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Effect of the Different Feed Formulas on Physiological Changes and Milk Production Performance of Holstein-friesian Crossbred Dairy Cows

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Abstract: The effect of 3 different feed formulas on some physiological changes, haematological changes, cortisol levels and milk production performance of Holstein-Friesian crossbred dairy cows were studied during the early period of the first lactation, by Randomized Complete Block Design with 4 replications and 3 treatments. Twelve cows were randomly assigned to each of the 3 feed formula groups as follows; (1) Commercial Feed as control group, (2) Cooperative-mixed Feed and (3) Cooperative-mixed Feed with the supplement of 2 kilograms of whole cottonseed/head/day. They were raised and managed in Sakon Nakhon Livestock Breeding and Research Station. The significant effects of feed formulas on physiological responses (rectal temperature, respiration rate, pulse rate and heat tolerance), haematological changes, cortisol levels and Average Daily Milk Yield (ADMY) were observed ($p<0.05$). The cows in group 3 showed higher Heat Tolerance Coefficient (HTC) than the cows in groups 1 and 2. The ADMY of cows in group 3 (7.89±0.62 kg/d) was higher than the cows in group 1 and 2 (7.72±0.32 and 7.70±0.64 kg/d), respectively. But milk composition was found only significant difference ($p<0.05$) in milk fat percentage.

Key words: Whole cottonseed, physiological changes, holstein-friesian crossbred cows, milk production performance

INTRODUCTION

The tendency of dairy production efficiency in Sakon Nakhon province nearly remained to static ADMY situation due to the milk productive performance of dairy cows did not increase. The farmers mostly expected the increase of raw milk price only when comparing the production costs and the price of raw milk. The dairy farming condition under the management of small-holders faced serious problem on the exacberating of concentrate price. The solutions were aimed to the modified feed formulas (local feedstuff usage) for reducing concentrate costs which served as alternative and appropriate for feeding dairy cows in tropical area. The effects of tropical condition influenced the productivity of dairy cows such as poor fertility due to the cows had long calving-interval or low conception rate, which were relatively influenced by heredity, environment and raising management.

This research aimed to study the effect of different feed formulas on some physiological changes and milk production performance of Holstein-Friesian crossbred dairy cows under the raising and management condition in Sakon Nakhon Livestock Breeding and Research Station by comparing among 3 feed formulas: commercial feed, cooperative-mixed feed and cooperative-mixed feed with the supplement of whole cottonseed, which would be useful and practical approach for small-holders to increase milk yield of dairy cows and for sustainable dairy production efficiency.

MATERIALS AND METHODS

Twelve Holstein-Friesian (HF) crossbred dairy cows (75 or over 75% of HF blood with uniform body weight) were studied during the early period of the first lactation, by Randomized Complete Block Design (RCBD) with 4 replications and 3 treatments. All data were analyzed by ANOVA and treatment mean comparison was determined by Duncan's New Multiple Range Test (Umpapol, 2005). The experimental feeds were the 3 different feed formulas as follows; (1) Private Company Commercial Feed as control group, (2) Phupan Dairy Cooperative-mixed Feed and (3) Phupan Dairy Cooperative-mixed Feed with the supplement of 2.0 kilograms of whole cottonseed per head per day. All groups of dairy cows acquired the same feeding practice and management, 18% crude proteins concentrate

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(NRC, 2001) and ruzie grass soilage was fed to the cows.

Temperature-Humidity Index (THI), black globe temperature, respiration rate, pulse rate, body temperature, Heat Tolerance Coefficeincy (HTC), haematological changes, cortisol levels and milk yield were collected for study.

RESULTS AND DISCUSSION

General data of the ambient environment: The general ambient environment during the experiment were studied on maximum and minimum temperature, the different temperature between max.-min. temperature and THI. The results of analysis showed that THI mean was 88.97±3.37 (Table 1) which indicated that the experimental area was tropical zone (Vajrabukka, 1996; Umpapol, 2002).

The solar radiation effected on the temperature of dairy cow experimental house, the study revealed that solar radiation mean was 2.35±0.13 which affected on THI mean into 82.64±0.12 throughout the experiment period (Table 2), the intense of sunlight caused the heat increase in the house (Eley *et al.*, 1978; Collier *et al.*, 1981; Beede *et al.*, 1987).

Table 1: Effects of environment on experimental house

Item	Mean
Maximum temperature (°C)	34.97±0.36
Mean temperature (°C)	29.61±0.19
Minimum temperature (°C)	24.12±0.13
Different temperature (°C)	10.85±0.24
Relative humidity (%)	83.92±0.31
Black globe temperature (°C)	48.66±0.74
Ambient temperature (°C)	37.04±0.39
Radiation (°C)	11.45±0.47
THI	88.97±3.37

Table 2: Effect of solar radiation on experimental house

Environment factor	Value
Black globe temperature (°C)	36.25±0.34
Ambient temperature (°C)	33.90±0.31
Radiation (°C)	2.35±0.13
Air temperature (°C)	33.86±0.13
Maximum temperature (°C)	34.97±0.31
Mean temperature (°C)	29.54±0.19
Minimum temperature (°C)	24.12±0.13
Different temperature (°C)	10.85±0.24
THI	82.64±0.12

Physiological changes: The effect of the 3 different feed formulas on physiological changes of Holstein-Friesian crossbred dairy cows. The feed formulas were: (1) commercial feed as control group, (2) cooperative-mixed feed and (3) cooperative-mixed feed with the supplement of 2 kilograms of whole cottonseed/ head/day and they were raised and managed under the condition in Sakon Nakhon Livestock Breeding and Research Station. The results of physiological changes were as follows.

General physiology: The 3 different feed formulas effected on rectal temperature, pulse rate and respiration rate of dairy cows with no significant differences ($p>0.05$), but HTC and sweating rate found significant differences ($p<0.05$) (Table 3).

When THI mean was raised up over 72 it caused heat stress to dairy cows (Wiersma and Stott, 1966). The dairy cows were raised in heat stress condition (Johnson *et al.*, 1960) the THI mean would increase that affected on body heat balance and caused the physiological changes for regulating the increased body temperature (Yousef, 1985). When body heat accumulation was increased as the rules of Van't Hoff effect, so the cows would regulate to static body temperature by many means, the most outstanding responses were the increase of respiration rate, pulse rate and rectal temperature (McDowell, 1972; Bucklin *et al.*, 1988; Bond and Laster, 1975; Eley *et al.*, 1978). The results were shown on Table 3.

The cows fed with the supplement of whole cottonseed showed HTC mean higher than the other two groups ($p<0.01$), but the comparison between Group 1 and Group 2 were not significantly different ($p>0.05$) (Sirvastana and Sindhu, 1977). The whole cottonseed supplement could reduce efficiently the heat from SDA of cow body, therefore they could regulate and balance the body heat even THI value was increased (Vajrabukka, 1996) so it enhanced the cows to reduce heat stress effectively (Umpapol *et al.*, 2001).

Haematological changes: The results showed that haematological mean of average haematocrit percentage of the cows in Group 1, 2 and 3 were not significantly different before the experiment ($p>0.05$), but during the experiment, at the end of experiment and throughout the experiment the average haematocrit percentage were significantly different ($p<0.05$). The results were shown on Table 4.

The cow body could operate a mechanism of body heat regulation under the hot climate by sweating and increased water intake. While the water outside was absorbed into the blood vessels gradually, which caused diluted red blood cell or increased plasma volume so the haematocrit percentage was lower (Hafez, 1968; Garg and Nangia, 1981).

The results showed the average value of haemoglobin concentration of the cows in Group 1, 2 and 3 were not significantly different ($p>0.05$) before the experiment, but during the experiment, at the end of experiment and throughout the experiment the average value of haemoglobin concentration were significantly different ($p<0.05$) (Table 5).

The value of haemoglobin concentration had a positive correlation with the number of red blood cell due to haemoglobin is an important component of red blood cell. Likewise haematocrit, when the ambient

Table 3: The effects of feed formulas on general physiology of dairy cows

General physiology	Feed formulas 1	2	3
Rectal temperature (°C)	39.46±0.03	39.45±0.03	39.09±0.02
Pulse rate (b/min)	82.43±4.76	82.31±2.73	79.59±4.53
Respiration rate (br/min)	82.18±5.73	82.00±6.73	78.34±3.51
Heat tolerance coefficient (%)	80.95±4.60[a]	80.94±6.03[a]	87.65±4.38[b]
Sweating rate (ml/m²/h)	1020.40±46.72[a]	1050.27±00.28[a]	881.15±25.74[b]

Mean within row with different superscript differ significantly (p<0.05)

Table 4: Average of haematocrit in this experiment

	Haematocrit (%)			
Feed formulas	Before experiment	During experiment	End of experiment	Throughout experiment
1	31.34±0.89	36.52±0.81[e]	41.04±0.92[e]	36.36±0.80[e]
2	31.23±0.96	37.30±0.24[b]	41.70±0.94[b]	36.88±0.61[b]
3	31.35±0.04	39.68±0.40[a]	46.84±0.27[a]	40.05±0.64[a]

Mean within column with different superscript differ significantly (p<0.05)

Table 5: Average value of haemogoblin in this experiment

	Haemoglobin (g/100 ml blood)			
Feed formulas	Before experiment	During experiment	End of experiment	Throughout experiment
1	42.00±0.82	50.63±0.47[a]	56.00±0.82[a]	49.81±0.84[a]
2	42.50±0.29	52.13±0.98[a]	55.50±0.94[a]	50.56±0.64[a]
3	42.25±0.26	55.50±0.34[b]	62.25±0.67[b]	53.88±0.64[b]

Mean within column with different superscript differ significantly (p<0.05)

temperature was increased the cows obtained heat stress, cow body could operate a mechanism of body heat regulation under the hot climate by sweating and increase water intake, which increased water volume or plasma volume of blood circulatory ways so the value of haemoglobin concentration became lower (Umpapol, 2002).

Cortisol levels: The result of this study showed that cortisol levels of the cows in Groups 1, 2 and 3 were not significant different before the experiment (p>0.05), but during the experiment, at the end of experiment and throughout the experiment, they were significant different (p<0.05) (Table 6).

The result of the study revealed that the average of cortisol levels in cow serum were increased due to the response of adrenalcortical, when sensory nerve of the cow skin sent neural message to hypothalamus and anterior pituitary gland that resulted on the secretion of cortisol from adrenal cortex (Christison and Johnson, 1972; Hafez, 1968). Heat stress caused on reduction of blood volume that circulated to rectum, but increased blood volume to flow to adrenal cortex and medulla, whereas metabolism including catecholamine and cortisol secretion were increased. The effect of high ambient temperature stimulated sensory nerve of skin and sent neural current via neural connections to hypothalamus and anterior pituitary gland that caused on the increase of cortisol secretion from adrenal cortex (Christison and Johnson, 1972; Wise *et al*., 1988; Umpapol *et al*., 2001; Umpapol, 2002).

Blood glucose levels: The result of this study found that blood glucose levels of the cows in Groups 1, 2 and 3 were not significantly different in each period viz. before the experiment (p>0.05), during the experiment (p>0.05), at the end of experiment and throughout the experiment, they were not significantly different (p>0.05) (Table 7).

Blood urea nitrogen: The result of this study found that average values of blood urea nitrogen of the cows in Groups 1, 2 and 3 were not significantly different in each period viz. before the experiment (p>0.05), during the experiment (p>0.05), at the end of experiment and throughout the experiment, they were not significantly different (p>0.05) (Table 8).

Milk production performance: The result of this study showed that the cows in Group 1, 2 and 3 were highly and significantly different in roughage intakes (p<0.01), but were not significantly different in concentrate intakes (p>0.05). The exact ADMY found highly significant difference, but 4%FCM and daily milk fat weights were not significant (p>0.05). The study on body condition score found no significant difference in both pre-experiment and post-experiment (p>0.05).

The result of milk composition showed that the cows in Group 1, 2 and 3 were significantly different in milk fat (p<0.05), but were not significantly different in protein, lactose, Solid Not Fat (SNF) and Total Solid (TS) percentages (p>0.05). The result was shown on Table 9.

Table 6: Effect of feed formulas on cortisol levels of dairy cows

	Average of cortisol level (ηg/ml)			
Feed formulas	Before experiment	During experiment	End of experiment	Throughout experiment
1	96.00±2.58	89.88±2.85[a]	80.25±1.26[a]	89.00±6.27[a]
2	96.75±1.71	80.38±4.34[b]	72.25±1.26[b]	82.44±9.71[b]
3	96.25±1.71	76.13±3.44[b]	69.25±0.96[b]	79.44±0.73[b]

Mean within column with different superscript differ significantly (p<0.05)

Table 7: Average blood glucose values in this experiment

	Average of blood glucose (mg/100 ml)			
Feed formulas	Before experiment	During experiment	End of experiment	Throughout experiment
1	53.23±0.45	54.48±0.68	56.32±0.87	54.63±1.30
2	53.17±0.74	54.69±0.99	56.64±0.92	54.80±1.53
3	53.56±1.12	55.27±1.10	57.94±0.68	55.51±1.88

Mean within row with different superscript differ significantly (p<0.05)

Table 8: Average values of blood urea nitrogen of the cows in this experiment

	Average of blood urea nitrogen (mg/100 ml)			
Feed formulas	Before experiment	During experiment	End of experiment	Throughout experiment
1	14.04±0.25	15.17±0.41	15.66±0.32	15.66±0.32
2	14.06±0.27	15.09±0.51	16.12±0.14	16.12±0.14
3	14.06±0.09	14.97±0.36	16.11±0.37	16.11±0.37

Mean within column with different superscript differ significantly (p<0.05)

Table 9: Milk production performance of dairy cows in this experiment

	Feed formulas		
Item	1	2	3
Voluntary feed intake			
Roughage (kg)	6.64±0.25	6.48±0.32	6.72±0.08
Concentrate (kg)	5.02±0.02	5.06±0.01	5.04±0.01
Milk performance production			
Milk yield (kg/d)	7.72±0.32	7.70±0.64	7.98±0.62
FMC 4% (kg/d)	7.34±0.34[a]	7.30±0.63[a]	7.80±0.68[b]
Body condition score			
Pre-experiment	2.76±0.04	2.72±0.03	2.74±0.03
Post-experiment	2.72±0.03	2.66±0.03	2.68±0.02
Milk composition			
Fat (%)	3.32±0.20[a]	3.30±0.12[a]	4.60±0.18[b]
Protein (%)	3.26±0.08	3.20±0.06	3.38±0.05
Lactose (%)	4.34±0.19	4.28±0.07	4.66±0.11
Solid not fat (%)	8.85±0.51	8.76±0.58	9.05±0.58
Total solid (%)	12.84±0.57	12.76±0.62	12.96±0.42

Mean within row with different superscript differ significantly (p<0.05)

The dairy cows decreased milk yield when they were under the ambient climate of THI of 72 or over (Johnson *et al.*, 1963) due to the mechanism of body heat balance of cows (McDowell, 1972; Yousef, 1985; Johnson and Givens, 1961), for ventilating the body heat by means of evaporative heat loss which needed more energy in this process and affected the energy utilization for body maintenance. Likewise, McDowell *et al.* (1969) concluded that the process of metabolic heat production in body would decrease continuously when the cows were under high ambient temperature for long time because they reduced feed intakes that caused low energy obtaining and the same as reports of Johnson *et al.* (1966); Curran and Okantah (1982); Smith (1984) which concluded that high ambient temperature influenced directly to the functions of hypothalamus and anterior pituitary gland causing the mechanism of cortisol secretion from adrenal cortex increase. But when the cows faced heat stress continuously for long time, the cortisol concentration would decrease which was the mechanism of adaptation of body to prevent the over metabolic heat from food combustion due to the influence of cortisol function, or the adjustment of cortisol metabolism. Therefore, feed intake, metabolism and metabolic heat were all decreased. However, the efficiency of energy that the cows obtained during hot climate, could utilize less for milk production due to the cost of maintenance energy was higher than 20% when compared between 35°C and 20°C.

It concluded that the heat stress condition effected to beget the stress in dairy cows which could determine from the values of general physiological changes that were mostly increased (Singh and Bhattacharya, 1990; Legates *et al*., 1991; Kabuga, 1992) so that effected haematologic values (Hafez, 1968; Umpapol, 2002), especially haematocrit percentage and haemoglobin concentration value were increased (Abilay *et al*., 1975), which were the indicators that caused HTC values became lower (Sirvastana and Sindhu, 1977) then effected to endocrine system functions particularly the cortisol concentration levels would be increased (Abilay *et al*., 1975) for reducing metabolic heat due to decrease feed intake (Smith, 1984; NRC, 2001). And later on the adjustment of body heat balance occurred and related to cortisol reducing including finally the dairy cow would decrease milk production (Johnson *et al*., 1960; Wayman *et al*., 1962; McDowell, 1972; Thatcher *et al*., 1974; Yousef, 1985) to encourage cow body to normal condition.

The dairy cows fed whole cottonseed would acquire the efficiency increment in heat ventilation of body so to keep the body heat balance efficiently and would be one way to increase energy obtaining for milk production (Hafez, 1968; Eley *et al*., 1978; Bucklin *et al*., 1988). The management of a mechanism of body heat balance for increasing heat ventilation efficacy of the dairy cows would cause in feed intake quantity and feed energy gain more than the mitigated heat stress cows. Similar results from the experiments that were conducted to reduce heat stress of cows by comparison of the untreated groups (without shelter addition or hair cut) ensued lower milk yield than the treated groups (Johnson *et al*., 1960; Thatcher *et al*., 1974) or lower milk yield than the hair cut groups (Boonprong, 1999).

Whole cottonseed supplement would role similarly by-pass fat feedstuff in concentrate, which caused ruminal heat production deceleration (Yousef, 1985) and meanwhile the cows acquired the increased energy (Wrenn *et al*., 1978) particularly maintenance energy for the utilization of body heat ventilation (Church, 1979) so to remain the normal body temperature and increasing net energy gain for more milk production (Andrew *et al*., 1991; Kim *et al*., 1993), likewise Harrison *et al*. (1995) reported that the supplement of by-pass fat feed as Ca-LCFA as 5% level in TMR to Holstein dairy cows, found that dry matter feed intake were similar ($p>0.05$) as 20.50 and 19.70 kilograms per day in control group and treated group, respectively (Kim *et al*., 1993).

The results of this experiment found that the milk composition was not significantly different ($p>0.05$) which was similarly related to Azizan and Phipps (1997) used bST with the supplement of calcium soap in Sahiwal Friesian dairy cows could increase milk production compared to the untreated group, but milk composition was not significantly different ($p>0.05$) due to milk composition would vary on heredity. Therefore, this experiment found that the milk composition was not significantly different ($p>0.05$) due to lower milk producing cows adapted body under the high ambient temperature by regulation of body heat balance, which cortisol level would initially increase ensuing decrease for reducing body heat and metabolism by decrease of feed intake so that milk yield became lower than the treated group, while milk composition was not effected due to the dairy cows adjusted to reduce only milk production but the milk composition was not significantly different.

Conclusion and recommendations: Based on this experiment, it could be concluded that ambient environment effected to experimental house of dairy cows, causing the increase of THI to 72 or over that affected the general physiological changes, haematocrit and hemoglobin changes, cortisol levels and milk production performance. In addition, the dairy cows acquired the whole cottonseed supplement could regulate body heat balance which caused the changes of the general physiology, haematocrit and hemoglobin levels and cortisol levels that showed lower values than commercial feed and cooperative-mixed feed groups. The dairy cows obtained the whole cottonseed supplement could produce the highest average daily milk yield, ensuing the commercial feed and cooperative-mixed feed groups which both of them were not significant different. However, digestibility and utilization of whole cottonseed should be studied for the use in feed formulas of dairy cows efficiently. Furthermore, the influential and related factors should be jointly studied such as housing adjustment, dairy cow management for improving milk production performance especially in summer or hot season.

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