Chapter VI

NUTRITIONAL AND SEASONAL EFFECTS ON THE SOLIDS-NOT-FAT CONTENT OF MILK

In the previous chapter the results on milk composition as affected by seasons have been discussed.

In this chapter the following aspects are presented:

Review of literature, i.e., nutritional and seasonal effects on milk SNF content.

Results and discussion on the nutritional and seasonal effects on milk SNF content.
NUTRITIONAL AND SEASONAL EFFECTS ON THE SOLIDS-NOT-FAT CONTENT OF MILK

Review of literature

The non fatty constituents of cow's milk, which make up about 8.7 percent of the total weight (i.e., more than 70 percent of the total solids) contain the most important animal protein and potassium required by the young suckling for muscle and tissue growth, the calcium and phosphorus needed for the bone and most of the B-vitamins essential for the metabolic activities of both the young and pre-ruminant calf and the human infant (Sen and Anantakrishnan 1960).

It was considered that the SNF content of the milk was not influenced by feeding. However, in various parts of the world, the low SNF content of the milk of a number of dairy herds has caused much concern to both the producer as well as the distributor. This occurrence of low SNF has important legal, commercial and nutritional bearings, its main significance being lower food value of the milk received by the consumer and it is a problem in which there is widespread interest.

The average composition of commercial supplies of milk in England and Wales was about 3.8 percent fat and 8.7 percent SNF (Milk Marketing Board, 1958-'59). The various records on the fat and SNF contents of commercial milk that have become available since the beginning of the century, have been collected by Davis (1952) and by the Animal Husbandry Panel of the Cook Committee (1960). As pointed out in both publications the trend in milk composition indicated by these
records particularly for the early years, and the samples tested were often from restricted areas and too small in number to characterise milk generally. The records suggested however, that between 1900-1950, there was a gradual decline in fat percent of about 0.1 to 0.2 percent. Since 1950, there has been a recovery, particularly marked with the Friesian breed (E.M.B. 1958-'59) to about the original level.

The SNF percentage, initially (1900-1930) there was a rise, from 8.8 to 8.9 and then a fall to about 8.7. Abrupt, but temporary falls in SNF content occurred in the early 1930's and in the early years of the Second World War they were probably due to a restricted supply of imported concentrate feeds (and consequent under feeding) and to a change in the scarce of the liquid milk supply during these periods. The various causes contributing to the long-term changes in milk composition have not been clearly established, but a change since the 1930's in the dominant breed structure of dairy herds, from Shorthorn to a Friesian type, may be one of them. In Scotland, where most of the milk comes from cows of the Ayrshire breed, the SNF content has remained steady during the past 40 years (Waite and Petersen 1959).

Although presumptive legal standards for milk exist in many countries, no comprehensive survey of the composition of the milk of Zebu cattle has so far been made (Mahadevan, 1966). But the excellent study initiated by the Allahabad Agricultural Institute and published by the I.C.A.R. (INDIA, 1948) contain a wealth of information which may be used as a basis for our understanding of the variations in the quality of Zebu milk. The collection of the data for that study extended over a period of three years. Pure bred Sindhi, cross-bred Holstein - Sindhi and village cows were included in this study.
The following two tables illustrate some of the facts:

Average values for the fat and SNF contents of the milk of the main British Dairy Breeds

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Ayrshire fat %</td>
<td>3.86</td>
<td>3.72</td>
<td>3.81</td>
<td>4.15</td>
</tr>
<tr>
<td>SNF %</td>
<td>8.73</td>
<td>8.72</td>
<td>8.96</td>
<td></td>
</tr>
<tr>
<td>Friesian fat %</td>
<td>3.54</td>
<td>3.45</td>
<td>3.62</td>
<td>3.49</td>
</tr>
<tr>
<td>SNF %</td>
<td>8.58</td>
<td>8.65</td>
<td>8.61</td>
<td></td>
</tr>
<tr>
<td>Guernsey fat %</td>
<td>4.56</td>
<td>4.41</td>
<td>4.54</td>
<td>4.99</td>
</tr>
<tr>
<td>SNF %</td>
<td>8.93</td>
<td>8.94</td>
<td>9.32</td>
<td></td>
</tr>
<tr>
<td>Jersey fat %</td>
<td>5.03</td>
<td>4.90</td>
<td>5.51</td>
<td></td>
</tr>
<tr>
<td>SNF %</td>
<td>9.10</td>
<td>9.49</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shorthorn fat %</td>
<td>3.58</td>
<td>3.65</td>
<td>3.70</td>
<td></td>
</tr>
<tr>
<td>SNF %</td>
<td>8.68</td>
<td>8.75</td>
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</table>

1. The figures relate to milk delivered to Milk Marketing Board, creameries.

2. The figures are based on a 20 percent systematic samples of all single breed herds recorded in the Boards 1955 census of the National Dairy Herd.

The average composition of the milk of Indian and European cow. (India: ICAR 1949)

<table>
<thead>
<tr>
<th></th>
<th>Fat</th>
<th>Casein</th>
<th>Albumin</th>
<th>T. Protein</th>
<th>Lactose</th>
<th>Ash</th>
<th>SNF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indian</td>
<td>4.83</td>
<td>2.38</td>
<td>0.40</td>
<td>2.78</td>
<td>4.56</td>
<td>0.74</td>
<td>8.69</td>
</tr>
<tr>
<td>European</td>
<td>3.67</td>
<td>2.86</td>
<td>0.56</td>
<td>3.42</td>
<td>4.78</td>
<td>0.73</td>
<td>9.02</td>
</tr>
</tbody>
</table>

* Davis (1939).
The mean SNF values for the Red Sindhi and Holstein x Sindhis were 8.497 and 8.079 percent. The comparison of two sets of figures showed quite clearly that the total solids of Indian cow's milk was higher and the butter fat content much higher than that of European cow's milk, the solids-not-fat content was lower, which was attributed to the lower protein and lactose content of Indian cow's milk. This showed that more than half of the number of genuine samples of milk of Red Sindhi and cross-bred cows failed to pass the legal test. According to Schneider et al. (1948) "it is doubtless too hard for sellers of milk of cows of these groups but what is even more worse is that even if milk is sold in the market of a herd of more than one cow there will be no elimination in the proportion of genuine samples failing to pass the legal test as long as the standard remains higher than the mean value."

According to Mahadevan (1966) "the SNF content of Indian cow milk is such that hard milk falling below the prescribed standard seems to warrant a reconsideration of this standard."

Schneider et al. (1948) further compared the results obtained with the data from England and Wales to determine the proportion of genuine samples falling below the minimum limits prescribed under the legal standards. It was observed that 5.2 percent of the samples fall below the standard. Thus under the existing standard, in India, 5.7 percent of the samples of individual cow's milk failed to pass the legal limits. This would seem to suggest that in our country a genuine product will be punished about the same number of times as in other countries and an attempt to enhance the standard will increase the proportion of genuine samples punishable under the law.
Basu et al (1962) also carried out extensive studies on the composition of Zebu milk. Their values for the Tharparkar breed were: fat 4.55, TS 13.25, SNF 8.70, TP 3.35, Casein 2.59, lactose 4.83 and ash 0.68 (in percent).

The values were higher when compared with the values obtained by Schneider et al (1948) for the Zebu milk (Red Sindhi). This study was conducted at the Southern Regional Station of National Dairy Research Institute, Bangalore. The optimum climate and feeding practices might have resulted in this increased compositional value. However, they also noticed several samples falling below the legal standard for SNF, i.e., 8.5 percent.

Gupta and Dastur (1959) while studying the estimation of SNF in milk by a modified Richmond’s Formula also noted a range of SNF from 8.11 to 9.55 at the National Dairy Research Institute, Karmal farm itself. But no explanation was given regarding these varied values. Various reasons are attributed to the changes in the SNF content of milk such as breed, strain and individuality, stage of lactation, age of the cow, plane of energy and protein intake in the feed, and seasonal changes (Brock, 1961). Of these, well recognised nutritional and seasonal changes are reflected in the SNF content of milk.

**Variation in SNF content due to energy levels**

The studies carried out in the year of 1923 revealed that 16 percent of herd samples were below 8.5 percent SNF (Granfield, et al 1927).

Riddet et al (1941) have presented a valuable study of the relation of the plane of nutrition of the cow to milk production and milk
composition. By two series of trials, on the double reversal system, they have shown that changing cows from normal production to half production ration caused a definite fall ranging from 0.3 to 0.5 percent in the SNF content of milk. The fall mainly affected the protein content of milk.

Rowland (1944) stated that as many as 81 and 86 percent of the milk samples collected in early months of 1942 and 1943 at two creameries contained less than 8.5 percent SNF. The SNF content showed a substantial improvement in May when cattle had access to ample supply of young grass. It was suggested that the low SNF in milk was due to a low plane of nutrition of the herds at that period under war time conditions of a much reduced supply of concentrates.

Edwards (1958) analysed 416 samples of milk from individual cows from 14 herds and observed low SNF in many samples. The difference in SNF content between the normal and sub-standard group was attributed equally to a lowering in lactose and crude protein in milk. Greater proportion of sub-standard milk was noticed in (a) Friesian breed (b) during 45th to 105th day in lactation and (c) in the milk from animals older than seven years or in lactation later than fourth.

In a summary of the position presented by Kay (1948), the causes for low compositional quality were attributed to both breeding and feeding deficiencies, the latter assuming more importance during the period of war time shortage.

Rowland (1946) conducted an experiment to ascertain the effect of known separate deficiencies of energy and protein in the feed of the cow on the composition of milk. Both low energy and low protein
rations appreciably reduced the SNF content of milk, the lower energy ration affected to a greater extent. The deleterious effect of a deficiency of SE on the percentage of milk protein was considerably more marked than that of a relatively higher deficiency of food protein. The range of SNF observed was from 8.34 to 8.68 percent.

Breirem (1949 a, b) analysed the data on Norwegian experiments, and observed that a long term energy and protein under feeding resulted in a considerable fall in the protein content of milk, thus lowering the SNF content of the milk.

Bailey (1952) also observed that the SNF content of milk varied directly with the amount of SE and inversely with dry matter content of the diet. The low SNF of milk in winter was attributed to a greater dry matter intake by the animal.

Holmes et al (1960) have shown that feeding at starch equivalent levels above the usually accepted standard can lead to production of milk with an increased SNF content which was due to an increase in the protein content of milk. The SNF ranged from 8.3 percent to 8.6 percent with the four levels of energy feeding.

Rook and Line (1961) while studying the effect of plane of energy nutrition of the cow have reported very interesting results. The widest contrast was with the cow Valient and a change of high energy to low energy diet produced a fall in SNF from 8.69 to 8.18 percent.

When, Huber and Boman (1966) fed four levels of grain to cows on pasture (0, 0.14, 0.29 and 0.57 kg per kg milk), the SNF content for the respective levels averaged 8.51, 8.64, 8.86 and 9.08 percent.
Variation due to energy concentration

In most of the studies, the effects of energy concentration have been difficult to separate from those of energy levels, because grain was fed to achieve higher planes of nutrition, resulting in increased energy concentration. Balch et al. (1955, a) noted greater increase in SNF (0.4 to 0.5 percent) than could be attributed to the energy levels alone, when cows were changed from a normal ration to one low in hay and high in flaked maize.

In a study by Huber et al. (1965) cows grazing medium quality bluegrass pasture were supplemented with varying levels of corn and corn silage. The milk from the group receiving corn ad lib was higher in SNF (9.16 vs 8.22 percent).

Burt (1957 a, b) observed only slight increase in SNF when oats and barley were used to raise the energy levels to 25 percent above the recommended standard. Brown et al. (1962) fed ad lib concentrate mixture containing 75 percent corn and cobmeal to one group of cow and increased the TDN intake to 23 percent above the control group. However, these workers could not observe any significant differences in the SNF or protein content of milk.

Variation due to protein supply and SNF content

There is further correlation between the protein content of the ration and the protein content of the milk produced (total nitrogen and to some extent SNF). Given varying levels of protein in the feed, however, the protein content of milk alters to a far less extent than where the supply of energy varies, and particularly so
where ration balanced with regard to energy are fed. Protein levels only slightly above and below the protein requirements have little influence on the SNF or protein content of milk. (Rook, 1953, Holmes et al 1956, Zorin 1956, Frans and Dijkstra 1959, Politiek and Sybrands 1962). Yield also varies little under these circumstances although the level of protein in the diet is decisive for milk production as a whole.

Where the rations are obviously deficient in protein, the total protein content of the milk is quite considerably reduced (Perkins et al 1932, Steensberg 1937, Nehringer 1938, Kajanoja 1944, Rowland 1944, 1946, Lutz 1947, Nesenf and Korprich 1947, Breezen 1949 a, b, Amsholer 1951, Waite 1956, Rook and Line 1962). In some cases it is some tenths percent lower. In experiments conducted by Issachsen et al (1956) it fell from 3.2 to 2.84 percent. Duration and extent of the protein deficiency are of particular importance. The lowered protein content in milk also resulted in low SNF content. On the other hand when the level of protein intake is raised, the protein content of the milk also shows an increasing trend.

Leaving aside the colostral milk, with its high content of immunoglobulin, the proportion of casein in the total protein remains fairly constant for the remainder of the lactation, (Waite et al 1956, Jarrige and Rossetti 1957, Comberg and Voigtlander 1959). Changes do take place however, within a lactation in casein itself and in the milk serum protein (Larson et al 1956, Larson and Kendall 1957, Comberg and Voigtlander 1959). Alteration in the individual casein fraction are slight but they are by no means always in the same direction. The condition under which the animals are kept and particularly differences in temperature can alter the composition.
Direct nutritional influences have also been reported on the individual protein. Thus the casein fraction increases when the animals are put out to grass just as when high energy rations are fed (Jarrige 1953, Rook 1953, Holmes et al 1956, Rook and Rowland 1959, Rook et al 1960). It decreases again, however in the course of the summer (Reinart and Nesbitt 1956 and 1961).

The effects of energy and protein levels on casein content have already been demonstrated. In most cases, casein content rises with increased total nitrogen. Further effects of feeding on casein content have been reported by Storgards (1947).

The interaction of dietary protein and energy in milk composition was recently investigated by Virginia workers (Huber and Boman 1966). Cows on medium quality bluegrass pasture were supplemented with two concentrate mixtures containing 8 and 23 percent crude protein at four levels (0, 0.14, 0.29 and 0.57 kg per kg milk). Significant linear responses to concentrate levels were noted for SNF protein, lactose and mineral in milk. The protein content of the ration did not significantly affect SNF or its constituent at any of the energy levels.

**Variation due to different seasons in SNF content**

Houston and Hale (1932) found that the SNF was markedly depressed when the environmental temperature was high.

Bartlett (1935) showed a significant lowering (0.15 percent)
in the SNF content when the temperature was increased from 47 to 87°F.

Jacobson (1936) analysing over 100,000 samples of milk delivered to plants in New England (USA) observed that the lowest minimum of SNF was recorded in the hot months of the year, i.e., July and August.

Davis (1937) enumerating the causes of low SNF content of milk stated that hot-dry summer weather was one of the causes of it.

Regan and Richardson (1938) showed that the composition of milk was uniform till 80 to 85°F, but after this critical temperature, the SNF content decreased from 8.5 to 7.6 percent.

Harman (1938) reported that the effect of season and temperature was very difficult to be separated from each other under practical conditions. Higher temperature was largely responsible for the fall in SNF content during summer months. In Missouri, he found lower than average SNF content in a herd of cows during the months of July, August and September (at that time the range was from 7.9 to 8.7 with an average of 8.45 percent) when cows were turned to pasture in April and May, SNF was affected although milk yield increased.

Cranfield et al (1923) found that the level of SNF content remained between 8.9 to 9.2 percent throughout the whole period of July and August except for a drought in July 1937, when it fell to 6.0.

Eggar (1941) analysing a very large number of milk samples
found that the average SNF content as 9.25 percent in January, dropped steadily to minimum of 8.82 percent in July and then increased continuously to a maximum of 9.5 percent in December.

Hassan (1944) found that the highest concentration of SNF in milk was reached in winter with Egyptian buffaloes and in summer with the cows.

Rowland (1944) investigating into the low SNF content of winter milk in war years in 1942-1943, found that SNF content was low in many samples in the months of January to April and it improved rapidly to normal levels in the month of May when the herd received ample young grass. The low SNF content during the winter months was ascribed to a low plane of nutrition.

Overman (1945) showed the maximum values of SNF (9.26 percent) in 2426 milk samples collected from cows of different breeds in January. The minimum value was 9.16 in the month of July.

Rensburg and Van (1946) investigating into the various factors responsible for low SNF content of milk in South Africa found that the milk of herd of mastitis free grade Friesian was that monthly average of SNF content showed a minimum of 8.44 and 8.46 percent in June, July and August and a maximum of 8.64 to 8.72 percent in October to December, when pasture was abundant and nutritious.

In another communication, Rowland (1946) in a survey of the SNF content of individual herd milk in England and Wales found that the percent of SNF content was highest when herds were on grass of high nutritive value.
Kastli and Benz (1946) in Switzerland noted that there was a rise in SNF content of milk from 6.97 in March to a maximum of 9.12 percent in October-November. The difference between the maximum and minimum values for each centre was approximately 0.15 percent.

Davis et al. (1947, c), from a study of pure bred Jersey, Holstein, Guernsey and mixed herd, each of 30 cows or more, found that the serum solids were low in summer and highest in winter. High environmental temperature in summer months of the region was the major factor for this decrease in SNF.

Bees (1947) from the analysis of the milk of a processing plant in Tasmania over a period of three years from 1943-46 found a regular annual variation in SNF content. The SNF content showed a progressive depression during the winter and sharp rise in spring, progressive depression during the summer and recovery to a second maximum in autumn.

Schneider et al. (1948) have reported that the SNF content in Sindhi cows was lower than the average during the months of April to September and higher during October to March.

Balakor (1948) observed in South Africa that the air temperature appeared to have no effect on SNF content of milk, while it was highest in the rainfall season and lowest in dry months. He suggested that there was a relationship of SNF content and the feeding value of pasture.

Rick and Lee (1948, a) by subjecting four cows to the
exposure of 95°F at high humidity found that the SNF content was increased from 10.1 to 10.7 percent.

Grigg (1948) in New Zealand, after studying the 20 years records stated that the SNF content of milk decreased steadily throughout the winter and rose sharply to a maximum in late spring.

Honer and Harzer (1949) found that the SNF content in different seasons in Mississippi reached the maximum average of 9.34 in winter and a minimum of 8.60 percent in summer.

Bayouni (1951) in England stated that the highest averages were obtained in the spring for the SNF content. The lowest values occurred in summer months.

Fabris (1952) in Milan, from the analysis of 30,000 samples of milk during several years found that the SNF content was lowest in August being 8.71 and highest in April being 9.05 percent. The average for the whole year was 8.87 percent.

Cobble and Herman (1951), analysing the milk of cows subjected to different levels of high and low temperature in psychrometric laboratory in Missouri, arrived at the following conclusions: total solids became significant at a higher temperature, below the freezing point than at 50°F, SNF tended to increase but the difference in it became significant at lowest temperature levels. Analysing some 2,500 samples collected from 42 cows of different breeds from the same laboratory, the same authors showed that the SNF content decreased above 85 to 90°F.

Bailey (1952, a) in a study of seasonal variation stated
that no regular trend was observed between December and March in the
SNF content of milk. Its level rose from April to May, fell from
May to July and rose again from August to September. The May–July
fall was approximately equal to the sum of the rises in the other
two periods. The decline in SNF of milk from the first calving was
significant from the month of January to April and August. It was
later suggested by Bailey (1952, a) that low SNF of milk was due to low
starch and food quality given to the animals.

Overman et al (1953) from the mixed herd of Brown Swiss
found that the SNF was lowest in August and highest in January.

Nicholas and Few (1950) found considerable seasonal
variation in the SNF of milk which tended to be lowest when the cold
dry weather started in late winter.

Provan (1955) from the studies of the data of the
composition of milk in England and Wales between (1947–1952) found
that the SNF content was lowest in March and April and much higher
in June.

Waite et al (1956) observed that the SNF content of milk
was at minimum in March and April, while SNF reached the highest
value in May and June. They concluded that the dietary changes would
not entirely account for these changes in the milk, nor would it
appear that climate was a major factor.

Merilan and Bower (1959) Kiermeier and Renner (1960, a)
Akmalkhonov (1962) and Rees (1964) also noted a reduction in SNF
content at temperatures above 27°C.
Only slight changes in SMF content at higher temperature on the other hand were established by Johnson and Givens (1961) and Wayman et al. (1962).
RESULTS AND DISCUSSION

**Solids-not-fat**

The average values for SNF content as affected by different levels of TDN and DCP feeding and overall nutritional and seasonal averages are summarised in Table VI A and in Figure 8. Tables VI B and C present their statistical analysis.

During the winter trial it was observed that the SNF content of milk was directly correlated with the level of TDN feeding. The higher TDN group animals produced on an average 8.729 percent SNF. The higher TDN feeding showed a higher value of SNF and vice versa (Table VI A).

In the summer trial, the trend was again similar. The high, medium and low TDN group cows produced on an average 8.674, 8.660 and 8.396 percent SNF respectively.

The hot-humid season studies also showed similar trends. The values obtained were 8.824, 8.654 and 8.468 percent SNF for the high, medium and low energy fed groups.

The DCP treatments also showed differences and responses in the SNF production.

In the winter trial, the high, medium and low DCP fed animals produced on an average 8.795, 8.553 and 8.426 percent SNF respectively.

In the summer trial, the higher protein fed cows on an
NUTRITIONAL EFFECTS ON SNF CONTENTS IN DIFFERENT SEASONS

OVERALL NUTRITIONAL AND SEASONAL CHANGES IN SNF
average produced 8.798, percent SNF. The medium and low DCP groups also produced 8.686 and 8.554 percent SNF.

The hot-humid animals also showed similar trends in their SNF production. The average recorded values were 8.873, 8.702 and 8.586 percent for the high, medium and low DCP fed groups, respectively.

The overall average for the SNF content of the TDN groups came to be 8.809, 8.571 and 8.369 for the high, medium and low TDN fed groups, respectively.

In the DCP groups, the overall average came to be 8.822, 8.647 and 8.522 percent SNF for the high, medium and low DCP fed animals, respectively.

Seasonal variation in SNF contents have been reported from many parts of the world. But no such data are available on the well known tropical milk breeds under field or laboratory conditions. Thus, the results obtained are of special interest as to how the seasons affect the SNF production in tropical dairy breeds and how far proper feeding (energy and protein levels) can maintain the SNF above the legal standard in all the seasons under a system of open yard housing.

The overall average values for the different seasons are as follows. In the TDN groups, the average SNF values were 8.457, 8.644 and 8.648 percent respectively for winter, summer and hot-humid seasons.

The DCP group animals also showed similar trends. However,
the average values were above the legal standard prescribed, i.e., 8.5 percent. The winter, summer and hot-humid season produced on an average 8.591, 8.679 and 8.720 percent SNF respectively. From the above mentioned results recorded, it was evident that nutrition played an important role in bringing about compositional changes in milk; especially the SNF content (the effect was due to changes in total protein, casein and lactose content). In the present investigation, in all the three seasons studied the level and type of energy supplied and protein were kept more or less same.

It was also observed that the energy content of the ration is more decisive for the richness of milk, rather than the protein. In the present investigation the first group cows were fed with medium level of DCP with three levels of TDN content whereas in the second group the TDN level was kept constant with those variables for DCP. The effect was more clear for different energy levels (TDN) than the protein.

As no data is available on the effect of these nutritional factors on the milk of tropical Zebu animals, the results obtained are discussed only with the values for European breeds, for which a wealth of information is, however, available.

Statistical analysis was carried out to study the effect of energy and protein levels as well as overall treatment and seasonal effects on the SNF content of milk. It is evident from Table VI B that in the winter season, the different TDN treatments resulted in highly significant (P < 0.01) effects on the SNF content. The SNF was 8.244 percent for the low TDN group and 8.397 for the medium fed
animals. Both these values fell below the prescribed legal standard of milk SNF of 8.5 percent. However, the high energy group maintained a maximum value, well above the standard. These investigations revealed that high level of energy feeding (TDN) specially in the winter season will be highly desirable, so that the richness of the milk is maintained. As already described, the open cattle yard provides an additional added disadvantage by demanding more energy for the maintenance of body temperature.

In the summer trial also, the different treatments showed highly significant variation (P<0.01). The low TDN group produced milk of lowest SNF, which was even lower than the legal standards prescribed in India. However, the medium fed animals produced SNF above the prescribed standard while the higher group was well above the legal limits.

In the hot-humid season also the trend was similar. Here also, highly significant (P<0.01) treatment differences were obtained. Only the low energy fed cows produced milk of low compositional value which was again below than the legal standard.

Thus in all the treatments the higher levels of TDN resulted in higher production of SNF over other groups. In the winter all the values were lower than that obtained in other seasons. The seasonal differences will be discussed later in this chapter.

The present values are in agreement with various other findings. The degree of variation between treatments are determined by the standard of feeding practiced, breed, type of feed etc. So minor differences in the degree of these relationships are always
observed. However, the basic fact and trend is same in all the observed experiments. Our present values could be compared with the observation of Riddet et al (1941), Rowland (1944, 1946), Kay (1948), Provan and Jenkins (1949), Breirem (1949, a), Davis (1939), Bailey (1952 a, b), Balch et al (1955, a), Castle et al (1959), Rock and Line (1961), Huber and Ruman (1966) and Smith and Boyd (1968).

For the DCP treatments also, the general trend was similar to that of the TDN treatments. However the degree of variation observed was not so marked as in that of the TDN groups. Another important point to be considered in discussing these results is that all the animals were provided with medium TDN levels. Whereas in low TDN groups as discussed earlier the animals were comparatively under-fed. Thus the variation observed in the SNF levels was mainly due to different levels of DCP fed.

The treatments showed highly significant differences in the winter season in the SNF content with the three levels of DCP studied. The higher group produced 8.795 percent SNF. The low group recorded only 8.426. The lower levels of DCP feeding gave lower levels of SNF as compared to legal standards.

In the summer trial, all the observed values were above the prescribed legal standard of 8.5 percent.

In the hot-humid season also, the values were within the safe limits as compared with that of legal standards. However, in the summer and hot-humid seasons all the treatments showed highly significant differences (P < 0.01).
Thus, here, the effect of the level of protein feeding depends on the energy of the ration and the season. Thus, in the winter season, the low SNF recorded for the low group might have been due to the low TDN (even though in all the season, the TDN levels were same, the winter season demands more as compared with the other seasons studied.

Another important observation was that even though all the treatments showed highly significant values in all the seasons studied the range of variation was narrower in DCP variable groups than for the TDN variable groups.

Many references are available on the effect of different levels of protein on the effect of milk SNF contents. However, most of the data are contrary to one another. Levels only slightly above or below the protein requirements have little effect. Thus several workers (Rock, 1953, Holmes et al 1956, Zorin 1956, Frens and Dijkstra 1959, Politiek and Sybrandy 1962) have noticed only very little differences and in some cases no difference at all was recorded. But in the present investigation, the levels were 25 percent above and below of the whole ration. Thus significant variations due to different levels of DCP were obtained.

However, when the rations were obviously deficient in protein, the total protein content, i.e., the SNF of milk was reduced. The results obtained by Perkins et al (1932), Steensberg (1937), Mehring (1938), Kajanoja (1944), Rowland (1944, 1946), Lutz (1947 a, b), Neisen and Korprich (1947), Breirem (1949 a, b), Amschler (1951),
Waite (1956) and Rook and Line (1962) are in agreement with the present investigation. The duration and extent of protein deficiency, the plane of energy nutrition, are important in these determinations. In the experiments conducted by Isaachsen et al (1956) there was a reduction of SNF and this was brought about by a reduction of protein of the milk from 3.24 to 2.84.

Seasonal alterations in SNF content

It is very difficult to separate out the effect of nutrition and season, as the seasonal influences are due to several factors. In the present investigation in all the seasons the level of feeding and treatment intensities were kept similar so that the seasonal effects could be separated.

The overall treatment averages were calculated for all the seasons for both the TDN and DCP groups (Table VI A). In the TDN groups the lower group produced 8.369 percent SNF only. Thus the recorded value was below the legal standard. However, the other two treatments showed normal or higher values. Analysis of variance was done to formulate statistical interpretations (Table VI C). There was highly significant differences (P < 0.01) between the treatments, the maximum effect resulted with the higher energy groups.

From the analysis of the data for the overall seasonal averages in TDN groups revealed highly significant variations between the seasons (P < 0.01). In the winter months, the value was 8.457 percent. Other values were higher than these values. Thus the milk
produced failed to pass the legal standard of 8.5 percent SNF. The summer milk was richer and on the safer side. However, the hot-humid season produced the richest milk. Thus the level of nutrition in bringing about compositional changes were reflected clearly in all the seasons.

In the DCP treatment groups the statistical analysis of data showed highly significant differences between the treatments. The SNF values obtained in all the treatments were above the 8.5 percent limit. However, the low DCP group was on the margin, i.e., 8.522. Thus, caution is needed in lowering the DCP of the feed, when the TDN is maintained at medium levels.

The overall seasonal analysis also showed highly significant differences ($P < 0.01$) between the seasons. As in the TDN group, the higher value was in the hot-humid season, followed by summer and winter months. All the values were above the legal limits.

The importance of nutrition especially the level of energy is reflected in all the results obtained. Thus, if the cows are provided with adequate nutrition and protected from the climatic hazards, especially the extreme cold, the Tharparkar breed will maintain the SNF above the legal standard throughout the year. However, some individual animals produced low SNF even with the high treatment. The nature of these causes are beyond the scope of the investigation as hereditary factors are also important. Thus once the animals are selected for the SNF above the legal limits, adequate nutrition will maintain the richness of the milk.
A wealth of literature is available on the seasonal changes in SNF from foreign countries. In India, studies carried out by Schneider et al. (1948) at the Allahabad Agricultural Institute have presented their results. However, no nutritional or seasonal studies have been carried out by them. They conducted experiments with the Red Sindhi and Holstein × Sindhi crosses and the averages for SNF were 8.497 and 8.079 percent, respectively. While commending on the results Mahadevan (1960) stated that "the SNF content of Indian cow is such that herd milk falling below the prescribed standard seems to warrant a reconsideration of this standard". However, further data is required to find out the nutritional and seasonal effects of SNF in various regions of the country and on different pure and cross-bred cows before any definite conclusion can be drawn. As far as the Tharparkar is concerned, there is no fear that the milk will not pass the legal standard.

Basu et al. (1962) also carried out investigations on the milk of the Tharparkar cows. Their study was at Bangalore (Southern Regional Station of National Dairy Research Institute), where the climate remains mild. Their average value for SNF was 8.70. However, they also noticed several individual samples falling below the legal limits as was also noticed in present studies.

Gupta and Dastur (1959) while working on the estimation of SNF in milk by a modified Richmond's Formula at the Karnal herd also observed values from 8.11 to 9.55 percent.
Rowland (1951), Provan (1949, 1956), Bailey (1952 a, c) also emphasised a well recognised effect of season, feed and climate on the SNF content of milk. Thus, as far as the tropical Zebu is concerned, the higher temperature did not affect the milk production or composition (already discussed in Chapters III to V). The general trend in low SNF values of summer season are a direct effect of low plane of nutrition and low compositional value of the summer forage. Even for the foreign breeds, several authors have observed reduced SNF value in summer or hotter months (Houston and Hale 1932, Cobble and Herman 1951, Bergman and Joost 1953, Ponomarev 1952, Bergman and Joost, 1953, Akmalkanov 1962 and Rees 1964), when the temperature rose above 27°C. But at the same time slight change in milk SNF was reported by Johnson and Givens (1961), Wayman et al (1962) and Rees (1964).

Thus, as far the present results go, the winter months are more detrimental to the SNF values rather than the hot season studied. This is due to the inherent adaptive capacity of the Zebu for the hot climate rather than the cold season. However the cold months are also optimum, when the plane of nutrition is well above than the hot months. The present data are slightly contrary to many workers for the SNF content on the summer season. The higher values in summer are mainly due to better adaptability of these cattle and the better nutritional status.
### TABLE VI A

**AVERAGE VALUES FOR SOLIDS-NOT-FAT IN PERCENT**

**(Nutritional)**

<table>
<thead>
<tr>
<th>TDN</th>
<th>DCP</th>
<th>WINTER</th>
<th>SUMMER</th>
<th>HOT-HUMID</th>
</tr>
</thead>
<tbody>
<tr>
<td>125</td>
<td>100</td>
<td>8.729</td>
<td>8.874</td>
<td>8.824</td>
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<tr>
<td>100</td>
<td>100</td>
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<td>8.660</td>
<td>8.654</td>
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<tr>
<td>75</td>
<td>100</td>
<td>8.244</td>
<td>8.396</td>
<td>8.468</td>
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<td>100</td>
<td>125</td>
<td>8.795</td>
<td>8.798</td>
<td>8.873</td>
</tr>
<tr>
<td>100</td>
<td>100</td>
<td>8.553</td>
<td>8.686</td>
<td>8.702</td>
</tr>
<tr>
<td>100</td>
<td>75</td>
<td>8.426</td>
<td>8.554</td>
<td>8.586</td>
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</table>

**OVERALL TREATMENT AND SEASONAL AVERAGES**

<table>
<thead>
<tr>
<th>SEASONS</th>
<th>TDN GROUP</th>
<th>TREATMENTS</th>
<th>TDN GROUP</th>
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</thead>
<tbody>
<tr>
<td>WINTER</td>
<td>8.4569</td>
<td>HIGH</td>
<td>8.8092</td>
</tr>
<tr>
<td>SUMMER</td>
<td>8.6437</td>
<td>MEDIUM</td>
<td>8.5706</td>
</tr>
<tr>
<td>HOT-HUMID</td>
<td>8.6485</td>
<td>LOW</td>
<td>8.3696</td>
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<table>
<thead>
<tr>
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<th>TREATMENTS</th>
<th>DCP GROUP</th>
</tr>
</thead>
<tbody>
<tr>
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<td>8.8220</td>
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<tr>
<td>SUMMER</td>
<td>8.6790</td>
<td>MEDIUM</td>
<td>8.6470</td>
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<tr>
<td>HOT-HUMID</td>
<td>8.7200</td>
<td>LOW</td>
<td>8.5220</td>
</tr>
<tr>
<td>Source</td>
<td>Degrees of freedom</td>
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</tr>
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<td>-----------------</td>
<td>--------------------</td>
<td>-----------</td>
<td>----------</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Winter</td>
<td>Summer</td>
</tr>
<tr>
<td>Squares</td>
<td>2</td>
<td>0.813 **</td>
<td>0.2554 **</td>
</tr>
<tr>
<td>Animals/squares</td>
<td>6</td>
<td>0.608 **</td>
<td>0.1100 **</td>
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<tr>
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<td>4.6965 **</td>
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<tr>
<td>Error</td>
<td>9</td>
<td>0.0142</td>
<td>0.0088</td>
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</table>

* Statistically significant at P < 0.05  
** Statistically significant at P < 0.01
<table>
<thead>
<tr>
<th>Source</th>
<th>Degrees of freedom</th>
<th>Mean squares for</th>
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</thead>
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<td></td>
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<td>Animals/seasons/squares</td>
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<tr>
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</tr>
<tr>
<td>Treatments</td>
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<td>11.7701 **</td>
</tr>
<tr>
<td>Treatments x seasons</td>
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</tr>
<tr>
<td>Error</td>
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<td>0.0257</td>
</tr>
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</table>

* Statistically significant at $P < 0.05$
** Statistically significant at $P < 0.01$