

Estimation of Solids-not-Fat in Milk Using Specific Gravity Lactometers

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■ The payment of milk is based on its fat and solids-not-fat (SNF) contents. Both these constituents being variable a correct estimation of milk fat and solids-not-fat is most important from a commercial standpoint. Slight error in the estimation of fat and SNF, especially when milk is handled in large quantities in a dairy plant, can result in big discrepancies in the balance sheets and recovery accounts.

A variety of methods such as gravimetric, volumetric, instrumental etc. have been proposed and used for the determination of fat and SNF. However, none of them satisfies the requirement for both speed and precision. The gravimetric methods are more accurate but they are more time consuming and demand a better analytical skill. At the field level, the volumetric methods are being followed and well established procedures are available for cow milk. Application of such methods to buffalo milk, which is richer both in fat and SNF than cow milk and is the main source of supplies of all dairies in India, revealed some differences in the values obtained by volumetric and gravimetric methods.

Lactometric methods for the estimation of SNF are rapid and simple. To-day more than 60 different equations for calculating the relation between fat content and specific gravity and the total solids/SNF of milk are available. Among all these, only two are very popular—Babcock formula used in United States of America and the Richmond's formula used in Europe. The Richmond's formula using specific gravity readings and a modified Richmond's formula using density readings have been widely

the in our country for calculating the SNF in cow and buffalo milk. Wide variations in the results have been reported by different workers. This is mainly because the different dairies used different types of lactometers, and there is no uniformity in the formulae followed to calculate the SNF content of milk. In order to remove the confusion prevailing in the dairy industry with regard to the distinction between various lactometers and proper use of the formulae for determination of SNF in milk, a systematic study has been carried out on the suitability of Richmond's formula so that the SNF values are in close agreement with the gravimetric method.

Materials and Methods

Milk samples from individual animals (cows and buffaloes) were collected from the herd maintained at the Institute. Fresh skim milk and cream were collected from the Experimental Dairy of the Institute to prepare milk samples of desired fat percentage by mixing in different proportions of skim milk and cream or by addition of skim milk/cream to the milk. By this method milk samples prepared had a range of fat percentage from 2 to 10. All milk samples were heated to 45°C and held at that temperature for five minutes to ensure complete liquification of milk fat globules and thoroughly mixed avoiding incorporation of air. The samples were then brought to the temperatures of determination (84° and 60°F) and lactometer readings were taken. All milk samples were analysed for fat by Gerber method (ISI-1977) using 10.75 ml. milk pipette and Rose-Gottlieb method (ISI-1961); and for total

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Solids/Solids-not-fat by gravimetric method (ISI-1961). The following formulae were used for the calculation of total solids/SNF by the volumetric method. (i) When *QUEVENNE* specific gravity lactometer, calibrated at 60°F, was used (BSI-1959).

$$TS = 0.25L + 1.2F + 0.14$$

$$\text{or } SNF = 0.25L + 0.2F + 0.14$$

Where L = lactometer reading taken at 60°F, and
 F = % of fat by Gerber method.

(ii) When *ZEAL* specific gravity lactometer, calibrated at 84°F, was used. The formula suggested by Sebastian *et al* (1974) was followed.

$$TS = 0.25L + 1.2F + 0.50$$

$$\text{or } SNF = 0.25L + 0.2F + 0.50.$$

Where, L = lactometer reading taken at 84°F,
and

F = % of fat by Gerber method.

Solids-not-fat by gravimetric method SNF_G was obtained by subtracting the fat determined by Rose-Gottlieb method from the total solids estimated gravimetrically by oven-drying method.

Both the lactometers, *Quevenne* (Made in Germany) and *Zeal* (Made in London) were checked for their accuracy before use (ISI-1965).

Results and Discussion

The SNF values of milk samples as obtained by the three different methods and the algebraic means of the differences between SNF values as determined by the gravimetric method and those determined by the two volumetric methods are presented in Table 1. The frequency distribution of differences in SNF of milk by gravimetric method and by volumetric method using specific gravity lactometers is given in Table 2. From Table 1, it can be seen that the

Table 1. Solids-not-fat of milk samples of varying fat percentage as determined by gravimetric method and by calculation using specific gravity lactometers.

Fat % Range	No. of sample	Range of SNF (%) as determined by different methods			Range of difference in SNF as related to gravimetric method	
		SNF_G	SNF_Q	SNF_Z	$SNF_G - SNF_Q$	$SNF_G - SNF_Z$
2.1-3.0	19	8.52-9.73	8.91-9.99	8.52-9.85	-0.85 to +0.35	-0.71 to -0.49
3.1-4.0	19	7.65-10.59	7.78-10.37	7.76-10.28	-0.13 to +0.57	-0.11 to -0.74
4.1-5.0	26	8.30-10.52	8.11-10.12	8.20-9.94	-0.27 to +0.57	-0.17 to +0.94
5.1-6.0	16	7.86-10.50	7.88-10.05	7.89-9.91	-0.23 to +0.72	-0.03 to +0.89
6.1-7.0	20	8.38-10.55	7.42-10.01	8.15-9.75	-0.23 to +0.71	-0.18 to +0.90
7.1-8.0	22	7.66-10.47	7.84-10.20	7.92-9.85	-0.29 to +0.58	-0.26 to +0.77
8.1-9.0	18	8.01-10.66	7.54-10.17	7.30-10.03	-0.17 to +1.07	-0.03 to +1.36
9.1-10.0	11	9.79-10.97	8.88-9.69	8.61-9.47	+0.25 to +1.28	+0.47 to +1.67

SNF_G = Gravimetric method.

SNF_Q = *Quevenne* lactometer method.

SNF_Z = *Zeal* lactometer method.

Table 2. Frequency distribution of differences in SNF of milk by Gravimetric method and by calculations using specific gravity lactometers.

Difference in SNF Range	Frequency	
	SNF _G	SNF _Z
Upto -0.50	2	1
-0.49 to -0.40	0	1
-0.39 to -0.30	1	0
-0.29 to -0.20	7	1
-0.19 to -0.10	11	7
-0.09 to -0.00	15	7
+0.01 to +0.10	25	16
+0.11 to +0.20	27	19
+0.21 to +0.30	20	21
+0.31 to +0.40	15	17
+0.41 to +0.50	6	13
+0.50	22	48

calculated values of SNF by the two volumetric methods were both higher and lower than the gravimetric values.

The mean values of SNF of milk samples as determined by three different methods are given in Table 3, From this Table, it can be seen that the differences between the mean values of SNF_G and SNF_Q and SNF_G and SNF_Z are more than the critical difference which indicates that there is significant difference between the gravimetric method and the Richmond's formula using Quevenne and Zeal specific gravity lactometers.

Table 3. Mean values of SNF of milk samples as determined by three different methods.

No. of samples	SNF _G	SNF _Q	SNF _Z	Critical difference
151	9.52	9.32	9.15	0.0459

The statistical analysis of the results (Table 4) showed that there is a significant difference between three methods of estimating SNF. From this it can be concluded that the Richmond's formula using Quevenne and Zeal specific gravity lactometers do not give a true estimate of SNF in milk.

Table 4. Analysis of variance table.

Source of variance	Degrees of freedom	Sum of squares	Mean sum of squares	'F' value
Between Samples	150	151.7950	1.0119	24.442**
Between methods	2	10.2370	5.1185	123.635**
Error	300	12.4393	0.0414	

**Significant at 1% level
Critical difference=0.0459

Modification of correction to Richmond's formula:

Since the two volumetric methods of estimating SNF in milk did not give its true estimate, it was thought to modify or apply correction to the existing formulae. The data were statistically analysed for the correlation regression equation for the SNF_G and SNF_Q and SNF_G and SNF_Z. From the statistical analysis, it was observed that a single correction to the existing formulae was not possible. So a range of corrections to the two formulae was calculated.

(a) *Correction to Richmond's formula using Quevenne specific gravity lactometer:* The results obtained by SNF_G and SNF_Q were statistically analysed for paired 't' test to get the desired correction for the existing Richmond's formula (Table 5). From this

Table 5. Paired 't' test for SNF_G and SNF_Q

SNF Range	No. of samples	$d \pm S.E.$	't' cal.
upto 6.5	19	-0.01 \pm 0.07	0.8295
6.5-9.0	30	-0.02 \pm 0.04	0.06065
9.0-9.5	24	+0.09 \pm 0.03	2.4165
9.5-10.0	30	+0.21 \pm 0.05	4.2179*
10.0-10.5	39	+0.38 \pm 0.04	9.7631*
10.5-11.0	9	+0.73 \pm 0.11	6.3885*

*Significant at 5% level.

Table, it can be seen that there is insignificant difference between SNF_G and SNF_Q upto 9.0% SNF, indicating that these two methods are in close agreement upto a level of 9.0% SNF. However, significant differences were observed between these two methods when the SNF level exceeds 9.0% indicating a need to include some correction factor in order to get the results in agreement with the standard gravimetric method.

Table 6 shows the various correction factors to be applied to the existing Richmond's formula for the different ranges of SNF. From this it is seen that there is increase in the correction factor with the corresponding

Table 6. 't' calculated values for SNF_G and SNF_Q using modified constant factors in original Richmond's formula using Quevenne specific gravity lactometer.

SNF Range	No. of samples	't' cal.	Constant factor	Correction to be applied
upto 8.5	9	-0.8295	0.14	0.00
8.5-9.0	30	-0.6065	0.14	0.00
9.0-9.5	34	-0.06479	0.23	+0.09
9.5-10.0	30	-0.0000	0.35	+0.21
10.0-10.5	39	-0.0094	0.52	+0.38
10.5-11.0	9	-0.0000	0.87	+0.73

increase in SNF. To get the true estimate of SNF by SNF_Q method, the value of SNF could be obtained by following the existing formula ($SNF = 0.25L + 0.2F + 0.14$) and then from the Table the corresponding correction factor could be added to this value. When this was done with the data obtained in this study, the values obtained by SNF_Q method were in close agreement to those obtained by SNF_G.

(b) *Correction to modified Richmond's formula using Zeal specific gravity lactometers:* Similarly, the results obtained by SNF_G and SNF_Z were statistically analysed for paired 't' test to get the desired correction for the modified Richmond's formula using Zeal specific gravity lactometer (Table 7). In this case also there is a remarkable variation between the results of the two methods. Hence, the correction factors for the various ranges of SNF were calculated.

Table 7. Paired 't' test for SNF_G and SNF_Z

SNF Range	No. of Samples	$d \pm S.E.$	't' cal.
upto 8.5	9	+0.04 \pm 0.09	0.4902
8.5-9.0	30	+0.10 \pm 0.04	2.3303*
9.0-9.5	34	+0.20 \pm 0.03	5.8339*
9.5-10.0	30	+0.39 \pm 0.05	8.6152*
10.0-10.5	39	+0.64 \pm 0.04	16.2668*
10.5-11.0	9	+0.94 \pm 0.13	6.9672*

*Significant at 5% level.

Table 8 shows the various correction factors to be applied to the SNF values as obtained by the existing modified Richmond's formula ($SNF = 0.25L + 0.2F + 0.50$) using Zeal specific gravity lactometer. When these corrections were applied to the data in the present study, the values of SNF_Z obtained were in close agreement to those determined by SNF_G.

Table 8. 'r' Calculated values for SNF_G and SNF_Q using modified constant factors in Richmond's formula as suggested by Sebastian *et al.* (1974) using Zeal specific gravity lactometer.

SNF Range	No. of samples	'r' cal.	Constant factor	Correction applied
upto 8.5	9	+0.4902	0.50	0.00
8.5—9.0	30	+0.0751	0.60	+0.10
9.0—9.5	34	-0.087	0.70	+0.20
9.5—10.0	30	+0.008	0.89	+0.39
10.0—10.5	39	+0.065	1.14	+0.64
10.5—11.0	9	+0.016	1.44	+0.94

Conclusion

From the present investigation it is clear that the original Richmond's formula using Quevenne specific gravity lactometer and modified Richmond's formula using Zeal specific gravity lactometer and Gerber fat estimated by using 10.75 ml. pipette could be used in the determination of SNF in milk by volumetric method and then subsequently applying correction to the SNF value from the Table to get its true estimate.

Acknowledgement

The authors are thankful to Dr. K.M. Narayanan, Scientist S-3 and Head of Dairy Chemistry Division for his valuable suggestions and keen interest in this study and Mr. K.N.S. Sharma for help in the statistical analysis of the data.

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