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Evaluation of The Milkoscan 104 A/B for Determination of Milk Fat, Protein and Lactose in Milk of Some Mammals

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ABSTRACT

The Milkoscan 104 A/B was evaluated for the analysis of fat, protein, lactose and total solids in milk from individual cows, buffaloes, goats and sheep. Milk samples were analysed by the Milkoscan, as well as by a reference method, for each constituent and the results were then analysed statistically.

Infra-red analysis of milk fat was carried out at 5·73 and 3·4 μm wavelengths. Fat determination at 3·4 μm was more reproducible and accurate than at 5·73 μm. Both measurements showed high correlation coefficients with fat, determined by the Gerber method. Slight differences were observed in the reproducibility and accuracy of tests for different milk constituents in the milk of different animals. Purging efficiency was 98–99%. The results indicated that the Milkoscan was capable of analysing milks other than cow's with comparable accuracy.

INTRODUCTION

The infra-red method has emerged as the technique most suited to the wide-scale analysis of milk and has been well established in the dairy industry.

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Concentrations of milk components have been estimated by measuring absorption at a number of frequencies in the infra-red spectrum (Goulden, 1964).

In 1975, Foss Electric A/S, Hillerod, Denmark, introduced the first single cell dual wavelength infra-red milk analysers (Milkoscans 203 and 300). For each milk component, light at two different wavelengths is sent alternately through the cell. At the sample wavelength, the component shows maximum absorption and, at the reference wavelength, the absorption is minimum. The difference in light intensity at the two wavelengths is an expression of the component in question. The Milkoscans 203 and 300 were tested, recommended and approved by the AOAC for milk analysis (Biggs, 1978).

The Milkoscan 104 represents a second generation of the single cell dual wavelength instruments manufactured by Foss. A number of changes have been incorporated into this instrument to reduce alignment and scattering problems. Van De Voort (1980) reported that the Milkoscan 104 was capable of matching the AOAC specifications for fat, protein and lactose analysis.

The success of the infra-red method in the analysis of milk has been due, in great part, to the relatively consistent composition of cow's milk. However, there has been increasing concern with infra-red analysis of milk from other animals, particularly that of variable composition.

The original infra-red method for fat determination is based on relative absorption by carbonyl groups in ester linkage. This means that the fat is measured by counting the number of fatty acid chains. However, the fatty acid composition of milk fat is influenced by species, breeds, feeding pattern and season, which can cause erroneous estimation of fat. In attempts to minimize variation from chemical analysis, measurement of absorption at 3·4 μm (fatty acid C—H) has been recommended (Gecks, 1981; Kold-Christensen, 1982).

The new version of the Milkoscan A/B is equipped with the original filter, as well as a new one for fat determination. This offers the possibility of testing the two bases of fat determination by infra-red over a wide range of fat content and in milk from different animals.

With this in mind, the present study was planned to evaluate the Milkoscan 104 A/B for milk analysis under conditions prevailing in Egypt where milk from buffaloes, cows, goats and sheep is available for processing. The results are presented in this paper.

EXPERIMENTAL PROCEDURE

Apparatus

The instrument used was a Milkoscan 104 A/B type 19900. As well as protein and lactose determination, this instrument has been designed for fat determination on two different bases. The first wavelength for fat measurement (F_A) is 5·73 μm, which is the absorption characteristic of the ester bond or the attachment points between the glycerol and the fatty acid chain in the fat molecule. The second wavelength (F_B) of 3·4 μm is characteristic of the C—H bond in the fatty acid chains.

Materials

Fresh milk samples were obtained from individual cows, buffaloes, goats and sheep of herds at the National Research Centre, Ain-Shams University and Zagazig University, Moshtohor, and also from farms in the Giza area. Potassium dichromate (0·02 %) was added to milk samples as a preservative. Fifty samples from each species were collected and analysed.

Methods of analysis

Instrumental analysis

Linearity checks and adjustment of the Milkoscan 104A/B for protein and lactose were carried out using calcium propionate and lactose monohydrate, respectively. For fat content, linearity adjustment was achieved by using several dilutions of recombined, homogenised cream from cow's milk. The ash content of milk from Egyptian buffaloes averages 0·78 % (Abd El-Salam & El-Shibiny, 1966); from Egyptian breeds of sheep (*ossimi*, *bakri* and *rahmani*) it averages 0·75 %, 0·74 % and 0·84 %, respectively (Helal *et al.*, 1984) while that of goat's milk averages 0·69 % (Abou-Dawood & El-Sawaf, 1977) and 0·84 % (El-Zayat *et al*, 1984). Therefore, the correction factor used for cow's milk (0·75 % for ash content) was adopted for milk from other species in the estimation of total solids in milk. The samples were warmed to 40 °C and measurements were carried out following the guidelines given by the manufacturer (Foss Electric A/S, 1982).

Reference methods
Methods used were the Gerber method for milk fat determination (BSI, 1955), the macro-Kjeldahl method (AOAC, 1975) for total protein determination (TN × 6·38), the gravimetric method for lactose determination (IDF, 1978) and drying in an oven at 105 °C for 3 h for total solids determination.

Evaluation tests

Evaluation of the Milkoscan 104 A/B has been carried out relative to the general specifications recently set out by Biggs (1979) as follows.

Reproducibility (repeatability)
This was determined by calculating the standard deviation of differences (SDD) between duplicate instrumental results, and the mean difference (MD) between duplicate instrumental results.

Correlation
The relationship between the instrumental and chemical analysis of milk components was determined by calculating the correlation coefficient between values obtained by these methods for milk components according to Snedecor & Cochran (1967). The squared correlation coefficients (R^2) were also calculated.

Accuracy
This was determined by calculating the standard deviation of differences and mean differences between chemical and instrumental results for the different milk components.

Purging efficiency
The purging efficiency of the Milkoscan 104 A/B on all components was evaluated by duplicate analysis on milk samples followed by duplicate analysis of one water sample, repeating this ten times. Purging efficiency was calculated according to the formula:

$$\text{Purging efficiency} = \frac{M_1 - W_2}{M_2 - W_2} \times 100$$

where M_1 is the sum of the first milk results, M_2 is the sum of the second milk results and W_2 is the sum of the water results.

RESULTS AND DISCUSSION

Table 1 shows the fat content of milk from individual cows, buffaloes, goats and sheep as determined by the Gerber method and the Milkoscan 104 A/B using the 5·73 μm filter. The fat content of the milks showed a wide range of variation. The results of the instrumental method for fat analysis were close to that determined by the chemical method. Testing the repeatability of the Milkoscan for fat determined at 5·73 μm showed mean difference and standard deviation of differences in cow's milk to be the lowest, and that for buffalo's milk the highest. The values for reproducibility of Milkoscan with respect to buffalo's milk and goat's milk were slightly higher than the specifications set by AOAC for reproducibility of fat determination by instrumental methods (Biggs, 1979). Comparing the results obtained by the Gerber method and the Milkoscan at 5·73 μm showed mean differences of 0·011, 0·056, 0·064 and 0·060 for cow's, buffalo's, goat's and sheep's milk, respectively, and that the standard deviation of differences were lowest in cow's milk and highest in sheep's milk. These values were higher than those specified by the AOAC for accuracy of fat determination by instrumental methods (Biggs, 1979). This was probably due to the use of milk from individuals with wider variation whilst the specifications were set for bulk milk samples with more consistent composition. The present results are in agreement with those given by Kold-Christensen (1982) who gave SDD of 0·051 and 0·131 for fat contents in bulk and individual cow's milk, respectively, using the 5·73 μm filter.

Use of the 3·4 μm filter improved the repeatability and accuracy of fat determinations in milk from different animals (Table 2). Thus, evaluation tests for reproducibility showed that the instrumental method satisfies the specifications given by the AOAC (Biggs, 1979). The mean differences between the Gerber method and instrumental analysis at 3·4 μm for fat determination in all milks satisfy the recommendations, except that of buffalo's milk which showed slightly higher values. Standard deviation of differences between Gerber and instrumental fat determination at 3·4 μm was less than the corresponding values at 5·73 μm, indicating that the use of the 3·4 μm filter materially improved the accuracy of fat determination. However, these figures were higher than those recommended for bulk cow's milk (Biggs, 1979). The present results are in good agreement with those given by Gecks (1981) and Kold-Christensen (1982).

Table 3 shows the total protein of milk from individual cow's, buffalo's,

TABLE 1

Comparison Between Fat Contents (wt %) of Individual Cow's, Buffalo's, Goat's and Sheep's Milk as Determined by the Gerber Method and the Milkoscan 104 A/B using 5·73 μm Filter (F_A)

Type of milk	*Gerber*		*Milkoscan*		*Repeatability*		*Accuracy*		R^e	R^{2f}
	Range	*Average*	*Range*	*Average*	*MD*[a]	*SDD*[b]	*MD*[c]	*SDD*[d]		
Cow's	1·50–4·40	2·90	1·64–4·53	2·91	0·010	0·010	0·011	0·116	0·992	0·984
Buffalo's	4·70–8·40	6·20	4·79–8·34	6·22	0·022	0·024	0·056	0·188	0·995	0·990
Goat's	2·70–5·70	3·90	2·67–5·88	3·98	0·021	0·024	0·064	0·124	0·970	0·940
Sheep's	3·70–10·2	6·60	3·75–10·1	6·57	0·018	0·020	0·060	0·189	0·998	0·997

[a] MD, mean difference between duplicate analysis.
[b] SDD, standard deviation of differences between duplicate analysis.
[c] MD, mean difference between chemical and instrumental analysis.
[d] SDD, standard deviation of differences between chemical and instrumental analysis.
[e] R, correlation coefficient between chemical and instrumental analysis.
[f] R^2, squared correlation coefficient.

TABLE 2

Comparison Between Fat Contents (wt %) of Individual Cow's, Buffalo's, Goat's and Sheep's Milk as Determined by the Gerber Method and the Milkoscan 104 A/B using 3·4 μm Filter (F_B)

Type of milk	*Gerber*		*Milkoscan*		*Repeatability*		*Accuracy*		R^e	R^{2f}
	Range	*Average*	*Range*	*Average*	*MD*[a]	*SDD*[b]	*MD*[c]	*SDD*[d]		
Cow's	1·50–4·40	2·90	1·61–4·43	2·94	0·011	0·015	0·035	0·090	0·996	0·992
Buffalo's	4·70–8·40	6·20	4·71–8·35	6·27	0·019	0·021	0·070	0·130	0·894	0·800
Goat's	2·70–5·70	3·90	2·67–5·65	3·92	0·019	0·022	0·030	0·116	0·962	0·925
Sheep's	3·70–10·2	6·60	3·65–10·2	6·64	0·015	0·017	0·038	0·058	0·999	0·997

[a] MD, mean difference between duplicate analysis.
[b] SDD, standard deviation of differences between duplicate analysis.
[c] MD, mean difference between chemical and instrumental analysis.
[d] SDD, standard deviation of differences between chemical and instrumental analysis.
[e] R, correlation coefficient between chemical and instrumental analysis.
[f] R^2, squared correlation coefficient.

TABLE 3

Comparison Between Total Protein Contents (wt %) of Individual Cow's, Buffalo's, Goat's and Sheep's Milk as Determined by the Macro-Kjeldahl Method and then Milkoscan 104 A/B

Type of milk	*Macro-Kjeldahl*		*Milkoscan*		*Repeatability*		*Accuracy*		R^e	R^{2f}
	Range	*Average*	*Range*	*Average*	*MD*[a]	*SDD*[b]	*MD*[c]	*SDD*[d]		
Cow's	2·88–3·87	3·62	2·80–3·94	3·69	0·010	0·008	0·070	0·010	0·942	0·889
Buffalo's	3·32–4·88	4·06	3·47–4·96	4·13	0·016	0·018	0·109	0·140	0·944	0·891
Goat's	3·02–3·81	3·45	2·99–4·05	3·48	0·009	0·010	0·025	0·101	0·909	0·825
Sheep's	3·37–5·94	4·47	3·54–6·33	4·71	0·010	0·012	0·070	0·145	0·967	0·936

[a] MD, mean difference between duplicate analysis.
[b] SDD, standard deviation of differences between duplicate analysis.
[c] MD, mean difference between chemical and instrumental analysis.
[d] SDD, standard deviation of differences between chemical and instrumental analysis.
[e] R, correlation coefficient between chemical and instrumental analysis.
[f] R^2, squared correlation coefficient.

TABLE 4

Comparison Between Lactose Monohydrate Contents (wt %) of Individual Cow's, Buffalo's, Goat's and Sheep's Milk as Determined by the Standard Gravimetric Method and the Milkoscan 104 A/B

Type of milk	*Gravimetric*		*Milkoscan*		*Repeatability*		*Accuracy*		R^e	R^{2f}
	Range	*Average*	*Range*	*Average*	*MD*[a]	*SDD*[b]	*MD*[c]	*SDD*[d]		
Cow's	4·39–5·16	4·77	4·45–5·12	4·787	0·007	0·008	0·030	0·050	0·974	0·949
Buffalo's	4·09–5·62	4·87	4·17–5·72	4·966	0·014	0·018	0·068	0·071	0·929	0·863
Goat's	4·12–5·32	4·40	4·10–5·44	4·486	0·011	0·013	0·070	0·072	0·943	0·893
Sheep's	4·08–4·65	4·35	4·30–4·61	4·430	0·009	0·010	0·040	0·066	0·860	0·740

[a] MD, mean difference between duplicate analysis.
[b] SDD, standard deviation of differences between duplicate analysis.
[c] MD, mean difference between chemical and instrumental analysis.
[d] SDD, standard deviation of differences between chemical and instrumental analysis.
[e] R, correlation coefficient between chemical and instrumental analysis.
[f] R^2, squared correlation coefficient.

TABLE 5

Comparison Between Total Solids Contents (wt %) of Individual Cow's, Buffalo's, Goat's and Sheep's Milk as Determined by the Standard Method and the Milkoscan 104 A/S

Type of milk	*Standard method*		*Milkoscan*		*Repeatability*		*Accuracy*		R^e	R^{2f}
	Range	*Average*	*Range*	*Average*	*MD*[a]	*SDD*[b]	*MD*[c]	*SDD*[d]		
Cow's	10·0–13·8	11·9	10·2–13·8	12·0	0·020	0·025	0·080	0·187	0·985	0·969
Buffalo's	12·8–18·8	15·9	13·1–18·7	16·1	0·016	0·018	0·088	0·196	0·893	0·798
Goat's	11·1–14·2	12·3	11·1–14·3	12·6	0·023	0·026	0·080	0·140	0·990	0·979
Sheep's	12·0–20·5	17·1	12·3–20·5	17·3	0·023	0·026	0·080	0·140	0·997	0·994

[a] MD, mean difference between duplicate analysis.
[b] SDD, standard deviation of differences between duplicate analysis.
[c] MD, mean difference between chemical and instrumental analysis.
[d] SDD, standard deviation of differences between chemical and instrumental analysis.
[e] R, correlation coefficient between chemical and instrumental analysis.
[f] R^2, squared correlation coefficient.

goat's and sheep's milk as determined by the macro-Kjeldahl method and the Milkoscan 104 A/B. The total protein contents from different milks varied widely. Evaluation tests of reproducibility of the instrumental method of analysis showed that it satisfied the specification (Biggs, 1979). The mean differences in protein determinations by the chemical and instrumental method of analysis were lowest in goat's milk (0·025) and highest in buffalo's milk (0·109). On the other hand, SDD were lowest in cow's milk (0·01) and highest in sheep's milk (0·145). These deviations are largely due to individuality and species differences.

Analysis of lactose (as monohydrate) by the gravimetric method and the Milkoscan 104 A/B is shown in Table 4. The average lactose content of cow's milk, as determined by the instrumental method, was comparable with that determined by the gravimetric method, while instrumental analysis gave higher lactose than the gravimetric method in the case of buffalo's, goat's and sheep's milk. Evaluation of reproducibility of instrumental measurements of lactose showed excellent results that satisfy the recommended values (Biggs, 1979) while accuracy tests showed slightly higher values than that recommended (Biggs, 1979).

The reproducibility of the Milkoscan 104 A/B for total solids determinations (Table 5) satisfies the recommendations (Biggs, 1979). Comparing the TS content of milk, as determined by the oven and the Milkoscan, the latter method gave slightly better results than the former. Evaluation of accuracy showed that the mean differences between the two methods were within the recommended limits, while the SDD were slightly higher, probably due to the use of individual, instead of bulk, samples.

The overall purging efficiency of the cell was assessed with every set of determinations. The average purging efficiency was nearly the same for different milks and ranged from 98% to 99% for different milk constituents. These values were quite satisfactory.

From the foregoing results one can conclude that the Milkoscan 104 A/B was capable of analysis for fat, protein, lactose and TS of milk from buffaloes, sheep and goats with reasonable accuracy (compared with cow's milk).

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