Modifications in Richmond formula for calculating Solids-not-fat/Total solids percent in cows’ milk in Gujarat State

K.J. Patel* and V.R. Boghra

Department of Dairy Chemistry,
S.M.C College of Dairy Science, Anand Agricultural University, Anand-388 001, Gujrat, India.

Received: 10-10-2017
Accepted: 11-09-2018
DOI: 10.18805/ajdfr.DR-1312

ABSTRACT

SNF/TS percent in cows’ milk, collected from five dairy plants of Gujarat state were estimated using both volumetric and gravimetric method. Separate modified Richmond formulae for calculating SNF/TS have been proposed for each dairy plant. The equations worked out for individual dairy plant reflects region specificity in composition of milk. The correction factor ranged from 0.57 to 1.24 in one equation and 0.42 to 1.11 in the second to match with the results obtained by gravimetric method.

Key words: Correction factor, Gravimetric method, Lactometer method, Richmond formula, Solid-Not-Fat (SNF), Total Solids.

INTRODUCTION

In India, milk payment is based on fat and snf content. Richmond formula is taken as a basis for calculation of SNF in procured milk and it is applied after suitable modification in different countries. The formula is based on interrelationship among TS/SNF, milk fat and specific gravity of milk. However, the composition of milk which is variable due to many factors and sample size cause differences in such equations. Nevertheless, it remains an extensively used rapid test while receiving, dispatching and in-processing standardization of milk.

The corrected lactometer reading coupled with the fat content of milk as determined by Gerber test provides data for application of Richmond formula by which either the total solid (TS) content or the solid – not –fat of milk can be calculated. However, it has been proved that the Richmond formula suggested for specific gravity lactometers was not justifiable when applied to different lactometers and erroneous results were obtained (Sebastian and Rao, 1974). This error in calculation would also affect payment related to the quality of milk in which the producer, the processor and the consumer are affected. Previously, different equations for estimation of TS and SNF content in milk from the specific gravity and fat contents were proposed. SNF determination using different methods would give varied SNF per cent results. Hence, it is imperative that the formula which gives closest results to gravimetric method should be adopted. In India there are 20 varieties of Richmond formula for SNF estimation by volumetric method (Ganguly and Kuchroo, 1980). When different dairies get into contract for purchase and sale of milk in large quantities, it is quite likely that shortages in SNF contents will create big disputes (Patel and Gandhi, 1980). Therefore there is an urgent need for development of a uniform Richmond formula for all dairies or otherwise use of arithmetic constant in basic Richmond equation so as to have computed value for a large number of samples in agreement with gravimetric method.

Keeping this in view the present study was undertaken to suggest modifications in Richmond formula for calculating SNF/TS percent in cows’ milk in different dairy plants of Gujarat state of India.

MATERIALS AND METHODS

Sample collection from dairy plants: Five well known big capacity dairy plants of Gujarat State were selected for the study and were denoted as A, B, C, D and E. From each plant 50 samples of cow milk were taken for analyses as per the procedure (BIS, 1981). Samples were analyzed for fat by Gerber method [IS: 1224 (Part I)-2009] and SNF/TS by gravimetric [IS: 1479 (Part II)-2009] and lactometer method [IS: 9585-1980]. The raw milk samples were kept in a water bath maintained at 45°C for 2-3 minutes before taking lactometer reading. The samples were then cooled down to 29 °C one by one. The calibrated Zeal lactometer was also kept in a water bath maintained at 29 °C throughout the analysis. The lactometer reading was taken and subsequently put in the two equations of either TS or SNF determination as given below.

\[ \text{TS} = \frac{\text{CLR}}{4} + 1.22F + \text{Correction factor} \quad (M_1) \]
\[ \text{SNF} = \frac{\text{CLR}}{4} + 0.22F + \text{Correction factor} \quad (M_1) \]
\[ \text{TS} = \frac{\text{CLR}}{4} + 1.25F + \text{Correction factor} \quad (M_2) \]
\[ \text{SNF} = \frac{\text{CLR}}{4} + 0.25F + \text{Correction factor} \quad (M_2) \]

*Corresponding author’s e-mail: kinpatel11@gmail.com
The data obtained for each of the attribute under study were subjected to statistical analysis in t-test and normality test. Studentized ’t’ test was used to compare the different methods (gravimetric and volumetric) for estimation of TS (Agrawal, 2009). For testing the normality of the data, Kolmogorov-Smirnov test was applied using SAS 9.3 (2011) software.

RESULTS AND DISCUSSION

**Dairy Plant A:** Under study, for dairy plant A, fifty samples, each in raw form from cows milk supplies were collected were analyzed for milk fat, total solids by Gerber, gravimetric and lactometer (volumetric) methods. Based on analysis of 50 samples of cow milk, two probable equations derived statistically are given as under.

- TS = CLR/4 + 1.22 F + 0.86 \[M_1\]
- TS = CLR/4 + 1.25 F + 0.73 \[M_2\]

It was evident from Table 1 that volumetric method without correction factor gave lower values of TS, whose difference was statistically significant than the gravimetric method. While using \(M_1\) and \(M_2\) formula with correction factor, the values for TS showed a non-significant difference indicating almost similar values for TS in comparison with gravimetric method.

It was inferred that the values for TS obtained either by \(M_1\) and \(M_2\) formulae without correction factor were very low indicating implication of respective correction factors for both the equations.

The Richmond’s formula has been found to be fairly satisfactory for normal milk samples in United States (Yastgard et al., 1951), while Desai and Patel (1945) reported that Richmond’s formula yielded results higher than the values obtained by gravimetric method for cow milk. MacMohan et al., 1932 concluded that Richmond’s formula was not applicable in tropical countries.

Overman et al. (1945) studied the relation of TS and sp. gravity by taking 1158 individual, 134 random and 40 vat samples of cow’s milk. They found that the standard deviation of the difference for the three groups of samples were 0.340, 0.242 and 0.100 per cent, respectively. The standard deviation is a measure of variability, as the number of cows contributing to the milk sample was increased; the variability in the deference between the TS by weight and their corresponding percentage of TS by formula was markedly decreased. They suggested that formula TS = L/4 + 1.2F + 0.173 in computing the percentage of TS in milk from individual cow is accurate but the variability within the results was to great to make it of any practical use.

Rao and Bector (1980) reported that modified Richmond’s formula (SNF= 0.25 D + 0.2F +0.50) using Zeal lactometer and BSI formula (SNF= 0.25D + 0.22F + 0.72) using density hydrometer along with fat estimated by Gerber method gave higher and lower SNF values than the gravimetric values indicating that these methods did not give a true estimate of SNF in cow or buffalo milk.

**Dairy Plant B:** Same way analysis of 50 samples of cow milk collected from Dairy Plant B, two probable equations derived statistically are given as under.

- TS = CLR/4 + 1.22 F + 0.57 \[M_1\]
- TS = CLR/4 + 1.25 F + 0.42 \[M_2\]

In volumetric method using \(M_1\) formula without correction factor, the minimum, maximum and average values of total solids from cows milk were 10.27, 16.20 and 12.78 respectively, while using \(M_2\) formula, these values were 10.37, 16.43 and 12.92, respectively. While addition of 0.57 correction factor in \(M_1\) formula, the minimum, maximum and average values of total solids were 10.83, 16.77 and 13.35 respectively, and addition of 0.42 correction factor in \(M_2\) formula, these values were 10.80, 16.86 and 13.35, respectively. By using gravimetric method the minimum, maximum and average values of total solids were 10.69, 17.01 and 13.35, respectively shown in Table 2.

**Dairy Plant C:** In case of Dairy plant C, two probable equations derived statistically are given as under.

- TS = CLR/4 + 1.22 F + 0.66 \[M_1\]
- TS = CLR/4 + 1.25 F + 0.52 \[M_2\]

In volumetric method using \(M_1\) formula without correction factor, the minimum, maximum and average values of total solids in cows milk were 11.81, 13.46 and 12.50 respectively, while using \(M_2\) formula, these values for TS were 11.93, 13.62 and 12.64, respectively. Addition of 0.66 correction factor in \(M_1\) formula gave minimum, maximum and average values of 12.46, 14.11 and 13.16, per cent total solids respectively and addition of 0.52 correction factor in \(M_2\) formula these values were 12.45, 14.14 and 13.16, respectively. By using gravimetric method the minimum, maximum and average values of total solids were 12.39, 14.20 and 13.16, respectively. (Table 3).

**Dairy Plant D:** In Dairy plant D, 50 cow milk samples were analyzed, two probable equations derived statistically are given as under.

- TS = CLR/4 + 1.22 F + 1.24 \[M_1\]
- TS = CLR/4 + 1.25 F + 1.11 \[M_2\]

The minimum, maximum and average values of total solids were 7.91, 13.33 and 11.49, respectively for \(M_1\) formula while these values were 8.00, 13.50 and 11.62, respectively for \(M_2\) formula without correction factor in volumetric method. On addition of 1.24 correction factor in \(M_1\) formula, the minimum, maximum and average values of total solids were 9.15, 14.57 and 12.72, respectively and on addition of 1.11 correction factor in \(M_2\) formula, these values were 9.10, 14.60 and 12.72, respectively.
### Table 1: Total solids of cows milk obtained by different formulae for Dairy Plant A.

| Method      | Total solid, per cent | Without correction factor | With correction factor |
|-------------|-----------------------|---------------------------|------------------------|
| Gravimetric |                       |                           |                        |
| M₁          | CLR + 1.22F           | 4                         |                        |
| M₂          | CLR + 1.25F           | 4                         |                        |
| Volumetric  |                       |                           |                        |
| M₁          | CLR + 1.22F + 0.86    | 4                         |                        |
| M₂          | CLR + 1.25F + 0.73    | 4                         |                        |
| Minimum     | 11.83                 | 10.96                     | 11.06                  |
| Maximum     | 14.55                 | 13.70                     | 13.87                  |
| Average     | 12.99                 | 12.13                     | 12.26                  |
| t-test      | 6.092                 | 5.095                     | 1.30 X 10⁻¹⁴           |
| Result      | S                     | S                         | NS                     |

S= Significant  NS= Non significant

### Table 2: Total solids of cows milk obtained by different formulae for Dairy Plant B.

| Method      | Total solid, per cent | Without correction factor | With correction factor |
|-------------|-----------------------|---------------------------|------------------------|
| Gravimetric |                       |                           |                        |
| M₁          | CLR + 1.22F           | 4                         |                        |
| M₂          | CLR + 1.25F           | 4                         |                        |
| Volumetric  |                       |                           |                        |
| M₁          | CLR + 1.22F + 0.57    | 4                         |                        |
| M₂          | CLR + 1.25F + 0.42    | 4                         |                        |
| Minimum     | 10.69                 | 10.27                     | 10.37                  |
| Maximum     | 17.01                 | 16.20                     | 16.43                  |
| Average     | 13.35                 | 12.78                     | 12.92                  |
| t-test      | 2.89                  | 2.16                      | 9.10 X 10⁻¹⁵           |
| Result      | S                     | S                         | NS                     |

S= Significant  NS= Non significant

### Table 3: Total solids of cows milk obtained by different formulae for Dairy Plant C.

| Method      | Total solid, per cent | Without correction factor | With correction factor |
|-------------|-----------------------|---------------------------|------------------------|
| Gravimetric |                       |                           |                        |
| M₁          | CLR + 1.22F           | 4                         |                        |
| M₂          | CLR + 1.25F           | 4                         |                        |
| Volumetric  |                       |                           |                        |
| M₁          | CLR + 1.22F + 0.66    | 4                         |                        |
| M₂          | CLR + 1.25F + 0.52    | 4                         |                        |
| Minimum     | 12.39                 | 11.81                     | 11.93                  |
| Maximum     | 14.20                 | 13.46                     | 13.62                  |
| Average     | 13.16                 | 12.50                     | 12.64                  |
| t-test      | 8.06                  | 6.27                      | 0                      |
| Result      | -                     | S                         | NS                     |

S= Significant  NS= Non significant

**Dairy Plant E:** From the analysis of cow milk of Dairy Plant E, derived are as under.

\[
\text{TS} = \frac{\text{CLR}}{4} + 1.22F + 0.68 - M₁
\]

\[
\text{TS} = \frac{\text{CLR}}{4} + 1.25F + 0.54 - M₂
\]

In volumetric method using M₁ equation without correction factor, the minimum, maximum and average values of total solids were 9.74, 14.43 and 11.97 respectively, while using M₂ equation, these values were 9.83, 14.62 and 12.10, respectively. Addition of 0.68 and 0.54 correction factor yielded 10.42, 15.10 and 12.65 and 10.37, 15.16 and 12.65 as the minimum, maximum and average values of total solids in M₁ and M₂ equation respectively. The gravimetric method resulted 10.46, 14.94 and 12.65 per cent as minimum, maximum and average values of TS respectively (Table 5).
Table 4: Total solids of cows milk obtained by different formulae for Dairy Plant D.

|                       | Total solid, per cent |                       |                       |                       |                       |
|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
|                       | Gravimetric method    | Volumetric method     | Without correction factor | With correction factor |                       |
|                       | M₁                   | M₂                   | M₁                   | M₂                   |                       |
|                       | CLR+1.22F           | CLR+1.25F           | CLR+1.22F+1.24       | CLR+1.25F+1.11       |                       |
| Minimum               | 8.95                 | 7.91                 | 8.00                 | 9.15                 | 9.10                  |
| Maximum               | 14.66                | 13.33                | 13.50                | 14.57                | 14.60                 |
| Average               | 12.72                | 12.50                | 11.62                | 12.72                | 12.72                 |
| t value               | -                    | 6.58                 | 5.83                 | 0.00                 | 9.36 X 10⁻¹⁵          |
| Result                | -                    | S                    | S                    | NS                   | NS                    |

S= Significant  NS= Non significant

Table 5: Total solids of cows milk obtained by different formulae for Dairy Plant E.

|                       | Total solid, per cent |                       |                       |                       |                       |
|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
|                       | Gravimetric method    | Volumetric method     | Without correction factor | With correction factor |                       |
|                       | M₁                   | M₂                   | M₁                   | M₂                   |                       |
|                       | CLR+1.22F           | CLR+1.25F           | CLR+1.22F+0.68       | CLR+1.25F+0.54       |                       |
| Minimum               | 10.46                | 9.74                 | 9.83                 | 10.42                | 9.10                  |
| Maximum               | 14.94                | 14.43                | 13.50                | 15.10                | 14.60                 |
| Average               | 12.65                | 11.97                | 11.62                | 12.65                | 12.72                 |
| t value               | -                    | 3.92                 | 3.11                 | 2.09X 10⁻¹⁴          | 1.022X 10⁻¹⁴          |
| Result                | -                    | S                    | S                    | NS                   | NS                    |

S= Significant  NS= Non significant

Table 6: Probable TS formula of cows milk for different Dairy Plants of Gujarat State.

| Sr. No. | No. of samples | Name of the Dairy Plant | Probable TS formula by taking a factor of 1.22F | Probable TS formula by taking a factor of 1.25F |
|---------|----------------|-------------------------|-------------------------------------------------|-------------------------------------------------|
| 1       | 50             | Dairy Plant A           | TS = CLR+1.22 F +0.86                           | TS = CLR +1.25F +0.73                           |
| 2       | 50             | Dairy Plant B           | TS = CLR+1.22 F +0.57                           | TS = CLR +1.25F +0.42                           |
| 3       | 50             | Dairy Plant C           | TS = CLR+1.22 F +0.66                           | TS = CLR +1.25F +0.52                           |
| 4       | 50             | Dairy Plant D           | TS = CLR+1.22 F +1.24                           | TS = CLR +1.25F +1.11                           |
| 5       | 50             | Dairy Plant E           | TS = CLR+1.22 F +0.68                           | TS = CLR +1.25F +0.54                           |
| Overall | 250            |                         | TS = CLR+1.22 F +0.86                           | TS = CLR +1.25F +0.88                           |
It is inferred that the values for TS obtained either by $M_1$ and $M_2$ formulae without correction factor were very low indicating implication of correction factors for both the equations is required.

We assume that the variability observed in the quantity of TS/SNF as reported to be influenced by breed of cow, environmental conditions, stage of lactation, age of cow,udder condition and animal health etc. Therefore, the difference observed in the quantity of TS/SNF at different dairy plants might be due to the aforementioned reasons.

Pruthi and Bhalerao (1973) had proposed the modification of existing ISI formula for cow milk as $TS = 0.25D + 1.22F + 0.87$. However, some investigators (Desai and Patel, 1945; ICAR, 1951; EL-Solkany and Harsan, 1953) had given contradictory reports and observed Richmond's formula to give higher SNF values than the gravimetric procedure.

Therefore, in the present investigation correction factor of 1.22 and 1.25 used along with Richmond formula were found to be necessary useful in calculation of TS/SNF for the values obtained from volumetric method so as to have consonance with gravimetric (official) Method. The overall equations derived for computing TS values by volumetric method for cow are show in Table 6. It is evident that overall equation can be used by all the dairy plants when they get in contract for transportation of milk from one plant to another for purchase & sale in large quantities.

**CONCLUSION**

The results obtained in the present investigation revealed that maintaining all the aspects almost same, the correction factor varied from 0.57 to 1.24 in $M_1$ equation while it ranged between 0.42 and 1.11 in $M_2$ equation for various dairy plants. It could be seen that a correction to be applied in $M_1$ equation ranged from 0.67 to 1.66, while it varied from 0.44 to 1.45 in $M_2$ equation. The variations in correction factor in present study were within the limits reported by earlier workers. It showed that the equation $TS = CLR/4 + 1.25F +$ correction factor was more convenient as compared to $TS = CLR/4 + 1.22F +$ correction factor, and provided the TS/SNF in very close proximity to the results for TS obtained by gravimetric method. It reflected that variations are from non-assignable causes and therefore, every Dairy Plant has to evolve its own equation for TS/SNF by lactometer method.

**REFERENCES**

Agrawal BL (2009) Basic Statistic. Willey Eastern LTD., New Delhi

BIS (1981) Handbook of Food Analysis (SP: 18-part I): Methods of Sampling. BIS, New Delhi.

IDF (1995) Milk payment systems for Ex-farm milk. *Bulletin of the IDF No.305*: 2.

Desai CM and Patel AH (1945) Determination of total solids in milk. *Current Sci.* 14: 203.

EL-Solkary AM and Hasman AH (1953) SNF in milk by calculation. *Indian J. Dairy Sci.* 6: 93.

Ganguli NC and Kuchroo N (1980) Technological approaches for infant food manufacture from modified cow milk. *J. food Sci.* 45 (5): 1333-1335.

ICAR (1951) First Ann. Rept. Allahabad Agric. Inst. p. 90.

IS: 1183 (1965) Specification for density hydrometer for use in milk (revised). Indian Standards Institution, New Delhi.

IS: 1224 (Part-1) 2009 Determination of fat by Gerber method. Indian Standard Institution, New Delhi.

IS: 1479 (Part II) (2009) Determination of total solids by gravimetric method. Indian Standard Institution, New Delhi.

IS: 9585 (1980). Determination of total solids by lactometric method. Indian Standard Institution, New Delhi.

MacMohan, P. S., Gupta, B. and Mukherjee, P. C. (1932). An investigation into the composition of milk at Lucknow: superintendent, printing and stationary U.P. Allahabad.

Overman, O. R. (1945). Relation of solids in milk to fat and specific gravity of the milk. *J. Dairy Sci.*, 5: 22.

Patel M M and Gandhi NN(1980)SNF testing by lactometer. *Indian Dairyman*, 32(1): 31-33.

Pruthi TD and Bhalerao VR(1973)Application of Richmond’s formula for the estimation of S.N.F in milk. *Milchwissenschaft*, 28(40): 210-211.

Ramachadran KS, Venkatesware Rao R and Basu KP(1953) Determination of total solids in milk. *Indian J. Dairy Sci.* 6:111.

Sandhu S S(2003). Make your Solid-Not-Fat (SNF) calculation easy. *Indian Dairyman*. 55 (4): 51-53.

SAS 9.3 software (2012)SAS Institute Inc., Cary, N. C, USA.

Sebastian J and Rao MB(1974) Determination of solid content of milk by specific gravity lactometer; Modification of Richmond formula. *ISI bulletin*, 26: 221-223.

Ystgaard, O.M., Homeyer, P.G. and Bird, E.W. (1951). Determination of total solids in normal and watered milks by lactometric methods. *J. Dairy Sci.*, 34: 689.