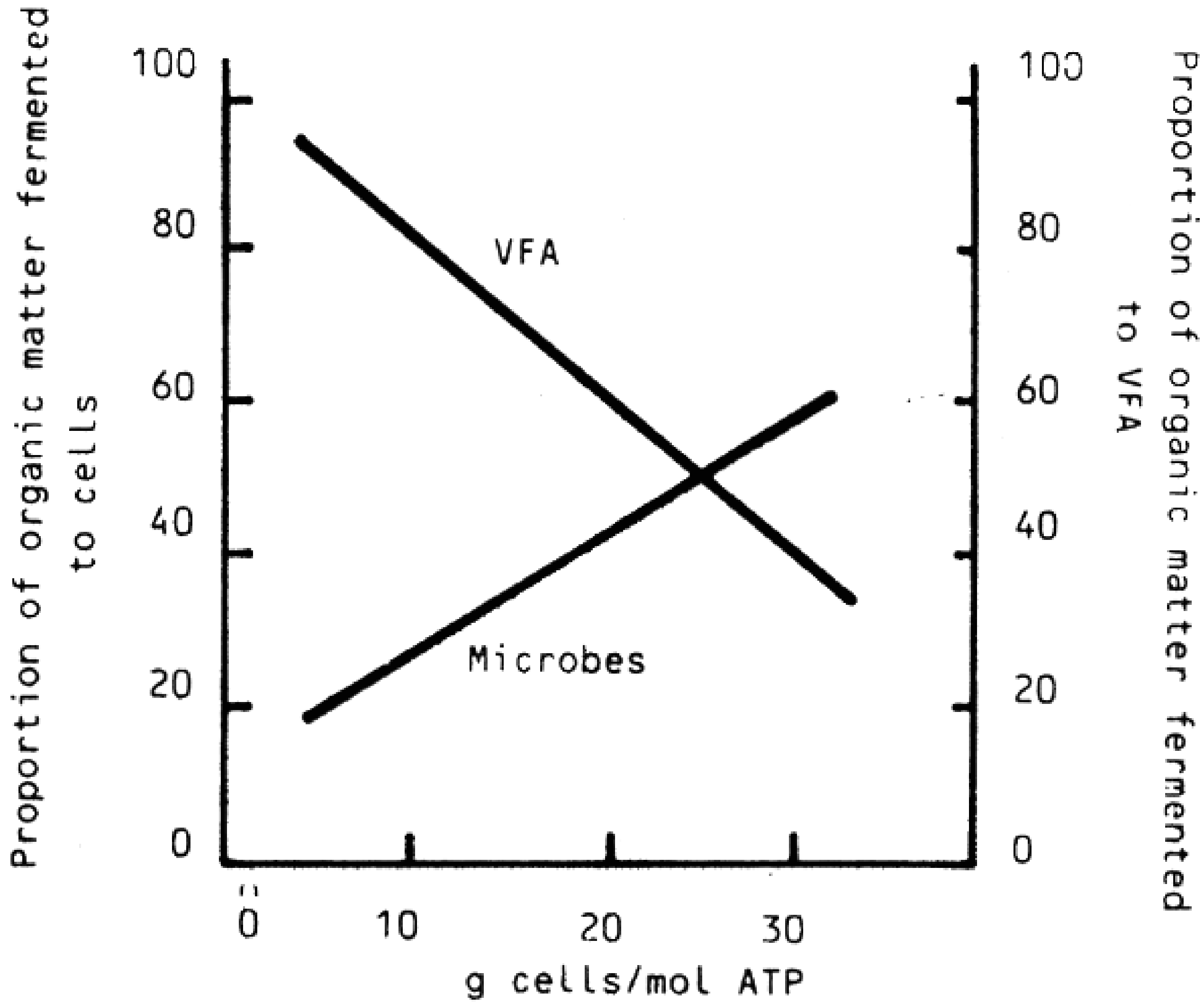
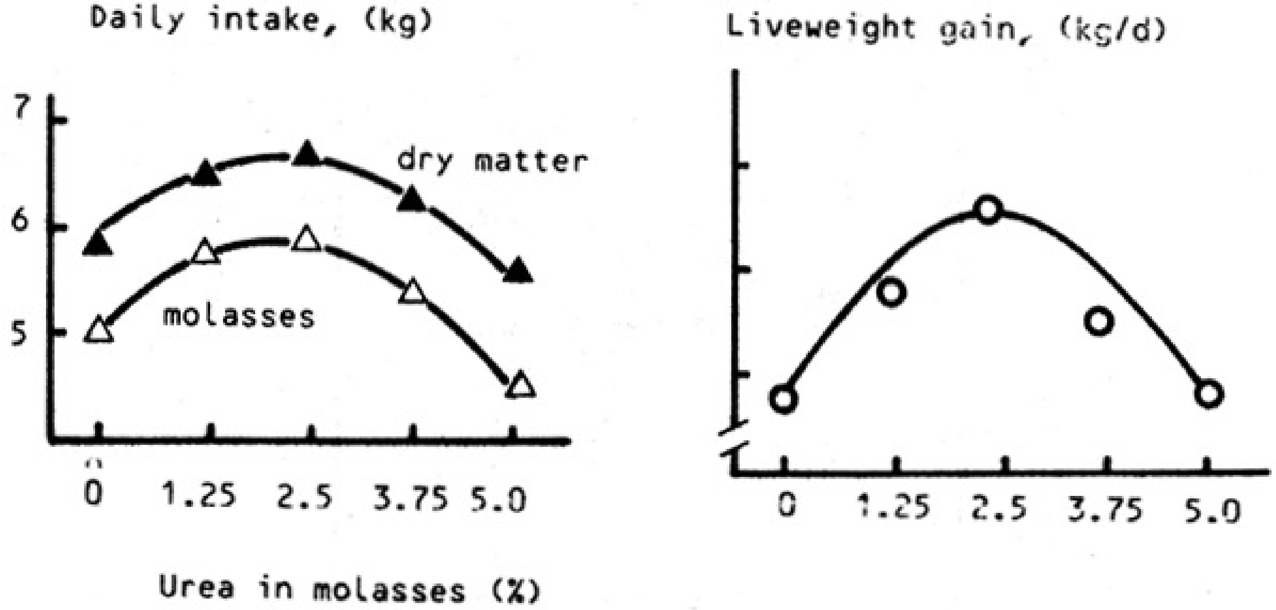
Figure 1: The relationship between the efficiency of microbial growth (Y-ATP) and the proportion of the fermented organic matter that is converted to VFA, methane and carbon dioxide and that entering cellular growth (Leng, 1982)

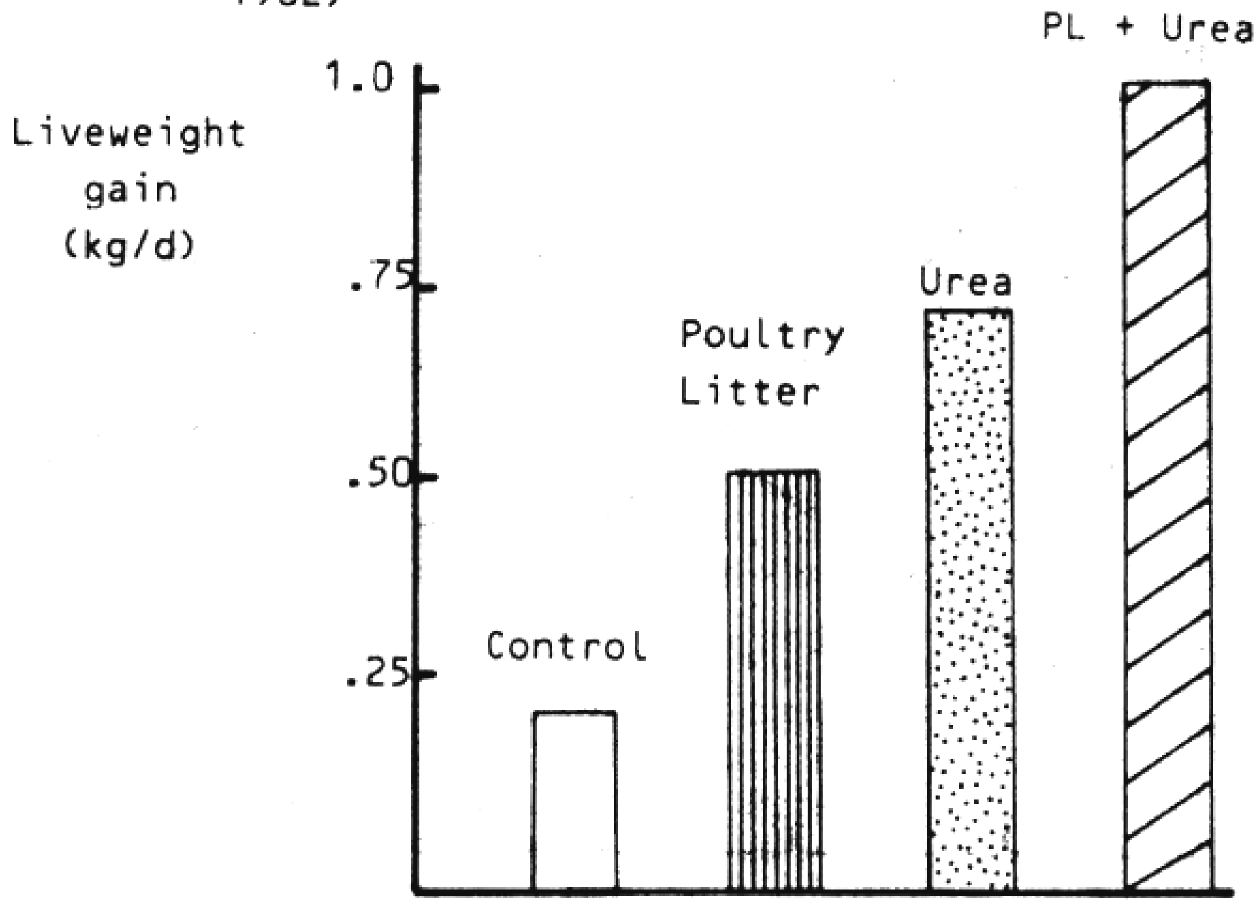


<u>Figure 2</u>: Effect of urea concentrations in molasses on daily intake of molasses and total dry matter and Liveweight gain (Yee Tong Wah <u>et al</u>., 1981)



<u>Figure 3</u>: In cattle fed on ad libitum molasses plus restricted cane tops and wheat bran (1 kg/d), urea as a fermentable N source increased production more than poultry litter but the two combined increased growth further (Meyreles and Preston, 1982)

1982)



<u>Figure 4</u>: The effects of adding fishmeal to a molasses based diet given to cattle, on liveweight gain and food conversion efficiency (Preston and Willis, 1974)

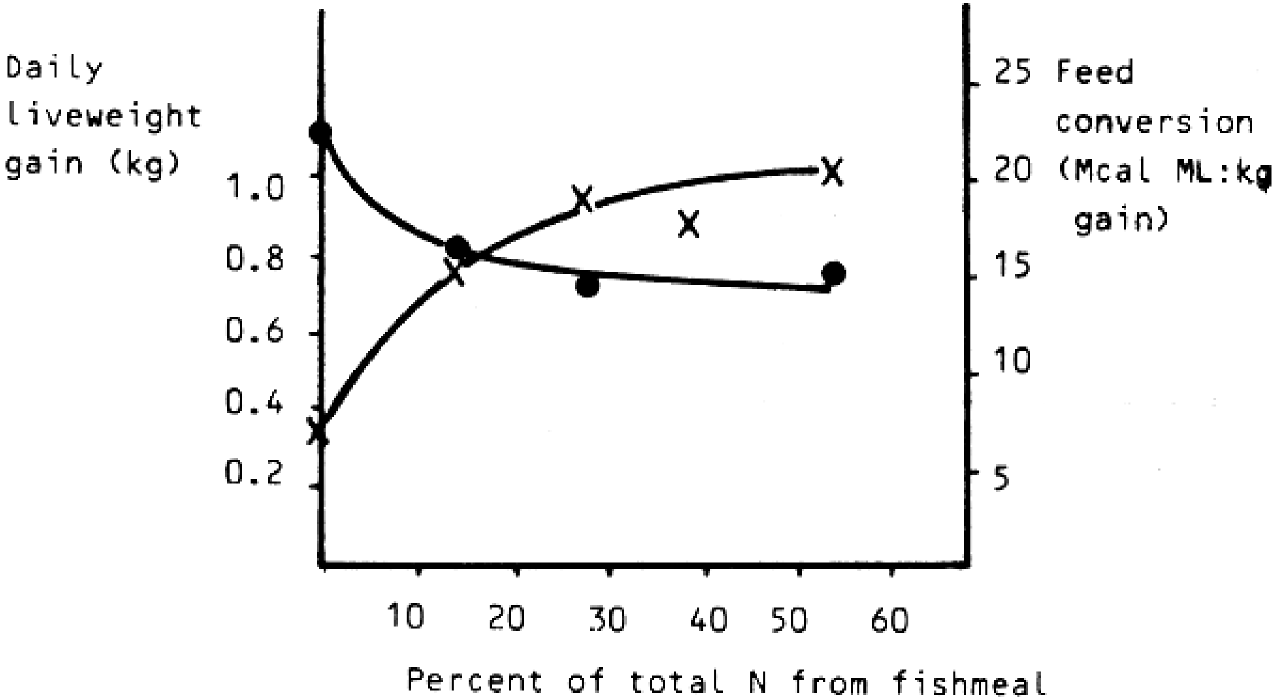


Figure 5: Effects of replacing maize with molasses on the pattern of rumen fermentation and milk yield of Holstein cows (Clark et al., 1972)

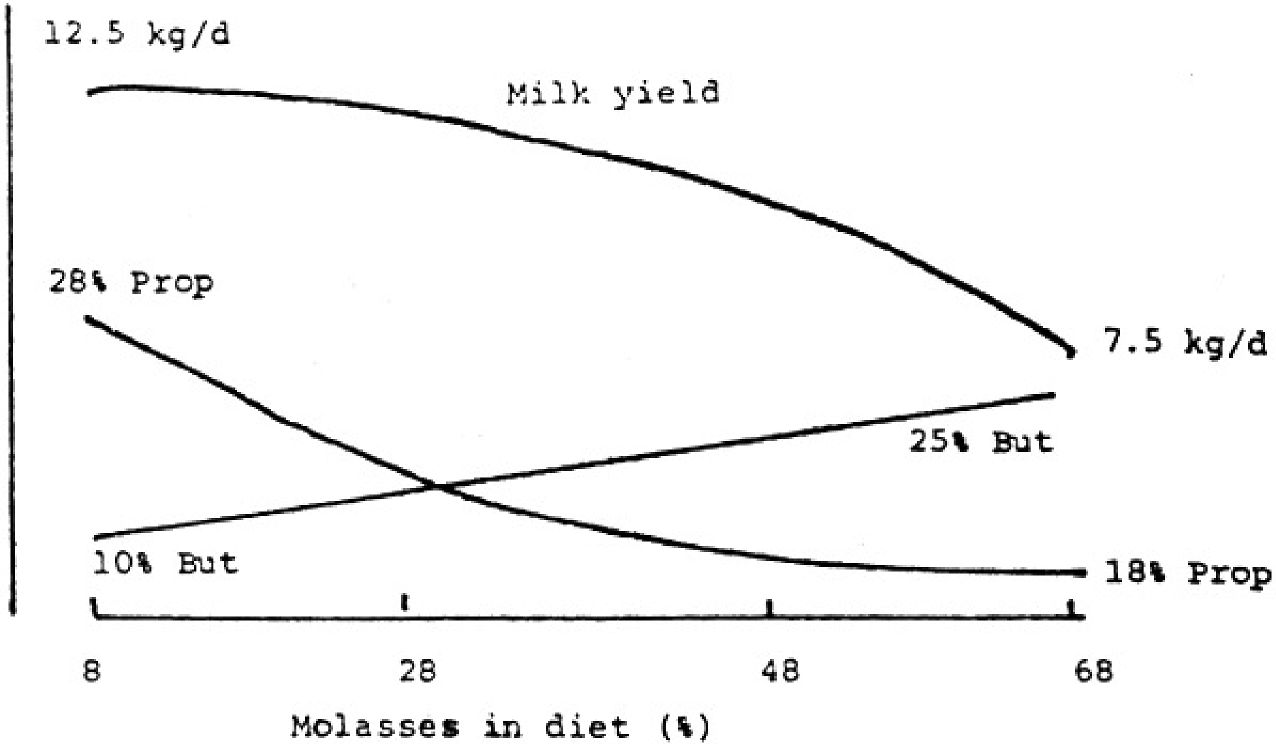
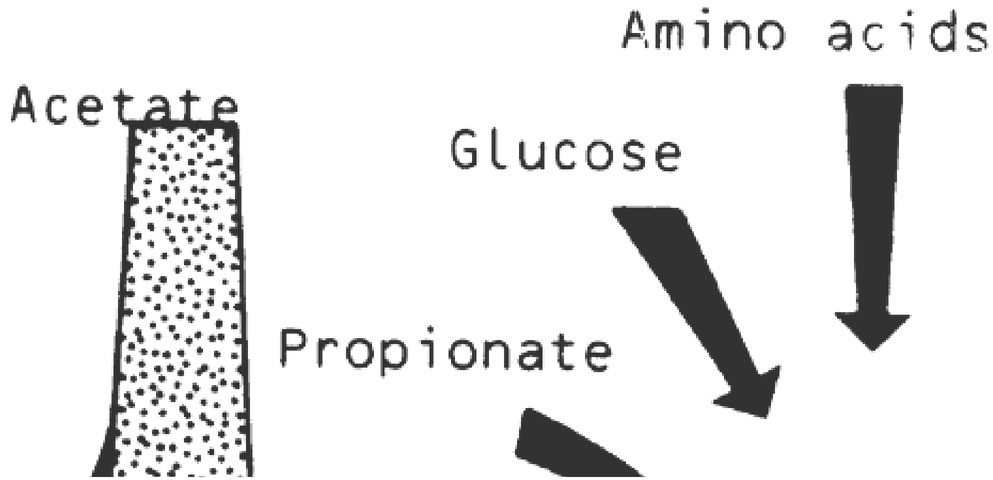


Figure 6: Diagram of the relationships between availability of glucogenic precursors and pattern of acetate utilization (from Oldham, 1983)



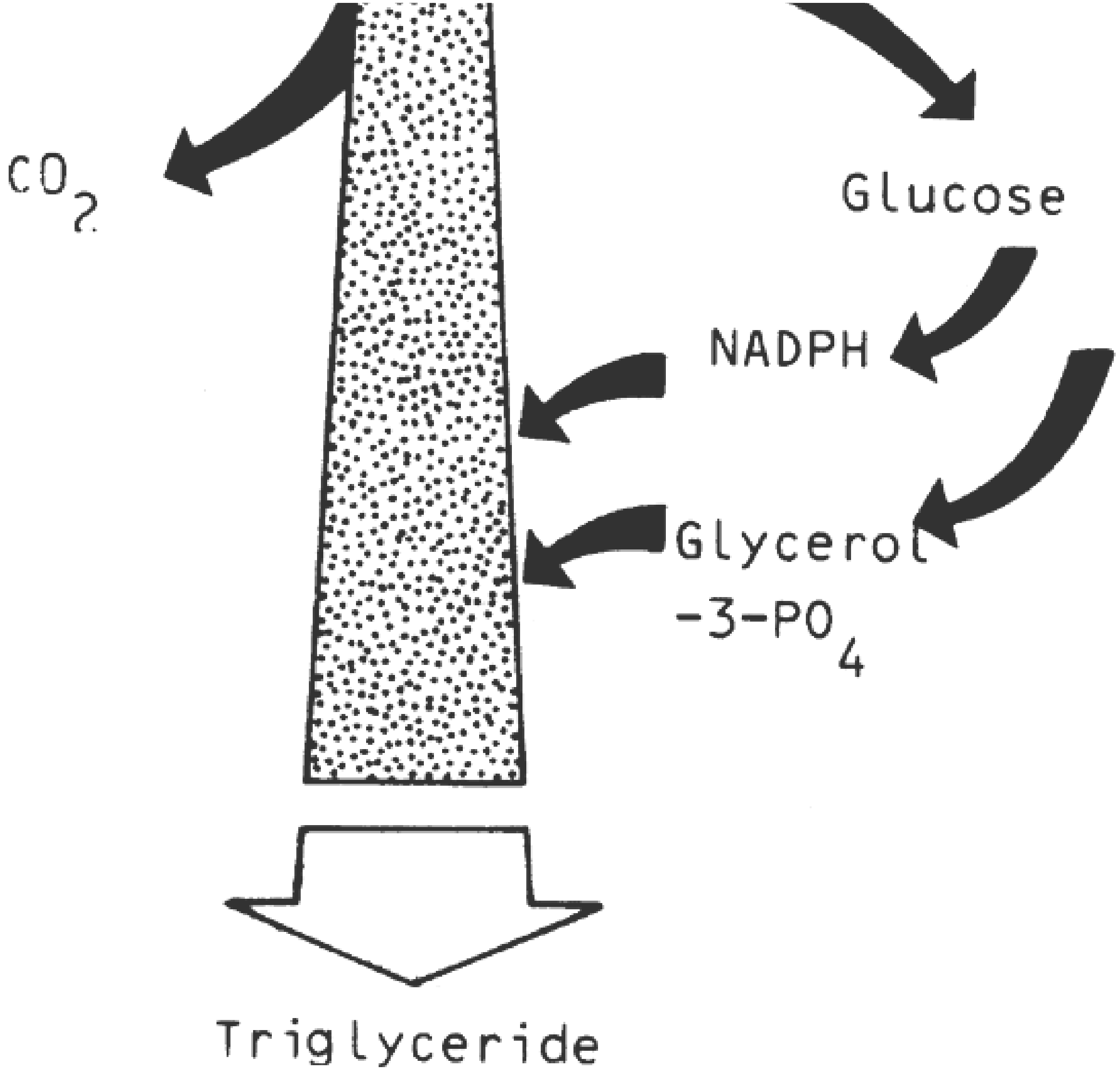
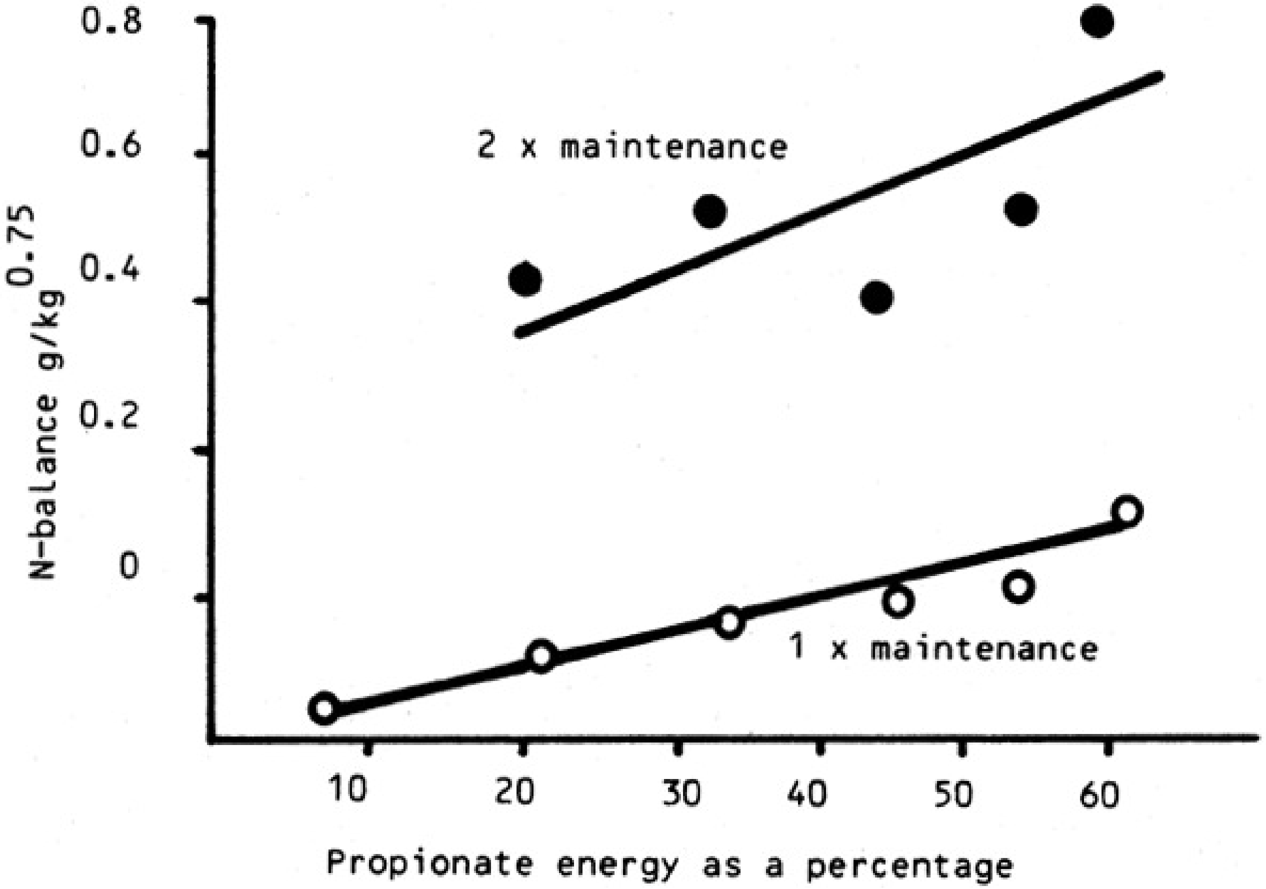


Figure 7: Relationship between proportion of glucogenic energy in the mixture of VFA infused into the rumen of sheep and the N retention (Preston and Leng, 1985 - adapted from Orskov et al., 1979)



<u>Figure 8</u>: Relationship between the molar proportion of propionic acid in the rumen VFA and the efficiency with which metabolizable energy consumed above maintenance is used for tissue synthesis (Preston and Leng, 1979; adapted from Blaxter, 1962)

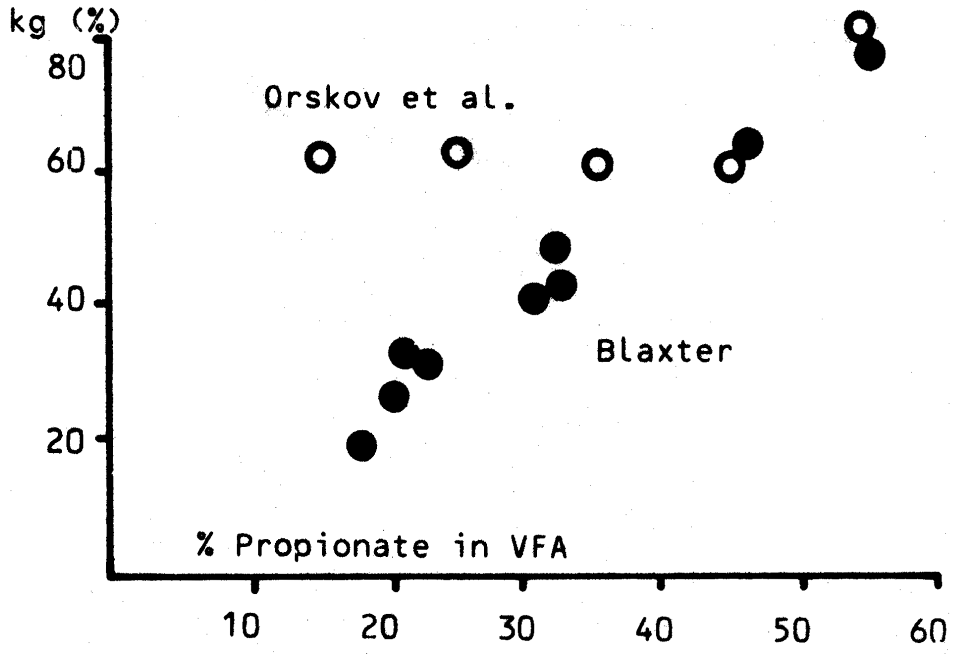
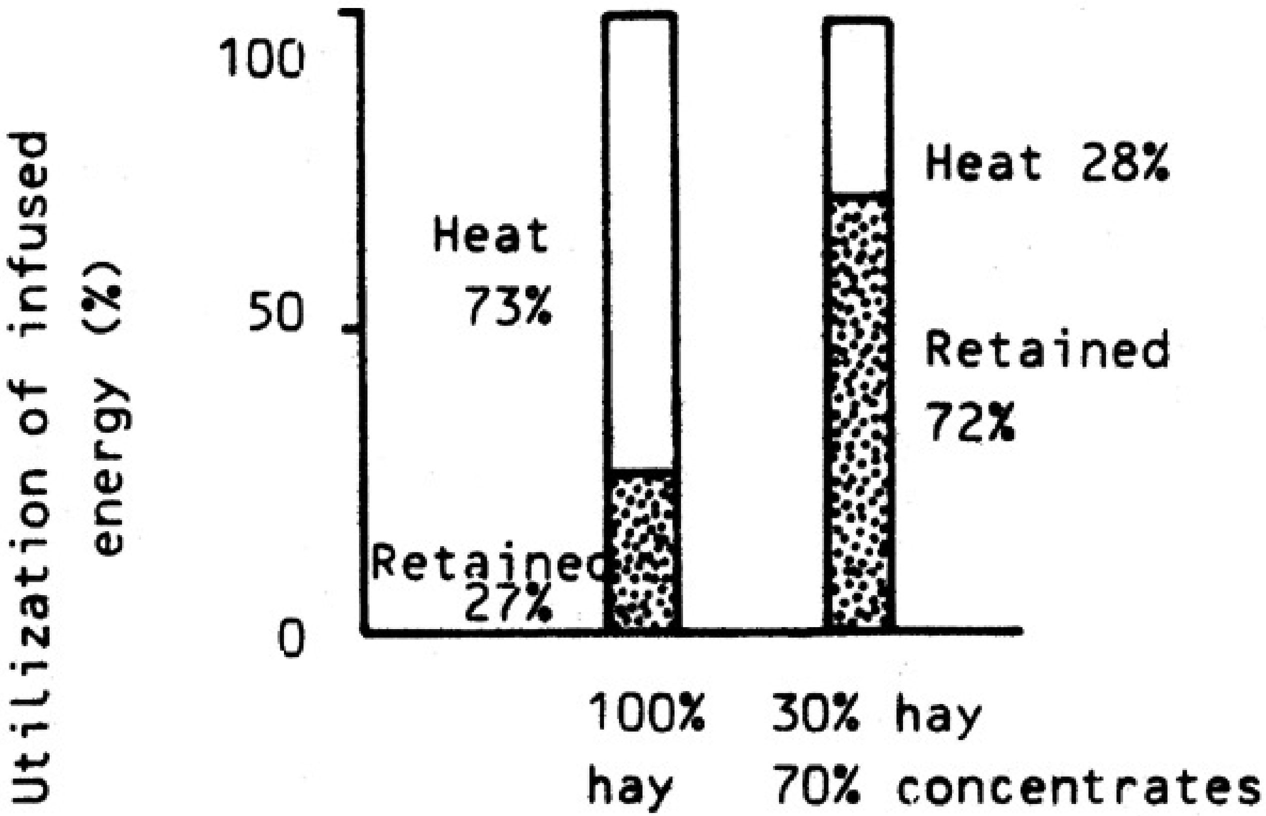


Figure 9: Effect of the basal diet on the efficiency of utilization of acetic acid infused into the rumen of cattle. The highest retention of energy was on the diet rich in glucose precursors (Preston and Leng, 1984 adapted from Tyrell et al. 1979)



<u>Figure 10</u>: Effects of supplementation with rice polishings on growth rates of Zebu bulls on a basal diet of whole sugarcane that had been chopped or de-rinded (Preston et al., 1979)

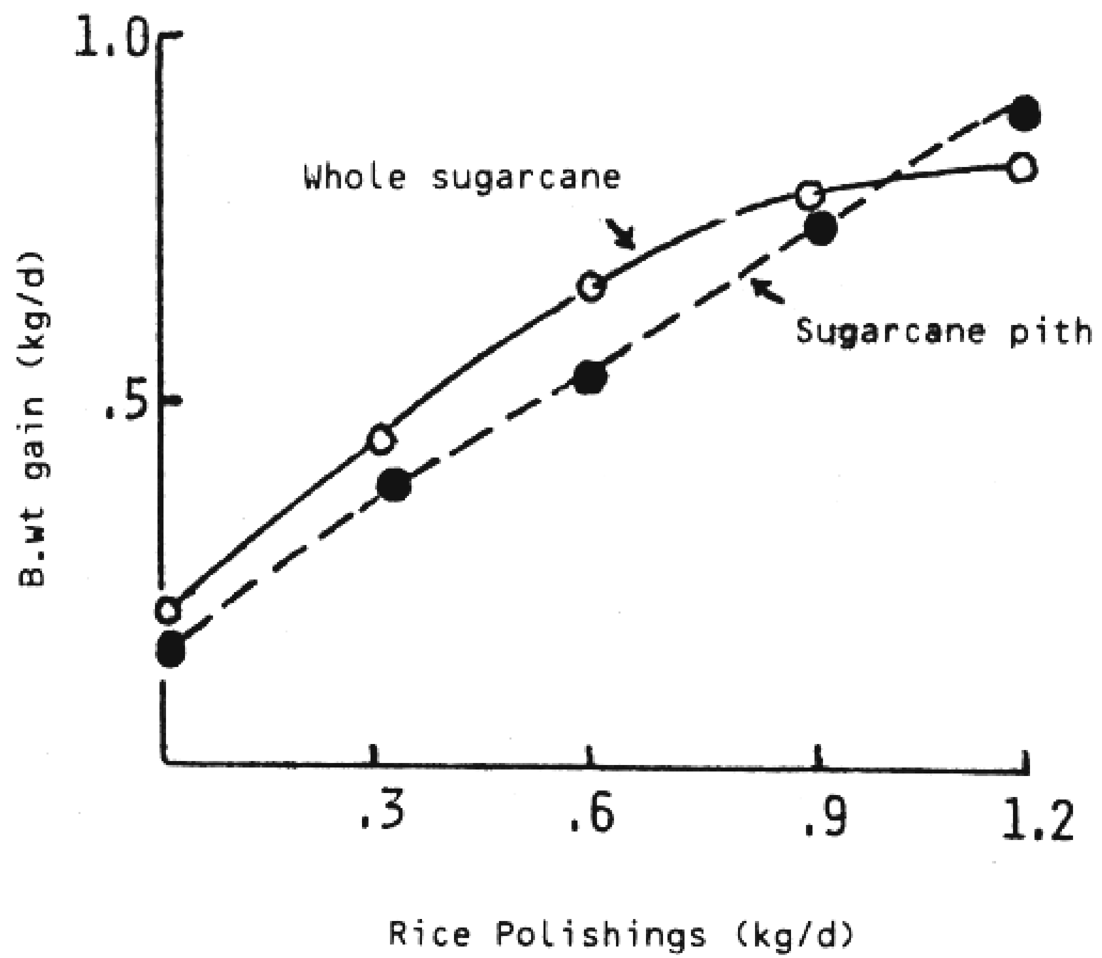


Table 1: Dynamics of protozoa in the rumen of sheep and cattle given a variety of diets

Animals (no. in brackets)		Major protozoal species	Rumen fluid t 1/2	Protozoa			
				(t 1/2) (min)	Pool size (g N)	A.Prod.rate (g N/d)	Lysis rate (%)
Sheep	(6)	Entodinia	492	846	2.5	2.0	65
Sheep1	(2)	Entodinia	542	832	1.8	2.2	-

Sheep[1]	(2)	Polyplastron	542	1 362	1.5	1.1	-
Cattle[2]	(7)	a) Entodinia	618	990	19.7	20.3	84
Cattle[2]	(7)	b) Entodinia	414	1 068	21.8	19.7	64
		plus some					
		Holotrichs					
Cattle[3]	(3)	Isotricha (80%) Dasytricha (20)	465	12 240	32.0	2.8	-
Cattle[4]	(6)	Dasytricha (50%) Isotricha	373	1 982	17.0	7.5	70

1 Sheep were given 720 g oaten chaff, 80 g Lucerne and 100 g molasses (Leng, 1982b)

2 Cattle were given (a) 65 g molasses, 35 g forage; or(b) 65 g forage, 35 molasses (Ffoulkes and Leng, 1985)

3 Cattle were given sugarcane based diets (Leng et al., 1981)

4 Cattle were given ryegrass pasture, freshly cut (Leng et al., 1984b).

Table 2: A comparison of post-ruminal flows of non-ammonia-N (NAN) in faunated and defaunated sheep (from Bird and Leng, 1985)

Diet[1]	Nitrogen (intake) (g/d)	No. of animals	Site of measurement	N-compound	Faunated sheep (g/d)	Defaunated sheep (g/d)
1[a]	25	2	Abomasum	Total NAN	18.3	21.3
				Bacterial - N	12.0	14.0

1[b]	33/24[2]	2	Abomasum	Total NAN	29.4	31.7
				Bacterial - N	18.0	19.3
2	25	5	Abomasum	Total NAN	18.0	19.3
				Microbial - N	14.7	16.7
3	21/20[2]	4	Abomasum	Total NAN	17.0	24.8
				Microbial - N	15.4	19.2
4	25	3	Duodenum	Total -N	19.0[a]	22.0[b]
				Microbial - N	11.8	15.0
5	14/13[2]	3	Duodenum	Total NAN	15.6[a]	17.4[b]
6	23/22[2]	6	Duodenum	Total NAN	23.4[a]	32.8[b]
				Microbial - N	15.3	18.1

ab: Values with different superscripts significantly different atp <0.05.

2 The two values represent average nitrogen intake (g/d) in fauntedand defaunted sheep respectively.

1 Diets:	1)	Lindsay & Hogan (1972):	a) 1 000 g lucerne hay.
			b) 1 000 g red clover.
	2	Bird (1982):	430 g oaten chaff, 430 g sugar,

			35 g fish meal
	3	ICI/UNE (1980) Unpubl:	720 g oaten chaff, 100 g casein,
			80 g lucerne, 100 g molasses
	4	Rowe et al. (1981):	500 g hay (medium quality),
			225 g oats, 115 g sugar, 70 g
			fishmeal, 30 g urea.
	5	Veira, Ivan & Jui (1983):	Corn silage (48%), shelled
			corn (47%), 1% urea, 4% mineral
			mix.
	6	Ushida et al. (1984):	Lucerne hay 67%, barley 30%,
			wheat straw 3%.

Table 3: The effects of defaunation of cattle on VFA proportions in rumen fluid and on feed intake, growth and feed conversion ratio (from Bird and Leng, 1978) Each value is the mean ±SE of nine animals. Each animal in Groups A and B were consuming approximately 3.3 kg molasses mixture and 1.5 kg cereal hay. Animals in Groups C and D were each consuming approximately 3.7 kg molasses, 1.5 kg cereal hay and 240 g protein pellets.

Group	**Initial liveweight (kg)**	**No. of protozoa in rumen fluid [1] (10^{-5}/ml)**	**% VFA in rumen fluid as**				**Mean dry matter intake (DMI) (kg/d)**	**Mean growth rate (g/d)**	**Feed conversion ratio (g DMI/g growth)**
			Acet.	**Prop.**	**But.**	**Others**			
A	177 ± 9	2.6	55	17	24	4	3.76	451 ± 93)	8.3
B	178 ± 10	-	50	17	30	3	3.65	490 ± 59)NS)	7.4
C	176 ± 12	1.7	60	15	21	4	4.15	530 ±	7.8

C	176 ± 12	1.7	60	15	21	4	4.15	61))[2]	7.8
D	185 ± 10	-	49	14	32	5	4.23	757 ± 61) [2]	5.6

NS - not significant;

2 significant at P <0.05

1 The mean numbers of the protozoal species present/ml were as follows for groups A and Crespectively:

Isotricha spp. 2.7×10^4 and 2.5×10^4;

Polyplastron spp. 6.7×10^3 and 8.0×10^3;

Epidinium spp. 2.3×10^4 and 2.2×10^4.

Entodinium spp. 2.0×10^5 and 1.2×10^5.

Four samples of rumen fluid were taken from all cattle over the experimental period and theresults were averaged for each animal and then for each group.

Table 4: The approximate effects of site of digestion of a protein meal, VFA produced and protein to energy (P/E) ratio (g protein/MJ VFA energy). The example is based on a steer consuming daily 4 kg fermentable carbohydrate (Leng, 1982) and supplemented with urea and 0.5 kg fishmeal

Site of digestion of fishmeal	VFA energy (MJ)	Micro. prot. (g)	Diet. prot. (g)	Total prot. (g)	P/E ratio (g/MJ)

100% rumen	36	910	0	910	25
66% intestines/33% rumen	34	890	200	1 090	32
100% intestines	34	800	300	1 100	32

Table 5: Approximate pattern of VFA production in ruminants on sugar based diets

Diet	**Proportion (%) of VFA as**		
	Acetate	**Propionate**	**Butyrate**
Molasses	55	15	30
Sugarcane stalk	72	18	10
Sugarcane juice	66	22	20
Grain	55	35	10

Table 6: Efficiency of utilization of metabolizable energy for fattening cattle (kf) according to the nature of the ingredients in the diet. The ration combinations containing maize grain and clover forage were used more efficiently than those containing barley grain or ryegrass forage (Thomson, 1978)

Forage/grain[1]	**Energetic efficiency (kf%)**
Ryegrass + barley	36
Ryegrass + maize	42
Clover + barley	44
Clover + maize	50

Table 7: The effects of bypass protein (fishmeal) and glucogenic energy (glucose infused into the abomasum) on feed intake, growth rate and feed conversion in lambs fed a basal diet of sugar/oat chaff (rumen fermentable carbohydrate) (Economides, S. and Leng, R.A., unpublished data)

Fishmeal	**(%)**	**0**	**6**	**0**	**6**
Glucose	**(g/d)**	**0**[1]	**0**[1]	**80**	**80**
Feed intake	(g/d)	890	1 140	770	1 070

Liveweight gain	(g/d)	100	200	130	260
Feed conversion	(g/g)	8.9	5.7	5.9	4.1

1 Infusion of 0.9% NaCl

Table 8: Suggested constraints to the utilization of cane tops in diets for cattle and the means of overcoming these

Constraint	Solution
Low digestibility	Treat with alkali to increase digestibility.
Low fermentable N	Add urea at 2% DM.
Low bypass protein)	Supplement with a bypass protein
Low dietary fat)	source containing lipid (oil seed cake).
Low glucogenic potential from	a) Manipulate rumen (monensin) and
fermentation end products	b) Feed bypass starch (rice and maize grain).
Low dietary fat	Supplement with brans, polishings or oil seed meals.
Poor quality forage fibre	Supplement with green legume or young grass.
Low minerals	Add all minerals particularly S.

LIMITACIONES A UNA UTILIZACION EFICIENTE DE LA CAÑA DE AZUCAR Y SUS SUBPRODUCTOS EN LA ALIMENTACION DE RUMIANTES DE GRAN TAMAÑO

por

R.A. Leng y T.R. Preston

La caña y sus subproductos se utilizan ampliamente en la alimentación de los rumiantes, pero para obtener buenos resultados se requiere una suplementación equilibrada.

Los criterios de la suplementación son los siguientes:

1. **Establecer un ecosistema eficiente en el rumen;**
2. **Equilibrar los nutrientes absorbidos con nutrientes alimenticios para satisfacer las necesidades de producción.**

Para satisfacer el primer criterio, se deben suministrar al ganado los componentes siguientes:

a. **N fermentable a fin de optimizar la concentración de amoníaco en el rumen (por ejemplo, urea);**

b. **Cofactores para el ecosistema microbiano del rumen (por ejemplo, proteínas relativamente insolubles para proporcionar aminoácidos; péptidos y gallinaza para proporcionar cofactores);**

c. **Forraje de buena calidad para mantener un buen tránsito de sustancias digeridas y estimular la mezcla del contenido del rumen;**

d. **Agentes químicos o naturales para manipular los microbios del rumen a fin de obtener una elevada relación proteínas/energía en los productos de digestión fermentativa.**

El criterio 2 puede satisfacerse administrando a los animales nutrientes sobrepasantes. La calidad y la cantidad dependé del nivel y el tipo de producción (por ejemplo, proteína sobrepasante de harina de pescado, almidón sobrepasante de maíz, grasa sobrepasante de ambos).

Se hace hincapié en las necesidades de aminoácidos esenciales y precursores de glucosa superiores a los proporcionados por un ecosistema eficiente del rumen. La suplementación

con una fuente de ácidos grasos de cadena larga es esencial y puede afectar considerablemente a la cantidad de glucosa efectivamente necesitada por el animal.

FRACTIONATION OF SUGARCANE FOR FEED AND FUEL

by

T.R. Preston

INTRODUCTION

When commercial production of sugar first began, the crop produced food for people, the fuel needed for processing and the feed for the animals used to transport the cane to the mill. Sugarcane processing remains a unique industry in not requiring exogenous sources of fuel, irrespective of whether the technology employed is industrial (crystalline sugar) or artisanal ("panela" or "gur"). The mules and oxen still used in many countries for hauling cane to the mill traditionally have been fed on the tops of the cane, the molasses and scums.

FRACTIONATION OF SUGARCANE

The extremely low fermentability of sugarcane fibre and the negative effect this had on voluntary intake of the overall diet was the reason for developing methods so that the juice and the residual fibre/sugar in the pressed stalk could be treated as separate entities.

This new approach to utilization of sugarcane for livestock feeding and fuel production was first developed in Mexico (Preston, 1980). The aim was to achieve only a partial extraction of the juice using simple low-cost cane crushers, of the kind developed for "panela" and "gur" production. This reduced the investment in machinery and the energy cost of milling (the stalk is passed only once through the crusher).

The justification for this system is that the juice carbohydrates (sucrose, glucose and fructose) are completely digestible by both ruminant and non-ruminant livestock and are thus viable alternatives for the starch in cereal grains. The tops of the cane and even the bagasse, which still contain appreciable amounts of sugars in the residual juice, have a potential digestibility of between 50 and 60 percent, and if adequately supplemented with fermentable nitrogen (urea or ammonia) have a nutritive value similar to Elephant grass. The bagasse can also be converted into charcoal (Ffoulkes et al., 1980) or producer gas (A. Lindgren, personal communication) or can be burned directly. It can also be fed to small ruminants which are able to select the sugar-rich pith, leaving the lignified rind as a source of fuel.

Sugarcane juice for ruminants

The fermentable carbohydrates in both sugarcane juice and molasses are sucrose, glucose and fructose. Molasses is the soluble residue after extraction of the sucrose from cane juice. Compared with cane juice, molasses is therefore richer in minerals, organic acids and other plant solubles.

Diets based on cane juice support much higher levels of animal productivity as compared to those based on molasses. The rates of growth and feed conversion efficiency recorded in studies with crossbred and zebu cattle in Mexico (Mena, 1986) are comparable with those recorded in intensive grain-based systems. Rumen microbial growth appears to be highly

efficient on cane juice diets since the zebu cattle grew at 800 g per day on a minimum protein intake (5 percent protein in the diet dry matter supplied from leucaena) with the fermentable N provided by aqueous ammonia. This is in contrast to the average grain-based feeding system where at least 12 percent of the diet dry matter is protein.

It appears that on a cane juice diet, the end-products of rumen fermentation are well balanced and therefore support high animal productivity, much more than any other low-N diet. This indicates the extremely efficient microbial growth which must have supplied an almost ideal protein/energy ratio for production with minimum supplementation. Two observations on cane juice feeding should be emphasized, as they relate closely to the concepts underlying appropriate use of sugar-rich feeds by ruminants (Leng and Preston, 1986):

- **Proprionate levels in the rumen were over 20 percent of the total VFA, considerably higher than on a molasses diet (Figure 1). Thus the glucogenic status of a diet of cane juice may be adequate for high growth rates.**

- **Protozoal biomass in the rumen was lower in animals fed cane juice than in those fed molasses (D. Harrison, personal communication) which will enhance the protein:energy ratio in the nutrients arising from rumen digestion.**

Sugarcane juice for monogastric animals

The most appropriate commercial application for sugarcane juice is as the basis of a feeding system for monogastric animals. Traditionally in tropical countries these species have been managed as scavengers. When more intensive systems were introduced, imported cereal grains were the principal feed resources, thus competing directly with humans for food.

Sugarcane juice for pigs:

The research underlying the feeding of cane juice as the only carbohydrate source for pigs was initiated in Mexico and extended in the Dominican Republic where it has become the basis of commercial pig feeding systems on both large and small farms (Mena, 1986).

Cane juice has been shown to be a satisfactory carbohydrate source for all classes of pigs; however, its commercial usage is mostly in the finishing stage from 30 to 95 kg liveweight. Usually a commercial protein supplement (40 percent protein), fed on a restricted scale, provides all the amino acid needs; and the juice is given ad libitum.

Interesting developments (Mena, 1986), which promise to reduce feed costs, are that:

- **protein levels in the finishing stage can be reduced to as low as 5 percent of the diet dry matter without apparently affecting performance**
- **protein-rich foliages from cassava and sweet potato can replace at least 25 percent of the protein in the supplement**
- **when cane juice is fed during pregnancy, birthweights and vigour in the newborn are increased.**

Sugarcane juice for poultry:

Developments in the use of sugarcane juice as a grain substitute in poultry diets are still in the early stages; however, the preliminary findings are encouraging. Broilers in the finishing stage (from 1 to 2 kg liveweight) readily consume cane juice fed alone or dissolved in the drinking water. In the latter system the maximum rate of substitution was about 15–20 percent of the diet dry matter, possibly because additional drinking water was not provided and the birds became dehydrated (J. Montilla, personal communication).

Providing the juice and a protein supplement (39 percent protein) in separate feeders, both on a free choice basis, appears to be a more practical method. In this system, cereal grain is not fed but water is freely available. In a preliminary trial (Mena, 1986), intake of juice accounted for some 60 percent of total dry matter intake and performance levels were encouraging. Results from ongoing experiments in Colombia indicate that growth and feed conversion rates are only marginally inferior to those recorded on a conventional cereal-based diet (L. Possada and T.R. Preston, unpublished data).

Utilization of the residual pressed cane stalk

The maximum economic benefit from the use of sugarcane juice for livestock feeding will only be realized if technologies are developed to use the residual pressed stalk. The options being pursued for the use of this material include:

- **feeding to large ruminants, especially draught animals**
- **feeding to small ruminants (sheep and goats) in a way that will permit a high degree of selection (e.g. by giving 200 percent of the normal dry matter intake)**
- **production of charcoal**
- **conversion to producer gas as a substitute for diesel fuel.**

Converting the pressed cane stalk into a suitable material for gasifying requires sundrying to 80 percent dry matter and chipping into particules of 10–20 mm. A gasifier has been designed with specific characteristics to use dried sugarcane chips (A. Lindgren, personal communication). Making charcoal from pressed cane stalk is simple but requires briquetting to produce a readily saleable product (Ffoulkes et al., 1980).

A highly promising development is the use of the pressed (extracted) cane stalk as a basal diet

for small ruminants. If the freshly pressed stalk is offered to goats, they consume avidly the sugar-rich pith and discard the lignified rind. In studies in the Dominican Republic goats on a mixed diet of pressed stalk and fresh gliricidia foliage selected and apparently preferred the pith to the green foliage (A. Mena, unpublished data).

EQUIPMENT FOR CANE FRACTIONATION

The juice is extracted from the sugarcane in a simple three-roll press, or mill, of the kind employed in the "gur" and "panela" industry. Extraction rates (expressed as weight of raw juice as percentage of weight of cane stalk) vary from 45 to 55 percent, depending on the construction of the press and the setting of the rollers. This is less than the current norms of producers of "panela" who regularly report extraction rates of between 60 and 65 percent. The difference can be explained in part by the fact that in "panela" manufacture, the residual bagasse is used as fuel for the boilers, while when cane is pressed for animal feed, the bagasse can be used as forage for ruminants, thus there is not the same economic pressure to maximize juice extraction, since the residual sugar in the bagasse increases its feed value.

ECONOMICS OF CANE FRACTIONATION

The economics of using sugarcane juice for feed and fuel production depend on the relative opportunity costs of cereal grain, sugarcane, protein supplements and labour. In most countries where sugarcane is (or can be) grown, cereal grain for animal feed purposes usually has to be imported (requires hard currency!) and the price is usually in the range of US$150 to 200/tonne. The opportunity price of sugarcane depends on many factors, among them:

- **Is there an alternative market for the cane (e.g. a nearby sugar mill) and what is the transport cost?**

- **Is the country a sugar exporter, and to which market (e.g. EEC or free world market)?**
- **What is the opportunity value of the residual cane tops and bagasse?**

Present prices in Colombia can be used as an example of the calculations that must be made. The opportunity price for sugarcane standing in the field is US$ 13.00/tonne for a contract with a sugar mill and US$ 10.00/tonne (no contract) when the buyer is a manufacturer of “panela”. The buyer in both cases assumes the cost of harvesting and transport to the mill. The cost of unskilled labour (minimum wage) is US$ 3.00/8-hour day which becomes US$ 4.50/day when social benefits are included; and the harvesting, transport (by mule) and processing (feeding the cane into the mill and forage chopper) require one work day (8 hr) per tonne of cane. Thus the products from one tonne of stalk cane (500 kg of juice, 500 kg of bagasse and 250 kg of cane tops) will cost US$ 17.20 assuming the opportunity cost of the cane stalk is the price paid by the factory.

If no use is made of the residual forage (bagasse and tops) then the price of the juice will be US$ 36.78/tonne fresh basis (equivalent to US$ 166.00/tonne grain of 10 percent moisture). On the other hand, if it is assumed that the residual forage from the sugarcane after juice extraction (bagasse plus tops) is fed to cattle and that its feeding value is half that of a forage crop such as Elephant grass then the cost of the juice falls to US$ 15.33/tonne fresh basis (US$ 69.00/tonne grain equivalent).

The basis for these calculations is that Elephant grass grown for forage produces 24 tonnes dry matter/ha/yr and contains 17 percent dry matter. The opportunity price of the Elephant grass standing in the field is the same as for a crop of cane (i.e. 100 tonnes cane stalk × US$ 13.00/tonne = US$ 1 278.00). Harvesting costs for Elephant grass are almost twice those of cane due to the lower dry matter content (17 percent versus 30 percent). Thus the final cost is US$ 77.60/tonne dry matter harvested and chopped ready for feeding.

The present Government-supported price for sorghum grain is US$ 189.00/tonne and the price of soybean meal is US$ 432.23/tonne. Indicative levels of protein are assumed to be (dry matter basis) 15 percent for a cereal-based diet and 11 percent for a cane juice diet. On this basis the comparative costs of pig rations based on grain or cane juice are likely to be those shown in Table 1. Obviously, the economic feasibility of using sugarcane juice as a substitute for cereal grain is highly dependent on integrating the pig poultry enterprises with either ruminant livestock and/or fuel production, so as to make effective use of the bagasse and cane tops.

CONCLUSIONS

The severe pressure now being put on the traditional sugarcane industry because of competition from grain-based syrups and general overproduction throughout the world calls for imaginative action by producers to develop alternative uses for this high yielding crop. An option which is profitable and at the same time satisfies the present-day food and energy needs is the integrated production of livestock products and fuel in a confinement system which facilitates recycling of nutrients through biodigesters, ponds and crops. Figure 2 illustrates the potential of this approach.

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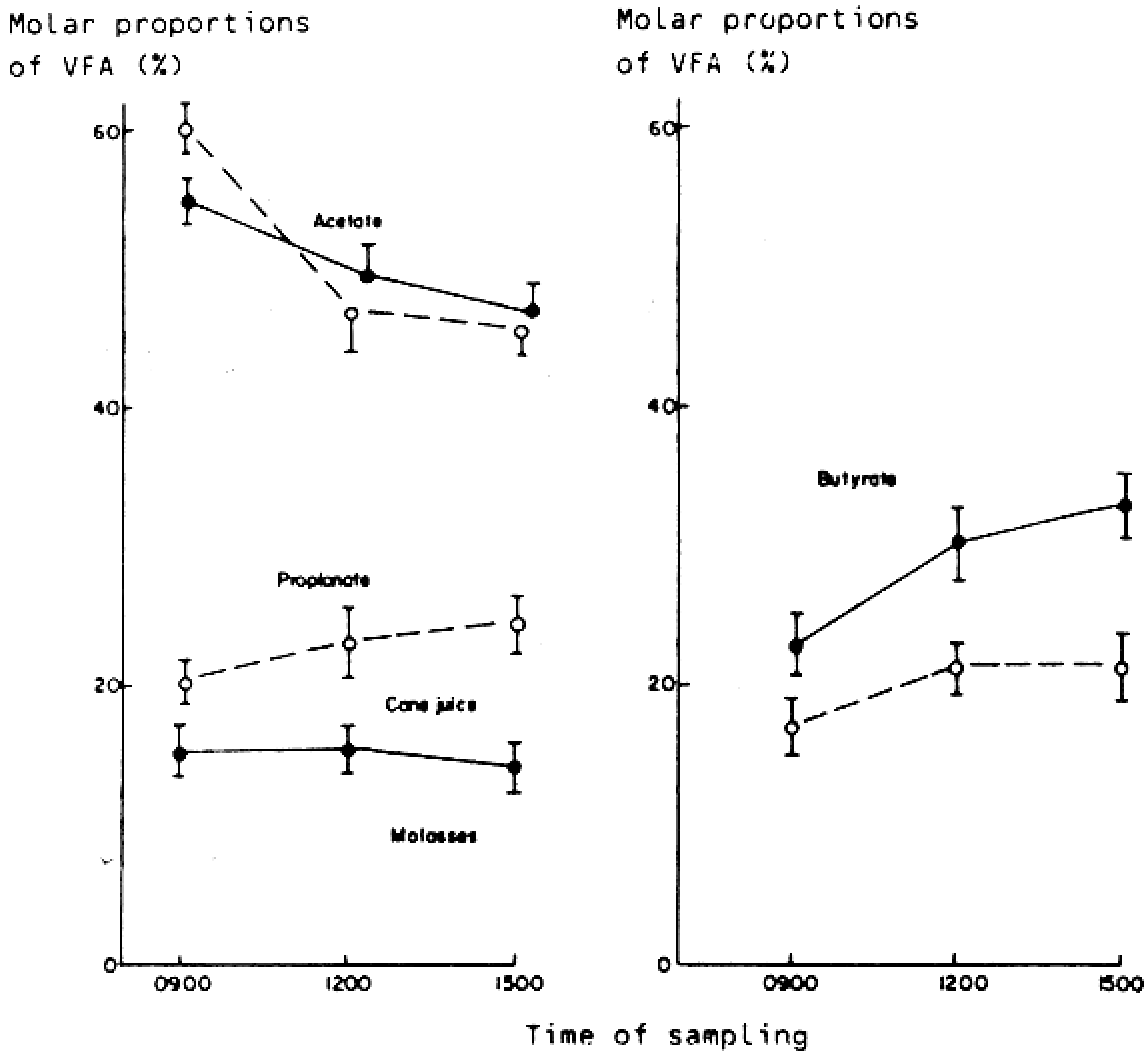
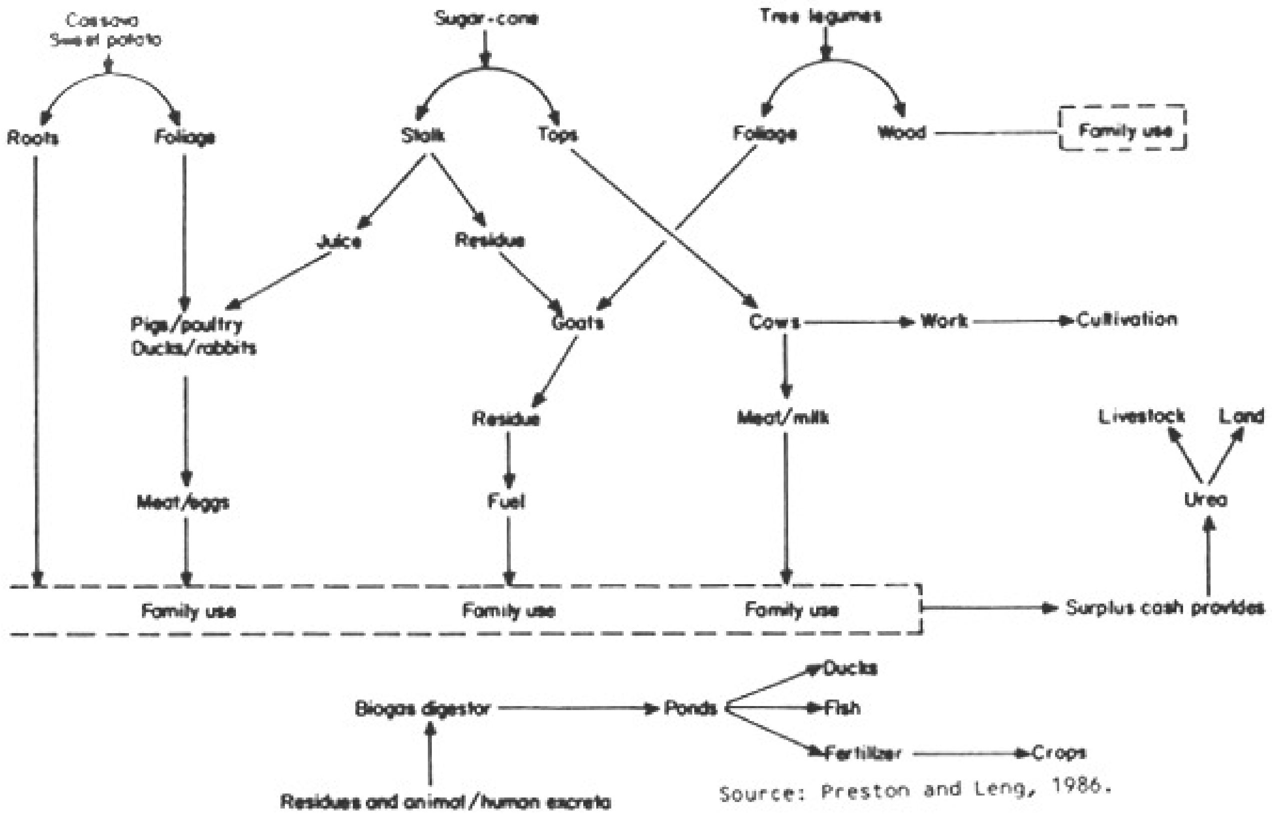
Figure 1: There were higher molar proportions of propionic acid and Lower proportions of butyric acid in rumen fluid of cattle fed sugarcane juice than with cattle fed molasses.



Source: Perez *et al.*, 1981.

<u>Figure 2</u>: Model which illustrates the potential productivity from a mixed farming system.



Source: Preston and Leng, 1986.

Table 1. Estimated cost for feeds for pigs based on cereal grain or sugarcane juice (T.R. Preston and R. Botero, unpublished data)

	Proportion of diet (%)		**Diet cost (US$/tonne)**
	Grain	**Soyabean meal**	
Grain diet	87	13	220.62
Cane juice diet*	78	22	224.19
Cane juice diet**	78	22	148.90

*** Assumes no use made of the residual bagasse/cane tops**

**** Assumes that the feeding value of the residual bagasse/tops is halfthat of Elephant grass (dry matter basis)**

FRACCIONAMIENTO DE LA CAÑA DE AZUCAR PARA SU UTILIZACION COMO PIENSO Y COMO COMBUSTIBLE

por
T.R. Preston

La fuerte presión a que se ve sometida actualmente la industria tradicional del azúcar por la competencia de jarabes a base de cereales y la superproducción mundial ha estimulado la búsqueda de otros usos para la caña de azúcar.

Una opción que satisface las necesidades actuales tanto alimentarias como de energía es la producción integrada de piensos y de combustible mediante el fraccionamiento del tallo de la caña para la obtención de jugo (pienso para toda clase de animales) y los residuos prensados (combustible y/o piensos para rumiantes).

El fraccionamiento de la caña puede hacerse en las prensas o molinos tradicionales (como los utilizados para la producción de panela y de gur), que en su nivel tecnológico más bajo pueden ser accionados por animales. Se están desarrollando máquinas para la doble función de extraer el jugo y picar los residuos.

El jugo de caña se utiliza en granjas pequeñas y grandes como base de los sistemas de alimentatación de los cerdos, y se ha demostrado que técnicamente es viable su utilización como base de las dietas de las aves de corral y los rumiantes.

La caña prensada se ha utilizado como componente principal de la dieta de pequeños rumiantes y animales de tiro. Puede convertirse fácilmente en carbón vegetal y gas pobre.

El fraccionamiento de una tonelada de tallos de caña rinde aproximadamente 500 kg de jugo (100 kg de sólidos solubles) y 500 kg de forraje (200 kg de materia seca), 35 kg de carbón vegetal o equivalente de gas pobre con un valor energético de 60 l de diesel. Además, los cogollos proporcionan 250 kg adicionales de forraje (75 kg de materia seca). Los precios de oportunidad de estos productos en la explotación son tales que el valor total de la planta fraccionada puede ser igual o superior al precio de los tallos de caña vendidos para su transformación y consumo como azúcar.

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