Effect of Supplementation of Several Edible Plant Oils on Nutrient Utilization and Blood Profile of Beef Cattle

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ABSTRACT
Background: In Southeast Asia a high level with the agricultural productivity, especially rice straw is produced for livestock feed such as buffalo and beef cattle. However rice straw is poor quality (low in protein and its high silica content). Subsequently, ruminant nutritionists have established to increase the potential of poor quality roughages for animal feeding such as Total mixed ration (TMR) using rice straw as a roughage source with vegetable oils to increase energy density in the diet, that can improve by produced for ruminant diet.

Methods: In this field-laboratory investigation during 2017-2018. Three animals, one and half year old with live weight 120 ± 15.50 kg, were randomly assigned in 3 × 3 latin square design. Each period of feeding lasted for 21 days. During the experimental periods, all cattle were fed total mixed ration (TMR; containing rice straw: concentrate ratio as 40:60), adding soybean oil (SO), palm oil (PO) and sunflower oil (SFO) supplementations. Total fat in TMRs were at 3 percentages.

Result: Our investigations were to evaluate the effect of soybean oil (SO), palm oil (PO) and sunflower oil (SFO) supplementations at 3 percentages of total fat in total mixed ration on voluntary feed intake, digestibility, blood profile and fatty acid compositions in the plasma of crossbred Thai native x American Brahman Cattle. The results revealed that treatments did not affect voluntary feed intake (kgDM/head/day; g/KgW0.75) (P>0.05), but feeding with soybean oil, it was non significantly higher (2.94 kgDM/day). Additionally, nutrient intake and apparent digestibility of organic matter (OM), crude protein (CP), neutral detergent fibre (NDF), acid detergent fibre (ADF) and rumen fermentation except total volatile fatty acids (VFAs) were not affected among all the three treatments, but dry matter (DM) digestibility in soybean and palm oil group animals were recorded significantly higher (P<0.01) than sunflower oil. However, blood glucose, blood urea nitrogen, cholesterol, triglyceride, high density lipoprotein and low density lipoprotein and fatty acid composition in plasma were not influenced due to treatments (P>0.05). Based on this study, feeding beef cattle with SO, PO and SFO should not exceed 3% in TMR to achieve 7% without any adverse effect on nutrient utilization, rumen fermentation, blood profile and fatty acid compositions in plasma.

Key words: Beef cattle, Blood profile, Feed intake, Nutrient utilization, Palm oil, Sunflower oil, Soybean oil.

INTRODUCTION
Ruminants have been fed with the poor quality of roughages and concentrates, that is the most factor to develop daily growth and high quality products i.e.meat and milk products. Generally, the degradation of feeds in the rumen are active by microorganisms (Kim et al., 2005) and the end products from microorganisms depend on the type of feeding (Grinari and Bauman. 1999; Wood et al., 2008; Pilajun and Wanapat. 2011).

Addition of 4.5% of soybean oil and sunflower oil in goats did not affect digestibility, but muscle PUFA and CLA content were increased (Raes et al., 2001). Chilliard et al. (2003) reported that dietary linseed oil or sunflower oil increased vaccenic acid (VA) and CLA in goat's milk and Khöf et al. (2018) who supplemented ruminant diets with flax seed (50 g of crushed flaxseed) enhanced (unsaturated fatty acid) UFA and CLA contents but decreased SFA content and ω-6 to ω-3 fatty acids ratio in milk of goats.

Therefore, the study was conducted to compare the effect of soybean, palm and sunflower oil supplementation on voluntary feed intake, nutrient intake, digestibilities, rumen characteristics, blood chemistry and fatty acid compositions in plasma of Crossbred Thai Native x American Brahman.

MATERIALS AND METHODS
Animals, experimental design and treatments
Three crossbred Thai native x Brahman cattle, one and half year old with 120 ± 15.50 kg live weight were selected. The cattle were treated for intestinal worms and injected with a mixture of vitamins A, D₃ and E. The cattle were randomly assigned in a 3 × 3 Latin square design with 21 days per
period, that during each period, animals were received ad libitum of total mixed ration (TMR). All animals were kept in individual cage and received free access to water and mineral-salt block. The adaption period was 14 days and experiment period was totally 63 days. The dietary treatments were three fat source diets; soybean oil (SO), palm oil (PO) and sunflower oil (SFO) with oil supplementation at 3% along with Total mixed ration (TMR) and rice straw as a roughage source (Table 1).

Sample collections
The beef cattle were fed individually two times a day at 07:00 and 16:00 h in two equal portions. Voluntary feed intake and refusal were recorded daily by weighing the offered diets for dry matter intake (DMI) measurement. Feed samples were randomly collected once a week for dry matter (DM) analysis using hot air oven at 100 ± °C for 24 h (AOAC 1997). Faeces excreted was collected, of all the animals in the last 5 days in each period, The feces was sampled 100 g/kg of total fresh weight and divided into two parts; the first part was for analysis of DM daily during the collection days and the second was kept in refrigerator and pooled by each animal at the end of each period at -10°C for later analysis.

Feeds, feed refusals and fecal samples were dried at 60°C for 48 h and ground (1 mm) for chemical analysis using standard methods by AOAC (1997) and fibre fractions as per Goering and Van Soest, (1970).

Rumen fluid samples were collected, by a suction pump, 4 h after the morning feeding on the last day of each experimental period. Directly, after collection pH of rumen fluid samples were recorded and filtered through four layers of cheesecloth and preserved as per standard methods for further analysis of individual and TVFAs. On the last day of each experimental period before feeding in the morning, 10-mL blood samples were collected, centrifuged at 2,500 × g for 15 min and the plasma was analysed for blood glucose, blood urea nitrogen (BUN), triglycerides, high density lipoprotein (HDL) and low density lipoprotein (LDL) by standard methods. All the samples were analysed for total lipids and fatty acid composition by GLC (Raes et al., 2001).

Statistical analysis
Data were analyzed using a 3 × 3 Latin square design with three periods and three treatments. Individual beef cattle were the experimental units (3 replications). The statistical model included the fixed effects of the square and treatment and the random effects of the period beef cattle. Statistical analyses were performed using PROC GLM of SAS (SAS, 2001). When the treatment F-test was significant at P<0.05. The mean values were compared by applying the probability of difference option of the Duncan’s New Multiple Rang Test (DMRT) (Steel and Torrie, 1980).

RESULTS AND DISCUSSION
Chemical composition of experimental diets, nutrient intake and digestibilities
Chemical compositions of three dietary treatments consisting of SO, PO and SFO in TMR are shown in Table 2. Percentage of crude protein was 17.51, 16.31 and 16.71 and ether extract was 3.37, 3.85 and 3.90, respectively. Total dry matter intake and nutrient intake did not influence by oil supplementations. Digestibility of CP, EE, NDF and ADF were not significantly (P>0.05) affected due to treatments (Table 3). Dietary supplementation with SO and PO had increased digestibility of DM (P < 0.01) than SFO group animals.

Ordinarily, feeding high fatty acids directly in ruminants reduce feed intake and digestibility as a result of inhibition of rumen fermentation by microorganisms (Chilliard, 1993; Allen, 2000; Martin et al., 2008). In the present experiment, feed intake was unaffected by feeding soybean oil, palm oil and sunflower oil to beef cattle at 3% approximately of total EE in TMR of oil daily, that is optimum level could not depress the intake and apparent digestibility. Similarly, Jenkins (1993); Petit (2002) who recommended the total dietary fat is below 6% of dietary dry matter without any adverse effect on microbial activity and total tract nutrient digestion, especially fiber digestion (Morsy et al., 2015; Kholf et al., 2016).

In the present study, digestibility of CP, EE, ADF and NDF were not influenced by feed supplementation with different oils. According to Pilajun and Wanapat (2011) who reported that feed supplementation with coconut oil and

| Table 1: Feed ingredients in experimental diets. |
|-----------------------------------------------|
| Ingredients (KgDM) | (T1) | (T2) | (T3) |
| Rice straw | 40.0 | 40.0 | 40.0 |
| Cassava chips | 30.5 | 30.5 | 30.5 |
| Soybean meal | 20.0 | 20.0 | 20.0 |
| Soy bean oil | 3.0 | - | - |
| Palm oil | - | 3.0 | - |
| Sunflower oil | - | - | 3.0 |
| Urea | 2.0 | 2.0 | 2.0 |
| Molasses | 2.0 | 2.0 | 2.0 |
| DCP | 1.0 | 1.0 | 1.0 |
| Limestone | 1.0 | 1.0 | 1.0 |
| Premix | 0.3 | 0.3 | 0.3 |
| Salt | 0.2 | 0.2 | 0.2 |
| Total | 100.0 | 100.0 | 100.0 |

| Table 2: Chemical compositions in total mixed ration (TMR). |
|-----------------------------------------------|
| Chemical composition | Attribute (%) | (T1) | (T2) | (T3) |
| DM | 85.92 | 86.41 | 84.54 |
| CP | 17.51 | 16.31 | 16.71 |
| OM | 91.23 | 92.55 | 91.79 |
| EE | 3.37 | 3.85 | 3.90 |
| NDF | 30.72 | 34.78 | 32.26 |
| ADF | 19.13 | 28.17 | 19.98 |
| Ash | 8.77 | 7.45 | 8.21 |

SO= Soybean oil; PO= Palm oil; SFO= Sunflower oil; DCP= Dicalcium phosphate.
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Table 3: Effect of oil supplementations on total dry matter intake (kg/day), nutrient intake (kg/day) and apparent digestibilities in crossbred Thai Native x American Brahman.

| Items                           | SO (T₁) | PO (T₂) | SFO (T₃) | SEM | Significance |
|--------------------------------|---------|---------|----------|-----|--------------|
| DM intake, (kg /day)           |         |         |          |     |              |
| kg/d                           | 2.94    | 1.96    | 2.19     | 0.31| ns           |
| Nutrient intake (kg/day)       |         |         |          |     |              |
| OM                             | 1.87    | 2.94    | 1.70     | 0.16| ns           |
| CP                             | 0.35    | 0.54    | 0.31     | 0.03| ns           |
| NDF                            | 0.90    | 0.68    | 0.70     | 0.05-| ns           |
| ADF                            | 0.43    | 0.70    | 0.41     | 0.03| ns           |
| EE                             | 0.07    | 0.11    | 0.07     | 0.01| ns           |
| Apparent digestibilities (%)   |         |         |          |     |              |
| DM                             | 73.33a  | 65.97a  | 59.14b   | 0.25| ns           |
| CP                             | 85.95   | 81.14   | 79.79    | 0.48| ns           |
| EE                             | 91.36   | 92.42   | 89.73    | 0.57| ns           |
| SEM = standard error mean; SO = Soybean oil; PO= Palm oil; SFO= Sunflower oil; ns = not significant, **P <0.01.

Table 4: Ruminal pH, NH₃-N concentration (mg/100ml) and Volatile fatty acids concentration (%) in rumen in crossbred Thai Native x American Brahman.

| Items                           | SO (T₁) | PO (T₂) | SFO (T₃) | SEM | Significance |
|--------------------------------|---------|---------|----------|-----|--------------|
| Rumen parameters               |         |         |          |     |              |
| Rumen pH                       | 6.53    | 6.40    | 6.13     | 0.05| ns           |
| Rumen NH₃-N mg/100 ml          | 13.67   | 11.80   | 12.60    | 0.58| ns           |
| Total VFAsmol/100 mol          | 119.17* | 115.83* | 108.60b  | 0.69| ns           |
| Acetate, %                     | 63.60   | 64.30   | 67.60    | 1.36| ns           |
| Propionate, %                  | 23.23   | 22.93   | 22.07    | 0.80| ns           |
| Butyrate, %                    | 11.63   | 12.70   | 12.07    | 0.12| *            |
| C2:C3                          | 2.75    | 2.82    | 3.08     | 0.09| ns           |
| (C2=C4): C3                    | 3.25    | 3.38    | 3.63     | 0.11| ns           |
| SEM = standard error of the mean; SO = Soybean oil, PO= Palm oil, SFO= Sunflower oil; ns = not significant, *P <0.05.

Rumen pH in this experiment remained within normal range similar to the earlier reports Wanapat. (1999) who recommended that ruminal pH of cattle ranged from 6.5 to 7.2.

Supplementation with SO, PO and SFO to beef cattle diets did not affect ruminal NH₃-N that has been reported as optimal level for microbial activity (Kongmun et al., 2011) according to Lunsin et al. (2012) who supplemented dairy cows diets with rice bran oil and observed no effect on ruminal fermentations. Additionally, 70-85% of the energy supply in ruminants that derived from rumen fermentation and could be absorbed as volatile fatty acids (Weimer, 1998), especially propionate portion is transformed to glucose in the liver by gluconeogenesis pathway (Lane and Jesse, 1997). In this study volatile fatty acid concentrations were not influenced by SO, PO and SFO supplementation, similarly Toral et al. (2010) who mixed fish oil and sun flower oil together in the diet found no effect on volatile fatty acid concentrations in ewes.

Ruminal pH, NH₃-N and Volatile fatty acids concentrations

Oil supplementation with SO, PO and SFO on pH, NH₃-N and volatile fatty acids in beef Cattle were not significantly different among treatments (P>0.05). Animals of SO and PO supplemented groups recorded higher (P<0.05) concentration of total VFAs as compared to SFO supplemented animals (Table 4).
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Table 5: Blood plasma attributes (mg/dl) in beef cattle.

| Item (mg/dl)   | SO (T₁) | PO (T₂) | SFO (T₃) | SEM  | Significance |
|---------------|---------|---------|-----------|------|--------------|
| Blood glucose | 82.67   | 111.00  | 85.67     | 8.96 | ns           |
| BUN           | 12.83   | 12.80   | 9.90      | 0.86 | *            |
| Triglyceride  | 92.00   | 92.00   | 86.00     | 4.79 | ns           |
| HDL           | 55.83   | 63.07   | 59.27     | 4.95 | ns           |
| LDL           | 60.50   | 76.80   | 63.17     | 5.87 | ns           |

SEM = standard error of the mean; BUN = blood urea nitrogen, HDL = high density lipoprotein, LDL = low density lipoprotein. ns = non significance, * P <0.05.

Table 6: Plasma fatty acid profiles (g/100g total fatty acids) of experimental animals.

| Fatty acids | SO(T₁) | PO(T₂) | SFO(T₃) | SEM  | Significance |
|-------------|--------|--------|---------|------|--------------|
| C14:0       | 0.28   | 0.28   | 0.30    | 0.01 | ns           |
| C16:0       | 8.88   | 7.74   | 7.93    | 0.34 | ns           |
| C16:1       | 0.22   | 0.24   | 0.24    | 0.02 | ns           |
| C18:0       | 13.06  | 14.53  | 14.30   | 0.61 | ns           |
| C18:1       | 8.94   | 8.86   | 8.81    | 0.05 | ns           |
| C18:2       | 28.59  | 32.00  | 29.13   | 0.59 | ns           |
| C18:3       | 1.58   | 1.81   | 1.86    | 0.07 | ns           |
| C20:0       | 3.83   | 3.26   | 3.74    | 0.28 | ns           |
| C20:1       | 0.10   | 0.11   | 0.11    | 0.003| ns           |
| SFA         | 26.05  | 25.82  | 26.27   | 0.98 | ns           |
| MUFA        | 9.26   | 9.21   | 9.16    | 0.03 | ns           |
| PUFA        | 30.17  | 33.81  | 31.00   | 0.59 | ns           |
| ω-3         | 1.58   | 1.81   | 1.86    | 0.07 | ns           |
| ω-6         | 2.50   | 2.41   | 2.36    | 0.04 | ns           |
| ω-9         | 9.26   | 9.21   | 9.16    | 0.03 | ns           |
| MUFA/SFA    | 0.35   | 0.36   | 0.35    | 0.01 | ns           |
| PUFA/SFA    | 1.16   | 1.32   | 1.18    | 0.05 | ns           |

SEM= Standard error of the mean; SFA = saturated fatty acid, MUFA= monounsaturated fatty acid, PUFA= polyunsaturated fatty acid. ns= non significance, * P <0.05, ** P <0.01.

Blood chemistry

Oil supplementations did not affect (P>0.05) blood glucose, blood urea nitrogen, triglyceride, HDL and LDL concentrations (Table 5). The results indicated that plasma glucose concentration was 82.67, 85.67 and 111.00 mg/dl respectively in SO, SFO and PO supplemented groups. However, HDL and LDL concentrations tended to increase non significantly in PO supplemented animals while triglyceride level was similar in animals of SO and PO supplemented (92 mg/dl).

Fatty acid compositions in plasma

BUN, plasma glucose, triglyceride, HDL, LDL were not affected due to supplementation with SO, PO and SFO in beef cattle but these lipoproteins tended to be higher in PO supplemented group. HDL is the major source of essential fatty acids in ruminant plasma means high level of HDL may be an indication of cardiovascular health (Lorenza et al., 2012). Moreover, triglyceride and free fatty acids fractions have rapidly to turnover and supply fatty acids to other tissues (Sterk et al., 2012).

Fatty acid compositions in blood plasma

Results indicated that plant oils supplementation has not influenced (P>0.05) the proportions of C14:0, C16:0, C16:1, C18:0, C18:1, C18:2, C18:3, C20:0, C20:1, SFA, MUFA, PUFA, ω-3,ω-6,ω-9, MUFA/SFA ratio and PUFA/SFA ratio (Table 6). These findings are in line with Harfoot and Hazlewood. (1997) who reported that feeding plant oils modify ruminal bio-hydrogenation of fatty acids mostly from ruminal bio-hydrogenation of LA. Inclusion of vegetable oils which are high in PUFA, C18:1 and C18:2 concentrations in meat and milk products (Sterk et al., 2012). In addition, Khalif et al. (2018) who reported that feeding crushed flaxseeds and flaxseed oil which are abundant sources of LNA and PUFA that altered milk fatty acid profile in goats and beneficial for human consumption. Chilliard et al. (2007) fed dairy ruminants with unsaturated fatty acids in the ration such as oleic acid LA and have been shown to be an efficient strategy to modify milk’s fatty acid content. SFA concentration was 26.27 g/100g total fatty acids when feeding with SFO in this experiment (Table 6).
CONCLUSION
It may be concluded that supplementations of 3% soybean oil and palm oil in TMR enhanced DM digestibility, total VFAs, without any adverse effect on nutrient intake, OM, CP, NDF and ADF digestibility blood profile and fatty acid compositions in plasma of beef cattle.

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