An evaluation of feeding liquid sugar to pigs lairaged overnight before slaughter

G.A. GARDNER and T.J.R. COOPER

Ulster Curers' Association, 2 Greenwood Avenue, Belfast BT4 3JL, N. Ireland

The automated Lairose system of feeding liquid sugar to pigs held overnight in lairage under factory conditions was found to increase the carcase yield and weight of liver. Carcase yields were increased by 0.79%/kg glucose and 1.28%/kg sucrose, and liver weights were increased by 0.26 kg liver/kg glucose and 0.39 kg liver/kg sucrose; thus for similar quantities of sugar, sucrose had 62% more effect than glucose in increasing carcase yield and was 50% more effective in increasing liver weight. Bacon yields were slightly but significantly lowered 0.58% by feeding glucose, but not sucrose.

Bewertung von der Fütterung mit Zuckerlösung von Schweinen, welche über Nacht im Stalle vor der Schlachtung bleiben müssen

G.A. GARDNER and T.J.R. COOPER

Ulster Curers' Association, 2 Greenwood Avenue, Belfast BT4 3JL, N. Ireland

Es wurde gefunden, dass das automatisierte Lairoseverfahren für die Fütterung mit Zuckerlösung von Schweinen, welche über Nacht im Stalle unter Betriebsverhältnissen bleiben müssen, eine Zunahme in der Körperausbeute sowie im Lebergewicht erwirkte. Die Körperausbeute erhöhte sich um 0,79%/kg Glukose und 1,28%/kg Sukrose, und die Lebergewichte erhöhten sich um 0,26 kg/kg Glukose und 0,39 kg/kg Sukrose; bei gleichen Mengen Zucker also war die durch Sukrose veranlasste Erhöhung der Ausbeute um 62% grösser und jene des Lebergewichts um 50% grösser. Die Fütterung mit Glukose verursachte eine schwache, jedoch signifikante Verringerung der Baconausbeute um 0,58%; dies war aber nicht der Fall bei Sukrose.

I.I

Evaluation de l'alimentation du sucre liquide aux porcs laissés pendant la nuit dans les cages avant l'abattage

G.A. GARDNER and T.J.R. COOPER

Ulster Curers' Association, 2 Greenwood Avenue, Belfast BT4 3JL, N. Ireland

On a constaté que le système automatisé Lairose d'alimenter du sucre liquide aux porcs laissés pendant la nuit dans les cages dans des conditions industrielles augmente le rendement anatomique ainsi que le poids du foie. Les rendements anatomiques ont augmenté de 0.79%/kg de glucose et 1.28%/kg de sucrose, et les poids de foie ont augmenté de 0.26 kg/kg de glucose et 0.39 kg/kg de sucrose; par conséquent, pour des quantités égales de sucre le sucrose a effectué une hausse du rendement anatomique plus importante de 62% que le glucose et une hausse du poids de foie plus importante de 50%. Les rendements de bacon ont subi une réduction faible, néanmoins significative de 0.58% par l'alimentation du glucose, mais non du sucrose.

Оценка свиней, накормленных перед убоем и убойным содержанием сахарным раствором.

Г.А.ГАРДНЕР и Т.Й.Р.КУПЕР
Ulster Curers' Association, 2 Greenwood Avenue, Belfast BT4 3JL, N. Ireland

Авторы определили, что при содержании свиней одну ночь перед убоем и кормлении их жидким сахаром автоматическим методом типа Lairose увеличивается анатомический выход, а также вес печени. В случае кормления глюкозой анатомический выход увеличивался на 0,75%, а при кормлении сахарозой - I,25%. Выход печени в случае глюкозы 0,26кг/кг, сахарозы - 0,39 кг/кг. В результате этого при кормлении одинаковым количеством сахара анатомический выход с сахарозой был на 62% больше, чем у глюкозы, а у печени увеличение роста было 50%. При кормлении глюкозой выход бэкона немного снизился (понижение 0,58%, значимое).

An evaluation of feeding liquid sugar to pigs lairaged overnight before slaughter

G.A. GARDNER and T.J.R. COOPER

Ulster Curers' Association, 2 Greenwood Avenue, Belfast BT4 3JL, N. Ireland.

Introduction

Since feeding sugar to pigs prior to slaughter was first suggested by Bate-Smith (1937), there has been much work in many countries on the associated benefits (Fernandes, 1976). The objective has been to reduce or overcome the problem of inferior meat quality (high pH) from fatigued or stressed pigs.

The main effects of sugar feeding are: (a) the restoration of muscle glycogen leading to lower ultimate pH values of the meat, which improves the keeping quality and reduces the incidence of Dark Firm Dry (DFD) meat (e.g. Clark, 1973); (b) a marked increase in the weight of liver in the animal, which has improved texture, juiciness, but a weaker flavour (McDougall & Rhodes, 1977); and (c) carcase yields of sugar-fed pigs may (Gallwey, Tarrant & McMahon, 1977) or may not (Wismer-Pedersen, 1959) be increased.

Unfed pigs which are lairaged overnight have a lower carcase yield than those slaughtered on the day of arrival at the factory, due to loss of water by excretion and associated shrinkage of the tissue. In Northern Ireland under certain circumstances up to 30% of all pigs slaughtered may have to be lairaged overnight. The subject of this paper is to ascertain if sugar-feeding of such pigs under the practical conditions of the bacon factory would prevent losses in carcase yield. In addition, both liver and bacon yields were determined and a comparison made between the effects of feeding glucose and sucrose. As there is a paucity of data on the effect on pH of meat from pigs fed glucose, measurements of both pH_1 and pH_2 of these pigs were obtained.

Experimental

In each experiment 60 pigs were chosen from one or more producers and after live weighing were divided equally according to source into 2 lots, one batch to serve as controls (access to water only) and the other for sugar feeding. All pigs had been transported on that day from farms 30-70 km from the factory. Each batch of 30 pigs was penned separately with a floor space allowance of 0.5 m^2/pig. In the pen equipped for sugar feeding the minimum drinking trough space was 1 place (30 cm wide) for every 2 pigs.

Sugars

(a) Glucose (hydrolysed maize syrup) of specific gravity 1.40 (42 DE) was diluted 50/50 with water to a specific gravity of 1.20. This was fed at a rate of 4 litres/pig = ca. 2 kg dry sugar.

(b) Sucrose (cane sugar) was dissolved in water at a concentration of 50 kg/120 litres. Each animal was allocated 4 litres = 1.7 kg/pig.

After preparation, samples of the sugar solutions were taken for dry matter analysis.

Feeding

The Lairose System (Lairose Ltd., London) for the automatic feeding of sugar solutions was installed for these trials. Immediately on penning the sugar solution was made available to the pigs (4 l/pig). After 4 hr or when the allocation is consumed, the system automatically cuts off the supply of sugar solution and replaces it with water, which is available to the pigs until their removal for slaughter (on average ca. 18 hr). Control pigs had access to water throughout the lairage period. There were 3 replicate experiments for each sugar.

Measurements of yields

Live weights and hot carcase weights (taken 1 hr after slaughter) were measured to the nearest 0.5 kg. Pork sides butchered for Wiltshire style bacon on the day after slaughter were injected with brine, tanked for 4 days, and matured for 4 days before weighing (to 0.25 kg). "Hot liver" weights (to 0.03 kg) were obtained within 30 min of removal from the pig. Data were recorded for every individual animal in each experiment.

$$\text{Carcase yield (\%)} = \frac{\text{Hot carcase wt}}{\text{Live wt}} \times 100$$

$$\text{Bacon yield (\%)} = \frac{\text{Wt of the 2 bacon sides}}{\text{Hot carcase wt}} \times 100$$

Using a portable pH meter 29 (Radiometer A/S, Copenhagen), pH_1 values were measured directly in muscles, longissimus dorsi, at the 5th rib, 45 min after slaughter. On the following day pH_2 values of the chilled carcases were measured in the l. dorsi, adductor and semispinalis capitis muscles. pH measurements were only obtained on glucose-fed and corresponding control carcases.

Results and Discussion

The live weights of the experimental animals, carcase yields and liver weights of pigs fed glucose are shown in Table 1 and those fed sucrose in Table 2. There were 30 pigs allocated to each treatment in each experiment. A few were condemned for veterinary reasons and some were unsuitable for bacon manufacture. In all these experiments the sugar allocated was totally consumed, but in some trials mechanical malfunction of some valves prevented all the sugar solution being dispensed, and these experiments were abandoned.

Table 1. Live weights, carcase yield and liver weights of pigs fed glucose

		Means						Overall average	
		Expt. 1		Expt. 2		Expt. 3			
		$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
Sugar consumed per pig (kg)		2.00		1.85		1.92		1.92	
Live wt (kg)	SF	82.53	2.66 NS	83.88	4.21 NS	83.03	4.17 NS	83.14	3.74 NS
	C	83.21	3.99	83.45	3.79	82.90	4.01	83.18	3.87
Carcase yield (%)	SF	78.34	1.31 ***	77.86	2.45 SL	76.73	2.16 **	77.64	2.11 ***
	C	76.22	1.83	76.86	1.99	75.31	1.73	76.13	1.94
Liver wt (kg)	SF	1.87	0.31 ***	1.87	0.33 ***	1.94	0.27 ***	1.89	0.30 ***
	C	1.38	0.13	1.32	0.14	1.47	0.19	1.39	0.17

SF; sugar-fed pigs. C; control pigs (water only)
$\bar{x}$ = mean
s = standard deviation
NS = difference is not significant
SL = difference is slightly significant (at 10% level)
* = difference is significant (at 5% level)
** = difference is highly significant (at 1% level)
*** = difference is very highly significant (at 0.1% level)

Table 2. Live weights, carcase yield and liver weights of pigs fed sucrose

		Expt. 4		Expt. 5		Expt. 6		Average	
		$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
Sugar consumed per pig (kg)		1.69		1.56		1.69		1.65	
Live wt (kg)	SF	81.57	4.53 NS	84.17	4.61 NS	82.68	5.23 NS	82.81	4.86 NS
	C	81.00	3.31	82.78	5.10	80.88	6.48	81.58	5.21
Carcase yield (%)	SF	78.95	1.68 ***	78.59	1.51 ***	79.45	3.14 ***	78.99	2.22 ***
	C	77.62	1.13	77.12	1.78	75.93	1.94	76.87	1.80
Liver wt (kg)	SF	1.85	0.38 ***	1.84	0.46 ***	1.93	0.33 ***	1.87	0.39 ***
	C	1.20	0.14	1.17	0.10	1.31	0.23	1.22	0.18

Carcase yield

In each of the 6 experiments there was no significant difference between the live weights of the sugar-fed pigs and control pigs. Of the pigs fed glucose (Table 1) there was some variation between the three replicates in the degree of significance of the increase in carcase yield. Increases of 1.0% (Expt. 2) to 2.12% (Expt. 1) ranged from slightly significant to very highly significant. However, the average increase in carcase yield of 1.51% was a very highly significant increase ($P < 0.001$).

In all 3 experiments on pigs fed sucrose very highly significant increases ($P < 0.001$) in carcase yields were found (Table 2). Again there were differences between experiments (1.33% - 3.52%) and the overall average increase in carcase yield was 2.12% ($P < 0.001$).

Much of the early published work involved feeding sugar in solid form mixed in different proportions with normal feed at the farm prior to transportation and also in the abattoir. Feeding liquid sugar to pigs lairaged in the factory is a more recent development (Clarke, 1973) which has been patented (Clarke & Teal, 1976), but there is relatively little published data using this method. Fernandes (1976) has shown that under highly controlled experimental conditions and with small numbers (7) of animals 1.5 kg glucose increases the carcase yield by 3.3%. However in 2 experiments under factory conditions with 18-24 animals per treatment increases of 2.31% from 1.78 kg glucose and 1.69% from 2.56 kg glucose were obtained from pigs which had access to sugar for 4 hr followed by water for 12 hr before slaughter. In one experiment pigs killed on arrival at the factory had 1.37% additional carcase yield when compared to those held overnight on water only. In the second experiment under similar conditions there was no difference in carcase yield attributed to lairaging without sugar. Gallwey et al. (1977) used a total of 50 sugar-fed

and 30 control pigs in 4 trials of overnight lairaging and found that the carcase yield was increased by 3.3% from the consumption of 2.27 kg glucose.

Thus pigs held overnight in lairage, which are sugar-fed, have higher carcase yields than corresponding unfed controls. The extent of this effect will depend largely on the state of the animals being lairaged (e.g. time from last feed , transportation distance, transportation time) or their degree of physical exhaustion.

Liver weights

The weight of liver of all sugar-fed pigs was significantly ($P < 0.001$) heavier than the corresponding control pigs (Tables 1 and 2). These are summarised in Table 3. In each batch of sugar-fed pigs it was obvious from the individual liver weights that not all pigs had consumed the sugar to the same extent.

Table 3. Increases in liver weight of sugar-fed pigs

Sugar	Expt.	Increase in wt (kg)	Percentage increase
Glucose	1	0.49	35.5
	2	0.55	41.7
	3	0.47	32.0
Average		0.50	35.9
Sucrose	4	0.65	54.2
	5	0.67	57.3
	6	0.62	47.3
Average		0.65	53.3

Weights of ca. 1.4 kg, similar to the controls, were recorded, but other pigs had liver weights as high as 2.7 kg. This is illustrated from the much higher standard deviations in comparison to control pigs and confirms the observations of Gallwey et al. (1977). The average increase in response to sucrose (+ 53.3%) was greater than to glucose (+ 35.9%), which corresponds to an increase of 0.39 kg liver/kg sucrose and 0.26 kg liver/kg glucose. Clarke (1973) found that sucrose feeding increased liver weights by 0.32 kg/kg sugar and Gallwey et al. (1977) 0.20 kg liver/kg glucose. In two "commercial" experiments Fernandes (1976) found that liver weights were increased by 0.15 and 0.16 kg liver/kg glucose. Under highly experimental conditions the liver increase/kg glucose fed varied from 0.37 to 0.58 depending on the amount of the sugar fed, and in a comparison between glucose and sucrose the increase in liver weight was 0.34 kg/kg and 0.62 kg/kg for glucose and sucrose respectively.
As stated above, in relation to carcase yield the "return" in liver from sugar-fed pigs will largely depend on the state of the animals being fed, but it would appear that feeding sucrose will yield higher liver weights than glucose. A detailed statistical analysis was carried out and the correlation coefficient between liver weight and carcase yield was so low as to indicate that these feature are weakly linked, if at all.

Bacon yield

The differences in the bacon yields of the sugar-fed pigs are summarised in Table 4. There were variations between experiments, but the overall conclusion is that there was a small but significant ($P < 0.1$) loss of 0.58% in bacon yield for pigs fed glucose, whereas there was no significant difference in pigs fed sucrose. Gallwey et al. (1977) found that feeding 2.27 kg glucose increased bacon yield by 0.2%, but this difference was not significant. Such a finding is similar to Expt. 2 (Table 4) in our work, but in the other glucose experiments significant reductions in bacon yield were found.

Table 4. Differences[1] in bacon yield of sugar-fed pigs

	Expt. 1	Expt. 2	Expt. 3	Average
Glucose	- 0.70% SL	+ 0.11% NS	- 1.03% *	- 0.58% SL
	Expt. 4	Expt. 5	Expt. 6	Average
Sucrose	+ 0.64% NS	+ 0.35% NS	- 0.04% NS	+ 0.30% NS

[1] Difference = bacon yield of sugar-fed pigs - bacon yield of control pigs

It must be stressed that bacon yield as defined in this paper can be influenced by many factors, such as losses in chilling, butchery of carcases, temperature of pork, amounts of brine injected, positions in curing tank and on pallets during maturation. However, both sugar-fed and control pigs were processed at the same time under normal factory procedures.

pH values

The pH of the muscles of glucose-fed pigs is shown in Table 5. Measurements of pH_1 made in the l. dorsi 45 min after slaughter showed that in 2 out of the 3 experiments and in the overall average there was a reduction of 0.12 units ($P < 0.001$). The number of pigs in all experiments with pH_1 of 5.9 or less, an indication of potential pale soft exudative meat (PSE), was 9 (10%) in those fed glucose and 6 (6.7%) in the control pigs. Thus the feeding of glucose would not appear to markedly exacerbate the potential of producing PSE meat.

Although there were slight differences between experiments, the overall effect of feeding glucose was to reduce the pH_2 of the l. dorsi by 0.21 units, the adductor by 0.35 units and the semispinalis capitis by 0.44 units ($P < 0.001$ in all cases).

Fernandes (1976) found that glucose-fed pigs had lower pH_2 of the muscles (0.24 - 0.46 units) and Gallwey et al. (1977) recorded reductions of 0.10 - 0.27 units.

Table 5. pH values of muscles of glucose-fed pigs

			EXPERIMENT 1			EXPERIMENT 2			EXPERIMENT 3			AVERAGE		
			$\bar{x}$	s		$\bar{x}$	s		$\bar{x}$	s		$\bar{x}$	s	
pH_1														
	l. dorsi	SF	6.23	0.32	*	6.45	0.30	NS	6.27	0.28	***	6.32	0.31	***
		C	6.39	0.30		6.36	0.35		6.56	0.23		6.44	0.31	
pH_2	l. dorsi	SF	5.72	0.41	NS	5.65	0.13	***	5.72	0.20	***	5.70	0.26	***
		C	5.77	0.28		5.97	0.29		5.99	0.26		5.91	0.30	
	adductor	SF	5.68	0.21	**	5.60	0.08	***	5.71	0.14	***	5.66	0.36	***
		C	5.85	0.23		6.00	0.30		6.19	0.28		6.01	0.30	
	semispinalis capitis	SF	5.94	0.23	***	5.89	0.11	***	5.92	0.17	***	5.91	0.18	***
		C	6.28	0.25		6.33	0.24		6.44	0.27		6.35	0.26	

General conclusions

This study was undertaken to assess the feeding of liquid sugar, sucrose or glucose, to pigs which of necessity had to be held overnight in the lairage before slaughter. The effects of increased carcase yield and liver weight and in the case of glucose a small reduction in bacon yield have to be balanced against the costs of the sugar and the feeding system. These effects will also vary with the state of the animals at the time of arrival at the factory. The main objective in commercial terms is to prevent losses associated with lairaging. Thus each processing factory would have to assess the system in relation to the pigs they process and the products they manufacture. It seems logical that fatigued, hungry, highly stressed pigs, which have travelled long distances, would respond more to sugar-feeding than well-fed, rested pigs. It is difficult to evaluate the economy in increased keeping quality, which is associated with the reduction in muscle pH of sugar-fed pigs. Certain companies and different meat products may suffer much more than others from poor keeping quality associated with high pH meat.
However, there is no doubt that sugar feeding can negate the deleterious effects of transportation and lairaging on both the quantity and quality of the meat.

References

BATE-SMITH, E.C. (1937). A. Rep. Fd. Invest. Bd. London, p.15.
CLARKE, J.B.K. (1973). Proc. Inst. Fd. Sci. Technol. (UK) 6, 136.
CLARKE, J.B.K. & TEAL, B.M. (1976). Patent Specification, London, No. 1,427,023. H.M.S.O.
FERNANDES, T.H. (1976). The effects of administration of sugars to pigs prior to slaughter on carcase yield and quality. Ph.D. thesis. University of Newcastle-upon-Tyne.
GALLWEY, W., TARRANT, P.V. & McMAHON, P. (1977). Ir. J. Fd. Sci. Technol. 1, 71.
MACDOUGALL, D.B. & RHODES, D.W. (1977). J. Sci. Fd. Agric. 28, 1030.
WISMER-PEDERSEN, J. (1959). Fleischwirtschaft 11, 653.