New Zealand Society of Animal Production online archive

This paper is from the New Zealand Society for Animal Production online archive. NZSAP holds a regular annual conference in June or July each year for the presentation of technical and applied topics in animal production. NZSAP plays an important role as a forum fostering research in all areas of animal production including production systems, nutrition, meat science, animal welfare, wool science, animal breeding and genetics.

An invitation is extended to all those involved in the field of animal production to apply for membership of the New Zealand Society of Animal Production at our website www.nzsap.org.nz

View All Proceedings | Next Conference | Join NZSAP

The New Zealand Society of Animal Production in publishing the conference proceedings is engaged in disseminating information, not rendering professional advice or services. The views expressed herein do not necessarily represent the views of the New Zealand Society of Animal Production and the New Zealand Society of Animal Production expressly disclaims any form of liability with respect to anything done or omitted to be done in reliance upon the contents of these proceedings.

This work is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License.

You are free to:

Share— copy and redistribute the material in any medium or format

Under the following terms:

Attribution — You must give appropriate credit, provide a link to the license, and indicate if changes were made. You may do so in any reasonable manner, but not in any way that suggests the licensor endorses you or your use.

NonCommercial — You may not use the material for commercial purposes.

NoDerivatives — If you remix, transform, or build upon the material, you may not distribute the modified material.

http://creativecommons.org.nz/licences/licences-explained/

The breath-test for sheep: a possible means of identifying lean genotypes

S. W. PETERSON

Animal Science Department
Massey University, Palmerston North

ABSTRACT

Calorimetry apparatus was used to measure CO_2 production and oxygen consumption in 2 Romney and 2 Southdown ewes. Each pair consisted of a long-lean ewe and of a short-fat ewe as determined from previous records of height, length, weight and ultrasonic back fat thickness. The respiratory exchange ratio (RER) was calculated as the ratio of CO_2 produced/d to O_2 consumed/d. When the 4 ewes were fed, the RER remained about 1, characteristic of the oxidation of glucose and short chain fatty acids. When the ewes were fasted for 4 to 5 days the RER declined in a straight linear fashion with time. This is consistent with the mobilisation of long chain fatty acids. The ewes of fatter genotypes exhibited significantly steeper regressions of RER on time.

Keywords Sheep; fat; lean; fasted; calorimetry; respiratory exchange ratio

INTRODUCTION

The number of lamb carcasses graded F (overfat) in the 1980-81 season was 308 414 (0.99%) and the MF (overfat mutton) grade contained 201 349 (2.85%) (New Zealand Meat Producers Board 59th Annual Report 1981). However a survey of British wholesalers and retailers indicated that they had a strong preference for lambs with a subcutaneous fat cover over the rib eye area of no more than 4 mm (Frazer, 1982). Frazer stated that 'if we were to fully meet this requirement within our 1982 export production, then around 25% would not qualify'.

The present experiment was part of a study set up to investigate factors controlling lipid metabolism in sheep to discover differences in lipid metabolism between genetically fat and lean ewes, with a view to developing methods for identifying genetically superior sheep for use in breeding programmes.

A previous calorimetry experiment showed that metabolic rates of the experimental sheep did not differ on a metabolic body weight basis (LWT kg $^{0.75}$), so that if there were real differences in their ability to produce adipose tissue (which had not then been determined) they had to be due to differences in the efficiency of utilisation of energy for maintenance and/or anabolism. Differences in the partitioning of energy between maintenance and growth may also have been involved. It was thought that perhaps the BMR was lower for the fat animals leaving more energy available for growth; or perhaps the lean sheep responded to periods of feed deficit by mobilising fat more quickly or in larger amounts than did the fat ones.

MATERIALS AND METHODS

Four 4-tooth (3.5 yr) ewes consisting of 2 Romney and 2 Southdown were selected from the Massey-DSIR research flock on the basis of weight-corrected back fat

TABLE 1 Phenotypic Characteristics of the ewes.

Breed	Ewe No.	Apparent Phenotype	Back fat Depth mm a	Fat depth % dev. b	Length mm c	Length % dev. b	Live weight kg
Southdown	56	Short/fat	17.5	+93	660	−8	50.8
Southdown	73	Long/lean	8.5	−65	787	+6	58.5
Romney	313	Short/fat	12.8	+68	711	−1	50.4
Romney	323	Long/lean	9.5	−19	787	+3	68.0

a The mean value for fat depth assessed ultrasonically between ribs 12 and 13 on both sides.

b The percent deviation for the actual fat depth or body length from the value predicted using regression equations of log fat depth or log body length against log live weight for the Southdown flock (42 ewes) or the Romney flock (21 ewes).

c Length measured by calipers from the front of the brisket to a point on the pin bones (Tuber ischii).

thickness and body length with the objective of obtaining a long lean and a short fat ewe of each breed.

The sheep were weighed and their back fat thicknesses measured ultrasonically (Gooden *et al.*, 1980). Similar values were obtained when the sheep were remeasured 2 months later (Peterson, 1983). It was considered that these measurements indicated the existence of differences in fatness between the 2 ewes of each breed which might have a genetic basis (Table 1). The experiment was a reversal or switchback trial (Brandt, 1938) in which sheep were alternately fasted and fed for 4 or 5 days while in the calorimeters. Only 2 sheep could be monitored at once so 1 sheep of each breed was 'fasted' while the other was fed, then after a restabilisation period of at least 10 days on the following diet the treatments were reversed.

The sheep were fed 1.25 × maintenance (M) energy requirements, on the basis of LWT $kg^{0.75}$ with 1 × M as nuts and 0.25 × M as hay. The 'fasted' sheep were not in fact starved but fed 0.25 × M i.e. one-fifth of the normal ration in the same proportions.

TABLE 2 Experimental Design (sheep number).

Period	Chamber 1	Chamber 2
1	323 Fasted	313 Fed
2	73 Fasted	56 Fed
3	73 Fed	56 Fasted
4	313 Fasted	323 Fed

Indirect calorimetry equipment (Holmes and McLean, 1974) was used to measure O_2 consumption and CO_2 production by the sheep and the ratio of CO_2 production to O_2 consumption (RER) was calculated. Since ruminants utilise acetate and glucose as their major substrates for energy storage and oxidation in the fed state (Bassett, 1975) the RER characteristic of the fed state should be about 1.0 since the RER associated with the complete oxidation of either glucose or acetate is 1.0. The oxidation of long chain fatty acids is associated with an RER of about 0.7, the RER decreasing as the length of the fatty acid increases (Table 3).

TABLE 3 Theoretical respiratory exchange ratios for the oxidation of glucose and fatty acids.

		CO_2/O_2	RER
	Oxidation of glucose	6/6	1.0
	Oxidation of Fatty Acids with n carbons		
n =			
2	acetic	2/2	1.0
3	propionic	6/7	0.86
4	butyric	4/5	0.80
5	valeric	10/13	0.77
•			
•			
•			
16	palmitic	16/23	0.696
18	stearic	18/26	0.692

Assuming that lipolysis results in the mobilisation and oxidation of long chain fatty acids, the RER of a fasted animal should move towards 0.7. With this in mind the RER was calculated to express the fasting response.

Weights and back fat thicknesses were recorded before and after the trial.

RESULTS

The RER of the fed sheep remained about 1 with a mean of 1.066 ± 0.032. The fasted sheep had a lower mean RER value of 0.950 ± 0.074 ($P < 0.025$, Fig. 1). The RER's of the fasted sheep declined with time, while those of the fed sheep did not. The slopes of individual regression lines of fed sheep did not differ ($P > 0.25$) from the slope of a common regression line for the fed sheep. The slopes of individual regression lines of fasted sheep differed ($P < 0.005$) but nevertheless a common regression line for fasted sheep was derived and found to have a different slope ($P < 0.005$) from that of the fed sheep.

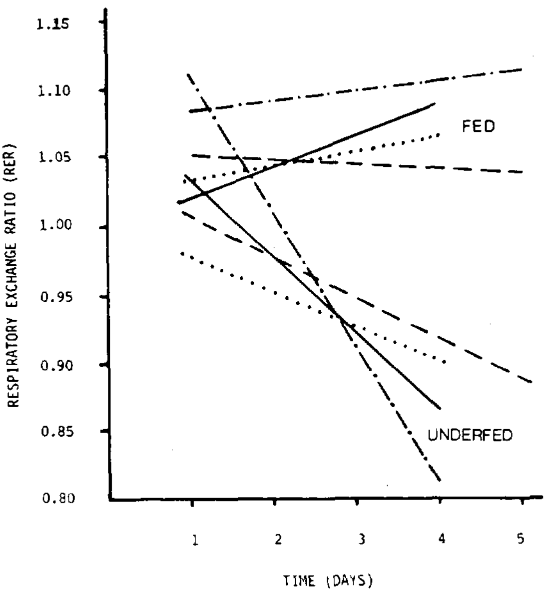

FIG. 1. Slopes of regressions of RER on time for 4 ewes when underfed of when fed.

Southdown ewe 56 (fat) —·—·—·
Southdown ewe 73 (lean) — — — —
Romney ewe 313 (fat) ————
Romney ewe 323 (lean) ....

The RER response to fasting was a straight-line relationship with correlation coefficients of -1.000, -0.987, -0.888 and -0.991. Correlations in the fed sheep were lower (0.934, 0.941, -0.191, and 0.475).

The fat group exhibited steeper regression slopes when fasted than the lean group ($P = 0.002$). Within the fat group, Ewe 56 had a steeper regression slope ($P = 0.03$) than Ewe 313. No differences were detected in weight or back fat thickness over the trial.

DISCUSSION

As was expected, the RER's of the fed sheep remained about 1, while the values for fasted sheep declined in a straight line with time. Since the RER's of fasted sheep did not stabilise at a lower level but were still falling linearly, it was assumed that a steady state of fasting metabolism was not reached and so the BMR could not be calculated. Extrapolation of the regressions indicated that 3 or more extra days of fasting may have been needed to reach a steady state of fasting metabolism in the lean sheep, assuming the responses remained linear and straight, and that an RER of about 0.7 is characteristic of fasting metabolism.

Modyanov (1967) starved sheep for 144 h and found that the heat production decreased until the end of the third day, then became somewhat stable and remained at the same level subsequently. The non-protein RER after 72 h of starvation was 0.72 which Modyanov said was typical of fat combustion. The fact that the sheep in the present experiment did not fall below 0.8 after 4 or 5 days can most likely be attributed to their intake of a quarter of their maintenance requirements daily compared to Modyanov's sheep which were starved. Nevertheless it indicates that the sheep in the present study did not reach a basal metabolic state.

Annison *et al.* (1967) reported RER for fed sheep of 1.03 and for 24 h fasted sheep of 0.94 but pointed out that these values were more than usually difficult to interpret in ruminants where a significant proportion of the total CO_2 output arises by anaerobic fermentation in the rumen.

The 2 groups of ewes differed in their response to fasting as measured by RER. The fat pair had steeper regression slopes which possibly indicated a greater rate of mobilisation of fat i.e., a more accelerated lipolysis than the lean sheep. Note that this does not indicate an earlier response.

Sidhu *et al.* (1973) found that basal lipolysis increased with fatness in homogenates of lamb adipose tissue and postulated that factors affecting deposition of fat compensate for increased lipolysis.

No conclusions can be made regarding BMR since it was not determined. Nevertheless it is evident that the response to fasting was an extremely straight linear decrease in RER with respect to time, which was steeper in the fat ewes, especially in the Southdown ewe 56.

It is hoped that the RER response can be used to accurately identify superior genotypes with respect to lean carcass characteristics.

REFERENCES

Annison E. F.; Brown R. E.; Leng R. A.; Lindsay D. B. and West C. E. 1967. Rates of entry and oxidation of acetate, glucose, D(–)–ß–hydroxybutyrate, palmitate, oleate and stearate, and rates of production and oxidation of propionate and butyrate in fed and starved sheep. *Biochemical journal* **104:** 135-147.

Bassett J. M. 1975. Dietary and gastro-intestinal control of hormones regulating carbohydrate metabolism in ruminants. *In*: Digestion and Metabolism in the Ruminant, Eds. I. W. McDonald and A. C. I. Warner, University of New England Publishing Unit, Armidale. 383-398.

Brandt A. E. 1938. Tests of significance in reversal or switchback trials. Iowa Agricultural Experiment Station Research Bulletin **234:** 60-87.

Frazer A. E. 1982. Trends in meat market requirements: Implications for producers. *Proceedings of the New Zealand Society of Animal Production* **42:** 99-103.

Gooden J. M.; Beach A. D.; Purchas R. W. 1980. Measurement of subcutaneous backfat depth in live lambs with an ultrasonic probe. *New Zealand journal of agricultural research* **23:** 161-165.

Holmes C. W.; McLean N. R. 1974. The effect of low ambient temperatures on the energy metabolism of sows. *Animal production* **19:** 1-12.

Modyanov A. V. 1967. Energy metabolism of sheep under different physiological conditions. *In*: Energy Metabolism of Farm Animals. Proceedings of 4th Symposium Warsaw, Poland, Eds, K. L. Blaxter, J. Kielanowski and G. Thorbek, European Association for Animal production Publication No. 12, Oriel Press. 171-176.

New Zealand Meat Producers Board 59th Annual Report 1981.

Peterson S. W. 1983. Aspects of lipolysis in sheep. Thesis. Massey University, Palmerston North.

Sidhu K. S.; Emery R. S.; Parr A. F. and Merkel R. A. 1973. Fat mobilizing lipase in relation to fatness in lambs. *Journal of animal science* **36:** 658-662.