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Comparative Study of Various Lactometric Methods to Estimate Total Solids in Milk of Jersey Cows*

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ABSTRACT

To ascertain the comparative assessment of various lactometric methods to estimate total solids in milk of Jersey cows maintained at Anand Campus, four lactometers, namely, Watson, Avon, Zeal and Desko, calibrated at different temperatures were used. The per cent of total solids were calculated by using their respective suggested formulae and the results obtained by these lactometric methods were compared with the standard AOAC method.

Watson's lactometer calibrated at 102°F gave an accurate results when compared with time consuming and labourious AOAC method. These two methods were highly correlated with each other (r.0.99) for samples of morning or evening milk. The other three methods did not give satisfactory results.

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INTRODUCTION

Milk fat has served as the basis for the payment of milk. However, the value of the non-fat milk solids must not be overlooked. Stein (1958) reported that among the various methods tried to estimate the total solids of milk, the lactometric methods proved to be the simplest and quickest.

Babcock (1892), Richmond (1893) were the pioneers, to provide various formulae based on lactometer reading to estimate the total solids in milk. The lactometers used by these research workers were calibrated at 60°F. Similarly sharp and Hart (1936) and Herrington (1946) estimated the total solids in milk with the help of Lactometer calibrated at 84°F. However Babad, Pinsky and Sharon (1954) reported that Richmond's formula was not applicable for the milk of Israel cows. Similarly Kothawala (1949), Ramchandran, Venkateswara Rao and Basu (1953), Parekh and Gangwar (1969), Sharma, Agarwal and Singh (1970) and Vyas, Patel and Mishra (1973) found that the Richmond's formula was not applicable under Indian conditions for cow's as well as for buffaloes' milk.

Watson (1957) calibrated the lactometer at 102°F and derived the following formula

$$T.S. = 1{\cdot}35\ F + \frac{273\ L}{L + 1000} - 0{\cdot}40$$

and got accurate estimation of total solids of milk compared to over drying AOAC method where F = per cent of fat, L = Lactometer reading at 102°F.

Similarly Madden, Brunner and

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Hedrick (1958), Lamb, McGillard and Brunner (1960), Watson and Tinsley (1961), Haenlein (1964) and Vega et al. (1977) studied the application of Watson's lactometer and obtained interesting and accurate results which were reasonably comparable to the standard AOAC method.

Recently pure-bred Jersey cows were purchased from Australia and are reared at the Anand campus of the Gujarat Agricultural University. A study to estimate total solids with the help of various lactometric methods was undertaken to find out the applicability of these methods for the milk of cows maintained under Indian conditions.

MATERIALS AND METHODS

The milk samples were collected for 50 weeks from the project of the Indian Dairy Corporation at Anand Campus of the Gujarat Agricultural University. In all 100 samples (50 morning + 50 evening) of milk were analysed for fat and total solids by lactometric as well as by the AOAC method.

Analysis

a. Determination of Total Solids

The standard method recommended by AOAC was employed and total solids were determined as per standard method for the examination of dairy products (1960).

b. Determination of Fat

The Gerber method of fat determination was used to estimate the percentage of fat in milk samples.

c. Determination of Sheath [illegible]

[illegible]

RESULTS AND DISCUSSION

[illegible]

Total solids [illegible] standard AOAC method

The average total solids [illegible] morning milk samples was [illegible] [illegible]

content in evening milk samples was 14·342 per cent.

(ii) *Total solids content determined by lactometric method calibrated at 102°F as suggested by Watson:*

The temperature of the milk samples was raised to 102°F with the help of hot water bath and then the lactometer reading was recorded. Per cent total solids were calculated by using the Watson's formula:

$$\text{T.S.} = 1{\cdot}33\text{F} + \frac{273\text{L}}{\text{L} + 1000} - 0{\cdot}40$$

The average per cent total solids obtained by this method was 13·685 for morning milk samples whereas for evening milk samples the average per cent total solids was 14·324.

(iii) *Total solids content determined by the Zeal lactometer calibrated at 84°F.*

The temperature of the milk samples was lowered down to 84°F with the help of ice-water bath and lactometer reading was taken by the Zeal lactometer. The per cent total solids were calculated by using Sharp and Hart's formula:

$$\text{T.S.} = 1{\cdot}2537\text{F} + 0{\cdot}2680\,\text{L}$$

The average total solids obtained by the method was 13·476 per cent for morning samples whereas the average total solids content for evening milk samples was 14·062 per cent.

(iv) *Total solids content determined by Avon lactometer calibrated at 84°F.*

The temperature of milk samples was adjusted to 84°F by same technique given above but the lactometer reading was taken by using the Avon lactometer. The percentage of total solids was calculated by using Sharp and Hart's formula:

$$\text{T.S.} = 1{\cdot}2537\text{F} + 0{\cdot}2680\,\text{L}$$

The average total solids obtained by using this method was 13·338 per cent for morning milk samples. For the evening milk samples the average total solids of 13·9136 per cent was obtained.

(v) *Determination of total solids of milk by Richmond formula by a lactometer calibrated at 60°F.*

In this case the lactometer reading was taken by a lactometer calibrated at 60°F and Richmond's formula $\text{T.S.} = 1{\cdot}2\text{F} + 0{\cdot}25\text{L} + 0{\cdot}14$ was used to calculate the total solids content of milk. The average total solids in morning and evening milk samples were 12·9138 and 13·4668 per cent respectively.

Analysis of Variance:

The data were statistically analysed by using randomised block design with the five methods (treatments) and 100 samples of morning and evening (taken in 50 weeks) and the details of the same are presented in analysis of variance Table 1 and 3.

The analysis of variance reveals that the calculated "F" for methods was highly significant. This indicates that various methods studied differed signi-

ficantly. Similarly, the calculated "F" for weeks (samples) was highly significant. That means the total solids content from the samples obtained from various weeks differed significantly. This might be due to seasonal and lactational effect on the milk composition.

Comparison of Methods (for morning samples):

The critical difference (C.D.) was calculated to know the relationship among various methods. The value of C.D. is 0·0478 at 5% level of significan The means obtained for per cent to solids by different methods are presen in Table 2.

It can be seen from Table 2 th there was no significant difference b tween per cent total solids obtained the two methods namely, AOAC a Watson's formula. In further compa son of mean per cent total solids obtain by AOAC method with Sharp a Hart's formula applied to the Zeal a the Avon lactometers indicated th

TABLE 1

Analysis of variance for morning samples.

Sr. No.	Sources of variation	D.F.	S.S.E.	M.S.S.	Cal. F.	Table F 5%	1%
1	Methods	4	21·0733	5·2683	354·57**	2·41	3·41
2	Weeks	49	56·3900	1·1508	77·45**	1·42	1·62
3	Error	196	2·9122	0·0148			
4	Total	249	80·3755				

** =Highly significant at 1% level.
S.Em =0·01724

TABLE 2

Average of per cent total solids from morning milk samples.

Methods	AOAC	Watson's formula for Watson lactometer	Sharp & Hart's formula for Zeal lactometer	Sharp & Hart's formula for Avon lactometer	Richmond's formula for lactometer
Mean (per cent total solids)	13·7008	13·6854	13·4760	13·3380	12·9138

TABLE 3

Analysis of variance for evening samples.

Sr. No.	Sources of variation	D.F.	S.S.	M.S.S.	Cal. F.	Table F 5%
1.	Methods	4	25·7729	6·4432	348·28**	2·41
2.	Weeks	49	72·3275	1·4760	79·78**	1·42
3.	Error	196	3·6283	0·0185		
4.	Total	249	101·7287			

** =Highly significant at 1% level.
S.Em. = 0·1804

these methods differed significantly from AOAC method. That means that Sharp and Hart's formula is not applicable as it gives lower values than standard method. Similarly, the average mean per cent total solids obtained by Richmond's formula applied for the Desko lactometer also differed significantly from standard AOAC method. The Richmond's formula gave lower results than the standard AOAC method and hence not applicable.

The analysis of variance revealed that the calculated "F" for methods as well as for weeks (samples) were highly significant in evening milk samples also.

Comparison of Methods (for evening samples):

Since the various methods differed significantly hence critical difference (C.D.) was calculated. The value of C.D. is 0·0518 at 5% of level of significance. The mean obtained for per cent total solids by different methods are presented in Table 4.

As can be seen from Table 4 that there was no significant difference between per cent total solids obtained by the two methods namely AOAC and Watson's formula.

Similar results were also obtained by Watson (1958), and Madden *et al* (1958) in cow milk, as well as by Vyas *et al* (1973) under Indian conditions which revealed that the Watson's lactometer gave results as accurate as AOAC method.

The mean per cent total solids calculated by using Sharp and Hart's formula applied to the Zeal and the Avon lactometer differed significantly from the mean per cent total solids obtained by using standard AOAC method. That means Sharp and Hart's formula is not applicable as it gives lower values than standard AOAC method. The results obtained are in close agreement with those obtained by Herrington (1946). However, when this Sharp and Hart's formula was applied with some modifications known as Sharp-Hart-Herrington's formula by Ystgaard *et al* (1951) gave higher results than the standard oven drying method, proving thereby the unsuitability of the method. Vyas *et al* (1973) compared the Sharp and Hart's formula with standard AOAC method for Kankrej Cow's milk and concluded that Sharp and Hart's formula gave lower results and therefore was not applicable.

Similarly, there was significant difference between the mean per cent total solids obtained by Richmond's formula

TABLE 4

Average of per cent total solids from evening milk samples.

Methods	*AOAC*	*Watson's formula for Watson Lactometer*	*Sharp & Hart's formula for Zeal lactometer*	*Sharp & Hart's formula for Avon lactometer*	*Richmond's formula for Desko lactometer*
Mean	14·3424	14·3240	14·0620	13·9136	13·4668

(per cent total solids).

TABLE 5

The correlation coefficients of total solids for different lactometric methods and AOAC method.

Sr. No.	*Method correlated*	*Correlation co-efficient***	
		Morning samples	*Evening Samples*
1.	A.O.A.C. with Watson	0·99	0·99
2.	A.O.A.C. with Zeal	0·90	0·94
3.	A.O.A.C. with Avon	0·90	0·94
4.	A.O.A.C. with Desko	0·89	0·90

** All the values highly significant at 1% level.

and AOAC method. The per cent total solids obtained by Richmond's formula was lower than that obtained by standard AOAC method. This indicates that the Richmond's formula is not applicable for determination of total solids from the milk of Jersey cow.

Kothawalla (1949) found that the Richmond's formula gave both higher and lower values for total solids than those obtained by direct evaporation. Similar results were reported by Ramchandran *et al* (1953) after analysing 1529 individual and herd samples of cow and buffalo milk. Parekh and Gangwar (1969) also reported that the Richmond's formula gave lower results than gravimetric method. Sharma *et al* (1970) analysed 927 samples of cows and buffaloes milk and concluded that average total solids per cent values were higher by Richmond's modified formula. Vyas *et al* (1973) found wide difference between the standard AOAC method and Richmond's formula after studying 100 samples of Kankrej cow's milk and 250 samples of Surati buffaloe's milk.

Correlation :

The effect of milk samples during different weeks were highly significant, to find out consistency among the result of different lactometric methods, the correlation coefficient were estimated for total solids. The "r" values between each lactometric method and AOAC method were calculated separately for morning and evening milk samples. The values are given in Table 5.

It is evident from the above table that there was very high degree of correlation (0·99) between Watson and AOAC method for morning as well as evening milk samples collected for 50 weeks.

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