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# Biochemical mechanisms related to overfatness in lambs

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A continuing problem in lamb production is overfatness of the carcass. This characteristic may be breed specific. Under conditions of unlimited feed availability there are a large number of biochemical changes that could cause abnormal fatness as shown in Diagram 1.

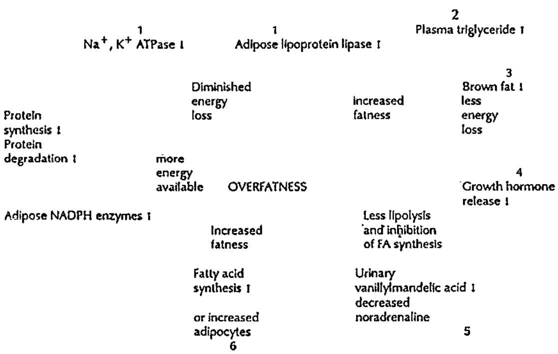


**Diagram 1.** Some changes in biochemical factors leading to overfatness ( ↑ increase, ↓ decrease). Overfatness results diminshed energy loss (1,2), hormones (3,4), increased fat (5,6) or increased energy available.

Southdown and Suffolk lambs and their Coopworth crosses were compared with the objective of investigating if some of the factors in Diagram 1 contributed to overfatness. The numbers in the diagram relate to the experimental approaches.

## MATERIALS AND METHODS

1. Six Suffolk x Coopworth, six Southdown x Coopworth and six Coopworth wether lambs were slaughtered at 3 weeks, 3 months and 6 months of age. Tissues were analysed for lipoprotein lipase (Tume *et al.*, 1983), $Na^+$, $K^+$ ATPase (Forbush, 1983) and carcass composition.
2. To test for the occurence of brown fat, Suffolk and Southdown lambs were injected with noradrenaline and the tissue temperature changes at selected sites were measured using a sensitive temperature probe and readout on a recorder.
3. Vanillylmandelic acid (VMA), a metabolite of noradrenaline was measured in total urine collections by HPLC from 12 Suffolk and 8 Southdown lambs, 5 months old, which were fed varying intakes of fresh cut grass.
4. The plasma growth hormone (GH) response to intravenous injection of 5 mg L-DOPA was measured on 6 months old Suffolk x Coopworth and Southdown x Coopworth lambs - 3 lambs of each breed per treatment.
5. Triglyceride (TG) entry rate was measured in Coopworth lambs and Merino sheep by the increase in plasma TG after inhibiting uptake of TG by lipoprotein lipase with Triton WR1339 (Otway and Robinson, 1967).
6. Fatty acid (FA) synthesis was measured *in vivo* using tritiated water (Jungas, 1964) in Southdown and Suffolk lambs (5 month ram lambs fed fresh cut ryegrass/clover and 9 month wether lambs fed lucerne/barley pellets).

## RESULTS AND DISCUSSION

1. There was no difference in adipose or muscle $Na^+$, $K^+$ ATPase which has been attributed to utilise up to 40% of maintenance energy requirements in tissues (Milligan, 1971) nor was there any difference in adipose lipoprotein lipase between breeds as has

**TABLE 2** Fatty acid synthesis in lambs

| Breed | Growth Rate g/d | Carcass Wt kg | FA Synthesis n moles/ gfat/min | Carcass Fat Synthesis g/d |
|---|---|---|---|---|
| Southdown(n=4) | Nil[a] | 12.2 | 7.6±1.6 | 7.7±1.2 |
| Suffolk(n=4) | Nil | 11.5 | 6.4±0.4 | 4.0±0.7 |
| Southdown x Coopworth(n=3) | 112[b] | 21.8 | 13.5±5.4 | 46.8±20.8 |
| Suffolk x Coopworth(n=3) | 212 | 20.8 | 8.8±2.9 | 17.5±13.1 |

[a] fed chopped fresh ryegrass/clover ad lib

[b] fed lucerne-barley pellets

been reported for different genetic lines of pigs (McNamara and Martin, 1982).

Analysis of total carcass components of the 6 month lambs showed there was no change in total fat but increased total protein ($P<0.05$) in Suffolk lambs.

**TABLE 1** Total fat and total protein of carcasses of different breed.

| Breed | Total Fat (Kg) | Total Protein (Kg) |
|---|---|---|
| Coopworth | 3.10±0.36 | 2.25±0.15 |
| Southdown x Coopworth | 3.72±0.32 | 2.35±0.09 |
| Suffolk x Coopworth | 3.60±0.12 | 2.86±0.08 |

2. No temperature rises following noradrenaline injection were detected at tissue sites similar to those where brown fat has been found in newborn lambs (Gemmell, *et al.*, 1972) or humans (Rothwell and Stock, 1979). Brown fat seems unlikely to be involved.

3. There was a slight increase in VMA output in Suffolk lambs with dry matter intake per kg metabolic body weight ($P<0.05$) i.e. an increased noradrenaline output in Suffolk lambs with increasing feed intake compared with Southdown lambs (Figure 2). The effect of intake on VMA was similar to previous observations for noradrenaline (Landsberg and Young, 1978). Noradrenaline is likely to have a negative effect on fat accumulation due to inhibition of fatty acid synthesis (Yang and Baldwin 1973) and its lipolytic effect.

4. L-DOPA caused a rise in plasma GH after 0.5h in Southdown lambs, rather than Suffolk lambs (Figure 1) as might have been expected from the report showing GH release in lean but not obese humans (Barbarino, *et al.*, 1978).

5. Neither starvation nor hormones such as GH or oestradiol caused any significant change in TG entry rate. Though Suffolk and Southdown breeds were not studied it is suggested that TG play an insignificant role in overfatness.

6. There was a small increase in fatty acid synthesis in Southdown lambs compared with Suffolk lambs but it was not significant (Table 2).

Overall there was little difference in most components measured. The differences in fatness of Southdown and Suffolk lambs (Kempster and Cuthbertson, 1977) may reflect differences in body size and total protein rather than the amount of fat. Differences in growth rate of the skeleton, relative rates of protein synthesis and degradation or multigene effects involving small changes are possible sources of these differences.

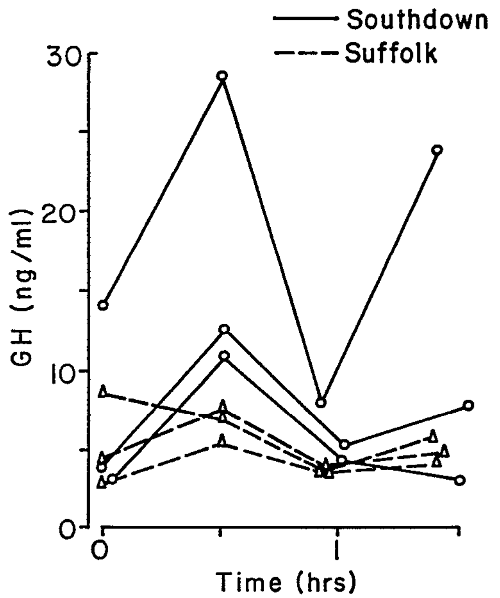


**FIG 1** The response of GH to an intravenous dose of L-DOPA in individual lambs.

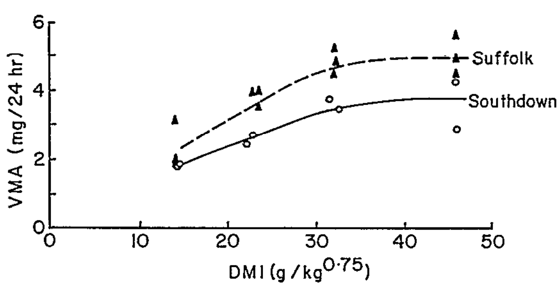


**FIG 2** The variation in VMA with dry matter intake (DMI) per kg metabolic liveweight.

## REFERENCES


Barbarino, A.; De Marinis, L.; Troncone, L. 1978. Growth hormone response to propanolol and L-DOPA in obese subjects. *Metabolism 27*: 275-278.

Forbush, B. 1983. Assay of $Na^+$, $K^+$-ATPase in plasma membrane preparations: increasing the permeability of membrane vesicles using sodium dodecyl sulphate buffered with bovine serum albumin. *Analytical Biochemistry 128*: 159-163.

Gemmell, R.T.; Bell, A.W.; Alexander, G. 1972. Morphology of adipose cells in lambs at birth and during subsequent transition of brown cells to white adipose tissue in cold and in warm conditions. *American Journal of Anatomy 133*: 143-164.

Jungas, R.L. 1968. Fatty acid synthesis in adipose tissue incubated in tritiated water. *Biochemistry 7*: 3708-3716.

Kempster, A.J.; Cuthbertson, A. 1977. A survey of the carcass characteristics of the main types of British lamb. *Animal Production 25*: 165-179.

Landsberg, L.; Young, J.B. 1978. Fasting, feeding and regulation of the sympathetic nervous system. *New England Journal of Medicine 298*: 1295-1301.

McNamara, J.P.; Martin, R.J. 1982. Muscle and adipose tissue lipoprotein lipase in fetal and neonatal swine as affected by genetic selection for high or low backfat. *Journal of Animal Science 55*: 1057-1061.

Milligan, L.P. 1971. Energetic efficiency and metabolic transformation. *Federation Proceedings 30*: 1454-1458.

Otway, S.; Robinson, D.S. 1967. The use of a non-ionic detergent (Triton WR1399) to determine rates of triglyceride entry into the circulation of the rat under different physiological conditions. *Journal of Physiology 190*: 321-332.

Rothwell, N.J.; Stock, M.J. 1979. A role for brown adipose tissue in diet-induced thermogenesis. *Nature 281*: 31-35.

Tume, R.K.; Thornton, R.F.; Johnson, G.W. 1983. Lipoprotein lipase of sheep and rat adipose tissues. *Australian Journal of Biological Sciences 36*: 41-48.

Yang, Y.T.; Baldwin, R.L. 1973. Preparation and metabolism of isolated cells from bovine adipose tissue. *Journal of Dairy Science 56*: 350-365.