

Compact serpentine race system for beef abattoirs

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Cattle move more easily through a curved single file race with the handler working along the inner radius, compared to a straight race. Observations indicated that at slaughter speeds ranging from 60 to 300 cattle per hour, a curved race usually required fewer people to move the cattle, compared to a straight race. A straight race usually required at least one additional person. The races had solid sides. The inside radius of the curved races was 3.5 to 5m.

A compact serpentine race was recently constructed in a beef abattoir. It has the advantages of a curved race, but it required less floor space. The layout of the race has two 180 degree curves. The inside radius of the two curves is 1.5m. The race has solid sides spaced 81cm apart and it was constructed in a continuous smooth curve. Two people can move 150 cattle per hour, from the lairage and into a conveyor restrainer for stunning. For maximum efficiency, the two handlers should remain on the inner radius of the two curves as much as possible. The walkway for the handlers runs alongside the race. The distance from the top of the race fence to the platform the person walks on is 100cm. The sides of the race are 1.67m high to prevent the cattle from looking out over the top of the race. The first 3 to 4m of the race where it joins onto the crowd pen should be relatively straight, prior to the first curve with a 1.5m inside radius. Balking may occur if a curve with a 1.5m inside radius starts at the junction between the single file race and the crowd pen. For smaller abattoirs, a race with a single 90 degree to 180 degree curve with a 1.5m radius can be used.

This system can handle a variety of cattle types. The abattoir using the serpentine race slaughters, grain fattened steers, grain fattened bulls, grass fed cattle and cull dairy cows. The breeds are Holstein, Angus, Hereford and crossbreds of most of the commonly used breeds in the U.S.

To prevent bunching and jamming at the entrance to the race, the crowd pen should have one straight fence and the other fence should be on 30 degree angle. The crowd pen fences and the crowding gate should also be solid to prevent cattle from seeing moving objects outside the pen.

Watering and feeding pigs during road transport for 24 hours

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Six journeys with the Institute's vehicle were organised to transport pigs 3 x 8 hours with resting periods of 2 x 1 hour in a shed. During the resting periods the pigs were provided with water or water and food. After the first 8 hour transport the 24 pigs were unloaded and rested for 1 hour in a shed. Four pigs were separated and remained in a pen in the shed. After the second 8 hour transport the 20 pigs were rested for 1 hour and again 4 pigs were separated and remained in a pen in the shed. All pigs were transported to a slaughter-house and slaughtered after the third 8 hour transport.

Upon arrival when the pigs entered the shed they ate and drank a little after which they examined their surroundings. Thereafter they ate and drank. Within half an hour most pigs laid down in a wet place. Sometimes fighting was observed. The pigs which had remained in the shed after 1 x 8 hour transport ate their ration in about 10 minutes. The pigs transported 2 x and 3 x 8 hours did not always eat their full ration. The pigs transported 3 x 8 hours consumed on average 1.6 l water/pig, while the pigs transported 1 x 8 hours drank on average 4.1 l water/pig.

The meat quality parameters were within normal limits, however the pH₁ (45 minutes post mortem) was rather high. Significant differences ($p < 0.05$) were observed between animals transported for 1 x, 2 x and 3 x 8 hours in the glucose level of the blood plasma and the pH₁ of the M. semimembranosus which were lower and higher respectively in pigs transported 2 x 8 hours.

In conclusion: The results of these experiments suggest that during long distance transports by road (3 x 8 hours) of pigs with resting periods of 2 x 1 hour in a shed the water intake is very much restricted. However the water intake may increase when the resting period is of at least 3 hours duration. At the same time the food consumption is restricted and slow. The observations of fatigued pigs are in conflict with the meat quality parameters as indicators of stress.

Influence of halothane genotype on meat quality in pigs subjected to various pre-slaughter treatments

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The aim of this experiment was to investigate the influence of various treatments immediately prior to slaughter on the meat quality of pigs with known halothane genotype.

All pigs received the same treatment up until the point of driving to stunning i.e. a short considerate transport with no holding period in the lairage. Some pigs were then driven to low voltage electrical stunning in a restrainer under less than optimal conditions (abattoir A), whereas others were electrically stunned on the floor or using CO₂ with a minimum of stress (abattoir B). There were only minor differences between the two abattoirs with respect to slaughter process and chilling was traditional in both cases. Meat quality was estimated using slaughter line measurements and estimations the day after slaughter.

The results showed that pigs of the nn-genotype were relatively insensitive to changes in pre-slaughter treatment, whereas pigs of the Nn-genotype - and more particularly the NN-genotype - were more sensitive:

	% PSE		
	nn	Nn	NN
el.-restrainer	100	33	33
el.-floor	74	17	8
CO ₂	79	13	0

A reduction in pre-slaughter stress will therefore improve the meat quality of Nn- and NN-pigs.

Very fast rigor development was only found in pigs with the nn-genotype, where 7-18% (depending on pre-slaughter treatment) were already in full rigor 6 mins. after slaughter. Very fast development of PSE was also especially associated with the nn-genotype and between 29 and 62% were already more or less PSE 45 mins. after slaughter.

The results also showed that there is no great difference between low voltage electrical stunning on the floor and CO₂-stunning with respect to meat quality, when the treatment before stunning is extremely considerate. This observation is, however, of academic interest only, as the considerate treatment used in this experiment cannot be carried out under normal abattoir conditions.

Sight restriction as a means of reducing stress during slaughter

DOUGLAS, A. G., DARRE, M. D. and KINSMAN, D. M.

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An experiment was designed to determine the effect of restricting the animal's vision prior to and during slaughter on the level of pre-slaughter stress experienced by the animal, and to determine the effect on meat quality. A preliminary experiment was designed using poultry. An adaptation of these techniques is currently being tested with beef cattle.

For this study 16 eighteen-week-old Single Comb White Leghorn male chickens were divided between control and treatment (sight restricted) groups. The birds were fitted with bi-polar needle electrodes attached to the pectoral muscles for the recording of heart rate and respiratory rate. The measurement of heart rate, respiratory rate and body temperature were chosen as indicators of stress because they are all directly affected by the release of corticosterone from the adrenal gland and can be monitored with relative ease without disturbing the animal. Heart and respiratory rates were interpreted from electrocardiogram recordings of the birds at rest in holding crates, while suspended on the processing line, and during slaughter. The respiratory rate was interpreted as the modulation of the electrocardiogram complex wave. Simultaneously, rectal temperature was measured using a copper-constantan thermocouple. Exsanguination bleed-out time, blood volume, blood pH were measured and pH of the gastrocnemius pars externa muscle was recorded at five minute intervals for fifty minutes post-slaughter. The pH measurements were made using a portable pH meter with an insertion probe. The data was analyzed by analysis of variance to determine treatment differences. Sight restriction had a marked effect on the birds' behavior. The birds became distinctly more docile and manageable. Generally sight restriction had a marked soporific effect on the birds. Although the behavioral effects were difficult to quantitatively measure, they were reflected in a gradual reduction in heart rate. At slaughter, heart rate (343 vs 395 beats per minute) and respiratory rate (41.6 vs 51.0 breaths per minute) were significantly lower ($p < .05$) in the sight restricted than in the control birds, respectively. Post-mortem ultimate carcass pH was also significantly ($p < .05$) lower in the sight restricted birds (pH 5.96 vs 6.12). It is well documented that reducing the level of stress experienced by the animal prior to and during slaughter has a marked effect on the quality of the meat. The results of this study strongly suggest that pre-slaughter sight restriction can be instrumental in reducing the stress associated with slaughter as measured by these parameters.

Liquid smoke as an odour masking agent to reduce fighting and stress in slaughter pigs

BRAATHEN, O.S. and JOHANSEN, J.

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In order to disguise the differences in smell which pigs from different pens or farms possess and recognise about themselves, we thought that "meat related" materials like oleoresins or extracts from different spices might be suitable. Fighting might thereby be reduced. Due to the high price of spices, an inexpensive liquid smoke aroma (even cheaper than the type commercially used for sausage production) was chosen for our tests.

It was found that the pH-values 30 minutes post-mortem in carcasses from sprayed pigs were significantly higher than in carcasses which were not sprayed on the farms with liquid smoke aroma. Visually the sprayed pigs were found to be much less aggressive during transport, and less fighting was observed in the pens. Also the pig skins showed less red wounds and bloodstained marks from fighting.

Unfortunately the pH-values were not measured again 24 hours post-mortem in all the carcasses, so there is a small possibility that the incidence of DFD-meat might have been increased. As this is not very likely due to the calm behaviour of the sprayed pigs, it may be concluded that the use of 250 ml smoke aroma per 40 pigs reduced the incidence of pale, soft exudative meat. Altogether 500 pigs were used in these tests.

Regrouping and subsequent behaviour patterns in young bulls and steers

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Although the advantages of using bulls rather than steers in beef production are clear, some management problems make producers reluctant to feed bulls, and packing companies reluctant to buy them. It has been established that encounters among unacquainted animals lead to a higher level of agonistic interaction among bulls than among steers. This could result in injury or death in the feedlot, and 'dark cutting' after slaughter. However, in many commercial situations mixing strange cattle together may be desirable to minimise overhead costs. This study was designed to determine the behavioural responses of bulls and steers to such regrouping at various ages.

Thirty two male calves were selected at random from a group of 64 and castrated at about two months of age. The 64 remained together until weaning at about six months and were then assigned, within gender, to pens of eight cattle each. Both groups were fed ad libitum a typical high energy feedlot diet. At the age of about nine, 12 and 15 months (January, April and July), the cattle were repenned in such a way that, within gender on each occasion, each animal was placed with six strangers and one acquaintance. Each pen was then observed, from a hide, in three 22.5 min observation periods each day (morning, afternoon and evening) for ten consecutive days. The occurrence of specified behaviours was recorded: 'sexual' behaviour (mounting, chinresting and flehmen), 'aggressive' behaviour (head bunting, other bunting, threatening), 'other' behaviour (grooming and cribbing) and time spent fighting (head bunting).

Animals of both genders fought when repenned. At all ages bulls were more aggressive than steers. The time spent fighting was highest in both genders at nine months, and lowest at 15 months, but the number of aggressive contacts peaked at 12 months. In both genders, at all three ages, the number of 'aggressive' acts reduced substantially over the ten-day period. Although initially much higher in bulls than steers, animals of both genders showed similar and low levels of these activities by the tenth day (and in most cases by the fifth). The frequency of 'sexual' behaviour in bulls also followed a decay pattern over the ten days; there was little 'sexual' behaviour in steers. The behavioural differences between bulls and steers increased with age, suggesting that steers are behaviourally less mature than bulls. The distinction between 'aggressive' and 'sexual' behaviour is by no means clear; mounting, for example, may be an aggressive, rather than sexual act when performed by one bull on another.

It is concluded that in small groups aggressive behaviour among bulls penned with strangers quickly decays and is similar to that of steers by ten days. However, the initial levels of aggression are much higher in bulls than steers and may present the danger of serious injury, particularly among bigger, older bulls and especially during cooler weather.

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Hormonal and metabolite changes in the blood of pigs following loading and during transport and their possible relationship with subsequent meat quality.

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The stress induced by transportation is associated with changes in the levels of many hormones and metabolites in the blood. In the past there have been a number of attempts to identify a single plasma indicator of stress. Of particular use would be a single, easily measured substance that can give an indication of the degree or amount of stress that the animal undergoes. Many earlier studies were confounded by the stress of sampling, and of those which used stress-free sampling procedures none have examined, in depth, the temporal changes in the levels of the "indicators".

In the present study we have examined stress-induced changes, in the plasma levels of a number of substances, with time and then attempted to use these findings in a further study.

Pork weight pigs were fitted with indwelling jugular vein catheters which were exteriorised between the shoulders. The pigs were allowed at least seven days to recover from operation. During the recovery period they were kept in metabolism crates and were frequently sampled to accustom them to the handling procedure. This allowed the sampling to become a "stress-free" procedure. On the day of experiment the animals were subjected to a loading stress and hormone levels monitored throughout.

Plasma levels of glucose, lactate, insulin and thyroxine all increased rapidly to a peak value ($p < 0.01$) by about five minutes after stress. The insulin increase was small and short-lived, but the changes in glucose, lactate and thyroxine were more marked and it took 30-45 minutes before the concentrations had returned to pre-stress levels. Cortisol and T_3 increased to a peak at 10-15 minutes after loading ($p < 0.05$) and returned to resting levels by 60 minutes. There was an immediate decrease ($p < 0.01$) in free fatty acid (FFA) which was maintained for 20 minutes, the levels then rose increasingly and remained elevated during the second, third and fourth hour after loading. There was no change ($p > 0.05$) in any of these parameters in the absence of stress. In the same pigs (about one week later) plasma cortisol measurements were used as an indicator of stress during loading and transportation. Following loading, cortisol levels reached the same concentration as during the earlier experiment (ca. 20 $\mu\text{mol/l}$) but when the pigs were sampled ten minutes after the start of transport the levels had increased even further (ca. 40 $\mu\text{mol/l}$). At the end of a one hour transport the cortisol concentrations were still at the higher level.

Both resting and stressed cortisol levels were higher (approximately double) in stress-sensitive Pietrain pigs than in the Gloucester Old Spot or Large White breeds; their cortisol levels also took longer to return to basal levels during post-transport lairage.

From these data we conclude that cortisol may be both a qualitative and quantitative indicator of stress. It also appears that transportation provides an additional stress to that inflicted by loading procedures.

The incidence of carcass damage in slaughter pigs

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During transport and lairage prior to slaughter pigs from different rearing groups are frequently mixed. The fighting which often ensues leads to unsightly lacerations on the carcass which, in severe cases, may lead to its downgrading. In the UK, such carcasses are given Z-grading under the Meat and Livestock Commission pig classification scheme. While this grade is not restricted to carcasses damaged through ante mortem fighting observation suggests that these carcasses make up the overwhelming majority of those which are downgraded.

In this study, the incidence of downgrading was recorded in 300,045 carcasses from pigs killed during one year in three bacon factories. The overall frequency was 4.67%. The incidence of Z-grading varied between the three factories but in each plant the frequency was always higher in boars than in non-boars and the differences were very highly significant ($P < 0.001$). The average frequency in boars was 5.29% compared with 4.51% in non-boars. However, there was evidence that the quality of preslaughter handling, rather than sex, was the most important factor determining the incidence of damage. No seasonal effect was apparent.

The variation in the incidence of damaged carcasses between the three plants suggests that much of the problem could be avoided by different preslaughter handling procedures, whenever possible avoiding mixing groups of unfamiliar pigs.

The effects of electrically induced live-animal muscle contraction on bovine muscle glycogen

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The effects of electrically induced immobilization (EI) and exogenous epinephrine on bovine longissimus muscle glycogen content were examined on 39 castrated males. The study was conducted in three trials on animals weighing about 445 kg and fed a high-energy density diet. Immobilization was accomplished by placing an electrode intramuscularly in the vicinity of the animal's tailhead and another electrode clamped to the jaw. A current of 55 volts at 240 milliamps was administered for 15 min. Epinephrine was administered subcutaneously (13.2 mg/100 kg live-animal weight). A needle biopsy and local anesthesia procedure was used to obtain a 2-gm longissimus muscle sample. The EI treatment had no effect on muscle glycogen content .5 or 24 h post-treatment; and free glucose, lactate or glucose-6-phosphate 24 h post-treatment. Exogenous epinephrine treatment of steers depleted (P<.01) muscle glycogen 30 to 35% of control animal muscle content 24 h post-treatment. No EI by epinephrine treatment interactions were observed. Data indicate that EI may be effectively used for immobilization and analgesia without affecting muscle carbohydrate metabolism.

The Effect of Preslaughter Stressors on the Blood Profiles of Pigs

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The amount of stress an animal undergoes preslaughter markedly affects meat quality. Severe stress or increased sensitivity to stress just prior to slaughter results in pale soft exudative meat (PSE) in pigs. Several parameters eg thyroid and adrenal function, serum enzymes have been implicated in the aetiology of the PSE condition and the stress response.

Experiments were designed to study some of the stressors that pigs are subjected to preslaughter. These included the effect of mixing, fasting and overnight lairage. Several experimental studies were undertaken, the main parameters measured were plasma cortisol and thyroxine and in some experiments serum enzyme activities.

In experiments where blood samples were collected prior to despatch to the abattoir and blood collected at slaughter, plasma cortisol levels were significantly higher and thyroxine levels significantly lower at slaughter. To examine the effects of fasting and mixing of pigs on circulating hormone levels, blood samples were taken from two groups of pigs on three consecutive days over a period of three weeks. There was considerable day to day variation in the measured circulating cortisol and thyroxine levels. Mixing the two groups of pigs together resulted in significant increases in plasma cortisol levels in the order 50 percent. In one group of pigs which was fasted after mixing to simulate conditions of overnight lairage, the fasting had no marked additional effect on cortisol and thyroxine levels.

To investigate the effect of overnight lairage on hormonal status, blood samples were taken from 4 different producer groups of pigs when they arrived at the abattoir, 3 h and 24 h after arrival. During lairage the pigs were not fed but had free access to water. Plasma cortisol levels 24 h after arrival (4.6 µg %) were significantly lower than those on arrival (5.6 µg %). Serum thyroxine levels at slaughter were significantly lower than at all previous sampling times in the lairage.

The collection of blood samples may result in considerable variation in the circulating hormone levels, due to the amount of stress involved during sampling or the sensitivity of the animal to stress. Of the preslaughter stressors examined the results indicate that mixing may be the greatest stress as measured by cortisol levels and that during overnight lairage pigs may settle down.

The effect of short or long electrical stunning times upon pork quality

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There is very little information in the literature about the effect upon meat quality of short or long electrical stunning of pigs. Sometimes stunning times in excess of 12 seconds are used. During these long stunning times, the animals are "fixed" and are easily shackled afterwards. When stunning for 2 seconds, strong clonic contractions make the bleeding operation difficult especially when collecting blood for human consumption.

It was anticipated that long stunning times might create more PSE and DFD, as well as bloodsplash; it was thought also that it might increase the incidence of broken bones.

In the tests carried out, stunning times of 2 or 12 seconds with 320 volts A.C. were used for pigs standing on the floor. It was found that the longer stunning times increased the incidence of stress meat, as well as bone fractures and bloodsplash.

A method of pre-slaughter immobilization of animals

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On the basis of theoretical and experimental studies a universal method of pre-slaughter immobilization of animals has been developed; it involves automatic stunning with direct electric current on the conveyor. The use of this method and device allows

- to shorten stunning time down to 0.1 s;
- to eliminate animals' tactile and painful feelings, vocalization, heart fibrillation, haemorrhages in the internal organs, muscle and fat tissues;
- to improve the results of veterinary and sanitary inspection;
- to improve considerably meat quality.

To immobilize animals, a single pulse of electric current with the duration of up to 0.6 s is used, the current being transmitted from the head down to the legs of the animal. The above pulse of electric current immobilizes rabbits, beef animals, pigs and small cattle. After stunning muscles are relaxed and heartbeating is maintained, this effect being due to a short treatment which in duration and value is equal to the postsynaptic potential of the brain of the immobilized animals.

Histological examination demonstrated a more complete bleeding of the muscular and fatty tissues and internal organs as compared to stunning with different methods (with electric current 50 Hz, 2400 Hz, with a pistol, etc). The water holding capacity of the meat of the animals stunned with the developed method is also higher.

The specification on the suggested device is as follows:

- | | |
|--|------------|
| - output, heads/hr | up to 840 |
| - consumed power, kWt | up to 10 |
| - power consumption per 1,000 heads/kWhr | up to 2 |
| - overall dimensions, mm: length | 1,300 |
| width | 800 |
| height | 1,900 |
| - weight, kg | up to 800. |

The effects of inducing a cardiac arrest at stunning on brain function, bleeding efficiency and susceptibility to carcass bruising in sheep

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This series of experiments examined the humanitarian and commercial effects of using a stunning method which simultaneously induced a cardiac arrest.

Electrically-induced cardiac arrest in anaesthetised sheep resulted in brain failure, as determined by the evoked potential technique, in 28 sec. This was quicker than the time to loss of evoked responsiveness in the brain for sheep stunned and slaughtered by traditional methods which did not involve a cardiac arrest. In 30 unanaesthetised sheep, it was found that a cardiac arrest plus epileptiform activity in the brain could be induced by using the head-to-back electrical stunning method when it delivered 1 amp of current. In 61 sheep which were stunned with the same current but using the head-only tongs, it was found that only one animal developed a cardiac arrest.

The effect of inducing a cardiac arrest at electrical stunning on the susceptibility of the carcass to bruising and the rate of bleeding from the sticking wound were evaluated in thiopentone anaesthetised sheep. Bruising was induced with a percussion pistol and measured in terms of meat appearance and extractable haem pigments. Cardiac arrest caused a prompt and marked reduction in susceptibility to bruising before the animal was stuck. Stunning without inducing a cardiac arrest was only associated with a reduction in bruising once 50 per cent of the total blood loss had occurred after the animal had been stuck. The rate of bleeding from the sticking wound was slower when the animal was subjected to a cardiac arrest at stunning.

It is concluded that inducing a cardiac arrest at stunning was a quicker method of killing the animal than the conventional methods involving head-only stunning followed by sticking. Inducing a cardiac arrest at stunning can be achieved with the head-to-back method when using 1 amp of current. Such methods can result in slower bleeding at sticking, and they would help to reduce the expression of bruises inflicted at the point of slaughter.

The effects of dietary management on beef composition and quality

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The effects of prefinishing nutritional regimen (low and high-energy) and the subsequent effects of feeding a high-energy density diet for 0, 56, 112, or 168 d of 20 mo of age on beef composition and quality were studied. One-half Simmental x 1/4 Hereford or 1/4 Angus x 1/4 Bos Taurus steers (n=162) were selected from 8 mo old calves and assigned to one of two prefinishing diets. At 14 mo of age steers were assigned to length of time by slaughter age treatments (n=18). At a constant age, amount of connective tissue increased with increased length of time steers were fed for the longissimus muscle (LM). Peak shear force decreased after 56 d on feed and subsequent 56 d of feeding produced no decrease in peak force for the longissimus. Tenderness was not affected by length of time fed. Increased length of time on the high-energy diet resulted in higher marbling scores, dressing percent, longissimus area and USDA yield grade. Steers on a low prefinishing regimen required at least 112 d on a high-energy finishing diet to attain acceptable quality and yield grade; whereas, steers prefinished on a high-energy diet required only 56 d.

A comparative study of the rate of fat deposition in two strains of broiler cockerels

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Over the past 25 years, improvement in the broiler industry through genetic selection, improved diets and more efficient management practices has resulted in a broiler that is slaughtered at a younger age. The modern broiler chicken, however, has been criticized for its excessive fat, particularly abdominal fat. This excessive fat has become a source of concern for the industry in that it is increasing trimming loss associated with further processing. Complaints of excessive fat have also been heard from the consumer and the fast-food trade. The question then arises whether the seemingly excessive fatness observed in the modern broiler is the result of a change in the pattern of fat deposition or of changes in the broiler rearing conditions that took place during the last 25 years.

Two strains of broiler cockerels, one experimental and one modern commercial stock, were serially slaughtered between one week and 17 weeks of age. The experimental strain, unselected since 1956, represented broilers of that period. All birds (53 for experimental strain and 52 for the commercial stock), hatched and reared simultaneously using modern practices, were fed a broiler starter ration (23% CP and 13.18 MJ/kg ME) and subsequently a broiler finisher ration (18% CP and 13.1 MJ/kg ME). Abdominal fat (consisting of gizzard and leaf fat) and the chemically determined fat (ether extract) of the eviscerated carcass were recorded for each broiler. The rate of deposition of these two fat components relative to the eviscerated carcass was then calculated using the allometric equation $Y = ax^b$, where 'Y' is the weight of fat, 'X' the weight of eviscerated carcass, 'b' the relative rate of deposition for fat and 'a' a constant.

Under modern rearing conditions, the modern broiler cockerel was heavier ($P < 0.01$) and indeed contained ($P < 0.01$) more chemical and abdominal fat than the experimental broiler cockerel when compared at a similar age. The rate of deposition relative to the eviscerated carcass for chemical fat did not differ ($P > 0.05$) between the two strains (1.10 and 1.08, respectively). Similarly, the intercepts ('a') for these relationships were not different ($P > 0.05$). The relative rate of deposition for abdominal fat was slower ($P < 0.01$) for the modern cockerel (1.35 vs 1.76) but this slower rate was compensated by a larger intercept. Hence, at equal weight of eviscerated carcass, differences in carcass chemical fat and in abdominal fat were minimal, particularly in the 900-1400g weight range.

It is hypothesized that the perceived excessive fat found in the carcass of the modern broiler arose not from changes in the broiler stocks during the past 25 years but rather from changes in broiler rearing conditions. Furthermore, a downward shift in the relative rate of deposition for abdominal fat was observed but did not drastically change the abdominal fat content of the carcass, particularly at the weight range relevant to the broiler industry.

Pig carcass assessment in grading and breeding

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The average weight of carcasses in the Swedish pig production is close to 75 kg. Most carcasses have a weight within the 70-80 kg range. Expressed in relation to carcass weight without head, the meat percentage averages 58. Pigs in the pig progeny testing system are about one percentage unit leaner. The amount of fat is about 30 percent, skin included.

A new grading system has been used since April 30, 1984. It is based on an estimated meat percent, the estimation being based on two backfat readings and one measure of the thickness of m. longissimus dorsi. The measurements are made with the Hennessy Grading System. The measures are combined in the following equation to give the estimated meat percent of the carcass

$$\text{MEAT \%} = 65.10 - 0.20 \cdot f_1 - 0.54 \cdot f_2 + 0.12 \cdot m$$

where

f_1 and f_2 are the thickness of backfat 8 and 6 cm from the mid-line at last rib and third/fourth last rib respectively

m is the thickness of m. longissimus dorsi at third/fourth last rib.

The calculated meat percent is marked on the carcass and used as base for payment to the producer and in the trade with carcasses.

In the pig progeny testing system the carcasses are evaluated by cutting the carcass and defatting back and ham. The percentage of ham, percentage of meat plus bone in back and ham together with the length and sex of the carcass are combined in a multiple regression equation that gives an estimate of the meat in the whole carcass. Different equations are used for the four breeds (Landrace, Yorkshire, Hampshire and Duroc). About 5,000 carcasses are evaluated each year according to these rules. 400 of these carcasses are completely dissected. The result from these dissections are used for recalculation of the equations each year.

Variation in the shape of the leg from beef carcasses of different conformation : application to beef carcass classification

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Variation in conformation of the hind limb of cattle has been studied by measuring, on photographs of carcasses adjusted to the same leg length, the morphological traits of the apparent profiles of the leg, in the medial and in the dorsal views.

The carcasses studied were those chosen by the European Association for Animal Production (EAAP) for the standardised system of appraisal of beef carcass conformation. The EAAP standards have been used to obtain two sets of black and white photographs scaled so that AS = 15 cm or AB = 20 cm (where A = apparent calcaneum tuber, B = lower caudal edge of the last lumbar vertebra, S = cranial edge of the symphysis pubis). On these photographs conformation of carcasses was assessed by the measured distances between external outlines of carcasses (profiles) and some reference axes (e.g. AB, AS, DS, and vertical axis passing through D, where D = lower edge of the hook supporting the carcass at the level of Achilles tendon).

The results show that with the improvement of conformation, from the class 1 - to the class 5 +, the changes in the profiles are of greater extent in the posterior area of the limb than in the anterior one and more evident in the medial portion of the limb than in the lateral one. The variation depends on the reference axes considered and on the observation angle relative to these axes.

The relationships existing between the EAAP conformation classes and the morpho-anatomical traits of the profiles have been studied by multivariate analysis (method of centered data). It appears that the different measurements studied are not equally suitable to assess the differences existing between animals. Their usefulness depends on the reference axes and on the anatomical level of observation.

The best ranking of individuals, between carcasses considered at constant AB length (= 20 cm), was observed from the medial view of the carcass, using the transverse diameter (X) measured by drawing, from the point I (such as AI = 35/100 AB) an inclined axis at an angle of 70° to AB. The value (Y) of the transverse horizontal diameter of the dorsal view of the carcass at the level of I may be incorporated to calculate a conformation index (C), which is the product XY and which is highly related to the values of the conformation score calculated from the references classes of the EAAP system.

It could thus be suggested to adopt this new index (C) to objectively assess the carcass value for conformation and to define reference standards in any international system of beef carcass classification (such as the EEC one). The methods to use, in practice, to measure this index are discussed in the paper.

Interrelationships between some physico-chemical traits of muscles from beef carcasses of different conformation, weight and age

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The basic biochemical composition of meat was studied in five muscles (Adductor (AD), Biceps femoris (BF), Longissimus dorsi pars lumborum (LDL), Longissimus dorsi pars thoracis (LDT), Semimembranosus (SM)) by considering the following characteristics: pH, amount of haem iron (Fe), frequency of the isoenzyme 5 of LDH (ISO 5), amount of sarcoplasmic protein nitrogen (Nps) and its ratio to total nitrogen (Nps/Nt) and to soluble nitrogen (Nps/Ns), and the ratio of 1-Ns/Nt. Analyses were made on meat taken at 3-4 days post mortem from ten beef carcasses chosen to represent a commercial sample of the type of carcasses existing on the French market (carcass weight = 316.2 ± 66.9 kg, age = 51.2 ± 23.7 months, conformation score (EAAP method) = 9.1 ± 3.3).

The relationships existing between traits were studied by the multivariate analysis of the centered data. The level of each character was found to differ between muscles. Each muscle was well defined by a specific average biochemical profile. The traits differed in their variability (coefficients of variation (%)) ranged between 1.3 - 1.9 for pH, 1.7 - 2.9 for 1-Ns/Nt, 9.2 - 15.0 for ISO 5, 18.7 - 22.9 for haem iron, 6.1 - 26.3 for Nps, 7.9 - 26.2 for Nps/Nt, 3.2 - 16.1 for Nps/Ns).

The relative importance of each trait in explaining the within-muscle variability of biochemical composition between the different animals was slightly different from one muscle to the other. ISO 5 is the major trait for explaining the differences existing between carcasses for AD, BF and LDL, and Nps discriminates better between animals for LDT and SM. Whatever the muscles a strong opposition exists in the projection between some traits, e.g. between ISO 5 and Nps, or between Nps and 1-Ns/Nt. The opposition between ISO 5 and Fe is very clear in BF, but less marked in LDL or LDT, and least in AD or SM. In the projection space determined by the first three axes, which together explained on the average 98% of the variation found in the muscles - a very constant reciprocal opposition, two by two, was found between each of the traits of the triplet (ISO 5, Fe, Nps) or between those in (Nps, ISO 5, 1-Ns/Nt). The same situation was also found in pigs and thus the equilibrium existing between ISO 5, Fe and Nps seems to be a general rule of the organization of biochemical composition of muscle generally.

The effect of conformation on the variation in biochemical composition is more or less evident depending on the particular muscles, and the variation in conformation does not affect in the same way the same traits of the different muscles. For SM and AD a strong opposition exists along the first axis of projection between conformation and Nps; for SM, LDL and LDT Fe is opposed to conformation along the third axis of projection.

The consideration of the other characteristics such as carcass weight or age shows that they affect the muscle composition more than conformation does. Their effects on the various traits are not the same for all muscles. In all muscles but SM, Fe is closely related to age and opposed to weight; the latter is strongly opposed to Nps in SM and AD.

Pig carcass evaluation with Fat-o-Meater device

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In order to apply EEC Grading, linear measurements of fat and muscle thickness were taken by Fat-o-Meater device on 537 pig carcasses, from which 200 were dissected within the range of 70-95 kg net weight. Mean lean content of carcasses was $49.0 \pm 3.1\%$ with RSD = 0.73% lean as reference of dissection.

Compared to previous programming, the Danish equation over-estimated the lean content by 2.9%, while the German equation provided a correct estimation of lean, giving agreement with EEC Grades for 72.5% of the total sample.

New programs were established related to the dissection results in order to accommodate various slaughter line speeds: the complete equation, including the net weight and 3 other measurements gave error RSD = 1.76% lean, while simplified equations without weight and only 2 measurements gave error RSD = 2.11% lean. In these procedures, agreement with EEC grades was found for 74.5 and 68% of carcasses.

In other ways, the fat content was evaluated with higher accuracy than the lean content with FOM measurements, without weight. Conversely, net weight and carcass length may be used for estimating muscle "blockiness" in combination with fat and muscle thickness. Further research is necessary in order to assess the importance of large variations in muscular development, ("conformation scores") as additional criteria in EEC grades.

Comparison between carcass quality from steers and cows

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Meat from cull cows comprises about 40% of the red meat for consumers in Brasil and at the present time it is sold for the same price as meat that comes from steers. The present work was conducted to compare carcasses and meat quality from old cows (15 Charolais and 15 Devon) with meat from steers of about 2.5 years old (12 Charolais and 12 Devon) that were kept partially on cultivated grass during the winter time. Cows were fattened on native grasses only. At slaughter both groups presented similar carcass weights, 203.87 and 208.84 kg for steers and cows respectively. Cows displayed a better finish, 2.65 mm of external fat and a small amount of marbling, against 1.37 mm and a slight amount for steers. Steers presented "Good" conformation, whereas cows, "Standard". Steers also displayed non-significantly better muscling as evidenced by larger Longissimus area and thickness of cushion (round). The proportion of the pistol cut (8 ribs) was similar for both groups: 49.19% for steers and 49.51% for cows. Meat from cows was evaluated as being coarser and darker in colour, and the steaks when cooked to an internal temperature of 70°C, significantly less tender than the ones from steers.

Collagen content of meat carcasses of known history

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Thirteen beef carcasses and twenty-seven pig carcasses were analysed for collagen content. The beef carcasses were drawn from four breeds, Hereford, Friesian, Charolais and Aberdeen Angus; they included animals from four levels of fatness. They were dissected into ten joints: from the forequarter; shin, brisket, Jacob's ladder, clod, sticking, fore-rib and chuck; from the hindquarter; leg, thin flank and other joints (which included rump, loin and top-piece). Samples of each joint were analysed for fat, moisture and collagen. Samples of the total forequarter and hindquarter meat were also analysed.

The pig carcasses were drawn from three weight groups; heavy, bacon and pork weight, and three levels of fatness; fat, average and lean. Samples from each carcass were analysed for fat, moisture and collagen. Six of the pigs, selected to cover the differing weight groups and fat levels, were dissected into five joints: hand, collar, back, streak and ham. Samples of each joint were analysed as above.

Results from beef carcasses showed that the level of collagen in meat from the forequarter (3.2% wet fat-free) was significantly higher than in meat from the hindquarter (2.7% wff). Mean collagen values for butchered joints range from 2.3% wff in the loin to 4.8% wff in the shin. Within the forequarter percentage collagen in the shin was significantly higher than in the other six joints. Within the hindquarter percentage collagen was significantly highest in the leg (4.2% wff) and significantly higher in the thin flank (2.96% wff) than in the "other joints" (2.34% wff).

Results for pig carcasses showed an overall mean value for collagen of 2.2% wff. Collagen levels in butchered joints ranged from 1.8% wff in the ham to 2.9% wff in the hand. Percentage collagen was significantly highest in the hand.

The effects of anabolic agents on aspects of carcass value in cattle

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Over 50% of unbred cattle slaughtered in the United Kingdom are implanted with anabolic agents, and this management practice has extensive economic implications for the meat industry. Evidence for this is based almost entirely on growth performance and related feed costs; there is little information available on the changes in carcass composition, yield and meat quality which are themselves important economic factors. This study examined the effects on these traits of a twice-implanted (80d and 300d) combined androgenic/oestrogenic compound (Revalor, Hoechst) in cattle twins, and three comparisons were made within pairs: (i) bulls (B1)/steer (S); (ii) bull (B2)/implanted steer (IS); (iii) bull (B3)/implanted bull (IB). All animals were fed a complete pelleted diet *ad libitum* to slaughter at 400d of age.

Final live weight was significantly different only in (i), with values of (B1) 409 kg and (S) 379 kg ($p < 0.05$). Feed intake was not significantly different in any comparison, but the conversion of feed into lean tissue (kg DM/kg) was significantly different in (i) and (ii), with values of (B1) 22.7, (S) 27.0 ($p < 0.01$) and (B2) 23.3, (IS) 26.6 ($p < 0.001$) respectively. Bulls (B1) were leaner than steers (S), (657 and 601 g/kg respectively, $p < 0.01$), and bulls (B2) were leaner than implanted steers (IS), (654 and 605 g/kg respectively, $p < 0.001$). Control bulls (B3) were significantly less fat than implanted bulls (IB) for both subcutaneous and intermuscular depots (52, 116 and 64, 127 g/kg respectively). Certain neck muscles were significantly heavier in B1 than S, but differences were reduced between B2 and IS, and the trend was for these muscles in IB to be bigger than in B3. The ratio of lean to bone was greater in B1 than S (4.00 and 3.74 respectively, $p < 0.01$) and although the difference was reduced in (ii), it was significantly greater in B2 than IS, (4.12 and 3.95 respectively, $p < 0.05$). Within any comparison, there were only small differences in the chemical composition of the lean tissue, and these were related to the differences in dissectible fat proportion. Thus, there was more lipid in S than B1, and in IS than B2 (43, 25 and 37, 28 g/kg wet weight, respectively).

Anabolic agents appear to have small effects in bulls. In steers they allow animals to be slaughtered at heavier weights without increasing the fat to lean ratio, and they improve lean to bone ratio. There is little effect on meat quality and the net result is an increase in carcass value.

New equipment for estimating carcass composition by measuring the speed of ultrasound in the living animal

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New equipment for measuring the speed of ultrasound in the soft tissues of farm livestock is described and its application to the estimation of carcass composition is reported. The equipment, built to MRI specification by Wells Krautkramer Ltd. has been undergoing field trials since April, 1982. Two ultrasonic transducers, one acting as a transmitter, the other as a receiver are held in-line and facing one another at predetermined points on opposite sides of the animal using a specially designed frame. An electronic system automatically carries out a standard sequence of operations to obtain a valid measurement of the mean reciprocal speed (T/V). It measures the time of flight (τ) of an ultrasonic pulse from one side of the animal to the other, records the distance (d) separating the transducer faces and computes the ratio $\tau/d = T/V$. The three parameters are displayed by the unit and are available on an RS232 line for external logging and printing. The precision of the measurements is discussed. The field trials have confirmed on female cattle a highly significant and useful correlation between ultrasonic measurements of the live animal and the composition of the carcass, determined by dissection, supporting earlier findings on steers and bulls.

The relationship between liveweight and carcass weight in steers of different maturity type fed high and low energy diets

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One hundred and ninety feeder steers, comprising 64 small rotational crossbreds (mainly Hereford crosses), 66 large rotational crossbreds (mainly Charolais and Simmental crosses) and 60 Holsteins were fed either a concentrate diet based on corn silage and high moisture corn, or a forage diet based on corn silage and alfalfa haylage. All steers were fed ad-libitum, weighed every 28 days and slaughtered at random to cover the normal ranges in market weights. Steers were removed from feed 36 h and water 16 h prior to slaughter. The internal organs, visceral fat depots (including kidney and pelvic fat), components of the emptied digestive tract and other non-carcass parts (head, hide and feet) were weighed fresh in the abattoir. One side from each carcass was physically separated into fat, lean and bone.

Large rotational crossbreds had the highest proportion of warm carcass weight relative to empty body weight, while Holsteins had the lowest when comparisons were made at the same degree of external fatness. Small rotational crossbreds had intermediate values. Large rotational crossbreds had significantly lower proportions of body organs (liver, lungs, kidneys), non-carcass parts (head, hide) and digestive tracts (rumen, omasum, small and large intestines) relative to empty body weight than small rotational crossbreds. Holsteins had the lowest proportions of hide, but had the greatest proportion of their empty bodies as body organs (spleen, heart, liver, lungs, kidney), visceral fat depots (caul, mesenteric, kidney and pelvic), components of the digestive tract and non-carcass parts (head and feet). There were no differences in the proportion of carcass weight relative to empty body weight for animals fed concentrate or forage diets. However, animals fed concentrate diets had a greater proportion of their empty bodies as liver, lungs and visceral fat and a lower proportion as head, hide, feet and components of the digestive tract than animals fed forage diets. Growth coefficients revealed that warm carcass weight increased at a similar rate to empty body weight while the body organs and digestive tract became a lower proportion of empty body weight gain as empty body weight increased. The visceral fat depots however became an increasing proportion of empty body weight gain with increasing empty body weight.

The present study has shown important differences in dressing percentage for steers of different maturity types caused by differences in distribution of offal components when compared at the same level of external fatness. Diet was found to have no influence on dressing percentage when the effect of gutfill was removed.

The effect of the dietary concentration of linoleic acid on its deposition and on the consistency of pig backfat

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High proportions of linoleic acid, n-6 C18:2, in the lipid are a major cause of softness of pig backfat but as an essential fatty acid it is a necessary component of the pig's diet. The AFRC recommended allowance is 3% of digestible energy (DE) in pigs up to 35 kg live-weight and 1.5% DE for animals fattened to 90 kg. The proportion of linoleic acid deposited in the backfat depends upon its concentration in the diet, the degree of fatness of the carcass and the rate of fat deposition. Tissue firmness has been determined, until recently, by a subjective finger probe method but a mechanical technique, developed at this Institute, has made it possible to quantify the tissue consistency. The aim of this study was to determine the relationship between the proportion of linoleic acid deposited in backfat in pigs fed with three concentrations of linoleic acid up to 35 kg live-weight and to 85 kg and to relate this to the firmness of the tissue.

Groups of 20 weanling pigs were fed starter diets containing 0.8%, 1.1% and 1.8% linoleic acid and when they reached 35 kg live-weight, 5 pigs from each group were slaughtered. The remainder were changed to finisher diets containing 1.0%, 1.2% and 1.4% of linoleic acid respectively and were slaughtered when they reached 85 kg live-weight. The diets were fed ad lib until the end of week 8 after which the pigs were restricted to 2.6 kg/day.

The pigs grew at similar rates on all three diets with an average daily gain on the starter diet of 0.72 kg and on the finisher diet of 0.87 kg. The inner layer of backfat contained 9.8%, 13.6% and 17.0% linoleic acid in the lipids of pigs at 35 kg fed on the low, medium and high linoleate diets respectively. In the backfat of pigs slaughtered at 85 kg the proportions of linoleic acid were 8.6%, 11.0% and 13.9% respectively. There was a highly significant ($P<0.01$) inverse relationship between the backfat thickness and the proportion of linoleic acid present in pigs fed either on the medium or high linoleate diets. The firmness of the backfat measured mechanically or by using the finger as a probe decreased as the proportion of linoleic acid in the diet increased but the finger test was less discriminatory than the mechanical probe. The firmness of backfat from pigs on the high and medium linoleate diets was inversely related to the concentration of linoleic acid in the lipid but the relationship was not significant for pigs fed the low linoleate diet.

None of the pigs had unacceptably soft fat, usually indicated by more than 15% linoleic acid in the backfat, and pigs on the low and medium linoleate diets would not have reached this value even at a backfat thickness (P_2) of 5 mm. However, this concentration would have been exceeded by pigs on the high linoleate diet at a P_2 of less than 11-12 mm. Since all the finisher diets exceeded the AFRC recommended linoleate concentration, the latter is compatible with the production of firm backfat at least in pigs fattened at similar rates to those in this study.

Carcass quality in refed cull Friesian cows

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Cull cows are an important source of beef in the United Kingdom, contributing 25% to all cattle slaughterings. Of these over 76% are derived from the dairy herd. The carcasses, and meat, from these animals, particularly when in poor condition, have traditionally been regarded as inferior in quality when compared with 'clean beef' and this is reflected in the large price differential between the two types. However, cull cows in good condition at specified weights command a premium over poorer animals. This suggests that some producers may be able to improve economic returns on cattle sales by feeding their cull cows prior to disposal.

This study examined the effects of feeding complete pelleted diets, containing 10.6 or 11.7 MJ metabolisable energy/kilogram dry matter to cows in thin condition for periods of 28, 56 or 112 days. Carcass composition, saleable meat yields and components of trim were determined, using standard dissection and butchery methods, on a total of 28 cows.

There were small, non-significant effects of diet on all parameters measured. The data presented is therefore pooled across diets. With time on feed carcass weight increased significantly ($P<0.05$), from an initial value of 235kg, to 254, 286 and 303kg after 28, 56 and 112 days respectively. Killing-out percentage also improved significantly ($P<0.05$), from 47.0%, to 47.1, 51.5 and 50.8. As carcass weight increased so too did fatness, resulting in increasing levels of fat trim with time on feed (5.9, 11.6 and 13.8% at 28, 56 and 112 days). As the level of carcass finish (subcutaneous fatness) is an important determinant of perceived carcass value, all data were examined, by covariance, at a constant subcutaneous fat level of 6.35%. When compared in this way there were no significant differences between cows slaughtered after 28, 56 or 112 days in saleable meat content (72.4, 71.9, 71.1%), percent fat in saleable meat (13.0, 13.8, 13.4) or percent lean in the side (87.0, 86.2, 86.6). This is mainly a reflection of consistent trimming during preparation and retail jointing. However, muscle:bone ratio was significantly ($P<0.01$) influenced by time on feed (3.77, 4.04, 3.68) reflecting variation in percent bone trim (18.5, 17.1, 17.4). The carcass Retail Value Index (RVI) was not significantly different between slaughter groups (68.7, 67.5, 65.8), but did tend to decline with time on feed, which was consistent with the overall decline in saleable meat content of the fatter animals, and the positive relationship between RVI and percent saleable meat. At constant subcutaneous fat content the proportion of saleable meat in the high-priced cuts was similar between groups (45.2, 45.1 and 43.4% at 28, 56 and 112 days respectively).

These results suggest that feeding cull Friesian cows, for up to 112 days, can lead to an increase in the value of the animal. This increase in value comes about by an increased weight of carcass and an increase in price/kilogram paid for that carcass because of the added weight and improved fat cover.

