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DURHAM COUNTY COUNCIL.

EDUCATION COMMITTEE.

REPORTS

ON

DAIRY INVESTIGATIONS

AT

OFFERTON HALL, COUNTY DURHAM,

AND IN THE NORTH OF ENGLAND,

INCLUDING REPRINTS OF OFFERTON BULLETINS, Nos. 1-3.

Issued by

THE AGRICULTURAL DEPARTMENT

OF

ARMSTRONG COLLEGE, NEWCASTLE-UPON-TYNE

(In the University of Durham).

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INTRODUCTION.

Dairy Investigations in County Durham and the North-East of England.

The Agricultural Department of Armstrong College, Newcastle-upon-Tyne, commenced an inquiry into the variations in the composition of milk at the beginning of 1903. The first tests were made at the request of the Northumberland and Durham Dairy Farmers' Association, and these were elaborated at the instigation of the Northumberland County Council, which desired that some reliable information on the subject should be placed before the dairy farmers of that County.

It was soon felt, however, to be desirable that work of a more permanent character should be carried out; and, as the Northumberland station at Cockle Park is mainly engaged in work connected with farm crops and the rearing and feeding of live stock, the authorities of Armstrong College submitted a scheme for experiments in dairy work to the Durham County Council. This scheme was accepted, and as a result the work is now being done at Offerton Hall, about 3 miles from Sunderland. This farm is about 580 acres in extent, 165 acres of which are pasture, and there is a herd of 50 dairy cows. By arrangement with Mr. James McLaren, the tenant of the farm, the College authorities may at any time select 10 cows for an experiment, and place them in a separate cow-house, while experiments in calf-rearing may also be undertaken. A laboratory and a weigh-bridge have been provided.

Mr. James McLaren, junior, a former student of the College, supervises the experiments, such as weighing out the rations and the feeding and weighing of the cows, and carries out the milk testing. The College was fortunate in securing the ready co-operation of Mr. McLaren and his son, to both of whom the success of the work is largely due.

This pamphlet contains:—Reprints of the first report issued by the College in 1903 on variations in the composition of milk; reprints of Offerton Bulletins, Nos. 1 to 3; soya cake for milch cows; a reprint of a report of experiments with the milk of newly calved cows at Offerton; the composition and manurial value of foods; daily rations for fattening cattle and milch cows; calf rearing at Newton Rigg; prevention of tuberculosis by open-air treatment; and tests for farmers' milk.

These reprints and articles have been prepared at the request of the Durham Education Committee, for the use of dairy farmers in the county, as most of the reports are now out of print, and there is a great demand for them.

In preparing for publication a considerable amount of matter which was not included in the original reports has been added.

These dairy investigations have aroused great interest, not only in the County of Durham, but throughout the North of England, and in the country generally. The County of Durham has, by the grant which has enabled the College to establish the Offerton Hall Dairy Research Station, made the College scheme of Agriculture Research more complete, and that this work is appreciated by dairy farmers is evident from the great interest taken in it by the Northumberland and Durham Dairy Farmers' Association, and other similar bodies, and also from the large number of inquiries made to the College by dairy farmers and by all interested in dairying.

Offerton Bulletins 1 and 2 were written by Professor C. Bryner Jones, M.Sc., now of the University College of Wales,

Aberystwyth, when Lecturer in Agriculture in this College, while Offerton Bulletin 3 was written by Mr. Frank P. Walker, B.Sc., the present Lecturer in Agriculture, who, with myself, is responsible for the planning and conduct of the experiments, the details being under his charge. A large amount of the work has been done by Mr. S. H. Collins, M.Sc., Lecturer in Agricultural Chemistry in this College. Mr. W. T. Lawrence, Manager of the Cumberland and Westmorland Farm School at Newton Rigg, has most kindly contributed an article giving the results of his valuable experiments on calf rearing and feeding, and Mr. Nichol, Bradford, near Belford, has kindly allowed an account of his method of rearing calves in the open air to be inserted. My assistant, Mr. T. R. Ferris, B.Sc., has also given considerable assistance, especially in preparing many of the tables.

The College authorities have had the advice and assistance of the Advisory Agricultural Committee of the Durham Education Committee in the conduct of this work, the present members of which are:—Wm. Fleming, Esq. (Chairman), Alderman W. A. Weightman, Councillor G. Davison, Thos. Davis, Esq., W. Parlour, Esq., R. Richardson, Esq., W. L. Walker, Esq., J. A. L. Robson, Esq. (Secretary). Alderman Weightman, one of the largest and most successful dairy farmers in Durham, has been especially helpful in this work.

Liability of milk to be under standard.—The Board of Agriculture regulations for milk are that it must contain not less than 3 per cent. of fat and 8·5 per cent. of solids not fat. It is presumed that milk is not genuine when under these standards, and that it has been tampered with, either by the extraction of milk-fat (cream), or by the addition of water, *until the contrary is proved.*

The Board also issued a circular in December, 1901, in which they state that although genuine milk is usually well above the standards, it may occasionally, especially in certain seasons of the year, fall below these limits. They suggest in

such cases, that, in the absence of special circumstances indicating fraud, the local authority might in the first instance call the vendor's attention to the analyst's report and ask him if he has an explanation to offer. If this were satisfactory, they might at their discretion refrain from proceedings. They suggest, however, that further samples of milk should be taken in such cases, so that a satisfactory conclusion can be reached.

In the Offerton reports which follow, it will be seen that the mixed milk of five cows was very frequently under the 3 per cent. standard of fat, especially in the morning's milkings, and that it was also occasionally under the 8.5 per cent. of solids not fat. The last three lines of the twenty tables dealing with the average percentages of fat and solids not fat should be consulted for this purpose.

The organization of this work has been of special interest to myself, as the practical and scientific sides of dairy farming have always occupied a large part of my attention.

DOUGLAS A. GILCHRIST,

Professor of Agriculture.

ARMSTRONG COLLEGE, NEWCASTLE-UPON-TYNE,

November, 1909.

Variations in the Composition of Milk and their Probable Causes.

Published December, 1903.

BY DOUGLAS A. GILCHRIST.

An inquiry into the variations in the composition of milk by the Agricultural Department of the Durham College of Science* has been in progress since January 1st, 1903. At the request of the Northumberland County Council, the College undertook to make these investigations of a more thorough character, and to extend this work in that county.

A large number of samples of milk of individual cows and of mixed milk have been collected from different farms, and the amounts of butter fat and of solids not fat contained therein have been estimated. The breed of the cows, the times of milking, the weather conditions, the temperature outside and inside the cowsheds, and the daily rations fed to the cows, have all been noted. Mr. James McLaren, Offerton Hall, and Mr. Charles Marshall, Broomhaugh, both placed their herds at the disposal of the College, and samples of milk from individual cows and from the mixed milk of these herds have been taken fortnightly and tested at the College. Samples have also been taken and tested from cows on the Duke of Northumberland's Home Farm, Alnwick, and from the herd of Mr. J. Swann, Lookout Farm, Seaton Delaval. As changes in the composition of milk of individual cows occur very quickly, the milk of one cow has been regularly tested at Cockle Park during the greater part of 1903, so that their extent might be noted.

* Now Armstrong College.

Sampling and testing.—The proper sampling of milk for testing is very difficult. Every care was taken that all the first drawn milk and all the strippings were included in the bulk from which the sample was taken, as the former is poor, and the latter rich, in butter fat. Each lot of milk was thoroughly mixed before the sample was taken, and this was taken from the middle of the bulk, this precaution being necessary, as cream soon begins to rise to the surface. The samples have nearly all been taken by Dr. Potts, Mr. R. R. Swann, B.Sc., Mr. Geo. Willis, and Mr. James McLaren, jun.

All the samples of milk from Offerton and Broomhaugh have been tested by Mr. S. H. Collins, the College Lecturer in Agricultural Chemistry. Those at Cockle Park were tested by Mr. J. H. J. Farquhar, B.Sc.; at Seaton Delaval by Mr. R. R. Swann, B.Sc.; and at Alnwick by Mr. A. W. Patten. In all cases the fat was ascertained by the Gerber butyrometer; and from this and the specific gravity the solids not fat were calculated. Mr. Collins checked his results by other methods.

Mr. W. T. Lawrence, the manager of the Cumberland and Westmorland Farm School, has placed the results of a year's tests of the school herd at the disposal of the College.

OFFERTON RESULTS.

At Offerton, the milk of each of twelve cows was tested once a fortnight, from January 10th till March 21st, 1903. The cows had all calved between July 19th and December 20th, 1902. They were milked three times a day, at 5 a.m., 1 p.m., and 6 p.m., the intervals being therefore 11, 8, and 5 hours. The amount of milk given by each cow averaged about $11\frac{1}{2}$ pints in the morning, 7 pints at mid-day, and 4 pints in the evening, this being equivalent to about $2\frac{1}{4}$ gallons per cow daily. The milk is all retailed in the Sunderland district. Each cow received daily 100 lb roots, 8 lb hay, 10 lb cake and

meal, and as much oat straw as she could eat. They were either not turned out at all or for about half an hour only. The cows were all ordinary shorthorns and fairly representative of the herd of over fifty cows.

TABLE XIV.—OFFERTON DAIRY HERD. COMPOSITION OF MIXED MILK OF TWELVE COWS (CALCULATED).

Date.	Fat.			Solids not fat.			Pints.			Weather conditions.
	M.	N.	E.	M.	N.	E.	M.	N.	E.	
1903.										
Jan. 10 ..	3·03	4·03	4·02	9·36	9·17	9·43	135	85	48	Mild, wet, sleet later, strong north wind.
„ 24 .	3·62	4·46	4·53	8·76	9·03	9·26	148	87	37	Fine day, mild previous evening.
Feb. 7 .	3·33	4·31	4·39	8·82	8·83	9·13	143	87	46	Fine morning, wind and gale later.
„ 21 ..	3·30	4·22	4·21	8·91	9·07	9·11	135	80	42	Windy, fair morning, rain later.
Mar. 7 ..	3·60	4·24	3·89	8·97	9·05	9·23	133	64	40	Fine after frosty night.
„ 21 ..	3·32	4·30	3·95	8·84	8·88	9·06	136	70	47	Mild and windy.
Average	3·36	4·26	4·16	8·94	9·00	9·21	138	79	43	

Mixed milk.—More milk was produced in the first milking than in the last two taken together. The solids not fat tended to increase during the day; and the fat percentage was much higher (nearly 1 per cent.) at mid-day than in the morning, but not higher for the third milking than for the second, though the interval before the third is three hours less, and the quantity is less at this time. The cows, however, were not milked so clean in the evening, and this probably explains the results. Had a third milking not been done each day it is probable that the morning's milk would have occasionally contained less than the standard of fat. In no case did the fat or solids not fat fall below the standard, but the fat varied considerably within a fortnight in some cases.

Individual milk.—The milk of the individual cows showed great variation. Two hundred and sixteen tests were made, with the following results:—

Mornings' milk, 72 tests :—

15 tests under fat standard (3 per cent.).

1 test under solids not fat standard (8·5 per cent.).

Noons' milk, 72 tests :—

None under fat standard (3 per cent.).

None under solids not fat standard (8·5 per cent.).

Evenings' milk, 72 tests :—

6 tests under fat standard (3 per cent.).

None under solids not fat standard (8·5 per cent.).

The milk of the individual cows varied considerably in quantity, but increase in quantity did not usually mean a falling off in quality nor *vice versa*. In the case of the mixed milk, the largest quantity of morning milk produced (Jan. 24th) was also the richest in fat, while the smallest quantity of noon milk (March 7th) was poorest in fat.

BROOMHAUGH RESULTS.

At Broomhaugh, the milk of each of twelve cows has been tested as at Offerton, but the tests have been continued each fortnight throughout the whole of 1903. The cows have not been the same throughout, as none of them continued in milk for this period. The times of milking were 5·30 to 6·30 a.m., and 4 to 5 p.m. The cows were all shorthorns, from a herd consisting of from thirty-six to thirty-eight cows. The milk was all sent off by rail.

Mixed milk.—The mixed milk was under the standard of fat once only, viz., on the morning of September 24th, when the fat percentage was 2·8. The solids not fat were five times just under the standard in the evening, being only so in July and August; and once in November they were as low as 8·2 per cent. in the morning's milk. The effects of indoor and pasture feeding were as follows:—Average fat in milk: winter feeding indoors, 12 tests, morning, 3·7 per cent.; evening, 4·0 per cent. Pasture feeding outdoors, 9 tests, morning, 3·4 per cent.; evening, 4·1 per cent. These averages show that the milk at Broomhaugh was practically as rich in fat during

TABLE XV.—BROOMHAUGH DAIRY HERD. COMPOSITION OF MIXED MILK OF TWELVE COWS (CALCULATED).

Date.	Fat.		S.N.F.		Pints.		Outside temperature.		Time out of doors.	Daily ration.*	Weather conditions.
	E.	M.	E.	M.	E.	M.	12 hours previous to E.	12 hours previous to M.			
1903.							Deg. Fah.	Deg. Fah.			
Jan. 14 ..	4.3	3.7	8.8	9.1	9	9½	21	22	Half-an-hour for water	10 lb. cake and meal, 21 lb. swedes, 17 lb. hay	North-easterly breeze.
" 28 ..	3.8	3.8	8.7	8.7	8	9½	44	38	"	"	Fine, mild.
Feb. 12 ..	3.8	3.7	8.6	8.8	8	9	38	54	"	"	W. wind, fair.
" 26 ..	3.8	3.6	8.87	9.0	8	10½	38	38	"	"	"
Mar. 12 ..	4.0	3.8	8.7	9.0	10	11½	36	42	"	"	Fair, very little wind.
" 26 ..	4.5	3.9	8.5	8.8	7	9	45	52	"	"	Mild, S.W. wind.
April ..	4.3	3.4	8.7	8.8	9½	11	31	40	2 hours ..	10 lb. cake and meal, 21 lb. swedes, 17 lb. hay	Fine warm day, N. wind.
" 23 ..	4.3	3.4	8.7	8.8	9½	11	31	40	8 hours: on grass	11½ lb. cake and meal, 20 lb. mangels, 7 lb. hay, and pasture	N. wind.
May 7 ..	3.8	4.3	8.9	8.8	11½	13½	..	49	10 " All day and night	Pasture and 8 lb. cake and meal ..	Gentle breeze from S.W.
" 21 ..	3.7	3.8	8.8	8.7	11½	12½	34	55	"	Pasture, 5 lb. cake and meal, cut grass and clover	Calm.
June 4 ..	4.0	3.5	8.8	8.7	11½	11½	47	57	"	"	Slight W. breeze, with rain.
" 18 ..	3.5	3.6	8.7	8.7	9½	10½	..	49	"	"	Wind N.W. as a whole, but very changeable.
July 9 ..	4.4	3.3	8.4	8.6	9½	9½	..	65	"	"	Calm.
" 23 ..	3.7	3.5	8.49	8.6	8	8½	56	66	"	Pasture, 6 lb. cake and meal, cut grass and clover	Strong W. wind, showery.
Aug. 6 ..	4.5	3.6	8.4	8.6	8½	8½	..	63	"	Pasture, 8 lb. cake and meal, new hay .. cut clover	Mild, with showers.
" 28 ..	4.6	3.6	8.49	8.5	8	8½	52	64	"	"	Cold N.W. wind, very humid.
Sept. 10 ..	4.3	3.6	8.6	8.8	8½	9	..	51	"	"	Dull, close day.
" 24 ..	4.0	2.8	8.5	8.6	7½	8½	43	68	"	"	W. wind, with rain.
Oct. 8 ..	4.1	3.7	8.4	8.5	7½	8	..	52	"	"	" fine.
" 22 ..	4.6	3.3	8.5	8.7	8½	8½	..	48	8 hours, in at night	Pasture, 8 lb. cake and meal, cut clover, turnip tops	"
Nov. 5 ..	4.0	3.5	8.6	8.2	7½	8	43	46	8 " "	28 lb. white turnips, 6 lb. hay, 6 lb. cake and meal	Fine and cold.
" 19 ..	4.0	3.7	8.9	9.1	7	9	..	34	6 " "	28 lb. swedes, 12 lb. hay, 6 lb. cake and meal	Dull and close, with rain.
Dec. 3 ..	4.1	4.2	9.1	8.8	6½	9	..	29	5 " "	"	"
" 17 ..	4.4	3.6	9.2	9.3	6½	7½	32	37	5 " "	"	"

* In addition to straw *ad lib*. Heavy milkers get in addition a mash made of 7 lb. of a mixture of oat dust, dec. cot. cake meal and maize meal.

the summer as during the winter, and thus it differed materially from that at Newton Rigg. The cows at the latter place received no concentrated food during the first two months on pasture, and only from $1\frac{1}{2}$ lb to 2 lb daily during the remaining three months, but those at Broomhaugh received from 5 lb to 8 lb concentrated food daily all the time they were on pasture.

The quantity of milk given on the average by each cow was as follows:—During winter, morning, 10 pints; evening, $8\frac{3}{4}$ pints. During summer, morning, $9\frac{1}{4}$ pints; evening $8\frac{1}{2}$ pints. The twelve cows therefore produced an average of $2\frac{1}{4}$ gallons milk daily. The amount of fat generally shows considerable variation from fortnight to fortnight, especially in the evening's milk.

Individual milk.—The milk of the individual cows again showed great variation here. Five hundred and four tests were made, with the following results:—Morning's milk (252 tests), 40 tests under standard of 3 per cent. fat; 46 tests under standard of 8·5 per cent. of solids not fat. Evening's milk (252 tests), 17 tests under standard of 3 per cent. fat; 62 tests under standard of 8·5 per cent. of solids not fat. Here also increased quantity did not usually mean a falling off in quality. Some striking variations occur in the milk of the cows at Broomhaugh that are evidently due to the individual characteristics of the cows themselves. The yield and amount of fat in the milk of a cow called "Fidget" was extremely variable; this cow was quick-tempered and very excitable. Two cows called "Slaggy" and "Ruth" were of quiet and peaceful dispositions, and the milk of these cows was very even, both in quality and quantity. Another cow, "White Rose," was quiet, but she allowed her milk to run from the udder, and in this case the amount of fat was variable.

RESULTS AT SEATON DELAVAL.

The mixed milk of six grade shorthorn cows was tested daily from March 4th till May 12th, 1903. They were all of a good size, and were useful breeding animals, but not heavy milkers. Two of the cows had calved recently, and other two were nearly at the end of their lactation period, but one of the latter was replaced on March 23rd by a pure bred shorthorn cow; the other was dried off on April 1st, and her place was taken on April 9th by a recently calved Irish heifer. The cows were milked twice a day, at 6 a.m. and 4.30 p.m.

Mixed milk.—During the whole period (seventy days) the solids not fat were remarkably constant, their limit of variation being from 9.1 to 8.5 per cent., and on only one occasion were they as low as the 8.5 per cent. standard. They were almost invariably rather lower in the afternoon's than in the morning's milk. The butter fat also was never once under the standard (3.0 per cent.) during the whole of this time, either in the morning or afternoon. The extreme limits were 3.1 to 4 per cent. in the morning, and 3.5 to 4.9 per cent. in the evening. The greater variation in the afternoon is probably due to the greater liability of the cows to be exposed to exciting conditions during the day. The cows were in at night for the whole time except for the last four evenings, and were thus protected from exciting conditions and weather changes during the night. During the whole seventy days the average amount of fat was 3.55 per cent. in the morning and 4.09 per cent. in the afternoon. The yield of milk from all the cows varied from 6 to 8 gallons in the mornings, and from 5 to $6\frac{3}{4}$ gallons in the afternoons. The intervals between milking were ten and a half hours during the day and thirteen and a half hours during the night. The shorter interval before the afternoon's milking was the main cause of the milk being less in quantity and richer in fat at this time.

TABLE XVII.—DAIRY HERD AT SEATON DELAVAL. COMPOSITION OF MIXED MILK.

Date of Sampling.	Weather.	Wind.	Outside temperature.		Mixed milk.					
			Twelve hours previous to Morning.	Twelve hours previous to Evening.	Fat.		S.N.F.		Pints.	
					M.	E.	M.	E.	M.	F.
1903. March 5th ..	Dry, cold ..	Strong ..	F. 44°	F. 34°	3.3	3.7	8.80	8.66	57	46
" 20th ..	Fine ..	Moderate ..	50°	49°	3.5	3.8	8.84	8.68	52	42
April 9th ..	Dry, mild ..	Strong ..	58°	52°	3.8	3.8	8.90	8.68	65	54
" 23rd ..	Mild, after severe frost and snow ..	Light ..	48°	48°	3.4	3.8	8.82	8.65	63	53
May 8th ..	Fine, after much rain ..	Calm ..	54°	50°	3.9	4.1	8.92	8.73	111	97
" 22nd ..	Warm, nights colder ..	Calm ..	61°	51°	3.4	4.4	8.82	8.77	117	96
June 4th ..	Very warm ..	Calm ..	69°	60°	3.6	3.9	8.86	8.67	113	89
" 17th ..	Fine, after cold, wet night ..	Light north wind ..	..	47°	3.4	4.6	8.57	8.56	105	90
July 2nd ..	Warm, dry ..	Light south wind ..	70°	60°	3.6	4.4	8.86	8.77	92	80

Weather effects.—A strong west breeze was blowing on March 4th and 6th, but this moderated on the 7th, and the fat contents of the milk increased 1·1 per cent. that afternoon over that of the previous afternoon. The cows had been out about five hours on each of these days. On April 5th and 8th there was comparative calm after wind, and on each of these days the afternoon's milk had $\frac{1}{2}$ per cent. more butter fat. On April 11th a strong north-west breeze was blowing, and the fat went down by ·3 per cent. A cold north wind continued till April 18th, accompanied by a considerable drop in the fat of the afternoon's milk on many of the intervening days, although there was an unaccountable rise of 1 per cent. of fat during one of them. On April 19th a calm day followed and the fat increased. The fluctuations in percentage of fat were greatest during the cold weather with north winds between April 11th and 25th. Wet weather with no wind followed till May 6th, during which time the afternoon's milk had more fat and less variation in amount. The cows were usually turned out five to six hours a day from March 4th till May 8th. They were turned out for about half that time on April 12th to 15th, and on May 2nd, 3rd, and 6th. On five of these seven days the afternoon's milk had an increased amount of butter fat, and this may have been prevented by the severe weather of the remaining two days. On May 22nd the evening's milk was 1 per cent. richer in fat than that of the morning, this being a warm day after a cold night. Apparently the cold night reduced the fat percentage of the morning's milk, but the warm day which followed considerably increased it. On June 18th, when it was fine after a cold, wet night, there was 1·2 per cent. more fat in the evening's than in the morning's milk—a similar result to what had taken place on May 22nd. Again, on April 9th, a strong wind was blowing when the cows were turned out during the day, and this may be the cause of the evening's milk being no richer on that day than that of the morning. On June 4th

the weather was very warm, and the evening's milk was very slightly richer in fat than that of the morning, which may be due to the effect of the heat on the cows. The cold, wet night of June 17th affected the milk of cow No. 1, by greatly reducing the quantity of her morning's milk, while the fat percentage in the milk of cow No. 8 was reduced very largely on the same morning.

Change of food.—The cows were turned out at night on and after May 9th, and their milk was tested till May 12th. The weather was fine and the evenings were mild. They received grass only after being turned out. Notwithstanding this complete change of conditions there were practically no changes in the quantity or quality of the milk. From March 4th till 10th each cow received daily 86 lb mangels, 20 lb hay, and 10 lb linseed cake. On March 11th a compound cake replaced the linseed cake, with no change in the quantity or quality of the milk. On March 24th, 6 lb of another compound cake with 4 lb of maize and oatmeal were given, and still there was no change in the milk. The quantity of mangels given was reduced to 50 lb per cow daily on April 23rd, but the quantity and quality of the milk produced by the cows were not reduced thereby. Nor was this so when the mangels were withdrawn altogether on April 30th. When the mangels were stopped the cows would have remained out all day if the weather had been fair, but as wet weather followed, they were out only for the same time as before.

Individual milk.—The individual milk, as well as the mixed milk, of 6 to 8 cows was tested once every fortnight from March 5th till June 18th, 1903. The solids not fat were in eighteen instances under the 8·5 per cent. standard out of 128 tests of the milk of the individual cows. They were always above the standard in March and April. The cases when they were under standard occurred in May, June, and July. At no time did the fat or solids not fat fall below the

standard in the mixed milk. Two cows of a nervous temperament gave milk in which the fat varied considerably. Frequently when the cows gave more milk it had more fat, and when they gave less milk it had less fat.

ALNWICK RESULTS.

The mixed milk of three shorthorn cows was tested daily at the Duke of Northumberland's Home Farm, from March 19th till April 20th, 1903. The three cows were from five to nine years old, and calved on January 5th, February 7th, and February 27th respectively. One was a pedigree and two were non-pedigree animals, the latter being purchased for rearing calves. They were milked at 6 a.m. and 6 p.m. They gave on the average nearly 5 gallons of milk in the morning and about 4 gallons in the evening (an average of 3 gallons a cow daily), so that with equal time between milking the morning quantity was greatest. The morning's milk was fourteen times, and the evening's milk seven times, under the fat standard during thirty-three days. The fat in the morning's milk varied from 2.15 to 4.25 per cent., and in the evening's from 2.45 to 4.35 per cent.

Effects of weather.—The cows were turned out from 11 to 1 o'clock daily after March 24th. The milk had more fat for a few days afterwards, but a reaction followed, as the poorest milk was given on the last three days of March. The weather was not colder, but a strong wind on March 28th and 29th may have upset the cows and reduced the fat in the milk. The milk of each of these cows was tested on April 2nd and 17th. On the first morning the milk of each cow was under the fat standard, one having less than 2 per cent. of fat. A strong north-west wind was blowing during that and the previous day, which, as all the cows were affected, probably reduced the fat in the milk. On April 17th the cow that had previously given milk with less than 2 per cent. of fat now gave the same with over 4 per cent. of fat, while the milk

of the others was also better. The evening's milk of two of the cows was poorer on that day than that of the morning; this was probably caused by the wind changing to the north on that day. On seven of ten days that the wind changed to the north the evening's mixed milk was poorer than that of the morning, the reverse being the normal condition.

The milk contained 1.55 per cent. less fat on the morning of the 14th than on that of the 13th, and 1.45 per cent. less on the morning of the 17th than on that of the 16th. This was probably caused by the severe weather. The cows were not turned out for the customary two hours on the days when snow fell, which probably increased the fat in the evening's milk of these days, but when turned out on the following days, when cold winds prevailed, the fat was very much reduced, probably as a result. The figures show that the milk was frequently poorest in fat in the evening during the severe weather, whereas during the preceding genial weather the opposite was the case. The results show how great the variations in the amount of fat may be in the milk of a few cows, and how much these variations may be increased by severe and changeable weather; they also show that a small number of cows receiving fair feeding and attention may frequently produce milk which is under the standard. Even though the intervals between the milkings were equal, the morning's milk has been greater in quantity and poorer in butter fat than that of the evening. The cows each received daily about 5 lb linseed cake and meal, 20 lb roots, and as much hay and straw as they would eat.

COCKLE PARK RESULTS.

Regular tests of one cow's milk have been made daily from January till October, 1903, mainly with the object of noting the changes from day to day, and comparing these changes with the meteorological conditions of which a complete record is kept. The milk of a grade shorthorn cow

(No. 3) was tested from January 1st till April 23rd. She had probably some Channel Islands blood, was six years old, had calved her third calf in the last week of October, 1902, and was of a quiet and docile disposition. She was milked at about 6 a.m. and 4.15 p.m. on week days, but half an hour later in the afternoons during April, and on Sundays at 8 a.m. and 4 p.m. She received from 5 lb. to 8lb. of cake and meal daily with hay and water. She was turned out when weather permitted from 9.30 a.m. till 3.30 p.m. The following table shows the limits of variation of the milk of this cow:—

			Jan.	Feb.	March.	April.
Per cent. of fat—						
Morning	...	...	3.8—5.3	3.8—5.0	3.5—7.1	4.1—5.2
Afternoon	...	...	4.8—7.3	5.1—7.5	4.7—7.8	4.7—6.9
Per cent. of solids not fat—						
Morning	...	...	8.3—9.4	8.3—9.3	8.3—9.4	7.9—9.6
Afternoon	...	...	7.3—9.6	7.0—9.5	7.8—9.3	8.3—9.2
Quantity (lb.)—						
Morning	...	...	9—12	7—11	5—10	5—7
Afternoon	...	...	3—6	3—7	3—6	4—7

The milk of this cow never contained less than 3.5 per cent. of fat during this time, and it actually was as high one afternoon as 7.8 per cent. The milk was considerably richer in fat in the afternoon than in the morning, and the variations in fat were greatest in the afternoon. The greatest variations took place as follows:—

			Thurs., Mar. 19.	Fri., Mar. 20.	Sat., Mar. 21.	Sun., Mar. 22.	Mon., Mar. 23.
Per cent. of fat—							
Morning	...	...	5.0	4.7	7.1	3.6	4.7
Afternoon	...	...	5.3	7.3	7.8	5.4	6.2
Quantity (lb.)—							
Morning	...	...	7	5	6	5	7
Afternoon	...	...	5	6	4	4	5

The causes of these have not been ascertained. So far as can be judged the weather was not accountable. The solids not fat have been very frequently considerably under the standard. When this cow was in season, on April 12th, neither the quantity nor the quality of the milk was materially

affected. On the whole, the milk on Sunday afternoons was richer, because of the shorter interval between the milkings on that day, and Monday morning's milk was poorer for the opposite reason.

The milk of a small red shorthorn cow (No. X) was tested from the beginning of May till the end of October. She calved (her third calf) on May 3rd. This cow is also quiet and good tempered. She was out at night from June 4th till October 8th. She received 6 lb to 8 lb cake and meal daily during the whole period, and was milked as follows:—May and June, 8 a.m. and 6 p.m.; July and August, 7 a.m. and 6 p.m.; September and October, 7.30 a.m. and 5 p.m.; but on Sundays during the whole period, 8 a.m. and 4 p.m.

During one hundred and sixty-five days the solids not fat were fifty-eight times under the 8.5 per cent. standard in the morning, and fifty-seven times in the evening. These were higher during September and October, but lower and more variable during June, July, and August. The limits of variations in solids not fat were:—In morning, 7.08 per cent. on July 2nd and 9.83 per cent. on October 10th; in evening, 7.00 per cent. on July 1st and 9.52 per cent. on October 9th. During the same time the fat was thirty-five times under the 3 per cent. standard in the morning and twenty times in the evening. This cow has very frequently had less fat in her milk in the evening than in the morning, and had less fat on the average during July than during the other months.

The fat in the evening's milk was very low after the hot day on July 1st and after the thunderstorm on July 2nd. Great and sudden variations occurred throughout the whole period. Cold nights occurred in June, at which time the morning milk was usually much poorer than that of the evening, but during the fine days in July the reverse was usually the case. This cow gave about 4 gallons a day for the first three months, but less during August, about 3 gallons a day during September, and about 2 gallons a day during

October. Sunday evening's milk was usually rich in fat, because of the short day interval, but Monday morning's was usually poorer and greater in quantity. On Thursday morning, September 10th, this cow produced 16 lb milk, with 1.1 per cent. of fat, and on the following morning 19 lb of milk, with 6.8 per cent. of fat. The first of these was preceded by a cold and wet evening, while the following was a better night. Evidently, therefore, the poorer milk was caused by the cow being upset by exposure during a bad night, after which a big reaction followed. Tuesday, July 14th, was a hot day, and that evening the cow gave rather less milk with only 1.8 per cent. of fat, whereas the milk of the previous evening had contained 4.6 per cent. of fat. When this cow was in season on June 10th, the morning's milk contained 1.5 per cent. of butter fat only, although the quantity was not reduced.

NEWTON RIGG RESULTS.

Mixed milk.—The milk of seventeen cows was tested for fat once a month during one year. Milking took place at 6 a.m. and 5 p.m. The following average results, which compare the effects of indoor and pasture feeding, are interesting:—

	Average fat in milk.	
	Morning.	Evening.
December, 1902, to April, 1903 (cows indoors)	3.8 %	4.2 %
May to October, 1903 (cows on pasture) ...	3.5 %	3.6 %
November, 1903 (cows indoors)	3.6 %	3.7 %

It will be seen that during the winter months the milk contained much more fat, and also that the evening's milk was relatively much richer, when the cows were indoors than when they were on pasture. The morning's milk on September 15th had just the standard amount of fat (3 per cent.). The table of results shows that in all other cases it was well above the standard. The solids not fat (calculated from individual samples) were well over the standard during most of the year, especially during the first six months. They were lowest in the autumn, and were only just above the standard on the evening of August 15th.

TABLE XVIII.—NEWTON RIGG DAIRY HERD. COMPOSITION OF MIXED MILK OF 17 COWS (ANALYSED).

Date.	Fat.		Daily ration.	Weather conditions.		
	M.	E.		Previous evening.	Same day.	
1902. Dec. 15th ..	4.0	4.2	8 lb. cake and meal, 42 lb. swedes, one foddering hay, two fodderings straw	Very wet ..	.. ..	Very wet and strong wind.
1903. Jan. 15th ..	3.9	4.0	" "	Very hard frost ..	.. ..	Very hard frost.
Feb. 14th ..	3.3	3.9	" "	Frost ..	.. ..	Dull, with a little rain, milder.
Mar. 14th ..	4.0	4.3	" "	Cold and fine ..	.. ..	Cold and wet.
Apr. 15th ..	3.6	4.4	Same, except 28 lb. mangels instead of swedes	Cold N. wind, storms, a little snow ..	..	Cold N. wind and storms.
May 15th ..	3.3	3.7	" "	Fine but cold. (Cows out on grass; their first week)	.. ..	Fine, but cold.
June 15th .	3.6	3.7	On grass day and night, no other food ..	Fine and not cold ..	.. ..	Drizzling rain, not cold.
July 15th ..	3.7	3.5	" "	Very wet ..	.. ..	Very wet.
Aug. 15th ..	3.4	3.4	1½ lb. dec. cot. cake since July 20th ..	Mild, some rain ..	.. ..	Mild, showers.
Sept. 15th ..	3.0	3.8	2 lb. dec. cot. cake since August 21st ..	Fine, S.E. wind, bright sunshine (a fine week)	..	Fine, S.E. wind, bright sunshine.
Oct. 15th ..	3.9	3.6	" "	Mild and wet ..	.. ..	Mild and wet.
Nov. 14th ..	3.6	3.7	Winter ration as in December ..	Wet and rather cold. (Cows indoors)	..	Wet and rather cold.

Milking time at 6 a.m. and 5 p.m. all the year round.

Individual milk and variation in age.—The milk of each of the seventeen cows was also tested once a month for fat and for solids not fat. Four of the herd were in milk after their first calf. These gave about 1 gallon of milk each in the morning and $\frac{3}{4}$ gallon in the evening, for three or four months, and continued in milk for from five to eight months. Their milk contained the high average of about 4 per cent. of butter fat, and in no case was it under the standard. Five of the cows were in milk after their second calf. These gave about $1\frac{1}{2}$ gallons in the morning and about $1\frac{1}{4}$ gallons in the evening for the first few months. Their milk contained about 3·6 per cent. of fat on the average, and in only four cases was it under the standard. Seven of the cows were milking after their third and fourth calves. These gave for some time after calving about $1\frac{3}{4}$ gallons in the morning and $1\frac{1}{2}$ gallons in the evening. The average fat contents of their milk was about 3·4 per cent. A cow in milk after her seventh calf gave results very similar to the foregoing.

It is evident from the great variations that occurred that the amount of fat in the milk of any cow may be greatly increased or decreased by certain conditions, such as nervous temperament, excitement, weather conditions, or other causes which cannot be traced to food or times of milking. One cow gave milk with 5·2 per cent. of fat in April, and with 2·6 per cent. only in May, and there were many other similar cases.

SUMMARY OF RESULTS.

(1) **When fat may be low.**—The morning's milk of a herd may frequently be under the standard of 3 per cent. of fat when milking takes place early in the afternoon, to allow of this milk being retailed on the same day. For this the only effective remedy seems to be to milk three times a day, to have the third milking as late in the evening as possible, to refrigerate the latter so as to keep it in the best condition possible over night and to either retail this by itself next

morning or mix it with the morning's milk. The morning's milk will be distinctly better in quality although less in quantity if milking is done three times a day.

(2) The Alnwick and other tests show that the *milk of a few cows* may very frequently be under the standard, even when the intervals between milking are nearly even. It is evidently desirable that when a sample is taken from the milk of a few cows, and found to be suspicious, that a prosecution should not be decided on till further investigations are made.

(3) **Appeal to the cow.**—This is not by any means a safe test. When the mixed milk of six cows was tested at Seaton Delaval there were two cases in which the variation in amount of fat was over 1 per cent. in the afternoon's milk within twenty-four hours. The Offerton and Broomhaugh results show that the variations from fortnight to fortnight may be considerable.

(4) **Solids not fat.**—These were under the standard at Broomhaugh during July and August, and were low in the autumn at Newton Rigg. They may, therefore, be under the standard in the autumn, and this might be helped by a number of cows calving at that time, as the Cockle Park tests indicate that these are higher for some time after calving.

(5) **Effects of feeding.**—Although considerable changes have been made in the feeding of the different herds while the tests were in progress, none of these have materially affected the quantity or quality of the milk. There is no doubt also that improper or careless feeding upsets the cows, and in consequence interferes with the quantity and quality of the milk. It is probable that feeding experiments on cows from which the production of large amounts of milk are desired will give most useful results. Some time ago a herd of cows, which was producing milk rather poor in fat, was found to be receiving more food than they were likely to be able to assimilate.

The food was reduced, and after a short time the milk materially improved. At Seaton Delaval the withdrawal of 70 lb of mangels daily did not reduce the quantity or quality of the milk, but it was found on inquiry that the remainder of the food they were receiving contained sufficient feeding material for the cows. At Broomhaugh the cows each received 5 lb to 8 lb concentrated food daily while on pasture, with the result that the milk was as rich in fat in summer as in winter, instead of being poorer as at Newton Rigg.

(6) **Effects of weather.**—The weather conditions have evidently an important influence on milk production. This is especially noticeable in the Seaton Delaval results, where cold north and north-east winds have considerably lowered the fat contents of the milk. The milk of one cow at Cockle Park has been reduced in percentage of fat by cold nights in June and by hot days in July. It is therefore advisable to guard against exposing cows unduly to either severe or hot weather, and especially to great variations in temperature.

(7) **Milk of nervous cows variable.**—Cows of an excitable and nervous temperament may show considerably greater variations than those of a quiet and docile disposition. This is illustrated by the results from individual cows at Broomhaugh. The milk of one cow at Broomhaugh, which dropped her milk easily, was also variable.

(8) There are probably numerous hidden causes of considerable variation in the milk of individual cows. When a cow is in season the milk has usually less fat and is less in quantity. It has been noticed in one or two cases that the milk is richer in fat immediately before this time.

(9) **Regularity of feeding and milking.**—These are most important, so as to produce the best results as to quantity and quality of milk. Regularity in the length of time cows are turned out is also important. Feeding and milking are usually

rather irregular on Sundays, and this causes great variation in the quantity and quality of the milk.

(10) Greater quantity of milk does not as a rule mean poorer quality, nor the reverse. This is well shown by the results of tests of individual cows at Broomhaugh and Offerton.

(11) It is desirable that cows which give poor quality milk should not be retained in a breeding herd, as they are likely to produce poor milkers. The individual cows that have been tested show wide variations in the quantity and quality of their milk, so that there are ample opportunities for selection.

OFFERTON BULLETIN No. 1.

Experiments on the Feeding of Dairy Cows.

Published October, 1905.

BY C. BRYNER JONES.

MODERATE *VERSUS* HEAVY RATIONS OF CONCENTRATED FOOD.

Object.—The special object of these experiments was to test the effect of moderate and heavy rations respectively of concentrated food upon the quantity and quality of milk. It was not the intention of those responsible to enter upon the larger question of the effect of food upon milk generally, but rather to determine, once the cows receive an adequate allowance of concentrated food in their daily ration to keep them in a good and thriving condition, whether there is any real advantage in increasing this allowance with the idea of improving the milk either in yield or quality, or both.

Two series of experiments have now been completed, in each of which two lots of cows were fed with different quantities of the same concentrated food, all other conditions being the same.

Sampling and testing.—In the preliminary trials, the cows were tested individually at weekly intervals. In all the experiments, the mixed milk of each lot of cows was sampled daily, morning, noon, and evening, each sample being placed in a bottle and labelled. There were, thus, every day, three samples taken from each lot. The total milk of each lot was weighed at each milking, and the quantity recorded on sheets printed for the purpose. The butter-fat was estimated

by means of a Gerber Acid-Butyrometer, and the "solids not fat" calculated from the usual formula.

FIRST SERIES OF EXPERIMENTS.

Preliminary trials.—To secure cows which were fairly regular in the yield and quality of their milk, a preliminary test extending over three weeks was made. Sixteen short-horn cows of the usual type in the North of England, all having calved between the end of September and the end of October, were selected from the herd, and each cow was tested for yield of milk and percentage of butter-fat once a week. At the end of this period, ten of the most "regular" cows from this number were finally selected. The average quantity of milk and other particulars relating to these ten cows are given in Table I. In all the feeding experiments described in this Report, the cows were milked at 5 a.m., 12:30 p.m., and 6 p.m.

TABLE I.—YIELD OF MILK AND PERCENTAGE OF BUTTER-FAT IN PRELIMINARY TRIALS.

Lot I.							
No. of cow.	Average yield of milk (in pints).			Average percentage of butter-fat.			Live weight of cows (in lb.) at the end of preliminary trials.
	Morning.	Noon.	Evening.	Morning.	Noon.	Evening.	
85	9.33	6.50	4.50	3.06	3.65	4.15	994
88	11.16	8.33	5.00	2.85	3.95	4.60	1,064
92	8.50	6.83	4.00	3.55	3.45	4.55	1,109
93	12.30	8.50	3.83	2.55	3.45	4.20	1,127
95	12.66	9.83	6.33	2.82	3.60	3.95	1,026
Average	10.79	7.99	4.73	2.96	3.62	4.29	1,064
Lot II.							
89	8.66	6.66	4.66	2.75	4.85	4.75	1,064
91	13.00	11.83	7.33	1.55	3.10	4.45	1,106
94	11.16	9.50	5.83	2.22	3.50	4.50	1,176
97	11.16	7.66	4.83	2.87	3.40	4.20	1,008
98	10.33	7.33	5.33	3.15	3.75	4.60	986
Average	10.86	8.59	5.59	2.51	3.72	4.50	1,068

As soon as the preliminary trials were concluded, the ten cows selected were divided into two lots as above according to their live-weight, and were put on their respective rations on February 10. At the commencement of the experiment, therefore, the two lots stood as follows:—

			Average yield of milk per cow per day.	Per cent. of butter-fat.	Average live-weight.
Lot I.	...	...	23·47 pints.	3·45	1,064 lb.
Lot II.	...	...	25·04 pints.	3·36	1,068 lb.

Rations.—As the object of the experiment was to test the effect of a moderate and heavy allowance of concentrated food respectively on the quantity and quality of the milk, it was decided that the amount of bulky food supplied to each lot should be the same in both cases, but that one lot of cows should receive 4 lb. of concentrated food per day more than the other. Accordingly the following rations were fixed upon:

Lot I.		Lot II.	
8 lb. con- centrated food	3 lb. maize meal.	12 lb. con- centrated food	4½ lb. maize meal.
	2 lb. malt dust.		3 lb. malt dust.
	3 lb. Egyptian cotton cake.		4½ lb. Egyptian cotton cake.
	6 lb. straw chaff.		6 lb. straw chaff.
	15 lb. hay.		15 lb. hay.
	60 lb. roots.		60 lb. roots.
Albuminoid ratio, 1 : 6·1.		Albuminoid ratio, 1 : 5·7.	

In calculating the ration for lot I., care was taken that each animal should, on the average, receive in its daily ration the minimum amount of organic matter required. With a view to making a sufficient allowance for individual differences among the cows, the ration was calculated for 1,150 lb. live-weight. The daily ration supplied to lot I. originally contained 29·24 lb. organic matter, and that for lot II. 32·52 lb. Water was supplied *ad lib.* to both lots.

It should be stated that at the end of a fortnight the amount of hay per cow was reduced from 15 lb. to 12 lb. daily in each case, it being found that the cows did not consume the quantity originally allowed. The total organic matter in the daily ration was thus reduced to 26·9 lb. in the case

of lot I. and to 30.18 lb. in lot II. With this difference, the rations as given above were used throughout the present test (Experiment A), which was commenced on February 10 and continued till May 3, 1904, a period of 12 weeks.

A second test (Experiment B) with the same cows was commenced on June 1, the cows being then out on grass. The two lots were in this case reversed, lot I. being placed on what was regarded as a fairly heavy ration for summer feeding and lot II. on a light ration. The allowance per day was as follows:—

Lot I.		Lot II.	
8 lb. concentrated food	4 lb. maize meal.	4 lb. concentrated food	2 lb. maize meal.
	4 lb. Egyptian cotton cake.		2 lb. Egyptian cotton cake.
	3 lb. straw chaff.		3 lb. straw chaff.

It was impossible to determine the quantity of grass consumed on the average by the cows, and no attempt was therefore made to adopt any theoretical basis in fixing the rations. From the middle of July, the cows had a small quantity of green tares in addition to their other food, each lot receiving the same allowance.

The cake and meal and chopped straw were throughout made into "crowdy" daily before being fed to the cows. The mixture of concentrated food and chop, already weighed out for each lot, was placed in a vessel and hot water poured upon it.

EXPERIMENT A.

Results.—Average quantities are given in all cases, but the figures are so arranged as to show the fluctuations which occurred from week to week throughout the trials. Table II. gives the quantity of milk yielded per day by each lot for 12 weeks.

As is usual more milk was obtained in the morning than at noon and evening, and this applies equally to both lots. The daily yield was greater throughout in the case of lot II. than in that of lot I. As shown above, the average for the

TABLE II.—QUANTITY OF MILK IN PINTS PER LOT
PER DAY FOR 12 WEEKS.

Week ending:—		Lot I.				Lot II.			
		Morn.	Noon.	Even.	Total.	Morn.	Noon.	Even.	Total.
Feb.	16 ...	47·25	30·5	24·7	102·45	53·5	32·3	28	113·8
„	23 ..	43	29·2	22·8	95·0	53·1	35·5	30·25	118·85
March	1 ...	44·3	29·3	22	95·6	55·2	35	28	118·2
„	8 ...	45	29	23	97·0	52·6	34·3	29·2	116·1
„	15 ...	44·3	29	22·5	95·8	53·5	34·7	29·5	117·7
„	22 ...	43	28·8	21·8	93·6	51·3	33·5	27·5	112·3
„	29 ...	39·3	27·4	21	87·7	47·6	31·8	25	104·4
April	5 ...	42	28	21·2	91·2	47·8	31	24·5	103·3
„	12 ...	41·3	28 5	21	90·8	47·4	31	24	102·4
„	19 ..	41	28	21·6	90·6	49	33	28·4	110·4
„	26 ...	44	30·5	23	97·5	51·8	34·5	28	114·3
May	3 ...	43	30·3	25	98·3	51·2	35	30	116·2
Average per lot per day ...		43·12	29·04	22·46	94·62	51·16	33·46	27·69	112·31

latter was 94·62 pints per day as against 112·31 pints per day for the former. This works out to nearly 19 pints per cow per day in lot I., and nearly 22½ pints in lot II., or a difference in favour of lot II. of about 3½ pints per cow per day. It would be unfair, however, to attribute this difference entirely to the food, for, as has been already shown, the cows in lot II. gave more milk on the average in the preliminary trials than those in lot I. The difference between the two lots, it is true, was less marked in the preliminary trials than during the period of the experiment, but it is nevertheless somewhat difficult to say to what extent the food is responsible for the larger quantity of milk produced by lot II. here. But when allowance is made for the original difference between the cows composing the two lots, the above table would appear to show that the additional 4 lb. per head of concentrated food supplied to lot II. gave rise to an increased yield, as compared with lot I., of nearly 2 pints per cow per day.

The total yields on the whole decreased in both lots up to April 12, and a slightly further decrease occurred in lot I. up

to April 19. From this onwards there is a considerable increase in the daily yield up to the end of the experiment. From about the middle of April, according to notes taken at Offerton, there was a decided improvement in the weather, especially as regards temperature, and this change for the better in the climatic conditions practically coincides with the improvement in the milk yield.

The quality of the milk.—Table III. shows the amount of butter-fat in the milk of the two lots of cows. The general average butter-fat in the total daily yield of milk is calculated from the morning, noon, and evening averages for the whole period of the experiment and allowance is, of course, made

TABLE III.—AVERAGE PERCENTAGE OF BUTTER-FAT IN MILK FOR 12 WEEKS.

Week ending:—	Lot I.			Lot. II.		
	Morning.	Noon.	Evening.	Morning.	Noon.	Evening.
February 16 ...	2·83	3·97	3·92	2·50	3·60	3·50
„ 23 ...	2·84	3·87	3·94	2·33	3·50	3·61
March 1 ...	2·92	3·95	4·16	2·57	3·60	3·90
„ 8 ...	3·06	4·00	4·00	2·60	3·60	3·70
„ 15 ...	3·13	3·90	3·60	2·50	3·60	3·50
„ 22 ...	3·00	4·00	4·00	2·50	3·70	3·60
„ 29 ...	3·00	3·90	4·00	2·60	3·80	3·70
April 5 ...	3·00	3·90	4·00	2·80	3·90	3·80
„ 12 ...	2·90	3·80	3·90	2·50	3·70	3·60
„ 19 ...	3·00	4·10	3·90	2·60	3·80	3·60
„ 26 ...	3·00	4·00	3·70	2·70	3·70	3·60
May 3 ...	3·00	3·90	3·70	2·70	3·80	3·50
Average	2·97	3·94	3·90	2·57	3·69	3·63
Times milkings were under standard*	32	...	...	80	...	...
Highest	3·4	4·5	4·5	3·2	4·4	4·5
Lowest	2·1	3·4	3·3	2·1	3·2	3·1

	Lot I.	Lot. II.
General average for day's milk	3·48	3·16
Total butter-fat per day	4·25 lb.	4·58 lb.

* Out of a possible of 84.

for the difference in the average yield of milk morning, noon, and evening for the same period.

These figures show that lot I. gave milk which was considerably richer in butter-fat than did lot II. This is a somewhat striking result, as the heavy feeding appears to have lowered the quality of the milk although it has increased the yield. In the preliminary trials, the butter-fat in the milk of lot I. and lot II. respectively was 3.45 per cent. and 3.36 per cent. There was thus only a difference of .09 per cent. in favour of lot I. During the period of the experiment, however, this slight difference was increased to .32 per cent. in favour of the same lot, a result, so far as it goes, totally unfavourable to the heavier ration, if we regard the question from the milk-seller's standpoint. From the butter-maker's point of view the results are slightly different. The actual amount of butter-fat produced by lot II. was 4.58 lb. per day as against 4.25 lb. in the case of lot I. This means a difference of about $2\frac{1}{2}$ lb. of butter-fat per week in favour of lot II. But this difference hardly justifies the use of the heavier ration, which, from every point of view, must be regarded as unprofitable as far as the butter-fat is concerned.

The morning milk in the case of lot II. was, on the weekly averages, invariably below the legal standard in butter-fat. The morning milk of both lots, however, was below the standard on the average of 12 weeks, but lot I. was by no means so consistently low as lot II.

Table IV. shows the amount of "solids not fat" in the milk of the two lots during the period of the experiment.

It will be seen that both in butter-fat and "solids not fat," the milk of lot I. was, on the average, superior throughout the experiment to that of lot II. As showing how milk may vary in quality without much apparent cause, attention may be called to the decrease in the average percentage of "solids not fat" during the last week of the trials. For that week, it is the lowest average throughout the period of the experiment.

TABLE IV.—AVERAGE PERCENTAGE OF SOLIDS NOT FAT
IN MILK FOR 12 WEEKS.

Week ending:—			Lot I.			Lot II.		
			Morning.	Noon.	Evening.	Morning.	Noon.	Evening.
February	16	...	9.13	9.00	9.27	8.80	9.00	8.90
"	23	...	8.87	9.00	9.20	8.60	8.60	8.80
March	1	...	9.20	9.10	9.20	8.93	9.10	9.20
"	8	...	9.30	9.20	9.30	9.00	9.20	9.10
"	15	...	9.20	9.00	9.00	8.50	8.70	8.90
"	22	...	8.90	9.20	9.30	8.70	8.80	8.90
"	29	...	9.00	9.20	9.10	8.70	8.80	8.80
April	5	...	9.10	9.00	9.20	8.70	8.90	8.80
"	12	...	9.30	9.20	9.30	9.00	8.90	8.90
"	19	...	9.20	9.30	9.10	9.00	9.00	8.80
"	26	...	9.10	9.10	9.20	8.90	9.10	8.90
May	3	...	8.80	8.70	8.90	8.50	8.50	8.50
Average	...	...	9.09	9.08	9.17	8.77	8.88	8.87
Times milkings were under standard*...			4	2	1	10	6	3
Highest	...	...	9.9	10.1	10.0	9.4	9.6	9.6
Lowest	...	...	8.2	8.1	8.0	8.0	7.8	8.0

General average for day's milk: Lot I. 9.10, Lot II. 8.82.

* Out of a possible of 84.

The live-weight of the cows.—The cows were weighed at the commencement, and at the end of every month afterwards throughout the experiment. The fluctuation in the average live-weight from month to month is shown in Table V.

TABLE V.—AVERAGE LIVE-WEIGHT PER COW FOR EACH
LOT (IN LB.).

	Commence- ment.	March 8.	April 5.	May 3.	Average increase during experiment.
Lot I. ...	1,064	1,098.5	1,100.6	1,096.2	32
Lot II. ...	1,068	1,111.3	1,143.2	1,130	62

It will be observed that both lots gained during the experiment in average live-weight, the increase being the greater where the heavier ration of concentrated food was used. The

figures, however, show that both lots thrived on the rations supplied to them, and the increase in live-weight in lot I. would no doubt have been greater than it is, had it not been that two of the cows, Nos. 85 and 93, were "off their food" for some days during the period, when they both actually lost weight. The two cows were not ailing at the same time, and it should be stated that their condition did not, apparently, affect the milk in any way.

EXPERIMENT B.

At the end of four weeks from the completion of Experiment A just described, a second experiment was commenced with the same cows. In this case they were out on grass, but received an allowance of concentrated food in addition, the two lots of cows being reversed as already explained, lot I. receiving the heavier ration.

Table VI. gives the yield of milk by the two lots for 12 weeks.

TABLE VI.—QUANTITY OF MILK IN PINTS PER LOT PER DAY FOR 12 WEEKS.

Week ending:—		Lot I.				Lot II.			
		Morn.	Noon.	Even.	Total.	Morn.	Noon.	Even.	Total.
June	8 ...	54·8	33	29·6	117·4	54·6	33·5	30	118·1
„	15 ...	54·6	33	28·2	115·8	53·1	33·2	30	116·3
„	22 ...	55·7	34·7	29·6	120	53	33	29	115
„	29 ...	54	33	28	115	51	32·6	29	113·6
July	6 ...	55	33·7	27	115·7	53	34	29	116
„	13 ...	53	32	27	112	50	31	28	109
„	20 ...	50	29	25·5	104·5	47	29	26	102
„	27 ...	46	28·4	24·4	98·8	44	29	25	98
August	3 ...	42·7	26	21	89·7	42·6	26	24·5	93·1
„	10 ...	41	24·8	20·5	86·3	42·5	26·3	23·8	92·6
„	17 ...	38·5	24	20	82·5	42·9	27·2	23·7	93·8
„	24 ...	37	23	20	80	41·6	26	24	91·6
Average per lot per day...		48·52	29·55	25·06	103·14	47·94	30·14	26·83	104·92

The effect of grass on the yield of milk is obvious, especially during the first half of the period, and more particularly in the case of lot I. Here, then, it may be urged, is a case of the food directly affecting the yield. There was certainly an increase in the yield of lot I. during the first half of this second experiment as compared with the end of Experiment A, as will be seen by comparing Tables II. and V. But there was also an increase in the yield of lot II. at first, although it was slight compared with that in lot I. Moreover, the superiority of lot I. over lot II. is not maintained, and by the end of the period of experiment, the average yield per day is below that of lot II., as it was in Experiment A. The difference between the two lots in this second experiment, it is true, is not so great as in the first. The fact remains, however, that lot II. from the very outset, and in spite of the alteration in the amount of concentrated food, has given a higher average yield than lot I. In the preliminary trials the two lots were fed alike, but lot II. gave the greater yield. During Experiment A, lot II. received the heavier ration, and again gave more milk than lot I. And finally, in Experiment B, during the summer, when lot II. received only half the quantity of concentrated food supplied to lot I., the average yield of milk in lot II. was again higher than in lot I. This certainly seems to indicate, as has been repeatedly maintained, that the character of the cows is of greater importance as a determining factor in the yield of milk than the food supplied to the cows. And coming to the question more especially under investigation in the present experiment, there is not, so far, sufficient evidence to prove that heavy, as compared with moderate, feeding is always advantageous in the case of dairy cows, when the results are regarded from the milk-seller's point of view.

The quality of the milk.—Table VII. shows the amount of butter-fat in the milk of each lot.

TABLE VII.—AVERAGE PERCENTAGE OF BUTTER-FAT IN MILK FOR 12 WEEKS.

Week ending:—			Lot I.			Lot II.		
			Morning.	Noon.	Evening.	Morning.	Noon.	Evening.
June	8	...	3·27	3·90	3·80	3·10	3·80	3·80
„	15	...	3·20	3·80	3·80	3·00	3·85	3·80
„	22	...	3·10	4·00	3·60	3·10	4·00	3·70
„	29	...	3·70	4·00	3·60	2·90	3·70	3·60
July	6	...	3·10	3·90	3·50	2·90	3·60	3·50
„	13	...	3·10	3·80	3·50	2·90	3·70	3·60
„	20	...	3·00	3·70	3·60	3·00	3·50	3·80
„	27	...	3·20	3·70	4·20	3·00	3·70	3·80
August	3	...	3·40	3·90	3·60	3·10	3·90	3·50
„	10	..	3·40	3·80	3·80	3·10	3·80	3·60
„	17	...	3·20	3·80	3·70	3·10	3·80	3·80
„	24	...	3·20	3·70	3·80	3·20	3·70	3·70
Average ...			3·23	3·83	3·70	3·03	3·75	3·68
Times milkings were under standard*...			2	—	—	24	—	—
Highest	...	...	3·7	4·3	4·1	3·5	4·3	4·2
Lowest	...	...	2·7	3·4	3·4	2·7	3·3	3·0

General average for day's milk	...	...	Lot. I.	Lot II.
Total butter fat per day	...	...	3·51	3·40
			4·67 lb.	4·60 lb.

* Out of a possible of 84.

The milk of both lots was richer in butter-fat during the summer than during the winter trials—lot II. shows much more improvement in this respect than lot I.—a result no doubt largely due to grass feeding. A comparison of the two lots, however, shows that lot I. still leads as far as the average percentage of butter-fat goes. Thus, both with the smaller allowance of concentrated food in the winter, and with the larger allowance in the summer, the same lot of cows, in spite of the change of food, has throughout given, on the average, the richer milk. The inference, therefore, from these results is that the quality of the milk, like the yield, is also less dependent upon the feeding than upon the character of the cows. From the butter-maker's standpoint, lot I. gave slightly better results than lot II., but the difference is

so slight that it only amounts to less than $\frac{1}{2}$ lb. of butter per week in favour of lot I.

Independently of the results of Experiment A, the above table indicates that, as far as the butter-fat is concerned, there has been but little advantage from using the heavier ration of concentrated food while the cows were on pasture, for the two lots stand in much the same relation to

TABLE VIII.—AVERAGE PERCENTAGE OF SOLIDS NOT FAT
IN MILK FOR 12 WEEKS.

Week ending :—			Lot I.			Lot II.		
			Morning.	Noon.	Evening.	Morning.	Noon.	Evening.
June	8 ...	...	8.95	9.10	9.00	8.90	8.80	8.80
„	15 ...	...	9.00	8.90	9.10	8.80	9.10	8.80
„	22 ...	...	9.10	9.50	9.20	9.00	8.90	9.00
„	29 ...	...	9.00	9.10	9.40	8.70	8.80	9.00
July	6 ...	...	8.80	9.00	8.90	8.70	9.00	9.00
„	13 ...	...	8.90	8.90	8.90	8.70	8.90	8.90
„	20 ...	...	8.80	9.00	9.20	8.80	9.20	9.20
„	27 ...	...	8.90	9.10	9.10	8.90	9.10	9.10
August	3 ...	...	9.00	9.10	9.00	9.00	9.00	8.90
„	10 ...	...	9.00	9.00	9.00	8.80	8.90	8.90
„	17 ...	...	8.70	9.00	8.90	8.60	8.90	8.80
„	24 ...	...	9.00	9.00	9.10	8.80	9.00	8.90
Average ...			8.92	9.05	9.06	8.80	8.96	8.94
Times milkings were under standard*			5	1	—	3	2	3
Highest ...			9.6	9.7	10.0	9.4	9.7	10.0
Lowest ...			8.3	8.4	8.7	8.2	8.3	8.3

General average for day's milk ; Lot I. 8.99, Lot II. 8.82.

* Out of a possible of 84.

each other in this respect at the end of the experiment as they did in the preliminary trials. On the other hand, what is abundantly clear, when Experiments A and B are compared, is the effect on both lots of cows of the change from stall-feeding to grass. This has obviously exerted so much influence that it is somewhat difficult to draw satisfactory conclusions as to the real effect of the concentrated food on either lot in Experiment B.

There is on the average a decrease in the "solids not fat" in lot I., compared with Experiment A, but it is still superior to lot II., whose milk remains unaltered in this respect. It is obvious that the influence of the food on the "solids not fat" in the milk is very slight, and the effect of change in other conditions is, apparently, as little.

The live-weight of the cows.—The cows were weighed monthly throughout the summer trials as during the winter experiment. Table IX. shows the average weight at the end of each month.

TABLE IX.—AVERAGE LIVE-WEIGHT PER COW FOR EACH LOT
(IN LB.)

	End of experiment A.	June 29.	July 27.	August 24.	Average increase during experiment.
Lot. I.	1,096·2	1,102	1,140·4	1,206·4	110·2
Lot. II.	1,130	1,114	1,148	1,202	72

It will be observed that in both experiments each lot gained on the average in live-weight, and the greater increase follows the heavier ration of concentrated food. Not unnaturally, the increase was greater in both lots in the summer than in the winter, the gain in live-weight in lot I. during the summer trials being somewhat striking. The results in this connection seem to indicate that a heavy ration, although it may not pay for itself always in an increased milk yield, or in an improvement in the yield of butter, may, nevertheless, be advantageous when it is desired to sell the cows to the butcher at the end of the lactation period as is frequently done.

It is interesting to note that the total gain in live-weight per cow from February 10 to August 24 was nearly the same in both lots, the total food received being also nearly the same.

SECOND SERIES OF EXPERIMENTS.

As soon as the first series of experiments was completed, it was decided to carry out a second series on the same lines, and to commence sufficiently early in the winter so that the two sets of trials, covering altogether six months, could be completed before the cows were turned out to grass. Accordingly, ten fresh cows, all shorthorns, which had calved during September, were selected in the beginning of October, 1904, and preliminary trials extending over one month were commenced.

TABLE X.—YIELD OF MILK AND PERCENTAGE OF BUTTER-FAT IN PRELIMINARY TRIALS.

Lot I.							
No. of Cow.	Average yield of Milk (in pints).			Average percentage of butter-fat.			Live-weight of cows (in lb.) at the end of preliminary trials.
	Morning.	Noon.	Evening.	Morning.	Noon.	Evening.	
38	15.0	8.0	7.5	2.8	3.2	3.8	1,148
60	14.0	8.7	7.9	2.9	3.4	3.5	1,155
84	12.6	8.2	6.0	2.5	3.8	3.6	1,260
105	11.7	7.7	6.9	3.0	3.6	4.2	952
106	10.0	7.0	6.3	3.1	4.2	4.2	1,155
Average	12.6	7.9	6.9	2.9	3.6	3.8	1,134

Lot. II.							
70	13.6	8.7	6.7	3.0	3.2	3.4	1,204
79	14.6	8.1	7.5	3.0	3.8	3.2	1,260
86	12.9	7.0	6.4	3.1	3.1	3.6	1,204
103	11.4	7.6	7.0	3.1	3.7	4.1	1,064
104	11.6	8.1	6.9	2.8	3.8	3.5	1,246
Average	12.8	7.9	6.9	3.0	3.5	3.6	1,195.6

Preliminary trials.—The preliminary trials were conducted as in the previous case. Each cow was tested for yield of milk and quantity of butter-fat once per week throughout the month of October. When the results were obtained, the cows were divided into two lots according to the average yield of milk and quantity of butter-fat, and not, as

in the former case, according to live-weight. Particulars relating to the two lots will be found in Table X.

Instead of dividing the cows into two lots of five according to their average live-weight as in the first series of experiments, the lots were arranged this time as far as possible according to the yield and quality of the milk. It will be seen from the figures above that it would have been difficult to get two lots to agree more closely in yield of milk and percentage of butter-fat than these did at the commencement of the experiment. The live-weight varied considerably.

The two lots were put on their respective rations on November 1, when Experiment C commenced. At that time the two lots stood as follows:—

		Average yield of milk per cow per day.		Per cent. of butter-fat.		Average live-weight.
Lot I. ...	...	27.4 pints	...	3.32	...	1,134 lb.
Lot. II....	...	27.6 pints	...	3.23	...	1,195.6 lb.

Rations.—In the first series of experiments, as already shown, the two lots of cows were supplied with 8 lb. and 12 lb. of concentrated food respectively during the first three months (Experiment A), the bulky food being the same in both cases. For the second three months (Experiment B) the rations were reversed. The same plan was again adopted, but as the cows were considerably heavier than those used in Experiments A and B, it was considered necessary to give them heavier daily rations, which were accordingly calculated for 1,200 lb. live-weight. The rations per 1,000 lb. live-weight were as follows:—

LOT I.		LOT II.	
8 lb. con- centrated food	{ 4 lb. maize meal. 2 „ Bombay cotton cake. 2 „ linseed cake. 6 „ chopped straw. 12 „ hay. 50 „ roots.	12 lb. con- centrated food	{ 6 lb. maize meal. 3 „ Bombay cotton cake. 3 „ linseed cake. 6 „ chopped straw. 12 „ hay. 50 „ roots.
Albuminoid ratio, 1 : 6.		Albuminoid ratio, 1 : 5.7.	

The total amount of organic matter supplied in the present case was 30·98 lb. per cow per day for lot I., and 34·94 lb. for lot II. The present test (Experiment C) commenced on November 1, 1904, and continued till January 23, 1905, a period of 12 weeks.

The two rations were reversed as soon as Experiment C came to an end, lot I. receiving the heavy ration and lot II. the lighter. The further test (Experiment D) commenced on February 1, and continued till April 25, 1905, another period of 12 weeks.

As in the earlier experiments, the cake and meal and chopped straw were made into "crowdy" and water was supplied *ad lib.*

EXPERIMENT C.

Results.—Table XI. shows the quantity of milk given by the two lots of cows during Experiment C, when lot I. received the moderate, and lot II. the heavy ration.

TABLE XI.—QUANTITY OF MILK IN PINTS PER LOT PER DAY FOR 12 WEEKS.

Week ending:—	Lot I.				Lot II.			
	Morn.	Noon.	Even.	Total.	Morn.	Noon.	Even.	Total
Nov. 7 ...	61	37	33	131	65	39	36	140
„ 14 ...	58·5	34·5	31	124	67	38·5	35·5	141
„ 21 ...	58	34·5	29·5	122	61·5	36	32·2	130
„ 28 ...	54	33	27	114	59	36	29	124
Dec. 5 ...	51	31	26	108	62	38	30·5	130·5
„ 12 ...	54	34·5	29	117·5	63	38·5	30	131·5
„ 19 ...	57	34·5	27·5	119	64	38	30	132
„ 26 ...	58	35·5	27	120·5	62·5	39	30	131·5
Jan. 2 ...	57	34	26	117	64	38	30·5	132·5
„ 9 ...	57	33	27	117	63	37	30	130
„ 16 ...	57	36	27·5	120·5	64	39	30·5	133·5
„ 23 ...	58·5	35·5	27·5	121·5	62	37·5	30	129·5
Average per lot per day	56·75	34·41	28·16	119·33	63·08	37·87	31·18	132·16

On comparing Table XI. with that on page 32, it will be seen that the two present lots of cows gave considerably more milk than those used in the first series of experiments, but the figures showing the average quantity of milk morning, noon, and evening, bear much the same relation to one another as those in Table II. There was more milk in the morning than at noon and evening, and this applies to both lots. The total daily yield was greater throughout in lot II. than in lot I., the average for lot I. for the whole period of the experiment being about $119\frac{1}{2}$ pints per day, and for lot II. slightly over 132 pints, or a difference in favour of lot II. of over $12\frac{2}{3}$ pints per day. The average yield per cow in lot I., according to these figures, was 23.86 pints per day, and in lot II., 26.43 pints. It will thus be seen that the average per cow is less in both lots than it was in the preliminary trials, but the drop in the case of lot II. is only slight. During the preliminary trials, all the cows received the ration generally used at Offerton Hall, viz., about $9\frac{1}{2}$ lb. of concentrated food per head per day. The decrease in the average yield of milk in lot I. during the period of the experiment cannot be attributed to any difference in the quantity of concentrated food supplied during the experiment and that which the cows had been receiving before the experiment commenced, for, as the rations were calculated for 1,200 lb. live-weight each cow, even in lot I., would be receiving actually more concentrated food during the experiment than before. In lot II., where there was also a slight decrease on the average as compared with the preliminary trials, each cow received during the period of the experiment over $3\frac{1}{2}$ lb. more concentrated food per day than during the preliminary trials, and this only caused a small increase in the yield during the *first two weeks*. It is perhaps necessary to say this much, as otherwise it might be concluded that the sudden drop in the yield of lot I. in the first week of the experiment was due to the cows receiving a smaller ration than before.

The result of this experiment, as shown in the table, was an increase in the yield in favour of the heavy ration of about $2\frac{1}{2}$ pints per cow per day. This would appear to be a decisive result, as the two lots yielded at the commencement of the experiment almost exactly the same amount of milk per day, and the treatment of the two lots was identical throughout, except as regards the amount of concentrated food supplied in the rations. The increase, however, is hardly sufficient to pay for the extra concentrated food which went to produce it, and, as has been shown, it took place chiefly during the first two weeks of the experiment.

The quality of the milk.—It has been shown that the average percentage of butter-fat in the preliminary trials was very similar for the two lots of cows, viz., 3·32 for lot I., and 3·23 for lot II. Table XII. shows the average butter-fat in the milk of the two lots during Experiment C.

TABLE XII.—AVERAGE PERCENTAGE OF BUTTER-FAT IN MILK FOR 12 WEEKS.

Week ending:—	Lot I.			Lot II.		
	Morning.	Noon.	Evening.	Morning.	Noon.	Evening.
November 7 ...	2·8	3·7	3·8	2·9	3·9	3·6
„ 14 ...	2·8	3·8	3·8	2·9	3·7	3·5
„ 21 ...	2·8	3·7	3·8	2·8	3·7	3·8
„ 28 ...	2·9	3·7	3·8	2·9	3·8	3·6
December 5 ...	3·0	3·6	3·8	2·9	3·9	3·3
„ 12 ...	2·9	3·6	3·7	2·9	3·8	3·6
„ 19 ...	2·8	3·8	3·7	2·9	3·8	3·5
„ 26 ...	2·9	3·7	3·7	3·0	4·0	3·4
January 2 ...	3·0	3·5	3·6	3·0	3·9	3·3
„ 9 ...	2·9	3·6	3·6	3·0	3·7	3·2
„ 16 ...	2·9	3·7	3·6	3·2	3·9	3·3
„ 23 ...	2·9	3·7	3·6	3·0	3·8	3·3
Average ...	2·88	3·59	3·70	2·95	3·82	3·45
Times milkings were under standard*	55	—	—	33	—	—
Highest ...	3·2	4·3	4·2	3·3	4·3	4·0
Lowest ...	2·5	3·2	3·2	2·6	3·3	3·0

General average for day's milk	...	...	Lot I.	3·28	Lot II.	3·31
Total butter-fat per day	...	...	...	5·05 lb.	...	5·64 lb.

* Out of a possible of 84.

There is here again a slight advantage in favour of lot II., but the difference in the general average is so small that it is not in any way important. The morning milk, on the average of 12 weeks, is below the standard in both lots, being slightly better in lot II. than in lot I. In lot I. the evening milk is the richest, while in lot II. the noon milk is, with one exception, the best throughout. Taking the quality of the morning milk in both lots into consideration, as well as the general average composition, it is obvious that there has not been any appreciable advantage from using the heavy ration, when looking at the results from the milk-seller's standpoint. The average gain in favour of the heavy feed only amounts to .03 per cent., which is certainly not enough to justify the extra cost of the food.

If the milk had been used for butter-making, the results would have been more favourable to lot II., which gave over half-a-pound of butter per lot per day or about 4 lb. per week more than lot I. Whether there would have been this difference between the two lots in actual practice, it is impossible to determine, seeing that nothing is known about the respective churnability of the two milks. It is clear, however, even assuming that lot II. would have given 4 lb. per week more butter than lot I., that feeding in this manner would have resulted in a loss. From no point of view, therefore, has the heavy ration been profitable as far as the butter-fat in the milk is concerned.

In this respect, this experiment confirms the results of Experiment A, which showed a decrease in the average percentage of butter-fat from the heavy feed. The position is slightly reversed in the present case, but with the same result financially as before.

Table XIII. shows the percentage of "solids not fat" in the milk of the two lots.

There was not much variation in the "solids not fat," and the results here are much what might have been expected. The general average for the day's milk is the same for both lots

TABLE XIII.—AVERAGE PERCENTAGE OF SOLIDS NOT FAT
IN MILK FOR 12 WEEKS.

Week ending :—			Lot I.			Lot II.		
			Morning.	Noon.	Evening.	Morning.	Noon.	Evening.
November	7	..	8·7	8·9	8·7	8·6	9·1	8·8
„	14	...	8·7	8·9	8·8	8·7	8·9	8·8
„	21	...	8·5	8·9	8·9	8·6	9·0	8·8
„	28	...	8·7	9·0	8·9	8·7	9·0	9·0
December	5	...	8·8	8·9	8·9	8·7	8·9	9·0
„	12	...	8·9	9·0	9·0	8·9	9·0	9·1
„	19	...	8·8	9·0	9·0	8·9	9·0	9·0
„	26	...	8·9	9·1	9·1	8·8	9·1	9·1
January	2	...	9·0	9·0	9·1	8·9	9·0	9·0
„	9	...	8·9	9·1	9·0	8·8	9·2	9·1
„	16	...	8·9	9·0	9·0	8·9	9·1	9·0
„	23	...	8·9	9·1	9·2	8·9	9·1	9·1
Average	...	...	8·80	8·99	8·96	8·78	9·03	8·98
Times milkings were under standard*	...	...	3	—	—	4	—	1
Highest	...	...	9·3	9·5	9·6	9·5	9·4	9·5
Lowest	...	...	8·3	8·5	8·5	8·2	8·5	8·4

General average for day's milk : Lot I., 8·8 ; Lot II., 8·8.

* Out of a possible of 84.

of cows, viz., 8·8 per cent. In calculating the general average, allowance is of course made, as with the butter-fat, for the difference in the average quantity of milk, morning, noon and evening. The morning milk was slightly lower, on the average, in lot II. than in lot I., but in both cases the milk was well above the standard, and the difference between the two lots is so small as to be negligible.

The effect of the rations on the average live-weight of the cows, which were weighed monthly during the period of the experiment, is shown in Table XIV.

The results show an average decrease of 13 lb. per cow in lot I., and an average gain of 25 lb. in lot II. This loss of weight in lot I. was largely due to one cow (No. 60) which, owing to some unknown cause, lost 91 lb. during the first month of the experiment. The same cow, during the second

TABLE XIV.—AVERAGE LIVE-WEIGHT PER COW FOR EACH LOT (IN LB.).

	Commence- ment.	Nov. 28	Dec. 26.	Jan. 23.	Increase (+) or decrease (-) during experiment.
Lot I.	1,134	1,113	1,120	1,121	- 13
Lot II.	1,195	1,191	1,205	1,220	+ 25

month, however, gained 14 lb. It is necessary to mention this fact, otherwise it might be concluded that the loss in live-weight in lot I. was due to insufficient food, which was certainly not the case. It will be observed that the cows in lot II. also lost weight on the average during the first month. This again is due to one cow (No. 86). Had it not been for this, the average increase in lot II. would have been greater than it is. It may be pointed out that an average gain of 25 lb. only was hardly sufficient to make good the loss on the heavy feed supplied to this lot.

The figures in Tables X. and XI. suggest that there may be a connection between the gain or loss in live-weight and the milk produced by the cows. It has been shown that both lots of cows lost weight during the first month of the experiment. On looking at Table X. it will be seen that the total quantity of milk gradually went down during that period. During the second and third month, when the cows in both lots were improving in live-weight, there is an increase in the milk yield in both lots also, the increase in lot I. being the more striking. But in neither lots is the increase altogether consistent, and the connection between the two points is perhaps more apparent than real.

Similarly, on looking at Tables XI. and XII., it will be noticed that during the first month, when both lots of cows were losing weight, the quality of the morning milk especially is poorer, on the whole, than during the two succeeding months, when both lots were gaining weight. This experi-

ment by itself, however, does not furnish sufficient evidence to draw any conclusions on this point, and especially as it has been shown already that the loss of weight was largely due to one cow in both lots. Moreover, the figures in Experiment A, as shown in Tables II. and III., do not indicate that when the cows are gaining in live-weight there is any improvement in the yield or quality of the milk. It stands to reason, of course, that if there is any large decrease in live-weight due to ill-health or improper feeding, there should be a falling off in the milk yield. Such, however, was not the case in this experiment.

EXPERIMENT D.

As soon as Experiment C was completed, the rations were reversed, lot I. now receiving the heavy and lot II. the moderate ration. The cows were left for one week to settle down to the changed conditions before any samples of milk were taken. The fourth experiment, here described as Experiment D, continued from February 1, to April 25, 1905,

TABLE XV.—QUANTITY OF MILK IN PINTS PER LOT PER DAY FOR 12 WEEKS.

Week ending:—		Lot I.				Lot. II.			
		Morn.	Noon.	Even.	Total.	Morn.	Noon.	Even.	Total.
Feb.	7 ...	50·5	31	24	105·5	57	33·5	29	119·5
„	14 ...	57	35	28	120	59	35·5	31	125·5
„	21 ...	59·5	36·5	29	125	56	35·5	28	119·5
„	28 ...	52	32	25	109	50	31	25·5	106·5
March	7 ...	49·5	30	25	104·5	50	31	26	107
„	14 ...	54	33	26	113	54	33·5	28	115·5
„	21 ...	52·5	33·5	25·5	111·5	53	33·5	27	113·5
„	28 ...	51·5	32	25	108·5	54	34	26	114
April	4 ...	48·5	33	23	104·5	54	33	25·5	112·5
„	11 ...	46	30·5	23·5	100	54	32·5	28	114·5
„	18 ...	46	30·5	23	99·5	51·5	32	25·5	109
„	25 ...	50	31·5	25·5	107	53	30·5	27	110·5
Average per lot per day...		51·41	32·37	25·20	109	53·79	32·95	27·20	113·95

and Table XV. shows the yield of milk by the two lots of cows during this period.

The total daily yield is again greater on the average in lot II. than in lot I., in spite of the rations having been reversed. For this period, lot I. gave an average of 109 pints per day, and lot II. 113.95 pints, or nearly 5 pints per day more than lot I. From the results of Experiment C it seemed fairly clear that the heavy ration fed to lot II. had caused an increase in the milk yield, and if this increase was directly due to the ration, it would be natural to expect the position of the two lots reversed in Experiment D. But such is not the case, for, with two exceptions, the yield is higher throughout in lot II. than in lot I. The advantage, therefore, as far as yield is concerned, is throughout the whole period of the two experiments with lot II. It is true that there is not the same difference on this occasion between the two lots as there was in the preceding experiment, but it is sufficiently great to be perfectly clear. It must be pointed out that by the end of the second period, April 25, the cows were falling off in yield, and it appears as if lot I. was falling off a little more rapidly than lot II. Both lots of cows had calved nearly about the same time, so that there was not much difference in the length of the lactation period between the two lots up to this time and it is important to observe that the heavy ration supplied to lot I. in Experiment D does not appear to keep up the flow of milk any better than the moderate ration given to lot II. The change from moderate to heavy feeding in lot I. caused the yield to go down very considerably for the first week, although it went up again in the second and third weeks, after which it dropped once more. Assuming the increase during these two weeks to be due to the heavy feed, it is clear its effects were only temporary, and it is a significant fact that, with the exception of the third week mentioned, lot I. on the heavy ration does not come up to where it stood at the end of the preceding experiment on the

moderate ration. Some allowance must, of course, be made for the advance in the lactation period, but even when this is done, there is little that can be said in favour of the change in the ration as far as lot I. is concerned.

While there has thus been an increase in the yield of lot I. during the second and third weeks, it will be observed that there was an increase during the second week also in lot II., although there was a marked falling off in the first week as compared with the end of Experiment C. It seems fairly clear that while increasing or decreasing the quantity of concentrated food may cause temporary differences in the milk yield, there does not appear to be any regular and consistent connection between the two things, as long as a moderate ration is supplied to the cows.

One other observation may be made in this connection. The results seem to indicate that a heavier ration may be used with profit early in the lactation period than can be employed as the period advances. To increase the ration with the object of improving the milk yield does not, as far as we can judge from these experiments, have the desired effect, provided always that the cows receive in the first place an adequate ration to maintain their condition. It seems also that to reduce the ration of concentrated food even to the extent of 4 or 5 lb. per cow per day, does not cause the diminution in the yield that one might expect, provided again that the cows are left at the end with a moderate allowance. These experiments show that an allowance of 12 lb. of concentrated food or more per cow per day may not generally be employed with profit. Moreover, in view of the observations already made on the effect upon the milk of altering the ration, it may be suggested that the allowance of concentrated food given to dairy cows should to a great extent be regulated *according to the amount of milk the cows yield*, the actual quantity fixed upon at the commencement of the lactation period to be dependent, of course, upon the size and weight of the cows.

The milk for this last period was, as will be seen, considerably richer in butter-fat than during Experiment C. Only in one instance was the morning milk here under the standard, viz., in the week ending February 21, and it is interesting to observe that it was the same in both lots on that occasion. As far as the general average of butter-fat is concerned, the advantage is in favour of lot I., which gave

TABLE XVI.—AVERAGE PERCENTAGE OF BUTTER-FAT
IN MILK FOR 12 WEEKS.

Week ending:—				Lot I.			Lot II.		
				Morning.	Noon.	Evening.	Morning.	Noon.	Evening.
February	7	...	...	3·2	3·7	3·9	3·2	3·9	3·3
„	14	...	...	3·1	3·8	3·8	3·0	4·0	3·5
„	21	...	...	2·9	3·9	3·4	2·9	4·0	3·4
„	28	...	...	3·0	3·9	3·9	3·1	4·0	3·5
March	7	...	...	3·1	3·9	4·0	3·1	3·9	3·3
„	14	...	...	3·0	3·9	3·8	3·0	4·0	3·3
„	21	...	...	3·1	3·8	3·8	3·2	4·0	3·5
„	28	...	...	3·2	3·9	3·8	3·0	4·1	3·4
April	4	...	...	3·5	3·7	4·0	3·3	3·9	3·9
„	11	...	...	3·3	3·9	3·8	3·3	3·9	3·3
„	18	...	...	3·2	4·0	3·7	3·3	4·0	3·5
„	25	...	...	3·2	3·8	3·8	3·2	4·0	3·6
Average	...	...	...	3·15	3·85	3·80	3·13	3·97	3·45
Times milkings were under standard* ..				8	—	—	9	—	—
Highest				4·1	4·6	4·3	3·5	4·6	4·6
Lowest				2·8	3·3	3·2	2·7	3·5	3·1

		Lot I.	Lot II.
General average for day's milk	...	3·50	3·44
Total butter-fat per day	...	4·92 lb.	5·06 lb.

* Out of a possible of 84.

an average of 3·5 per cent. as against 3·44 for lot II., a difference in favour of the former of ·06 per cent. The difference between the two lots is chiefly in the evening milk. This result suggests an improvement in the quality due to the heavy ration. The difference, however, is too small to be decisive, and the higher percentage of butter-fat in lot I. might easily be due to the greater falling off in the milk yield during the

experiment, as pointed out already. Moreover, the butter-fat was increased in *both* lots during this experiment as was also the case with the previous set of cows in Experiment B. It is very evident that the milk improved in quality as the lactation period advanced, and that independently of the quantity of concentrated food supplied to the cows. The difference in percentage of butter-fat, on the average, between the two lots in Experiment D, when lot I. received 4 lb. concentrated food per cow per day more than lot II., was actually less than it was in the preliminary trials, when the two lots were fed exactly alike.

The total amount of butter-fat produced by each lot is slightly less than in Experiment C, but the advantage here is again with lot II., as it was in the preceding experiment. Lot II. has, therefore, from the butter-maker's standpoint,

TABLE XVII.—AVERAGE PERCENTAGE OF SOLIDS NOT FAT
IN MILK FOR 12 WEEKS.

Week ending:—	Lot I.			Lot II.		
	Morning.	Noon.	Evening.	Morning.	Noon.	Evening.
February 7 ...	8.9	9.0	9.1	8.8	9.1	9.0
„ 14 ...	9.0	9.1	9.1	9.0	9.1	9.1
„ 21 ...	8.9	9.0	9.0	8.8	9.0	9.0
„ 28 ...	8.9	9.0	8.9	8.9	9.1	9.0
March 7 ...	8.8	9.1	8.9	8.7	9.1	8.8
„ 14 ...	8.8	8.9	8.9	8.7	8.9	8.7
„ 21 ...	8.8	9.0	9.0	8.8	9.1	8.8
„ 28 ...	8.9	9.1	9.0	8.8	9.0	9.1
April 4 ...	9.0	9.1	9.1	8.9	8.9	9.0
„ 11 ...	9.0	9.0	9.0	9.0	9.1	8.9
„ 18 ...	8.8	9.0	8.9	8.8	8.8	8.7
„ 25 ...	8.8	9.0	9.0	8.8	8.9	8.9
Average ...	8.88	9.02	8.99	8.83	9.00	8.91
Times milkings were under standard*...	3	—	—	3	—	3
Highest ...	9.3	9.8	9.4	9.4	9.5	9.4
Lowest ...	8.4	8.7	8.5	8.3	8.6	8.4

General average for days' milk:—Lot I., 8.9; Lot II., 8.8.

* Out of a possible of 84.

been the better lot throughout, whether on the heavy or moderate ration. Judged from this point of view, it would appear that the moderate ration has been the more economical.

The state of the "solids not fat" in each lot very nearly agrees with the results of Experiment C. There is here a slight advantage in favour of lot I., showing that the milk of this lot was of somewhat better quality generally during this experiment than that of lot II. The noon milk was the best in both lots in "solids not fat," which was also the case in the previous experiment. The quality, on the average, is so equal in the two lots that there is hardly much reason to infer from the above figures that the heavy ration is to be recommended on economical grounds.

On the main points of inquiry, Experiments C and D confirm the results of the first series, and it is brought out very clearly that *heavy rations of concentrated food do not pay as compared with moderate ones* for dairy cows.

Table XVIII. shows the effect of the two rations on the live-weight of the cows in Experiment D. As in Experiment C, the cows were weighed monthly during the period of the trials.

TABLE XVIII.—AVERAGE LIVE-WEIGHT PER COW FOR EACH LOT (IN LB.).

	End of exper.ment C.	Feb. 28.	March 28.	April 25.	Increase (+) or decrease (-) during experiment.
Lot I. ...	1,121	1,164	1,175	1,187	+ 66
Lot II. ...	1,220	1,211	1,198	1,211	- 9

During the experiment, there was an increase on the average of 66 lb. per cow in lot I., and a loss of 9 lb. per cow in lot II. This loss of weight in lot II. is again largely due to two cows, Nos. 79 and 103, the former having lost 61 lb. during the second month, and the latter 86 lb. during the

third month. The cows in lot I. put on flesh from the beginning of the experiment, the explanation, no doubt, being that the heavy ration was given to them at a time when they were already beginning to go off their milk. Taking the whole period during which the cows were under experiment, lot I. gained on the average, 53 lb. per cow, and lot II. 16 lb. per cow.

Summary and General Conclusions.—The following summarizes the results:—

FIRST SERIES OF EXPERIMENTS.

PRELIMINARY TRIALS.—SET OF 10 COWS IN TWO LOTS OF 5.

		Milk per cow per day.		% fat.		Average live-weight per cow.
Lot I. ..	...	23·47 pints	...	3·45	...	1,064 lb.
Lot II. ...	...	25·04 pints	...	3·36	...	1,068 lb.

EXPERIMENT A.

12 Weeks, Feb. 8—May 3, 1904.

	Amount of concentrated food per cow per day.	Average milk per cow per day.	% fat.	Total butter-fat per cow per day.	% S.N.F.	Gain (+) or loss (–) in average live-weight per cow.
Lot I....	8 lb.	18·92 pints	3·48	0·85 lb.	9·10	+ 32 lb.
Lot II.	12 lb.	22·46 pints	3·16	0·91 lb.	8·82	+ 62 lb.

EXPERIMENT B.

12 Weeks, June 1—Aug. 24, 1904.

Same cows on grass. Rations reversed.

Lot I....	8 lb.	20·63 pints	3·51	0·93 lb.	8·99	+ 110·2 lb.
Lot II.	4 lb.	20·98 pints	3·40	0·92 lb.	8·82	+ 72 lb.

SECOND SERIES OF EXPERIMENTS.

PRELIMINARY TRIALS.—FRESH SET OF 10 COWS.

		Milk per cow per day.		% fat.		Average live-weight per cow.
Lot I. ...	...	27·4 pints	...	3·32	...	1,134 lb.
Lot II. ...	...	27·6 pints	...	3·23	...	1,195 lb.

EXPERIMENT C.

12 Weeks, Nov. 1, 1904—Jan. 23, 1905.

	Amount of concentrated food per cow per day.	Average milk per cow per day.	% fat.	Total butter-fat per cow per day.	% S.N.F.	Gain (+) or loss (-) in average live-weight per cow.
Lot I....	8 lb. per 1,000 lb. L. W.	23·86 pints	3·28	1·01 lb.	8·8	- 13 lb.
Lot II.	12 lb. per 1,000 lb. L. W.	26·43 pints	3·31	1·13 lb.	8·8	+ 25 lb.

EXPERIMENT D.

12 Weeks, Feb. 1—April 25, 1905.

Same cows. Rations reversed.

Lot I....	12 lb. per 1,000 lb. L. W.	21·80 pints	3·50	0·98 lb.	8·9	+ 66 lb.
Lot II.	8 lb. per 1,000 lb. L. W.	22·79 pints	3·44	1·01 lb.	8·8	- 9 lb.

The two series of experiments dealt with had for their special object to discover whether it is profitable to use a heavy ration of concentrated food for dairy cows as against a moderate allowance, having regard to both the quantity and quality of the milk produced. Two different sets of cows were tested at different times, each set being under experiment for 24 weeks. Each set consisted of two lots of five cows, and each lot was in turn placed on a heavy and a moderate ration of concentrated food for a period of 12 weeks. The trials from beginning to end covered a period of 48 weeks. The following general conclusions may be drawn:—

(1) A heavy ration, of not less than 12 lb. of concentrated food per head per day, may cause an increase in the milk yield, as compared with a moderate ration, provided the cows are not far advanced in the lactation period (Tables II. and

XI.), but it is doubtful whether, on the average, this temporary increase is commensurate with the cost of the food, and it is certain that a heavy ration of this description may not be employed throughout the lactation period with economy.

(2) While it is clear that an increase in the milk yield at first may be caused by increasing the amount of concentrated food, there is a limit, even when the cows are in full milk, beyond which the amount cannot be increased with profit.

(3) When cows have been milking for some considerable time, and begin to fall off in their yield, an increase in the concentrated food does not check the falling off, except temporarily, if the cows are indoors (Table XV.). When, on the other hand, the cows are turned out to grass, the flow of milk is increased, for at least a considerable time at first, irrespective of the quantity of concentrated food supplied at the same time (Table VI.).

(4) The food has more direct effect upon the quantity of milk produced than on the quality.

(5) With regard to the quality generally, provided a moderate allowance of concentrated food is given to the cows, it is doubtful, when all the evidence supplied by these experiments is taken into account, whether increasing the allowance has any appreciable influence.

(6) The morning milk of an average lot of cows, even when they are well fed, may frequently be under the standard in butter-fat, during the earlier part of the lactation period, and an augmented ration of concentrated food causes but little improvement in this respect (Tables III. and XII.).

(7) As the lactation period advances the percentage of butter-fat in the milk increases independently of the quantity of concentrated food in the ration (Tables VII. and XVI.).

(8) While it has been shown that there does not appear to be any regular and consistent connection between the amount of concentrated food in the ration and the quantity

and quality of the milk, provided we take the lactation period throughout, and that the cows receive adequate nourishment, it is clear that a heavy ration has a much more distinct effect upon the live-weight of the cows than a moderate one, and what is not recovered in the milk is partially recovered in this form.

(9) The character of the cows has much more to do with determining the quantity and quality of the milk than the actual amount of concentrated food in the daily ration.

(10) Finally, as the results obtained in these experiments indicate that a larger quantity of concentrated food may be employed with profit early in the lactation period than can be done as the period advances, it seems probable that the most economical method of feeding dairy cows, having regard only to the milk produced, would be to make the ration largely dependant upon the amount of milk the cows yield.

EXPERIMENT E.

EQUAL *versus* UNEQUAL INTERVALS BETWEEN MILKING.

Object.—The object was to test the effect upon the quantity and quality of milk of an equal and unequal interval between milking.

The experiment was commenced on May 7, 1905, the cows used in Experiment D being employed for the purpose, the same cows forming lots I. and II. respectively in both experiments. The average amount of milk for the week ending April 25 in Experiment D (Table XV.), was for lot I., 107 pints per day, and for lot II., 110½ pints. The average percentage of butter-fat for the same week was 3·52 for both lots, the morning average being 3·2 also for both lots. There were thus in Experiment E two lots of five cows each, which gave at first nearly the same daily yield of milk, and exactly the same percentage of butter-fat. Any appreciable difference in either the yield or quality of the milk under the new con-

ditions would, therefore, be readily noticed. The experiment extended over 18 days, from May 7 to May 24 inclusive. Lot I. was milked at 6 a.m. and 4 p.m., and lot II. at 6 a.m. and 6 p.m.

The results are given in Table XIX.

TABLE XIX.—QUANTITY OF MILK, AND PERCENTAGE OF FAT AND SOLIDS NOT FAT, WITH EQUAL AND UNEQUAL INTERVALS BETWEEN MILKING.

Date.	Lot I. Milked at 6 a.m. and 4 p.m.						Lot II. Milked at 6 a.m. and 6 p.m.					
	Morning.			Evening.			Morning.			Evening.		
	Milk in pints.	Fat. Per cent.	S.N.F. Per cent.	Milk in pints.	Fat. Per cent.	S.N.F. Per cent.	Milk in pints.	Fat. Per cent.	S.N.F. Per cent.	Milk in pints.	Fat. Per cent.	S.N.F. Per cent.
May 7	51	3·4	8·9	40½	4·0	8·8	47½	3·6	9·0	50	3·5	8·6
" 8	48	3·5	8·9	41	3·8	8·8	45½	4·0	8·7	51	3·5	8·6
" 9	50	3·5	8·6	42	3·9	8·8	45	4·1	8·8	52	3·6	8·9
" 10	51	3·8	8·5	39½	3·8	8·7	44½	4·0	8·6	50	3·5	8·7
" 11	51	3·7	8·7	39	4·0	8·8	44	4·1	8·6	51	3·8	8·6
" 12	49½	3·5	8·9	39½	3·9	8·8	46	3·9	8·7	53½	3·5	8·8
" 13	51½	3·8	9·0	36½	3·6	8·6	46½	4·1	8·7	49½	3·4	8·7
" 14	54	3·6	9·0	41½	3·9	8·5	49½	4·0	8·8	50	3·5	8·6
" 15	45½	3·8	8·9	41½	3·9	8·8	48	4·0	8·8	51	3·8	8·7
" 16	48½	3·6	8·5	39	4·1	9·1	47½	4·0	8·8	49½	3·9	9·0
" 17	49	3·9	8·6	41½	4·1	8·9	48	4·1	8·6	55½	3·7	8·8
" 18	52½	3·6	8·8	41	4·0	9·1	52	4·1	8·6	52½	3·8	8·7
" 19	52	3·7	8·5	41½	3·9	8·8	49	4·0	8·6	53	3·8	8·6
" 20	55	3·6	8·7	39	4·0	8·9	53	4·1	8·9	52½	3·8	8·9
" 21	55½	3·7	8·9	40½	4·1	8·9	55	4·4	8·9	53½	3·7	8·6
" 22	52	3·7	8·7	41	4·0	8·7	55	4·0	8·4	48	3·7	8·9
" 23	53½	3·8	8·8	44	4·1	9·1	51	4·1	8·7	57½	3·5	8·9
" 24	54½	3·7	9·0	47	4·0	8·9	53½	4·1	9·0	59	3·7	8·8
Average	51·3	3·6	8·7	40·8	4·3	8·8	48·9	4·0	8·7	52·1	3·6	8·7

	Lot I.	Lot II.
Total daily yield of milk	92·1 pints.	101 pints.
Average percentage butter-fat ...	3·91	3·78
Average percentage in morning milk	3·6	4·0
Average percentage "solids not fat"	8·74	8·70

It will be observed that when the total daily yield of milk is taken into consideration, that lot II. gave about 9 pints more on the average than lot I. Whether this is due to the

intervals between milking being equal in the case of lot II., it is difficult to say. It is worthy of note, however, that there was much less difference in quantity between morning and evening milk in lot II. than in lot I., although the difference was less marked towards the end of the experiment, and it is to be noted also that in lot II., where the intervals between milking were equal, there was more milk, on the average, in the evening than in the morning. In lot I., on the other hand, with unequal intervals between milking, there was a very considerable difference between the yield in the morning and evening, that in the morning, after the long interval, being not unnaturally the greater.

As far as the quality of the milk is concerned, the striking point in the results is the high percentage of butter-fat, on the average, in the morning milk of lot II. Although both lots are well above the standard in the morning, the results show that when the intervals between milking are equal, the morning milk is likely to be much richer in fat than when the interval between evening and morning milking is a very long one. The evening milk of lot I. is very rich in butter-fat, and when the daily yield is taken into account, the milk of this lot is generally richer in butter-fat than that of lot II. It will be observed that the greater the yield the poorer the quality as far as butter-fat is concerned, and this applies equally to both lots.

The "solids not fat" are fairly constant in both lots.

Summary and conclusions.

(1) Trials to test the effect of equal and unequal intervals between milking were conducted in May last with two lots of five cows each, and extended over 18 days. Lot I. was milked at 6 a.m. and 4 p.m., and lot II. at 6 a.m. and 6 p.m.

(2) The results show that lot II. gave about 9 pints of milk per day more than lot I. The difference in quantity between morning and evening milk was considerable, amounting to $10\frac{1}{2}$ pints in lot I., and small, amounting only to 3 pints in lot II.

(3) Lot I. gave the greater yield in the morning, after the long interval, and lot II. the greater yield in the evening.

(4) With the equal intervals, the morning milk was considerably richer in fat than with the unequal intervals, the figures being 4 per cent. and 3.6 per cent. respectively. The richest milk of all, on the average, was the evening milk of lot I., after the short interval.

(5) The percentage of "solids not fat" was practically the same in both lots.

(6) The results generally seem to indicate that, while in this particular experiment the milk of both lots was above the standard in the morning, it is better, in order to ensure this, that the intervals between milking should be as nearly equal as convenient. In this, the experiment confirms the results on this point obtained elsewhere. It would seem, moreover, that with equal intervals, the yield of milk may be greater.

EXPERIMENT F.

CREAM-RAISING TESTS.

Object.—The object of this series of tests was to determine (a) whether it is possible to get the cream to rise to the same extent in refrigerated milk as in milk naturally cooled, and (b) to determine the percentage of cream which rises in milk refrigerated and subsequently warmed as compared with milk which has not been warmed. It has been frequently suggested that, as a means of improving the quality of morning milk, especially when milked after a long interval, that the previous evening's milk should be mixed with it. These tests have a direct bearing upon this point.

Two sets of tests were made, the first in January, 1904, and the second at various times in the beginning of 1905. A quantity of milk, warm, cooled, or mixed, was placed in numbered jars employed for the purpose, and allowed to stand for a number of hours, the percentage of cream being then

measured. A careful record of the temperature of the milk was kept throughout. The results, with details relating to the various tests, will be found in Tables XX. and XXI.

Summary and conclusions.

(1) A series of tests were made in 1904-5 to determine the extent to which cream would rise in refrigerated milk and mixed milk under various conditions.

(2) The results as set out in the foregoing tables show that the amount of cream obtained from milk which has been refrigerated is generally less than when the milk is set warm.

(3) When, however, the refrigerated milk after standing a number of hours (such as evening milk which has stood overnight), is warmed up again to a temperature near that at which new milk is found when brought to the dairy, the amount of cream obtained from it may then even exceed what is obtained from new milk set immediately after leaving the cows. The same applies to mixed milk.

TABLE XX.—FIRST SERIES OF CREAM-RAISING TESTS.

Date.	No. of jar.	State of milk when set (all within half-an-hour of milking!).	Temperature. ° Fahr.	Hours left standing.	Percentage of cream.	If mixed again or not.	Hours left standing after mixing.	Percentage of cream second time.
1904.								
Jan. 11	1	Cooled	60	12	21·5	No.	—	—
	2	Warm	85	12	21	No.	—	—
	3	Cooled to 60° and warmed to ...	78	12	20	No.	—	—
„ 12	1	Warm	86	12	18·5	Yes.	11	15·5
	2	Cooled	58	12	18	Yes.	11	15
	3	Cooled to 58° and warmed to ...	88	12	13	Yes.	11	12·5
„ 13	1	Warm	84	14	18	No.	—	—
	2	Cooled	58	14	17·5	No.	—	—
	3	Cooled to 58° and warmed to ..	86	14	17	No.	—	—
„ 14	1	Warm	83	11	17	No.	—	—
	2	Cooled	57	11	16	No.	—	—
	3	Cooled to 57° and warmed to ...	86	11	16·5	No.	—	—

TABLE XXI.—SECOND SERIES OF CREAM-RAISING TESTS.

Date.	No. of jar.	Description of milk and state when set.	Temperature. ° Fabr.	Hours standing.	Percentage of cream.
1905.					
Jan. 25	1	Straight from the cow	87	12	16.5
	2	Cooled	48	12	15.5
	3	Cooled to 48° and warmed again to...	84	12	18
April 19	1	Straight from the cow	85	12	15
	2	Cooled	44	12	12
	3	Cooled to 43° and warmed again to...	86	12	17
	1a	Morning milk, warm	92	24	10.5
	2a	Evening milk, cooled, mixed with warm morning milk	68	24	11
	3a	Evening milk warmed from 68° to ...	92	24	14.5
April 26	1	Morning milk, warm	93	12½	11.5
	2	Warm morning milk at 95° mixed with cooled evening milk at 44° ...	65	12½	11.25
	3	Warm morning milk warmed from 65° to	92	12½	14
	1a	Warm evening milk	90	12	16.5
	2a	Evening milk cooled	47	12	14
	3a	Cooled to 48° and warmed again to...	94	12	18
	1	Cooled evening milk mixed after standing 12 hours	47	12	11.5
	2	Warm morning milk	84	12	10
	3	Nos. 1 and 2 mixed	63	12	15
	1a	Warm evening milk	93	12	15
	2a	No. 1a cooled to	49	12	14
	3a	No. 1a cooled to 49° and warmed again to	92	12	17
	1	Warm evening milk	91	12	13
	2	No. 1 cooled	50	12	12.5
	3	No. 1 cooled to 50° and warmed again to	94	12	14
	1a	Warm morning milk	91	12	10
	2a	No. 1a cooled to 50° mixed with cooled evening milk	49	12	11
	3a	Warm morning milk mixed with cooled evening milk which had stood 12 hours	63	12	10

OFFERTON BULLETIN No. 2.

Experiments on the Feeding of Dairy Cows.

Second Report, published January, 1907.

By C. BRYNER JONES.

THE FEEDING OF CONCENTRATED FOOD ON PASTURE.

Object.—The object of the present experiments was to determine the effect of a supply of concentrated food upon the quantity and quality of milk during the summer months when cows are on pasture. The results of feeding experiments previously carried out at Offerton indicated clearly that to increase the actual weight of food given to cows, provided they already receive a sufficient allowance to maintain their condition, does not result, except temporarily, in a corresponding improvement in the yield and quality of the milk. This point having been demonstrated with cows fed indoors during the winter, it might be inquired to what extent it is advantageous to use additional food on grass during the summer.

Sampling and testing.—In the preliminary trials, the cows were tested individually at weekly intervals. In all the experiments, as on previous occasions, the mixed milk of each lot of cows was sampled daily, morning, noon, and evening. The total milk of each lot was weighed at each milking, and the quantity recorded. The butter-fat in each sample was estimated by means of a Gerber acid-butyrometer, and the “solids not fat” calculated from the usual data.

EXPERIMENT G.

This experiment was commenced on June 19, 1905, and continued till September 12, a period of twelve weeks.

Preliminary trials.—These extended over one month. The cows were dairy shorthorns of the usual type in the north of England, all having calved from September to November, 1904. Each cow was tested for yield of milk and percentage of butter-fat once a week. At the end of the period, the ten most "regular" cows were selected, and divided into two lots of five each, as far as possible according to the yield and quality of their milk. When the experiment was commenced, the two lots stood as follows:—

			Average yield of milk per cow per day.	Per cent. of butter-fat.	Average live-weight.
Lot I.	...	...	34.0 pints	3.40	1,134 lb.
Lot II.	...	...	33.4 pints	3.38	1,103 lb.

All the cows were milked at 5 a.m., 12.30 p.m., and 6 p.m.

Rations.—With a view to showing the general effect on the milk of concentrated food when consumed on grass, as well as that of different quantities of the same food, the term of the experiment was divided into two equal periods of six weeks. As no satisfactory estimate could be made as to the quantity of grass consumed by the cows, no attempt was made to adopt any theoretical basis in fixing the rations supplied to the lot receiving concentrated food. The two lots were fed as follows:—

LOT I.	LOT II.
FIRST PERIOD.—	
2 lb maize meal.	Grass only.
2 lb. Bombay cotton Cake.	
2½ lb. straw chaff.	
Grass.	
SECOND PERIOD.—	
4 lb. maize meal.	Grass only.
4 lb. Bombay cotton cake.	
3 lb. straw chaff.	
Grass.	

Lot II. thus received no concentrated food throughout the experiment, while lot I. received what was regarded as a moderate allowance of cake and meal during the first period, and double this amount for the second period. The cows grazed with the rest of the herd, and the pasture may be described as of average quality.

The concentrated food and chaff supplied to lot I. were made into "crowdy" and fed to the cows in this form twice a day, before the noon and evening milkings. The cows had access to water at all times, being out night and day except at milking time.

Results.—The yield of milk, the percentage of butter-fat and "solids not fat" are dealt with separately, but the results of both periods are given together throughout, instead of in separate tables. Average quantities are given in all

TABLE XXII.—AVERAGE QUANTITY OF MILK IN PINTS PER LOT PER DAY FOR 12 WEEKS.

Week ending:—		Lot I.				Lot II			
		Morn.	Noon.	Even.	Total.	Morn.	Noon.	Even.	Total.
June	27 ...	68	47	35	150	65·5	46	36·5	148
July	4 ...	61	42	32·5	135·5	61·5	41	34·5	137
"	11 ...	57	40·5	33·5	131	56·5	40	32	128·5
"	18 ...	54·5	38	31	123·5	52·5	38	30·5	121
"	25 ...	53	36	29	118	54·5	36·5	30	121
Aug.	1 ...	50	35	27	112	51·5	36	29	116·5
"	8 ...	48	34	27	109	50	35	28·5	113·5
"	15 ...	51	33·5	29	113·5	50·5	35	28·5	114
"	22 ...	52	34	28	114	49	32·5	27·5	109
"	29 ...	51	35	27	113	49	32·5	26	107·5
Sept.	5 ...	52·5	35	27	114·5	48·5	31·5	25·5	105·5
"	12 ...	52·5	34	27	113·5	48·5	32	25	105·5
Average for 1st period ...		57·2	39·7	31·3	128·3	57·0	39·6	32·1	128·7
Average for 2nd period ...		51·16	34·25	27·5	112·91	49·25	33·1	26·83	109·17
Average for 12 weeks ...		54·18	36·97	29·4	120·6	53·12	36·35	29·46	118·93

cases in the tables, but the highest and lowest amounts are also stated when dealing with the butter-fat and "solids not fat." The figures are so arranged as to show the fluctuations which occurred from week to week throughout the two periods. Table XXII. shows the quantity of milk given per day by each lot for twelve weeks.

It will be remembered that at the end of the preliminary trials, the two lots of cows were very nearly on a level, there being a slight advantage in favour of lot II., and also that during the experiment lot I. received cake and meal, while lot II. received nothing in addition to grass. Bearing this in mind, the similarity between the two lots in the above table is particularly striking. During the first six weeks, there was practically no difference between lot I. and lot II., and even in the second period, when lot I. was receiving double the quantity of cake and meal that it received in the first period, the difference is by no means great, and is confined to the last three weeks. When the whole period of twelve weeks is taken into account the difference, on the average, between the total yield per lot per day is slightly over $1\frac{1}{2}$ pints only in favour of lot I. Taking the experiment as a whole, it would appear that when cows are on grass in the summer, if the pasture is of average quality, there is very little to be gained, as far as the milk yield is concerned, from giving them any extra concentrated food at all, except perhaps a small quantity towards the end of summer when the grass is becoming stale and the nights are getting cold.

As to the effect of increasing the allowance of cake and meal in the case of lot I., it will be seen that the results hardly justified the change. It is true that the yield from week to week was more regular in lot I. than in lot II. after the increase in the food had been made. But this, after all, has nothing to do with the point at issue. The average yield of lot I. during the first six weeks, on 4 lb. per day of concentrated food, was slightly over 128 pints per day, and during

the second six weeks, on double the quantity of concentrated food, it was about 113 pints, a drop of about 15 pints per day. The drop in lot II. for the same two periods was only about $4\frac{1}{2}$ pints more, although this lot received no extra food whatever. It is obvious that the increase in the cake and meal given to lot I. did not prevent the average yield going down during the second, as compared with the first, six weeks, and

TABLE XXIII.—AVERAGE PERCENTAGE OF BUTTER-FAT IN MILK FOR 12 WEEKS.

Week ending:—			Lot I.			Lot II.		
			Morning.	Noon.	Evening.	Morning.	Noon.	Evening.
June	27	...	3·2	4·0	3·7	3·1	4·0	3·5
July	4	...	3·3	3·8	3·7	3·3	4·1	3·5
„	11	...	3·2	3·9	3·9	3·4	4·1	3·8
„	18	...	3·4	3·8	3·7	3·4	4·1	3·5
„	25	...	3·3	3·7	3·5	3·3	3·9	3·6
August	1	...	3·1	3·5	3·8	3·3	3·8	3·6
„	8	...	3·3	3·5	3·5	3·3	3·9	3·5
„	15	...	3·2	3·3	3·7	3·2	3·9	3·7
„	22	...	3·3	3·6	3·9	3·2	3·9	3·9
„	29	...	3·2	3·8	4·0	3·3	4·1	3·9
September	5	...	3·1	4·0	4·0	3·2	4·0	3·8
„	12	...	3·1	4·0	4·0	3·0	4·0	3·8
Average for 1st period			3·25	3·78	3·71	3·3	4·00	3·58
Average for 2nd period			3·20	3·70	3·86	3·2	3·96	3·76
Average for 12 weeks			3·22	3·74	3·78	3·25	3·98	3·67
Times milkings were under standard*...			6	—	—	3	—	—
Highest	...	...	3·8	4·5	4·4	3·7	4·5	4·2
Lowest	...	...	2·8	3·0	3·1	2·8	3·6	3·3

Average percentage in total daily yield, 1st period	...	Lot I.	3·52	Lot II.	3·58
„	„	2nd period	...	3·51	3·56

* Out of a possible of 84.

the cows would probably have done just as well without it. Allowance must be made, of course, for the advance in the lactation period, which affected both lots alike. The effect generally of increasing the food is what might have been anticipated in the light of previous experiments. (See Offerton Bulletin I., Experiments B, C, and D).

Quality of the milk.—The inference to be drawn from the figures already given is that, as far as the milk yield is concerned, there was very little advantage from using concentrated food at all. Table XXIII. shows the average percentage of butter-fat in the milk of the two lots of cows under notice, and table XXIV. the average percentage of “solids not fat” during the twelve weeks over which the experiment extended.

It will at once be seen that the results from the two lots are again strikingly similar. As far as the butter-fat in the milk is concerned, there was no advantage whatever from giving the cows the extra food, the results, indeed, being slightly in favour of lot II. which received nothing but grass. It is interesting to observe that there were occasions when both lots were under the standard in the morning, and the advocates of heavy feeding will note that lot I. was in this respect the worse of the two.

TABLE XXIV.—AVERAGE PERCENTAGE OF SOLIDS NOT FAT IN MILK FOR 12 WEEKS.

Week ending :—	Lot I.			Lot II.		
	Morning.	Noon.	Evening.	Morning.	Noon.	Evening.
June 27 ...	8·6	8·7	8·7	8·7	8·8	8·5
July 4 ...	8·8	8·6	8·6	8·7	8·5	8·6
„ 11 ...	8·6	8·5	8·5	8·6	8·6	8·6
„ 18 ...	8·4	8·5	8·4	8·5	8·4	8·5
„ 25 ...	8·4	8·6	8·4	8·4	8·5	8·3
August 1 ...	8·6	8·4	8·5	8·5	8·3	8·5
„ 8 ...	8·3	8·3	8·4	8·6	8·3	8·5
„ 15 ...	8·6	8·4	8·5	8·6	8·4	8·4
„ 22 ...	8·6	8·5	8·7	8·6	8·5	8·5
„ 29 ...	8·4	8·5	8·6	8·4	8·6	8·6
September 5 ...	8·6	8·6	8·6	8·6	8·5	8·5
„ 12 ...	8·6	8·7	8·5	8·6	8·5	8·6
Average for 1st period	8·56	8·55	8·51	8·56	8·51	8·50
Average for 2nd period	8·51	8·50	8·55	8·56	8·46	8·55
Average for 12 weeks	8·53	8·52	8·53	8·56	8·48	8·52
Times milkings were under standard*...	18	31	28	24	28	20
Highest ...	9·1	9·2	9·0	9·2	9·1	8·9
Lowest ...	8·1	7·9	7·9	7·9	8·0	8·0

* Out of a possible of 84.

The "solids not fat" were on the average throughout the experiment somewhat low, and the number of times during the twelve weeks the milk was under the standard of 8·5 per cent. is truly remarkable. In the case of lot I., for example, taking individual milkings and not weekly averages, the milk was, as shown in the table, under the standard on 77 occasions out of 252, which is equal to 30 per cent. It should be observed that this was the lot which received the extra food. Lot II. was slightly better. As a general rule in all previous experiments, the "solids not fat" have been well above the standard on the weekly averages, while in the present case they were frequently below.

Live-weight of the cows.—The cows were weighed at the commencement of the experiment, and at the end of each period of six weeks.

TABLE XXV.—AVERAGE LIVE-WEIGHT (IN LB.) PER COW OF EACH LOT.

Commencement.				August 1.				September 13.				Gain or Loss over whole period.
Lot	I.	...		...				...				
Lot I.	...	1,134	...	1,141	...	1,162	...	...	...	...	...	+ 28
Lot II.	...	1,103	...	1,092	...	1,092	...	...	...	...	...	- 11

The concentrated food caused only a small increase in the average live-weight of the cows in lot I., the increase being greatest in the second period, when the double quantity of cake and meal was supplied. The comparatively small loss in the case of lot II. took place during the first half of the experiment. During the second half, three out of the five cows actually gained weight, and the loss in the average weight is entirely due to one cow, No. 93. Similarly, the gain in the average weight in lot I. is also due to one cow, No. 91. If these two cows were left out of the calculation, there would have been very little difference in the average live-weight of the two lots at the end. But, even taking the figures as they appear in the table, there is not much to be said in favour of the concentrated food, for a gain of 28 lb. live-weight per

cow in twelve weeks for the consumption of an average of 6 lb. of cake and meal per day for the same period, is, in the absence of a great difference in the milk yield, scarcely a profitable increase.

EXPERIMENT H.

The results described in the preceding pages were of so interesting a character, and so different from what is alleged to be the experience of practical men, that it was decided to repeat the experiment during the summer of 1906. Accordingly, after a series of preliminary trials had been carried out in the usual manner, a set of cows was selected for the purpose, eight out of the ten being entirely fresh. The two cows which were in the previous year's experiment, Nos. 96 and 98, were not placed in the same lot as in 1905. The cows which had all calved before Christmas, were again divided into two lots according to the quantity and quality of their milk. At the end of the preliminary trials, the two lots were practically on a level in this respect, as will be seen from the following figures:—

		Average yield of milk per cow per day.		Per cent. of butter-fat.		Average live-weight.
Lot I.	...	30·2 pints	...	3·48	...	1,086 lb.
Lot II.	...	30·2 pints	...	3·46	...	1,122 lb.

Owing to unavoidable causes, the experiment was not commenced for nearly a fortnight after the preliminary trials came to an end. It was continued for a period of ten weeks, viz., from June 18 to August 27, 1905.

Rations.—The experiment, as regards the feeding, was conducted on exactly the same lines as in the previous season. The period of the experiment was a fortnight shorter this time, otherwise there was no difference as compared with 1905. The ten weeks were divided into two equal periods of five weeks each, during the first of which lot I. received per cow per day, 2 lb. Bombay cotton cake, 2 lb. maize meal, and

2½ lb. straw chaff, the cake and meal being doubled, and the straw chaff increased to 3 lb., for the second period. Lot II. received nothing but grass throughout. The concentrated food and straw chaff supplied to lot I. were made into "crowdy" and served twice a day as before. The cows were grazed with the rest of the herd on the same pasture as that used the previous year.

Results.—Table XXVI. shows the quantity of milk given by the two lots during the whole period of the experiment.

TABLE XXVI.—AVERAGE QUANTITY OF MILK IN PINTS PER LOT PER DAY FOR 10 WEEKS.

Week ending :—			Lot I.				Lot II.			
			Morn.	Noon.	Even.	Total.	Morn.	Noon.	Even.	Total.
June	25	...	64·5	44	36·5	145	67	42·5	39	148·5
July	2	...	64·5	44	35	143·5	65	42	37	144
"	9	...	63	43	33·5	139·5	64	42	35·5	141·5
"	16	...	57	40·5	33·5	131	58·5	40·5	33·5	132·5
"	23	...	57	36	30	123	57·5	36·5	31·5	125·5
"	30	...	55	36	30	121	52·5	33·5	30	116
August	6	...	52	32	26·5	110·5	50	33	27·5	110·5
"	13	...	54	34·5	27·5	116	51	32	26	109
"	20	...	53	33	27	113	48·5	31	25	104·5
"	27	...	45·5	30	26	101·5	49	29	25·5	103·5
Average for 1st period			61·2	41·5	33·7	136·4	62·4	40·7	35·3	138·4
Average for 2nd period			51·9	33·1	27·4	112·4	50·2	31·7	26·8	108·7
Average for 10 weeks			56·55	37·3	30·55	124·4	56·3	36·2	31·05	123·55

These figures are just as remarkable as they were the previous summer, and the results as a whole afford a striking confirmation of those already obtained. The cows in Experiment H gave more milk, on the average, than those in Experiment G, but the relation between the two lots, when the full period is taken into account, was practically the same as in 1905. In the present experiment the two lots were exactly

on a level at the end of the preliminary trials, as far as the milk-yield was concerned, but at the end of the first five weeks, there was actually an advantage in favour of lot II. of 2 pints per day, although it was the other lot which received the cake and meal. The results during the second period of Experiment H are almost identical with those of the second period of Experiment G the previous summer, there being in both experiments a drop in the average in the second period as compared with the first, and a greater drop in 1906 than in 1905. Lot II. also in Experiment H dropped more, relatively to lot I., during the second period than was the case in Experiment G. Taking the whole period of ten weeks, lot I. gave, on the average, less than 1 pint per day more milk than lot II., in spite of the daily allowance of cake and meal supplied to it throughout the experiment. When the second period alone is considered, the yield in lot I. appears to have been kept up, until the last week, better than in lot II., but considering the dryness of the summer, it is somewhat surprising that the difference between the two lots was not much greater during August than it was. The difference shown in the table is certainly not enough to make the use of the concentrated food profitable, and especially when it is remembered that during the second period lot I. was receiving double the quantity of cake and meal it received in the first period. Taking the two experiments together, the results indicate clearly that the advantage accruing from using concentrated food of this description on grass of average quality during the summer months is, on the whole, surprisingly small. When the pasture becomes dry and the keep short, a small quantity may, perhaps, be used, but if the cows are far advanced in the lactation period, even this is not to be greatly recommended.

The increasing of the quantity of concentrated food in lot I. during the second period was attended with much the same result in both experiments. In neither case did it increase the milk yield, nor is it at all clear that it even prevented the falling off in the yield.

On the financial aspect of the question, the two experiments are in striking agreement as they are on other points. The milk of lot I. over the whole period in each experiment was produced at practically double the cost of that of lot II., the selling price of the milk being the same, of course, in both cases. With the slight difference in the yield of the two lots, a very simple calculation will show the reader how unprofitable lot I., in each experiment, has been when compared with lot II.

A criticism which may occur is that some other kind of concentrated food might have given different results. It does not follow, of course, that the results would be the same from all foods, but the food used in these experiments was of a kind which is usually employed in practice during the summer, and there is no reason to believe that, if any other food had been used which was similar in composition to the mixture employed here, the results would have varied very much.

Quality of the milk.—The effect of the two systems of feeding on the butter-fat in Experiment H is shown in Table XXVII.

There was great similarity in the results from the two lots of cows here as in Experiment G. The milk was somewhat poorer in butter-fat than was the case in the previous summer but the results are in effect practically the same, as far as the relation between the two lots is concerned. In Experiment G, the two lots were very close, what difference there was being in favour of lot II. The difference between the two lots is greater in Experiment H, but is again in favour of lot II. It is clear that the concentrated food given to lot I. produced no advantage as regards the butter-fat. This may safely be inferred, but the evidence is perhaps not sufficiently strong to warrant the conclusion that it actually caused a reduction in the butter-fat. The milk of lot I. was slightly richer in the second period of Experiment H than in the first, but so it was also in the case of lot II. The improvement

TABLE XXVII.—AVERAGE PERCENTAGE OF BUTTER-FAT IN MILK FOR 10 WEEKS.

Week ending:—			Lot I.			Lot II.		
			Morning.	Noon.	Evening.	Morning.	Noon.	Evening.
June	25	...	3·0	3·9	4·0	3·0	3·8	3·9
July	2	...	2·8	3·6	3·6	3·0	3·8	3·7
"	9	...	3·0	3·7	3·7	3·1	3·8	3·7
"	16	...	3·1	3·5	3·8	3·1	3·5	3·8
"	23	...	3·1	3·5	3·6	3·1	3·6	3·8
"	30	...	3·1	3·4	3·9	3·1	3·7	3·9
August	6	...	3·0	3·7	3·9	3·1	4·0	4·0
"	13	...	3·1	3·6	3·7	3·1	4·1	3·8
"	20	...	3·1	3·6	3·7	3·1	3·9	3·6
"	27	...	3·1	3·6	3·7	3·1	3·9	3·9
Average for 1st period			3·0	3·64	3·74	3·06	3·70	3·78
Average for 2nd period			3·8	3·58	3·78	3·10	3·92	3·84
Average for 10 weeks			3·04	3·61	3·76	3·08	3·81	3·81
Times milkings were under standard*...			21	—	—	13	—	—
Highest	...	...	3·4	4·2	4·2	3·4	4·4	4·4
Lowest	...	...	2·6	3·0	3·3	2·7	3·4	3·2

			Lot I.	Lot II.
Average percentage in total daily yield, 1st period	...		3·37	3·43
"	"	2nd period	3·39	3·52

* Out of a possible of 70.

must not, therefore, be attributed to the increased allowance of concentrated food given to this lot in the second period. It was probably due to the advance in the lactation period. A somewhat curious point will be observed in this connection in the present experiment. Lot I. gave, on the average, during the whole period of the experiment, considerably poorer milk than in the preliminary trials, if we look at the percentage of fat in the total daily yield of milk. This is rather difficult to explain. Lot II. also fell slightly below the preliminary trials in the first half of the experiment, but not so much as did lot I., whilst in the second half, the butter-fat in this lot was higher than in the preliminary trials, which might have been expected. But these details apart, the

results of Experiment H agree on the main point at issue with those of Experiment G. The reader will note the number of times the milk was under the standard in the morning, and it is an interesting fact that lot I., as in Experiment G, was again the worse.

Although on the general average the "solids not fat" were satisfactory, they were on occasions very low, and in a considerable number of cases in both lots, well below the standard of 8.5 per cent. In comparing the two lots, it will be observed that lot II. was throughout, on the average, superior to lot I. Both experiments clearly show that the quality of the milk was in no way improved by the use of the concentrated food.

TABLE XXVIII.—AVERAGE PERCENTAGE OF SOLIDS NOT FAT IN MILK.

Period (5 weeks) ending:—	Lot I.			Lot II.		
	Morning.	Noon.	Evening.	Morning.	Noon.	Evening.
July 23 ...	8.74	8.66	8.74	8.78	8.76	8.88
August 27 ...	8.70	8.66	8.72	8.80	8.74	8.78
Average for 10 weeks	8.72	8.66	8.73	8.79	8.75	8.83
Times milkings were under standard*	8	8	4	7	6	1
Highest ...	9.4	9.1	9.1	9.3	9.2	9.2
Lowest ...	8.2	8.3	8.2	7.9	8.3	8.4

* Out of a possible of 70.

The live-weight of the cows.—As in the preceding experiment, the cows were weighed at the commencement and at the end of each period of five weeks. The average weight of the cows is shown in Table XXIX.

TABLE XXIX.—AVERAGE LIVE-WEIGHT (IN LB.) PER COW OF EACH LOT.

	Commence- ment.	July 23.	August 27.	Loss over whole period.
Lot I. ...	1,086	1,069	1,012	74
Lot II. ...	1,122	1,117	1,103	19

It is somewhat curious to find that both lots lost weight during the experiment, and very difficult, at first sight, to understand why the cows in lot I. especially should have lost so much. The loss here was due very largely to two cows, Nos. 98 and 115, which decreased in weight during the second five weeks, 63 lb. and 105 lb. respectively. There does not appear to have been any special cause for this loss of weight. None of the cows in this lot gained at all in weight during the period of the experiment. In lot II. the loss in live-weight is very much less than in lot I. One cow in this lot, No. 114, actually gained 56 lb. during the experiment, while two other cows, Nos. 79 and 112, gained a stone each in the first five weeks, which they more than lost again during the second five weeks. It is obvious from these results that concentrated food which is not paid for in the milk yield, is not always recovered in the form of live-weight in the case of dairy cows on grass. In neither of the two experiments here described did the cake and meal produce, on the average, any appreciable benefit whether as regards the yield and quality of the milk, or the live-weight of the cows. Profit was, in both cases, out of the question. Indeed, there was a serious loss, financially, which was even greater in Experiment H than in Experiment G.

EXPERIMENT G (1905).

SET OF 10 COWS ON PASTURE IN TWO LOTS OF 5.

PRELIMINARY TRIALS.

Experimental Results.						Average live-weight
		Milk per cow per day.	% Fat.			per cow.
Lot I. ...	...	34 pints	...	3.40	...	1,134 lb.
Lot II. ...	...	33.4 pints	...	3.38	...	1,103 lb.

Results for first 6 weeks, June 21—August 1.

	Amount of concentrated food per cow per day.	Average milk per cow per day.	% Fat.	% S.N.F.	Gain (+) or loss (-) in average live-weight per cow.
Lot I...	4 lb.	25.66 pints	3.52	8.54	+ 7 lb.
Lot II.	—	25.74 pints	3.58	8.52	- 11 lb.

Second 6 weeks, August 2—September 12.

Lot I...	8 lb.	22·58 pints	3·51	8·52	+ 21 lb.
Lot II.	—	21·83 pints	3·56	8·52	—

EXPERIMENT H (1906).

ANOTHER SET OF 10 COWS ON PASTURE IN TWO LOTS OF 5.
PRELIMINARY TRIALS.

		Milk per cow per day.		% fat		Average live-weight per cow.
Lot I. ...	...	30·2 pints	...	3·48	...	1,086 lb.
Lot II. ...	...	30·2 pints	...	3·46	...	1,122 lb.

Results for first 5 weeks, June 19—July 23.

	Amount of concentrated food per cow per day.	Average milk per cow per day.	% fat.	% S.N.F.	Gain (+) or loss (-) in average live-weight per cow.
Lot I...	4 lb.	27·3 pints	3·37	8·71	- 17 lb.
Lot II.	—	27·7 pints	3·43	8·81	- 5 lb.

Second 5 weeks, July 24—August 27.

Lot I....	8 lb.	22·5 pints	3·39	8·69	- 57 lb.
Lot II.	—	21·7 pints	3·52	8·77	- 14 lb.

Summary and general conclusions.—For the convenience of the reader the results of the two experiments are here summarized, the chief data only being given.

The two experiments described had for their special object to determine the effect of concentrated food upon the quantity and quality of milk when cows are on pasture during the summer. The first experiment was carried out in the summer of 1905, and extended over twelve weeks. The second experiment was conducted during the summer of 1906, and continued for ten weeks. There was two lots of 5 cows in each experiment, one lot receiving nothing but grass throughout, and the other lot 4 lb. per cow per day concentrated food in

addition to grass during the first half of each experiment, and 8 lb. of the same food during the second half. From the results obtained, which have already been described in detail, the following general conclusions may be drawn :—

(1) The advantage of giving dairy cows which are out on grass during the summer months a supplementary ration of from 4 to 8 lb. of concentrated food, consisting of Bombay cake and maize meal, is exceedingly small as regards the yield of milk, provided the pasture is of average quality. (Tables XXII. and XXVI.)

(2) Any small benefit derived from concentrated food so employed is observable only towards the end of the season, when the pasture is beginning to become stale, and the nights cold. (Tables XXII. and XXVI.)

(3) Having regard to actual profit, it is doubtful whether any concentrated food of this description should be used at all on grass during the summer, provided always that the pasture is of average quality, the season normal, and the cows in a healthy and thriving condition. It is certain that these experiments conclusively show that the cost of the concentrated food, when used at the rate of from 4 to 8 lb. per cow per day, is out of all proportion to the value of the increase in the milk yield, which occurred only towards the end of the season.

(4) The cows receiving nothing but grass gave, relatively, a much more profitable return than those which were supplied with concentrated food, the milk costing nearly double to produce in the latter case what it did in the former.

(5) To increase the concentrated food as the season advances is not to be recommended, for it does not, except temporarily, cause an increase in the milk or even check the fall in the yield, which always takes place as the lactation period advances, while owing to the extra cost of the food, the profit is relatively reduced.

(6) As regards the quality of the milk, there does not seem to be any advantage whatever, on the average, from using concentrated food on pasture of the description employed in these experiments. (Tables XXIII., XXIV., XXVII., and XXVIII.) The quality of milk is mainly dependent upon the character of the cows, and, provided the animals receive adequate nourishment, no increase in the ration is likely to affect the quality to any appreciable extent. (See also Offerton Bulletin I.)

(7) It is not to be assumed that concentrated food given to cows on grass necessarily causes an increase in the live-weight of the cows, and that what is not recovered in the milk is always, even partially, recovered in this form, as is undoubtedly the case when cows are indoors. Cows receiving concentrated food under these conditions may, on occasions, actually lose more weight than those which receive none. (Tables XXV. and XXIX.)

(8) On the principal point under discussion, viz., the effect of an extra allowance of food on the quantity and quality of milk generally, these experiments confirm those previously carried out at Offerton, and show that, on the average, whether cows are indoors or on pasture, provided the cows receive *enough food to keep them in a thriving condition*, there is no advantage, having regard to profit, in giving them more than this. Presumably, when cows are fed on fairly good grass in the summer, they do not require much additional artificial food, and when such is supplied, it is at a loss as far as the milk is concerned. Confirmation is also given to the conclusion previously formed that no addition to the food could prevent, except temporarily, the falling off in the milk yield as the lactation period advances, and there is nothing in these results which makes it necessary to modify the suggestion made in connection with the feeding experiments described in the Offerton Bulletin I., that, in general, the most economical method of feeding dairy cows would be to make the amount

of food supplied largely dependent upon the amount of milk produced, provided that the cows are at all times adequately fed.

THE EFFECT OF BREWERS' GRAINS ON MILK.

Object.—In a district where brewers' grains are largely used for the feeding of dairy cows, and where opinion largely differs as to their merits as a food and their specific effect upon the produce, an experiment dealing with this matter might reasonably be expected to yield interesting results. Such an experiment was conducted at Offerton during the winter of 1905-6, the special object in view being to discover the effect on the quantity and quality of the milk of a ration containing a certain amount of brewers' grains as compared with a ration which contained none, and thus to determine the general effects of brewers' grains when used under ordinary circumstances.

EXPERIMENT I.

Preliminary trials.—A number of cows were tested in the usual manner, ten cows being finally selected for the purpose of the experiment, and they were arranged in two lots of five according to the yield and quality of the milk. Unfortunately, owing to the scarcity of grains at the time, the experiment could not be commenced for some weeks after the preliminary trials were completed. The two lots of cows, however, were fed in the meantime exactly alike. The experiment commenced on December 16, 1905. The cows were milked three times a day as usual, and the milk was sampled and tested as in all the other experiments.

At the end of the preliminary trials, the two lots stood as follows:—

			Average yield of milk per cow per day.		Per cent. of butter-fat.		Average live-weight.
Lot I.	...	...	28·36 pints	...	3·57	...	1,156 lb.
Lot II.	...	...	28·08 pints	...	3·55	...	1,132 lb.

Rations.—The same plan was followed in the general arrangement of the experiment as in previous experiments, viz., the cows were fed on certain rations for a period, after which the rations were reversed, and the experiment continued for a similar period under the altered conditions. In the present case, the rations used were as follow per 1,000 lb. live-weight:—

Lot I.	Lot II.
4 lb. maize meal.	4 lb. maize meal.
2 „ Bombay cotton cake.	2 „ Bombay cotton cake.
3 „ chopped straw.	3 „ chopped straw.
12 „ hay.	12 „ hay.
60 „ swedes.	20 „ brewers' grains.
	20 „ swedes.

The cows were fed as above for eight weeks. There was practically the same amount of organic matter in each ration, but that given to lot II. was more nitrogenous than the other. The difference, however, was not great, and it probably varied a little from time to time, owing to the variation in the composition of the brewers' grains.

As before, the cake and meal and chopped straw were made into "crowdy" before being served to the cows, and water was supplied *ad lib.*

Results.—As usual, the yield of milk, the percentage of fat, and of "solids not fat," are tabulated separately, the figures given in the tables being the weekly averages. Table XXX. shows the quantity of milk produced by the two lots in Experiment I.

The results as regards the yield were clearly in favour of the brewers' grains throughout, lot II. giving, on the average, nearly 14 pints more milk per day than lot I. The difference in the relative yield of the two lots was more marked towards the end of the experiment than it was in the beginning, lot II. keeping up its yield much better than lot I. It will be seen on comparing the results with the preliminary trials that both lots had gone off their milk by the beginning of the

TABLE XXX.—AVERAGE QUANTITY OF MILK IN PINTS PER LOT PER DAY FOR 8 WEEKS.

Week ending :—			Lot I.				Lot II.			
			Morn.	Noon.	Even.	Total.	Morn.	Noon.	Even.	Total.
Dec.	22	...	52·5	33	28	113·5	54	35 5	29·5	119
„	29	...	56	36·5	27	119·5	60	37	30	127
Jan.	5	...	55	34	26	115	62	36·5	30	128·5
„	12	...	55	32	25	112	61	36	31·5	128·5
„	19	...	53·5	32·5	24·5	110·5	60·5	37	31	128·5
„	26	...	53	32·5	25·5	111	59	36	31	126
Feb.	2	...	53	33	25·5	111·5	59·5	38	31	128·5
„	9	...	52·5	32·5	24·5	109·5	59	38	30·5	127·5
Average per lot per day...			53·81	33·25	25·75	112·81	59·37	36·75	30·56	126·68

experiment, which was to be expected. It is interesting, however, to observe that at the end of the experiment, taking the average yield per cow, those in lot I. had dropped $5\frac{3}{4}$ pints per head per day, while the cows in lot II. had only dropped $2\frac{3}{4}$ pints per head per day compared with their respective yields at the end of the preliminary trials. At the end of the experiment, the average daily yield of lot I. was 4 pints less than it was at the beginning. On the other hand, the daily yield of lot II. was $8\frac{1}{2}$ pints higher at the end than at the beginning of the experiment. There were some fluctuations in both lots, but lot II. not only gave more milk than lot I., but decreased in its milk yield much less rapidly with the advance in the lactation period also than did lot I. In every way, as regards the quantity of milk, lot II. was superior to lot I., thus showing in a striking degree the effect of the brewers' grains in increasing the yield.

Quality of the milk.—The average percentage of butter-fat in the milk of each lot is shown in Table XXXI.

The results here are very interesting, especially from the milk-seller's point of view. Taking the percentage of fat in the total daily yield of each lot, there was an advantage of

TABLE XXXI.—AVERAGE PERCENTAGES OF BUTTER-FAT IN MILK FOR EACH OF 8 WEEKS.

Week ending:—	Lot I.			Lot II.		
	Morning.	Noon.	Evening.	Morning.	Noon.	Evening.
December 22 ...	3·2	3·6	3·9	2·7	3·8	3·7
„ 29 ...	3·0	3·7	3·6	2·5	3·8	3·4
January 5 ...	3·0	3·8	3·8	2·5	3·7	3·5
„ 12 ...	3·1	3·6	3·6	2·5	3·4	3·4
„ 19 ...	3·0	3·7	3·7	2·6	3·5	3·4
„ 26 ...	3·2	3·8	3·8	2·6	3·5	3·6
February 2 ...	3·1	3·6	3·8	2·6	3·5	3·5
„ 9 ...	3·1	3·6	3·7	2·6	3·4	3·5
Average	3·10	3·67	3·73	2·57	3·57	3·50
Times milkings were under standard*...	9	—	—	56	—	—
Highest	3·4	4·1	4·1	2·9	4·0	3·9
Lowest	2·9	3·3	3·4	2·3	3·3	3·2

Out of a possible of 56.

	Lot I.	Lot II.
Average percentage in total daily yield ...	3·41	3·08
Total butter-fat per day	4·96 lb.	5·03 lb.

·33 per cent. in favour of lot I. Lot II. was only slightly above the standard, viz., 3·08 per cent., which is very low for the whole day's milk. It is with the morning milk, however, that difficulties are usually experienced, and it is a remarkable fact that the morning milk of lot II. in the present experiment was *under the standard every day* for the eight weeks, while in the case of lot I., it was only nine times under the standard during the same period. The morning milk of lot I. remained practically the same in butter-fat as it was in the preliminary trials, while that of lot II. decreased, on the average, by ·35 per cent. The butter-fat in the total daily yield of lot I. decreased, on the average, during the experiment, by ·16 per cent. as compared with the preliminary trials. In lot II. the decrease was ·47 per cent. The milk of lot II. was poorer on the average throughout than that of lot I. This was not entirely due to the food, for it was slightly

poorer originally, and it is difficult to say to what extent the actual reduction in the quality of the milk is directly due to the brewers' grains, although it appears on the face of it obvious. The results of this experiment would seem to confirm the experience of dairymen, the majority of whom appear to have found in their own practice that the usual effect of brewers' grains is to increase the flow of milk, but at the same time to impair its quality. But the fact must not be overlooked that cows which are not fed on brewers' grains may give milk just as poor in butter-fat, at least in the morning, as lot II. did in the present experiment. Although the figures in the table may strike the reader as being unusually low, and consistently so throughout in the morning, he will find exactly the same thing in the Offerton Bulletin I., Experiment A, where the average morning fat for twelve weeks was precisely the same as it is for eight weeks in the present experiment, viz., 2·57 per cent., and where not only no brewers' grains were used, but the cows were given 12 lb. per head of cake and meal per day. The low morning fat in the present experiment is thus not unprecedented, and, therefore, although there are grounds for believing that the food had something to do with it, it would be hardly legitimate to hold the brewers' grains entirely responsible for what occurred without further evidence.

TABLE XXXII.—PERCENTAGES OF SOLIDS NOT FAT IN MILK
FOR 8 WEEKS.

	Lot I.			Lot II.		
	Morning.	Noon.	Evening.	Morning.	Noon.	Evening.
Average for 8 weeks	8·75	9·01	8·91	8·71	9·00	8·81
Times milkings were under standard* ...	—	—	—	2	—	—
Highest	9·1	9·3	9·3	9·2	9·3	9·1
Lowest	8·5	8·6	8·5	8·3	8·5	8·5

Average percentage in total daily yield :—Lot I., 8·86 ; Lot II., 8·81.

* Out of a possible of 56.

The "solids not fat" were all through well above the standard, and are given in Table XXXII.

It is important to observe that although the milk of lot II. was very poor in butter-fat, it was, on the whole, very satisfactory as regards the other solids, so that the food does not appear to have affected the quality of the milk in this respect to any appreciable extent. The morning milk of lot II. was twice under the standard; but this might easily have happened had the conditions been totally different.

The live-weight of the cows.—The cows were as usual weighed at the commencement and at the end of each month afterwards. The average live-weight for both lots is shown in Table XXXIII.

TABLE XXXIII.—AVERAGE LIVE-WEIGHT (IN LB.) PER COW
OF EACH LOT.

		Commence- ment.		January 12.		February 9.		Average loss during experiment.
Lot I.	...	1,156	...	1,104	...	1,114	...	42
Lot II.	...	1,132	...	1,094	...	1,111	...	21

The loss in live-weight took place, as will be seen, mostly during the first month, when all the ten cows, with the exception of No. 59 in lot I., lost weight. Two cows in lot I. lost 90 lb. and 92 lb., respectively, in the first month, and this accounts in a great measure for the average loss in this lot being so high. Lot II. gained a little more during the second month than did lot I.

EXPERIMENT J.

As soon as the experiment just described was completed, the rations were reversed, with the object of discovering whether the brewers' grains would have the same effect on the other lot of cows as they had on those to which they were given originally. There was no interval at all between the two experiments. The second experiment, here described as Experiment J, commenced on February 10, and continued till April 7, 1906. The results are given in the following tables. Table XXXIV. shows the yield of milk in each lot.

TABLE XXXIV.—AVERAGE QUANTITY OF MILK IN PINTS PER LOT PER DAY FOR 8 WEEKS.

Week ending:—	Lot I.				Lot II.			
	Morn.	Noon.	Even.	Total.	Morn.	Noon.	Even.	Total.
Feb. 16 ...	53	34	27·5	114·5	52·5	32·5	26·5	111·5
„ 23 ...	54	35	29	118	50	29·5	26	105·5
Mar. 3 ...	55·5	35	28	118·5	50	31	24	105
„ 10 ...	55·5	35	29·5	120	50·5	31	25	106·5
„ 17 ...	55·5	32·5	29	117	47·5	29	23·5	100
„ 24 ...	56	31·5	29	116·5	48	28·5	23	99·5
„ 31 ...	54	35	28	117	45·5	26·5	22	94
Apr. 7 ...	55·5	35·5	29·5	120·5	46	27·5	23·5	97
Average per lot per day	54·88	34·2	28·7	117·75	48·75	29·42	24·20	102·37

After reversing the rations, the greater yield is given by lot I., which, if the increased flow of milk in the previous experiment was due to the brewers' grains, is precisely what should have happened. There is not the same difference between the two lots on the average as there was in Experiment I., but making certain allowance for the advance in the lactation period, the effect of the brewers' grains on lot I. in the present experiment is almost as striking as it was on lot II. in the previous one. Taking the two experiments together, there can be no reasonable doubt as to the effect of brewers' grains in materially increasing the flow of milk, and that their effect continues over a considerable period of time. Previous experiments have shown that a change of food may, at any time, cause a temporary increase in the milk yield, but the increase is maintained in this case to the end of the experiment. The drop in the yield of lot II. after the change, when they no longer received any brewers' grains, was even more remarkable than the increase in the yield of lot I., after the change. In the first week of the experiment, there was a drop on the average of 16 pints per day in lot II., and the milk continued to decrease, although not regularly, till nearly the end of the experiment. In the last week of all there was an increase in the yield of both lots, which is impossible to explain.

It has been suggested that brewers' grains produce a specific physiological action, which may account for the increased milk yield consequent upon their use. It was beyond the scope of these experiments to enquire into this particular matter, but it is clear that brewers' grains have an effect on the milk which may not be produced by ordinary concentrated food such as cake and meal. This effect consists in not merely increasing the flow for the time being, but also in keeping up the increase and thus lengthening materially the lactation period. It will be seen that, so far, Experiment J confirms the results of Experiment I.

Quality of the milk.—The butter-fat in the milk of each lot is shown in Table XXXV.

It appeared from the previous experiment as if the brewers' grains had reduced the butter-fat considerably, but in the present case they do not seem to have had any appreciable effect in that direction, even in the morning milk. The per-

TABLE XXXV.—AVERAGE PERCENTAGE OF BUTTER-FAT IN MILK FOR 8 WEEKS

Week ending:—	Lot I.			Lot II.		
	Morning.	Noon.	Evening.	Morning.	Noon.	Evening.
February 16 ...	3·1	4·0	4·0	2·8	3·3	3·8
„ 23 ...	3·1	3·9	3·9	2·9	3·6	3·9
March 3 ...	3·1	3·8	4·0	2·9	3·7	3·9
„ 10 ...	3·0	3·8	4·0	2·8	3·7	4·0
„ 17 ...	3·1	3·7	4·0	2·9	3·7	4·1
„ 24 ...	3·0	3·9	3·9	2·9	3·6	3·8
„ 31 ...	3·2	3·8	4·0	3·0	3·7	3·9
April 7 ...	3·0	3·8	3·9	3·0	3·8	3·9
Average ...	3·07	3·83	3·96	2·90	3·63	3·91
Times milkings were under standard*...	10	—	—	35	—	—
Highest ...	3·4	4·2	4·3	3·1	4·3	4·4
Lowest ...	2·7	3·5	3·6	2·6	3·2	3·6

Average percentage in total daily yield ...	Lot I.	Lot II.
Total butter-fat per day	3·51	3·34
	5·33 lb.	4·41 lb.

* Out of a possible of 56.

centage of fat in the total daily yield of lot I., in spite of the brewers' grains, is materially higher in the present experiment than in the preceding one, a point which is worthy of note. Some allowance perhaps should be made for the advance in the lactation period. In any case, it is clear from the table above that brewers' grains do not always reduce appreciably the butter-fat in the milk, however obvious this may have seemed from Experiment I. In the experiment now under notice, the milk of lot I. on the brewers' grains ration was ten times under the standard in the morning. But in the previous experiment, when these cows received no brewers' grains, their morning milk was nine times under the standard, and the actual percentage of fat in the morning for this lot, on the average, is only '03 less in Experiment J than in Experiment I. These figures, therefore, do not furnish much evidence to show that brewers' grains materially reduce the quality of the milk. Moreover, if we take the record of lot II., the evidence is by no means conclusive on this point if we take the two experiments together. In Experiment I, lot II. was fifty-six times under the standard in the morning. But in Experiment J, when the cows no longer received any grains, their morning milk was again thirty-five times under the standard. The butter-fat in their morning milk was certainly '33 per cent. higher on the average in Experiment J than it was in the preceding experiment, when they received brewers' grains, but this no doubt is partly accounted for by the advance in the lactation period. It will be observed that lot II. gave poorer milk in the morning all through than did lot I., and it is perfectly obvious now that the low morning fat in lot II. in Experiment I was not altogether due to the brewers' grains. Taking all the facts into consideration, therefore, there is not, after all, clear and unmistakable evidence that brewers' grains have the effect of reducing the butter-fat in milk to any serious extent. It appears tolerably certain that any effect brewers' grains may have on the quality of the milk is very much less than what they have on the quantity.

The “solids not fat” were again satisfactory and much above the standard as a rule in both lots. A summary of the results is given in Table XXXVI.

TABLE XXXVI.—AVERAGE PERCENTAGE OF SOLIDS NOT FAT IN MILK FOR 8 WEEKS.

	Lot I.			Lot II.		
	Morning.	Noon.	Evening.	Morning.	Noon.	Evening.
Average for 8 weeks	8·85	9·1	8·9	8·91	8·98	8·98
Times milkings were under standard*...	—	—	—	1	—	—
Highest	9·2	9·4	9·2	9·1	9·3	9·4
Lowest	8·5	8·5	8·5	8·3	8·5	8·7

Average percentage in total daily yield :—Lot I., 8·93 ; Lot II., 8·94.

* Out of a possible of 56.

Live-weight of the cows.—The fluctuation in the average live-weight of the cows is shown in Table XXXVII.

TABLE XXXVII.—AVERAGE LIVE-WEIGHTS (IN LB.) PER COW OF EACH LOT.

	End of Experiment I.	March 10.	April 7.	Gain or loss during experiment.
Lot I. ...	1,114 ...	1,142 ...	1,176 ...	+ 62
Lot II. ...	1,111 ...	1,125 ...	1,111 ...	—

Lot I. in this case not only gave more milk than it did in the previous experiment, and more also than did lot II. in the present experiment, but at the same time increased in live-weight on the average by 62 lb. per cow. Lot II. increased in average live-weight during the first month, but lost again in the second, so that at the end of the experiment it was on the average exactly where it was in the beginning. Taking the whole period of sixteen weeks, covering both experiments, lot I. gained, on the average, 20 lb. per cow in that time, and lot II. lost 21 lb. The two lots gave very nearly the same amount of milk during the sixteen weeks they were under experiment.

Summary and general conclusions.—A brief summary of the results is given below.

PRELIMINARY TRIALS.

SET OF 10 COWS IN TWO LOTS OF 5.

		Milk per cow per day.	% Fat.		Average live-weight per cow.
Lot I.	...	28·36 pints	3·57	...	1,156 lb.
Lot II.	...	28·08 pints	3·55	...	1,132 lb.

EXPERIMENT I.

8 weeks, December 16, 1905—February 9, 1906.

	Food.	Average milk per cow per day.	% Fat.	Total butter-fat (lb.) per cow per day.	% S.N.F.	Gain (+) or loss (—) in average live- weight.
Lot I.	No brewers' grains...	22·56 pints	3·41	·99	8·86	— 42
Lot II.	20 lb. brewers' grains	25·34 pints	3·08	1·00	8·81	— 21

EXPERIMENT J.

8 weeks, February 10—April 7, 1906.

Lot I.	20 lb. brewers' grains	23·55 pints	3·51	1·07	8·93	+ 62
Lot II.	No brewers' grains...	20·47 pints	3·34	·88	8·94	—

The two experiments had for their object to discover the effect of brewers' grains upon the quantity and quality of milk. A set of ten cows which had undergone a preliminary trial were under experiment for sixteen weeks. The cows were divided into two lots of five, and each lot was placed in turn on a ration containing 20 lb. of ordinary brewers' grains, and fed on this ration for eight weeks. The following conclusions are based upon the results obtained from the two experiments:—

(1) A moderate allowance of, say, 20 lb. of brewers' grains per day has the effect of materially increasing the daily yield of milk. (Tables XXX. and XXXIV.)

(2) The experiments did not continue long enough to show the exact duration of this effect, but it would appear to be more or less permanent, and would in practice cause cows to yield

considerably more than their normal quantity of milk during the lactation period, which indeed might also be materially lengthened by the judicious use of brewers' grains.

(3) The effect of brewers' grains on the yield is relatively greater early in the lactation period than it is later on, but they cause a material increase in the yield even when used comparatively late in the lactation period (Table XXXIV., lot I.), an effect which is clearly not due to the mere change of food.

(4) The evidence of these experiments is not so conclusive as might be desired as to the effect of brewers' grains on the percentage of butter-fat in the milk, but there are indications that early in the lactation period, they tend to slightly reduce the butter-fat. (Table XXXI.) Towards the end of the lactation period, they do not seem to have any appreciable effect in this direction. (Table XXXV.)

(5) In the case of cows whose mixed morning milk is habitually low in butter-fat, brewers' grains are probably not a food to be recommended, having regard to the 3 per cent. standard, and especially during the earlier portion of the lactation period. (Table XXXI.)

(6) The effect of brewers' grains on the non-fatty solids in the milk is apparently unappreciable.

(7) As regards the live-weight of the cows, the effect of brewers' grains, in these experiments, was not in any way striking, but it appears that they may cause an increase in the milk yield and in the average live-weight simultaneously. (Tables XXXIV. and XXXVII., lot I.)

(8) Speaking generally, and having regard to the milk only, the best time to use brewers' grains for dairy cows is when the cows are well advanced in the lactation period, when the milk yield is falling off, and when, as a rule, the butter-fat is higher than it is early on. They may be a very useful food under these conditions, but milk-sellers should use them sparingly even then if their milk is regularly low in butter-fat.

OFFERTON BULLETIN No. 3.

Experiments on the Feeding of Dairy Cows.

Third Report, published July, 1909.

BY FRANK P. WALKER.

A SECOND EXPERIMENT TO TEST THE EFFECT OF BREWERS' GRAINS ON THE QUANTITY AND QUALITY OF MILK.

Object.—The main object of the present experiment was to see how far the deductions made from Experiments I and J described in the above Bulletin were reliable. It was thought another experiment on exactly the same lines would yield equally interesting results. The special object was to discover the effect on the quantity and quality of milk of a ration containing a moderate amount of brewers' grains compared with a ration containing none.

EXPERIMENT K.

Preliminary trials.—Those cows which were to be used in the experiment were average dairy cows, and before the experiment was begun all of them were tested for tuberculosis. The ten selected satisfactorily passed the test. They were newly calved and were arranged in two lots of five each according to the yield and quality of the milk. The preliminary trials lasted for three weeks. The experiment commenced on December 8, 1907. A short time elapsed before the actual experiment commenced after the preliminary trials

were finished. This was unavoidable as the necessary selections had to be made from the results obtained in these trials. In the meantime the cows were fed exactly alike. Each of the Experiments I and J lasted respectively eight weeks. Experiment K was carried on for ten weeks. For purposes of comparison, however, the results are tabulated both for eight and ten weeks. The cows were milked as usual three times a day, and the milk was sampled and tested as in all the other experiments.

A point of interest worth recording is that those cows which received the brewers' grains in their ration had a nicer bloom than those which did not at the time receive any grains.

At the end of the preliminary trials, the two lots stood as follows:—

	Total yield in pints per lot per day.	Average yield of milk per cow per day.	Per cent. of butter fat in total daily yield.	Average live-weight.
Lot I. ...	117	23·4 pints.	3·33	1050 lb.
Lot II. ...	118	23·6 pints.	3·40	1038·8 lb.

Rations.—The same plan was followed in the general arrangement of the experiment as in previous experiments, viz., the cows were fed on certain rations for a period, after which the rations were reversed, and the experiment continued for a similar period under the altered conditions. In the present case, the rations used were as follows per 1,000 lb. live-weight:—

LOT I.	LOT II.
4 lb. maize meal.	4 lb. maize meal.
2 „ Bombay cotton cake.	2 „ Bombay cotton cake.
3 „ chopped straw.	3 „ chopped straw.
12 „ hay.	12 „ hay.
20 „ brewers' grains.	60 „ swedes.
20 „ swedes.	

There was practically the same amount of organic matter in each ration, but that given to lot I. was more nitrogenous than the other. The difference, however, was not great, and it probably varied a little from time to time, owing to the variation in the composition of the brewers' grains.

The cows were fed as above for ten weeks. At the end of this period, the rations were reversed, the brewers' grains being now given to lot II. instead of to lot I. This further test (Experiment L) was commenced on February 16, 1908, and continued for another period of ten weeks.

As before, the cake and meal and chopped straw were made into "crowdy" before being served to the cows, and water was supplied *ad lib.*

Results.—As usual, the yield of milk, the percentage of fat, and of "solids not fat," are tabulated separately, the figures given in the tables being the weekly averages. Table XXXVIII. shows the quantity of milk produced by the two lots in Experiment K.

Briefly, Table XXXVIII. shows that while the brewers' grains have not produced so striking an increase in the flow of milk as they did in Experiment I, yet there is an increase from their use and it may be assumed that the experiments are confirmatory one of the other. By those who study the table in greater detail it will be seen that in this and the other tables the results have been tabulated to show the fluctuations during the first eight weeks of the experiment as distinct from the fluctuations of the ten weeks. In both of the experiments, as shown by the Tables XXXVIII. and XLII., there is a distinct drop during the last two weeks in the quantity of milk produced by both lots of cows. On page 87 of Offerton Bulletin No. 2 it is recorded that "in the last week of all there was an increase in the yield of both lots, which is impossible to explain." The last week of this particular Experiment J was the eighth week. It is rather a suggestive fact that in both of the present Experiments K and L, during the eighth week of the experiment there is a distinct increase in the quantities of milk produced in three cases, while in the fourth case it remains the same as in the seventh week (see Tables XXXVIII. and XLII.). The same tables show that during the ninth and tenth weeks there is a very appreciable

decrease in the quantity of milk produced by both lots of cows in both Experiments K and L.

Practical feeders are well aware that a change of diet is beneficial to the general health of cattle. It may be that the above changes are an indication of the length of time that any particular ration is likely to produce the most economical results.

Another reason, as previously mentioned, for tabulating the fluctuations during the first eight weeks of these experiments is to make the results more comparable with those obtained in Experiments I and J in Bulletin No. 2.

At the commencement of Experiment K both lots of cows had gone off their milk, though only to a slight extent. This was to be expected. It must be noticed that lot I. had gone

TABLE XXXVIII.—AVERAGE QUANTITY OF MILK IN PINTS PER LOT PER DAY FOR 8 WEEKS AND 10 WEEKS.

Week ending:—	Lot I. (Grains).				Lot II. (No grains).			
	Morn.*	Noon.*	Even.*	Total.	Morn.*	Noon.*	Even.*	Total.
Dec. 14 ...	51·5	34·5	27·5	113·5	52·5	35	29·5	117
" 21 ...	55·5	35	29	119·5	52·5	34	28	114·5
" 28 ...	52·5	34·5	27	114	52·5	33	26	111·5
Jan. 4 ...	53	34·5	27·5	115	51	34	27	112
" 11 ..	53·5	35	27	115·5	52·5	33·5	25·5	111·5
" 18 ...	50·5	34	27	111·5	53	34	26	113
" 25 ...	53	35·5	27	115·5	54	35·5	26	115·5
Feb. 1 ...	55	36·5	28	119·5	59	36	27·5	122·5
Average per lot per day for each of 8 weeks ...	53·06	34·94	27·5	115·5	53·38	34·37	26·94	114·7
Week ending:—								
Feb. 8 ...	51·5	32	24·5	108	55·5	34	27	116·5
" 15 ...	51·5	33·5	26·5	111·5	55·5	34	27	116·5
Average per lot per day for each of 10 weeks ...	52·75	34·5	27·1	114·35	53·8	34·3	26·95	115·05

* The times of milking were 5 a.m., 12-30 p.m., and 6-30 p.m.

off to a greater extent than lot II. Unfortunately also one of the cows in lot I., receiving brewers' grains, during the first few days in January was slightly off her food and produced only 16 pints of milk per day. In Experiment I, Bulletin No. 2, the results as regards the yield of milk during the eight weeks of the experiment were distinctly in favour of the lot receiving brewers' grains. During the first eight weeks of Experiment K, Table XXXVIII., the total yields of lot I. are in favour of the brewers' grains. On the other hand it will be noticed that for the ten weeks period, the results are slightly in favour of lot II., receiving no brewers' grains. The difference of only half a pint, however, in the totals is so small as to be negligible and cannot be said to negative the result of Experiment I so far as it went in the least degree. Especially is this the case when it is realised that at the end of eight weeks of Experiment K, lot I. had only dropped in the average $1\frac{1}{2}$ pints per day as compared with the total average at the end of the preliminary trials. While lot II. had dropped $3\frac{1}{2}$ pints compared with the similar average at the same time. The difference at the end of the ten weeks is also in favour of lot I. At the end of eight weeks of Experiment K, Table XXXVIII., the average increase per day in the total yield of lot I. is 6 pints, while the average increase per day in the total yield of lot II. is $5\frac{1}{2}$ pints. On the other hand, at the end of the ten weeks, the average decrease per day for lot I. is 2 pints, while for lot II. it is only half a pint. It is very unfortunate that one of the cows in lot I. should have sickened for a time. Had this not been the case it is possible that the present experiment would have been to a greater degree confirmatory of the previous similar experiments which showed that brewers' grains possessed in a striking degree the power of increasing, at all events for a time, the total milk yield. It is possible, however, from the results in Tables XXXVIII. and XLII. that the returns from brewers' grains are not so economical when continuously fed as is generally supposed.

Quality of the milk.—The average percentage of butter-fat in the milk of each lot is shown in Table XXXIX.

From the milkseller's point of view, the results are again of interest, though they are not so varied as in Experiment I.

TABLE XXXIX.—AVERAGE PERCENTAGES OF BUTTER-FAT IN MILK FOR EACH OF 8 WEEKS, AND 10 WEEKS.

Week ending:—	Lot I. (Grains).			Lot II. (No grains).		
	Morn.	Noon.	Even.	Morn.	Noon.	Even.
December 14 ...	2·8	3·9	3·9	2·8	3·8	3·5
„ 21 ...	3·1	3·8	3·9	3·0	4·1	3·4
„ 28 ...	2·9	3·8	3·9	3·1	4·0	3·4
January 4 ...	2·8	3·9	3·8	2·9	4·0	3·7
„ 11 ...	2·9	3·9	3·4	2·8	3·9	3·6
„ 18 ...	2·9	3·8	3·6	3·1	4·1	3·3
„ 25 ...	2·7	3·7	3·9	2·9	4·3	3·3
February 1 ...	2·7	3·6	3·6	3·0	4·2	3·0
Averages for each of 8 weeks ...	2·85	3·8	3·75	2·95	4·05	3·4
Week ending:—						
February 8 ...	2·8	3·6	3·6	3·0	4·0	3·1
„ 15 ...	2·9	3·8	3·9	2·9	4·2	3·2
Averages for each of 10 weeks ...	2·85	3·78	3·75	2·95	4·06	3·35
Times milkings were under standard during first 8 weeks* ...	42	—	—	29	—	2
and During last 2 weeks	9	—	—	7	—	—
Total number of times under standard during 10 weeks†	51	—	—	36	—	2
Highest ...	3·8	4·3	4·2	3·5	4·7	4·1
Lowest ..	2·4	3·3	3·1	2·5	3·5	2·9

* Out of a possible of 56.

† Out of a possible of 70.

	Lot I.		Lot II.	
	For 8 weeks.	For 10 weeks.	For 8 weeks.	For 10 weeks.
Average percentage of butter-fat in total daily yield ...	3·35	3·34	3·38	3·37
Total butter-fat per day ...	4·99 lb.	4·93 lb.	5·01 lb.	5·00 lb.

From the average quantity of milk produced by the cows in these Experiments K and L, it is fair to presume that they were not such heavy milkers as those used in the Experiments I and J, Bulletin No. 2. Speaking generally, heavy milkers produce milk of somewhat poorer quality than cows of the same breed which do not milk heavily. From the results obtained in the preliminary trials, preceding Experiments K and L, it may be said that both lots of cows produced milk of good average quality. Taking the period of eight weeks, the difference in the percentage of fat in the case of lot I. shows an increase of .02 per cent., while in the case of lot II. there is a decrease of .02 per cent. The difference is so slight that it cannot be attributed to the effect of the brewers' grains. The results over the period of ten weeks are practically identical with those obtained over the period of eight.

It is usually the morning's milk which is below the standard. In Experiment I those cows which received brewers' grains produced milk every morning during the eight weeks below the standard, while those which did not receive brewers' grains in the same period only nine times below. In a similar period during Experiment K, lot I. produced milk below the standard on 42 mornings, while lot II. did the same on 29 mornings only. That is, lot I. produced milk below the standard on 13 mornings more than lot II. Over the period of ten weeks this number of times is slightly increased and is 15.

On referring to Table XXXIX. it will be seen that the milk of lot I. is somewhat poorer throughout in the morning's and noon's milkings than lot II., but this is counterbalanced by the evening's average quality being considerably higher. It cannot be said that over the whole period of the experiments the brewers' grains have had any effect in deteriorating the quality of the milk. The Table XXXIX. also shows that on two occasions the evening's milk of lot II. fell below the standard.

TABLE XL.—PERCENTAGES OF SOLIDS NOT FAT IN MILK FOR 8 WEEKS AND 10 WEEKS.

	Lot I. (Grains).			Lot II. (No grains).		
	Morn.	Noon.	Even.	Morn.	Noon.	Even.
Average for 8 weeks	9·06	9·21	9·12	8·99	9·11	9·07
Average for 10 weeks	9·08	9·24	9·15	9·01	9·14	9·09
Times milkings were under standard ...	—	—	—	—	—	—
Highest	9·4	9·5	9·6	9·3	9·5	9·4
Lowest	8·8	8·8	8·8	8·5	8·8	8·6

					Lot I.	Lot II.
Average percentage of solids not fat in total daily yield ...					9·14	9·06
Total solids not fat per day					13·48 lb.	13·44 lb.

The “solids not fat” in both lots of milk were well above the standard. The results are summarised in Table XL.

The live-weight of the cows.—The cows were weighed at the commencement of the experiment, at the end of each month afterwards and at the end of the experiment. The average live-weight for each lot is shown in Table XLI.

TABLE XLI.—AVERAGE LIVE-WEIGHT (IN LB.) PER COW OF EACH LOT.

		Commence- ment.	January 6.	February 4.	February 17.	Average gain or loss during experiment.
Lot I.	...	1,050	1,041·6	1,057	1,047·2	— 2·8
Lot II.	...	1,038·8	1,045·8	1,052·8	1,044·4	+ 5·6

There is a slight loss in weight, as shown in Table XLI., during the whole period of the experiment in the case of the cows constituting lot I. In lot II. the cows have gained in weight to a small extent.

EXPERIMENT I.

As soon as the experiment just described was completed, the rations were reversed, with the object of discovering whether the brewers' grains would have the same effect on

the other lot of cows as they had on those to which they were given originally. There was no interval at all between the two experiments. The second experiment, here described as Experiment L, commenced on February 16, and continued till April 25, 1908. The results are given in the following tables. Table XLII. shows the yield of milk in each lot.

In comparing the respective yields of milk given by the two lots of cows (see Table XLII.), it is again necessary to confine ourselves to the period of the first eight weeks of the experiment. When the rations were reversed it is unfortunate to have to record that lot II. never quite took to the grains and only with reluctance ate them. In spite of this fact, lot II. receiving the grains gave, during the period named, a greater average yield of milk than lot I. If the greater increase in the quantity of milk yielded in Experiment K was due to the brewers' grains the result in Experiment L is what

TABLE XLII.—AVERAGE QUANTITY OF MILK IN PINTS PER LOT PER DAY FOR 8 WEEKS AND 10 WEEKS.

Week ending :—	Lot I. (No grains).				Lot II. (Grains).			
	Morn.	Noon.	Even.	Total.	Morn.	Noon.	Even.	Total.
Feb. 22 ...	52·5	34	25·5	112	53·5	34·5	27·5	115·5
„ 29 ...	49	33·5	24·5	107	48·5	32·5	26·5	107·5
Mar. 7 ...	49·5	34	24	107·5	50·5	34	27·5	112
„ 14 ...	50	33	23·5	106·5	52·5	34·5	27	114
„ 21 ...	50	32·5	23·5	106	52	34·5	27·5	114
„ 28 ...	48·5	31	23	102·5	49·5	31	24·5	105
Apr. 4 ...	48	32	25·5	105·5	49·5	32	26	107·5
„ 11 ...	48·5	32·5	26·5	107·5	49	31·5	27	107·5
Average per lot per day for 8 weeks	49·5	32·81	24·5	106·81	50·62	33·06	26·66	110·37
Week ending :—								
Apr. 18 ...	48	32·5	24·5	105	47·5	31·5	26	105
„ 25 ...	44·5	30·5	24·5	99·5	44·5	29·5	24	98
Average per lot per day for 10 weeks	48·85	32·55	24·50	105·9	49·7	32·55	26·35	108·6

might have been expected. In Experiment J, Bulletin No. 2, after the rations were reversed there was a distinct drop during the first week of the experiment on the average of 16 pints in the yield of the cows which had previously received the grains, while in the case of those cows which had not previously received grains there was an increase on the week's average of 5 pints per day when they did receive the grains. At the beginning of the present experiment the average yield of lot I. during the first week of the experiment increased by half a pint, while that of lot II. decreased by 1 pint. These two results might appear to contradict each other, but the difference is only slight in the latter case, and having regard to the fact that lot II. did not take to the grains should not be looked upon as producing a negative result. Especially is this the case in regard to the fact that the milk yield of lot I. consistently declined from the first week to the sixth, while that of lot II. was fairly well maintained throughout the whole period of eight weeks. It will be noted that during the last two weeks of the experiment both lots showed a considerable falling off in the milk yield, while in the eighth week in the case of lot I. there was an increase in the average flow of milk. In the same period lot II. maintained its yield. It has already been suggested from this and the previous experiments that the eighth week may mark the period of time when any particular ration might be economically changed for another. Having regard to the period of lactation and results already obtained, it is safe to assume that brewers' grains do increase the flow of milk and that the effect is maintained for a considerable period, though eight weeks in these particular experiments would serve to indicate the limit. It must be borne in mind that the cows under experiment were pregnant and not, as in so many cases where grains are largely used, in a barren condition.

Quality of the milk.—The butter-fat in the milk of each lot in Experiment L is shown in Table XLIII.

TABLE XLIII.—AVERAGE PERCENTAGES OF BUTTER-FAT
IN MILK FOR EACH OF 8 WEEKS AND 10 WEEKS.

Week ending:—	Lot I. (No grains.)			Lot II. (Grains.)		
	Morn.	Noon.	Even.	Morn.	Noon.	Even.
February 22 ...	3·0	3·7	3·8	3·1	4·1	3·4
„ 29 ...	2·9	3·7	3·8	3·1	4·0	3·6
March 7 ...	2·9	3·7	3·9	2·8	4·0	3·5
„ 14 ...	3·1	3·9	4·0	3·2	3·9	3·7
„ 21 ...	3·1	3·8	4·0	3·1	4·0	3·8
„ 28 ...	3·1	3·8	4·1	3·0	3·9	3·5
April 4 ...	3·1	3·9	4·1	3·0	3·7	3·4
„ 11 ...	2·9	3·9	3·8	2·9	3·8	3·6
Average for each of 8 weeks ...	3·01	3·8	3·94	3·02	3·92	3·56
Week ending:—						
April 18 ...	3·0	4·1	4·1	3·1	4·0	3·7
„ 25 ...	3·1	4·0	4·0	3·1	4·2	3·8
Average for each of 10 weeks ...	3·02	3·85	3·96	3·04	3·96	3·60
Times milkings were under standard during first 8 weeks* ...	16	—	—	19	—	—
And during last 2 weeks ...	2	—	—	1	—	—
Total number of times under standard during 10 weeks†	18	—	—	20	—	—
Highest ...	3·7	4·5	4·7	3·9	4·8	4·3
Lowest ...	2·7	3·4	3·4	2·7	3·4	3·0

* Out of a possible of 56.

† Out of a possible of 70.

	Lot I.		Lot II.	
	For 8 weeks.	For 10 weeks.	For 8 weeks.	For 10 weeks.
Average percentage of butter-fat in total daily yield ...	3·46	3·49	3·41	3·45
Total butter-fat per day ...	4·77 lb.	4·77 lb.	4·86 lb.	4·83 lb.

In the previous experiments it was concluded that the effect of the brewers' grains was to produce no effect in the long run in the quality of milk. In the present experiment a similar result is shown. In both lots the percentage of fat on the average is considerably higher than in the previous experiment. There is no doubt that the period of lactation

has something to do with this increase, as it is generally known that as the period of lactation progresses the quality of milk slightly improves. The total number of times the milk was under the standard in the morning with lot II. was 20, while in the previous experiment it was 36 times under the standard in the morning. In the case of lot I. during the present experiment the morning's milk was under the standard 18 times, while in the previous experiment it was under the standard 53 times. From these figures it might be suggested that the effect of the brewers' grains did affect the quality of the milk and as the flow of milk is always greater in the morning, perhaps it does. On the average daily output, however, it may be safely said that the brewers' grains do not appreciably affect the quality so far as the fat is concerned.

TABLE XLIV.—PERCENTAGES OF SOLIDS NOT FAT IN MILK FOR 8 WEEKS AND 10 WEEKS.

Week ending:—	Lot I. (No grains.)			Lot II. (Grains.)		
	Morn.	Noon.	Even.	Morn.	Noon.	Even.
Average for 8 weeks	9·15	9·27	9·25	9·06	9·15	9·11
Average for 10 weeks	9·15	9·29	9·25	9·05	9·16	9·09
Times milkings were under standard...	—	—	—	—	—	—
Highest	9·7	9·6	9·7	9·4	9·5	9·6
Lowest	8·7	8·9	8·9	8·5	8·6	8·5

Average percentage of solids not fat in total daily yield ...	Lot I.	Lot II.
	9·21	9·09
Total solids not fat per day	12·59 lb.	12·73 lb.

The “solids not fat” were in no case below the standard.

Live-weight of the cows.—The average live-weight of the cows is shown in the following table:—

TABLE XLV.—AVERAGE LIVE-WEIGHT (IN LB.) PER COW OF EACH LOT.

	End of Experiment (K).	March 16.	April 12.	April 27.	Average gain or loss during experiment.
Lot I. ...	1,047·2 ...	1,036 ...	1,044·4 ...	1,033·2 ...	— 14
Lot II. ...	1,044·4 ...	1,023·4 ...	1,057 ...	1,024·8 ...	— 19·6

The fluctuation in the average live-weight of the cows during Experiment L is shown in Table XLV.

At the end of the preliminary trials the cows in lot II., were giving on an average 1 pint of milk per day more than lot I. Assuming it is fair to suppose that the two lots would have continued to milk in the same relation if they had been fed on the same rations, lot II. during the ten weeks would have given 70 pints of milk more than lot I. As a matter of fact, during the ten weeks of the Experiment K, while lot I. received the grains the cows in lot II. only gave 49 pints more in total than lot I. During Experiment L, however, when lot II. received the grains the total increase of milk given by lot II. over that of lot I. was 189 pints.

The average loss in live-weight per cow in lot I. during the period of 20 weeks was 16·2 lb., while that in lot II. for the same period was 14 lb.

Summary and general conclusions.—Below is a brief summary of the results:—

PRELIMINARY TRIALS.

SET OF 10 COWS IN TWO LOTS OF 5.

		Milk per day per cow.		% of Fat in total daily yield.		Average live-weight per cow.
Lot I.	...	23·4 pints	...	3·33	...	1,050 lb.
Lot II.	...	23·6 pints	...	3·40	...	1,038·8 lb.

EXPERIMENT K.

10 Weeks, December 8, 1907—February 15, 1908.

	Food.	Average milk per cow per day.		% Fat.		Total butter-fat per cow per day.		S.N.F. %	Gain (+) or loss (-) in average live-weight during 10 weeks.
		During 1st 8 weeks.	During 10 weeks.	During 1st 8 weeks.	During 10 weeks.	During 1st 8 weeks.	During 10 weeks.		
Lot I.	20 lb. brewers' grains ...	pints.	pints.			lb.	lb.		lb.
		23·1	22·87	3·35	3·34	·99	·99	9·14	- 2·8
Lot II.	No brewers' grains ...	22·94	23·01	3·38	3·37	1·00	1·00	9·06	+ 5·6

EXPERIMENT L.

10 Weeks, February 16—April 27, 1908.

Lot I.	No brewers' grains ...	21·36	21·18	3·46	3·49	·95	·95	9·21	- 14
Lot II.	20 lb. brewers' grains ...	22·07	21·72	3·41	3·45	·97	·97	9·09	- 19·6

The two experiments had for their object to discover the effect of brewers' grains upon the quantity and quality of milk. A similar set of experiments was reported on in Offerton Bulletin No. 2. A set of ten cows which had undergone a preliminary trial was under experiment for twenty weeks. The cows selected had satisfactorily passed the tuberculin test. They were divided into two lots of five, and each lot was placed in turn on a ration containing 20 lb. of ordinary brewers' grains and fed on this ration for ten weeks. It should be noted that the cows experimented upon were kept for breeding. On the whole it may be said that the two latter experiments are confirmatory in their results of the two previous experiments and the following conclusions are based on the results of the series:—

(1) A moderate allowance of 20 lb. of brewers' grains per day has the effect of increasing, at all events for a certain period, the daily yield of milk (Tables XXXVIII. and XLII.).

(2) It would seem from a study of the above tables that the period over which such increase is maintained has its limit, and that the practise of exercising a change of diet is a good one.

(3) The effect of brewers' grains in the yield is not confined to the earlier period of lactation. By a judicious use of brewers' grains such lactation period might be considerably extended.

(4) The evidence of the experiments with regard to the percentage of fat in the milk seems conclusive that so far as

the daily average of fat is concerned brewers' grains in moderate quantities produce in the long run no appreciable diminution of fat.

(5) Although the average daily yield of butter fat is not appreciably affected by a moderate quantity of grains, the percentage of butter fat in the morning's milk does seem to be lowered more frequently. Having regard to this fact and the 3 per cent. standard, where the mixed milk of a herd of cows is habitually low in the morning brewers' grains are not to be recommended.

(6) It must also be borne in mind that the above conclusions are based on results obtained by feeding brewers' grains in moderate quantities only and with a good complement of artificial foodstuffs.

(7) In these experiments no effect was produced by the brewers' grains on the non-fatty solids.

(8) So far as the effect in the live-weight of the cattle is concerned the results are in no way very marked.

(9) With ordinary dairy cows, which are kept as breeding stock, brewers' grains in moderate quantities may be safely used as food when the stock are otherwise well fed.

THE TRANSFER OF BORIC ACID FROM CATTLE FOOD TO COW'S MILK.

BY S. H. COLLINS.

It is more than ten years ago since Jay and Dupasquier pointed out* that boric acid was present in many food materials in small amount, but they did not find any boric acid in milk, though more recently Wiley found boric acid in women's milk.† Also the writer has published a short note on the subject in the *Proceedings* of the University of Durham Philosophical Society, 1907-8, p. 33.

* *Comptes rendus*, 1895, 260.

† *Journal of Biological Chemistry*, 1907, p. 11.

During the last few years a considerable change has occurred in the feeding of cows by the introduction of Indian cotton cake. The Indian cotton seed from which the cake is prepared, is often kept in store under damp conditions, and the seed is apt to become mouldy or discoloured, to prevent which boric acid is used as a preservative. Whilst some samples of Indian cotton cake are free from boric acid, others contain nearly 1 per cent.; and whilst some dairy farmers do not use Indian cotton cake at all, others have used as much as 12 lb. a day to each cow. Under such circumstances it has become necessary to carry out experiments to determine whether under these new conditions cows' milk may or may not contain boric acid. The subject is the more important because a farmer selling milk containing boric acid is liable to prosecution for adulteration.

EXPERIMENT M.

Two cows were fed on 5 lb. maize meal and 3 lb. decorticated cotton cake, with sufficient straw chaff and hay throughout the experiment, whilst two other cows were fed the same in all respects except that they received a small quantity of "boric meal" made from 19 parts of maize meal and 1 part of boric acid, instead of an equal amount of pure maize meal. The boric meal used contained 5 per cent. of boric acid, of which from $\frac{1}{4}$ lb. to 1 lb. was fed. All the other foods used were tested for boric acid and found to be free from that impurity.

It is interesting to note that boric acid appeared in the milk as soon as the cows received a ration containing any boric acid, although there is a slight "lag" in the amounts, since the cows did not reach the maximum amount of boric acid in the milk till three days after receiving the maximum amount of boric acid in the food. The amount of boric acid returned is very small, being only one fiftieth part of the amount fed, yet this small amount would be sufficient to render the milk seller liable to prosecution under the Food

and Drugs Act. The amount of boric acid fed is by no means excessive since it is only equal to 5lb. of a Bombay cotton cake containing 1 per cent. boric acid, an amount which might be exceeded in practice. Further it will be seen that by feeding 8lb. of Bombay cotton cake containing 0.15 per cent. of boric acid, the milk would contain 0.001 per cent. boric acid.

The following table gives the result of the experiment:—

TABLE XLVI.—BORIC ACID IN MILK.

EXPERIMENT M.

Date.	Lot I.		Lot II.	
	Boric meal-fed.	Boric acid in milk.	Boric meal-fed.	Boric acid in milk.
	lbs.	parts per million.	lbs.	parts per million.
May 5	—	0	—	0
" 6	—	0	$\frac{1}{4}$	10
" 7	—	0	$\frac{1}{2}$	20
" 8	—	0	$\frac{3}{4}$	20
" 9	—	0	1	30
" 10	—	0	1	40
" 11	—	0	1	50
" 12	—	0	1	40
" 13	—	0	1	40
" 14	—	0	1	40
" 15	—	0	1	40
" 16	—	0	1	40
" 17	—	10	1	40
" 18	—	0	$\frac{1}{2}$	30

EXPERIMENT N.

This experiment was designed to find out whether very small amounts of boric acid in foods would get into the milk. In this experiment there were two lots of five cows each, but the "boric meal" was made to contain only 1 per cent. of boric acid instead of 5 per cent. It will be seen in Table XLVII. that the results of this experiment followed closely on those of the Experiment N, about one seventieth of the boric acid fed being returned in the milk. As the testing was carried out more delicately than before, minute traces of boric acid were found in the preliminary tests before any boric acid had even

arrived at the farm. Many ordinary foods, however, contain traces of boric acid, and hence minute traces will often be found in milk. There is nothing new in finding minute traces of boric acid in most common objects, many investigators have noted this fact before.

TABLE XLVII.
EXPERIMENT N.

	Lot I.		Lot II.	
	Boric meal-fed.	Boric acid in milk.	Boric meal-fed.	Boric acid in milk.
Date.	lbs.	parts per million.	lbs.	parts per million.
June 15	—	1	—	2
" 16	—	1	—	1
" 17	—	1	—	2
" 18	—	1	—	1
" 19	—	*	—	1
" 20	—	1	—	0
" 21	—	0	—	0
" 22	—	0	$\frac{1}{4}$	1
" 23	—	0	$\frac{1}{2}$	*
" 24	—	0	$\frac{3}{4}$	2
" 25	—	0	1	4
" 26	—	0	$1\frac{1}{4}$	4
" 27	—	0	$1\frac{1}{2}$	4
" 28	—	0	$1\frac{3}{4}$	5
" 29	—	0	2	5
" 30	—	0	2	7
July 1	—	0	2	7
" 2	—	0	2	10
" 3	—	0	2	10
" 4	—	0	2	8
" 5	—	0	2	8
" 6	—	0	2	8
" 7	—	0	2	8
" 8	—	0	2	9
" 9	—	0	2	9
" 10	—	0	2	9
" 11	—	0	2	9
" 12	—	0	2	10
" 13	—	0	—	9
" 14	—	0	—	6
" 15	—	0	—	3
" 16	—	0	—	0
" 17	—	0	—	0
" 18	—	0	—	0
" 19	—	0	—	0

* Broken in transit.

Conclusion.—The main question, “Can boric acid get into milk as the result of feeding cows on food containing boric acid” is answered in the affirmative. However, the amount of boric acid that can get into the milk from food is small and could not possibly enable the milk to keep sweet for a longer time. As milk needs $\frac{1}{4}$ per cent. boric acid to produce any useful preservative influence, there seems no difficulty in distinguishing between milk preserved with boric acid and milk contaminated by the use of foods containing boric acid. If milk be found to contain more than 0.1 per cent. boric acid the milk has probably been deliberately preserved with some boric preservative, but if less than 0.01 per cent. boric acid be found in the milk, the source of that small amount of boric acid is to be looked for in the food of the cow; whilst if between .1 per cent. and .01 per cent. boric acid be found the origin of the boric acid is uncertain. With small amounts of boric acid in the food about one sixtieth part of the total amount of boric acid fed finds its way into the milk.

ON THE DIFFICULTIES OF TAKING A SAMPLE OF MILK.

BY S. H. COLLINS AND FRANK P. WALKER.

Milk is so important a food, so much used for infants and invalids, that no excuse can be made for those who deliberately adulterate it. The proof that any particular quantity of milk has been adulterated is, however, beset with difficulties. One of these difficulties is that of obtaining a sample of milk which really represents the milk as actually produced. Vessels are made to deliver milk either by drawing from a tap at the bottom or by dipping into them with a small can at the top. The milk in the vessel is mixed either by hand-stirring or by the shaking of the cart in which the milk is carried.

Such admixture is probably imperfect in practice, but even if great care were always taken some interval of time must elapse between such mixing and the actual withdrawal of the small quantity to the purchaser.

A question therefore arises: How long may milk stand at rest without making the part withdrawn differ appreciably from the bulk?

Among other things the rate at which cream rises to the surface of milk depends on the temperature, but the control of temperature presents difficulties. The water supply on many farms is insufficient for effective cooling, and many customers will not accept milk unless it is warm. Even if the milk has been cooled and customers are willing to accept it cool, the sun's heat during transit cannot always be avoided.

These considerations suggested an experiment on the variation of the composition of milk due to sampling and the opportunity of the presence of the Dairy class was taken to carry out such an experiment. The samples were taken under the supervision of Miss Maidment, Dairy Instructress for the County of Durham. A four gallon vessel with a tap at the bottom was about three quarters filled with milk and samples drawn from the bottom tap, or taken from the top at intervals, and subsequently analysed in the Chemical Department.

Inspection of the results given in tables A, B and C will show at once that when high temperatures prevail even a few minutes' rest suffices to give useless samples, but that when low temperatures prevail the danger is smaller.

Whilst these experiments add but little to what was known before, they serve to emphasise the difficulties of sampling milk, and in consequence the difficulties of dealing in milk. This commodity is so different from other farm produce that the properties of milk demand from its producers a special study.

A.—HOT WEATHER.

Ref. No.	Description of sample.	Butter fat %.	Solids not fat %.
2516	Well mixed sample	3.10	9.0
2517	Top after $\frac{1}{4}$ hour	7.25	8.6
2518	Bottom „ $\frac{1}{4}$ „	2.27	8.85
2519	Top „ $\frac{1}{2}$ „	Over 9 %	—
2520	Bottom „ $\frac{1}{2}$ „	2.02	9.05
2521	Top „ 1 „	Over 9 %	—
2522	Bottom „ 1 „	1.80	9.0

B.—COOL WEATHER.

Ref. No.	Description of sample.	Butter fat %.	Solids not fat %.
2526	Well mixed sample	3.55	8.5
2527	Bottom after 5 minutes	3.50	8.5
2528	„ „ 10 „	3.50	8.6
2529	„ „ 15 „	3.42	8.7
2530	„ „ 20 „	3.30	8.7

C.—MILK WARMED TO 75° F.

Ref. No.	Description of sample.	Butter fat %.	Solids not fat %.
2531	Well mixed sample	3.65	9.10
2532	Bottom after 5 minutes	3.52	8.85
2533	„ „ 10 „	3.32	8.95
2534	„ „ 15 „	2.85	8.95
2535	„ „ 20 „	2.70	9.05

Trials of Soya Cake for Milch Cows.

BY DOUGLAS A. GILCHRIST.

Trials to test the comparative feeding value of soya and decorticated cotton cakes have been carried out at Newton Rigg, the Cumberland and Westmorland Farm School, under the supervision of the manager, Mr. W. T. Lawrence.

Soya cake is produced from soy or soya (soja) beans (from which some of the oil is extracted), which are now being extensively imported from Manchuria to this country.

Three cows and three heifers after their first calf were set apart on February 6th, 1909, for these trials, which continued for twelve weeks. They were all at an early stage of their lactation period at the commencement, and as the milk naturally declined in quantity as the trials progressed it was decided to feed soya cake during the first and last three weeks, and decorticated cotton cake during the middle six weeks. During the first six weeks swedes were used, and during the last six weeks mangels.

Each cow received daily:—49 lb. swedes (or 42 lb. mangels), 14 lb. hay and 7 lb. oat straw, 4 lb. crushed oats, and:—
4 lb. soya cake (for first and last three weeks).

4 lb. decorticated cotton cake (for middle six weeks).

The results were as follow:—

	Weight of Six cows.			Gallons of milk produced	Percentage of Butter fat.
	Cwt.	Qrs.	Lb.		Per cent.
At commencement	63	2	18	—	—
At end of first three weeks (soya cake)	63	1	8	315	3·7
At end of middle six weeks (dec. cotton cake)	63	2	21	527	3·9
At end of last three weeks (soya cake)	64	2	8	225	4·1

Effects of the cakes on quantity of milk produced.—

The total milk yield of six weeks (throughout the first and last three weeks), when they were receiving soya cake, was 5,575 lb., or an average of 22 1-8 lb. (equal to 2 1-7 gallons) per cow daily; while the total milk yield of the same cows during the middle six weeks when they were receiving decorticated cotton cake was 5,438 lb., or an average of 21 3-5 lb. (equal to 2 1-11 gallons) per cow daily. So far as milk production, therefore, is concerned there was a slight advantage in favour of soya cake, but this is so small that it may be considered that the two cakes were equal in this respect.

Effects of the cakes on the quality of milk produced.

—The milk of the cows that received soya cake contained 3·7 per cent. fat in the first three weeks and 4·1 per cent. fat in the last three weeks. This is equal to an average of 3·9 per cent. fat. The milk of the cows that received decorticated cotton cake in the middle six weeks contained on the average 3·9 per cent. fat. Both foods, therefore, have given the same results as far as the fat content of the milk is concerned.

Effects of the cakes on the live-weights of the cows.

—The cows lost weight to a slight extent in the early weeks of the trial, when they were giving the largest amounts of milk, but they gained in weight during the last weeks. On the average the cows each lost 6 1-3 lb. in weight during the first three weeks, but they gained 6 5-6 lb. each during the middle six weeks, and 16 1-2 lb. each during the last three weeks. The net results, therefore, are that each cow gained 10 1-6 lb. in live-weight during the six weeks they were receiving soya cake, and 6 5-6 lb. during the six weeks they were receiving decorticated cotton cake. The advantage in this respect is, therefore, slightly in favour of the soya cake.

The following analyses have been made by Mr. S. H. Collins, M.Sc., Lecturer in Agricultural Chemistry:—

					Decorticated cotton cake.	Soya cake.	Soya beans.
					Per cent.	Per cent.	Per cent.
Moisture	..	...	...	...	10·89	13·31	10·23
Oil	...	...	...	...	13·18	6·00	15·62
Albuminoids	...	...	...	...	39·94	44·37	37·54
Carbohydrates	...	...	...	...	24·72	25·04	27·27
Woody fibre	...	...	...	...	4·13	3·90	5·02
Ash	...	...	...	...	7·14	7·38	4·32
					100·00	100·00	100·00
Nitrogen	...	...	...	...	6·39	7·10	6·01
Sand	...	..	...	...	none	1·20	none

The above table gives the analyses of the decorticated cotton cake and the soya cake used in the trials at Newton Rigg. It will be seen that both of these foods have a high feeding value indicated by their analyses. The decorticated cotton cake is a good sample, as this contains on the average only about 9·5 per cent. of oil. The soya cake contains about 4·5 per cent. more albuminoids, but about 7 per cent. less oil than the decorticated cotton cake. The results of the analyses indicate that their value when fed to milch cows is about equal. The analysis of a sample of soy beans is also given in the above table, from which it will be seen that these contain 15·62 per cent. of oil before any of this has been extracted. From other analyses of soya beans it may be assumed that they contain on the average about 18 per cent. of oil and about 40 per cent. of albuminoids.

Soy, soja, or soya beans have been known in China and Japan for a considerable time. Soy (shoyu), the universal condiment in Japan, is prepared from soy beans, mixed in equal quantities with either wheat or barley. The British Oil and Cake Mills, Ltd., Hull, inform us that about 400,000 tons of these beans have been exported from Manchuria during the present year, of which about 325,000 tons have come to Britain, including about half of this quantity to Hull. The new crop has been roughly estimated at about 500,000 tons,

and shipments of it will commence in December. This year the first shipments reached this country about the end of February. Three qualities of these are now imported: the Sakura, which are said to be the best, being shipped from Dalny, the Harbin from Vladivostock, and the Hankow from Shanghai.

These beans have been used as a food for milch cows and for human consumption in China and Japan for a considerable time, and have there a high reputation as a feeding stuff. The beans now being imported into this country are a light yellow in colour, and are about the size of ordinary peas. In the United States black, green, and brown beans are known, as well as the yellow variety, and there the soy bean is largely used as a hay and forage, as well as a seed crop.

Professor Henry, of Wisconsin, in his book on *Feeds and Feeding*, states that at the Massachusetts Experiment Station a comparative test of soya bean meal with cotton seed meal terminated in favour of the former for milk and butter production.

Soya or soja meal is being sold in this country, which is soya beans from which the greater part of the oil has been extracted. This may contain as little as 1·5 per cent. of oil, while the albuminoids and other constituents are consequently increased.

Soya cake is now sold in the Newcastle district at about £6 15s. to £7 a ton. From the results of the foregoing trials and the analysis of the cake it seems to be a moderately-priced food when compared with the prices of other foods at the present time.

The expressed oil is used for edible purposes and soap-making.

Experiments with the Milk of Newly-Calved Cows.

(Reprinted from the *Journal of the Board of Agriculture*, December, 1907.)

BY DOUGLAS A. GILCHRIST.

During the summer of 1907 experiments with the milk of newly-calved cows were made at Offerton Hall. The main object was to ascertain the period after calving at which the milk of newly-calved cows may be sold as normal milk. This work was done at the request of the Board of Agriculture in connection with a question arising out of a prosecution for milk adulteration, the point being whether the liquid known as colostrum could properly be sold as milk. (See *Journal of the Board of Agriculture*, July, 1906, p. 249.)

Colostrum and "biestings" are the names usually given to the milk of newly-calved cows. Colostrum has a rich yellow colour and is considerably more viscid than ordinary milk. It is easily coagulated by heat, owing to the large amount of albumen it contains. Only a small amount of albumen is present in milk. Occasionally the colostrum is reddish in colour owing to the presence of blood.

COW No. 1.—CALVED 7TH MAY, 1907.

		Morning. Per cent.		First day. Noon. Per cent.		Evening. Per cent.
Water	... ..	78·46	...	79·46	...	79·76
Total solids	... ..	21·54	...	20·54	...	20·24
Albumen and casein	...	14·85	...	13·05	...	10·37
Milk sugar	... ..	1·81	...	2·37	...	2·80
Ash	... ..	1·13	...	1·16	...	1·24
Nitrogen	... ..	2·33	..	2·05	...	1·63
Specific Gravity	... ..	1·0635	...	1·0577	...	1·049

Samples of the milk of newly-calved cows were collected by Mr. J. McLaren, Junr., the superintendent of the station, and forwarded to Mr. S. H. Collins, M.Sc., F.C.S., Lecturer in Agricultural Chemistry at Armstrong College. The results of Mr. Collins's analyses of these milks are given in the tables annexed.

The foregoing figures give a good idea of the composition of colostrum for the first whole day after calving. On the average, normal milk contains about the following:—Water, 87 per cent.; casein, 3 per cent.; albumen, 4 per cent.; milk sugar, 4.75 per cent.; fat, 3.6 per cent.; and ash, .75 per cent. The average specific gravity of milk is 1.032. In all Mr. Collins's results the fat was very irregular and the results with this constituent were worthless to further the objects of this enquiry. The high total amount of albumen and casein is entirely due to abnormal albumen, while milk sugar is considerably under, and ash considerably over, the average.

In the following cases the determinations were continued until the sixth or seventh days after calving. The mixed milk is a mixed sample of the two or three milkings of one day. The following contractions are used: M, morning; N, noon; E, evening:—

COW No. 2.—CALVED 20TH MAY, 1907.

	First day.			Second day. Mixed.	Thrd day. Mixed.	Fourth day. Mixed.	Fifth day. Mixed.	Sixth day. Mixed.
	M.	N.	E.					
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Water ...	77.70	82.32	83.68	—	—	—	—	—
Total solids ...	22.30	17.68	16.32	—	—	—	—	—
Albumen and casein	17.50	12.14	10.34	7.40	5.87	5.23	4.53	4.27
Milk sugar ...	1.64	3.22	3.81	3.75	4.40	4.87	4.25	4.28
Ash ...	0.48	0.96	0.68	—	—	—	—	—
Nitrogen ...	2.78	1.90	1.62	1.16	0.92	0.82	0.71	0.67
Specific gravity	1.0682	1.0553	1.0523	1.0470	1.0397	1.0384	1.0385	1.0375

COW No. 3.—CALVED 20TH MAY, 1907.

—	First day.	Second day.		Third day.	Fourth day.	Fifth day.	Sixth day.	Seventh day.
	E.	M.	E.	Mixed.	Mixed.	Mixed.	Mixed.	Mixed.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Water ...	73·48	80·06	82·40	—	—	—	—	—
Total solids ..	26·52	19·94	17·52	—	—	—	—	—
Albumen and casein ..	17·41	11·98	8·36	6·25	5·10	4·98	4·27	4·21
Milk sugar ...	1·76	2·30	3·20	3·57	2·69	4·03	3·50	3·87
Ash ...	0·86	0·68	0·90	—	—	—	—	—
Nitrogen ...	2·73	1·87	1·31	0·98	0·80	0·78	0·67	0·66
Specific gravity	1·0615	1·0470	1·0402	1·0368	1·0323	1·0328	1·0332	1·0335

COW No. 4.—CALVED 28TH MAY, 1907.

—	First day.	Second day.			Third day.	Fourth day.	Fifth day.	Sixth day.	Seventh day.
	E.	M.	N.	E.	Mixed.	Mixed.	Mixed.	Mixed.	Mixed.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Albumen and casein	16·84	16·02	12·12	14·54	5·48	4·91	4·08	3·83	3·57
Milk sugar	1·72	2·73	3·11	3·03	4·19	3·72	3·57	3·82	4·31
Nitrogen...	2·64	2·51	1·90	2·28	0·84	0·77	0·64	0·60	0·56
Specific gravity ...	1·0720	1·0560	1·0495	1·0550	1·0382	1·0400	1·0318	1·0365	1·0365

COW No. 5.—CALVED 31ST MAY, 1907.

—	First day.		Second day.			Third day.	Fourth day.	Fifth day.	Sixth day.	Seventh day.
	N.	E.	M.	N.	E.	Mixed.	Mixed.	Mixed.	Mixed.	Mixed.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Albumen & casein	23·47	22·01	19·65	15·31	8·29	6·70	4·40	4·27	4·15	4·08
Milk sugar ...	0·73	1·10	1·48	2·44	2·01	3·60	4·25	4·86	4·24	4·25
Nitrogen	3·68	3·45	3·08	2·40	1·30	1·05	0·69	0·67	0·65	0·64
Specific gravity	1·0740	1·0720	1·0685	1·0585	1·0625	1·0418	1·0365	1·0398	1·0377	1·0367

From the foregoing figures it will be seen that in the first milk taken after calving the percentage of albumen and casein varies from about 15 to about 23 per cent., by far the larger amount of this being albumen. These soon become reduced in quantity. On the fourth day they are on the average only a little under 1 per cent. over the seventh day. Another constituent—milk sugar—was present in the first of all the milkings to less than half the normal amount, being considerably under 2 per cent. This had increased to the normal, however, in all cases but one after the third day. The specific gravity was in all cases abnormally high in the first milkings, but by the end of the third day this comes within the limits of normal milk. The ash constituents vary considerably at first but they also soon become normal.

VARIATIONS IN PERCENTAGES OF ALBUMEN AND CASEIN.

Cow.	First day.			Second day,			Third day. Mixed.	Fourth day. Mixed.	Fifth day. Mixed.	Sixth day. Mixed.	Seventh day. Mixed.
	M.	N.	E.	M.	N.	E.					
No. 1 ...	14·85	13·05	10·37	—	—	—	—	—	—	—	—
No. 2 ...	17·50	12·14	10·34	—	7·40	—	5·87	5·23	4·53	4·27	?
No. 3 ...	—	—	17·14	11·93	—	8·36	6·25	5·10	4·98	4·27	4·21
No. 4 ...	—	—	16·84	16·02	12·12	14·54	5·48	4·91	4·08	3·83	3·57
No. 5 ...	—	—	22·01	19·65	15·31	8·29	6·70	4·40	4·27	4·15	4·08
Average	15·77			12·62			6·07	4·93	4·46	4·13	3·95

VARIATIONS IN PERCENTAGES OF MILK SUGAR.

Cow.	First day.			Second day.			Third day. Mixed.	Fourth day. Mixed.	Fifth day. Mixed.	Sixth day. Mixed.	Seventh day. Mixed.
	M.	N.	E.	M.	N.	E.					
No. 1 ...	1·81	2·37	2·80	—	—	—	—	—	—	—	—
No. 2 ...	1·64	3·22	3·81	—	3·75	—	4·40	4·87	4·25	4·28	?
No. 3 ...	—	—	1·76	2·30	—	3·20	3·57	2·69	4·03	3·50	3·87
No. 4 ...	—	—	1·72	2·73	3·11	3·03	4·19	3·72	3·57	3·82	4·31
No. 5 ...	—	0·73	1·10	1·48	2·44	2·01	3·60	4·25	4·86	4·24	4·58
Average	2·10			2·67			3·94	3·88	4·18	3·96	4·14

Albumen, casein, and milk sugar are the most abnormal constituents of the milk of newly-calved cows, and the tables on the previous page show how these constituents vary during the first seven days.

From the foregoing figures it will be seen that the casein and albumen are 12 per cent. above the normal on the first day and on the third day are only $2\frac{1}{2}$ per cent. above the normal. The latter would be even less if all the cows had calved on the morning of the first day. The milk sugar also has practically reached the normal on the third day. There are certain characteristics of the milk of newly-calved cows which do not disappear for a few weeks, but these affect the milk to a very slight extent and do not interfere with its use for all practical purposes. These results can be seen at a glance in the following diagram:—

THE UPPER LINE SHOWS THE AVERAGE PERCENTAGE OF ALBUMEN AND CASEIN, THE LOWER LINE THE PERCENTAGE OF MILK SUGAR.

It may fairly be assumed, as a result of these and other investigations, that the milk of newly-calved cows may be used for all ordinary purposes at the end of three complete days from calving, provided the milk is then free from blood and is apparently normal.

The popular opinion that "colostrum" or "biestings" is unwholesome is quite an erroneous one. Excellent "biestings" cheeses have been for long and are still made in some of our rural districts, the simple heating of this milk being sufficient to coagulate it into a cheesy condition. These cheeses will keep for a short time only. These, as well as various puddings and cheese-cakes prepared from this milk, are nutritious and palatable. It should not be so used, however, if the milk is at all tinged with blood.

Composition and Manurial Values of Foods.

COMPILED BY DOUGLAS A. GILCHRIST.

The following table shows the different constituents of foods and their relation to each other. The ash constituents are required for the formation of bone and to supply the salts of the blood. The albuminoids (proteids) are necessary for the formation of flesh, while they also produce fat, heat and force. Fats and carbo-hydrates produce heat, force and fat. Albuminoids and fats are the most valuable constituents of foods.

Table A gives the average composition of the more common feeding stuffs of the farm. The composition of all the more common farm foods used in the North of England is taken from the average of Mr. Collins' analyses. He has

TABLE A.—APPROXIMATE AVERAGE COMPOSITION OF VARIOUS KINDS OF FOODS.

	I.	II.	III.	IV.	V.	VI.	VII. VIII. IX. X. XI.				
	Water.	Ash.	Albuminoids (including amides.)	Carbo- hydrates.	Fibre.	Fat.	Digestible constituents.				
	%	%	%	%	%	%	Albumi- noids.	Carbo- hydrates.	Fibre.	Fat.	Nutritive ratio 1:—
Linseed (3) ...	11.0	4.0	22.0	22.0	7.2	34	20	12.1	4.3	29.2	5.3
Linseed cake (1) ...	13	5.5	32	32	7.0	11	27.5	25.6	3.5	9.9	1.9
Cotton seed (3) ...	10.3	3.5	18.4	24.7	23.2	19.9	12.5	12.4	17.4	17.3	5.8
Cotton cake (decorti- cated) (1) ...	9.0	6.7	43	24	6	11	38	18.2	2.4	10.4	1.2
Egyptian cotton cake (undecorticated) (1)	14.5	5.0	23	32.5	19.5	5.5	17.0	16.6	3.1	5.0	1.9
Indian cotton cake (undecorticated) (1)	14.0	5.5	19	35	21	4.5	14.1	17.8	3.4	4.1	2.2
Rape cake (2) ...	10.4	7.7	33	29	10.3	9.8	21	24		8	2.1
Soya cake (1) ...	13.3	7.4	44.4	25	3.9	6.0	38.6	19.0	1.6	5.7	0.9
Bean meal (2) ...	14	3.2	25	48	7.1	1.5	22	44.2	5.1	1.2	2.2
Pea meal (2) ...	14	2.8	22	54	5.4	1.6	19.6	50.2	3.6	1.2	2.8
Soya beans (3) ...	10.8	4.7	34	28.8	4.8	16.9	25.8	23.3	2.9	10.0	1.9
Wheat (2) ...	13.4	1.8	12.0	69	1.9	1.9	9.2	64	1.1	1.6	7.5
Barley (2) ...	14.3	2.5	10.6	66	4.5	2.1	7.4	60.7	2.5	1.9	9.3
Oats (2) ...	13	3.0	11.3	57.3	10.0	5.4	8.8	44.1	2.6	4.5	6.7
Rice meal (2) ...	10.3	9.0	12.3	47.8	8.6	12.0	7.7	41.1	2.2	10.2	8.9
Maize meal (1) ...	16	1.4	9	67	1.7	4.5	6.8	62.3	1.0	3.9	10.7
Bran (2) ...	13.2	5.8	14.1	56	7.2	3.7	11.0	42.6	2.2	2.7	5.0
Clover hay (good) (2)	16	6.3	13	37	25	2.5	8.3	26	11.7	1.5	5
Meadow hay (North of England) (1) ...	12	7	8.8	46	26	?	5.0	29.4	15.6	?	9
Seeds hay (North of England) (1) ...	11	8	11.3	44	25	?	6.4	28.2	15	?	6.8
Bean straw (2) ...	18.4	5.4	8.1	31	36	1.1	4.0	21	15	0.6	9.4
Pea straw (2) ...	13.6	6.6	9.0	34	35	1.6	5.4	21.8	18.2	0.74	7.8
Oat straw (1) ...	12.7	5.0	2.9	41.8	37.6	?	9	18.4	20.3	?	43
Wheat straw (2) ...	13.6	5.3	3.3	39	37	1.3	0.36	15.8	19.2	0.4	100
Barley straw (2) ...	14.2	5.7	3.5	39	36	1.5	0.7	21	20.1	0.6	60.1
Pasture grass (2) ...	76.7	2.3	4.0	10.9	5.2	0.9	2.9	8.4	3.6	.6	4.6
Silage from pasture grass (2) ...	67	3.8	4.8	13.2	9.7	1.5	?	?	?	?	?
Brewers' grains (wet) (2) ...	76.2	1.2	4.9	10.7	5.1	1.7	3.4	6.7	2.0	1.4	3.6
Brewers' grains (dry) (2) ...	9.5	4.7	20.6	42	16	7.0	16.3	24.4	8.3	6.4	3.0

The source of the above figures may be ascertained by the figures in brackets at the side of each food.

- (1) From analysis by Mr. S. H. Collins.
- (2) Warrington's Chemistry of the Farm.
- (3) Jordan's Feeding of Animals.
- (4) McConnell's Agricultural Note Book.

TABLE A.—APPROXIMATE AVERAGE COMPOSITION OF VARIOUS KINDS OF FOODS.—*Continued.*

	I. Water.	II. Ash.	III. Albuminoids (including amides).	IV. Carbo- hydrates.	V. Fibre.	VI. Fat.	VII. VIII. IX. X. XI. Digestible constituents.				
							Albumi- noids.	Carbo- hydrates.	Fibre.	Fat.	Nutritive ratio 1:—
Potatoes (2)	% 75	% 1.0	% 2.1	% 21	% 0.7	% 0.2	% 1.4	% 19.5	% 0.6	% 0.2	15
Carrots (2)	87	1.0	1.2	9.3	1.3	0.2	1.2	9.1		0.2	8
Mangels (2)	88	1.0	1.1	9.0	1.0	0.1	.7	8.6	0.8	0.1	14
Swedes (1)	88	0.8	1.2	9.0	1.1	0.2	.7	8.5	.9	.2	14
Turnips (1)	91	0.7	1.0	5.7	0.9	0.2	.6	5.4	.7	.2	11
Cabbages (2)	86	1.6	2.5	8.1	2.4	0.7	1.8	7.9		.35	4.9
Rape (3)	85	2	2.3	8.4	2.6	0.5	1.6	6.71		.34	4.8
Red clover (full flower) (4)	78	1.7	3.2	9.5	6.8	0.8	1.8	9.6		.5	6
Red clover (before flowering)	83	1.5	3.3	7.0	4.5	0.7	2.3	7.4	2.4	.5	4.8
Vetches (in flower) (4)	82	1.8	3.5	6.6	5.5	0.6	2.5	6.7		0.3	3.0

The source of the above figures may be ascertained by the figures in brackets at the side of each food.

- (1) From analysis by Mr. S. H. Collins.
- (2) Warington's Chemistry of the Farm.
- (3) Jordan's Feeding of Animals.
- (4) McConnell's Agricultural Note Book.

found that these usually differ considerably from the averages given in reference books. In practically all cases his averages are arrived at from large numbers of analyses. Columns i.—vi. show the composition of the principal foods; columns vii.—x. show the amount per cent. of the valuable constituents of the different foods which are actually digested by ruminants, as proved by German and American investigations. These are known as the digestible constituents. These figures not only vary with the different classes of animals, but also with individuals of the same class. The digestibility of food varies with the composition and especially with its condition, a musty or bad-conditioned food being of far less nutritive value. Any food also varies in digestibility with the character and amounts

of other foods fed with it. Column iii. gives the total nitrogen reckoned as albuminoid nitrogen. Column vii. gives the total nitrogen reckoned as albuminoid nitrogen which is actually digested. Column xi. gives the nutritive ratio, or the ratio of digestible albuminoids to the digestible carbo-hydrates, fibre, and fat.

The nutritive ratio is arrived at by multiplying the digestible fat in column x. by 2.5 (1 lb. fat being equivalent to about 2.5 lb. of carbo-hydrates), this product being added to the sum of the digestible carbo-hydrates and fibre in columns viii. and ix. The sum thus obtained is divided by the amount of digestible albuminoids in column vii., and the result is the nutritive ratio.

The nitrogen present in foods is not all in the albuminoid form. In mature foods, however, most of the nitrogen is in this form. In young grass about one-quarter, and in roots about one-half of the nitrogen present is non-albuminoid, and hence not so valuable for feeding purposes. Potatoes have about 60 per cent. and mangels about 40 per cent. of their nitrogen in the albuminoid form.

It should be explained here that the albuminoid ratio is obtained by adding the total fats, multiplied by 2.5 to the total soluble carbo-hydrates (the fibre being omitted in this case), and dividing the sum by the total nitrogen reckoned as albuminoids. The true albuminoid ratio is obtained in the same way, except that only the true albuminoid nitrogen is reckoned as albuminoids.

The total nitrogen in a food multiplied by 6.25 gives approximately the total nitrogen reckoned as albuminoids.

How the digestible constituents are calculated.—

These are obtained from the results of elaborate feeding experiments with ruminants,* the amount of each constituent actually

* Ruminants include cattle and sheep. Horses have considerably less power than these to digest bulky fodders containing large amounts of fibre, and such foods are quite unsuitable for pigs. Foods rich in fat are not suitable for horses, and they digest this only to a limited extent.

TABLE B.—FEEDING STANDARDS OR REQUIREMENTS PER
DAY BY DIFFERENT ANIMALS.

	I.	II.	III.	IV.	V.	VI.
	Total organic substances.	Digestible constituents.			Total digestible substances.	Nutri- tive Ratio 1:—
		Album- inoids.	Carbo- hydrat's	Fat.		
Per 1,000 lb. live-weight :—	Lb.	Lb.	Lb.	Lb.	Lb.	
Cattle at rest in stall	18	0·7	8·0	0·1	8·8	11·8
Sheep, long wool	20	1·2	10·5	0·2	11·9	9·1
Do. short wool	23	1·5	12·0	0·3	13·8	8·5
Horses moderately worked	24	2·0	11·0	0·6	13·6	6·2
Do. heavily worked	26	2·5	13·3	0·8	16·6	6·0
Milch cows, with daily milk yield of 16½ lb.	27	2·0	11·0	0·4	13·4	6·0
Milch cows, with daily milk yield of 27½ lb.	32	3·3	13·0	0·8	17·1	4·5
Fattening oxen, first period	30	2·5	15·0	0·5	18·0	6·5
Do. second period	30	3·0	14·5	0·7	18·2	5·4
Do. third period	26	2·7	15·0	0·7	18·4	6·2
Fattening sheep, first period	30	3·0	15·0	0·5	18·5	5·4
Do. second period	28	3·5	14·5	0·6	18·6	4·5
Fattening swine, first period	36	4·5	25·0	0·7	30·2	5·9
Do. second period	32	4·0	24·0	0·5	28·5	6·3
Do. third period	25	2·7	18·0	0·4	21·1	7·0
Growing cattle (beef breeds)—						
Age in months. Average live-weight.						
2—3 ... 165 lb.	23	4·2	13·0	2·0	19·2	4·2
6—12 ... 550 lb.	25	2·5	13·2	0·7	16·4	6·0
18—24 ... 935 lb.	24	1·8	12·0	0·4	14·2	7·2
Growing cattle (dairy breeds)—						
2—3 ... 150 lb.	23	4·0	13·0	2·0	21·0	4·5
6—12 ... 500 lb.	27	2·0	12·5	0·5	15·0	6·8
18—24 ... 900 lb.	26	1·5	12·0	0·3	13·8	8·5
Growing sheep (wool breeds)—						
4—6 ... 60 lb.	25	3·4	15·4	0·7	19·5	5·0
8—11 ... 85 lb.	23	2·1	11·5	0·5	14·1	6·0
15—20 ... 100 lb.	22	1·5	10·8	0·3	12·6	7·7
Growing sheep (mutton breeds)—						
4—6 ... 65 lb.	26	4·4	15·5	0·9	20·8	4·0
8—11 ... 100 lb.	24	3·0	14·3	0·5	17·8	5·2
15—20 ... 150 lb.	22	2·0	12·0	0·4	12·4	6·5
Growing swine (breeding stock)—						
3—5 ... 100 lb.	35	5·0	23·1	0·8	28·9	5·0
6—8 ... 175 lb.	28	2·8	18·7	0·3	21·8	7·0
Growing fattening pigs—						
2—3 ... 45 lb.	44	7·6	28·0	1·0	35·7	4·0
5—6 ... 150 lb.	33	4·3	22·3	0·6	27·2	5·5

digested varying considerably with the kind of food. Of the total organic matter there is on the average about 85 per cent. digestible in concentrated foods (cakes and meals) and in roots. Uncorticated cotton cake and brewers' grains are considerably, and oats and bran rather, less digestible. Of the various food constituents the fibre is naturally the least nutritive, although large proportions of this, especially in the best concentrated foods and in green foods, are actually digested.

Comparative values of foods.—Endeavours have been made to attach comparative values to carbo-hydrates, albuminoids, and fats, and so arrive at a method of comparing the commercial values of foods. One method suggested is to value the units as follows:—Digestible carbo-hydrates and fibre, 1s.; do. albuminoids, 2s. 6d.; do. fat, 2s. 6d. As, however, each of these varies greatly in commercial value in different foods, and as no satisfactory standard of comparison can be made, the systems of valuing foods according to "food units" are generally considered unreliable.

Table B shows the amount of digestible substances required per day by different classes of animals as determined by Dr. Wolff.

Example of a daily ration.—The following ration contains the daily requirements of a dairy cow, of about 1,000 lb. live weight, and giving $27\frac{1}{2}$ lb. of milk daily. The amounts of digestible ingredients are obtained in each case by multiplying the percentages of those contained in each food by the number of pounds of the same fed to the animal daily, and dividing the product by 100.

This ration comes near the standard, as is shown by comparing the figures in the two last lines. The digestible carbo-hydrates and fibre, as well as the fat, are rather high, but are quite near enough for practical purposes. The elaborate feeding experiments which have been made at Cockle Park and at Offerton Hall have all tended to show the approximate correct-

DAILY RATION FOR MILCH COW.

	Digestible constituents.				Nutritive ratio 1:—
	Album-inoids.	Soluble carbo-hydrates.	Fibre.	Fat.	
Swedes 42 lb.	·29	3·57	·38	·08	
Oat straw 17 lb.	·16	3·13	3·45	?	
Decorticated cotton cake 6 lb.	2·28	1·09	·14	·62	
Indian cotton cake ... 4 lb.	·57	·71	·14	·17	
Totals ...	3·30	8·50	4·11	·87	4·48
		12·61			
Feeding standard for a milch cow, 1,000 lb. live-weight, giving 27½ lb. of milk daily ...	3·30	13·00		·80	4·5

ness of the foregoing feeding standards; while the Offerton results distinctly indicate that when these are exceeded neither the feeding nor milking returns are satisfactory. At the same time there are indications from feeding experiments in this country and in America that the proportion of albuminoids may frequently be lower with equally good results.

In Table C nitrogen is valued at 12s., phosphoric acid at 3s., and potash at 4s., all per unit. One unit is equal to one per cent. of one ton (22½ lb.). Half the nitrogen, three-quarters of the phosphoric acid, and all the potash are valued in the full manurial values given on the table, these proportions being considered as the average amounts of the manurial constituents reaching the land in the dung. It should be explained that a great waste of nitrogen takes place owing to more than half the nitrogen (and this of the most valuable character) in the food passing off in the urine and the great difficulty of anything like completely conserving this in the dung, and also that in growing animals, and with animals producing milk, a considerable amount of the phosphoric acid is not returned in the dung.

The full manurial values are allowed when no crop has been taken from the dung, and half, one-quarter, and one-eighth respectively, when one, two, and three crops have been taken.

A limit of four years was decided on by Voelcker and Hall, after a full review of evidence that any manures applied to a first crop of a four years' rotation are, as a rule, nearly exhausted by that time. They also came to the conclusion that the unexhausted value should decrease by one-half each year, as the earlier crops of the rotation receive the greatest benefit from the manurial constituents applied to the first crop. The elaborate rotation experiments made by this College fully bear out these conclusions. (See College Bulletin No. 4.)

TABLE C.—MANURIAL VALUE OF FEEDING STUFFS.

(Extracted from article by Voelcker and Hall in Journal of Royal Agricultural Society, 1902.)

No.	Foods.	Percentage of			Full manurial value per ton of food consumed.
		Nitrogen.	Phosphoric acid.	Potash.	
1	Decorticated cotton cake ...	6.90	3.10	2.00	56/5
2	Undecorticated cotton cake*	3.54*	2.00	2.00	33/9*
3	Linseed cake ...	4.75	2.00	1.40	38/7
4	Linseed ...	3.60	1.54	1.37	30/6
5	Palm nut cake ...	2.50	1.20	0.50	19/8
6	Cocoa nut cake ...	3.40	1.40	2.00	31/6
7	Rape cake ...	4.90	2.50	1.50	41/1
8	Beans ...	4.00	1.10	1.30	31/8
9	Peas ...	3.60	0.85	0.96	27/4
10	Wheat ...	1.80	0.85	0.53	14/10
11	Barley ...	1.65	0.75	0.55	13/9
12	Oats ...	2.00	0.60	0.50	15/5
13	Maize ...	1.70	0.60	0.37	13/-
14	Rice meal ...	1.90	0.60	0.37	14/3
15	Locust beans ...	1.20	0.80	0.80	12/2
16	Malt ...	1.82	0.80	0.60	15/2
17	Malt combs ...	3.90	2.00	2.00	35/11
18	Bran ...	2.50	3.60	1.45	28/11
19	Brewers' grains (dried) ...	3.30	1.61	0.20	24/3
20	Brewers' grains (wet) ...	0.81	0.42	0.05	6/-
21	Clover hay ...	2.40	0.57	1.50	21/9
22	Meadow hay ...	1.50	0.40	1.60	16/4
23	Wheat straw ...	0.45	0.24	0.80	6/5
24	Barley straw ...	0.40	0.18	1.00	6/9
25	Oat straw ...	0.50	0.24	1.00	7/7
26	Mangels ...	0.22	0.07	0.40	3/1
27	Swedes ...	0.25	0.06	0.22	2/6
28	Turnips ...	0.18	0.05	0.30	2/4

* The figures given above apply to Egyptian cotton cake. Indian (Bombay) cotton cake contains rather less nitrogen, and its full manurial value is only 31/- per ton.

Rations for Fattening Cattle and Milch Cows.

The following rations have been carefully calculated as far as possible from average foods as grown in the North of England. The following are taken as being practically equivalents of each other:—

It has been found that 33 lb. of average swedes, or 44 lb. of average yellow turnips, contain practically the same feeding constituents as $2\frac{1}{2}$ lb. maize meal and 4 lb. oat straw.

It has also been found that 3 lb. maize meal contain practically the same feeding constituents as 5 lb. meadow hay of average quality grown in the North of England. Hay of the best quality and with a considerable amount of clover, has a considerably higher feeding value than is indicated by the foregoing, and on the other hand, hay of low quality has a considerably less feeding value.

Seeds hay has on the average a slightly higher value than meadow hay. It may be considered that, on the average of North of England samples, $4\frac{1}{2}$ lb. of seeds hay has about the same feeding value as 5 lb. of meadow hay. This also varies greatly in feeding value.

In November, 1903, the price of maize was 21s. 6d. a quarter of 480 lb. (£5 0s. 4d. a ton), while hay was selling in Northumberland at about £5 a ton. In October, 1908, maize was 30s. a quarter of 480 lb. (£7 a ton), while hay was under £4 a ton. From these figures and the foregoing equivalents it will be seen that it was profitable to sell hay from the farm in 1903 and buy maize or other meal, whereas at the present time this is not so, or in other words it is now advisable to make full use of the hay growing on the farm for feeding

purposes as far as possible, and to use maize or corn to the least extent possible. Oats can practically be substituted for maize or barley, but the former contain rather more albuminoids and less carbohydrates.

Barley or wheat meal may be considered as practically equivalent in feeding value to maize meal.

Bean and pea meal have a high feeding value, especially for milch cows. It may practically be assumed that 2 lb. of either of these can be substituted for 3 lb. of either Indian or Egyptian cotton cake, although from their chemical composition, these are not quite exact equivalents.

Oat straw varies even more in feeding value than meadow hay and seeds hay, but on the average it may be considered that $7\frac{1}{2}$ lb. meadow hay are practically equal to $7\frac{1}{2}$ lb. oat straw + $\frac{2}{3}$ lb. decorticated cotton cake and $\frac{1}{3}$ lb. Indian cotton cake.

A.—DAILY RATIONS FOR FATTENING CATTLE.

The following daily rations are calculated per 1,000 lb. live-weight (practically 9 cwt.). If the live-weights of the cattle are greater or less, the rations should be increased or diminished in proportion, as feeding experiments have amply shown that the amount of the daily rations should vary directly with the live-weight of the animal.

No. 1.—WITH FULL RATION OF ROOTS.

66 lb. swedes (or 88 lb. yellow turnips).	4 lb. maize meal.
2 lb. undec. cotton cake.	12 lb. meadow hay.
3 lb. dec. cotton cake.	

No. 2.—WITH HALF RATION OF ROOTS.

33 lb. swedes (or 44 lb. yellow turnips).	3 lb. dec. cotton cake.
$2\frac{1}{2}$ lb. maize meal	} as substitute for 4 lb. maize meal.
4 lb. oat straw	
	half roots.
2 lb. undec. cotton cake.	12 lb. meadow hay.

No. 3.—As No. 1, WITH MORE HAY AND LESS MAIZE.

66 lb. swedes (or 88 lb. yellow turnips).	1 lb. maize meal.
2 lb. undec. cotton cake.	17 lb. meadow hay.
3 lb. dec. cotton cake.	

No. 4.—As No. 3, WITH OAT STRAW INSTEAD OF HAY.

66 lb. swedes (or 88 lb. yellow turnips).	1 lb. maize meal.
4½ lb. dec. cotton cake.	17 lb. oat straw.
2¾ lb. undec. cotton cake.	

(To make oat straw equivalent to meadow hay 1½ lb. dec. cotton cake and ¾ lb. undec. cotton cake are added to make up the deficiency of the oat straw).

From the information as to feeding equivalents given above it will be found comparatively easy to make up rations with other kinds of foods. Water is needed with all the foregoing foods.

It may be advantageous to slightly improve the ration in the last week or two of the feeding period.

B.—DAILY RATIONS FOR MILCH COWS.

The following rations for milch cows are calculated per 10 cwt. and not per 1,000 lb. live-weight, as it is probable that 10 cwt. is about the average live-weight of good milch cows in the North of England. For cows of a greater or less weight than 10 cwt. the feeding rations should be increased or decreased in direct proportion to their weights, provided the quantity of milk given is also greater or less in the same proportion.

No. 1.—RATION FOR COWS GIVING 18½ LB. OF MILK (ROUGHLY 1½ GALLONS) PER DAY.

Quantities for cows 9 cwt. live-weight and giving 16½ lb. of milk daily are given within brackets.

39 lb. swedes or 52 lb. yellow turnips (35 lb. or 47 lb.).
19 lb. oat straw (17 lb.).
4¾ lb. decorticated cotton cake (4¼ lb.).

Roughly speaking, 1 lb. less of decorticated cotton cake might be given if the yield is 12½ lb. of milk daily instead of 18½ lb. daily.

NO. 2.—RATION FOR COWS GIVING $30\frac{1}{2}$ LB. OF MILK (ROUGHLY
3 GALLONS) PER DAY.

Quantities for cows 9 cwt. live-weight and giving $27\frac{1}{2}$ lb. of milk daily are given within brackets.

46½ lb. swedes or 62 lb. yellow turnips (42 lb. or 56 lb.).

19 lb. oat straw (17 lb.).

6¾ lb. decorticated cotton cake (6 lb.).

4½ lb. undec. cotton cake (4 lb.).

NO. 3.—AS FOR NO. 2, WITH HAY INSTEAD OF OAT STRAW.

Quantities for cows 9 cwt. live-weight and giving $27\frac{1}{2}$ lb. of milk daily are given within brackets.

46½ lb. swedes or 62 lb. yellow turnips (42 lb. or 56 lb.).

19 lb. meadow hay (17 lb.).

5 lb. decorticated cotton cake (4½ lb.).

3⅔ lb. Indian cotton cake (3¼ lb.).

Heavy milkers, giving about 4 gallons of milk daily, should have all the foods of the best quality possible, and could receive an addition like one of the following to that of Ration No. 3:—

2 lb. seeds hay.	} or }	2 lb. linseed cake.
2 lb. linseed cake.		2½ lb. maize meal.
1 lb. maizé meal.		

Ration No. 1 might also have hay substituted for oat straw, and if so the decorticated cotton cake could be reduced by about 2 lb. daily. This, however, is not quite an exact equivalent.

Any of these rations can have the roots considerably reduced by using a substitute for roots, as indicated at the beginning of this section.

Cows giving reduced quantities of milk as the lactation period progresses should have the concentrated food given to them reduced, but cows that are heavy milkers and have become reduced in condition, owing to their heavy milk yields, must not have the food reduced too quickly, to allow them to regain condition before coming to the next calving.

When cows are to be fattened off at the close of their milking periods, the ration should not be reduced as indicated above, but should have the ration gradually altered to that suitable for fattening animals as the flow of milk decreases.

Cows of 10 cwt. live-weight, dried off previous to calving, would probably do well with either of the following rations:—

Quantities for cows of 9 cwt. live-weight are given within brackets.

No. 1.—39 lb. swedes or 52 lb. yellow turnips (35 lb. or 47 lb.).

19 lb. oat straw (17 lb.).

$2\frac{3}{4}$ lb. maize meal ($2\frac{1}{2}$ lb.).

$2\frac{1}{2}$ lb. decorticated cotton cake ($2\frac{1}{4}$ lb.).

No. 2.—39 lb. swedes or 52 lb. yellow turnips (35 lb. or 47 lb.).

19 lb. meadow hay (17 lb.).

$2\frac{1}{4}$ lb. maize meal (2 lb.).

$\frac{3}{4}$ lb. decorticated cotton cake ($\frac{1}{4}$ lb.).

Additional water should be given to that contained in any of the foregoing rations, so that in all cases the cows should have access to water.

Calf Rearing at Newton Rigg.

BY W. T. LAWRENCE.

The County Council of Cumberland have been in possession of Newton Rigg for $13\frac{1}{2}$ years, during which time 265 calves have been born, all except eight of which have been reared successfully. These have been hand fed from birth, and with as little new milk as possible. Trial has been made of various substances as cream substitutes to be used with separated milk, those proving most successful being (1) ground linseed and flour porridge, and (2) cod-liver oil. Calves have also been fairly well reared by means of a calf meal instead of separated milk, to meet the case of milk-selling farms, and of whey and meal for use on cheese-making farms.

General principles.—(1) Calves should be fed with great regularity.

(2) Dietary changes should be brought about gradually.

(3) A dry and comfortable bed should always be available, and this is best secured by a bottom layer of moss litter (an inch or so) covered with straw.

(4) If at any time a calf hesitates to take its milk, at once remove the milk, and administer a tablespoonful of castor oil shaken up with twice as much hot water; this generally sets matters right, even when "white scour" is commencing.

I.—DIETARY FOR BUTTER-MAKING FARMS.

1st Week—Own mother's warm milk 3 times a day, commencing with a quart and increasing to 2 quarts.

2nd Week—2 quarts of warm new milk 3 times a day.

- 3rd Week*—2 pints of new and 3 pints of skim (or separated) milk three times a day, with half a pint of linseed porridge* or half a tablespoonful of cod liver oil.
- 5th Week*—3 quarts of warm skim milk three times a day, with one pint of linseed porridge or one tablespoonful of cod liver oil; a little sweet meadow hay increased week by week.
- 9th Week*—Mid-day milk and cream substitute omitted. 5 quarts of separated milk morning and evening, a handful of broken linseed cake at mid-day, and hay.
- 13th Week*—Milk as before; $\frac{3}{4}$ lb. linseed cake and crushed oats; $\frac{1}{2}$ gallon pulped swedes (green meat in summer) gradually increasing; hay *ad lib.*
- 21st Week*—Milk as before; 1 pound mixed linseed cake and crushed oats, and increasing quantities of roots and hay.
- 24th Week*—Evening milk discontinued.
- 27th Week*—Milk discontinued altogether.

CREAM SUBSTITUTES.

**Linseed Porridge*—Dust 7 parts of linseed with 1 part of Indian meal, and grind in an ordinary mill. Scald at the rate of one quart of this meal and a teacupful of flour with a gallon of boiling water.

Cod Liver Oil—The genuine article used as recommended in the above dietary table answers admirably; the warm milk and oil should be poured backwards and forwards just before serving to emulsify the oil. Cod liver oil is liable to be adulterated with fish oil or to be so badly refined as to be full of dregs; the eight calves referred to above as having died, were lost in two groups of four each, nearly two years apart, and with similar symptoms, all pointing to ptomaine poisoning from putrifying matter in the oil.

II.—DIETARY FOR MILK-SELLING FARMS.

Milk Substitute—14 parts of linseed cake meal.

5 parts of ground linseed.

2 parts of wheat flour.

2 parts of locust bean meal.

To be scalded at the rate of 3 pounds of the meal with 5 quarts of boiling water; add a sprinkle of salt.

1st Week—Mother's milk only.

2nd and 3rd Weeks—3 pints new milk and 1 pint of the gruel, 3 times a day.

4th and 5th Weeks—2 pints new milk and 2 pints of the gruel, 3 times a day.

6th and 7th Weeks—1 pint new milk and 3 pints of the gruel, 3 times a day.

8th and following Weeks—2 quarts of gruel and no new milk, 3 times a day.

Hay is introduced at the 5th week as with other calves.

III.—DIETARY FOR CHEESE-MAKING FARMS.

1st and 2nd Weeks—New milk only.

3rd and 4th Weeks—3 quarts of new milk and half of the whey and porridge recommended for 5th week per day, divided into 3 meals.

5th and following Weeks—Per day, 2 gallons of whey mixed with $\frac{3}{4}$ lb. linseed cake meal and $\frac{1}{4}$ lb. fine oatmeal that have been made into a thick porridge by scalding with 2 quarts boiling water.

Also a little hay gradually increased week by week, as with other calves.

Prevention of Tuberculosis by Open-air Treatment.

BY DOUGLAS A. GILCHRIST.

As tuberculosis gives so much trouble in our herds of milch cows, a method of rearing calves so as to keep them clear of this disease is of great importance. The successful results obtained by Mr. A. F. Nichol, Bradford, near Belford, in this connection are therefore of great importance.

Mr. Nichol has probably been one of the largest breeders of pedigree shorthorns in England for export, and as it is required that cattle before entering many countries must have passed the tuberculin test, the desirability of their being free from tuberculosis is apparent.

Mr. Nichol's farms extend to nearly 1,000 acres. His herd of pedigree shorthorns now numbers about 100, including calves. The calving of his cows is so arranged that lots of from 7 to 8 calve about the same time. When near calving they are brought in to one of the open folds near the home-stead, where they calve. These folds are about 30 yards long by 20 yards wide. A narrow part along the north, east, and west sides is covered with a roof, and there is a back but no front wall. After calving, the cows and calves have the run of a pasture field and the shelter of an open fold when necessary. They remain on the pasture till October or November. The calves are then weaned and divided into lots, bulls and heifers being now kept separate. These lots are kept in open folds, where they are wintered. They receive during the winter some linseed cake, hay, and turnips cut into fingers, and as much oat straw as they will eat. In these open folds the calves

have all the advantages of open-air treatment in the first winter of their lives, and at the same time a considerable amount of shelter from the walls and roofs of the folds.

The cows are in the fields during the whole winter, their only shelter being open folds and what they obtain from the hedges. Each field usually winters from 7 to 8 cows, and has an open fold, the gate of which is always open. This fold is about 25 yards long by 20 yards wide. The gate is in the middle of the south end. The fold is enclosed by walls from 7 to 8 feet high along the east, west, and south sides; and has

Bird's eye view of open fold.

on the north side a wall about a foot higher, along the south side of which a space, about 10 to 12 feet wide, is roofed over. This covered part has south walls at each end, where there are small enclosures railed off for straw, and these walls extend a few feet beyond these enclosures; otherwise the south side of the roofed part is open and has simply a pillar to support the roof.

During the winter the cows at first receive straw only in addition to the pasture foggage, and about Christmas an addition of a small amount of rough cotton cake and crushed

oats. As already stated, they come into the home folds to calve, after which they are fed more liberally. As each lot has gone together all the winter, they know each other and do not fight and gore.

Mr. Nichol, in over 20 years' experience, has never had an apparent waster in his herd, nor has he had any animal to react to the tuberculin test. He usually sells his young shorthorns for export at from 12 to 18 months old, and all have previously been so tested. He had 30 young shorthorns tested last year, without a trace of reaction.

It is desirable that Mr. Nichol's plan of rearing calves practically in the open air should be followed in all our cattle-rearing districts in the North of England, in view of his success in producing animals which do not react to the tuberculin test.

In this connection it may be noted that on the writer's suggestion a dairy farmer in North Buckinghamshire tested the whole of his cows with tuberculin in the year 1900. The cows in this herd were out on pasture practically all the year round, and were thus out of doors during day and night throughout the year. Only one animal reacted to the tuberculin test, and her history was doubtful. In this case also the great value of open-air treatment for preventing tuberculosis in cattle was demonstrated.

Dr. Clement Stephenson carries out this open air treatment to a large extent in the management of his herd of valuable Aberdeen Angus cattle at Baliol College Farm, Benton. In February, 1908, when the students from Armstrong College inspected his herd he addressed them as follows:—

“If you wish to succeed as breeders of cattle you must keep as close to nature as circumstances will allow, give the cattle wholesome food, and see that they have a supply of pure water in the fields as much as possible, and when in the house see that the buildings are adapted for the purpose. These should be well ventilated and lighted, no drains should open inside, but there should be an open channel through the byre that

empties itself into a trap drain outside the building. The yearling heifers are wintered out, with a shed to go into if inclined to do so. The cows and two-year-old heifers are kept

Sketch ground plan of open fold.

out up till calving time. The bulls, also, are kept in paddocks which have a shelter shed to the north during the summer. In winter they are kept in boxes with an open yard enclosed

by a wall, the door between the box and the yard being always open. They have, therefore, open air treatment all the year round.

“Prevention of tuberculosis is better than cure, and therefore you should see to it that your cattle are living in a healthy atmosphere. If the air is pure the cold will not hurt them. At the same time we must remember that tuberculosis is an infectious disease, and therefore care must be taken that no animal affected with the disease is kept in the herd.”

Practically the same method of rearing in the open air is carried out by Mr. T. H. Bainbridge, Eshott, Northumberland, in the management of his valuable herd of the same cattle; they are kept as much in the open air as possible, and the cattle have no other shelter than that of open sheds in the fields in winter; when the cows are brought indoors to calve they are kept in well ventilated byres, and the young calves are with them for a few weeks after calving.

The herds at Benton and at Eshott have always been remarkably healthy, and no doubt this is owing to the open air treatment they receive, and the natural conditions under which they are kept.

Volume I., part 4, of the *Proceedings* of Armstrong College Agricultural Students' Association contains a suggestive paper by Mr. Wade, Agricultural Instructor, co. Kildare, Ireland, on “Cheap Shelters and Sheds for Farms.”

Tests for Farmers' Milk.

The following information is taken from Leaflet No. 146, issued by the Board of Agriculture:—

“It is a well-known fact that in the vast majority of cases the milk given by the cows of this country exceeds in butter-fat and other milk solids the percentage specified in the ‘Sale of Milk Regulations, 1901,’ made by the Board of Agriculture. It happens, however, occasionally, that for one reason or another a cow may give milk which does not contain those percentages (3 per cent. of butter-fat and 8·5 per cent. of other milk solids); and in such cases the dairyman, when prosecuted, is required to prove that the milk is genuine. In order to avoid the trouble and annoyance of a prosecution, farmers, dairymen, and all other cowkeepers are strongly recommended to have samples of the milk of their cows tested from time to time. By this means they will be able to watch the seasonal and other variations in the fat contents of the milk, and by modifications in the feeding, housing, or time of milking of their cows, and, if necessary, by disposing of animals that give milk of low quality, to keep the quality of their milk at a satisfactory level.

“The Board have ascertained that, with the object of assisting farmers in the direction indicated, the Agricultural Department of Armstrong College has made arrangements for determining the percentage of butter-fat for a fee of sixpence per sample.

“It must, however, be understood that:—

- (a) The report sent will refer only to the percentage of butter-fat.
- (b) Each report refers only to the sample tested, and implies no guarantee whatever as to the bulk.
- (c) Each report is supplied solely for the information of the milk producer, and must not be used as evidence in case of any dispute between seller and buyer, or where the quality has been questioned by any public authority.

“The following directions must be carefully observed:—

1. The fee of sixpence should be sent with the sample.
2. A stamped and addressed envelope should be sent for the report.
3. Samples should not be sent so as to arrive between Friday night and Monday morning.
4. If it is proposed to send samples periodically, as may be in many cases advisable, the College should be so informed.
5. The sample bottles should be carefully sealed and packed in accordance with the requirements of the General Post Office, and the postage prepaid.
6. The following instructions as to taking samples should be closely followed.

INSTRUCTIONS FOR TAKING SAMPLES.

"A. Testing the Milk of One Cow.—The sample should be taken immediately after the cow has been milked. To ensure thorough mixing the milk should be poured from one vessel into another several times, and a small quantity then quickly removed and immediately transferred to a clean bottle, capable of containing at least a quarter of a pint. The bottle should at once be corked and sealed.

"B. Testing Mixed Milk.—In taking a sample from the milk of a herd it is often impracticable to mix the milk by pouring it from vessel to vessel. The sampling may then be done by using a strong glass tube, obtainable from any chemist, of about three-eighth inch bore and open at both ends. The tube must be sufficiently long to reach the bottom of the can, and should be slowly passed perpendicularly into the can until it touches the bottom. If this is done carefully it will then be found that the milk in the tube stands at the same level as the milk outside. The *upper* end of the tube should then be firmly closed with the thumb, when, if the tube is carefully withdrawn, the column of milk will remain in the tube, and may be emptied into a clean bottle by gently releasing the thumb so as to admit air. Samples taken in this way from all the pails should be thoroughly mixed in the same way as the sample from a single cow.

"If a glass tube is not available, the milk must be mixed thoroughly by pouring from vessel to vessel; stirring it is not enough.

"The bottle in which the milk is sent should be full, and a label should be affixed to it, bearing the name of the sender, full postal address, and the date on which the sample was taken."

When samples are sent information should accompany them as to:—

- (a) The hours of milking.
- (b) Whether they are taken from the morning's or the evening's milking; or the noon's milking, if milking is done three times a day.
- (c) The number of cows' milk from which the sample has been taken.

Particulars should be also sent of the feeding of the cows.

The tests will be made by Mr. S. H. Collins, M.Sc., the College Lecturer in Agricultural Chemistry, and the samples should be addressed "Agricultural Department, Armstrong College, Newcastle-upon-Tyne."

Applications for information and advice as to the feeding of dairy cows will be answered by the Professor of Agriculture, Armstrong College, Newcastle-upon-Tyne.

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