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Milk Composition and Quality of Sahiwal – Friesian Crossbred Cow Studied in Malaysia

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Abstract

Six groups of Sahiwal-Friesian crossbred cows, namely M50-1, M50-2, M50-3, M56, M63 and M75-1 were evaluated. In total 180 cows were used and milk collected was evaluated for composition and quality. The effect of genotypes was significant ($P \leq 0.05$) only for titrable acidity (TA) and milk yield (MY). The M50-1 had the highest milk yield per day (8.73 ± 1.65 kg) but this was not significantly different from the yields of M50-3, M56 and M75-1 (7.06 ± 0.84, 7.06 ± 0.96, 7.70 ± 0.82 kg), respectively. Lactation stage had significant ($P \leq 0.05$) effect on milk yield, fat content, solids-not fat (SNF) content, total solid (TS) content, moisture content and specific gravity (Sp. Gr). Fat content at early lactation was significantly ($P \leq 0.01$) lower than at middle and late lactation (3.69 vs 4.27 and 4.50, respectively). SNF content for middle lactation was significantly lower ($P \leq 0.05$) than that at early and late lactations. At late lactation, TS and moisture contents were significantly ($P \leq 0.05$) higher than those at early lactation. The range of milk composition and quality such as fat (3.96 - 4.50%), SNF (9.02 - 9.40%), TS (13.01-13.81%), moisture (86.26 - 87.07%), Sp.Gr. (1.030- 1.031), pH (6.74 - 6.91), TA (0.13 - 0.15%), MBRT (6.50 -7.40 h) belonged to normal range. M50-1, M50-3, M56 and M75-1 had higher test day milk yield. The optimum level of Friesian inheritance in combination with Sahiwal for MY appeared to be 75%, 56% and 50% with selection for milk production. The composition and quality of milk from the Sahiwal - Friesian crossbred cows met the required standard.

***Keywords*:** Milk composition, quality, Sahiwal – Friesian, crossbred

1. Introduction

The self- sufficiency for milk in Malaysia is only 4.5% (DVS, 1998). The dairy market in Malaysia is mainly dependent on imported milk and milk products. The import of dairy products leads to loss of foreign exchange. The demand for livestock products as a source of high quality protein is expected to continue to rise with the increasing population and per capita income, consistent with the overall rapid development of the country. In order to realise these targets, the government embarked on a crossbreding programmed involving the Sahiwal and Friesian dairy cattle breeds (Osman, 1993). It was expected that with substantial increase in the number of improved dairy cattle, the supply of milk and milk products from local sources would increase.

The Department of Veterinary Services imported a large number of Sahiwal × Friesian crossbreds and purebred Friesians from Australia and New Zealand in 1978 (Sivarajasingam *et al*., 1982). The crossbreeding programme aimed for grading up crossbreds by continual crossing with Friesian. Crossbreds with 50, 56.25, 62.5 and 75% Friesian genes have been produced as a result. Studied on milk production of various dairy cattle in Malaysia showed that Sahiwal – Friesian crossbred cows had good milking ability, second only M63 crossbred cows (Raymond and Ratnakumar, 1997). The present study was conducted to evaluate milk composition and quality of Sahiwal – Friesian crossbred cows in Malaysia.

2. Materials and Methods

Cows from the research farm of the Ladang Pusat Ternakan Haiwan at Ayer Hitam, Johor under the Department of Veterinary Service (DVS), Ministry of Agriculture, Malaysia, were used in this study. The farm was situated approximately 20 meters above sea level at latitude 5 ºN and longitude 102 ºE. The farm received an average annual rainfall of 3000 mm, mean monthly temperature ranging from 26 to 39 ºC, and average relative humidity of 60% to 90% (IHK, 1999).

The cattle production records studied were those between the years 1981 to 2002. They comprised of Sahiwal – Friesian crossbred cows of various percentage of Friesian inheritance. Sahiwal × Friesian F_1 crosses were imported from Australia and New Zealand as heifers or as heifer calves (Sivarajasingam and Kumar, 1993). Through *inter se* mating and crossbreeding, using imported semen and that from selected sires, a number of crossbred groups with Friesian inheritance ranging from 50-75% were produced.

Milk samples were collected from a sample of the breed group available at the Ladang Pusat Ternakan Haiwan at Ayer Hitam, Johor. Animals were selected on the basis of available breed group and stages of lactation. Thirty lactating cows from each breed group were used. Cows were selected on the basis of their stage of lactation (early lactation: 1-30 days, middle lactation: 110-130 days and late lactation: 290-305 days). Ten cows from each stage was studied for each breed group.

Individual milk samples were collected at three different times during the stage of lactation. 250 ml of milk sample from each cow was collected from morning milk in sterile sampling bottle and immediate by kept in icebox. Before testing the milk sample it was warmed to normal temperature and sample in bottles were shaken gently. Chemical analysis [fat content, solids-not fat (SNF) content, total solid (TS) content, moisture content, specific gravity (Sp. Gr), titrable acidity (TA), methylene blue reduction test (MBRT) and pH] of the samples was carried out in Milk Collection Centre (MCC) of the Institute Haiwan, Kluang, Johor.

Six crossbreed groups were evaluated. The crossbreed groups M50-1 (Sahiwal × Friesian F_2), M50-2 (Sahiwal × Friesian F_3), M50-3 (Sahiwal × Friesian F_4), M56 (Sahiwal × Friesian 45.75% Sahiwal × 56.25% Friesian BC_3), M63 (Sahiwal × Friesian, 37.5% Sahiwal × 62.5% Friesian BC_2), and M75-1 (Sahiwal × Friesian, 25% Sahiwal × 75% Friesian) were evaluated.

The breeding design practiced was continuous upgrading of the Sahiwal - Friesian F_1 to Holstein. Prior to 1989, all mating were accomplished by means of artificial insemination (AI) using imported semen of selected sires. Since 1989, the imported semen has been supplemented with semen collected at the National Animal Biotechnology Institute, Jerantut, Pahang. Cows were selected on the basis of their milk production.

The management practice was to keep cows on pasture throughout the day and night except during milking. The pastures were mainly of *Brachiaria decumbens* (90%), *Panicum maximum* and *Paspalm sp*. The heifer and cows were allowed to graze on pasture at the rate of 1.7 acre /animal. Milking cows were supplied with concentrate palm kernal cake (PKC) before milking. Level of feeding was determined on the basis of milk output, approximately 1 kg concentrate for every 4 kg of milk produced. The lactating cows were milked twice daily using machines, once in the morning (7.30 a.m.) and again in the afternoon (3.30 p.m.). Each milking was preceded by an udder wash with a clean warm towel. After milking the teats were dipped in iodine solution for prevention of mastitis. Morning and evening milk production were recorded to determine the total milk yield of a cow in a day.

The milk composition and quality tests from a total of 180 animals were analysed. The statistical analysis of the data was performed for analysis of variance model procedure of the Statistical Analysis System (SAS) for Windows 2000 PC software package. The differences between treatment means were examined using Duncan's multiple range test (DMRT).

The data on milk composition were analyzed using the following statistical model:

$$Y_{ijkl} = \mu + G_i + L_j + (G \times L)_{ij} + Y_k + e_{ijkl}$$

where,

- Y_{ijkl} = an observation on milk composition,
- μ = the overall mean,
- G_i = effect of breed group of cow (i = M50-1, M50-2, M50-3, M56, M63, M75-1),
- Lj = effect of the lactation stage (j = 1—3, 1 = early, 2= middle, 3= late),
- $(G \times L)_{ij}$ = effect of interaction between breed group and the lactation stage,
- Y_k = effect of year of calving (k = 1985 - 2001), and
- e_{ijkl} = random error, assumed to be normally distributed with mean zero and common variance.

3. Results and Discussion

The analyses of variance for the different milk composition and quality test are presented in Tables 1 and 2. There was no significant interaction between breed group except in MY in milk composition traits (Table 1). All milk composition traits were significantly different with lactation stage.

3.1. Effect of breed group

The effect of breed group was significant ($P \leq 0.05$) only for titrable acidity (TA) and milk yield (MY) **(**Table 3). M50-1, M50-3, M56 and M75-1 had higher test day milk yield however, they were not significantly different among them (Table 3). Although, Nevens (2010) stated that there was wide variation in the amount of milk produced by cows within a breed. The optimum level of Friesian inheritance in combination with Sahiwal for MY appeared to be 75-1%, 56%, 50-1% and 50-3% with selection for milk production.

Table 1. Analysis of variance of milk composition traits

Source of Variation	DF	MY		Fat		SNF		TS		H20	
		MS	Pr>F	MS	Pr>F	MS	Pr>F	MS	Pr>F	MS	Pr>F
BG	5	21.29	0.046	1.14	0.680	0.57	0.445	2.47	0.491	2.61	0.483
LS	2	309.83	0.000	10.64	0.003	2.42	0.019	11.37	0.018	9.89	0.036
BG*LS	10	12.32	0.213	0.68	0.957	0.67	0.351	1.12	0.944	1.31	0.918
Error	162	9.20		1.83		0.60		2.79		2.91	
R^2		0.363		0.102		0.129		0.092		0.088	

BG = Breed group, LS = Lactation stage, MY= milk yield, SNF=Solids- not fat, TS= Total solid

Table 2. Analysis of variance of milk quality traits

Source of Variation	DF	SG		pH		TA		MBRT	
			Pr>F	MS	Pr>F	MS	Pr>F	MS	Pr>F
BG	5	0.000	0.5805	0.12	0.220	0.002	0.041	3.25	0.3796
LS	2	0.000	0.0022	0.05	0.538	0.002	0.084	5.51	0.1662
BG*LS	10	0.000	0.3582	0.10	0.280	0.001	0.120	0.90	0.9808
Error	162	0.001		0.08		0.001		3.04	
R^2		0.145		0.112		0.167		0.068	

BG = Breed group, LS = Lactation stage, SG= Specific gravity, TA= Titrable acidity, MBRT= Methylene blue reduction test

Table 3: Milk composition and milk quality traits of different breed groups

Milk Composition Traits (mean±SE)									
BG	MY (kg)	Fat (%)	SNF (%)	TS (%)	H_2O (%)	Sp.Gr.	pH	TA (%)	MBRT
M50-1	8.73^{a}	4.20^{a}	9.40^{a}	13.60^{a}	86.40^{a}	1.031^{a}	6.74^{b}	0.15^{a}	7.00^{a}
	±1.65	±0.49	±0.38	±0.61	±0.62	±0.00	±0.07	±0.00	±0.58
M50-2	6.77^{b}	3.99^{a}	9.02^{a}	13.01^{a}	86.09^{a}	1.030^{a}	6.86^{ab}	0.13^{b}	7.40^{a}
	±0.84	±0.30	±0.23	±0.39	±0.45	±0.00	±0.05	±0.01	±0.55
M50-3	7.06^{ab}	4.50^{a}	9.31^{a}	13.81^{a}	86.19^{a}	1.031^{a}	6.79^{ab}	0.15^{a}	6.95^{a}
	±0.86	±0.36	±0.23	±0.45	±0.48	±0.00	±0.05	±0.01	±0.55
M56	7.06^{ab}	4.17^{a}	9.25^{a}	13.42^{a}	86.58^{a}	1.030^{a}	6.91^{a}	0.14^{ab}	6.50^{a}
	±0.96	±0.46	±0.29	±0.56	±0.57	±0.00	±0.14	±0.01	±0.48
M63	6.33^{b}	4.09^{a}	9.37^{a}	13.46^{a}	86.54^{a}	1.031^{a}	6.79^{ab}	0.14^{ab}	6.68^{a}
	±0.98	±0.43	±0.24	±0.54	±0.52	±0.00	±0.06	±0.01	±0.45
M75-1	7.70^{ab}	3.96^{a}	9.20^{a}	13.16^{a}	86.84^{a}	1.031^{a}	6.78^{ab}	0.13^{b}	7.20^{a}
	±0.82	±0.42	±0.20	±0.44	±0.44	±0.00	±0.05	±0.01	±0.50
Probability	P> 0.001	NS	NS	NS	NS	NS	P>0.02	P>0.019	NS

Overall means for a particular parameter (column) that do not share any of the superscripts are significantly different ($P \leq 0.05$).

BG=Breed group, MY= Milk yield, SNF=Solid not fat, TS = Total solid, SG = Specific gravity, TA= Titrable acidity, MBRT= Methylene blue reduction test.

There was no significant difference in the mean TA of milk among M50-1 and M50-3. The milk TA of M50-2 and M75-1 were significantly (*$P \leq 0.05$*) lower than M50-1 and M50-3.

The milk of the six breed groups did not differ in its fat, solid not fat (SNF), total solid (TS) and water content (H20). The quality of the milk did not differ with respect to the different breed groups. The fat content of milk in this study was 3.96 - 4.50%, which, is within the range for milk composition standard requirement for cows of 3.5 - 5.0% (Anantakrishnan *et al*., 1993). Herrinton (2000) described that the percentage of fat (3.65-3.90%) in milk shows more variation than percentage of the other major constituents. Farrington and Woll (2010) stated that the cow's milk generally contains between 3 and 6 per cent fat. The standard adopted by US government for fat in milk is 3.25 per cent. Although, Nevens (2010) found that the fat percentage of five dairy breeds (Ayrshire, Brown Swiss, Guersey, Holstein and Jersey) were ranged from 3.41% to 5.06%. Banerjee (2009) described that the fat percent of Indian dairy cattle ranged from 3.5 to 5.5%.

The mean for SNF in this study (9.02 - 9.40%) was within the recommended value of 8.5 - 9.5% (Anantakrishnan *et al*., 1993). TS content of the milk in the present study (13.01 - 13.81%) met the milk composition standard requirement for cows of 12.8 - 14.5% (Anantakrishnan *et al*., 1993). Although, Nevens (2010) described that the TS percentage of five dairy breeds (Ayrshire, Brown Swiss, Guersey, Holstein and Jersey) with ranged from 12.27 to 14.54%. The Indian dairy cattle milk TS percent ranged from 12.20 to 15.0% as described by Banerjee (2009).

The 86.26 - 87.07% water content observed in the milk of the present study met the milk composition standard requirement for cows (84 to 88%) (Anantakrishnan *et al*., 1993). Herrinton (2000) described that the percentage of water content of milk ranged from 87.20 to 87.90%. Farrington and Woll (2010) stated that the water content of normal American cow's milk ranged from 82 to 90%. Although, Nevens (2010) found that the H_20 percentage of five dairy breeds (Ayrshire, Brown Swiss, Guersey, Holstein and Jersey) ranged from 85.37 to 87.73%. The breed groups influences milk composition; when MY increases, the H_20 decreases. Animals belonging to the same breed group and maintained under uniform environmental conditions have been found to milk different composition (Anantakrishnan *et al*., 1993). The variation in MY and H_20 may be due to differences in composition of milk of individual animals.

For the milk quality traits, the milk Sp.Gr. was 1.030 - 1.031 for all breed groups which met the standard requirement for cow milk (1.028 - 1.032) (Anantakrishnan *et al*., 1993). TA of milk did not differ significantly (*$P>0.05$*) among M50-1, M50-3, M56 and M63. TA of milk for M50-2 and M75-1 was significantly (*$P \leq 0.05$*) different from that of M50-1 and M50-3. The mean TA value for the breed group ranged between 0.13 to 0.15. The natural acidity of fresh milk is within 0.13 to 0.21% (Anantakrishnan *et al*., 1993). The TA of milk in the present study met the required standard. The amount of phosphates, proteins, citrates and dissolved carbon dioxide in milk vary with breed groups and in turn affect the acidic nature of milk. The pH of milk in this study was significantly different among breed group. The highest pH was in M56 group and was the lowest in M50-1 group and the ranged was 6.74 – 6.91. Anantakrishnan *et al*. (1993) suggested that if the pH value of milk was 6.5 – 6.7, then the milk sample might be conferred free from mastitis or bacterial contamination.

The average mean of Methylene blue reduction test (MBRT) for the breed groups was 6.50 to 7.20 hour. Anantakrishnan *et al*. (1993) recommended that standard decolourization rate of milk was 5 hours and Devids (1999) studied that decolourization rate of milk May to October 4.5 hour and November to April 5.5 hours. Higher MBRT value of the studies suggests that bactological condition of milk was very less. The grade of milk of these studies was good.

3.2. Stage of lactation

Lactation stage had a significant (*P≤0.05*) effect on MY, fat, SNF, TS, H_20, TA and SG (Table 4). The means of milk constituents and quality traits at the different stages of lactation (early, middle and late) are shown in Table 4. MY was decreased, significantly (*P≤0.01*) with lactations stage. Nevens (2010) described that the daily milk yield and to some extent also percentage of butter fat in the milk are profoundly affected the stage of lactation. The milk produced by an animal does not follow a constant trend throughout the lactation period. The milk production for a mature cow generally increases rapidly after parturition, reaches a peak at around 90 day and then declines linearly (Wood, 1967; Schimidt, 1971; Kellogg *et al*., 1977).

Fat% of early lactation was significantly (*P≤0.01*) lower than middle and late lactations (3.69, 4.27 and 4.50, respectively). It might be due to the fact that fat and milk yield are inversely correlated. As milk yield increases fat percentage decreases. Banard *et al.* (1970) reported that approximately 10 weeks after calving fat concentration in the milk increased until the end of the lactation.

Late and early lactation milk SNF was significantly (*P≤0.05*) higher than SNF at middle lactation. Anantakrishnan *et al*. (1993) recommended that there is decrease in SNF content from the time animal pastorates until about 15 days when it is stabilized except during the last three months when there is continuous increase SNF%. Most literatures suggest that there is no increase in the SNF percentages of milk during the later part of lactation if the cows are not pregnant (Rook *et al*., 1965; Spike *et al.*, 1967).

There was no significant (*P>0.05*) different ness of specific gravity of milk in the stage of lactation. The ranges of specific gravity of milk in the stage of lactation was 1.030 to 1.031. Milk normally varies in specific gravity between 1.028 to 1.034. Anantakrishnan *et al.* (1993) reported that generally the specific gravity of cow's milk ranges from 1.028 to 1.032. The specific gravity of these studies required standard. TS content of late lactation of milk was significantly (*P≤0.05*) higher than milk of early lactation. Fat and SNF are the components in TS. These two components of milk increased in the late lactation and so TS also increased.

Water content of early lactation was significantly (*P≤0.05*) higher than that of late lactation. Water actually followed the similar trend as MY over the lactation stages. Early lactation TA was significantly (*P≤0.05*) higher (0.145) than middle and late lactations.

Table 4. Effect of stage of lactation on milk quality of different breed groups.

Traits	Stage of lactation		
	Early	Middle	Late
MY (kg)	$9.68^{a} \pm 0.70$	$6.99^{b} \pm 0.36$	$5.16^{c} \pm 0.36$
Fat (%)	$3.69^{b} \pm 0.07$	$4.27^{a} \pm 0.12$	$4.50^{a} \pm 0.15$
SNF (%)	$9.37^{a} \pm 0.06$	$9.03^{b} \pm 0.14$	$9.38^{a} \pm 0.09$
TS (%)	$13.05^{b} \pm 0.09$	$13.30^{ab} \pm 0.15$	13.90 ± 0.22
H20 (%)	$87.47^{a} \pm 0.51$	$86.66^{ab} \pm 0.17$	$86.16^{b} \pm 0.22$
Sp.Gr.	$1.031^{a} \pm 0.0$	$1.030^{a} \pm 0.0$	$1.031^{a} \pm 0.0$
PH	$6.78^{a} \pm 0.06$	$6.82^{a} \pm 0.03$	$6.84^{a} \pm 0.02$
TA	$0.145^{a} \pm 0.0$	$0.133^{b} \pm 0.0$	$0.137^{ab} \pm 0.0$
MBRT	$6.61^{a} \pm 0.20$	$7.17^{a} \pm 0.14$	$7.09^{a} \pm 0.15$

Means for particular parameter (row) that do not share any superscripts are significantly different (*P≤0.05*)

3.3. Correlation among milk composition traits

Correlations among the milk composition and quality traits for the six Sahiwal - Friesian crossbreed groups are presented in Table 5. Generally, none of the milk composition traits was correlated with MY. Fat and TS generally, had significant (*P≤0.05*) negative correlation with H_20 content for all breed groups. TS and TA was significantly (*P≤0.05*) correlated with fat and SNF. The rest of the milk composition traits did not show any consistent significant correlation, with respect to breed groups.

TS and SNF were positively correlated. Kaushik and Tandan (1979) and Darsal Lal and Narayanan (1990) found that TS and SNF was positively correlated. Milk fat and TS content, generally, had significant (*P≤0.05*), negative correlation with H_20 content of milk for all breed groups for the three lactation stages. It indicates that H_20 is correlated in an inversely with fat and TS. In the present study, fat and TS showed positive (*P≤0.05*) correlation in all lactation stages. Similar result was reported by Darshan Lal and Narayanan (1990) in milk of cows and Murrah buffaloes. Kaushik and Tandan (1979), however, found that fat and TS were negatively correlated in Hariana cattle. The variation may be due to milk samples being collected from different breed groups and farms and also management practices were different.

4. Conclusions

The optimum level of Friesian inheritance in combination with Sahiwal for MY appear to be 75%, 56% and 50% with selection for milk production. Therefore, the qualities of milk from the Sahiwal - Friesian crossbred cows met the required standard. It was revealed that the Sahiwal - Friesian crossbred animal was the best performer regarding the milk composition and quality.

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Table 5. Correlations analysis of milk composition traits. (Pearsons correlation coefficients)

	FAT	SNF	TS	SG	PH	TA	MBRT	MY	H20
FAT	1.000								
SNF	0.152*	1.000							
	0.041								
TS	0.885**	0.593**	1.000						
	0.000	0.000							
SG	-.0.243**	0.901**	0.230**	1.000					
	0.001	0.000	0.002						
PH	-0.149*	-0.035	-0.136	0.008	1.000				
	0.045	0.637	0.068	0.920					
TA	0.207*	0.235*	0.278**	0.140	-0.187*	1.000			
	0.005	0.002	0.000	0.061	0.012				
MBRT	-0.071	0.001	-0.055	0.039	0.206**	-0.255**	1.000		
	0.347	0.990	0.465	0.608	0.006	0.001			
MY	-0.103	0.080	-0.047	0.126	-0.121	0.075	-0.142	1.000	
	0.168	0.285	0.535	0.091	0.107	0.320	0.058		
H20	-0.866**	0-.599**	0-.987**	-0.244**	0.142	-.0.243**	0.059	0.035	1.000
	0.000	0.000	0.000	0.001	0.058	0.001	0.429	0.638	

Upper value 1, n=180, MY= Milk yield, SNF=Solid not fat, TS = Total solid, SG = Specific gravity, TA= Titrable acidity, MBRT= Methylene blue reduction test.

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