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# MILK PROTEIN PRODUCTION: AN ANALYSIS OF NEW ZEALAND'S PRESENT AND POTENTIAL CAPABILITIES

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SUMMARY

This contribution to the symposium is presented in four parts: first an analysis of present levels of production of milk protein in New Zealand, including assessments of average efficiencies; second, a consideration of the scope and means for increasing milk protein production through extension of existing farm practices; third, an assessment of the potential for expanding milk protein production to levels much higher than have been achieved to date. Some comparisons are made with other essentially conventional and alternative sources of high-quality protein representing possible competitors for land use; and fourth, a detailed analysis is made of the contribution that milk can and should make in the future as part of major changes and increases in the production of high-quality protein which this country has a unique opportunity to initiate and exploit.

## PRESENT LEVELS AND COSTS OF PROTEIN PRODUCTION FROM MILK

THE 2.4 million cows that comprise New Zealand's national dairy herd currently produce 255,000 metric tonnes of milk protein each year. These are derived almost entirely from grazed pasture, hay and silage, and 85% (Anon., 1970) of this total is transported as part of whole milk for processing in dairy factories. This tonnage represents, respectively, 1% and 0.2% of the annual world consumption of animal protein, and protein consumed from all sources (Altschul, 1966).

Because New Zealand's total production of milk protein has not changed appreciably during the past 5 years, these proportions have declined during this time.

Nevertheless, when assessed relative to labour and land areas involved, efficiency of milk protein production has increased appreciably. Between 1964-5 and 1968-9 it has been estimated that the yield of protein per hectare of land used for dairying increased steadily by about 2% per annum, primarily as a consequence of a 20% increase in carrying capacity, and, over this period, the total number of factory suppliers fell by 12% (Anon., 1970 ,1971).

### Average Level of Production

The average New Zealand dairy farm of 60 ha, 84% of which is grazed by a herd of 100 to 110 milking cows, produces each year 210 to 220 kg milk protein per grazed hectare.

### Efficiency Indexes

In general, dairy pastures produce 11,000 to 13,500 kg dry matter (D.M.) per hectare annually and have an average crude protein content of 17%. The gross efficiency of conversion of *available feed protein* to milk protein is therefore 10 to 12%. Expressed relative to the *actual feed* consumed this increases to 17%. Estimates cover the full 12 months, allowing for requirements of both the dry and lactation periods. Allowing also that over an average effective working life of 4 lactations, 3 surplus calves and a cow's carcass produce additional high-quality protein, these respective averages increase further to 11 to 13% and 20%.

### Cost

Between 1965 and 1969 total farm expenses averaged \$75.80 for cows which it is estimated had total factory supply yields for each season equivalent to 400 kg of milk solids (Anon., 1971). Farm costs per kilogram milk solids were therefore \$0.19, and the price increased to \$0.25/kg when cash returns to the farmer were included. Because all milk solids are recoverable and saleable as human food, these are probably the most realistic estimates available currently of producer costs for converting grass to milk protein.

## SCOPE AND MEANS FOR RAISING MILK PROTEIN OUTPUT

As for most components of milk, increasing milk protein yield requires the improvement of the genetic capability of the national herd to convert grass to milk; achieving an improved percentage harvest of the available D.M.; discovering more about cow requirements and how to meet these most effectively, and devising ways to raise further annual yields of available D.M.

TABLE 1

A: MEAN EFFICIENCY INDEXES (E%)
(kg D.M. required/kg milk protein produced)
Set means adjusted for treatment differences — based on 18 sets of identical twins in each season.

| *Season* | *1965-6* | *1966-7* | *1967-8* |
|---|---|---|---|
| E% | 30.9 ± 6.2 | 28.0 ± 3.7 | 26.2 ± 4.0 |

B: EFFECT OF FEEDING AND MANAGEMENT (SYSTEMS A, B, C) ON E%
Treatment means adjusted for sets — based on 12 set comparisons in each season

| *Treatment* | *1965-6* | *Season* *1966-7* *E%* | *1967-8* |
|---|---|---|---|
| A July calving (4.1 cows/ha) | 33.6 ± 8.7 | 29.6 ± 4.6 | 26.7 ± 3.9 |
| B July calving (4.9 cows/ha) | 31.7 ± 7.2 | 29.9 ± 4.3 | 27.4 ± 4.2 |
| C September calving (4.9 cows/ha) | 28.0 ± 3.6 | 25.1 ± 2.4 | 25.8 ± 3.2 |

## GENETIC IMPROVEMENT

Recent surveys (Anon., 1969) have shown that selection of bulls on the basis of the milk or fat yields of their daughters results in practically the same improvement in protein yield as when selection is based directly on this.

Measures of the variation in efficiency of conversion of pasture D.M. to milk protein by grazed lactating dairy cows have been calculated from several long-term feeding-management studies with identical twins at Ruakura Animal Research Station between 1965 and 1968 (Hutton, 1968). Average efficiency indexes computed as kilogram pasture D.M. required per kilogram milk protein produced are summarized in Table 1 (parts A and B). In Table 1A indexes have been adjusted for experimental treatment differences in each of three successive years; the nature of these treatments is described in Table 1B. From the average of the 3 seasons' results, it has been concluded that 28 kg D.M. were required on average during lactation to produce 1 kg of milk protein. The standard deviations describe between-set variation, providing a measure of genetic variability in the efficiency index. They indicate that in each year the most efficient 25% and 5% of cows included in these populations required, respectively, less than nine-tenths and two-thirds as much D.M./kg milk protein as cows about the group average.

Because these indexes of conversion efficiency and milk yield are reasonably highly correlated (($r$ = 0.91 (1965-6); = 0.88 (1966-7); = 0.83 (1967-8)), lowering the mean D.M. requirement per kilogram of milk protein from 28 kg to 22 kg should prove a reasonably attainable objective. If allowance is made also for feed consumed in the dry period this would represent a reduction from 31 kg to 25 kg D.M./kg milk protein, or a 20% improvement in protein conversion efficiency for a complete year.

## Improving Utilization of Available D.M. and Cow Nutrition

Using the averages described in the first section of this paper for milk and pasture yields and conversion efficiencies, and making additional allowances for feed consumed by dairy replacements, it is estimated that the percentage harvest of available pasture D.M. per grazable hectare is on average about 65% for New Zealand dairy farms. The most effective way to improve this is to raise carrying capacities. Surveys made of factory supply farms from 1964-5 to 1968-9 (Anon., 1971) show that over this period the number of dairy farms estimated to have produced more than 280 kg milk protein per hectare increased four-fold, and that these changes were closely associated with marked increases in carrying capacities. Moreover, in 1968-9, herds exceeding 350 kg protein per hectare, carrying almost double the average number of milking cows per grazable hectare, recorded per-cow productions well in excess of the national average, with a consequent reduction in costs of producing milk protein per unit area.

Data in Table 1B show, for carrying capacities one-third higher than these again, that even at exceedingly high stocking rates, provided appropriate associated changes are made to feeding and management so that cows are well fed during particularly critical periods each year, individual output and productive efficiency need not be reduced. In the example given, significantly the most efficient conversion of pasture D.M. to milk was consistently obtained with the more heavily stocked spring calving cows. This was primarily the result of a change in calving date from late winter (July) to spring (September), in association with a substantial increase in stocking rate, and with some modifications to pre- and immediate-post-calving feeding necessitated by these changes.

Attention has been drawn to both these sets of data and to the associated underlying principles, because of the primary importance of carrying capacity in affecting the percentage harvest of grazed forages and hence protein output. Evidence such as has been presented from these separate sources clearly refutes the misguided, now too frequently expressed generalization that in the recent past carrying capacities have been raised too high too fast, to the detriment of individual animal performance.

### Increasing Yields of Available Pasture D.M.

Despite certain largely theoretical claims to the contrary (Mitchell, 1969) most recent research and industry experiences confirm that pasture herbage and grazing management will continue as biologically and economically the most effective fodder producing and harvesting systems to apply to dairying within the New Zealand environment. Yields of herbage D.M. of 15 to 17,000 kg/ha are achieved regularly using intensive management practices at an approximate net annual cost of $100 or the equivalent of 0.6 cents/kg D.M. Increases beyond this level will occur in response to inputs such as irrigation, nitrogen fertilizer, and some degree of cropping, to name a few, but the extent of these yield increments and their additional cost is not yet clearly known. Hence for the calculations which follow it has been assumed that the yields as stated represent maxima at least for the near future.

## POTENTIAL FOR EXPANDING PROTEIN PRODUCTION

### Milk Protein

The yield figures quoted have been used to prepare part of the data presented in Table 2 which describe the milk protein producing potential of land capable of growing consistently 15,000 kg pasture D.M. per hectare per annum. Management systems which, for the complete year, enable 90% of the available D.M. to be harvested by grazing cows consuming, on average, 25 kg D.M. per kilogram of protein produced are also prescribed. Included in the resulting 580 kg of protein per hectare per annum is a proportion derived from carcasses of surplus calves and cull cows slaughtered during this time.

For comparison, the potential yield of protein per hectare obtainable from equally highly developed but alternative systems of dairying, such as are used in North

TABLE 2: POTENTIAL YIELD OF PROTEIN PER ANNUM FROM DAIRYING — GRASSLAND AND CROP HUSBANDRY SYSTEMS

| *Item* | *Yield (kg/ha)* | |
|---|---|---|
| | *Grass* | *Crops* |
| Protein | 580 | 420 |
| Essential amino acids | | |
| Isoleucine | 50 | 35 |
| Leucine | 60 | 42 |
| Lysine | 53 | 37 |
| Methionine | 16 | 11 |
| Phenylalanine | 28 | 20 |
| Threonine | 29 | 20 |
| Valine | 40 | 28 |
| Tryptophan | 7 | 5 |
| Total | 283 | 198 |
| Cost/kg ($) (based on farmer prices) | | |
| Total solids | 0.27 | 0.85 |
| Protein | 0.93 | 2.70 |

America and continental Europe, based on feedlot operations involving maize grain, soybeans as the protein supplement and conserved roughages (maize silage and lucerne hay), has been included also in Table 2.

Full details of the bases for these comparisons have been published (Hutton, 1970). The results are presented because opinions are frequently expressed that grain-feeding, forage-conservation feedlot systems which favour high individual animal performance could be employed with advantage for milk production in New Zealand. This analysis indicates, however, that given comparable levels of technological excellence, the yield of milk protein per hectare derived from grass will exceed that from crops by approximately one-third, and at substantially lower costs (Table 2).

## POSSIBLE ALTERNATIVES TO DAIRYING FOR INTENSIVE LAND USE

Although these levels of production are undoubtedly high, to ensure that best use is made of this country's limited resources, they must be compared with those obtainable from other systems that could be considered reasonable alternatives to dairying for highly productive land use. Table 3 lists the quantities of protein and essential amino acids potentially obtainable from grass-fed beef, and soybeans or maize grain productions. As in Table 2, levels of production for each system require a

TABLE 3: COMPARATIVE ANNUAL PROTEIN YIELDS FOR HUMAN FOOD FROM BEEF AND CROPS

| *Item* | *Beef* | *Soybean* | *Maize* | *Grass* |
|---|---|---|---|---|
| Protein (kg/ha) .... .... .... | 180 | 1350 | 740 | 2700 |
| Essential amino acids | | | | |
| Isoleucine .... .... .... | 9 | 78 | 30 | 135 |
| Leucine .... .... .... .... | 15 | 103 | 103 | 254 |
| Lysine .... .... .... .... | 15 | 89 | 21 | 173 |
| Methionine .... .... .... | 4 | 15 | 15 | 59 |
| Phenylalanine .... .... .... | 7 | 65 | 38 | 162 |
| Threonine .... .... .... | 7 | 53 | 26 | 140 |
| Valine .... .... .... .... | 10 | 70 | 37 | 178 |
| Tryptophan .... .... .... | 2 | 16 | 5 | 54 |
| Total .... .... .... .... | 69 | 489 | 275 | 1155 |
| Cost/kg ($) (based on farmer prices) | | | | |
| All edible constituents .... | 1.03 | 0.20 | 0.08 | 0.06 |
| Protein .... .... .... .... | 2.45 | 0.27 | 0.66 | 0.06 |

very high degree of technological skill. Beef is from Friesian steers marketed at 390 kg liveweight when 15 months old and requiring from weaning to slaughter 9.5 kg pasture D.M./kg liveweight gain. Pasture productions and percentage utilizations are comparable with those for dairying. Soybean yields are 3,900 kg/ha and maize 11,300 kg/ha, and percentage utilizations of each for human foods are 95 and 75, respectively. Comparisons, including data contained in Table 2, show milk to be more than 3 times as productive of protein and essential amino acids per hectare as beef; respectively, 40 and 60% as productive as soybeans; slightly lower in total protein output than maize, but similar in yield of essential amino acids. For maize, it should be appreciated that a large part of the protein is present as zein which is of relatively low biological value. This is indicated in some degree by concentrations of the individual amino acids.

Included also are estimates of protein costs calculated alternatively by dividing producer prices for each commodity* either by the total weight of all edible fractions obtained from each feedstuff, or by the weight of protein alone. Differences between both the yields and costs of producing milk and plant proteins are appreciably smaller than others often quoted previously (Altschul, 1966; Leng, 1968). They provide a useful measure of the extent to

*Per 100 kg — Beef carcass, $55; soybeans, $9.18; maize, $4.33.

which the lactating ruminant can compete with plants as producers of high-quality protein provided it has full opportunity to exploit its peculiar advantages.

## POSSIBILITIES FOR MILK AS PART OF FUTURE EXPANSIONS IN PROTEIN PRODUCTION

New Zealand has approximately 5.5 million hectares of either flat or rolling country (Gibbs, 1963), each of which grows or is capable of growing every year twice as much high-quality protein as an excellent crop of soybeans (Table 3). With procedures presently available, about 40% of the crude protein in green plants can be extracted and converted to forms suitable for inclusion in human foods (Pirie, 1953; Oelshlegel *et al.*, 1969). Even allowing for this relatively low recovery, the estimated price per kilogram, including growing and harvesting costs plus a reasonable return to the farmer, is less than for maize (Table 3). Herbage produced from a hectare of fertile land when treated in this way will provide residues capable of yielding 300 kg of milk protein additional (Hutton, 1970).

In terms of animal protein equivalents, therefore, this area alone has a productive potential approaching 7 million metric tonnes — more than sufficient to meet the world's present total deficit of animal protein (Altschul, 1966).

Only by exploiting this potential are we likely to contribute significantly to increasing world protein supplies both for human consumption and to meet rapidly increasing livestock requirements. The raw materials required for exploitation are available in our grasslands which are being maintained at appreciably less cost than in most other countries. The need is to raise their percentage harvest within an integrated programme which will include increasing numbers of livestock, having as their major role the conversion of by-product materials to high quality animal proteins, to sell to populations who prefer these and can afford to buy them.

It seems paradoxical, therefore, that currently while vast sums are being spent developing industries based on essentially limited resources, as for example the West Coast iron sands, and while we accept an increasing involvement in ventures like the recovery of potentially usable materials at present wasted by our animal industries, we make so little use of raw materials which are nationwide, which form the basis of New Zealand's economy, and the building blocks of foods for which there is world-wide demand.

A minimum requirement is therefore to intensify research into problems associated with the recovery of protein from grass, and to combine with this studies of ways to use effectively the residues from these processes, in particular, for feeding the lactating cow. This work should be fostered within research environments permitting rapid translation of results to the needs of practical management systems which can be evolved and tested contemporaneously to cover the most important anticipated requirements of commercial farming practice. This has not been done before but is essential to provide the guidelines to encourage commercial interest and acceptance and ensure success. Unfortunately most previous research related to this overall objective has been fragmentary and frequently has been attempted in unsympathetic environments. Realizing these requirements and obtaining the necessary data will involve considerable time. Such an approach will not assist materially therefore to alleviate immediately world protein shortages, or to provide a ready solution to this country's recurrent economic problems.

In the short term the greatest single contribution that New Zealand can make towards assisting developing countries to reduce present deficits of animal protein equivalents is by providing skilled technical assistance to encourage extended, more efficient use of each nation's available resources with minimal disruption to existing religious, social and economic customs and prejudices. There is ample evidence that, too frequently, aid programmes founder either because they do not have this objective, or because advisers have no conception or experience of low-cost systems of agricultural production, and of simple ways to encourage increased productivity in environments demanding these.

For such circumstances it should be recognized, despite the undisputedly high productivity of some plant proteins, that there is frequently enormous potential for increasing productivity from livestock. Of the world's total population of cattle, buffaloes, sheep and goats, two-thirds are in developing countries, as is one-half of total pig numbers. Thus, although at present only 10% of dietary protein is contributed by livestock products in these areas, by increasing the milk and meat yield per livestock unit to average levels being achieved now in developed regions, while maintaining present rates of increase in stock numbers, a three-fold increase in *per capita* consumption of animal protein could be achieved. The effect this would have on the dietary standard of populations in these areas, on world demand for animal protein, and hence on New Zealand's long-term economic outlook, will be readily appreciated.

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