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 supplementation 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 exaberating 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 Coefficient (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 affected 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>
<thead>
<tr>
<th>Item</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum temperature (°C)</td>
<td>34.97±0.36</td>
</tr>
<tr>
<td>Mean temperature (°C)</td>
<td>29.61±0.19</td>
</tr>
<tr>
<td>Minimum temperature (°C)</td>
<td>24.12±0.13</td>
</tr>
<tr>
<td>Different temperature (°C)</td>
<td>10.85±0.24</td>
</tr>
<tr>
<td>Relative humidity (%)</td>
<td>63.92±0.31</td>
</tr>
<tr>
<td>Black globe temperature (°C)</td>
<td>48.66±0.74</td>
</tr>
<tr>
<td>Ambient temperature (°C)</td>
<td>37.04±0.39</td>
</tr>
<tr>
<td>Radiation (°C)</td>
<td>11.45±0.47</td>
</tr>
<tr>
<td>THI</td>
<td>88.97±3.37</td>
</tr>
</tbody>
</table>

Table 1: Effects of environment on experimental house

<table>
<thead>
<tr>
<th>Environment factor</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black globe temperature (°C)</td>
<td>36.25±0.34</td>
</tr>
<tr>
<td>Ambient temperature (°C)</td>
<td>33.60±0.31</td>
</tr>
<tr>
<td>Radiation (°C)</td>
<td>2.35±0.12</td>
</tr>
<tr>
<td>Air temperature (°C)</td>
<td>33.96±0.13</td>
</tr>
<tr>
<td>Maximum temperature (°C)</td>
<td>34.97±0.31</td>
</tr>
<tr>
<td>Mean temperature (°C)</td>
<td>29.54±0.19</td>
</tr>
<tr>
<td>Minimum temperature (°C)</td>
<td>24.12±0.13</td>
</tr>
<tr>
<td>Different temperature (°C)</td>
<td>10.85±0.24</td>
</tr>
<tr>
<td>THI</td>
<td>82.64±0.12</td>
</tr>
</tbody>
</table>

Table 2: Effect of solar radiation on experimental house

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, affected 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, 1968). 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

<table>
<thead>
<tr>
<th>General physiology</th>
<th>Feed formulas</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Rectal temperature (°C)</td>
<td>39.46±0.03</td>
</tr>
<tr>
<td>Pulse rate (b/min)</td>
<td>82.43±4.76</td>
</tr>
<tr>
<td>Respiration rate (br/min)</td>
<td>82.18±5.73</td>
</tr>
<tr>
<td>Heat tolerance coefficient (%)</td>
<td>80.95±4.80</td>
</tr>
<tr>
<td>Sweating rate (ml/min)</td>
<td>1020±40±72</td>
</tr>
</tbody>
</table>

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

Table 4. Average of haematocrit in this experiment

<table>
<thead>
<tr>
<th></th>
<th>Haematocrit (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed formulas</td>
<td>Before experiment</td>
</tr>
<tr>
<td>1</td>
<td>31.34±0.80</td>
</tr>
<tr>
<td>2</td>
<td>31.23±0.96</td>
</tr>
<tr>
<td>3</td>
<td>31.35±0.04</td>
</tr>
</tbody>
</table>

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

Table 5. Average value of haemoglobin in this experiment

<table>
<thead>
<tr>
<th></th>
<th>Haemoglobin (g/100 ml blood)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed formulas</td>
<td>Before experiment</td>
</tr>
<tr>
<td>1</td>
<td>42.00±0.82</td>
</tr>
<tr>
<td>2</td>
<td>42.50±0.29</td>
</tr>
<tr>
<td>3</td>
<td>42.25±0.26</td>
</tr>
</tbody>
</table>

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 8).

The result of the study revealed that the average of cortisol levels in cow serum were increased due to the response of adrenal cortical, 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, 1988). 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

<table>
<thead>
<tr>
<th>Feed formulas</th>
<th>Before experiment</th>
<th>During experiment</th>
<th>End of experiment</th>
<th>Throughout experiment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>98.00±0.58</td>
<td>89.68±2.85</td>
<td>80.26±1.26</td>
<td>89.00±2.72</td>
</tr>
<tr>
<td>2</td>
<td>98.7±1.71</td>
<td>80.38±4.34</td>
<td>72.25±1.26</td>
<td>82.44±7.71</td>
</tr>
<tr>
<td>3</td>
<td>98.25±1.71</td>
<td>76.13±3.44</td>
<td>69.26±0.66</td>
<td>79.44±7.73</td>
</tr>
</tbody>
</table>

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

Table 7: Average blood glucose values in this experiment

<table>
<thead>
<tr>
<th>Feed formulas</th>
<th>Before experiment</th>
<th>During experiment</th>
<th>End of experiment</th>
<th>Throughout experiment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>53.23±0.45</td>
<td>54.8±0.68</td>
<td>56.32±0.87</td>
<td>54.83±1.30</td>
</tr>
<tr>
<td>2</td>
<td>53.17±0.74</td>
<td>54.68±0.99</td>
<td>56.04±0.92</td>
<td>54.90±1.53</td>
</tr>
<tr>
<td>3</td>
<td>53.56±1.12</td>
<td>55.27±1.10</td>
<td>57.94±0.68</td>
<td>55.51±1.88</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Feed formulas</th>
<th>Before experiment</th>
<th>During experiment</th>
<th>End of experiment</th>
<th>Throughout experiment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>14.04±0.25</td>
<td>15.17±0.41</td>
<td>15.68±0.32</td>
<td>15.66±0.32</td>
</tr>
<tr>
<td>2</td>
<td>14.08±0.27</td>
<td>15.06±0.51</td>
<td>16.12±0.14</td>
<td>16.12±0.14</td>
</tr>
<tr>
<td>3</td>
<td>14.06±0.09</td>
<td>14.97±0.36</td>
<td>16.11±0.37</td>
<td>16.11±0.37</td>
</tr>
</tbody>
</table>

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

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

<table>
<thead>
<tr>
<th>Item</th>
<th>Feed formulas</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voluntary feed intake</td>
<td></td>
<td>6.84±0.25</td>
<td>6.48±0.32</td>
<td>6.72±0.08</td>
</tr>
<tr>
<td>Roughage (kg)</td>
<td></td>
<td>5.02±0.02</td>
<td>5.06±0.01</td>
<td>5.04±0.01</td>
</tr>
<tr>
<td>Concentrate (kg)</td>
<td></td>
<td>7.72±0.32</td>
<td>7.70±0.64</td>
<td>7.98±0.62</td>
</tr>
<tr>
<td>Milk yield (kg/d)</td>
<td></td>
<td>7.34±0.34</td>
<td>7.30±0.63</td>
<td>7.80±0.68</td>
</tr>
<tr>
<td>FMC 4% (kg/d)</td>
<td></td>
<td>2.76±0.04</td>
<td>2.72±0.03</td>
<td>2.74±0.03</td>
</tr>
<tr>
<td>Body condition score</td>
<td></td>
<td>2.72±0.03</td>
<td>2.06±0.03</td>
<td>2.08±0.02</td>
</tr>
<tr>
<td>Milk composition</td>
<td></td>
<td>3.32±0.20</td>
<td>3.30±0.12</td>
<td>4.60±0.18</td>
</tr>
<tr>
<td>Fat (%)</td>
<td></td>
<td>3.28±0.08</td>
<td>3.20±0.06</td>
<td>3.38±0.05</td>
</tr>
<tr>
<td>Protein (%)</td>
<td></td>
<td>4.34±0.19</td>
<td>4.28±0.07</td>
<td>4.86±0.11</td>
</tr>
<tr>
<td>Lactose (%)</td>
<td></td>
<td>8.85±0.51</td>
<td>8.78±0.59</td>
<td>9.05±0.58</td>
</tr>
<tr>
<td>Solid not fat (%)</td>
<td></td>
<td>12.84±0.07</td>
<td>12.79±0.62</td>
<td>12.96±0.42</td>
</tr>
</tbody>
</table>

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, 1991), 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 affected to
beget the stress in dairy cows which could determine
from the values of general physiological changes that
were mostly increased (Singh and Bhattacharya, 1980;
Legates et al., 1991; Kabuga, 1992) so that affected
haematologic values (Hafez, 1968; Umpapol, 2002),
especially haematocrit percentage and haemoglobin
concentration value were increased (Ablay et al., 1975),
which were the indicators that caused HTC values
became lower (Sirvastana and Sindhu, 1977) then
effect to endocrine system functions particularly the
cortisol concentration levels would be increased (Ablay
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., 1986). 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 bypass
fat feedstuff in concentrate, which caused ruminal
heat production deacceleration (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 CalCF
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 Frisian 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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during acute, exposure to height environmental
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administration of bovine somatotropin on milk
production of Sahiwal Frisian. 19<sup>th</sup> MSAP Annual
Conference, 8-10 September.


