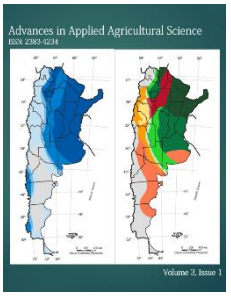
Advances in Applied Agricultural Sciences

Volume 03 (2015), Issue 01, 11-17

Journal homepage: www.aaasjournal.org



Research Article

Factors affecting milk fat percentage and solids-not-fat percentage and milk price of dairy cattle in humid tropics

Marykutty Thomas [1*] and Manju Sasidharan [1]

[1] *Livestock Research Station, Kerala Veterinary and Animal Sciences University, Thiruvazhamkunnu, Palakkad, Kerala, India.*

ARTICLE INFO

Article history:
Received: August 07, 2014
Revised: October 17, 2014
Accepted: December 05, 2014
Available online January 23, 2015

Keywords:
Herd milk composition
Milk price
Season

[*] Corresponding Author;
E. Mail: marykutty@kvasu.ac.in
Tel: +91-9446042919

ABSTRACT

Multiple component pricing based on percentages of fat and solids- not -fat (SNF) in milk is employed by dairy co-operatives to fix the price of milk collected from dairy farmers in Kerala (India). A retrospective study was conducted to determine herd milk fat percentage and solids-not-fat (SNF) percentage and milk price in an organised dairy farm over the period from 2009 to 2013. The influence of year, season and month on milk composition and price were also analysed. The mean fat %, SNF % and price of milk per kilogram of the morning herd milk were 3.71%, 8.51% and Rs. 28.67, while those of the afternoon herd milk were 4.8%, 8.39% and Rs. 30.59 respectively. The year, season and month had a highly significant influence ($p \leq 0.01$) on milk composition. The SNF % in the morning milk and both fat % and SNF % of afternoon milk were the lowest in the summer season. The summer season recorded drops of 1.59 % and 2.39 % in fat % of the morning and afternoon herd milk respectively; and drops of 1.44 % and 1.64 % in SNF % of morning and afternoon herd milk. The year and month of milk production had highly significant ($p \leq 0.001$) influence on per kilogram pooled milk price. Milk fetched the lowest price in March, when losses of Rs. 0. 49 and Rs. 0. 80 per kilogram of morning and afternoon pooled milk (equivalent to 1.68% and 2.57%) were evidenced. The results of the present study calls for a state specific milk composition data as the mean SNF percentage did not comply with provisions in the Prevention of Food Adulteration Act, 1955. Economic loss incurred due to variations in milk composition during summer points towards the need for special support pricing for milk during these months.

Multiple component pricing based on percentage of fat and solids- not -fat (SNF) is employed by dairy co-operatives to determine the price of milk collected from farmers in Kerala. Variations in the milk composition affect the profitability of dairy farmers (Elbehri et al 1994). Furthermore, milk with below the 3.5% and 8.5% of fat and SNF respectively is considered as adulterated as per the Prevention of Adulteration Act, 1955 (PFA Act, 1955). Besides its economic impact, alterations in

milk composition have an influence on public health (Schönfeldt *et al.*, 2012, Paula, 2014).

Studies regarding herd milk composition, its seasonal variations and economic impact in humid tropics are scanty, though there are reports pertaining to milk compositional changes of individual cows due to various genetic and environmental factors (Druet et al 2006; Huang et al, 2012; Schönfeldt *et al.*, 2012) The aim of the present study was to determine descriptive statistics of herd fat and SNF percentages and per kilogram price over the period from January, 2009 to December, 2013 under the humid tropical climate of Kerala. The year, season and month wise variations in milk fat and SNF percentages and milk price were also investigated.

Materials and Methods

The retrospective study was undertaken at Livestock Research Station, Thiruvazhamkunnu, Palakkad of Kerala Veterinary and Animal Sciences University, Kerala, India. Kerala has a humid tropical climate with an annual rainfall of 3000 mm and a temperature ranging between 19.8^0 C and 36.7^0 C. Milk production data from the dairy cattle farm from January 2009 to December 2013 were considered for the present investigation.

Dairy herd consists of an average 75 Sunandini crossbred cows in lactation. Cows are fed with *ad lib* green fodder and concentrates as per the ICAR (2013) recommendations. The concentrate with 16% digestible crude protein and 68% total digestible nutrients was given at a rate of 2kg per cow for maintenance and an additional allowance of 400g per kg of milk produced. The cows are machine milked twice daily at 4 a.m. and 1p.m. The major share of herd milk was sold to Kerala Co-operative Milk Marketing Federation (KCMMF) besides local sale and allocation to calves. The total daily milk sold to KCMMF averaged 336 ±73kg with daily morning and afternoon collections of 226 ±49kg and 110±30kg respectively. The pooled milk was sampled daily for fat and SNF analysis using both automatic milk analyser and manually using Gerber method for fat percentage and lactometer reading for the calculation for SNF percentage. Multiple component pricing based on fat and SNF was adopted by KCMMF to fix the price of milk. The per kilogram price of fat and SNF was Rs (1 US$ = Rs. 61.42). 202.93 and 248.03 respectively. Though there were two milk price revisions during the period of study, latest price published by KCMMF was adopted for the whole period for making comparisons meaningful. The fat %, SNF % and milk price per kilogram of morning and afternoon milk were taken for this retrospective study.

The four seasons were Southwest Monsoon Season: June to September; Post Monsoon Season: October to November; Winter: December to February and Summer: March to May.

Data were analyzed using GLM procedure by analysis of variance, which included the main effects of year, season and month of milk production. Data were presented as mean ± SEM, and statistical analysis was carried out using SPSS software, version 20.0. Level of statistical significance was set at $P<0.05$.The mathematical model used for the analysis of variance was as follows:

$$Y_{ijk} = \mu + a_i + b_j + c_k + e_{ijk}$$

Where,

Y_{ijk} : dependent variables (fat %, SNF% and price per kg of milk collected in the morning and afternoon) a_i :

effect of year (2009,2010,2011,2012,2013)

b_j: effect of season (South west monsoon, Post Monsoon, Winter and Summer seasons)

c_k: effect of month (January to December).

e_{ijk} = residual error.

Results and Discussion

The descriptive statistics of fat %, SNF % and per kilogram milk price are depicted in Table1. The results are higher than the state average of 4.1 % of fat and 8.3 % of SNF and the procurement price of 28.61 per kg (State Planning Board, 2013). While the mean SNF % of the morning milk was in compliance with the PFA rules, that of the afternoon milk was not. The SNF % of the afternoon milk was as low as 8.394%. The fat % showed more variation than solids-not-fat % in the milk. Bailey *et al.* (2005) and Chen *et al.* (2014) also estimated the high variability of fat compared to protein in milk. Generally, components of milk collected in the afternoon had high variation than that of morning milk (Radhika et al,2012). The milk collected in the afternoon fetched higher price than morning milk due to its superior fat content of 4.8%.

In the study, the herd milk fat % was as per the PFA standards in 96.5% for morning milk and 99% for afternoon milk. Radhika (1997) observed that 66.67% of crossbred cows in Kerala, in early lactation, produced milk fat below 3.5% in morning. Here, in the present study, milk fat % was optimal because milk was pooled from cows of all stages of lactation. However, SNF % didn't show compliance to the stipulated 8.5% in 26% and 60.1% with respect to morning and afternoon herd milk samples. Radhika *et al.* (2012) observed that 60.1% of morning milk samples and 77.6% of evening milk samples from individual cows had SNF levels below 8.5%. In surveys conducted by MRCMPU (1995), 73.8%, by Radhika (1997), 46.5% of milk samples from individual cows in the state could not meet the prescribed standards of SNF.

The different stakeholders in the dairy sector in the state have been demanding for the revision of PFA act 1955. Schonfeldt *et al.* (2012) argued the need for country specific milk composition data and quoted that in the U.S, the fat % and SNF% of milk are 3.25% and 8.48% respectively, whereas in South Africa milk contains 3.43% of fat and 8.05 % of SNF. The variations in milk composition are brought about by genetic and environmental differences (Laben, 1963; Schönfeldt *et al.,* 2012). Being a large country with 15 different agro climatic zones, India has diverse environment and cattle genotypes. In this context, a single nation specific data on milk composition cannot be used in all climatic zones. Moreover, the cattle genetics has undergone tremendous changes in the state of Kerala since 1955, when the PFA act was formulated. Ninety three percent of cattle population in Kerala are cross bred Sunadini cattle (State Planning Board of Kerala 2012). Besides, there has been a shift in climate in general with a mean rise of temperature by 0.47^{o}C during the period between 1956 and 2008 in Kerala (Prasada Rao *et al.,* 2013). All these facts, along with the results of present study, indicate the necessity of setting up of state-specific milk composition data.

Correlations among fat %, SNF % and per kilogram milk price of morning and afternoon herd milk were shown in table 2. The correlations between fat and SNF % in the morning and afternoon milk were negative and low.

Table 1. *Number of records, minimum and maximum values, mean ± standard error and standard deviation of fat, solids-n not- fat and milk fat%, fat%, price/kg of morning and afternoon milk*

	Variables	No of records	Minimum	Maximum	Mean± Std. error	Standard deviation
Morning milk	Fat%	1772	3.20	5.00	3.7146± 0.0047	.19842
	Solids-not-fat%	1772	8.00	8.90	8.5130± 0.0033	.13958
	Milk price /kg (INR)	1772	26.82	31.23	28.6676± 0.0120	.50697
After noon milk	Fat%	1754	3.10	5.60	4.8063± 0.0052	.21933
	Solids-not-fat%	1754	7.70	8.90	8.3934± 0.0045	.18878
	Milk price/kg (INR)	1754	27.46	32.67	30.5867± 0.0144	.60469

Table 2. *Impact of different year and different season on milk composition*

	Morning Milk			Afternoon Milk		
Fixed effects	Fat %	Solids not fat	Milk price/kg	Fat	Solids not fat	Milk price/kg
Year	***	***	***	***	***	***
2009	3.7033^{b}	8.4939^{c}	28.6000^{b}	4.8284^{c}	8.2660^{a}	30.3303^{a}
2010	3.6408^{a}	8.4615^{b}	28.3974^{a}	4.8294^{c}	8.2949^{b}	30.4009^{a}
2011	3.8518^{d}	8.4321^{a}	28.7533^{c}	4.8565^{c}	8.3435^{c}	30.5699^{b}
2012	3.7497^{c}	8.6098^{e}	28.9670^{d}	4.7788^{b}	8.5431^{d}	30.8840^{d}
2013	3.6241^{a}	8.5684^{d}	28.6159^{b}	4.7347^{a}	8.5273^{d}	30.7587^{c}
Season	**	***	NS	**	***	NS
South west monsoon	3.7567^{c}	8.5313^{b}	28.7961^{c}	4.8501^{c}	8.4393^{c}	30.7837^{d}
Post monsoon	3.6572^{a}	8.5686^{c}	28.6828^{b}	4.7849^{b}	8.4524^{c}	30.6827^{c}
Winter	3.7203^{b}	8.5160^{b}	28.6862^{b}	4.8377^{c}	8.3638^{b}	30.5796^{b}
Summer	3.6971^{b}	8.4452^{a}	28.4726^{a}	4.7343^{a}	8.3141^{a}	30.2537^{a}
Month	***	***	***	***	***	***

Least-squares means within a column that do not have a common superscript (a–e) are significantly different. ** $P < 0.01$; *** $P < 0.001$

Table 3. *Monthly mean maximum & minimum temperature in Palakkad based upon 1901-2000 data.*

Month	Jan	Feb	Mar	April	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max. Temp. (^{o} c)	33.0	35.4	37.3	36.5	34	29.7	28.3	28.8	30.3	31.2	31.8	31.9
Min. Temp. (^{o} c)	21.8	22.6	24.2	25.1	24.8	23.2	22.5	229.	23	23.2	22.9	22.2

Adapted from IMD

There was a very little association between fat % of morning and afternoon milk, whereas the SNF % of morning milk had a highly significant ($p \leq 0.01$) positive correlation with SNF% of afternoon herd milk.

The influence of year, season and month on herd milk components and per kilogram milk price, and year and season wise least square means of percentages of milk components and per kilogram herd milk price are presented in Table 3. The year had a highly significant ($p \leq 0.001$) influence on the milk composition and herd milk price. Season had a highly significant ($p \leq 0.01$) influence on all herd milk components studied (Table3). The seasonal variation of milk composition of pooled milk was reported earlier by Allore et al. (1997), Bailey et al. (2005) and Heck et al. (2009). The SNF% in the morning and afternoon herd milk and fat % in the afternoon milk recorded a sharp and significant decline during summer season, when the heat stress was at its peak level. These results are in accordance with the earlier findings of Allore et al. (1997), Bailey et al. (2005) and Smith et al. (2013).

There were 1.44% and 1.636% decline in SNF % of respective morning and afternoon milk in summer compared to south west monsoon season. The drop in milk fat % of afternoon milk produced in summer with respect to south west monsoon season was as high as 2.39%.This was higher than the findings of 0.5 and 0.2 percentage units' reduction of fat and protein respectively by Staples and Thatcher (2011) in summer due to heat stress. The morning fat % was significantly lowest in the post monsoon season, followed by summer season. The milk fat% was at the peak level during the south west monsoon season and SNF % was at the highest point during post monsoon, when the direct and indirect effects of heat stress were minimum.

The influence of month of milk production on milk components and milk price were also examined as the seasons are not as distinct in Kerala. The month had a significant influence ($p \leq .001$) on all milk components studied. This is in accordance with the earlier report by Ballou *et al.* (1995), Bailey *et al.* (2005) and Dairy Co (2013). Figure 1 and 2 portrays monthly variations of herd milk fat% and SNF% respectively. The morning fat % was lower during March and April period, followed by an upward trend up to July and thereafter again dwindled down wards. The morning milk recorded 4.33% reduction in fat in the month of March compared to June, when recorded the maximum fat % in the morning milk. The afternoon fat % was the lowest in the month of April. The afternoon fat % reductions were 4.26% and 3.38% respectively in April and March.

The SNF% of morning and afternoon herd milk showed a declining trend from January to March and followed by gradual increase up to August. The month of March when the heat stress is maximal, recorded the lowest SNF % of morning and afternoon milk. The reductions in SNF% of milk collected in morning and afternoon in March were 1.8022% and 2.3062% compared to October.

Monthly mean of maximum and minimum temperature in Palakkad based upon 1901-2000 data by Indian Meteorological Department (IMD) are given in table 3. The cattle were under maximum heat stress during March and April in Palakkad district of Kerala. As per the IMD weather data the maximum temperature of 37.3^0 C was recorded in the month of March followed by 36.5^oC in April. Hot environment negatively affects milk composition (Bernabucci and Calamari, 1998; Calamari and Mariani, 1998; Nardone et al 2010). Coppock et al. (1982) and Nardone et al 2010 attributed the reduced

feed intake and high metabolic heat production during heat stress for the deterioration of both quantity and quality of milk Reduced availability of fodder during these months might also have contributed to this.

Nevertheless, the reductions of fat % and SNF % in crossbred Sunandini under this study were much lower than the earlier reports by Mc Dowell *et al.* (1976) in Holsteins where milk fat, solids-not-fat percentage reductions were 39.7 and 18.9% due to thermal stress. In the current study, mean SNF% in the milk collected in the afternoon never touched the 8.5% target in any of the months.

The year and month of milk production had significant influence on the per kilogram milk price. The milk fetched the highest price in 2012, where the milk SNF% was at the peak level. Monthly variations of per kilogram milk price are depicted in Figure 3. The period from June to September fetched reasonably good per kilogram herd milk price. This was significantly better than the milk price received in the March to May period. The lowest milk price was obtained in the month of March when loss of Rs.0. 49 and Rs. 0.80 per kg of milk (equivalent to 1.68% and 2.57%) was recorded respectively in the morning and afternoon herd milk price due to the changes in milk composition alone. There were not many reports on the economic impact of alterations of milk composition in particular due to heat stress, though there were several studies related to economic impact of heat stress on milk production in general.

The results of the present study clearly indicated that even the herd milk produced by a well-managed farm in the state failed to comply with the PFA act, 1955, owing to its low SNF %. This calls for an urgent need for establishing a state specific milk composition data. Significant seasonal and monthly variations were observed in the milk composition. Generally, milk components were at the lowest percentage during summer months indicating the adverse effect of thermal stress on milk composition in humid tropics. Nevertheless, a detailed study is required to establish the impact of thermal stress on milk composition. Economic loss due to variations in milk composition alone in summer months was substantial. In this context, it is imperative to implement a support pricing strategy for dairy farmers during the summer months to tide over the financial losses.

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