EFFECTS OF SALBUTAMOL (GAH 034)[1] ON GROWTH, CARCASS AND MEAT QUALITY OF HEAVY PIGS[2]

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INTRODUCTION

Market related and nutritional aspects of meat production continue to demand a reduction of fat content in pig carcasses. In this contest considerable interest has been aroused by the possibility of acting on metabolism, using pharmaceutical substances in order to restrict the natural tendency of the organism to deposit lipids. The latest generation of such drugs consists of the so-called repartitioning agents, more properly called ß-agonists. They are neurotrasmitters and hormonal compounds which have a chemical structure similar to, and function in much the same manner as, catecholamines. ß-agonists interesting for animal production are of the type able to stimulate ß2 receptors or specific receptors of the brown fat cells membranes (Timmerman, 1987; Hanrahan, 1987).

The important advantage of these substances is the possibility of administering them orally mixed with feed.

The aim of this research has been to test one of such substances, the ß2 agonist salbutamol, on heavy pigs because in this type of production pigs are taken to higher weights and treatment lasts longer then usual.

MATERIALS AND METHODS

The study was conducted on 88 pigs (Dutch Large White x (Dutch Landrace x English Large White)), half castrated males and half females. The animals were divided into 4 groups of 22 pigs each; 2 control groups (1 castrated males and 1 females) and 2 similar experimental groups. The groups were made up of animals of an average weight of approximately 30 Kg. A dry ad libitum feeding regimen was employed. 2 ppm of salbutamol were added to the feed of the experimental groups. 2 experimental pigs (1 females and 1 males) died as a result of normal rearing diseases not associated with the treatment.

The animals were slaughtered at a mean live weight of 160 Kg after 208 days of treatment.

Carcass meat content was determined 20 minutes post mortem (p.m.) using the Fat-o-Meat'er (FOM).

At 45' p.m. a sample of semimembranosus muscle (SM) of the right thigh was trimmed from the exposed muscolar surface. 3 to 4 g of muscle were immediately homogenized with Ultra Turrax using a solution of 0.01 M Iodoacetic acid buffer at pH 7.0 (muscle/solution ratio = 1/10) for pH determination. Sections of approximately 10-15 g were also taken, cleaned of fat and visible connective tissue, wrapped in tin foil, immediately frozen in liquid nitrogen and stored at -70°C for glycogen, glucose, glucose-6-phosphate and lactic acid analysis (Dalrymple and Ham, 1973; Fabiansson and Laser-Reutersward, 1984; Monin & Sellier, 1985).

Duplicate measurements were carried out on each extract.

Colour of the freshly cut surface of the SM was measured, at 45' p.m.

using a Minolta Chromameter Reflectance II CR100/08 Colormeter wit a C-type light source (6774K) and calibrated with a Standard Gardner pink tile n.CG6625 (Y=45.97 x=0.3658 y=0.3250). 4 measures were taken on each thigh.
A piece of lard was taken from a position near the tail for analysis of fatty acid composition (Madarena et al., 1987) out of 10 animals chosen at random from each groups.
Proximate composition was determined on samples of l.dorsi (7th rib; 200 g) obtained from 6 randomly chosen carcasses of each group (A.O.A.C., 1980).
at 48 h p.m. pH was again determined by homogenising a sample of SM in water. Colour was also measured at the same time on the exposed surface of SM after the thighs had been trimmed for Parma ham production.
Colour and pH measures were carried out on all animals, while the tests for carbohydrate compounds were performed on 10 animals from each group selected in order to ensure an equal distribuition among animals in which pH values were either close or far (plus or minus) from mean values of the group.
All data were stored on a personal computer and statistical analysis was subsequently performed usin the SAS (1985) statistical package. Data presented in Tables are mean$\pm$ Standard Deviation. Comparison is among the 4 groups on one side and between all the treated animals versus all the control ones on the other side. Different superscript letters stand for a difference significant at the $P<0.05$ level.

RESULTS
The four groups were of sufficiently similar weight at the start of the experiment. Some differences did emerge, on the other hand, at the end so that the final weight of the treated groups was lower than that of controls. This is confirmed by the mean daily weight gain where differences are particularly evident in the case of females. Total feed consumption and feed conversion ratio are substantially different following salbutamol treatment with a lower consumption in the treated pigs associated with a higher conversion index. In this regard the comparison between treated and control males is particularly interesting since there is only a slight difference in body weight increase whereas feed consumption and conversion ratio are considerably different.
Measures taken on carcasses have shown a significant increase in lean meat content of treated animals. As regards carcass weight, differences are not significant but treated carcasses are slightly lighter than control ones, just as was the case of final live weights. No differences were observed in trimmed thigh weight. Fat and muscle thickness measurements obviously confirm observations on the quantity of lean meat and show, in treated animals, a reduction of approximately 6-7 mm in lard thickness and an increase of 3-6 mm in muscle thickness.
Post mortem glycolysis was studied both form the qualitative poin of view, i.e. its rate (pH 45'), and the quantitative one, i.e. its extent (final pH). The former is the best single parameter for PSE diagnosis while the latter is specific for the evaluation of DFD risk. As regards pH at 45' no differences have come out among the groups and, moreover, the data obtained did not show cases of post mortem glycolysis at faster rates than normal even in terms of individual animals. Differences were observed, instead, in

with variations in the repartition of carcass lean and fat contents.
On the other hand, subjective evaluation of trimmed thighs by experts of the trade was one of excessive leannes in a good number of cases of treated subjects (especially in females) if viewed in the contest of Parma ham production.
The data for pH and carbohydrate compounds exclude PSE type phenomena in the groups of animals studied, whether control or treated. Moreover, it seems that this treatment does not bring about an increased risk of PSE. Different considerations must be made, on the other hand, for final pH as a certain tendency was observed towards higher values in the treated animals, to the extent that in some cases a risk of DFD could envisaged.
In this research salbutamol feeding was stopped 36 hours prior to slaugther while a withdrawal period of 3 days in the case of cimaterol (Bekaert et al.,1987) and of 4 days for salbutamol (Cole et al., 1987) has proved sufficient for final pH to return to normal. The phenomenon here observed, though, was sufficiently limited so to enable a further reduction by means of suitable preslaughter management procedures. It should be noted that in cases of this kind it would be an unconventional type of DFD. The reduction of the a* parameter, in fact, would prevent the appearance of a dark colour while leaving the characters of firm and dry unaffected.
As far as colour is concerned literature on this topic reports no changes of L.dorsi in swine treated wit ß-agonists other than salbutamol (Jones et al., 1985; Moser et al., 1986; Wallace et al., 1987). It should be stressed, though, that the evaluation was a subjective one. In the only case in which colour had been objectively measured with a Labscan II (Bekaert et al., 1987) the value of a* (L.dorsi) was significantly lower in cimaterol treated animals compared to control, even though the differences were less marked than in the present research.
Considerations concerning colour may be connected to muscle histologic features. Cantoni et al. (1988) have performed myofibers typing on samples of longissimus dorsi of the same pigs employed in this experiment and have observed an increase in the relative content of type IIB myofibers in treated animals and an increase of the diameters of all fibres but particularly of type IIB fibres. Observations of this kind seem to provide a valid explanation of what has been observed as regards the a* and b* coordinates. It has to be remerbered, though, that in the present research salbutamol feeding began at 30 Kg live weight and went on for a period of 208 days until a weight of 160 Kg on average was reached. Similar experiments with light pigs started at initial weight range of 30-60 Kg to end at final weight of 100-110 Kg for a total period of between 50 and 100 days. The substantial time difference may well be the cause of unwanted phenomena such as the observed reduction of the colour of meat.
The variation induced by treatment with salbutamol on the fatty acid composition of subcutaneous fat did not provide any particularly new information. The quantitative reduction of fat laid down briught about an increase in the relative content of linoleic acid in treated animals as expected. However, the higher concentration of collagen (from the connective tissue matrix of adipose tissue) in the backfat of leaner pigs may help to compensate for the higher linoleic acid content of the-

final pH values though they were significant only for the mean value of the control groups taken together versus the treated ones. This phenomenon suggests that treated animals may well get to the moment of slaughter with lower muscular energy reserves than the control ones. This may give rise to cases of DFD meat. By convention meat is considered DFD if final pH is higher than 6.20. In this case only two males (one having a pH of 6.21) and two females would be classified in this manner. The distribution of compounds making up the glycolytic pathway essentially confirms what has been observed for pH values. Glycogen and glycolytic potential values of the female control group suggest higher energy reserves as compared to the other groups. On the other hand it is worth noting that the control males values are much the same as those of the treated males and females.
Surface colour measurements allow further interesting considerations. L* values did not show significant variations at 45' while at 48h the group of control females had a mean value significantly lower than that of the control males. More definite variations among the groups have been observed as regards a* and b* parameters. The data show significant differences for both a* and b*, at 45' and at 48h, between the treated and the control groups. Treatment, therefore, brought about an undoubted reduction in semimembranosus muscle colour intensity as measured by the a* and b* coordinates. The results confirm visual impressions at the time of slaughter.
L.dorsi muscle proximate composition did not show marked changes; the only significant difference being water content between control and treated animals. There appear, though, to be a trend towards a higher protein and a lower fat content in treated subjects. L.dorsi was poor in fat content in control pigs and, therefore, it has not been the best choice to emphasize possible changes in composition.
The changes observed in lard fatty acids, as expected, regarded a very limited number of compounds, i.e. unsaturated fatty acids with 18 carbon atoms. As for individual groups control females did not differ from the treated ones whereas control males showed more oleic acid (though not significant), less linoleic acid and more linolenic acid than the treated ones.
Considering the sum of control versus treated pigs, salbutamol has caused an increase in linoleic acid and a decrease of linolenic acid. In overall terms treated animals showed a higher content of polyunsaturated fatty acids and, therefore, a higher ratio between polyunsaturated and monounsaturated acids.

DISCUSSION

Breeding performances confirmed the results of other similar experiments conducted in other countries on light pigs with the same compound (Cole et al., 1987) and with other ß-agonists (Jones et al., 1987; Wallace et al., 1987; Van Weerden,1987). A reduction in mean daily weight gain was observed (especially in females) associated with a lower feed consumption and a higher feed conversion ratio. Salbutamol feeding brought about an increase in lean meat content of carcasses and a corresponding reduction of subcutaneous fat deposits without substantial changes in carcass or thigh weight. In overall terms, therefore, given the not significant differences in carcass weight, savings have been achieved in feed consumption without affecting body growth but

se animals as far as fat softness is concerned (Enser et al., 1984).

CONCLUSIONS

Feeding of pigs with 2 ppm of salbutamol from 30 to 160 Kg has induced a decrease in mean daily weight gain in females, a lower feed consumption, an improvement in the feed conversion ratio, no significant changes in carcass and trimmed thigh weight, a higher meat content of carcasses , a decrease in subcutaneous fat cover and an increase in dorsal muscle thickness.
pH and glycolytic potential determination has shown a higher risk of DFD in treated animals, while semimembranosus colour was lower. Linoleic acid content of subcutaneous fat increased.

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Table 1: Breeding performances: Initial and final live weight, mean daily weight gain, total feed consumption, feed conversion ratio

	Females		Males	
	Control	Treated	Control	Treated
Weight (Kg) initial	28.18	28.22	29.58	29.27
final	164.27	157.33	164.36	160.76
Daily weight gain (g)	650	610	640	630
Total feed cons. (Kg/head)	568.18	494.32	565.91	492.05
Feed conversion ratio	4.18	3.83	4.20	3.74

N.B.: Data are group values, therefore no statistical analysis has been performed.

Table 2: Carcass parameters: meat content (%), cold dead weight (Kg), trimmed thigh weight (Kg)

		Meat content	Dead weight	Thigh weight
Females	Control	46.46±3.88 ab	133.05±15.19 a	13.34±1.27 a
	Treated	46.95±3.28 a	129.62±13.17 a	13.36±1.34 a
Males	Control	45.65±2.70 b	136.00±12.69 a	13.06±1.22 a
	Treated	49.02±2.35 ab	131.19±13.98 a	13.38±1.54 a
All	Control	46.06±3.33 b	134.52±13.91 a	13.20±1.24 a
	Treated	49.34±2.83 a	130.40±13.44 a	13.37±1.43 a

Table 3: Fat and muscle thickness (mm) as measured by F.O.M.

		3-4 LV	3-4 LR (fat)	3-4 LR (muscle)
Females	Control	32.32±7.52 ab	33.27±8.89 ab	61.27±6.17 b
	Treated	26.67±6.38 c	27.33±7.47 b	67.24±8.18 a
Males	Control	33.50±5.40 a	35.05±6.43 a	59.77±4.64 b
	Treated	27.62±4.59 bc	27.62±5.73 b	62.86±6.04 ab
All	Control	32.91±6.49 a	34.16±7.72 a	60.52±5.45 b
	Treated	27.14±5.51 b	27.48±6.58 b	65.05±7.44 a

Table 4: pH values at 45' and 48h post mortem

		pH 45'	pH 48h
Females	Control	6.65±0.12 a	5.76±0.14 a
	Treated	6.71±0.17 a	5.89±0.30 a
Males	Control	6.66±0.12 a	5.79±0.19 a
	Treated	6.68±0.15 a	5.85±0.23 a
All	Control	6.65±0.12 a	5.77±0.16 b
	Treated	6.69±0.16 a	5.87±0.26 a

Table 5: Glycogen, glucose, glucose-6-phosphate, lactic acid and glycolytic potential

		Glycogen	*Glucose*	*Glucose-6-P*	*Lactic acid*	*Glycolytic Pot.*
Females	Control	2.40±0.53 a	0.15±0.04 a	0.05±0.05 a	1.59±0.30 a	6.78±0.90 a
	Treated	1.86±1.08 a	0.10±0.07 a	0.04±0.06 a	1.70±0.67 a	5.69±1.75 a
Males	Control	1.72±0.51 a	0.16±0.05 a	0.08±0.08 a	1.74±0.49 a	5.67±0.68 a
	Treated	1.95±0.81 a	0.10±0.04 a	0.05±0.09 a	1.59±0.49 a	5.79±1.33 a
All	Control	2.11±0.61 a	0.15±0.05 a	0.06±0.06 a	1.65±0.39 a	6.30±0.97 a
	Treated	1.90±0.92 a	0.10±0.05 b	0.04±0.07 a	1.64±0.57 a	5.74±1.50 a

Table 6: Colour measures

		45' p.m.			48h p.m.		
		L *	a *	b *	L *	a *	b *
Females	Control	40.34±1.34 a	6.30±0.55 a	2.52±0.58 a	45.58±2.57 b	7.86±0.85 a	4.82±0.91 b
	Treated	40.06±1.97 a	4.87±1.38 b	1.87±0.40 b	47.06±3.22 ab	5.66±1.88 b	3.63±1.23 c
Males	Control	41.00±1.34 a	7.07±1.16 a	2.57±0.54 a	47.97±2.85 a	8.55±1.71 a	5.86±1.23 a
	Treated	41.30±1.86 a	5.14±0.85 b	2.38±0.60 a	47.54±2.24 ab	5.69±1.10 b	3.94±0.75 bc
All	Control	40.65±1.36 a	6.69±0.98 a	2.54±0.55 a	46.78±2.94 a	8.20±1.38 a	5.34±1.19 a
	Treated	40.68±1.99 a	5.00±1.14 b	2.12±0.56 b	47.30±2.75 a	5.67±1.52 b	3.78±1.02 b

Table 7: Proximate composition of L.dorsi muscle (% of fresh weight)

		Water	Protein	Fat	Ash
Females	Control	75.58±0.50 a	23.05±0.49 a	1.73±0.37 a	1.12±0.04 a
	Treated	74.78±0.83 a	23.66±0.89 a	1.61±0.37 a	1.10±0.03 a
Males	Control	75.12±0.80 a	22.98±0.65 a	2.26±0.36 a	1.13±0.04 a
	Treated	74.36±0.64 a	23.63±1.04 a	1.84±0.59 a	1.11±0.04 a
All	Control	75.35±0.68 a	23.01±0.55 a	2.00±0.45 a	1.13±0.04 a
	Treated	74.57±0.74 b	23.65±0.92 a	1.72±0.48 a	1.11±0.03 a

Table 8: Fatty acid composition of subcutaneous fat

	Females		Males		All	
	Control	Treated	Control	Treated	Control	Treated
C12	0.08±0.03 a	0.07±0.01 a	0.09±0.03 a	0.08±0.02 a	0.08±0.03 a	0.08±0.02 a
C14	1.26±0.21 a	1.23±0.15 a	1.24±0.17 a	1.29±0.14 a	1.25±0.19 a	1.26±0.14 a
C16	22.37±1.71 a	22.02±0.76 a	22.29±1.23 a	22.45±1.04 a	22.34±1.50 a	22.24±0.92 a
C16:1	2.23±0.33 a	2.39±0.25 a	2.19±0.49 a	2.32±0.39 a	2.22±0.40 a	2.35±0.32 a
C17	0.30±0.17 a	0.34±0.12 a	0.27±0.20 a	0.28±0.05 a	0.29±0.18 a	0.31±0.10 a
C17:1	0.39±0.38 a	0.35±0.10 a	0.30±0.19 a	0.38±0.22 a	0.36±0.31 a	0.37±0.17 a
C18	11.94±1.33 a	11.45±1.10 a	12.62±1.03 a	12.69±1.83 a	12.22±1.24 a	12.10±1.62 a
C18:1	42.41±1.71 a	42.45±1.83 a	41.67±1.54 ab	39.83±1.76 b	42.10±1.65 a	41.08±2.20 a
C18:2	15.39±1.72 ab	16.05±1.44 ab	14.68±1.64 b	17.07±1.48 a	15.09±1.69 b	16.59±1.52 a
C18:3	0.98±0.28 b	1.00±0.20 b	1.44±0.31 a	0.97±0.18 b	1.17±0.37 a	0.98±0.19 b
C20	1.05±0.32 a	1.13±0.13 a	1.45±0.58 a	1.21±0.13 a	1.21±0.48 a	1.17±0.14 a
C20:2	0.79±0.36 a	0.81±0.16 a	1.00±0.41 a	0.84±0.26 a	0.88±0.39 a	0.82±0.22 a
C20:4	0.70±0.51 a	0.61±0.23 a	0.46±0.20 a	0.47±0.24 a	0.60±0.42 a	0.54±0.24 a
Saturated	37.00±1.74 a	36.23±1.25 a	37.95±1.49 a	38.00±1.95 a	37.40±1.68 a	37.16±1.85 a
Unsaturated	62.90±1.74 a	63.66±1.23 a	61.74±1.45 a	61.89±1.97 a	62.42±1.70 a	62.73±1.85 a
Monounsaturated	45.04±1.71 a	45.19±1.81 a	44.17±1.75 ab	42.54±1.76 b	44.68±1.74 a	43.80±2.21 a
Polyunsaturated	17.86±1.95 a	18.47±1.33 a	17.53±2.06 a	19.35±1.55 a	17.74±1.95 b	18.93±1.48 a
Sat./Unsat.	0.59±0.04 a	0.57±0.03 a	0.62±0.04 a	0.62±0.05 a	0.60±0.04 a	0.59±0.05 a
Polyuns./Monouns.	0.40±0.05 a	0.41±0.04 a	0.40±0.06 a	0.46±0.05 a	0.40±0.05 b	0.43±0.05 a