Brit. J. Nutr. (1960), **14**, 255

Analysis of longissimus dorsi muscles from cattle implanted with hexoestrol

By R. A. LAWRIE

Low Temperature Research Station, Cambridge

(*Received* 29 *August* 1959—*Revised* 13 *January* 1960)

It is now well established that the effect of synthetic oestrogens (administered orally or implanted as pellets) in enhancing the rate of weight gain in cattle and sheep is associated with a decrease in the percentages of subcutaneous, perinephritic and intermuscular fat. There is a concomitant increase in the percentages of bone and edible meat, the latter having an apparently higher moisture content (Burris, Bogart, Oliver, Mackey & Oldfield, 1954; Lamming, 1956; Bindloss, 1958). Despite certain reports that the muscles from implanted animals are 'dark-cutting', little attention has been given to the more detailed composition of the lean meat from implanted animals. The available analytical data refer almost exclusively to joints (Burris *et al.* 1954; Wierbicki, Kunkle, Cahill & Deatherage, 1956; Gee & Preston, 1957; Davey & Wellington, 1959). In the present paper a brief account is given of the effects of implantation in steers on the composition of the longissimus dorsi muscle.

METHODS

Animals. The principal source of samples was a group of twelve Friesian steers, paired on the basis of age and weight. One member of each pair was implanted in the ear with 120 mg hexoestrol (in pellet form) when 24–28 months old; the other was a control and was not treated. The steers were slaughtered when 36–40 months old. Samples were also obtained from certain unpaired implanted and control steers of different ages, including one animal implanted with 150 mg hexoesterol, and from a normal 12-day-old calf.

Sampling. That portion of the longissimus dorsi muscle corresponding to the 4th, 5th and 6th lumbar vertebrae was dissected from the carcasses at a standard time of 24 h *post mortem*. The muscular tissue was freed from intermuscular fat and from gross aggregates of connective tissue. It was then twice minced and thoroughly mixed. Samples were taken for chemical analyses.

Analysis. The dry weight, fat content and iodine value of fat in the samples were determined as described by Callow (1944), and ash was determined by ignition at 550°.

Total nitrogen, and non-protein, sarcoplasmic, myofibrillar and stroma nitrogen, obtained by differential extraction by the procedure of Helander (1957), were estimated by the usual micro-Kjeldahl technique, with some minor modification. Myoglobin, after extraction (Lawrie, 1950), was determined by the method of Biörck (1949), and the ultimate pH, i.e. the pH value finally reached when lactic-acid production

from glycogen, by anaerobic glycolysis *post mortem*, had ceased, was measured by a glass electrode. For this purpose 1 g of muscle was homogenized in 10 ml distilled water.

RESULTS AND DISCUSSION

It is clear from Table 1 that the content of intramuscular fat was lowered in the longissimus dorsi of implanted animals, but that the dry weights and ash content of the muscle were unaffected. There was thus no evidence of reversion to a form characteristic of the muscle of younger animals (cf. Table 3). Yet the lumbar region of the longissimus dorsi is a late-developing part (Hammond, 1932, pp. 392, 444) and might

Table 1. *Mean values with their standard errors for fat content and dry-matter content of longissimus dorsi muscles from six control and six implanted steers*

Variable	Control	Implanted
Intramuscular fat: content (%)	3·37 ± 0·33	2·42 ± 0·36
iodine value	57·45 ± 0·70	59·31 ± 0·90
Dry-matter content (%): whole-tissue basis	22·51 ± 0·13	22·70 ± 0·09
fat-free basis	23·29 ± 0·09	23·26 ± 0·09
Ash content (%, whole-tissue basis)	1·01 ± 0·04	1·02 ± 0·03

be expected to have a greater susceptibility to change. For example, under sub-maintenance conditions, the later-developing muscles tend to shrink more readily than those which develop early (Joubert, 1956); again, the lumbar regions of the longissimus dorsi are more severely affected by degenerative changes, in certain abnormal physiological conditions, than are portions in the thoracic region of the carcass (Lawrie, 1960). For unpaired samples the concentration of intramuscular fat was 2·99 ± 0·35% in fourteen controls and 1·97 ± 0·23% in seventeen implanted steers. It is also evident from the iodine values in Table 1 that the intramuscular fat of implanted steers was more unsaturated than that of the control steers, which could be explained by the inverse relationship between the percentage of intramuscular fat and its iodine value, referred to by Callow & Searle (1956–7).

The lower percentage of intramuscular fat found in implanted steers is in agreement with the general leanness superficially observed in the carcasses of treated animals. The relative absence of marbling fat tended to make the cut surface of the longissimus dorsi muscle at the quartering point appear somewhat redder than usual. In this sense only it was 'darker', but there was no suggestion whatever of the sticky condition and purplish hue of true 'dark-cutting' beef. Nevertheless, together with the sparse cover of subcutaneous fat, through which the purplish red colour of myoglobin in the underlying musculature will be more readily observed, this appearance may account for the frequent designation of hormone-implanted beef as 'dark-cutting'.

The nitrogen content of various muscle components, as defined by the method of Helander (1957), is given in Table 2. It is clear that the distribution of nitrogen was virtually identical in longissimus dorsi muscles from control and implanted animals. There was, again, no suggestion of a reversion to a form characteristic of younger

animals, in which a low percentage of fat and a high percentage of moisture is accompanied by a low nitrogen content, both overall and in myofibrillar and sarcoplasmic fractions (Table 3).

The mean ultimate pH, for the lumbar region of the longissimus dorsi muscle, was $5{\cdot}48 \pm 0{\cdot}01$ and $5{\cdot}51 \pm 0{\cdot}01$, respectively, in six pairs of control and treated carcasses. In somewhat larger unpaired groups the mean values were $5{\cdot}53 \pm 0{\cdot}02$ in fourteen control, and $5{\cdot}52 \pm 0{\cdot}01$ in seventeen implanted, animals. The major prerequisite for the occurrence of dark-cutting beef, namely a high ultimate pH (Lawrie, 1958), was thus absent. Moreover, the mean myoglobin concentrations in longissimus dorsi muscles from control and implanted animals were also identical, being within the range 0·42–0·43%. Reports of dark colour in the lean of implanted beef cannot, therefore, be substantiated by the alternative prerequisite of a higher pigment concentration in the muscles of implanted animals.

Table 2. *Mean values with their standard errors for nitrogen fractions in longissimus dorsi muscles from six control and six implanted steers*

Fraction	Control	Implanted
Total nitrogen (%): whole-tissue basis	$3{\cdot}51 \pm 0{\cdot}01$	$3{\cdot}53 \pm 0{\cdot}02$
fat-free basis	$3{\cdot}63 \pm 0{\cdot}01$	$3{\cdot}63 \pm 0{\cdot}03$
Non-protein nitrogen (%, whole-tissue basis)	$0{\cdot}43 \pm 0{\cdot}01$	$0{\cdot}44 \pm 0{\cdot}01$
Sarcoplasm nitrogen (%, whole-tissue basis)	$0{\cdot}88 \pm 0{\cdot}02$	$0{\cdot}89 \pm 0{\cdot}01$
Myofibril nitrogen (%, whole-tissue basis)	$1{\cdot}83 \pm 0{\cdot}06$	$1{\cdot}77 \pm 0{\cdot}05$
Stroma nitrogen (%, whole-tissue basis)	$0{\cdot}36 \pm 0{\cdot}06$	$0{\cdot}44 \pm 0{\cdot}06$
Ratio, myofibril nitrogen: total nitrogen	$0{\cdot}52 \pm 0{\cdot}02$	$0{\cdot}50 \pm 0{\cdot}01$

Table 3. *Comparison of composition of the longissimus dorsi muscle of calf and steer*

Characteristic of muscle	12-day-old calf	3-year-old steer
Dry-matter content (%)	21·49	22·20
Intramuscular fat (%)	0·55	3·69
Iodine value	82·41	56·50
Moisture (by difference) (%)	77·96	74·11
Ash (%)	1·17	0·96
Nitrogen (%)		
Total	3·30	3·52
Non-protein	0·36	0·39
Sarcoplasm	0·62	0·87
Myofibril	1·52	1·61
Stroma	0·80	0·65
Myoglobin (%)	0·07	0·46
Ultimate pH	5·54	5·57

The observations thus demonstrate that although the fat content of the longissimus dorsi muscle of steers implanted with hexoestrol was diminished there was no evidence that the muscle contained any more moisture or any less nitrogen than in untreated steers. The benefits of increased growth rate and high efficiency of food conversion, which are sought and generally effected by implantation, do not therefore appear to be offset by any deterioration in the quality of the musculature in the carcasses.

SUMMARY

1. One member of each of six pairs of Friesian steers was implanted with 120 mg hexoestrol when 24–28 months old. The steers were slaughtered at 36–40 months old and the longissimus dorsi muscles, at the level of the 4th, 5th and 6th lumbar vertebrae, were analysed for moisture, ash, intramuscular fat (and its iodine value), myoglobin, nitrogen distribution and ultimate pH.

2. Muscles of implanted steers had a lower content of intramuscular fat (with a higher iodine value) than those of the controls, but similar moisture and total nitrogen contents (on a fat-free basis).

3. These findings, together with a normal distribution of nitrogen between sarcoplasm, myofibrils, stroma and non-protein fractions, indicated that implantation caused no reversion to a more primitive muscle form.

4. Reports that implanted steers yield 'dark-cutting' beef were not substantiated by the values found for ultimate pH or myoglobin.

The co-operation of Dr G. E. Lamming of the School of Agriculture, University of Nottingham, and of Messrs B. M. Scott and J. E. Whybrew of the Ministry of Agriculture, Fisheries and Food Experimental Husbandry Farms at High Mowthorpe and Boxworth respectively is gratefully acknowledged.

Technical assistance was given by Messrs S. J. Dant, W. A. Deer and R. P. Houghton.

REFERENCES

Bindloss, A. A. (1958). *Proc. Brit. Soc. Anim. Prod.* p. 39.
Biörck, G. (1949). *Acta med. scand.* **133**, Suppl. no. 226.
Burris, M. J., Bogart, R., Oliver, A. W., Mackey, A. O. & Oldfield, J. E. (1954). *Tech. Bull. Ore. agric. Exp. Sta.* no. 31.
Callow, E. H. (1944). *J. agric. Sci.* **34**, 177.
Callow, E. H. & Searle, S. R. (1956–7). *J. agric. Sci.* **48**, 61.
Davey, R. J. & Wellington, G. H. (1959). *J. Anim. Sci.* **18**, 64.
Gee, I. & Preston, T. R. (1957). *Brit. J. Nutr.* **11**, 329.
Hammond, J. (1932). *Growth and Development of Mutton Quality in the Sheep*, 1st ed. London: Oliver and Boyd.
Helander, E. (1957). *Acta. physiol. scand.* **41**, Suppl. no. 141.
Joubert, D. M. (1956). *J. agric. Sci.* **47**, 59.
Lamming, G. E. (1956). *Rep. Sch. Agric. Univ. Nottingham*, p. 66.
Lawrie, R. A. (1950). *J. agric. Sci.* **40**, 356.
Lawrie, R. A. (1958). *J. Sci. Fd Agric.* **11**, 721.
Lawrie, R. A. (1960). *J. comp. Path.* (In the Press.)
Wierbicki, E., Kunkle, L. E., Cahill, V. R. & Deatherage, F. E. (1956). *Fd Tech., Champaign*, **10**, 80.

Printed in Great Britain