THE VALUE OF DRIED BUTTERMILK AS COMPARED WITH SKIM MILK FOR CALF REARING, AND THE EFFECT OF FEEDING AT TWO DIFFERENT LEVELS ON GROWTH TO WEANING UNDER NEW ZEALAND CONDITIONS.

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J.L. Corbett in partial
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INTRODUCTION.

It is startling fact that each year in New Zealand, the digestible protein lost for human consumption through the inefficient conversion of dairy by-products into pigment, is approximately twice the total annual output of protein in lamb and cheese; and the food energy lost nearly equals the energy in these two commodities (Filmer 1944). Though a proportion of the loss is through the associated feeding of coarse grain and meat meal, and also some from whey, the great majority arises from the feeding of skim milk and buttermilk which are of immediate human nutritional significance.

The case for making these high quality foods directly available for human consumption is strong, despite any repercussions on the pig industry and notwithstanding such economic considerations as secure markets. **In order to do so it is obvious that the raw materials must be processed to reduce bulk and improve keeping quality for transportation.** The utilisation in this way of skim milk is set back by the considerable problem of its collection from the cream supplying farms, though it may be easier where the density of these in an area is high. Since the buttermilk is produced at the dairy factory, this difficulty does not apply.

For many years the United States has dried buttermilk until now about 30% of the total creamery output is used in this way (Hunziker 1946), production of dried buttermilk having remained fairly steady during the past fifteen years or so at about sixty-six million pounds per annum (Cronshaw 1947). Much of this is made from sour cream, being thus used almost exclusively for animal feeding, notably hens and pigs. In New Zealand, however, the buttermilk is mostly derived from sweet cream.

Within the last few months (1949) the British

Ministry of Food has entered into a six year contract (with arrangements for its renewal) with the New Zealand Dairy Products Marketing Commission for the supply of dried buttermilk powder, the first year's price being £60 per ton. It is to be hoped that this is only a start in the more enlightened use of dairy by-products, for 75% of all milk produced is used in butter manufacture, and only about one-tenth of this by volume, containing comparatively little of the non-fatty solids, comes to the factories as cream.

Until this contract, New Zealand has annually been producing about thirty thousand tons of preserved milks (N.Z. Dairy Board 1948) of which 80% has been condensed or evaporated. The amount available for animal feeding has been small being mostly lactose mother liquor (not included in the above), and a few factories have been supplying dried buttermilk at the cost of threepence a pound. Now, because of the overseas demand, this price has risen to sevenpence (approximately £60 per ton). However, not all the export production will be suitable for human consumption. McDowall (1946) states that in the case of a butter factory with an output of two hundred tons of the dried material, about one hundred and fifty tons might be suitable. Whether or not this is unduly pessimistic from the factory's point of view, it does indicate that there will be fair supplies for stock feeding, and these should not be sold for the full price.

The particular interest to New Zealand farmers lies much in the use of the dried buttermilk for calf feeding on farms supplying cheese factories, condensories or town milk. The problem in striking a balance between growing good calves, yet feeding the minimum quantity of whole milk is considerable, although it is met in some cases by letting calves out for rearing, or in lesser degree by feeding meals. But the possibility of a good, reasonably priced, supply of dried buttermilk, found to be of value in calf rearing,

would much simplify the position. For this, the probable maximum demand has been estimated by McDowall (1946) as eight hundred tons, with four hundred and fifty tons as a more likely figure.

The local market is not the only outlet for second quality powder. In England the concentration on the liquid milk trade and the almost complete absence of any fresh milk by-product has caused the widespread use of varioys gruels as a whole milk substitute for calf rearing. These are purchased dry by the hundredweight and made up at the rate of one pound to nine pounds of water. Many of these contain dried milk products, often those intended for human consumption (mostly from the United States) which have deteriorated during carriage. Since the United Kingdom -- New Zealand contract calls for the supply of the buttermilk in sacks only, and not drums or barrels, it seems likely that some proportion of this will also be used in this way. As far as can be foreseen there will not for many years be any unsaleable surplus of whole milk in England, and the wholesale price ranging from one shilling and eightpence in summer to well over three shillings a gallon in winter makes the use of a whole milk substitute very attractive. The price of these has recently been raised from about thirty to forty shillings per hundredweight and the new price for roller buttermilk powder for stock feeding is fourty-four shillings and nine-pence. Thus on diluting, the cost of these feeds is four-pence or fivepence a gallon. Early in 1950 the subsidy on animal feeding-stuffs bought by the British farmer is to be removed altogether, and the cost of whole milk substitutes will probably rise by a further ten shillings per hundredweight. Cost per gallon (diluted substitute) will then be approximately sixpence. Even if it were found necessary, in England, to introduce a manufacturing price for surplus milk of say a shilling a gallon, or wholesale prices were to be reduced,

calf gruels would still be a good proposition especially in the winter months.

It is necessary to supplement them with some concentrated energy food, for the non-fatty solids represent only half the energy content of whole milk, and rolled oats, flaked maize, bran, linseed cake meal and fish meal are often fed. However such a mixture will also be given in conjunction with whole milk.

It may be questioned whether the price of dried buttermilk - £60 per ton - is not rather high. However, these are the first years of large scale production and initial outlay in plant and building has been fairly heavy, so that the price is justified even if as an insurance against non-renewal of the overseas contract. Future contracts may be settled at a lower price, especially if some dried buttermilk is exported specifically as stock feed. Mention must be made of the English poultry industry which is now, and will probably continue to be, a willing market for quantities of dried milk products.

Table I gives figures for the total milk powder imports of the United Kingdom (Monthly Digest of Statistics 1949).

TABLE I.

Year	U.K. Milk powder imports ('000 tons) Monthly average.
1935	0.9
1936	1.0
1937	1.2
1938	1.5
1944	6.9
1945	2.5
1946	3.1
1947	4.3
1948	1.7
1949 (first six months)	4.8

Home production is now averaging about seven

hundred tons weekly through the year, but the bulk is produced in the summer months. Though this may increase, the market for overseas producers will remain. Kay(1949) states that he believes Britain can use considerably increased quantities of some of the dairy by-products now being developed in New Zealand, referring particularly to skim milk powder and buttermilk powder, which he considers have great possibilities ahead of them for use in bread and other products.

The demand is at present largely met by imports from the United States, but because of Britain's efforts to purchase where possible from non-dollar sources, New Zealand has great opportunities for developing the export of dried milks so that they become an important contrinution to her national income.

It was with these broad considerations in mind, that this study on a particular aspect of dried buttermilk utilisation was undertaken.

OBJECTS OF THE EXPERIMENT.

The principal object of the experiment was to determine whether dried buttermilk reconstituted with a calculated amount of water so as to be similar in gross composition to skim milk, was equivalent in feeding value to the latter as judged by the growth of calves to weaning. Both feeds were given in conjunction with pasture ad libitum.

It was also felt that information should be obtained from feeding the buttermilk at more than one level.

Pedigree female Jersey and Friesian calves from the College herd were available for the experiment.

REVIEW OF LITERATURE.

McCandlish (1939) after reviewing the literature on various dried dairy products concluded that they could be used successfully in calf rearing, their constitution giving a fair guide to their relative feeding values.

Buttermilk itself has long been fed to calves. Thus Otis (1904) showed "beyond a doubt" that calves could be successfully raised on it, and in this experiment had less trouble from scours in the buttermilk fed calves than those skim fed. Archibald (1916) found it slightly superior to skim milk. Shepherd and Converse (1939) were rather more cautious, noting that buttermilk has practically the same composition as akim milk, but also contains a small amount of fat and has a certain acidity. They state that it should not be diluted by washing water or condensed steam and should be pasteurised, and since it may be somewhat more laxative than fresh skim milk, it is best not to change from whole milk until three to four weeks of age, and then gradually so as to avoid digestive disturbances. This advice most calf-rearers would in any case practice.

Woodward (1922) fed eight calves whole milk

until two weeks of age, and then changed them to condensed buttermilk during the following two weeks; after this condensed buttermilk only was fed along with alfalfa hay and a grain mixture. The animals made daily gains of 1.3 - 1.6 lb. until they were four to six months old, being fed 1¼ lb. per day of the condensed buttermilk initially, increasing to 4 lb. per day at three months. He noted that the calves were not subject to scouring as often as occurred with skim milk feeding.

Rogers Johnson and Albery (1926) have developed a method of preparing a condensed buttermilk with good keeping qualities, in which a culture of streptococcus and a mycoderm is used to develop an acidity sufficient to prevent growth of micro-organisms, the acid buttermilk then being condensed in a vacuum pan to approximately one third its volume. The feeding value of the buttermilk is reduced since much of the lactose is reduced to lactic acid, as shown by the following figures on composition (Hunziker 1935).

Total solids	25.00 - 32.70%
Fat	1.00 - 2.60
Protein	9.00 - 11.85
Lactose	3.96 - 12.00
Ash	1.70 - 7.51
Lactic acid	4.30 - 6.19
Water	67.30 - 75.00

The packaging and transport costs of this bulky and acid liquid - requiring wooden barrels - are high, but despite these and other disadvantages, large quantities are produced in the United States, being known as "semi-solid" buttermilk.

Rupel (1929) found this product fairly satisfactory for calf rearing, but less economical than skim milk. An experiment at the Idaho station (1929) agreed on this point; it was found difficult to change a group of four calves from sweet milk to semi-solid buttermilk, the animals being less thrifty than those skim-fed. They also scoured until they began to eat quantities of hay and grain.

Morrison and Rupel (1926) fed semi-solid buttermilk

to calves given a minimum of whole milk (less than 400 lb.) which was discontinued at seven to nine weeks old. Given together with dried skim milk it increased the rate of gain over calves getting whole milk, both groups receiving hay and a grain mixture. However, the cost of feeding was increased.

Eckles and Gullickson (1924) conducted an experiment using a very small number of calves (five), of different breeds and sexes. This heterogeneity and paucity of material is the great weakness of most of the experiments here reviewed. They reared the calves on condensed or powdered buttermilk, each being diluted so as to give a similar total solids percentage to fresh buttermilk, and each group was given good hay and a grain mixture. Whole milk was fed for the first two weeks of life, the changeover being made gradually. All the calves made excellent growth, the daily gain to six months being 1.3 lb. on average. Scours or indigestion were never present, and no trouble was experienced in getting the calves to take the buttermilk as prepared; rather they seemed to prefer it to whole milk. The calves were as a whole sleek coated and thrifty.

Ellington and Knott (1926) raised eight calves on semi-solid buttermilk (three lb. in nine lb. water) or dried buttermilk (one lb. in nine lb. water) together with alfalfa hay and grain. Comparing their growth with Eckles standards, the twp buttermilk products were concluded to be satisfactory substitutes for skim milk when this is not available.

In an experiment at the Idaho station (1928), calves were fed diluted powdered buttermilk as a substitute for skim milk, together with hay and grain. The animals suffered little from digestive disorders, were quite thrifty, and their growth in weight and height was very satisfactory.

Buttermilk powder has also been fed dry; Lindsey and Archibald (1929) found that in young calves it produced

almost the same rate of gain as skim milk powder. It was more economical, but not as palatable when first fed as the skim milk powder, and in some cases had a decided laxative effect.

In another experiment (Idaho, 1931) a group of Holstein calves was fed whole milk for two weeks, changed over to dried buttermilk solution during the third week and received twelve pounds of the solution daily during the fourth and fifth weeks. During the sixth week they were changed to a dry grain ration containing one third dried buttermilk powder and were also given alfalfa hay. From four to six months of age they were fed the alfalfa hay and grain mixture but without the buttermilk powder. A second group of calves was fed in the same manner except that up to four months of age they were given no buttermilk, but received a minimum of twelve lb. skim daily. Both at four and six months this latter group was considerably heavier and taller, (113% of "normal" weight as compared to 90% for the former at six months) and was also sleeker and thriftier in appearance.

Though buttermilk powder fed dry may not give quite as good results as when reconstituted, bearing in mind the drawbacks of this and the other experiments - the small number of animals used - it can be said that reconstituted buttermilk powder under the various experimental conditions has not given very different results in calf rearing from the fresh material, or indeed from skim milk. Semi-solid or condensed buttermilk appears to be slightly less valuable, largely owing to its acidity.

There are no experiments reported that are strictly comparable with that on level of feeding here conducted. Where trials of similar intent are described, the calves on the larger ration, as would be expected, showed the greater growth. Thus Woodward (1923) fed calves

- four in each group - on skim milk at one-fifth, one-sixth or one-seventh of body weight, and a further group was allowed as much as they would drink in two feeds daily. By drinking 80% more skim milk than calves on the lowest level of feeding, the latter group made 50% larger gains; it was noted that even though at times the calves were drinking more than 40 lb. per day there were no bad results, and was considered as indicating that overfeeding in itself is not a common cause of scours. This is surprising (taking "scours" to mean "nutritional scours") especially on considering the ages of the calves which were on the experiment for seventy days following their initial two weeks of life. Much would probably depend on the dry food given in addition, but no mention was made of this at all. Further, only four animals were used.

McCandlish (1939) reviews other trials variously conducted, which show that the more liberal allowance gives better results.

Campbell (1948) reported an experiment conducted under New Zealand conditions in which calves were fed skim milk, together with good pasture ad libitum. Two groups were fed equal quantities of skim milk per unit body weight, whilst one of them was given in addition $\frac{1}{2}$ lb. of meal per day (calculated to be the equivalent of 4 lb. skim milk). This latter group, however, only gained an additional 6 lb. in body weight on average during the age period six to twenty-two weeks so that the additional feeding had little effect, probably owing to the levelling influence of grass intake. In another trial, Campbell (1946) found very little difference between calves fed at either 10% or 15% of body weight of skim milk, with daily maxima of two and three gallons respectively, but in this year the season was exceptionally favourable for calf-rearing with good weather and grass growth, and low disease incidence (Campbell, personal communication).

Apparently, then, there is some question as to whether a higher level of milk feeding raises bigger calves under good New Zealand conditions. It must be emphasized that "good" conditions implies a supply of high quality grass.

The advantages or disadvantages which accrue from rearing calves at different rates will be discussed later.

DESIGN OF THE EXPERIMENT.

Data from previous calf experiments conducted by the Dairy Research Institute were examined in order to determine the variability in growth of similar animals at the age of twenty weeks, figures from ninety-one calves in five seasons with three or more top crosses of Jersey blood being used.

Now $$t = \frac{D}{\frac{s}{\sqrt{N}} \cdot \sqrt{2}}$$

Where D is the difference between the means of two groups, and the denominator is the standard error of this difference. N is the number of variates in each mean, and s in this case is the standard deviation of calf weights at twenty weeks of age.

Thence $$N = \frac{2t^2 s^2}{D^2} \quad \text{or} \quad D^2 = \frac{2t^2 s^2}{N}$$

By substituting a suitable value of t, and the calculated variance, it is easily calculated how many calves are required in each group to make a certain weight difference at twenty weeks significant at the particular level of significance.

With so large a sample as ninety-one calves, 2.0 was taken as a safe approximation of t at the 5% level, and 2.7 at the 1% level.

In calculating the standard deviation of twenty weeks weights, differences between treatments within years

were all non-significant and were ignored, but seasonal effects over the five years were marked. The variance s_i^2 for each year was calculated with the corresponding number of degrees of freedom N_i, and the variance between calves within seasons - s^2 - found

$$s^2 = \frac{\Sigma N_i s_i^2}{\Sigma N_i}$$

This gave a figure of 537.2 lb. and thence a standard deviation of 23.2 lb.

In Table II are given the required numbers of calves and weight differences. These figures are plotted in Graph I. (See page 13).

The value for the standard deviation and thence weight differences required may be enhanced somewhat by slight intraseason treatment differences, and possibly by breed effects, but the magnitude of this error is uncertain and is unlikely greatly to affect the figures and general conclusion that numbers in each group are required to be large. Accordingly it was decided to include such pedigree female Friesian calves as became available, in addition to pedigree female Jerseys.

Further, rather than reduce group size by including a third treatment, that is by feeding buttermilk at two levels, a simple factorial design was employed, both skim and buttermilk being fed at 10% or 15% of body weight levels, choice of levels being guided by the experience of previous Dairy Research Institute calf experiments.

It was decided to feed the reconstituted buttermilk on an equal energy basis with skim milk. From an analysis of each, given later, it was found that this was very nearly achieved by mixing each pound of the buttermilk powder with 9 lb. water, which incidentally was also feeding on an equal "total solids" basis.

TABLE II

Pounds difference in bodyweight between groups of calves at twenty weeks of age, required for significance.

Number of calves in each group.	5% level	1% level
2	46.4	62.6
3	37.9	51.1
4	32.8	44.3
5	29.3	39.5
6	26.8	36.2
7	24.8	33.5
8	23.2	31.3
9	21.9	29.5
10	20.8	28.0
11	19.8	26.7
12	18.9	25.6
13	18.2	24.6
14	17.5	23.7
15	16.9	22.9
16	16.4	22.1
17	15.9	21.5
18	15.5	20.9
19	15.1	20.3
20	14.7	19.8
25	13.1	17.7
30	12.0	16.2
35	11.1	15.0
40	10.4	14.0
45	9.8	13.2
50	9.3	12.5

GRAPH I