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Utilization of dietary energy for maintenance, milk production and lipogenesis by lactating crossbred cows during their midstage of lactation

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1. Twenty-four energy and nitrogen balances were determined using twenty-four crossbred cows (Brown Swiss × Sahiwal) during their midstage of lactation. Energy balances were estimated by subtracting milk energy and heat production from the metabolizable energy (ME) intake. Heat production was estimated by indirect calorimetry, by collection and analysis of respiratory gases. The cows were given amounts corresponding to 90, 110 and 130 % of the ME and 90 and 110 % of the digestible crude protein (DCP) standards of the (US) National Research Council (1966).

2. Energy requirements were estimated by partitioning the ME intake for maintenance, milk production and energy gain or loss by multiple regression of energy balance values. Heat production (and thus energy balance) was corrected for excess N intake.

3. Energy requirements for maintenance were 585·18, 580·17 and 574·41 kJ ME/kg body-weight$^{0.75}$ per d for cows in negative balance, cows in positive balance and for all cows, respectively.

4. The efficiency of utilization of ME for milk production was 68·52, 65·48 and 66·12 % respectively, for cows in negative balance, for cows in positive balance and all cows. Energy required per kg fat-corrected milk production was 4·580, 4·791 and 4·746 MJ ME for the respective groups of cows.

5. The efficiency of utilization of ME for tissue gain was 67·67 and 64·86 % for cows in positive balance and for all cows respectively.

It has been established that nutrient requirement of cattle vary with breed (Mullick, 1959; Hashizume, Kaishio, Ambo, Tanaka, Hamada & Takahashi, 1963; Vercoe, 1970) and climate (Kibler & Yeck, 1959; Johnson, Ragsdale, Berry & Shanklin, 1962; McDowell, Moody, Van Soest, Lehman & Ford, 1969). It would, therefore, appear that the requirements of different breeds of cattle would have to be determined under the climatic conditions where they are kept. Mullick & Kehar (1952), Mullick (1959) and Mudgal (1969) have reported that the energy requirement of Indian cattle was 20 % less than the energy requirement recommended for various other breeds. Earlier studies in our laboratory (Patle & Mudgal, 1975) indicate that the maintenance requirement of crossbred bullocks was similar to that reported by ARC (1965). In later studies (Patle & Mudgal, 1976*a*) the maintenance energy requirement of crossbred lactating cows in the early part of their lactation was found to be 22 % higher than the requirement for crossbred bullocks under the same climatic conditions. The present studies were undertaken to find out the energy requirement of crossbred cows in their midstage (60–198 d) of lactation.

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Table 1. *Details of the cows used in the energy balance experiments*

Group	Level of feeding†	Animal No.	Lactation No.	Initial FCM* yield (kg/d)	Stage of lactation at start of expt (d)	Stage of lactation at end of expt (d)
A	LP–LE	23	4	15·4	128	198
		43	4	17·2	79	149
		19	5	11·9	64	134
		50	5	10·7	127	197
B	LP–HE	73	3	10·6	67	160
		12	4	17·7	60	130
		22	3	10·8	119	189
		75	2	11·6	60	130
C	LP–VHE	25	3	13·3	128	198
		66	3	18·9	94	164
		46	3	10·9	122	192
		27	4	11·8	78	148
D	HP–LE	39	3	15·2	122	192
		56	3	15·3	63	133
		35	4	12·5	60	130
		15	3	11·2	127	197
E	HP–HE	44	3	15·0	128	198
		5	5	15·4	68	138
		54	3	12·6	110	180
		21	4	10·7	119	189
F	HP–VHE	34	4	14·4	118	188
		74	3	9·2	102	172
		7	5	11·5	111	181
		65	3	11·0	122	192

* FCM, fat-corrected milk.

† LP, HP, 90 and 110% of the (US) National Research Council (1966) recommended levels for digestible crude protein intake; LE, HE, VHE, 90, 110 and 130% of the recommended levels for metabolizable energy intake.

EXPERIMENTAL

Design

Twenty-four crossbred cows (Brown Swiss × Sahiwal, all F_1) 60–128 d post parturition were selected from the National Dairy Research Institute, Karnal, herd. The details of the experimental animals are given in Table 1. The cows were divided into six groups according to their milk yield during the period between the 2nd and 8th week of lactation. The trial included a 2-week control and a 6-week experimental period. The 7 d period preceding both the control and experimental periods was used for the changeover from the old to the new ration. The level of feeding was the same for all animals in the control period and equalled 100% of the (US) National Reasearch Council (1966) standards for the mean milk production during the fortnight preceding the control period.

The six treatments consisted of a factorial arrangement of three levels of metabolizable energy (ME) intake, 90, 110 and 130% of the (US) National Research Council (1966) maintenance and production recommendations and two levels of digestible crude protein (DCP) intake, 90 and 110% of maintenance and production

Table 2. *Composition (g/kg) of concentrate mixtures fed to different treatment groups of cows*

	Mixture					
Ingredients	A (LP–LE)	B (LP–HE)	C (LP–VHE)	D (HP–LE)	E (HP–HE)	F (HP–VHE)
Crushed yellow maize	600	660	690	550	600	550
Wheat bran	230	250	280	180	230	250
Groundnut cake (decorticated)	140	60	—	240	140	70
Sodium chloride	20	20	20	20	20	20
Mineral mixture*	10	10	10	10	10	10
Digestible crude protein	102	83	70	124	102	86
Metabolizable energy† (MJ/kg)	10·98	11·05	11·08	10·92	11·01	11·04

* Proprietary mixture 'Super Mindif' supplied by Boots Pure Drug Co. (India) Pvt. Ltd, Bombay-1, contained (g/kg): calcium 236, phosphorus 114, copper 1·8, cobalt 0·3, manganese 0·51, iodine 1·0, sulphur 7·5, iron 2·4, sodium chloride 300.

† Digestible crude protein (DCP) and metabolizable energy (ME) values were calculated from values reported by Sen & Ray (1964); ME was calculated from total digestible nutrient (TDN) on the basis that 1 kg TDN contains 15·0995 kJ ME.

recommendations. The 90, 110 and 130% energy levels were termed LE, HE and VHE and 90 and 110% protein levels were termed LP and HP. Rations were calculated for individual cows from their mean performance during the 2-week control period. Subsequently during the 6-week experimental period the requirements were calculated fortnightly by the method of equalized feeding (Lucas, 1943).

After the 2nd week of the experimental period, a conventional 7 d metabolism trial followed by 12 d respiration trial were conducted. During the collection period, a total collection of faeces, urine and milk was made. During the respiration trial, the heat production was measured by indirect calorimetry using Douglas bags for collection of respiratory gases and analysis of gases by Haldane gas analysis apparatus. Energy balances were calculated by subtracting heat production and milk energy from ME intake. A total of twenty-four energy balances were made on twenty-four cows.

Diets

Oat silage (*Avena sativa*) and berseem hay (*Trifolium alexandrinum*) were used as roughages. The quantities of berseem hay and oat silage were adjusted to provide maintenance requirements and for production of first 4 kg 4% fat-corrected milk (FCM). The requirements for production of milk beyond 4 kg FCM were met by various concentrate mixtures (Table 2). The calculations were made using the literature values for ME and DCP for various ingredients used. The feeding schedule of the cows used during the metabolism and respiratory trials is given in Table 3. The concentrates were given at the time of the three milkings (i.e. at 05.00, 12.00 and 19.00 hours). Hay was provided at 09.00 hours and the silage at 12.30 hours. Water was provided immediately after the three milkings and also at 09.00 and 16.00 hours.

Table 3. *Rations given to the cows in the different experimental groups (kg/d) and the amounts refused*

Treatment	Animal no.	Rations			Refusals
		Berseem hay	Oat silage	Concentrate*	
LP–LE	23	4·3	13·0	4·5	nil
	43	4·3	13·0	4·5	nil
	19	4·1	13·0	2·0	nil
	50	4·6	14·5	2·5	nil
LP–HE	73	3·0	23·0	2·8	6·0 (silage)
	12	3·0	25·0	5·5	8·5 (silage)
	22	3·0	25·0	4·5	5·5 (silage)
	75	3·0	23·0	3·5	nil
LP–VHE	25	1·7	34·0	6·0	12·5 (silage)
	66	1·8	35·5	8·0	15·0 (silage)
	46	1·7	34·0	4·5	6·5 (silage)
	27	1·8	35·5	5·0	6·0 (silage)
HP–LE	39	6·5	6·0	3·5	nil
	56	6·1	6·5	4·0	nil
	35	7·0	5·5	2·5	nil
	15	6·1	6·5	2·5	nil
HP–HE	44	5·1	15·5	5·5	nil
	5	5·6	18·0	5·5	nil
	54	5·1	15·5	3·5	nil
	21	5·0	19·0	3·5	nil
HP–VHE	34	3·9	26·0	6·5	9·0 (silage)
	74	3·9	26·0	3·5	10·0 (silage)
	51	3·9	25·0	4·0	4·0 (silage)
	65	4·0	27·5	5·0	5·0 (silage)

LP, HP, 90 and 110% of the (US) National Research Council (1966) recommended levels of digestible crude protein intake; LE, HE, VHE, 90, 110 and 130% of the recommended levels of metabolizable energy intake.

* See Table 2.

Housing and management

The cows were housed in a well-ventilated byre, specially partitioned with iron bars. During the collection period the animals were housed in metabolism stalls. All animals were weighed at the beginning and end of the control and experimental periods of 3 consecutive days. The average of their three weights was taken as the body-weight of the animals at that time. Weighings were done at 08.00 hours, before water and hay were provided in the morning. The difference in weight during the 6-week experimental period was used for calculating daily live weight change.

Analytical methods

Faeces were collected manually and the urine was collected using metal bowls similar to those described by Sen (1953). These metal bowls were closely fixed under the anus. The urine voided was carried by a long rubber tube connected to the bowl into a narrow-mouth metal container placed in a covered pit behind the animal. Methods followed for sampling and preservation of feeds, faeces and urine were the same as reported by Patle & Mudgal (1975). Milk samples were taken at each milking and the pooled sample was analysed for fat by the Gerber method (I.S., 1961) and the non-fat solids by calculation from the fat content and milk density readings (I.S., 1965). Daily milk samples were preserved for protein estimation and gross energy content with 2 ml potassium dichromate and mercuric chloride solution (Blaxter, Clapperton & Martin, 1966). All the samples were kept in the refrigerator until analysed. The methods described by the Association of Official Agricultural Chemists (1960) were used to determine moisture, diethyl ether extract, crude fibre and N in feed and faeces, except for the estimation of the moisture content of the faeces when the method of Bratzler & Swift (1959) was used. The feeding stuffs were analysed for their proximate constituents at intervals of 15 d throughout the control and experimental periods. The energy content of the feed, faeces, urine and milk were estimated using a ballistic bomb calorimeter (A. Gallenkamp & Co. Ltd, London). Before burning in the bomb calorimeter the urine was absorbed in a weighed amount of cellulose and dried in a vacuum oven. Milk was dried in the vacuum oven without using any primer for gross energy estimation. Digested carbohydrate was estimated by subtracting faecal crude fibre and N-free extract from the dietary crude fibre and N-free extract.

After completion of the metabolism trial, respiratory gases were measured from each animal for 3 consecutive days at 04.30, 09.00 and 15.00 hours. The methods of gas collection, gas volume measurements, gas analysis and calculation of heat have already been described in our earlier publication (Patle & Mudgal, 1975). Methane was estimated from the digested carbohydrates using the formula of Bratzler & Forbes (1940): $E = 4{\cdot}012\,x \pm 17{\cdot}68$; where E is methane produced (g) and x is carbohydrate digested (100 g). To obtain values for methane production in litres the values were divided by 0·716 (Brower, 1965). Heat production was calculated according to the formula described by Blaxter (1970). For calculation of heat production two values at 04.30 hours, one value at 09.00 hours and one value at 15.00 hours were averaged as suggested by I. A. F. Webster (personal communication).

RESULTS

The average chemical composition of oat silage, berseem hay and the six concentrate mixtures used during the experimental period is shown in Table 4, and the average nutrient intakes and live weight changes of various groups of cows are shown in Table 5. ME intake of all the groups was more than the (US) Nutritional Research Council (1966) recommendations. Still the cows in LE group lost weight during the trial irrespective of protein intake. The DCP intake as percentage of (US) National Research Council (1966) standards were 93·9% in LP–LE treatment and 119·5% in group HP–LE. It would thus appear that energy fed to the animals in LE groups was not adequate.

The energy balances per kg metabolic body size (body-weight $(W)^{0{\cdot}75}$) together with the analysis of variance of each item are presented in Table 6. Losses of energy in faeces, urine and as heat increased significantly ($P < 0{\cdot}01$) as the level of ME in the diet increased. Increase in protein level in the diet significantly ($P < 0{\cdot}01$) increased losses of energy in urine. However, protein level in the diet did not affect loss of energy

Table 4. *Average chemical composition of feeding stuffs used during the experimental period (dry matter basis)*

Feeding stuff	Dry matter (%)	Crude protein (%)	Ether extract (%)	Crude fibre (%)	N-free extract (%)	Ash (%)	Gross energy (kJ/g)
Berseem hay ...	87·4	13·6	1·7	31·0	40·9	12·8	18·29
Oat silage ...	31·5	7·9	1·9	38·4	43·0	8·8	18·37
Concentrates							
A	88·6	13·6	4·0	4·9	72·0	5·5	18·62
B	88·3	11·8	3·6	4·7	74·5	5·4	18·33
C	88·0	10·5	3·2	4·6	76·4	5·3	18·12
D	88·4	15·6	4·4	4·8	69·6	5·6	18·99
E	88·6	13·5	3·9	4·9	72·1	5·6	18·62
F	88·3	12·0	3·8	4·6	74·1	5·5	18·37

in faeces and heat loss. Secretion of energy in milk was not significantly affected either by energy or by protein levels in the diet. Energy retention increased significantly ($P < 0·01$) as the level of both energy and protein increased in the diet.

The ME requirement for maintenance, milk production and tissue gain was computed using the following model:

$$Y = a + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4,$$

where Y is ME intake (MJ): x_1 is $W^{0·75}$ kg; x_2 is energy secreted in milk (MJ); x_3 is energy retained in the body (MJ) and x_4 is energy lost from the body (MJ).

Excess N has been shown to increase heat production and thus there is a decrease in energy retention by 30·55 kJ/g excess N (Tyrrell, Moe & Flatt, 1970). Therefore the heat production values were adjusted by subtracting 30·55 kJ for each g of excess N intake. Excess N intake was computed by subtracting the N required for maintenance and milk production from digestible N intake. The N required for maintenance and milk production was calculated from N balance data for the same cows during the metabolism trial by regression analysis:

$$Y = a + b_1x_1 + b_2x_2 + b_3x_3,$$

where Y was DCP intake (g/kg $W^{0·75}$ per d); x_1 was $W^{0·75}$ kg; x_2 was DCP secreted in milk (kg/d); x_3 was N balance (g/d) (Patle & Mudgal, 1976*b*).

Separate regressions were computed for cows in negative balance, for cows in positive balance and for all cows. The multiple regressions of ME intake by cows are presented in Table 7.

In the above model b_1, b_2 and b_3 represent the amount of ME required for maintenance, milk production and energy gain and b_4 represents the amount of dietary ME which is spared per unit of body tissue loss. For estimation of maintenance energy requirements the value 'a' was divided by the average metabolic body size and was added to the value of b_1 in a similar way to that calculated earlier (Patle & Mudgal, 1975). The maintenance requirements of cows in negative balance, cows in positive balance and all cows were 585·18, 580·17 and 574·41 kJ ME/kg $W^{0·75}$ per d, respectively.

The ME required for the production of 1 kg of milk (FCM) was calculated by

Table 5. *Live-weight changes and nutrient intakes of cows given rations with different digestible crude protein (DCP) and metabolizable energy* (ME) *contents*

Group	A LP–LE Mean	A LP–LE SE	B (LP–HE) Mean	B (LP–HE) SE	C (LP–VHE) Mean	C (LP–VHE) SE	D (HP–LE) Mean	D (HP–LE) SE	E (HP–HE) Mean	E (HP–HE) SE	F (HP–VHE) Mean	F (HP–VHE) SE
Initial live wt. (kg)	409·2	18·3	381·5	17·0	365·0	13·3	391·2	25·3	401·0	25·5	366·7	18·6
Live-wt. change (kg/d)	−0·131	0·04	0·119	0·07	0·321	0·04	−0·166	0·03	0·250	0·02	0·357	0·03
Nutrient intakes/kg metabolic body size ($W^{0.75}$)												
Dry matter (g)	119·8	7·7	140·1	2·3	164·5	1·4	118·2	7·1	155·2	5·9	157·5	3·8
Digested carbohydrates (g)	59·10	3·8	80·73	2·1	102·62	4·0	57·46	2·0	79·01	2·6	93·50	4·4
ME (MJ)	1·222	0·08	1·307	0·02	1·620	0·04	1·109	0·02	1·482	0·05	1·519	0·04
DPC (g)	7·910	0·74	8·284	0·25	8·824	0·55	10·031	0·65	10·640	0·49	10·206	0·38
Nutrient intakes as a percentage of (US) National Research Council (1966) recommendations												
ME	101·7	1·5	112·9	4·6	126·5	2·3	100·5	0·7	129·3	1·0	132·0	1·8
DCP	93·1	1·5	94·7	2·7	87·7	1·4	119·5	1·6	120·8	1·7	115·5	3·0

LP, HP, 90, 110% of the (US) National Research Council (1966) recommended levels of DCP intake; LE, ME, VHE, 90, 110 and 130% of the recommended levels for ME intake.

Table 6. *Energy balances (MJ/kg body $W^{0\cdot75}$ per d) in cows in different groups*

Group	A (LP–LE)	B (LP–HE)	C (LP–VHE)	D (HP–LE)	E (HP–HE)	F (HP–VHE)	Statistical analysis SE	Statistical analysis Protein	Statistical analysis Energy	Statistical analysis Interaction
Energy intake	2·2062	2·5694	3·1240	2·1718	2·8547	2·9754	0·485	NS	**	NS
Energy in faeces	0·9001	1·0529	1·2504	0·8788	1·1350	1·2065	0·581	NS	**	NS
Energy in methane†	0·1417	0·1755	0·2231	0·1384	0·1860	0·2066	0·020	NS	**	NS
Energy in urine	0·0423	0·0334	0·0368	0·0504	0·0455	0·0426	0·005	**	**	NS
Energy in milk	0·4058	0·4018	0·4932	0·3714	0·4055	0·4076	0·039	NS	NS	NS
Heat production	0·7558	0·8260	0·9322	0·7545	0·8887	0·8992	0·016	NS	**	NS
Energy retained	−0·0188	0·0796	0·1881	−0·0219	0·1884	0·2128	0·018	**	**	*

LP, HP, 90 and 110% of the (US) National Research Council (1966) recommended levels of digestible crude protein intake; LE, HE, VHE, 90, 110 and 130% of the recommended levels for metabolizable energy intake.

Statistical significance of differences between treatments: * $P < 0\cdot05$; ** $P < 0\cdot01$; NS = not significant.

† Calculated values (Bratzler & Forbes, 1940).

Table 7. *Equations describing the relationship between metabolizable energy* (ME) *intake and metabolic body size, milk energy and energy balances*

$$\begin{aligned}&Y = 0{\cdot}545x_1+1{\cdot}512x_2+1{\cdot}542x_3-1{\cdot}738x_4+2{\cdot}529 \text{ (all cows)}\\ &\quad\pm0{\cdot}029,\ \pm0{\cdot}023,\ \pm0{\cdot}020,\ \pm0{\cdot}163\\ &\quad n = 24,\ R^2 = 0{\cdot}99,\ \text{Syx} = 0{\cdot}669\end{aligned}$$

$$\begin{aligned}&Y = 0{\cdot}544x_1+1{\cdot}527x_2+1{\cdot}478x_3+3{\cdot}130 \text{ (cows in positive balance)}\\ &\quad\pm0{\cdot}020,\ \pm0{\cdot}015,\ \pm0{\cdot}014\\ &\quad n = 17,\ R^2 = 0{\cdot}99,\ \text{Syx} = 0{\cdot}381\end{aligned}$$

$$\begin{aligned}&Y = 0{\cdot}612x_1+1{\cdot}459x_2-1{\cdot}536x_4-2{\cdot}480 \text{ (cows in negative balance)}\\ &\quad\pm0{\cdot}133,\ \pm0{\cdot}106,\ \pm0{\cdot}470\\ &\quad n = 7,\ R^2 = 0{\cdot}99,\ \text{Syx} = 1{\cdot}54\end{aligned}$$

Y, ME intake (MJ); x_1, metabolic body size ($W^{0{\cdot}75}$ kg); x_2, energy secreted in milk (MJ); x_3, energy retained in the body (MJ); x_4, energy lost from the body (MJ).

Table 8. *Metabolizable energy* (ME) *requirements for maintenance and milk production and partial efficiency of utilization of metabolizable energy for milk production and energy gain in cows*

	Requirement for maintenance (kJ ME/$W^{0{\cdot}75}$ kg per d)	Requirement for milk production (MJ ME/kg FCM)	Efficiency of utilization of ME for milk production	Efficiency of utilization of ME for tissue gain
All cows ...	547·41	4·746	66·12	64·86
Cows in positive balance	580·17	4·791	65·48	67·67
Cows in negative balance	585·18	4·580	68·52	—

W, body-weight; FCM, fat-corrected milk.

multiplying 1·512, 1·527 and 1·459, the coefficients for x_2 obtained in different equations furnished in Table 6, by 3·139 (presuming 1 kg FCM has 3·139 MJ). Thus the energy required for the production of 1 kg FCM was 4·580, 4·791 and 4·746 MJ ME for cows in negative balance, cows in positive balance and for all cows, respectively.

The percent efficiency of utilization of ME for milk production and tissue gain was estimated by dividing 100 by b_2 and b_3, respectively. The efficiency of utilization of ME for milk production was 68·52, 65·48 and 66·12% for cows in negative balance, cows in positive balance and for all cows, respectively. The efficiency of utilization of ME for tissue gain was 67·67 and 64·86% in cows in positive balance and all cows, respectively. The energy required for maintenance and milk production and the efficiency of utilization of ME for milk production and tissue gain is shown in Table 8.

DISCUSSION

Energy requirement for maintenance

The maintenance requirement of cows in the present experiment was 574·17 kJ ME/kg $W^{0{\cdot}75}$ per d, which is 32·9% higher than the value of 432·15 kJ ME/kg $W^{0{\cdot}75}$ per d, obtained for bullocks in our earlier studies (Patle & Mudgal, 1975). The figure is also higher than that recommended by the Agricultural Research Council (1965) (451·98 kJ ME/kg $W^{0{\cdot}75}$ per d) and by the (US) National Research Council (1966)

(494·71 kJ ME/kg $W^{0.75}$ per d). The maintenance energy requirement values recommended by the Agricultural Research Council (1965) and the (US) National Research Council (1966) are syntheses of estimates from several workers on steers and dry cows. The results of the present experiment show that the maintenance requirement values obtained for steers or dry cows cannot be used for lactating cows. The higher maintenance requirement of lactating cows than of dry cows has also been reported by Ritzman & Benedict (1938), Brody (1945), Hutton (1962), Neville & McCullough (1969) and Moe, Tyrrell & Flatt (1970). Probably the changes in amount of hormones produced, differences in voluntary activity, food intake, mastication and transport of food is connected with large energy expenditure by the lactating cows (Crampton & Harris, 1969; Leroy, 1970).

The maintenance requirement of crossbred cows in early lactation (40–80 d) obtained in our earlier studies (Patle & Mudgal, 1976*a*) was 546·89 kJ ME/kg $W^{0.75}$ per d. The difference in maintenance energy requirements of lactating cows during early lactation and mid-lactation appears to be a small one.

Energy requirements for milk production

The partial efficiency of utilization of ME for milk production was 68·52, 65·48 and 66·12 % for cows in negative balance, for cows in positive balance and for all cows, respectively. The efficiency of utilization of ME for milk production during early lactation of the crossbred cows was 64·4 % (Patle & Mudgal, 1976*a*). The efficiency of utilization of energy for milk production has been reported by other workers as 65–77 % (Hashizume, Morimoto, Masubuchi, Abe & Hamada, 1965), 63·8 % (Hoffman & Koriath, 1970), and 61·6 % (Moe *et al.* 1970). Thus the values in the present studies are similar to those obtained by other workers.

The ME required for the production of 1 kg FCM in early lactation was found to be 4·877 MJ (Patle & Mudgal, 1976*a*). The value for the cows in mid-lactation as obtained in the present studies was 4·746 MJ. Both these values are somewhat lower than 5·02 MJ recommended by the (US) Nutritional Research Council (1966) for cows producing less than 20 kg milk per d.

Energy required for tissue gain

The dietary ME required per MJ tissue gain was 1·478 MJ for cows in positive balance and 1·542 MJ for all cows (Table 7) and the efficiencies of utilization of ME for tissue gain were 67·67 and 64·86 % for the two groups of cows. These values are considerably higher than that reported for bullocks (54·5 %) in our earlier studies (Patle & Mudgal, 1975) and are not much different from the values of 66·12 % obtained in the present studies for milk production. Moe *et al.* (1970) also reported that efficiency of utilization of ME for lipogenesis in lactating cows was higher (74·7 %) than in dry cows (59·6 %). The energy balance experiments with lactating cows (Flatt, Moe, Oltjen, Putnam & Hoover, 1969) and with goats (Armstrong & Blaxter, 1965) also showed that the process of fattening in lactating animals was as efficient as for milk production. However, the above findings are not in agreement with those of Neville & McCullough (1969) who reported that the lactating cows required more energy per unit gain than the non-lactating ones. Armstrong & Blaxter (1965) stated that the improved efficiency of lipogenesis in lactating animals was due to the removal of acetate by the mammary gland with the result that the metabolites available for lipogenesis were of a type associated with efficient production of body fat. This theory is based on the assumption that lower efficiency of fattening in the non-lactating animal is due to the inefficient utilization of acetate for fat production.

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