CHAPTER VII
SUMMARY AND CONCLUSIONS
The experiments conducted in tropical and sub-tropical countries indicate that the requirements of nutrients for dairy cattle maintained in these areas are different than those maintained in the temperate climate. With the constant increase in the number of high yielding dairy animals through cross breeding in the country, there is an urgent need for evolving feeding standards for economic and optimum milk production. The present investigations have, therefore, been planned and executed on the crossbred cattle with the following objectives.

1. To study the energy and protein requirements for maintenance and milk production.

2. To study the inter-relationship between energy and protein utilization for maintenance and milk production.

To study the maintenance requirements for energy and protein, the balance trials were conducted on nine crossbred bullocks, following 3 x 3 Latin square design. The bullocks were fed nine different rations containing 75, 100 and 125 percent each of total digestible nutrients and digestible crude protein levels of NRC (1966) standards. The 75, 100 and 125 percent energy and protein levels were termed le, me, he and lp, mp, hp levels, respectively.

For maintenance and milk production requirements of lactating cows, forty two energy and protein balances were conducted, on eighteen cows in early lactation and on twenty four cows in mid lactation. In both early and
mid lactation studies the cows were divided into six groups following randomised block design. The six rations used contained 90 and 110 percent digestible crude protein and 80, 110 and 130 percent total digestible nutrients levels of NRC (1966) standards. The protein and energy levels were named lp, mp and le, me, he levels, respectively.

Heat production was measured by indirect calorimetry using Douglas bags for collection of respiratory gases and analyzing the gases by Haldane gas analysis apparatus.

The energy and protein requirements were computed by multiple regression analysis using energy and nitrogen balance data.

The observations and conclusions were as follows:

1. The average total digestible nutrients and digestible crude protein intakes of bullocks in le, me, he and lp, mp, hp groups were 67.95, 100.32, 128.21 and 73.71, 104.49, 133.52 percent of NRC standards, respectively. The average total digestible nutrients intakes of le, me and he groups of cows in early and mid lactation were, 90.99, 103.54, 117.13 and 98.65, 120.41, 134.24 percent of NRC standards, respectively. The average digestible crude protein intakes of lp and mp groups of cows in early and mid lactation were, 87.88, 100.47 and 92.10, 118.57 percent of NRC standards, respectively. The energy and protein intakes of early lactation cows in high energy and protein level groups were lower than the desired level because of larger weigh backs.
2. Faeces and heat production showed the largest and urine the least energy losses both in case of bullocks and lactating cows. The average percentage of gross energy excreted in faeces, methane, urine and heat production was 37.57, 7.11, 3.05 and 48.97 in case of bullocks, 38.83, 6.71, 2.01 and 33.23 in case of cows in early lactation and 40.19, 6.67, 1.63 and 32.11 in case of cows in mid lactation, respectively. Cows in early lactation secreted more percentage of energy in milk than cows in mid lactation. The corresponding values were 17.87 and 15.58 percent, respectively.

3. Increase in energy levels increased percent energy losses in methane, decreased percent energy losses in urine and heat, increased energy retention significantly \((P < 0.01)\) and did not affect energy losses in faeces and milk significantly \((P < 0.05)\) in all experiments.

4. Increase in protein levels, did not affect energy losses in faeces, decreased percent energy lost in methane and increased percent energy lost in urine both in case of bullocks and lactating cows. These differences were significant \((P < 0.01)\) in case of bullocks and cows in mid lactation. However, the effects were not significant \((P < 0.05)\) in case of cows in early lactation. The effects of protein levels on heat production and energy retention were quite opposite in bullocks and lactating cows. As the level of protein increased, the percentage of energy lost as heat increased and percent energy retention decreased
in case of bullocks; while the percent energy lost as heat decreased and percent energy retained increased in case of lactating cows. However, the effect of protein on heat production was not statistically significant ($P < 0.05$) in case of lactating cows.

5. Metabolizable energy as percentage of gross energy was not affected by both energy and protein levels; whereas, the metabolizable energy as percentage of digestible energy increased as the level of energy in the ration increased. This effect was not significant in case of cows in early lactation. Level of protein in the ration did not affect metabolizable energy as percentage of digestible energy also. The ratio of metabolizable energy to digestible energy was 0.83 for bullocks, 0.87 for cows in early lactation and 0.86 for cows in mid lactation.

6. The average percentages of dietary nitrogen lost in faeces and urine were 45.87 and 51.65 in bullocks, 38.32 and 31.79 in cows in early lactation and 40.64 and 28.87 in cows in mid lactation, respectively. Secretion of nitrogen in milk accounted for 28.22 and 24.40 percent for cows in early and mid lactation, respectively.

7. Increase in dietary energy caused increased percent nitrogen lost in faeces, decreased percent nitrogen lost in urine and increased percent nitrogen retained in the body; although the last effect was significant ($P < 0.01$) only in case of bullocks. Secretion of nitrogen in milk also
increased, however, the effect was significant \( (P < 0.01) \) only in case of cows in early lactation.

8. Increase in digestible protein intake caused increased nitrogen losses in faeces and urine and increased nitrogen retention per kg metabolic body size, in all experiments. Protein level did not affect secretion of nitrogen in milk.

9. Increased level of energy caused significant \( (P < 0.01) \) increase in digestibility of dry matter and nitrogen free extract and significant \( (P < 0.01) \) decrease in digestibility of nitrogen in all the experiments. Ether extract and crude fibre digestibilities were affected differently in bullocks and lactating cows due to variation in energy levels; although the effect was significant \( (P < 0.01) \) only in case of cows in mid lactation. Crude fibre digestibility increased in bullocks and decreased in lactating cows, though the effect was not significant \( (P < 0.01) \) in case of cows in mid lactation. On the other hand, ether extract digestibility decreased in bullocks and increased significantly \( (P < 0.01) \) in case of cows in early lactation as the level of energy increased. This effect was not significant \( (P < 0.01) \) in case of cows in mid lactation.

10. Increased protein level caused increased dry matter digestibility in all experiments, though, the effect was significant \( (P < 0.01) \) only in case of cows in mid lactation. Crude protein and crude fibre digestibility increased
significantly ($P < 0.01$) due to increased protein levels, in all experiments. Ether extract and nitrogen free extract digestibilities were not significantly affected due to protein levels.

11. Heat production, oxygen consumption, carbon dioxide production and methane production increased significantly ($P < 0.01$) as the level of energy increased, in all the experiments, however, energy levels did not affect ventilation rate significantly.

12. Protein levels did not affect heat production, carbon dioxide production, methane production and ventilation rate both in case of bullocks and lactating cows.

13. Heat production, oxygen consumption, carbon dioxide production, methane production and ventilation rates were distinctly higher in lactating cows than bullocks.

14. Increase in levels of energy caused significant ($P < 0.01$) increase in milk, 4 percent fat corrected milk solids-not-fat and fat yields; irrespective of the stage of lactation. The effect was more when the energy level was increased above low level as compared to its effect above medium level. The results, thus, show a curvilinear response of energy levels in milk yield.

15. Increase in protein levels also caused increased milk and 4 percent fat corrected milk yield, but the effect was statistically significant ($P < 0.01$) only in case
16. Level of energy did not affect fat percentage but increased protein and solids-not-fat percentage, though the effect was significant (P<0.01) only in case of cows in mid lactation.

17. Level of protein in the ration did not affect the fat, protein or solids-not-fat content of milk both in early and mid stage of lactation.

18. The efficiency of utilization of gross energy was 17.87 and 15.58 and that for metabolizable energy was 34.05 and 30.41 percent, respectively, for cows in early and mid lactation, showing higher efficiency of utilization of energy by cows during early lactation than during mid lactation. However, the partial efficiency of utilization of metabolizable energy for milk production (as estimated by multiple regression) was not different in cows in two stages of lactation (64.4 vs. 65.4, respectively).

19. The partial efficiency of utilization of metabolizable energy for fat deposition by bullocks, early lactating cows, mid lactating cows and all lactating cows was 54.5, 69.4, 64.0 and 62.5 percent, respectively. Thus lactating cows utilized metabolizable energy for lipogenesis better than bullocks; and with the same efficiency as for lactation.

20. Body tissue was utilized with 71.4, 89.8 and 69.1 percent efficiency for milk production by cows in early lactation, cows in mid lactation and all cows.
21. Dietary nitrogen was utilized with 28.22 and 24.40 percent and the digestible nitrogen with 45.92 and 61.43 percent efficiency for milk production by cows in early and mid lactation, respectively. As in case of energy, the nitrogen was also utilized better by cows in early as compared to mid stage of lactation.

22. The energy requirements for maintenance of bullocks in negative tissue balance, in positive tissue balance and all bullocks was 100.14, 103.78 and 103.35 Kcal ME/W\textsuperscript{75}/kg/day, respectively.

23. In case of cows in early lactation the energy requirements for maintenance were 128.17, 131.68 and 130.68 Kcal ME/W\textsuperscript{75}/kg/day, for cows in negative balance, cows in positive balance and all cows in early lactation, respectively. The corresponding values for cows in mid lactation were 131.65, 137.41 and 134.32 Kcal ME/W\textsuperscript{75}/kg/day, respectively.

The maintenance requirements were computed also for all cows in negative balances, all cows in positive balances and all cows both in early and mid stage of lactation. The requirements were 128.27, 134.32 and 131.49 Kcal ME/W\textsuperscript{75}/kg/day, respectively. The maintenance requirements of energy for lactating cows were thus 27.7 percent higher than the bullocks.

24. The metabolizable energy required per kg 4 percent fat corrected milk (containing 750 Kcal) was 1165.0, 1146.0
and 1152.0 Kcal for cows in early lactation, cows in mid lactation and for all cows, respectively.

25. The digestible crude protein required for maintenance of bullocks, cows in early lactation, cows in mid lactation and all cows were 2.100, 2.246, 2.227 and 2.314 g/kg/day. Thus the digestible crude protein requirements of bullocks and lactating cows were not apparently different.

26. The digestible nitrogen required per 100 g nitrogen secreted in milk was 151.1, 150.0 and 149.7 g for cows in early lactation, cows in mid lactation and all cows, respectively.

The results of the present studies indicate that the energy and protein requirements of the crossbred cattle are higher than other breeds of cattle reported by other workers in India. The studies further reveal that the maintenance energy requirements of lactating cows are higher than that of idle bullocks or the current standards used in the country. Thus to maintain optimum level of milk production, the high yielding crossbred cows should be fed with higher level of energy for maintenance.