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# Memoirs of the Department of Agriculture in India

## No. 4. VARIATIONS IN SOME CHARACTERISTICS OF THE FAT OF BUFFALO AND COW MILK WITH CHANGES IN SEASON AND FEEDING

## No. 5. THE MUTUAL APPLICABILITY OF THE ANALYTICAL FIGURES FOR BUTTER FAT AND *GHEE*

BY

F. J. PLYMEN, A.C.G.I

*Agricultural Chemist to the Government of Central Provinces*

AND

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# VARIATIONS IN SOME CHARACTERISTICS OF THE FAT OF BUFFALO AND COW MILK WITH CHANGES IN SEASON AND FEEDING.*

BY

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[Received for publication on the 17th March, 1921.]

Most of the work published in India up to the present time on the composition of dairy products deals almost entirely with milk alone. In these publications[1] data regarding the proportion of total solids, fat, solids not fat, protein, sugar, etc., are given, and the milk of both buffaloes and cows has been investigated from this standpoint. In the chemical control of dairy products and in standardizing the same, certain characteristics of the fats based upon their chemical properties are used in most countries as a guide to the purity or otherwise of butter and similar substances. In India little data bearing upon this point have been published although some useful determinations with respect to *ghee* (clarified butter) have been published elsewhere[2].

* Paper read at the Seventh Indian Science Congress, Nagpur, January 1920.

1 (*a*) *Mem., Dept. Agri. India, Chemical Series*, vol. II, nos. 2 and 4.
(*b*) *Analyst* (1901), vol. XXVI, p. 40.

2 (*a*) *Jour. Asiatic Society of Bengal* (1910), vol. VI, 181.
(*b*) *Jour. Soc. Chem. Ind.* (1910), 1428.
(*c*) *Analyst* (1911), vol. XXXVI, p. 392.
(*d*) *Jour. Soc. Chem. Ind.* (1915), vol. XXXIV, p. 320.
(*e*) *Analyst* (1915), vol. XXXV, p. 343.
(*f*) *Jour. Soc. Chem. Ind.* (1917), vol. XXXVI, p. 118.

The chief analytical processes used in the examination of butter fat are the Reichert Meissl, the Polenske and the Kirschner while in recent years the Barium method of Ave Lallement (*vide* Bolton and Revi's Fatty Foods, p. 126) has assumed considerable importance. In addition, the simpler determinations of saponification and butyro refractometer readings are usually made. Briefly the Reichert Meissl number indicates the quantity of volatile fatty acids present, these acids being chiefly butyric and caproic. The Polenske process differentiates between the volatile fatty acids soluble and insoluble in water while the Kirschner number affords an indication of the butyric acid present. The Ave Lallement process is considered a valuable auxiliary to the Reichert Meissl process in deciding whether butter fat is adulterated or not and is based on the relative solubilities in water of the barium salts of the fatty acids.

For the purposes of food control many countries have fixed limits for certain analytical determinations within which limits the analytical figures of any samples of butter fat must fall in order for the latter to be passed as pure.

It is not necessary to specify in full what these standards are as they may be found in well known text books (*vide* Allen's *Commercial Organic Analysis*, Vol. II, p. 303). The Reichert Meissl figure is the one to which most importance is attached and the following minimum limits are taken in various countries. In England a Reichert Meissl figure below 24 is generally considered as indicating impure butter but the figure is not a legal standard. The United States of America have a legally recognized standard of 24 as a minimum. In Belgium, if the Reichert Meissl figure is below 28, the butter is considered adulterated, but one at least of certain other conditions must be simultaneously obtained. Italy recognizes butter fats with a Reichert Meissl figure above 26 as pure and below 20 as adulterated and casts suspicion on anything giving a figure coming between these limits. Sweden takes the minimum figure as 23. It is recognized however that under special conditions, particularly with a single animal, quite unusual figures can be obtained even with perfectly genuine butter fat.

The authors were able to obtain samples of genuine butter fat from animals fed under various conditions at the Telenkheri and Agricultural College Dairies, Nagpur. The milk was brought direct from the dairy at the time of milking to the laboratory where it was separated, butter prepared from the cream by hand-churning and butter fat in a pure dry condition obtained in the usual way. Of these samples there can be no doubt that they are the perfectly genuine production of milch animals.

When dealing with the supply of dairy products in India it must be remembered that unlike some countries milk from an individual animal is very frequently sold while mixed milk from herds is also distributed. The peculiarities of the individual animal must therefore be taken in consideration.

The authors have obtained the butter fat produced by an individual cow and a buffalo during the course of their lactation periods and also that produced by mixed herds of cows and buffaloes. They have made the usual physical and chemical examinations of these samples in order to determine to what extent perfectly genuine samples of butter fat can vary during changes in feeding and season.

The data available on the nature of the butter fat produced by Indian milch cattle are at present very small. Most of that published deals with *ghee* or clarified butter fat which in the process of manufacture is heated to a boiling point for a considerable time.

The samples dealt with in this investigation were heated to a temperature not above 60° C. in order to melt and filter off the liquefied butter fat. There is little evidence to show whether the differences in the methods of preparation of butter and *ghee* would affect the chemical and physical values.

The authors have made a few determinations on butter fat and on the *ghee* prepared from the same. The figures tabulated below (Table I) were obtained from which it will be seen that the process used in the manufacture of *ghee* does not apparently modify the chemical and physical characteristics to any important extent. This point will be further considered. It must be taken however that the figures quoted later apply to pure butter fat.

## Discussion of results.

### *Single buffalo (Table II).*

The saponification number was high at the commencement of the lactation period during the hot dry months from March to June. It fell slightly when green food was available during the monsoon and also when the weather was really cold in December and January. In sympathy with the high saponification value, a high negative value for the Ave Lallement determination was obtained although on one or two rare occasions this figure changed slightly to the opposite sign. The Reichert Meissl figure was high all through but reached its lowest limit during the monsoon and cold months. The Polenske number was generally low compared with other published figures.

The butyro refractive index varied very little but increased towards the end of the lactation period. The iodine value is low but it may be noted that no linseed cake was fed during the course of the observation. It is useful to observe the rations fed during the lactation period.

| Months | Bulky food | Concentrated food |
|---|---|---|
| March and April .. .. .. | Dry grass and green clover | *Tur chuni*, cotton seed, *til* cake or undecorticated cotton cake, with *juar* grain from middle of September. |
| May .. .. .. .. | Dry grass and silage | |
| June and middle of July .. .. | *Juar* fodder | |
| Middle of July to middle of August .. | Green grass | |
| Middle of August to December .. .. | Green *juar* | |
| December to end of lactation period .. | Dry grass and green clover | |

*Daily ration.*

25 lb. green fodder plus 15 lb. dry fodder
or 35 „ green fodder alone .. ..
or 25 „ dry fodder alone .. ..

Plus 6 lb. (50 per cent. milk yield) concentrated food.

| | lb. |
|---|---|
| *Chuni* .. .. | 2 |
| Cake .. .. | 2 |
| Cotton seed .. .. | 1 |
| *Juar* or cotton cake .. | 1 |
| TOTAL .. | 6 |

*Single cow (Table III).*

The saponification numbers were generally lower than those obtained with the butter fat of the single buffalo. The same changes, *viz.*, high values at the commencement of the lactation period and low values during the monsoon months were observed. The Ave Lallement values were generally either slightly positive or slightly negative except early in the lactation period when high negative values were obtained.

The Reichert Meissl values were generally much lower than those obtained with the buffalo while the Polenske values were distinctly low all through and the same remark applies to the iodine values.

In some cases the Reichert Meissl value was lower than the minimum usually accepted in other countries; this was most noticeable in the monsoon months. The butyro refractive readings were higher than those given by buffalo butter fat.

*Rations fed during the course of observations.*

| Months | Bulky food | Concentrated food |
|---|---|---|
| February, March to middle of April | Green clover<br>*Juar* fodder | *Tur chuni* .. 1 lb.<br>Cotton seed .. 1½ „ |
| Middle of April to middle of July .. | Silage and *juar* fodder .. | *Til* or cotton cake .. 1½ „<br>Cotton meal .. 1 „ |
| Middle of July to middle of October .. | Green *sann* and *juar* fodder | After September 16th 1 lb. *juar* meal was given instead of 1 lb. cotton meal. |
| Middle of October to middle of December .. | Green *juar* | |
| Middle of December to end of lactation period | Clover and *juar* fodder. | |

*Daily ration.*

20 lb. green fodder plus 10 lb. dry fodder
or 30 „ green fodder alone .. ..
or 20 „ dry fodder alone .. ..

} Plus 5 lb. (40 per cent. milk yield) concentrated food.

*Herds of buffaloes and cows.*

The samples on which these determinations were made were taken from the Telenkheri Dairy Farm. Buffaloes and cows were fed on similar rations and as the observations were made over a complete year, the influence of the period of lactation of the individual animal was to a large extent eliminated. The herds may be said to have been fed in a manner common amongst professional dairymen.

The rations were as follows:—

| Months | Bulky food | Concentrated food |
|---|---|---|
| February and March .. | *Juar* fodder, dry grass and clover .. | Cotton seed, *chuni*, gram *phol*, *Til* cake. |
| April .. .. | Dry grass and clover .. | Cotton seed, *chuni*, gram *phol*, wheat *bhusa*. *Til* cake. |
| May .. .. | *Sann* and maize (green) dry grass | *Chuni*, cotton seed, *til* cake, cotton cake (from 13th May). |
| June .. .. | *Sann* and *juar* (green) .. | Cotton seed, *chuni*, cotton cake, *til* cake, linseed cake (26th to 30th only). |
| July .. .. | Green *juar* .. .. | Cotton seed, *chuni*, *til* cake, linseed cake, cotton cake (1st to 11th). |
| August .. .. | Green *juar* .. .. | Cotton seed (1st to 9th), *chuni*, linseed cake. |

| Months | Bulky food | Concentrated food |
|---|---|---|
| September .. | Green grass .. .. | *Til* and linseed cake, *chuni* (1st to 5th and 26th to 30th). |
| October .. .. | Do. .. .. | *Chuni*, *til* and linseed cake. |
| November.. .. | Do., dry grass .. | Ditto |
| December .. | Green grass, clover, dry grass .. | *Chuni*, *til* cake, linseed cake, cotton seed from 20th to 31st. |
| January .. .. | Clover and dry grass .. | *Chuni*, cotton seed, *til* cake, *tur phol* from 9th to 31st. Linseed cake (1st to 17th). |
| February .. .. | Clover, dry grass .. .. | *Chuni* (1st to 20th), *tur phol* (1st to 25th), *til* cake. |
| March .. .. | Clover and dry grass .. | *Chuni* (20th to 31st), cotton seed, cotton cake (20th to 31st). Linseed cake, *til* cake. |
| April .. .. | Clover and *juar* fodder .. | *Chuni*, cotton cake, linseed and *til* cake. |

*Approximate daily rations.*

15 to 20 lb. green fodder plus 20 to 25 lb. dry fodder plus concentrated food equivalent to 60 per cent. of the milk yield, the various concentrates being mixed in equal proportions.

MIXED BUTTER FAT FROM A HERD OF BUFFALOES (*Table IV*).

The outstanding features of these determinations are the low figures obtained for saponification, Reichert Meissl, Polenske and Kirschner numbers. The Ave Lallement determinations gave generally fairly high positive values. It is worthy of note that the lowest values were obtained during the hot dry months. Judged by the usual standards, the butter fats produced during these months by this herd would be classed in most countries as adulterated. Only during the months when green fodder was available, did the figures for Reichert Meissl number approximate to the standards of other countries. The iodine values obtained in these determinations were fairly high particularly during the months when linseed cake was fed. During those months, however, the melting point of the fat was low—a disadvantage from a commercial dairyman's point of view.

MIXED BUTTER FAT FROM A HERD OF COWS (*Table V*).

The remarks made upon the figures obtained from the butter fat from a herd of buffaloes apply equally well to those obtained from cows. Very low

values for saponification, Reichert Meissl, Polenske, etc., are characteristic of the dry months. The Ave Lallement figure was generally positive. The butyro refractometer readings for butter fat from buffaloes and cows fed under the same conditions were similar. The melting point of butter fat from cows was rather lower than that from buffaloes.

The thanks of the authors are due to Mr. Ram Narayan, B. Ag., for assistance in the analytical work and also to the officers in charge of the Telenkheri and Agricultural College Dairies, Nagpur.

## SUMMARY.

I. The authors have made a series of determinations of the physical and chemical characteristics of pure butter fat obtained from cows and buffaloes fed under known conditions.

Observations were made both on single animals and on herds.

II. Single animals can produce a butter fat which gives figures widely different from those of a herd.

III. Variations from the figures usually obtained in other countries are particularly noticeable in the case of saponification, Reichert Meissl, Polenske and Ave Lallement values.

IV. If judged by standards usually accepted in other countries, much of the butter fat produced by Indian milch cattle would be pronounced as adulterated.

V. In the case of herds, the departure from usually accepted figures is greatest during the months when hot dry weather prevails.

VI. The usual chemical and physical determinations made on butter fat do not differentiate between the butter fat produced by cows or buffaloes.

TABLE I.

| | Saponification No. | Iodine Wijs' No. | Reichert Meissl No. | Polenske No. | Kirschner No. | Ave Lallement | Melting point |
|---|---|---|---|---|---|---|---|
| Pure butter fat .. | 216·1 | 38·92 | 22·90 | 0·88 | 19·44 | +11·8 | 42·9 |
| *Ghee* prepared from above.. | 216·1 | 38·38 | 21·50 | 0·66 | 19·72 | +7·3 | 43·5 |
| Pure butter fat .. | 218·6 | 38·47 | 22·32 | 1·15 | 18·96 | +9·0 | 42·7 |
| *Ghee* prepared from above.. | 219·1 | 38·00 | 22·09 | 1·07 | 19·26 | −3·6 | 42·5 |

## TABLE II.

*Lendra single buffalo.*

*Date of calving*—17-2-14. *Experiments started from* 12-3-14.

| Month and numbers of samples | Time of milking | Saponification No. | Iodine Wijs' No. | Reichert Meissl No. | Polenske No. | Kirschner No. | Ave Lallement | Butyro refractive index at 40°C. | Melting point |
|---|---|---|---|---|---|---|---|---|---|
| 1916–17 | | | | | | | | | |
| March to April 1 to 8 | Evening .. | 236·8 | 25·0 | 33·36 | 1·37 | 31·67 | −42·0 | 41·3 | .... |
| | | 247·6 228·5 | 30·7 20·8 | 38·47 25·80 | 1·46 1·26 | 33·90 29·64 | −65·0 −25·5 | 42·3 40·7 | .... |
| | Morning .. | 235·9 | 26·1 | 35·90 | 1·10 | 31·69 | −62·8 | 40·9 | .... |
| | | 241·0 232·3 | 28·9 23·4 | 36·98 34·88 | 1·17 1·02 | 32·09 31·29 | −114·8 −29·8 | 41·3 41·0 | .... |
| April to May 9 to 16 | Evening .. | 233·4 | 25·3 | 36·89 | 1·28 | 32·85 | −17·8 | 40·85 | .... |
| | | 234·8 231·5 | 26·5 24·1 | 40·35 34·83 | 1·69 1·02 | 36·65 30·76 | +17·7 −30·8 | 41·20 40·50 | .... |
| | Morning .. | 231·8 | 25·9 | 38·65 | 1·74 | 32·12 | −20·5 | 40·88 | .... |
| | | 236·6 226·3 | 26·8 25·0 | 39·60 38·09 | 2·48 1·41 | 36·14 34·10 | −12·9 −31·2 | 41·10 40·70 | .... |
| May to June 17 to 24 | Evening .. | 233·3 | 25·1 | 37·52 | 1·65 | 32·85 | −41·5 | 40·75 | .... |
| | | 234·0 232·3 | 25·5 24·2 | 39·05 34·57 | 1·85 1·36 | 34·50 30·46 | −21·4 −70·4 | 40·90 40·70 | .... |
| | Morning .. | 233·4 | 23·0 | 37·99 | 2·23 | 33·63 | −65·1 | 40·75 | .... |
| | | 236·0 231·4 | 24·2 21·9 | 41·42 34·91 | 3·36 1·46 | 37·40 29·65 | −24·5 −123·2 | 41·20 40·00 | .... |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| June 25 to 32 | Evening .. | 229·8 | 25·8 | 37·01 | 1·42 | 32·35 | −49·8 | 40·90 | .... |
| | | 231·4 227·4 | 26·9 23·9 | 37·86 35·83 | 1·96 1·17 | 32·98 31·51 | −13·7 −97·8 | 41·50 40·40 | .... |
| | Morning .. | 229·8 | 25·7 | 36·33 | 1·59 | 32·11 | −54·3 | 41·35 | .... |
| | | 232·5 224·7 | 27·2 22·1 | 39·59 30·71 | 1·81 1·08 | 35·80 26·96 | −7·5 −60·0 | 41·80 41·00 | .... |
| July 33 to 40 | Evening .. | 227·4 | 23·4 | 32·23 | 1·00 | 28·75 | −36·3 | 42·1 | .... |
| | | 231·4 222·3 | 24·8 21·3 | 35·65 27·21 | 1·12 0·78 | 31·31 24·70 | −39·6 +34·3 | 43·2 41·8 | .... |
| | Morning .. | 228·3 | 26·8 | 32·39 | 1·27 | 27·64 | −68·2 | 41·7 | .... |
| | | 229·7 227·4 | 31·4 19·9 | 33·82 31·43 | 1·32 1·17 | 29·42 25·71 | −41·8 +85·9 | 42·3 41·4 | .... |
| July to August 41 to 48 | Evening .. | 228·6 | 25·2 | 32·01 | 1·12 | 28·05 | −56·3 | 42·5 | .... |
| | | 230·4 223·4 | 26·7 23·3 | 33·48 32·26 | 1·21 0·91 | 29·33 25·78 | −61·5 −50·3 | 42·8 42·0 | .... |
| | Morning .. | 228·8 | 23·3 | 30·80 | 1·29 | 27·30 | −55·5 | 42·6 | .... |
| | | 230·3 225·5 | 25·4 22·0 | 33·51 27·83 | 1·44 1·11 | 29·10 25·90 | −17·2 −93·1 | 43·4 41·8 | .... |
| August to September 49 to 56 | Evening .. | 228·0 | 25·3 | 31·65 | 1·23 | 27·33 | −30·0 | 42·9 | .... |
| | | 232·1 228·1 | 26·7 24·1 | 32·60 29·12 | 1·51 1·05 | 28·92 23·82 | −44·4 −16·6 | 43·6 42·3 | .... |
| | Morning .. | 228·0 | 23·3 | 32·77 | 1·33 | 28·85 | −16·1 | 42·7 | .... |
| | | 231·1 224·5 | 24·4 22·4 | 35·47 29·62 | 1·64 1·19 | 31·47 26·31 | −11·1 −17·1 | 43·2 42·6 | .... |
| September to October 57 to 64 | Evening .. | 228·9 | 23·2 | 31·70 | 1·37 | 27·66 | −39·3 | 42·6 | .... |
| | | 230·3 228·1 | 27·3 20·7 | 32·72 30·27 | 1·57 1·15 | 28·19 26·88 | +0·8 −75·0 | 42·9 42·1 | .... |
| | Morning .. | 232·4 | 24·1 | 34·33 | 1·49 | 29·40 | −38·4 | 42·2 | .... |
| | | 233·7 231·8 | 26·5 22·5 | 34·60 33·89 | 2·05 1·20 | 30·69 28·88 | −15·0 −64·6 | 42·6 41·9 | .... |

TABLE II—(*concld.*)

| Month and numbers of samples | Time of milking | Saponification No. | Iodine Wijs No. | Reichert Meissl No. | Polenske No. | Kirschner No. | Ave Lallement | Butyro refractive index at 40°C. | Melting point |
|---|---|---|---|---|---|---|---|---|---|
| October to November 65 to 72 | Evening .. | 232·5 | 24·7 | 33·26 | 1·75 | 29·05 | −45·1 | 42·4 | .... |
| | | 234·8 228·3 | 24·8 22·0 | 35·37 31·63 | 2·15 1·70 | 31·17 27·27 | −82·0 −25·3 | 42·6 40·9 | .... |
| | Morning .. | 235·1 | 22·2 | 34·68 | 1·76 | 30·26 | −83·9 | 41·3 | .... |
| | | 237·6 233·2 | 27·0 19·0 | 35·94 33·72 | 1·93 1·59 | 32·27 28·94 | −89·8 −78·1 | 41·9 40·9 | .... |
| November to December 73 to 80 | Evening .. | 234·4 | 23·2 | 36·5 | 2·27 | 31·62 | −38·4 | 41·1 | .. |
| | | 237·9 225·8 | 26·5 21·1 | 38·7 34·7 | 2·82 1·74 | 33·34 30·22 | −10·3 −79·8 | 41·3 41·0 | .... |
| | Morning .. | 235·0 | 24·6 | 36·3 | 2·35 | 31·84 | −50·5 | 40·9 | .... |
| | | 238·7 225·3 | 25·6 23·0 | 37·8 33·5 | 3·02 1·72 | 32·72 30·95 | −29·5 −65·4 | 41·3 40·4 | .... |
| December to January 81 to 88 | Evening .. | 225·6 | 30·2 | 31·85 | 1·24 | 27·84 | −9·5 | 42·6 | .... |
| | | 231·5 217·9 | 32·2 28·2 | 33·68 30·19 | 1·52 1·00 | 28·88 27·07 | +1·8 −24·4 | 43·2 41·7 | .... |
| | Morning .. | 229·9 | 29·7 | 31·24 | 1·21 | 27·24 | −9·7 | 42·8 | .... |
| | | 231·8 228·2 | 32·1 28·0 | 33·29 29·54 | 1·26 1·17 | 28·81 25·54 | 15·7 −17·2 | 43·0 42·2 | .... |
| January to February 89 to 96 | Evening .. | 227·3 | 32·1 | 28·80 | 1·20 | 26·83 | −64·0 | 43·0 | .... |
| | | 229·2 225·8 | 34·5 29·9 | 31·25 26·43 | 1·28 1·12 | 27·39 26·32 | −11·3 −107·0 | 43·5 42·6 | .... |
| | Morning .. | 229·8 | 29·3 | 29·80 | 1·24 | 27·63 | −69·2 | 43·0 | .... |
| | | 232·0 228·4 | 31·9 26·4 | 32·08 27·40 | 1·48 1·06 | 28·42 27·14 | −25·0 −96·9 | 43·9 42·6 | .... |

## TABLE III.

*Lendra single cow.*

*Date of calving*—5-2-16. *Experiments started from* 14-2-16.

| Month and numbers of samples | Time of milking | Saponification No. | Iodine Wijs' No. | Reichert Meissl No. | Polenske No. | Kirschner No. | Ave Lallement | Butyro refractive index at 40°C | Melting point |
|---|---|---|---|---|---|---|---|---|---|
| 1916–17 | | | | | | | | | |
| February to March 1 to 8 | Morning .. | 237·6 | 25·18 | 32·33 | 1·38 | 27·63 | −59·2 | 44 6 | 39·7 |
| | | 241·3 229·2 | 27·99 23·66 | 33·85 31·03 | 1·64 1·06 | 29·21 26·18 | −70·0 −22·7 | 45·4 43·6 | 40·1 39·5 |
| | Evening .. | 230·2 | 26·03 | 29·05 | 1·02 | 25·09 | −35·0 | 45 3 | 39·1 |
| | | 234·4 225·6 | 29·94 20·90 | 29·51 28·36 | 1·11 0·93 | 25·19 24·96 | −58·2 −18·2 | 46·1 44·7 | 40·3 37·5 |
| March to April 9 to 16 | Morning .. | 233·4 | 27·20 | 31·62 | 1·31 | 26·35 | −41·4 | 45·3 | 39·1 |
| | | 240·3 229·3 | 31·34 22·84 | 34·05 29·69 | 1·53 1·09 | 28·79 25·17 | −79·0 −19·0 | 46·3 43·4 | 40·9 37·7 |
| | Evening .. | 223·6 | 30·04 | 26·21 | 1·03 | 23·38 | −8·3 | 45·0 | 38·8 |
| | | 225·4 224·1 | 32·47 27·64 | 29·93 24·03 | 1·17 0·90 | 25·57 21·00 | −22·3 5·0 | 45·6 44·3 | 39·7 37·7 |
| April to May 17 to 24 | Morning .. | 227·4 | 24·99 | 30·48 | 1·19 | 25·36 | −8·5 | 43·4 | 37·8 |
| | | 228·9 224·3 | 34·0 18·98 | 31·64 27·61 | 1·30 0·96 | 26·82 23·26 | −9·9 −2·5 | 44·4 43·2 | 38·7 36·9 |
| | Evening .. | 229·6 | 24·39 | 30·15 | 1·10 | 25·64 | −22·4 | 44·0 | 39·8 |
| | | 234·8 226·5 | 26·06 22·91 | 32·35 28·24 | 1·17 0·93 | 27·44 24·17 | −58·3 −7·5 | 45·1 42·8 | 40·7 38·9 |

TABLE III—(*contd.*)

| Month and numbers of samples | Time of milking | Saponification No. | Iodine Wijs' No. | Reichert Meissl No. | Polenske No. | Kirschner No. | Ave Lallement | Butyro refractive index at 40°C. | Melting point |
|---|---|---|---|---|---|---|---|---|---|
| May to June 25 to 32 | Morning .. | 226·6 | 28·14 | 29·49 | 1·06 | 25·19 | −4·3 | 43·3 | 39·3 |
| | | 225·8 228·1 | 30·51 25·86 | 30·58 28·92 | 1·26 0·99 | 26·33 24·75 | −8·3 −0·1 | 43·8 42·8 | 40·1 38·3 |
| | Evening .. | 225·2 | 25·58 | 28·54 | 1·16 | 24·50 | −2·3 | 43·3 | 39·2 |
| | | 226·6 223·6 | 32·44 19·72 | 29·77 27·11 | 1·39 1·00 | 25·66 23·28 | −5·2 −0·3 | 43·7 43·1 | 39·7 38·1 |
| June 33 to 40 | Morning .. | 223·7 | 8·50 | 27·00 | 1·32 | 23·08 | +2·9 | 43·8 | 39·7 |
| | | 225·6 222·3 | 33·31 21·90 | 28·70 25·30 | 1·61 1·18 | 25·08 21·08 | +7·3 −1·0 | 44·3 43·2 | 40·3 38·9 |
| | Evening .. | 223·3 | 28·09 | 26·58 | 1·16 | 22·72 | +2·0 | 44·4 | 39·6 |
| | | 226·5 222·1 | 33·78 24·14 | 29·43 24·60 | 1·33 1·00 | 24·78 21·31 | +4·4 −1·6 | 44·8 40·8 | 41·1 37·7 |
| July 41 to 48 | Morning .. | 221·0 | 27·40 | 25·51 | 0·98 | 21·84 | +0·5 | 43·9 | 42·2 |
| | | 226·6 219·0 | 32·62 24·21 | 28·41 24·43 | 1·30 0·78 | 23·99 20·67 | +4·9 −5·3 | 44·8 42·5 | 44·1 39·9 |
| | Evening .. | 220·3 | 26·35 | 23·85 | 0·84 | 20·53 | +5·8 | 44·5 | 41·2 |
| | | 221·0 219·4 | 33·61 19·28 | 25·13 23·09 | 0·84 0·83 | 21·30 19·84 | +7·4 −3·1 | 45·1 44·1 | 44·3 38·7 |
| July to August 49 to 56 | Morning .. | 218·7 | 27·93 | 24·53 | 0·82 | 21·64 | +3·2 | 43·5 | 41·6 |
| | | 223·6 214·6 | 29·20 25·78 | 27·44 22·70 | 1·00 0·68 | 23·40 19·59 | +13·6 −1·7 | 44·6 42·8 | 45·0 39·9 |
| | Evening .. | 220·3 | 24·12 | 22·77 | 0·72 | 19·55 | −5·5 | 44·4 | 41·7 |
| | | 224·5 214·4 | 28·20 20·36 | 26·45 20·73 | 0·89 0·59 | 20·40 18·49 | +11·9 −3·61 | 46·5 42·1 | 43·7 40·3 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| August to September 57 to 64 | Morning .. | 219·4 | 27·32 | 24·05 | 0·80 | 21·18 | +1·5 | 43·9 | 40·3 |
| | | 221·9 215·3 | 38·10 20·45 | 25·36 22·93 | 0·96 0·72 | 22·63 20·22 | +6·5 −3·0 | 44·4 43·0 | 44·1 36·7 |
| | Evening .. | 221·7 | 26·28 | 24·42 | 0·91 | 20·78 | +3·8 | 43·3 | 40·8 |
| | | 222·4 221·1 | 32·81 32·40 | 25·39 23·49 | 1·15 0·75 | 21·51 19·76 | +11·0 −0·8 | 43·7 43·4 | 42·1 39·7 |
| September to October 65 to 72 | Morning .. | 223·7 | 30·36 | 26·10 | 0·92 | 22·53 | +0·65 | 42·4 | 42·7 |
| | | 225·5 222·2 | 33·37 28·20 | 28·42 24·31 | 1·06 0·81 | 24·49 20·91 | +6·0 −4·2 | 42·9 42·0 | 44·5 40·7 |
| | Evening .. | 223·5 | 29·05 | 26·40 | 0·99 | 22·62 | +3·05 | 42·1 | 41·9 |
| | | 224·8 223·0 | 32·81 27·62 | 26·92 25·66 | 1·05 0·88 | 23·18 22·00 | +4·6 +0·1 | 42·7 41·6 | 44·3 38·9 |
| October to November 73 to 80 | Morning .. | 221·2 | 33·37 | 25·22 | 0·93 | 21·44 | +6·5 | 43·0 | 41·7 |
| | | 222·6 218·4 | 36·72 32·46 | 27·63 23·00 | 1·12 0·82 | 22·95 19·69 | +12·1 +1·3 | 41·5 42·4 | 43·1 39·5 |
| | Evening .. | 219·6 | 32·08 | 24·10 | 0·80 | 20·85 | +7·2 | 43·2 | 43·6 |
| | | 221·9 218·3 | 38·85 26·63 | 25·06 23·27 | 0·96 0·71 | 21·74 20·03 | +9·5 +6·0 | 44·2 42·4 | 47·6 40·5 |
| November to December 81 to 88 | Morning .. | 223·7 | 29·23 | 26·56 | 0·97 | 22·94 | +4·6 | 42·2 | 43·1 |
| | | 223·0 224·4 | 33·31 24·88 | 27·69 25·72 | 1·13 0·85 | 24·03 21·52 | +5·7 +3·6 | 42·8 41·4 | 46·4 39·9 |
| | Evening .. | 223·9 | 30·64 | 26·26 | 0·92 | 22·51 | +4·1 | 42·6 | 42·2 |
| | | 225·0 223·2 | 31·86 28·51 | 26·72 25·53 | 0·99 0·80 | 23·02 21·74 | +6·8 +2·9 | 43·0 42·2 | 43·7 41·3 |
| December to January 89 to 96 | Morning .. | 226·1 | 30·91 | 27·18 | 1·52 | 22·79 | −1·0 | 42·6 | 41·3 |
| | | 229·9 223·2 | 33·78 29·11 | 27·60 26·79 | 1·33 0·99 | 22·99 22·60 | +4·3 −1·7 | 43·5 42·1 | 42·9 39·3 |
| | Ev | 223·9 | 32·83 | 25·23 | 1·25 | 21·45 | +6·9 | 43·3 | 40·9 |
| | | 223·1 221·0 | 36·53 30·71 | 26·93 23·78 | 1·10 0·82 | 22·69 20·48 | +10·0 +4·3 | 43·9 42·7 | 43·1 38·5 |

TABLE III—(*concld.*)

| Month and numbers of samples | Time of milking | Saponification No. | Iodine Wijs' No. | Reichert Meissl No. | Polenske No. | Kirschner No. | Ave Lallemen' | Butyro refractive index at 40°C. | Melting point |
|---|---|---|---|---|---|---|---|---|---|
| January to February 97 to 104 | Morning .. | 223·4 | 34·25 | 24·78 | 1·13 | 21·14 | +9·2 | 43·7 | 40·9 |
| | | 227·8 217·2 | 39·79 29·98 | 26·66 21·70 | 1·39 0·98 | 23·23 18·87 | +16·9 +3·1 | 44·9 42·8 | 42·5 38·5 |
| | Evening .. | 222·1 | 34·74 | 24·07 | 1·04 | 20·76 | +10·1 | 43·8 | 41·35 |
| | | 226·4 217·5 | 36·92 29·69 | 25·36 21·10 | 1·35 0·82 | 22·04 18·31 | +15·7 +6·4 | 44·5 42·5 | 42·5 39·1 |

## TABLE IV.

*Telenkheri herd of buffaloes.*

| Month and numbers of samples | Time of milking | Saponification No. | Iodine Wijs' No. | Reichert Meissl No. | Polenske No. | Kirschner No. | Ave Lallement | Butyro refractive ndex at 40°C. | Melting point |
|---|---|---|---|---|---|---|---|---|---|
| 1916–17 | Morning .. | 212·0 | 38·08 | 19·45 | 0·54 | 17·88 | + 18·1 | 45·7 | 44·9 |
| March to April 1 to 8 | Morning .. | 212·7 211·6 | 39·34 37·77 | 19·78 19·25 | 0·67 0·47 | 18·10 17·90 | +18·9 +16·4 | 46·4 45·0 | 45·4 44·1 |
| | Evening .. | 213·2 | 39·11 | 19·51 | 0·59 | 18·00 | +17·2 | 45·6 | 44·2 |
| | Evening .. | 214·6 212 2 | 40·06 38·20 | 20·16 19·18 | 0·62 0·55 | 8·67 17·59 | +20·6 +13·1 | 45·7 45·4 | 45·4 43·3 |
| April to May 9 to 16 | Morning .. | 212·1 | 38·91 | 19·50 | 0·62 | 17·98 | +17·3 | 45·4 | 43·9 |
| | Morning .. | 213·4 210·8 | 39·00 38·83 | 20·60 18·42 | 0·91 0·46 | 18·95 16·90 | +19·9 +14·9 | 45·4 45·3 | 44·7 43·1 |
| | Evening | 213·1 | 39·17 | 20·02 | 0·54 | 18·16 | +14·6 | 45·5 | 43·7 |
| | Evening | 214·3 211·8 | 40·06 37·34 | 20·42 18·80 | 0·59 0·52 | 19·67 17·00 | +18·1 +10·1 | 45·7 45·3 | 44·7 42·7 |
| May to June 17 to 24 | Morning .. | 213·0 | 39·50 | 19·46 | 0·63 | 17·54 | +15·3 | 45·3 | 43·8 |
| | Morning .. | 214·1 212·1 | 40·55 37·74 | 19·75 19·13 | 0·82 0·34 | 18·20 16·24 | +17·6 +12·4 | 45·7 45·2 | 44·3 43·2 |
| | Evening .. | 212·1 | 40·05 | 18·72 | 0·48 | 17·65 | +17·9 | 45·6 | 44·6 |
| | Evening .. | 213·9 210·8 | 41·22 38·61 | 19·36 18·02 | 0·56 0·42 | 18·19 17·19 | +21·1 +15·7 | 45·9 45·4 | 45·8 43·4 |
| June 25 to 32 | Morning .. | 213·2 | 39·63 | 18·98 | 0·71 | 17·12 | +14·9 | 45·6 | 43·9 |
| | Morning .. | 214·1 212·3 | 41·7 38·14 | 19·60 18·43 | 1·06 0·49 | 18·11 16·65 | +18·6 +12·5 | 46·3 44·8 | 44·7 42·3 |
| | Evening .. | 214·4 | 39·50 | 18·89 | 0·53 | 17·45 | +14·1 | 45·7 | 44·6 |
| | Evening .. | 215·9 212·5 | 40·52 38·09 | 20·19 18·08 | 0·70 0·33 | 18·69 16·71 | +18·2 +10·2 | 46·2 45·2 | 45·0 44·3 |

TABLE IV—(*contd.*)

| Month and numbers of samples | Time of milking | Saponification No. | Iodine Wijs' No. | Reichert Meissl No. | Polenske No. | Kirschner No. | Ave Lallement | Butyro refractive index at 40°C. | Melting point |
|---|---|---|---|---|---|---|---|---|---|
| July 33 to 40 | Morning .. | 216·7 | 39·80 | 21·75 | 0·71 | 19·57 | + 7·1 | 46·2 | 43·3 |
| | | 218·0 215·7 | 40·26 39·19 | 23·82 19·66 | 0·89 0·56 | 21·42 17·86 | +12·1 +2·6 | 46·4 46·0 | 45·1 42·1 |
| | Evening .. | 215·6 | 42·39 | 21·02 | 0·68 | 19·04 | +10·2 | 46·4 | 42·5 |
| | | 217·1 214·5 | 43·70 41·43 | 22·51 19·31 | 0·80 0·58 | 20·29 17·35 | +15·5 +7·3 | 46·7 46·0 | 43·5 41·5 |
| July to August 41 to 48 | Morning .. | 217·1 | 38·89 | 23·39 | 0·75 | 21·07 | +8·5 | 45·7 | 42·6 |
| | | 217·4 216·8 | 39·60 38·27 | 24·06 22·27 | 0·87 0·70 | 21·92 19·96 | +10·5 +5·5 | 45·8 45·5 | 43·0 42·5 |
| | Evening .. | 218·0 | 38·68 | 24·41 | 0·89 | 21·73 | +5·3 | 45·6 | 41·5 |
| | | 220·0 217·0 | 40·82 37·45 | 26·15 23·49 | 1·07 0·76 | 23·09 21·03 | +8·7 +3·1 | 45·8 45·1 | 42·5 40·3 |
| August to September 49 to 56 | Morning .. | 216·7 | 42·21 | 23·99 | 0·63 | 21·39 | +3·8 | 46·0 | 42·8 |
| | | 219·5 213·8 | 43·34 40·86 | 27·10 22·25 | 0·72 0·45 | 24·04 19·96 | +9·5 −7·5 | 47·0 45·2 | 43·3 42·3 |
| | Evening .. | 217·4 | 42·46 | 24·46 | 0·75 | 21·40 | +5·1 | 45·6 | 42·0 |
| | | 220·5 213·7 | 43·97 40·99 | 27·86 21·55 | 0·90 0·52 | 24·79 18·84 | +10·5 −2·5 | 46·4 45·3 | 44·1 41·1 |
| September to October 57 to 64 | Morning .. | 219·4 | 41·48 | 27·44 | 0·77 | 24·42 | +2·1 | 44·9 | 41·5 |
| | | 223·2 215·0 | 43·81 39·60 | 30·64 24·33 | 0·87 0·59 | 27·31 22·20 | +6·9 −2·0 | 45·8 44·0 | 43·1 39·7 |
| | Evening .. | 219·2 | 42·73 | 26·01 | 1·02 | 22·52 | +3·4 | 45·2 | 40·8 |
| | | 220·8 216·8 | 43·77 41·99 | 27·10 24·50 | 1·19 0·70 | 23·01 21·88 | +8·8 −1·2 | 45·6 44·8 | 42·7 37·7 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| October to November 65 to 72 | Morning .. | 220·3 | 40·50 | 27·14 | 0·73 | 24·05 | −1·8 | 44·9 | 41·2 |
| | | 224·1 218·7 | 42·47 38·10 | 30·11 25·88 | 1·03 0·58 | 26·26 22·93 | +2·1 −8·9 | 45·3 44·3 | 42·1 40·2 |
| | Evening .. | 221·6 | 40·89 | 27·95 | 0·84 | 24·59 | −2·4 | 45·1 | 40·7 |
| | | 224·6 219·7 | 41·20 40·16 | 29·04 26·74 | 1·04 0·72 | 25·33 23·25 | +1·5 −7·2 | 45·4 44·8 | 41·1 39·9 |
| November to December 73 to 80 | Morning .. | 219·1 | 41·38 | 25·82 | 0·64 | 22·98 | +4·4 | 45·3 | 41·6 |
| | | 220·1 218·3 | 42·73 40·31 | 27·32 24·6 | 0·78 0·54 | 24·10 21·85 | +7·7 +2·7 | 45·8 44·8 | 42·1 40·9 |
| | Evening .. | 219·3 | 41·34 | 25·27 | 0·77 | 22·50 | +6·5 | 45·4 | 41·9 |
| | | 220·5 216·9 | 43·83 40·37 | 26·80 22·39 | 0·87 0·62 | 23·95 19·84 | +10·7 +4·6 | 46·1 44·8 | 42·9 40·1 |
| December to January 81 to 88 | Morning .. | 220·7 | 40·04 | 26·12 | 0·80 | 22·96 | +1·8 | 44·8 | 42·0 |
| | | 223·0 219·4 | 41·37 38·65 | 27·35 24·39 | 0·99 0·67 | 23·99 22·36 | +2·7 +0·8 | 45·2 44·5 | 42·9 40·9 |
| | Evening .. | 219·3 | 41·01 | 25·31 | 0·76 | 22·70 | +4·8 | 45·1 | 41·7 |
| | | 221·0 218·1 | 41·70 40·41 | 25·63 24·70 | 1·09 0·60 | 23·05 22·37 | +7·1 +2·3 | 45·3 44·8 | 42·7 40·3 |
| January to February 89 to 96 | Morning .. | 219·5 | 40·18 | 24·35 | 0·73 | 21·61 | +3·9 | 45·1 | 40·5 |
| | | 222·1 215·8 | 41·86 37·76 | 24·91 23·46 | 0·79 0·69 | 22·06 21·13 | +9·4 +0·2 | 45·8 44·3 | 41·5 39·5 |
| | Evening .. | 220·2 | 40·97 | 24·63 | 0·68 | 21·99 | +3·6 | 44·4 | 41·3 |
| | | 225·2 216·8 | 43·03 39·46 | 27·53 22·69 | 0·76 0·61 | 24·55 20·37 | +10·6 −7·1 | 45·7 44·1 | 43·5 39·7 |
| February to March 97 to 104 | Morning .. | 214·3 | 41·73 | 21·64 | 0·60 | 19·76 | +12·1 | 45·6 | 42·9 |
| | | 215·9 212·7 | 43·72 39·62 | 23·68 19·96 | 0·66 0·49 | 21·37 18·20 | +16·3 +9·3 | 45·8 45·3 | 43·9 41·9 |
| | Evening .. | 214·7 | 40·37 | 21·34 | 0·55 | 19·50 | +12·9 | 45·5 | 43·1 |
| | | 216·2 212·8 | 43·13 33·13 | 22·15 19·78 | 0·59 0·50 | 20·05 18·39 | +18·5 +9·5 | 45·8 45·1 | 44·5 40·7 |

TABLE IV—(*concld.*)

| Month and numbers of samples | Time of milking | Saponification No. | Iodine Wijs' No. | Reichert Meissl No. | Polenske No. | Kirschner No. | Ave Lallement | Butyro refractive index at 40°C. | Melting point |
|---|---|---|---|---|---|---|---|---|---|
| March to April 105 to 112 | Morning .. | 217·1 | 41·55 | 23·81 | 0·57 | 21·77 | +8·1 | 45·0 | 41·9 |
| | | 218·8 215·4 | 42·73 39·89 | 26·23 22·20 | 0·61 0·55 | 23·79 20·52 | +11·6 +5·6 | 45·2 44·8 | 43·5 40·7 |
| | Evening .. | 215·6 | 41·78 | 22·73 | 0·64 | 20·66 | +9·3 | 45·4 | 42·3 |
| | | 217·1 214·7 | 43·39 39·93 | 23·39 22·19 | 0·80 0·56 | 21·44 20·00 | +12·7 +8·1 | 45·8 44·9 | 42·8 41·5 |
| April 113 to 119 | Morning .. | 212·2 | 42·55 | 20·65 | 0·64 | 18·97 | +7·5 | 45·1 | 43·7 |
| | | 212·9 218·8 | 43·07 42·03 | 21·21 20·18 | 0·69 0·56 | 19·12 18·79 | +9·1 +5·1 | 45·3 44·9 | 44·5 43·1 |
| | Evening .. | 211·9 | 45·09 | 19·44 | 0·61 | 18·33 | +14·7 | 45·4 | 42·4 |
| | | 213·9 210·3 | 46·22 43·29 | 21·07 17·13 | 0·64 0·57 | 19·45 17·43 | +17·5 +12·2 | 45·5 45·2 | 42·9 42·1 |

TABLE V.

*Telenkheri herd of cows.*

| Month and numbers of samples | Time of milking | Saponification No. | Iodine Wijs No. | Reichert Meissl No. | Polenske No. | Kirschner No. | Ave Lallement | Butyro refractive index at 40°C. | Melting point |
|---|---|---|---|---|---|---|---|---|---|
| 1916–17 | | 213·8 | 39·8 | 18·79 | 0·71 | 16·22 | +14·5 | 46·1 | 43·9 |
| March to April 1 to 8 | Evening .. | 214·3 213·3 | 41·15 36·91 | 19·94 18·25 | 0·78 0·55 | 16·65 15·75 | +19·7 +10·0 | 47·1 45·7 | 46·2 41·5 |
| | Morning .. | 215·3 | 30·00 | 19·84 | 0·86 | 17·24 | +8·6 | 45·6 | 41·1 |
| | | 216·4 214·4 | 40·56 39·44 | 20·99 18·58 | 1·03 0·77 | 18·01 15·90 | +14·8 +9·4 | 45·9 45·3 | 41·3 40·9 |
| April to May 9 to 16 | Evening .. | 215·9 | 39·99 | 20·13 | 0·79 | 17·23 | +14·7 | 45·5 | 40·6 |
| | | 216·5 214·8 | 40·76 38·46 | 21·17 19·54 | 0·85 0·68 | 18·44 16·67 | +17·9 +10·9 | 45·8 45·0 | 41·5 39·7 |
| | Morning .. | 216·1 | 38·60 | 19·92 | 0·65 | 17·12 | +14·8 | 45·6 | 42·0 |
| | | 217·0 215·0 | 39·90 37·46 | 20·59 19·35 | 0·75 0·55 | 17·51 16·64 | +15·9 +13·9 | 45·4 45·3 | 43·7 41·9 |
| May to June 17 to 24 | Evening .. | 214·3 | 38·81 | 19·23 | 0·64 | 16·64 | +16·7 | 44·8 | 42·1 |
| | | 215·8 212·4 | 39·58 37·84 | 20·43 18·21 | 0·76 0·61 | 17·74 15·75 | +19·9 +13·17 | 45·4 44·2 | 42·9 40·6 |
| | Morning .. | 219·9 | 37·56 | 19·55 | 0·76 | 16·89 | +13·4 | 44·8 | 41·1 |
| | | 216·7 213·3 | 39·82 33·21 | 20·58 18·23 | 0·97 0·61 | 18·02 15·99 | +16·3 +8·4 | 45·4 44·3 | 41·6 40·6 |
| June 25 to 32 | Evening .. | 213·5 | 42·06 | 18·65 | 0·81 | 15·88 | +18·1 | 45·4 | 41·4 |
| | | 215·4 211·0 | 43·90 40·41 | 19·70 17·39 | 0·98 0·69 | 16·55 14·94 | +21·6 +15·3 | 45·9 44·8 | 42·9 40·6 |
| | Morning .. | 214·7 | 40·79 | 19·15 | 0·82 | 16·57 | +17·6 | 45·2 | 42·3 |
| | | 215·3 213·9 | 42·12 40·16 | 20·26 17·88 | 0·88 ·75 | 17·57 15·59 | +22·0 +14·9 | 45·7 44·9 | 43·5 41·7 |

TABLE V—(*Concld.*)

| Month and numbers of samples | Time of milking | Saponification No. | Iodine Wij No. | Reichert Meissl No. | Polenske No. | Kirschner No. | Ave Lallement | Butyro refractive index at 40°C | Melting point |
|---|---|---|---|---|---|---|---|---|---|
| July 33 to 40 | Evening .. | 215·8 | 43·82 | 20·70 | 0·98 | 17·52 | +12·6 | 45·8 | 39·1 |
| | | 217·1 213·3 | 45·75 40·99 | 22·59 18·78 | 1·20 0·71 | 18·60 16·20 | +15·7 +9·9 | 46·3 45·4 | 39·3 38·9 |
| | Morning .. | 218·6 | 41·95 | 22·56 | 1·22 | 18·59 | +11·1 | 45·5 | 39·9 |
| | | 219·0 217·8 | 44·92 37·91 | 23·54 20·85 | 1·41 0·94 | 19·20 17·44 | +12·6 +9·9 | 45·6 45·4 | 40·1 39·7 |
| July to August 41 to 48 | Evening .. | 217·8 | 41·0 | 22·80 | 1·26 | 18·82 | +10·1 | 45·5 | 39·5 |
| | | 218·7 216·1 | 42·07 39·90 | 23·92 21·14 | 1·67 1·08 | 19·54 17·47 | +12·7+5·7 | 45·6 45·2 | 40·3 38·7 |
| | Morning .. | 220·2 | 37·51 | 24·35 | 1·29 | 20·14 | +5·6 | 44·6 | 40·3 |
| | | 220·5 219·8 | 37·79 37·10 | 24·83 23·72 | 1·46 1·16 | 20·27 19·83 | +7·6 +3·6 | 44·9 44·4 | 40·5 39·9 |
| August to September 49 to 56 | Evening .. | 220·85 | 40·79 | 25·13 | 1·15 | 20·76 | +2·7 | 44·7 | 38·1 |
| | | 222·8 219·4 | 42·71 40·06 | 27·08 23·24 | 1·30 0·93 | 22·32 18·67 | +8·0 −0·9 | 45·1 44·5 | 39·9 36·5 |
| | Morning .. | 222·40 | 38·87 | 25·45 | 1·16 | 20·00 | +3·5 | 44·3 | 39·1 |
| | | 224·8 219·8 | 40·40 37·50 | 26·87 24·27 | 1·48 0·78 | 21·35 19·22 | +5·4 +1·3 | 44·9 43·5 | 41·9 36·6 |
| September to October 57 to 64 | Evening .. | 223·3 | 40·4 | 25·96 | 1·08 | 20·88 | −0·4 | 44·5 | 38·8 |
| | | 224·5 219·6 | 43·95 37·50 | 27·80 23·84 | 1·36 0·83 | 21·86 19·33 | +8·6 −6·3 | 45·2 43·8 | 41·5 37·5 |
| | Morning .. | 223·5 | 37·0 | 26·39 | 1·44 | 21·14 | −1·0 | 44·0 | 38·8 |
| | | 224·5 223·0 | 37·56 36·45 | 27·40 24·89 | 1·57 1·24 | 22·21 19·88 | +4·6 − 5·2 | 44·2 43·9 | 40·5 38·0 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| October to November 65 to 72 | Evening .. | 222·1 | 39·93 | 25·00 | 1·15 | 20·07 | +6·4 | 44·5 | 37·95 |
| | | 223·2 221·1 | 40·51 39·32 | 26·36 24·08 | 1·32 1·00 | 20·33 19·90 | +9·1 +4·7 | 44·7 44·2 | 38·9 36·9 |
| | Morning .. | 221·7 | 37·97 | 25·59 | 1·23 | 20·75 | +1·7 | 44·3 | 38·80 |
| | | 224·3 218·8 | 39·53 35·82 | 26·32 24·89 | 1·48 0·87 | 21·70 20·09 | +6·9 −2·7 | 44·6 44·1 | 40·5 37·5 |
| November to December 73 to 80 | Evening .. | 219·2 | 42·21 | 23·58 | 0·93 | 19·17 | +7·1 | 44·8 | 39·2 |
| | | 221·9 217·3 | 43·36 41·09 | 25·05 22·76 | 1·08 0·71 | 19·48 18·45 | +11·0 +3·3 | 45·3 44·6 | 40·7 37·3 |
| | Morning .. | 221·2 | 40·61 | 24·29 | 1·04 | 19·58 | +6·4 | 44·5 | 38·1 |
| | | 222·5 219·8 | 41·40 39·85 | 25·34 23·11 | 1·17 0·77 | 20·40 18·99 | +9·3 +3·9 | 45·0 43·9 | 38·5 37·2 |
| December to January 81 to 88 | Evening .. | 220·0 | 40·22 | 23·36 | 1·13 | 19·88 | +9·4 | 44·5 | 38·8 |
| | | 224·0 217·3 | 42·00 38·64 | 24·51 22·41 | 1·34 0·90 | 19·83 18·41 | +11·7 +4·5 | 44·7 44·3 | 39·3 37·5 |
| | Morning .. | 222·3 | 38·33 | 24·56 | 1·38 | 19·60 | +6·7 | 44·2 | 38·1 |
| | | 224·5 221·2 | 39·24 37·53 | 24·93 24·31 | 1·51 1·08 | 19·91 19·17 | +7·6 +5·3 | 44·5 43·7 | 39·3 36·9 |
| January to February 89 to 96 | Evening .. | 222·1 | 39·53 | 23·73 | 1·35 | 18·98 | +8·7 | 44·7 | 38·8 |
| | | 226·1 218·0 | 41·07 38·74 | 25·11 22·10 | 1·49 1·29 | 19·96 18·50 | +15·8 +2·2 | 45·2 44·2 | 41·1 36·7 |
| | Morning .. | 222·6 | 39·78 | 23·74 | 1·24 | 18·47 | +7·2 | 44·5 | 37·4 |
| | | 225·0 219·8 | 40·65 39·23 | 24·64 22·33 | 1·40 1·01 | 18·82 17·85 | +12·0 +3·1 | 44·7 44·3 | 38·3 36·7 |
| February to March 97 to 104 | Evening .. | 217·1 | 42·6 | 21·60 | 0·86 | 18·30 | +10·8 | 45·3 | 39·2 |
| | | 217·9 216·2 | 43·8 41·8 | 22·24 21·25 | 1·02 0·68 | 18·86 17·70 | +13·7 +6·9 | 45·6 45·0 | 39·9 38·5 |
| | Morning .. | 219·4 | 39·8 | 23·70 | 1·02 | 19·38 | +7·2 | 44·6 | 38·4 |
| | | 221·0 217·5 | 40·9 38·2 | 23·82 23·54 | 1·14 0·80 | 20·30 18·58 | +12·3 +4·1 | 44·9 44·2 | 39·5 37·9 |

PART V—(*concld.*)

| Month and numbers of samples | Time of milking | Saponification No. | Iodine Wijs' No. | Reichert Meissl No. | Polenske No. | Kirschner No. | Ave Lallement | Butyro refractive index at 40°C. | Melting point |
|---|---|---|---|---|---|---|---|---|---|
| March to April 105 to 112 | Evening .. | 215·0 | 43·57 | 20·58 | 0·74 | 17·79 | +14·1 | 45·5 | 38·4 |
| | | 216·5 214·1 | 45·03 45·92 | 21·50 19·67 | 0·87 0·68 | 18·45 17·38 | +18·2 +9·8 | 46·0 45·0 | 38·9 38·1 |
| | Morning .. | 217·9 | 42·6 | 23·77 | 0·89 | 20·19 | +6·3 | 44·8 | 37·2 |
| | | 218·8 217·2 | 45·1 40·86 | 24·21 22·90 | 1·16 0·75 | 20·54 19·47 | +7·8 +4·4 | 45·4 43·9 | 38·4 36·1 |
| April 113 to 120 | Evening .. | 215·1 | 44·7 | 21·49 | 0·86 | 18·5 | +11·0 | 45·1 | 38·7 |
| | | 215·7 214·8 | 45·6 43·8 | 21·74 21·14 | 0·88 0·85 | 18·96 18·03 | +15·0 +4·8 | 45·3 44·8 | 39·3 37·9 |
| | Morning .. | 217·1 | 43·4 | 22·93 | 0·99 | 15·0 | +5·1 | 44·7 | 39·4 |
| | | 219·6 215·3 | 44·96 41·34 | 24·72 22·00 | 1·14 0·89 | 21·24 18·79 | +8·3 −1·4 | 45·4 44·0 | 40·5 38·1 |

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# MEMOIRS OF THE DEPARTMENT OF AGRICULTURE IN INDIA

## THE MUTUAL APPLICABILITY OF THE ANALYTICAL FIGURES FOR BUTTER FAT AND *GHEE*

BY

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[ Received for publication on the 17th March, 1921. ]

A FAIR amount of analytical data has been accumulated regarding the chemical and physical properties of butter fat. In view of the increased interest being shown in maintaining the purity of foods such data are of considerable value. Butter fat, however, comes upon the market after having been subjected to one of various forms of treatment. It may have been converted into *ghee* (clarified butter) after the cream has been heated and ripened naturally or with a starter. In the process of heating the temperature of the butter fat may have been raised as high as 155°-160°C. On the other hand, in the ordinary method of preparation of butter, the cream taken from milk by a separator may have been kept constantly cold and simply churned until butter forms. The available figures dealing with the fat of the milk of Indian cows and buffaloes are not usually accompanied by a detailed account of the conditions under which the butter or *ghee* samples analysed have been prepared. It is necessary therefore to know whether the analytical figures for butter fat which has been simply taken from the milk and churned will be very different to those of the same butter fat heated, ripened and again heated to make *ghee*. This will enable a decision to be formed whether the analytical figures obtained for butter fat as butter are applicable also to butter fat as *ghee* or *vice versa*.

* Paper read at the Eighth Indian Science Congress, Calcutta, January 1921.

In the experiments to be discussed in this paper cream was separated from cow or buffalo milk and portions of it converted into butter or *ghee* as follows :—

Cream unripened after separating and churned immediately.

The same converted into *ghee.*

Cream naturally ripened by allowing to stand overnight and then churned into butter.

The same butter converted into *ghee.*

Cream ripened with starter obtained from local butter-milk.

The same converted into *ghee.*

Cream ripened with Hansen's starter and churned.

The same converted into *ghee.*

In the manufacture of butter, the cream was kept at a low temperature as is the usual dairy practice. The *ghee* was prepared by heating the butter to 155°C. until clear. The pure butter fat required for analyses was prepared by melting the butter or *ghee* at a temperature not exceeding 60° C. and passing the melted fat through filter paper. Samples A, A.1, B, B.1, C, C.1, D, D.1 represent the fat of a herd of buffaloes treated as above.

Samples E, E.1, F, F.1, G, G.1, H, H.1 were obtained exactly as in the cases of A to D.1 except that the milk was boiled before separating the cream. This is in accordance with the practice usually followed in Indian houses.

The samples described represent butter or *ghee* prepared by all the methods prevailing in India. Milk boiled and unboiled, cream ripened by various starters or unripened, have all been included in the observations made.

Samples O to V.1 were from cows' milk treated in exactly the same way as buffalo milk samples A to H.1.

The method of preparing the various samples is tabulated below :—

| Method of preparation | Buffalo milk samples | | Cow milk samples | |
|---|---|---|---|---|
| | Unboiled | Boiled | Unboiled | Boiled |
| (1) Butter from unripened cream churned immediately .. .. .. | A | E | O | S |
| *Ghee* from above .. .. .. | A.1 | E.1 | O.1 | S.1 |
| (2) Butter from cream naturally ripened by allowing to stand overnight and then churned.. .. .. .. | B | F | P | T |
| *Ghee* from above .. .. .. | B.1 | F.1 | P.1 | T.1 |
| (3) Butter from cream ripened with starter obtained from local market .. | C | G | Q | U |
| *Ghee* from above .. .. .. | C.1 | G.1 | Q.1 | U.1 |
| (4) Butter from cream ripened with an artificial starter and churned .. .. | D | H | R | V |
| *Ghee* from above .. .. .. | D.1 | H.1 | R.1 | V.1 |

The upper half of Table I gives the figures obtained for buffalo milk unboiled and figures in the lower half of the table are for the same milk boiled before separating off cream for butter and *ghee*-making. The butters prepared by different methods can be compared with each other as can also the various samples of *ghee*. Further the figures obtained for a *ghee* sample can be compared with the butter from which it was prepared. In no case is there any marked difference in the Reichert Meissl, saponification, butyro refractometer and other figures which are generally used for judging the purity of a sample of butter or *ghee*.

Table II gives similar figures for boiled and unboiled cows' milk and the same remarks apply as in the case of buffalo milk. The results are worthy of note in view of the fact that all *ghee* samples had been heated to a temperature of 155°C. The authors conclude therefore that the results of the analysis of *ghee* or butter can be generally applied to butter fat from Indian milch animals without reference to the method by which the butter or *ghee* was prepared. The milk from which the butter fat was obtained was drawn from the herd in the month of September, 1920, and the ration fed to the animals at the time was composed of linseed cake, cotton seed and *tur* husk with green grass as a bulky fodder.

The samples dealt with so far in this paper have been of undoubted purity and derived from the herds of milch cattle on a Government Farm. It was thought desirable, however, to examine the ordinary butter sold in the bazaar in the same way. Sample X represents good butter as generally on sale to the public, X. 1 being *ghee* prepared from the same. Samples Y and Y. 1 are of medium quality butter and the *ghee* produced therefrom. There was no guarantee that samples X and Y were from cows or buffaloes or were even pure butter. The results obtained as tabulated in Table III again confirm our previous conclusion that the pure butter fat contained in either butter or the *ghee* prepared from the latter is not materially affected by the heating to which the *ghee* is subjected. The analytical figures for the butter could be applied to *ghee* and *vice versa*.

The authors had at their disposal some samples of pure butter fat which had been kept for some years. These were also examined before and after heating to the temperature of 155°C. which is the temperature reached in the process of *ghee*-making. The figures as tabulated in Table IV again show that the heating has no significant effect on the properties of butter fat.

The authors therefore conclude that whether butter fat is kept at a temperature below 60°C. or heated to a temperature of 155°C. the analytical figures obtained in the methods usually employed in the analyses of butter fat

are not materially affected. Published analyses of butter fat on the one hand or Indian *ghee* on the other are therefore mutually applicable.

## Summary.

1. Published analyses of *ghee* and butter prepared from the milk of Indian milch animals have not been always comparable as it was not known in every case how the samples were prepared.

2. In view of the fact that butter is prepared at a low temperature and *ghee* at a high temperature, the authors thought it desirable to prepare butter and *ghee* respectively from the same sample of milk. Following the Indian custom, samples were also prepared after boiling the fresh milk.

3. The cream was subjected to one of the following methods of treatment :—

(*a*) Unripened cream churned at once.

(*b*) Cream allowed to stand and then churned.

(*c*) Cream ripened with starter obtained from ordinary butter-milk and then churned.

(*d*) Cream ripened with an artificial starter and then churned.

These methods represent the processes generally used for butter-making in India.

4. From the results obtained, it is apparent that the various methods of ripening the cream and preparing butter at a low temperature or *ghee* at a high temperature do not have any significant effect on the analytical figures which are usually taken as criteria of purity.

5. Determinations were also made on samples of butter fat, which have been kept for three to six years and on *ghee* prepared from the same. It was again found that heating the butter fat to a high temperature as is necessary in the process of *ghee*-making does not materially affect the analytical figures or the conclusions which can be drawn from them.

6. The authors therefore conclude that the analytical figures published for butter fat are applicable also to *ghee* and *vice versa*.

## TABLE I.

*Butter fat from buffalo milk unboiled before separating cream.*

| Sample No. | Saponification No. | Iodine Wijs' No. | Reichert Meissl No. | Polenske No. | Kirschner No. | Ave Lallement | Butyro refractive index @ 40° C. | Melting point | Percentage of lactic acid in cream before churning |
|---|---|---|---|---|---|---|---|---|---|
| A. Butter | 226·4 | 30·15 | 32·35 | 1·19 | 28·80 | −12·2 | 41·9 | 40·8 | 0·11 |
| A.1. *Ghee* | 226·7 | 31·32 | 32·35 | 2·43 | 27·77 | −12·0 | 41·2 | 42·0 | |
| B. Butter | 228·3 | 31·92 | 32·10 | 0·95 | 27·84 | − 9·6 | 41·6 | 40·6 | 0·52 |
| B.1. *Ghee* | 228·2 | 32·22 | 31·42 | 1·03 | 27·59 | −18·1 | 41·8 | 41·8 | |
| C. Butter | 227·7 | 32·08 | 31·92 | 0·81 | 28·33 | −15·6 | 41·9 | 40·0 | 1·22 |
| C.1. *Ghee* | 228·6 | 31·88 | 31·89 | 1·06 | 28·10 | −15·2 | 41·8 | 42·2 | |
| D. Butter | 226·9 | 31·34 | 31·96 | 1·26 | 28·10 | − 9·1 | 41·9 | 40·8 | 0·57 |
| D.1. *Ghee* | 228·3 | 31·27 | 31·76 | 1·16 | 27·86 | − 7·4 | 41·7 | 42·2 | |
| *Butter fat from buffalo milk boiled before separating cream.* | | | | | | | | | |
| E. Butter | 227·2 | 31·50 | 32·06 | 0·89 | 27·93 | − 9·3 | 41·9 | 41·0 | 0·11 |
| E.1. *Ghee* | 226·5 | 31·94 | 37·76 | 1·31 | 27·29 | − 7·6 | 41·9 | 41·8 | |
| F. Butter | 227·8 | 32·12 | 31·82 | 0·85 | 27·78 | − 6·1 | 41·9 | 41·0 | 0·44 |
| F.1. *Ghee* | 226·7 | 31·63 | 31·33 | 1·23 | 27·32 | − 9·9 | 41·7 | 41·6 | |
| G. Butter | 225·5 | 31·97 | 31·59 | 0·84 | 27·29 | −12·9 | 41·6 | 41·0 | 1·90 |
| G.1. *Ghee* | 225·3 | 31·85 | 31·19 | 1·12 | 26·88 | −14·8 | 41·8 | 42·0 | |
| H. Butter | 226·8 | 31·97 | 31·79 | 0·83 | 26·86 | −11·0 | 41·7 | 40·6 | 1·12 |
| H.1. *Ghee* | 226·5 | 31·38 | 31·82 | 0·93 | 27·01 | − 4·7 | 41·8 | 42·0 | |

## TABLE II.

*Butter fat from cow milk unboiled before separating cream.*

| Sample No. | Saponification No. | Iodine Wijs' No. | Reichert Meissl No. | Polenske No. | Kirschner No. | Ave Lallement | Butyro refractive index @ 40°C. | Melting point | Percentage of lactic acid in cream before churning |
|---|---|---|---|---|---|---|---|---|---|
| O. Butter | 223·9 | 38·57 | 24·70 | 1·44 | 19·60 | − 1·0 | 43·8 | 35·6 | 0·11 |
| O.1. *Ghee* | 222·6 | 37·54 | 24·58 | 3·05 | 19·17 | + 0·4 | 43·8 | 36·0 | |
| P. Butter | 222·1 | 38·00 | 24·60 | 1·43 | 19·80 | + 1·0 | 43·9 | 36·4 | 0·54 |
| P.1. *Ghee* | 221·5 | 38·54 | 24·34 | 1·77 | 19·33 | + 0·9 | 43·5 | 36·6 | |
| Q. Butter | 221·9 | 37·63 | 24·37 | 0·94 | 19·33 | + 0·6 | 43·2 | 36·4 | 1·11 |
| Q.1. *Ghee* | 221·2 | 37·68 | 24·70 | 3·56 | 19·94 | + 7·1 | 43·6 | 37·2 | |
| R. Butter | 221·7 | 37·66 | 24·66 | 1·48 | 18·81 | + 4·6 | 43·8 | 36·4 | 0·58 |
| R.1. *Ghee* | 221·2 | 37·61 | 24·94 | 3·02 | 19·74 | + 6·2 | 43·5 | 36·6 | |
| *Butter fat from cow milk boiled before separating cream.* | | | | | | | | | |
| S. Butter | 222·4 | 38·02 | 24·48 | 1·30 | 19·08 | + 7·0 | 43·6 | 36·6 | 0·11 |
| S.1. *Ghee* | 222·0 | 38·22 | 24·48 | 1·58 | 18·73 | +11·2 | 43·5 | 38·6 | |
| T. Butter | 222·0 | 37·38 | 24·70 | 1·40 | 19·63 | + 4·7 | 43·7 | 37·4 | 0·33 |
| T.1. *Ghee* | 221·8 | 38·67 | 24·53 | 1·38 | 19·85 | + 4·8 | 43·7 | 37·4 | |
| U. Butter | 222·8 | 38·94 | 24·57 | 1·40 | 19·45 | − 1·1 | 43·0 | 37·0 | |
| U.1. *Ghee* | 220·8 | 37·54 | 24·56 | 2·84 | 21·29 | + 7·0 | 43·4 | 38·0 | |
| V. Butter | 222·0 | 37·96 | 24·38 | 1·83 | 18·91 | + 5·4 | 43·6 | 37·4 | |
| V.1. *Ghee* | 222·6 | 38·07 | 24·38 | 2·46 | 19·06 | + 3·1 | 43·5 | 37·8 | |

TABLE III.

| Sample No. | Saponification No. | Iodine Wijs' No. | Reichert Meissl No. | Polenske No. | Kirschner No. | Ave Lallement | Butyro refractive index @ 40° C. | Melting point |
|---|---|---|---|---|---|---|---|---|
| X. Good butter | 227·2 | 26·34 | 31·77 | 1·13 | 25·97 | −14·6 | 41·0 | 40·0 |
| X.1. *Ghee* from above .. | 226·3 | 26·72 | 31·38 | 1·52 | 25·80 | −15·3 | 40·6 | 40·0 |
| Y. Medium quality butter .. | 214·1 | 35·90 | 19·97 | 0·60 | 18·23 | +15·3 | 44·0 | 43·0 |
| Y.1. *Ghee* from above .. | 214·5 | 35·81 | 19·84 | 0·53 | 18·42 | +12·3 | 43·9 | 43·8 |

TABLE IV.

| Sample No. | Saponification No. | Iodine Wijs' No. | Reichert Meissl No. | Polenske No. | Kirschner No. | Ave Lallement | Butyro refractive index @ 40°C. | Melting point | Age of sample |
|---|---|---|---|---|---|---|---|---|---|
| I Butter from individual buffalo .. | 240·1 | 21·89 | 32·52 | 1·91 | 26·13 | −126·8 | 42·5 | 38·0 | 6 years |
| I.1. *Ghee* from above .. | 238·0 | 21·54 | 32·72 | 2·22 | 26·62 | − 71·6 | 42·6 | 38·2 | .. |
| J Butter from individual cow .. | 229·8 | 25·97 | 24·52 | 1·49 | 20·14 | − 51·0 | 44·7 | 40·2 | 4 years |
| J.1. *Ghee* from above .. | 229·8 | 26·60 | 24·34 | 1·91 | 20·10 | − 41·0 | 44·2 | 40·2 | .. |
| K Butter from herd of buffaloes. | 230·0 | 29·18 | 22·89 | 1·05 | 19·31 | − 64·2 | 45·9 | 42·4 | 4 years |
| K.1. *Ghee* from above .. | 228·7 | 28·98 | 22·06 | 0·83 | 18·96 | − 57·6 | 45·8 | 42·6 | .. |
| L Butter from herd of cows .. | 225·3 | 31·84 | 21·45 | 1·68 | 16·15 | − 53·0 | 45·9 | 38·8 | 4 years |
| L.1. *Ghee* from above .. | 225·4 | 32·12 | 21·15 | 2·26 | 16·72 | − 48·4 | 46·0 | 39·0 | .. |
| M Butter from herd of buffaloes. | 219·8 | 37·50 | 22·24 | 0·95 | 19·56 | − 31·2 | 46·5 | 40·0 | 3½ years |
| M.1. *Ghee* from above .. | 218·4 | 37·45 | 22·02 | 1·84 | 19·47 | − 30·1 | 45·3 | 39·8 | .. |
| N Butter from herd of cows .. | 220·0 | 33·69 | 18·98 | 1·47 | 15·04 | − 30·0 | 45·3 | 40·0 | 4½ years |
| N.1. *Ghee* from above .. | 221·2 | 33·37 | 18·76 | 1·74 | 15·21 | − 35·1 | 46·3 | 39·6 | .. |

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