CHAPTER I
INTRODUCTION
The present human population of India is estimated to be 550 millions. To provide 280 ml of milk per person (the recommended minimum requirement, Fatwardhan, 1961), India would require to produce about 56 million tonnes of milk a year. Against this the actual milk production in India is estimated to about 20-22 million tonnes (Kurien, 1970). In other words, to produce 56 million tonnes of milk, in all we need a population of 22 million cows with an average milking capacity of 2500 kg per year (Sundaresan and Iya, 1971). The average milk production of an Indian cow and Indian buffalo has been estimated to be about 187 kg and 500 kg respectively (Shyamlal, 1971), which is too low and has to be improved quickly to meet our milk demand.

The quickest method of obtaining high milk producing cows being adopted in this country is a crash programme of either by importing frozen semen of exotic breeds or by importing high quality bulls for cross breeding. Mishra (1970) states "considering the level of milk production of our indigenous cattle and that of exotic ones it can easily be calculated that in order to double the present milk production of our cattle the time required by selective breeding would be around 100 years, by grading up around 50 years and by crossing our indigenous cows to good exotic bulls about less than 10 years."

The National Dairy Research Institute, Karnal, embarked on a cross breeding project in 1963. Frozen semen from progeny tested Brown-Swiss bulls was imported from U.S.A. and was used with Sahiwal and Red Sindhi cows with
a herd average of 2100-2400 kg. Details of the performance of the cross breds are given in Table 1 (Nair, 1969).

Table 1. Performance of cross bred cows.

<table>
<thead>
<tr>
<th>Character</th>
<th>Cross breds</th>
<th>Sahiwal</th>
<th>Red Sindhi</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Age at first calving (months)</td>
<td>30.25</td>
<td>38.00</td>
<td>42.00</td>
</tr>
<tr>
<td>2. Milk in 305 days (kg)</td>
<td>3001</td>
<td>1706</td>
<td>1712</td>
</tr>
<tr>
<td>3. Length of lactation (days)</td>
<td>338</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4. Calving interval (days)</td>
<td>392</td>
<td>437</td>
<td>418</td>
</tr>
</tbody>
</table>

Much of the usefulness of the work of cross breeding and maintaining pedigree animals will be lost unless they are adequately fed. Proper feeding and management of animals alone can increase the milk yield in the country up to about 30 percent (Wright, 1952). Less than 20 percent of the variation between individual cows can be accounted for by heredity influences. A large part of the variation is of environmental origin, a term which includes nutrition (Blaxter, 1962).

Indian cattle are seldom judiciously fed. Generally in villages the cattle have been given the role of scavengers. They are fed those coarse fibrous feeds which can not be utilized by man, pigs or chickens. They graze on land unsuitable for cultivation because of its topography or lack of water. On the other hand, in well organized city
byres the quantity of feed fed is frequently as much as 50 percent higher of the requirement (Wright, 1952). A proper rationing system would tend to correct both these tendencies and increase milk production economically.

The feeding standards currently in use in India (Sen and Ray, 1964) present the average values for total digestible nutrients and digestible crude protein of Morrison's (1956) maximum and minimum values and the figures given for estimated net energy values have been computed into corresponding starch equivalent values. The Morrison's feeding standards (and also the standards recommended by National Research Council, Washington (1966) are based primarily upon the early dairy cattle feeding trials of Haecker (1903, 1914). In Morrison's feeding standards two values are given for crude protein requirements for milk production - the lower being Haecker's (loc cit) and the higher from Savage's (1912). Similarly two values are also given for total digestible nutrients. In early feeding standards digestible proteins, fats and carbohydrates were added together to give "total digestible nutrients" (TDN). Later on the current practice of multiplying fat by 2.25 was introduced from the consideration of physiological fuel value of Atwater which gives to fats two and one quarter times the energy value of either carbohydrate or protein, whereas no consideration has been given to the high calorific value for digestible protein (as compared to carbohydrate) considering the energy losses through urea in urine. Thus the term total digestible nutrients represents neither digestible nor metabolizable energy (Maynard, 1953).
The total digestible nutrient system is commonly in use in North and South America. Another feeding system most commonly in use in Great Britain and other European countries expresses energy requirements as starch equivalent (SE) and protein as protein equivalent (PE) (Woodman, 1948; Evans, 1960). The 14th edition of Bulletin No.48 (Woodman, 1957) gives requirements as digestible protein (DP). The starch equivalent system was evolved by Kellner (1926) which is based on net energy for fat production in mature bullocks. The Scandinavian Feed Unit system followed in Scandinavian countries and USSR is also based on net energy system and is now closely related to the starch equivalent system (Greenhalgh, 1969).

While balancing the dairy cattle rations according to these standards we use various assumptions which are incorrect in the light of the experimental evidences available. The assumptions are:

1. The starch equivalent values of feeding stuffs are based on the net energy values for fat production and it is assumed that the utilisation of foods for maintenance and fattening of animals was similar. In this method it is also postulated that the utilisation of the metabolizable energy was the same for maintenance as for fattening (Kellner et al., 1896), whereas ARC (1965) summarized various experimental results and calculated that the utilisation of metabolizable energy for fattening is never as good as for maintenance or
lactation. The efficiency with which the energy of the steam volative fatty acids replaced the body tissues as a source of energy during fasting was appreciably greater (about 85 percent) than the efficiency with which their energy was used to effect the synthesis of fat in animals (30-60 percent) (Armstrong and Blaxter, 1957; Armstrong et al., 1958; Blaxter and Wainman, 1961b). Flatt et al. (1965a) found the efficiency of utilisation of metabolizable energy for maintenance as 79 percent while that for fat production it was 50 percent. Mollgaard and Lund, (1929) found that 1000 Kcal milk energy were equal to 830 net Kcal for fattening (NKp). The British Standards (Woodman, loc cit) prescribe the maintenance requirements derived from Kellner’s work on bullocks (Kellner, 1926) and the standards for production are based on the work of Mollgaard and Lund (1929).

2. The total digestible nutrient system assumes that for any function metabolizable or digestible energy is utilised with constant efficiency regardless of the nature of the feed. For maintenance both roughages and concentrates are almost equally utilised (70-80 percent efficiency) but for fattening, the efficiency of retention of metabolizable energy varies widely with the nature of the diet (ARC, 1965). Kellner (loc cit) showed the efficiency of fat synthesis decreased as the fibre content of the diet increased. The experiments of Armstrong and Blaxter (1957),
and Armstrong et al., (1958), showed that the proportion of acetic acid in the digestion end products decreased efficiency of fat synthesis.

The highest efficiency for lactation is depended on certain ratio of acetic and propionic acids in the rumen. Blaxter (1962#) proposed that the utilisation of metabolizable energy for lactation would be maximal (approximately 70 percent) when rations resulting in 50 to 60 molar percent acetic acid in the rumen were fed. The efficiency, theoretically would decline outside this range. Even for maintenance requirements great ration effects were noted by Flatt et al., (1965b). Thus roughages in the starch equivalent system are under-estimated for maintenance and lactation functions, whereas the concentrates are under-evaluated in total digestible nutrient system particularly for fat production.

3. The present standard assumes that for individual cows a linear relationship exists between both energy and protein requirement and milk production. The experimental data reported by Jensen et al., (1942), Yates et al., (1942), Blaxter (1950), Hoglund and Wright (1952), Jawetz (1956) and Burt (1957b) showed that the relationship between feed intake and milk production was found to be curvilinear.

It was concluded that the law of diminishing returns applies to milk production. Rød (1956a, 1961a), Rød et al.,(1966), Blaxter (1962#) have suggested that there are three main factors involved in a decreasing output per unit of increased input in lactating dairy cows. The factors are:

(1) diminishing rates of digestibility with increasing
level of feed intake;

(ii) increasing proportions of dietary energy being diverted to the production of new body tissues with additional feed and

(iii) inefficient utilisation of nutrients in fattening as compared to milk production.

4. The energy needs of lactation cited in the feeding standards have been based on the contention that the ideal relationship is achieved if sufficient food is provided to the cow neither to lose nor to gain body weight. In other words the lactation proceeds with optimum efficiency when the energy reserves of the body are neither depleted nor repleted. Blaxter (1959, 1962a) concluded that maximum yield was not synonymous with stability of weight as in many economic situations neither was optimal efficiency of conversion of feed and other resources into milk. Many cows producing at low levels would yield much more if they were provided with more energy (Larsen and Eskedal, 1952; Blaxter, 1959).

5. The usual practices while rationing the dairy cows is that the cow is fed according to its previous week's milk yield and thus it is presumed that the cow's milk yield is solely determined by its heredity. By this method too little feed is provided in early lactation and too much in late lactation (Reid, 1961b).

6. Further assumption is that the requirements for lactation are fairly constant and are the same irrespective
of the level of lactation. The efficiency of utilization of nutrients throughout the lactation is not the same. The high yielding cows utilise considerable amount of body reserves during early lactation (Flatt et al., 1965c) and these tissues are recovered during the later stages of lactation and during the dry period. The efficiency of utilization of energy during early lactation is highest and gradually declines as the lactation proceeds. Body tissue is utilised with the efficiency of 82 to 84 percent and the feed nutrients 60 to 70 percent for milk production. The actual efficiency of utilization of energy depends upon the proportion of these two sources of energy utilized for milk production (Moe et al., 1971). Thus higher level of feeding during early lactation would be economical.

7. While using the present feeding standards for lactating animals it is presumed that the maintenance requirement of non-lactating and lactating cow is the same. Brody (1945), Brody and Procter (1935), Hutton (1962), Wallace (1956, 1961), Neville and McCullough (1969) reported that in general the maintenance requirements during lactation for housed animals is about 40 percent and for grazing animals about 100 percent more than the maintenance requirements of cows during the dry period.

8. The present standards presume that breeds of cattle have no influence on nutrient requirements. ARC (1965) states that breeds and sexes have an influence on energy
requirement but their effect appears to be relatively small in cattle. However, Japanese workers have noted relatively large breed differences (Hashizume et al., 1963). Vercoe (1970) found lower fasting metabolism in Zebuchan in the European breeds. The crosses were intermediate. Limited investigations carried out in India showed that the energy requirements for Indian breeds of cattle is approximately 20 - 25 percent lower than the requirements reported in the foreign feeding standards (Mullick and Kehar, 1952a,b, 1959; Mullick 1959a,b; Rao and Mullick, 1963). Similarly 25 percent less protein requirements of Indian breeds of cattle have been reported by Gupta et al., (1966) and Mudgal (1963, 1969).

9. The experiments conducted in Tropical and subtropical countries (Ragsdale et al., 1948; Kibler and Brody, 1950; Johnson et al., 1958; Mullick 1959a,b; Wayman et al., 1962; Saini et al., 1967; Vercoe, 1970) indicate that the cattle managed in these areas have different heat production and nutrient requirements. Kibler and Brody (1952) reported significant seasonal variation in heat production. Johnson (1967) and Kibler et al., (1965) reported decreased heat production during thermal stress; while Kibler (1962) reported that a year exposure to 80°F caused increases in level of rectal temperature and energy metabolism especially in Holstein heifers. Experiments conducted by McDowell et al., (1969) have shown that the maintenance requirements of Holstein were considerably higher under thermal stress.
(32.2°C) and also suggested that there might be additional losses of protein through the sweat glands.

10. The quality of roughage is reported to have great effect on the nutrient requirements of animals. Morrimoto et al. (1968) reported that when the rice straw was given to Holstein cows the requirement for total digestible nutrients was increased by an average of 6.4 percent. As the quality of roughages available in tropical and sub-tropical countries is quite inferior as compared to those available in the temperate countries, there may be difference in the requirements of animals fed in the above types of climates.

The present feeding standards followed for feeding of livestock in tropics were the same evolved in the temperate countries. Whereas the work carried out in India on the nutrient requirements of Indian breeds of cattle (Mullick and Kehar, 1952; Mullick, 1959a, b; Mudgal, 1963, 1969; Gupta et al., 1966; Gopal Krishna, 1971) has revealed that the requirements for these animals are not similar. With the launching of cross breeding programme more and more high producing cows are coming up for which the feeding standards for economic and optimum milk production are yet to be worked out. At present no systematic data are available on the nutrient requirements for maintenance or milk production of such cows. With this in view these studies have been undertaken with the following objectives:

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

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