

EFFECT OF FEEDING CORN DRIED DISTILLERS GRAINS WITH SOLUBLES (DDGS) ON MILK PRODUCTION OF COW UNDER HOT CLIMATE CONDITION

Pengaruh Pemberian Pakan Dried Distillers Grains with Solubles (DDGS) dari Jagung Terhadap Produksi Susu Sapi dalam Kondisi Iklim Panas

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ABSTRACT

Dried distillers grains with solubles (DDGS) is a co-product of ethanol industry made from grains through fermentation process and it can be used for animal feeding especially for dairy cows. A feeding trial on US corn DDGS was conducted at commercial dairy farm in Vietnam during hot condition in 2010. One hundred and fifty six dairy cows in a later stage of milk production were allotted randomly in three groups of 52 cows with similar milk production. Three dietary treatments offered comprised control diet, diet with 7.5% DDGS and diet with 15% DDGS. The diets were formulated to contain similar nutrient profiles and comprised forages (corn, elephant grass and alfalfa hay), brewery waste, soybean curd waste, corn, soybean meal, molasses and commercial dairy supplement. The diet was manufactured locally in total mixed ration system and delivered two times per day. Milk production, feed consumption and milk quality were measured for 5 days before the trial and 45 days after the trial. The result demonstrated that feeding DDGS could support higher milk production without affecting feed consumption. Feeding DDGS at 7.5% and 15% resulted in higher milk production of 2 and 4 kg per day respectively compared to cows fed control diet. Feed intake remained unaffected at around 35 kg per day. Milk quality as measured by total solid and fat content was similar in cows fed the control diet and DDGS at 7.5%. Feeding DDGS at 15% tended to have slightly better total solid and fat content. Feeding DDGS was able to reduce cost of the diets; diet cost for control, DDGS 7.5% and DDGS 15% were VND 2537, 2460 and 2399 per kg, respectively. It is concluded that DDGS can be economically used for feeding dairy cows in hot climate condition and improving milk production.

[**Keywords:** Dairy cattle, milk production, milk quality, DDGS, feeding value]

ABSTRAK

Dried distillers grains with solubles (DDGS) adalah produk ikutan dari industri etanol yang terbuat dari biji-bijian melalui proses fermentasi dan dapat digunakan untuk pakan ternak terutama sapi perah. Percobaan pemberian pakan DDGS jagung AS telah

dilakukan pada peternakan sapi perah komersial pada kondisi panas di Vietnam pada tahun 2010. Seratus lima puluh enam sapi perah dalam tahap produksi susu lanjut dibagi secara acak dalam tiga kelompok masing-masing 52 ekor dengan produksi susu yang sama. Tiga perlakuan pakan yang diberikan yaitu kontrol, pakan dengan 7,5% DDGS, dan pakan dengan 15% DDGS. Pakan diformulasikan mengandung gizi yang sama dan terdiri atas hijauan (jagung, rumput gajah, dan alfalfa), limbah pembuatan bir, limbah dadih kedelai, jagung, bungkil kedelai, molase, dan suplemen susu komersial. Pakan diproduksi secara lokal dalam sistem total mixed ration dan diberikan dua kali per hari. Produksi susu, konsumsi pakan, dan kualitas susu diukur selama 5 hari sebelum dan 45 hari setelah percobaan. Hasilnya menunjukkan bahwa pemberian DDGS dapat mendukung produksi susu lebih tinggi tanpa memengaruhi konsumsi pakan. Pemberian DDGS 7,5% dan 15% menghasilkan produksi susu lebih tinggi masing-masing 2 dan 4 kg per hari dibandingkan dengan sapi yang diberi pakan kontrol. Konsumsi pakan tetap tidak terpengaruh pada sekitar 35 kg per hari. Kualitas susu yang diukur berdasarkan kadar padatan total dan lemak hampir sama antara sapi yang diberi pakan kontrol dan DDGS 7,5%. Pemberian DDGS 15% menghasilkan susu dengan kadar padatan total dan lemak sedikit lebih baik. DDGS mampu mengurangi biaya pakan. Biaya pakan untuk kontrol, DDGS 7,5%, dan DDGS 15% masing-masing adalah VND 2537, 2460, dan 2399 per kg. Disimpulkan bahwa DDGS secara ekonomis dapat digunakan sebagai pakan sapi perah dalam kondisi iklim panas dan meningkatkan produksi susu.

[**Kata kunci:** sapi perah, produksi susu, kualitas susu, DDGS, nilai pakan]

INTRODUCTION

Dried distillers grains with solubles (DDGS) is a by-product of ethanol industry and contains a mixture of distiller grains with solubles from fermentation of corn. It has been used for animal feeding. Increase in ethanol production in USA for the last 15 years has resulted in a higher amount of DDGS available for animal feed. It was estimated that 35 million tons of DDGS were produced in 2012 and 4.5 million tons

were exported to different countries around the world (USGC 2012).

Research on feeding DDGS for dairy cows has been conducted in many universities in USA over the last 20 years. Recent review on use of DDGS for dairy was published by Schingoethe *et al.* (2009); DDGS was excellent feed for dairy cows. Based on previous studies on feeding DDGS to dairy cows, Kalscheur (2005) conducted a meta-analysis based on 23 studies and reported that DDGS are considered to be highly palatable and stimulated feed intake when included up to 20% of the dry matter in dairy cow diets. Feeding DDGS at 4-30% inclusion resulted in curvilinear response to increasing DDGS level, however at higher inclusion levels it tended to decrease milk production. A similar recent study reported by Janicek *et al.* (2008) indicated a linear increase in milk production from 0 to 30% inclusion of DDGS in diets.

In USA, initially DDGS is fed in a wet form to the cattle raised in proximity to the ethanol plant. Increasing number of modern ethanol plants have resulted in more DDGS being produced in dried form. Feeding trial of DDGS has been conducted in USA using DDGS derived from the older technology that has darker color. Power *et al.* (1995) reported that feeding darker color of DDGS resulted in a lower milk production compare to DDGS in lighter color.

Distiller's dried grains with solubles (DDGS) is a very good protein source for dairy cows. According to Schingoethe (2004), the protein content in high quality DDGS is typically more than 30% on a dry matter and DDGS contains 10% fat. DDGS is a good source of ruminally undegradable protein (RUP) or by-pass protein and the content was 55%. DDGS is also a very good energy source for dairy cattle with total digestible nutrient (TDN) value 77%, NE_{gain} 1.41 Mcal kg^{-1} , and $NE_{lactation}$ 2.26 Mcal kg^{-1} . This new energy value of DDGS is reported 10-15% higher than that reported by NRC (2001).

Most of the DDGS research involving dairy cattle has been conducted in temperate climates. Chen and Shurson (2004) reported from field feeding trial of DDGS to dairy cows conducted during summer period in Taiwan that inclusion of 10% DDGS in total mix ration (TMR) was able to increase milk production at 0.9 kg per day without affecting feed intake. DDGS can also be fed to growing heifers but the trial is limited. Kalscheur and Garcia (2004) reported that DDGS could be fed to heifers up to 40% in the rations.

Vietnam dairy industry is mainly located in the southern tropical areas and expanded to the central

and northern regions. The summer period in the north will be critical in feeding dairy cattle as the feed consumption decreases significantly and DDGS can be valuable feed ingredient for dairy cattle. Vietnam has been importing DDGS from USA from the last 4 years, but mainly used for swine and poultry feed and lately for fish feed. Currently no DDGS has been used for feeding dairy cattle despite there are 250,000 heads of dairy cattle population in Vietnam. Dairy production increased significantly in the last 5 years and it has been predicted that dairy production will increase more than 10% annually. Potential of DDGS for dairy cattle is significant. It was estimated that if 1 kg of DDGS can be fed to cattle every day, Vietnam may require 270,000 MT DDGS per year (USGC Vietnam, unpublished).

Dairy cattle are normally fed green roughage supplemented with a concentrate comprised of industrial by-products such as soybean meal, wheat bran, rice bran, cassava waste, cassava, molasses and mineral/vitamin mix. However, the use of DDGS in Vietnam is not known and it would be useful information if a feeding trial of DDGS can be conducted on dairy cattle in Vietnam. Objective of the study was to evaluate if DDGS can be effectively used for feeding dairy cows under hot and humid climate conditions.

MATERIALS AND METHODS

Materials

One hundred and fifty six dairy cows (Friesian Holstein breed) were selected based on similar milk production from a total of more than 300 dairy cow population at Phu Lam dairy farm, Tuyen Quang Vietnam. The cows were selected from the latest stage of milk production with average milking days of more than 200 days. The dairy cows were identified by an electronic cow identification system that can detect individual cow performance. The cows were randomly divided into three groups and each group was placed in steel pen and fed in special feed trough.

Corn DDGS was obtained from US ethanol plant and imported by local trader in Vietnam. The composition of DDGS was moisture 9.71%, protein plus fat 36.68%, crude fiber 6.4% and ash 3.87%, while the color is golden yellow. DDGS was transported to feedmill located at the farm, while other ingredients were obtained from local suppliers.

Environmental Condition

Average daily temperature of animal house during May to June 2010 when the feeding DDGS was performed, was recorded at 33°C, while minimum and maximum temperature were 28°C and 37°C, respectively. Average relative humidity was recorded at 82%, while minimum and maximum relative humidity were 74% and 88%, respectively. These times were well known as the hottest months of the year with high humidity in northern part of Vietnam. The animals were placed in open house and supported by centrifugal fan.

Dietary Treatment

Feeding trial was conducted in group of cows in three pens and each pen received different dietary

treatments. The dietary treatments were control (diet without DDGS), DDGS 7.5% (diet contains 7.5% DDGS in TMR), and DDGS 15% (diet contains 15% DDGS in TMR). Phu Lam Dairy Farm feedmill in Tuyên Quang Vietnam manufactured the dietary treatments according to formula met dairy cow requirement in total mixed ration (TMR) form. The feeds were formulated to have a similar nutrient composition as presented in Table 1. The formula price was based on the ingredients price during the trial at the farm. Each dietary treatment was fed to three groups of dairy cows placed in existing pen containing 52 cows per pen; therefore a total of 156 dairy cows were used. Each treatment was fed for 45 days and data on milk production from individual cow and feed consumption were collected 5 days prior to feeding and 45 days after feeding. Amount of feed given was calculated based on the cows and milk production within each pen.

Table 1. Dietary formula of total mixed ration containing dried distillers grains with solubles (DDGS) at 7.5% and 15% for feeding dairy cows at Vinamilk, Tuyen Quang, Vietnam, 2010.

Ingredients	Control	DDGS	
		7.5%	15%
Corn silage (%)	29.40	29.40	29.40
Elephant grass (%)	28.01	29.40	29.40
Alfalfa hay 22%	9.80	5.91	5.00
Brewery dried grains (%)	7.35	7.35	7.35
Soybean curd waste (%)	7.35	7.35	4.51
Corn, ground (%)	6.00	1.80	-
Molasses (%)	4.90	4.10	4.90
Dairy concentrate 40% (Guyomarch) (%)	3.40	3.40	3.40
Soybean meal (%)	2.75	2.75	-
Solid fat (Bergafat) (%)	0.39	0.39	0.39
Dicalcium phosphate (%)	0.30	0.30	0.30
Sodium bicarbonate (%)	0.30	0.30	0.30
Vitamin + mineral premixes ¹ (%)	0.05	0.05	0.05
DDGS (%)	-	7.50	15.00
Calculated nutrient content based on dry matter			
moisture (%)	51.70	52.80	53.00
Total digestible nutrient (%)	70.60	72.00	72.70
Net energy lactation (Mcal kg ⁻¹)	1.72	1.76	1.78
Crude protein (%)	15.10	17.10	17.00
Neutral detergent fiber (%)	29.80	33.30	38.60
Acid detergent fiber (%)	18.03	19.10	20.60
Calcium (%)	1.02	0.91	0.87
Phosphorus (%)	0.45	0.51	0.54
Sodium (%)	0.27	0.29	0.32
Magnesium (%)	0.21	0.20	0.20
Sulfur (%)	0.18	0.19	0.21
UDP (%)	8.60	9.70	9.30
RUP (%)	6.80	7.40	7.80
Cost (VND/kg)	2537	2460	2399

¹Supplemented vitamin and mineral premix to supply per kg of ration: vitamin A 3.000 IU, vit D3 1500 IU, vit E 5 mg, Co 0.001 mg, Cu 7 mg, Fe 225 mg, I 0.8 mg, Mn 60 mg, Se 0.025 mg, Zn 20 mg, Mo 1.7 mg.

Feeding System

Feeding system was conducted according to the existing system at Phu Lam dairy farm. Total mixed ration comprised roughage (napier grass and corn forages) and mixed with other ingredients include cassava, soybean curd waste, brewery waste, ground corn, soybean meal, supplement from feedmill (40%), molasses, solid fat and mineral-vitamin premixes. The least cost formulation was performed to provide sufficient nutrient to the cows need as suggested by NRC (2001). Cows were fed two times daily and feed refuse was weighed daily.

Measurement

Measurement was conducted for daily milk production, feed intake and milk quality comprising protein, fat, total solid and density. Milk production from individual cow was recorded by computer system based on the electronic cow identification system. For milk quality, five samples were collected for each dietary treatment at mid and end of the trial, therefore a total of 30 samples of milk were analyzed.

Statistical Analyses

Feeding trial was conducted in group of cows placed in a pen and milk production data during feeding experiment were subjected to simple regression analyses to measure rate of change in milk production.

RESULTS AND DISCUSSION

Milk Production and Feed Consumption

Daily milk production of cows fed different levels of DDGS was presented in Figure 1. All cows' milk production was in declining phase as they were in later stage of milk production. Figure 1 shows clearly that milk production from cows fed control diet declined in much faster rate than that cows fed DDGS 7.5% and the least decline was found in cows fed DDGS 15% in the total mixed ration.

Average feed intake and milk production of cows before and after feeding different levels of DDGS is presented in Table 2. Milk production of cows before feeding DDGS was higher than that of cows after feeding DDGS as the trial was performed at later

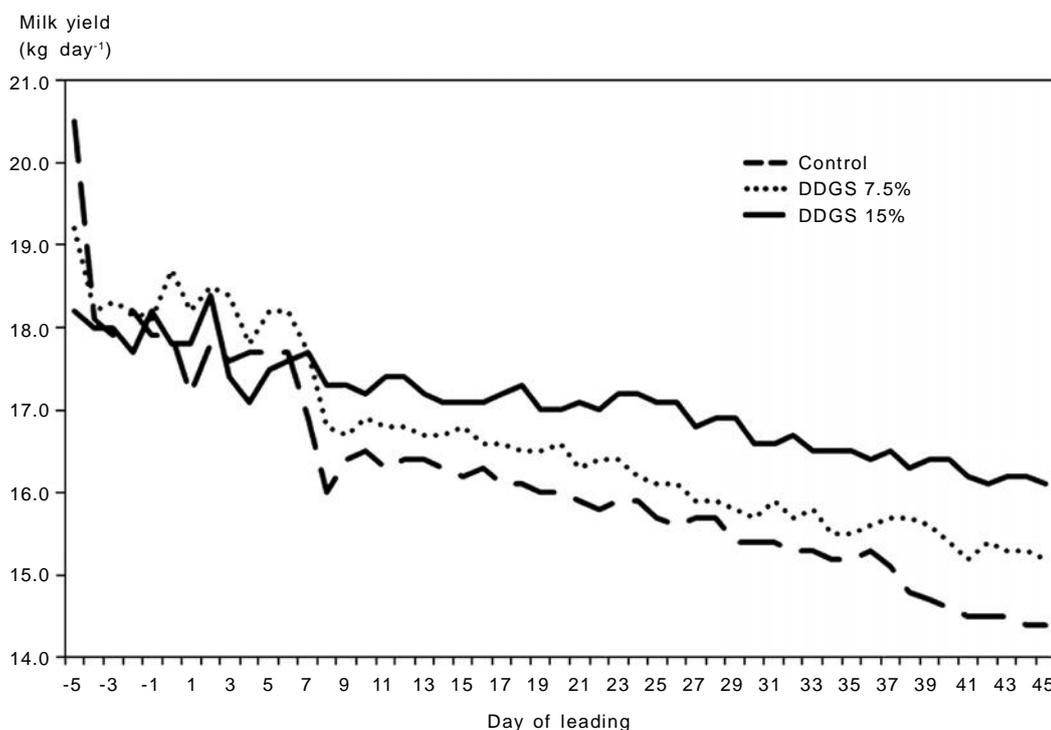


Fig. 1. Daily milk production of cows fed different levels of dried distillers grains with solubles (DDGS) under hot and humid conditions in northern Vietnam, 2010.

Table 2. Average milk production and feed consumption of cows before (5 days) and after (45 days) feeding dried distillers grains with solubles (DDGS) at different levels under hot climate condition in Northern Vietnam, 2010.

Treatment	Milk production (kg day ⁻¹)		Difference	Feed consumption (kg day ⁻¹)	
	Before DDGS	After DDGS		Before DDGS	After DDGS
Control	20.5	14.4a	6.1	36.8	35.6
DDGS 7.5%	19.2	15.2ab	4.0	38.3	35.3
DDGS 15%	18.2	16.1b	2.1	36.8	35.6

Numbers in the same column followed by different letters are significantly different at $P < 0.05$ and at standard error means (SEM) of 0.4 kg per day.

stage of milk production, therefore milk production decreased with continued feeding. The difference in milk production before and after feeding DDGS was used to indicate the effect of dietary treatment on milk production. Table 2 shows that difference in milk production was more pronounced in cows fed control diet compare to cows fed DDGS. The cows fed diet containing 7.5% DDGS had the milk production difference of 4.0 kg per day, while the control treatment resulted in 6.1 kg per day difference. Feeding DDGS at 15% in the diet resulted in the difference in milk production only 2.1 kg per day. Feeding DDGS significantly resulted in higher milk production compared to cows fed control diet.

Regression analysis of milk production during feeding DDGS at different inclusion rates in the diet is presented in Table 3. All cows showed a linear decrease in milk production during feeding as expected because of later stage in milk production. Rates of decrease in milk production were 0.036-0.070 kg per day. Feeding DDGS at 15% inclusion resulted in a slower rate of decrease (0.036 kg per day) compared to cows fed control diet without DDGS (0.070 kg per day)

Previous studies on feeding DDGS in temperate area showed that inclusion of 4-30% DDGS in the diet resulted in 0.4 kg higher daily milk production (Kalscheur 2005). During hot climate in Taiwan, inclusion of DDGS at 10% resulted in higher milk production by 0.9 kg per day (Chen and Shurson 2004). This study confirmed that DDGS improved milk production in hot and humid environment and milk production was increased more than 2 kg per day every 7.5% of inclusion rate. Part of the additional milk production due to DDGS may have been attributable to slightly more energy from a slightly higher fat content in DDGS diets because the fat content of diets was not always balanced across diets in all experiments (Schingoethe *et al.* 2009).

Table 3. Simple regression analyses of milk production from cows fed with different levels of corn dried distillers grains solubles (DDGS).

Treatments	Regression equation	Coefficient of determination (R ²)
Control	$y = -0.0358x + 17.806$	0.872
DDGS 7.5%	$y = -0.0677x + 18.033$	0.882
DDGS 15%	$y = -0.0699x + 17.55$	0.920

Other possible factors that influence DDGS on milk production may relate to less digestive disturbance found when DDGS was included in the diet during prolong period (Mpapho *et al.* 2006). Higher rumen undegradable protein (RUP) in DDGS diet may also contribute to higher milk production as found in Table 2. However, Pamp *et al.* (2006) reported that when DDGS was compared to soybean protein as the protein supplement, production was similar or higher, even when DGS and soybean-based diets were formulated to be equal in RUP and fat. DDGS contains reasonable amount of yeast as left over from fermentation. However, it is not known the importance of yeast in DDGS for milk production although some research has been conducted on the beneficial effect of yeast on dairy production (Poppy *et al.* 2012).

Result of this trial shows clearly that feeding DDGS was able to maintain higher milk production during hot condition in Vietnam. Feeding DDGS at 15% in the total mixed ration was able to produce 4 kg more milk per day compared to cows fed control diets. This result was in agreement with the feeding DDGS during summer period in Taiwan that feeding DDGS at 10% in the diet was able to increase milk production at 1 kg per day (Chen and Shurson 2004). The current trial in Vietnam showed a better production yield compared to the trial conducted in Taiwan.

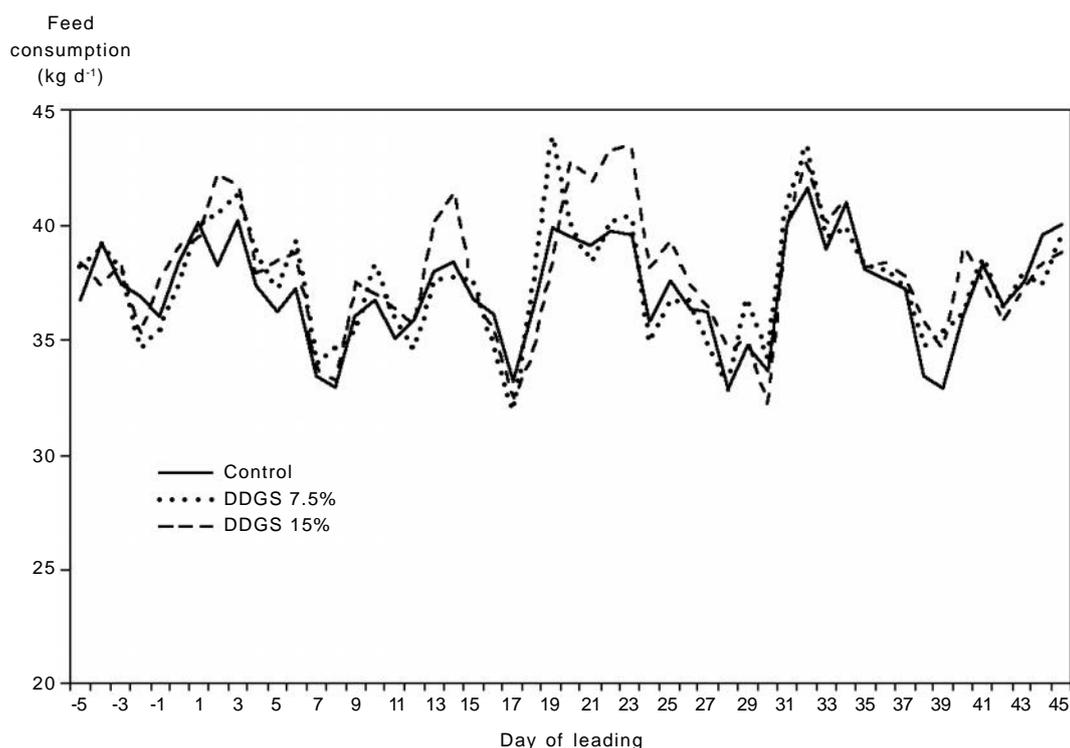


Fig. 2. Daily feed consumption of cows fed different levels of dried distillers grains with soluble (DDGS) under hot and humid conditions in northern Vietnam, 2010.

Table 2 shows that average daily feed consumption was not affected by dietary treatment. Fluctuation in daily feed intake was noticed during feeding trial and the data are presented in Figure 2. It was noticed that there was no difference in feed consumption between dietary treatments. The feed intake fluctuation was related with the temperature and humidity of the animal house during the day. When the temperature increased and humidity was high, the cows tend to reduce feed intake while feed consumption was higher at lower temperature.

Average daily feed consumption of cows fed control diet was 35.6 kg, while cows fed 7.5% and 15% DDGS was 35.3 and 35.6 kg, respectively. There was also no difference in feed consumption of cows before feeding trial was started. DDGS diet was readily consumed by cows within few days of adaptation.

Feeding DDGS was able to reduce cost of feed. Table 1 indicates that diet costs for control, DDGS 7.5% and DDGS 15% were VND 2537, 2460 and 2399 per kg, respectively. It is calculated that for every inclusion of 10% DDGS in the dairy cows diet, the cost of feed would decrease VND 95 kg⁻¹ or around 4%.

Milk Quality

Milk quality was measured based on total solid and fat content and the result of measurement of milk quality before and after feeding DDGS is presented in Table 4. Total solid and fat content of milk from cows fed 7.5% DDGS were not different with that milk from cows fed control diet. There was slightly higher total solid and fat content when cows fed 15% DDGS in the ration. The relative differences in milk quality before and after feeding 15% DDGS was found higher in milk from cows fed 15% DDGS.

Previous study by Kalscheur (2005) from extensive trial on DDGS indicated that milk composition was not affected by feeding DDGS at 4-30%. Feeding DDGS did not affect fat content in milk despite DDGS contains reasonable amount fat (>9%). Milk protein percentage was not different among cows fed diets containing 0-30% DDGS, and the form of the DDGS either wet or dried form did not alter milk protein composition (Kalscheur 2005). However, milk protein percentage decreased 0.13% when distiller's grains was included at concentrations greater than 30% of the diet compared to cows fed control diet. At the

Table 4. Total solid and fat content of milk from dairy cow before and after feeding corn dried distillers grains with solubles (DDGS) at different levels under hot climate condition in Northern Vietnam, 2010.

Treatment	Total solid (%)		Difference (%)	Fat content (%)		Difference (%)
	Before feed	After feed		Before feed	After feed	
Control	12.5	12.1	-0.4	3.8	3.7	-0.1
DDGS 7.5%	12.4	12.1	-0.3	3.8	3.7	-0.1
DDGS 15%	12.0	12.4	0.4	3.6	4.0	0.4

higher dietary inclusion levels, distiller's grains most likely replaced all other sources of protein in the diet. At these high levels of dietary inclusion, lower intestinal protein digestibility, lower lysine concentrations, and an unbalanced amino acid profile may all contribute to a lower milk protein percentage. It should be noted that the lower milk protein percentages were most evident in studies conducted in the 1980's and 1990's. Newer studies are not consistent in showing this effect. Lysine is very heat sensitive, and can be negatively affected in DDGS by high temperatures used during the production and drying in some ethanol plants. Improved processing and drying procedures in fuel-ethanol plants built in recent years, have increased amino acid digestibility of DDGS (USGC 2012).

In the last few years, ethanol production continued to change and at present time majority of ethanol plants have installed centrifuge to remove oil during the production and this method resulted in lower oil content of DDGS. Previously DDGS contains 10-12% fat but there are many DDGS contain 5-7% oil but may contain higher protein. Limited studies have been conducted on reduced oil DDGS for dairy cows but reduced oil content of DDGS may be desirable for dairy cows as many nutritionists believe that high oil of DDGS may limit the inclusion rate besides high unsaturated fatty acids found in DDGS oil (Owens 2009). More studies would be required to look at the impact of low oil DDGS on dairy cows.

CONCLUSION

Diet containing DDGS is readily consumed by dairy cows. Feeding DDGS was able to improve milk yield of cow raised under hot and humid condition. Diet containing 15% DDGS was able to maintain the daily milk production and resulted in 4 kg higher compared to control diet, while diet containing 7.5% DDGS resulted in 2 kg higher. Milk quality from cow fed 15%

DDGS was tend to be better compared to that cow fed 7.5% DDGS and control diet.

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