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Research Article

Influence of Distillers Dried Grain Solubles (DDGS) on Intake, Nutrients Digestibility and Milk Production of Dairy Buffaloes

Cherry Anne P. Alvaran[1], Irene J. Domingo[1], Daniel L. Aquino[2*]

[1]*Department of Animal Science, College of Agriculture, Central Luzon State University, Science City of Munoz, Nueva Ecija*

[2]*Philippine Carabao Center, Central Luzon State University, Science City of Munoz, Nueva Ecija*

***Corresponding author. E-mail address:** dalla_1358@yahoo.com (DL Aquino)

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Abstract: The effects of distillers dried grain solubles (DDGS) was assessed on its influence in milk production, milk components, nutrient digestibility and economic viability when fed to dairy buffaloes. Fourteen (14) Brazilian and Bulgarian buffaloes with 624kg average body weight were randomly assigned in three dietary treatments, namely; T1- roughage + dairy concentrates (RDC, control diet); T2 - R+ 75%DC + 25%DDGS and T3 – R + 50%DC + 50%DDGS. The buffaloes were on their second parity and last month of gestation. The dietary treatments had uneven replications with 5 replicates each for R1 and R2 while the R3 with 4 replicate buffaloes, arranged in a randomized complete block design (RCBD). Results showed numerical increase in milk production and milk composition however, these disclosed no significant differences between treatments. Buffaloes fed diet with 50% DDGS significantly increase the crude protein (CP) intake, while 25% in the diet increased the neutral detergent fiber (NDF) intake. In terms of digestibility, NDF digestibility was shown to be higher in 25% level than in 50% DDGS. The digestion coefficients for CP revealed comparable values in 25% and 50% DDGS in the ration. Incremental sales benefit from the milk of buffaloes fed with 25 and 50% DDGS were significant compared to buffalo cows without DDGS. The highest income over feed cost (IOFC) was observed in buffalo cows fed with 25% DDGS.

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INTRODUCTION

Distiller Dried Grains with Solubles (DDGS) is a by-product of corn grain fermentation from the ethanol industry in the USA. This is the easily transported and stored by-product from ethanol production because it is dry, it can be shipped to any location, from the country of origin to other countries and it can be safely stored under reasonable conditions. The production of DDGS continuously increased for the last 15 years with a production of 35 million tons, annually. Most of the DDGS produced are used for feeding ruminants, both for beef and dairy cattle and it is also used for feeding swine, poultry and fish. This industrial by-product has been used in many countries because it is available, cheap and a nutritious feed ingredient.

DDGS is a very good protein source for dairy cows. The protein content in high quality DDGS is typically more than 30% on a dry matter and DDGS contains 10% fat [1]. DDGS is a good source of ruminally undegradable protein (RUP), or by-pass protein and the content is 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, and $NE_{lactation}$ 2.26 Mcal/kg. This new energy value of DDGS is reported 10-15% higher than the reported value [2].

Researches on feeding DDGS for dairy animals had been done for the last 20 years. Based on the twenty-three studies which investigated the inclusion of distiller`s grain in dairy cow diets involving 96 treatment comparisons, **[3],** on meta-analysis, reported that distiller`s grain is considered highly palatable and stimulate feed intake when included up to 20% of the DM in dairy cow`s diet. Observation showed that milk production was not significantly impacted by the distiller`s grains, however, a curvilinear milk response to increasing distiller`s grain in dairy cow diets was noticeable.

Most of the research reports on DDGS involving dairy cattle were conducted in temperate climates however, Philippines and other countries in South East Asia are tropical countries with high temperature and humidity and this can be physiologically detrimental for dairy cattle especially for Friesian Holstein. During summer periods, ambient temperature may reach >35°C plus high humidity of >80% especially in rainy season. High temperature and humidity may not be ideal conditions for Friesian Holstein but may not be the case for the dairy buffaloes as this animal has adapted the tropical condition.

DDGS is an excellent, low-cost alternative feed ingredient that is continuously produced in large quantities by the dry-grind fuel ethanol industry. The high energy, mid-protein, and high digestible phosphorus content of DDGS make it a very attractive, partial replacement for some of the more expensive, traditional energy (corn), protein (soybean meal), and phosphorus (mono- or di-calcium phosphate) used in animal feeds. When DDGS is added to properly formulate feeds, it results in excellent animal health performance, and food product quality. These attributes have made DDGS one of the most popular feed ingredients for animal feeds.

The Philippine Carabao Center puts continuous effort to develop the buffalo industry in the country. To date, there is no information on the feeding value of DDGS in dairy buffaloes as most of DDGS feeding trials are conducted to dairy cattle. Study in Vietnam during summer period indicated that feeding DDGS in total mixed ration improved milk production. Feeding DDGS at 7.5% and 15% inclusion rate in the diet produced more milk at 2 kg/day in every 7.5% DDGS inclusion. Feeding trial on DDGS was also conducted in Indonesia with dairy cattle to replace concentrate with DDGS in the ratio of 1 kg concentrate with 1 kg DDGS improved daily milk production and contributed higher profitability to the farmers.

It is in this trial that similar response in increased milk production is expected in buffaloes as that of the effect of DDGS in dairy cattle when use as substitute to some levels of concentrates in the daily ration of dairy buffaloes. Improvement in milk quality and profitability in feeding supplementary DDGS to dairy buffaloes is expected as well [4]. This study aimed to assess the milk production and milk composition of dairy buffaloes as influenced by the levels of DDGS in the ration. This also determines the effects of DDGS on feed intake and nutrient digestibility by the dairy buffaloes. The income over feed cost and the incremental benefit on the sales of milk of buffaloes were also evaluated if these were influenced by DDGS supplementation.

MATERIALS AND METHODS

Experimental Animals/Design

Fourteen (14 hd) pregnant dairy buffaloes were used in four months feeding trial involving three lactating rations composed of corn silage and rice straw as basal roughages with supplementary dairy concentrates. The animals composed of Bulgarian (11hd) and Brazilian (3hd) buffaloes and were on their second parity and last month of gestation. The buffaloes were weighed two weeks before the expected parturition using an electronic livestock balance and immediately after calving. The animals were assigned in their respective ration shown below.

- T1- Control diet - with roughage and dairy concentrates at 4 kg per day
- T2- Control+25% DDGS - 3kg dairy concentrate + 1 kg DDGS
- T3- Control+50% DDGS - 2 kg dairy concentrate + 2 kg DDGS

The animals were arranged in randomized complete block designed with uneven replications which composed of five (5) lactating buffaloes for T_1 and T_2 while the T_3 has four (4) replicate buffaloes.

Housing and care management

The experimental animals were groomed and dewormed one month before the expected date of parturition. These were provided with individual pen with good ventilation and drainage system. Each animal pen is equipped with feed bunk and automatic drinking trough.

Feeding management

The basal ration (Table1) is composed of corn silage and rice straw. Dairy concentrate pellets and DDGS were mixed daily according to substitution rate for T2 and T3. The supplementary concentrates were given to the cows two weeks before the expected date of calving up to four months of lactation and is offered during milking according to the levels required for each treatment. All the cows were raised under complete confinement during the duration of the study.

Table 1. Dairy buffalo rations and nutrient composition

Feed source	Treatment		
	RDC	RDC +25% DDGS	RDC+ 50% DDGS
Corn Silage, kg	70.60	67.10	60.00
Rice Straw, kg	16.60	18.30	22.00
Dairy Concentrate, kg	13.40	11.00	9.00
DDGS, kg	00.00	3.60	9.00
Total	**100**	**100**	**100**
Nutrient composition			
CP, %	17.69	19.18	22.86
NDF, %	32.92	33.55	32.76
Fat, %	6.21	5.91	6.39
Ash, %	8.51	7.78	7.05
Ca, g	77.10	86.10	95.10
P, g	43.50	52.50	61.90

Digestibility trial

During the third month of the study, an *in vivo* digestibility trial was conducted involving three replicate cows from each treatment group. Before the digestibility trial, the replicate cows were first weighed to determine their live weights. A total fecal collection procedure for 24 hours was done for 5 consecutive days. The feeds offered and orts were weighed daily to calculate the feed intake. Collection of fecal samples, forage/feed offered and orts were done accordingly. The collected samples for 5 days were pooled, oven-dried, grounded and were analyzed for nutrient composition.

Milking Management

The lactating cows were milked following the milking procedure developed by PCC-GP farm. Milking was done twice a day using 2 x 6 tandem type e-Alpro milking machine. Milking starts at 4:00AM and 3:00 PM for the afternoon milking. The daily milk production of the cows was recorded. Monthly milk samples were collected and analyzed for nutrient composition and somatic cell counts using Milkoscan machine and Somatic Cell Counter, respectively.

Table 2. Effects of DDGS on the daily DM, CP, and NDF intakes of dairy buffaloes

Feed source	Treatment				
	RDC	RDC +25% DDGS	RDC+ 50% DDGS	± SE	*P*
DMI, kg/day	11.94	12.82	11.10	0.39	0.28^{ns}
CPI, kg/day	1.17	1.42	2.06	0.12	0.08**
NDFI, kg/day	5.09	5.67	4.69	0.20	0.12*

Ns – not significant, * significant; ** highly significant

Table 3. Effects of DDGS on the coefficient of DM, CP and NDF digestibility

% Digestibility	Treatment				
	RDC	RDC +25% DDGS	RDC+ 50% DDGS	± SE	*P*
DMI, %	69.00	68.91	63.19	1.53	0.43
CPI, %	64.37	64.47	74.94	0.68	0.22
NDFI, %	45.55	41.47	28.06	3.70	0.07

Table 4. Effects of DDGS on the milk production performance of dairy buffaloes

Month	Treatment, Kg				
	RDC	RDC +25% DDGS	RDC+ 50% DDGS	± SE	*P*
1st month	162.60	200.84	223.87	13.83	0.50
2nd month	233.42	178.50	309.17	11.54	0.06
3rd month	223.90	260.30	267.93	8.03	0.13
4th month	196.58	242.52	244.97	11.72	0.06

Data Gathered

Feed and Nutrient Intake - the feed and nutrients intake were determined by calculating the difference between the feed offered and orts. The daily dry matter intake (DMI), crude protein intake (CPI) and neutral detergent fiber (NDF) intake were calculated using the following formula:

DMI $_{kg}$ = (Feed Offered, kg – Feed Refusal, kg) × %DM

CPI $_{kg}$ = (Feed Offered, kg – Feed Refusal, kg) × %CP

NDF $_{kg}$ = (Feed Offered, kg – Feed Refusal, kg) × %NDF

Nutrient Composition and Digestibility- total collection method employed in determining nutrient digestibility was conducted during the middle part of the feeding trial. Laboratory proximate analysis for the nutrient contents of the feeds and feces such as dry matter, crude protein, and neutral detergent fiber was done. Formula in getting the DMD, CPD, and OMD are the following:

$$\%\ Digestibility = \frac{(Feed\ Consumed\ x\ \%\ Nutrient) - (Manure\ output\ x\ \%\ Nutrient)}{Feed\ Consumed\ x\ \%\ Nutrient} x\ 100$$

Milk Production- the daily milk yield of buffaloes was recorded using a 2 x 6 tandem type electronic -Alpro milking system.

Milk Quality: Monthly milk samples were collected from each of the dairy buffalo cow and the samples were analyzed using a Milkoscan machine for milk fat, protein, lactose, total solids and solid non-fat.

Body Weight: The initial body weight of the dairy buffaloes was obtained immediately after calving followed by monthly weighing for four months. The average daily gain (ADG) in weight of the dairy buffaloes was computed by dividing the final weight with the number of feeding days.

Economic Analysis: The income over feed cost (IOFC) of daily milk production was computed. Incremental benefit cost analysis was used to determine the effect of using DDGS in reducing the cost of milk production.

Statistical Analysis

All the data gathered during the feeding trial were consolidated and analyzed statistically in a randomized complete block design using statistical packages (SAS ver.

6.12) for Analysis of Variance. Significant effects were compared by Least Significant Difference. IOFC and incremental benefit cost analysis were interpreted in a descriptive analysis.

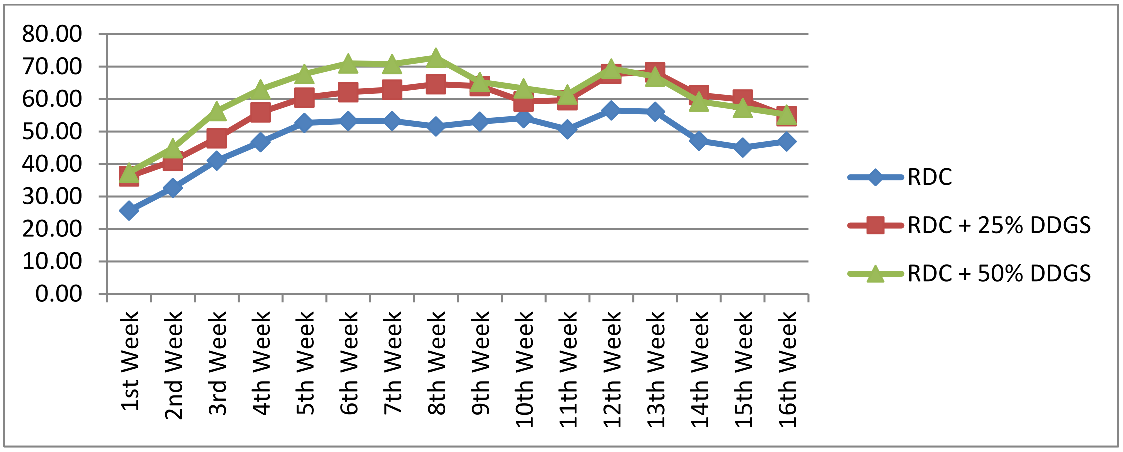

Figure1. Effects of DDGS on weekly milk production of dairy buffaloes

RESULTS AND DISCUSSION

Nutrient Intake

Animals with 25% DDGS had the highest DMI with an average of 12.82 kg/day while buffalo cows given 50% DDGS had the lowest DMI of 11.10 kg/day, (Table 2). Statistical analysis, however, did not reveal significant difference (P>0.05). Result obtained from this study did not agree with the previous results [5] using 30% DDGS which showed increased DMI in dairy cows.

In terms of crude protein intake (CPI), the 50% DDGS registered the highest CPI of 2.06 kg/day followed by 25% DDGS with 1.42 kg/day. The dairy buffaloes without DDGS had the lowest CPI of 1.17 kg/day. Statistical analysis revealed highly significant difference between the treatments. Comparison among means disclosed that the CPI of buffalo cows given 50% DDGS is statistically higher than the CPI of buffaloes fed 25% DDGS and those without DDGS. The CPI of buffaloes with 25% and those without DDGS however; were comparable. The CPI results agree with a previous study [4] that CP intake increased when DDGS is added to the diet.

The NDF intake of buffalo cows fed with 25% DDGS was highest at 5.67 kg/day, followed by the buffalo cows without DDGS with 5.09 kg/day. The 50% DDGS fed cows gave only 4.69 kg/day. Statistical analysis showed that 25% DDGS in the dairy ration significantly increased NDF intake compared to those given 50% and no DDGS in the diet. Buffaloes given no DDGS and with 50% DDGS have comparable NDF intakes.

Nutrient Digestibility

The coefficient of digestibility is presented in Table 3. It could be noted that DMD in 50% DDGS had the lowest digestibility while the highest DMD was from the buffalo cows with 25% DDGS. This, however, did not show statistically significant results.

Likewise, the CPD did not reveal significant differences, though numerically CPD in buffalo cows with 50% in the diet had the highest. In terms of NDF, highest value was (45.55%) from buffalo cows without DDGS, followed by those 25% DDGS in the diet (41.47%) and the least (28.06%) from the buffalo cows given 50% DDGS. The statistical analysis revealed no significant differences (P>0.05) between the DMD, CPD and NDFD.

Milk Production

All the dairy buffaloes were noted to have increased milk production during the 2nd month of milking (Table 4). Noticeably, the milk production of the dairy buffaloes fed with 50% DDGS as replacement of the dairy concentrates had numerically higher average milk production than the buffalo cows given 25% DDGS and those without DDGS that registered the lowest milk production during the entire duration of the study.

Findings showed numerical differences in milk production (Figure1), however, statistical analysis revealed no significant differences (P>0.05) between treatments. The results conformed to the study [6] that feeding 0, 10, and 20% DDGS did not affect milk yields of Holstein dairy cow. In addition [7, 8] noted that feeding DDGS with corn silage affected the milk production negatively which was attributed to reduced microbial growth in the rumen and low lysine content of the corn silage. Another study [9] agreed that feeding of DDGS resulted to digestive disturbance. In contrast however, [4] it was verified that milk production and milk protein were significantly affected by adding DDGS with 19% inclusion rate and during the hot climate in Taiwan. In addition, the inclusion of DDGS at 10% resulted to higher milk production by 0.9 kg per day [10].

Milk Nutrient Composition

Milk nutrient components such as: fat, protein, lactose, Solid-Non-Fat (SNF), and Total Solids (TS) is presented in Table 5. Milk fat percentage from the buffalo cows fed with 50% DDGS showed highest value with 7.18% while those fed with 25% DDGS and without DDGS had 6.00 and 6.36% fat, respectively. This, however, did not result to statistically significant difference. Previous study involving extensive trial on DDGS [5] indicated that milk composition was not affected by feeding DDGS at 4-30%. Feeding DDGS did cause milk fat depression and decrease daily fat yield. Similarly, the milk protein of Treatments 1, 2 and 3 showed statistically comparable values with 4.37, 4.36 and 4.39%, respectively. Milk protein was not affected by the replacement of dairy concentrate with 25 and 50% DDGS. The lactose (milk sugar) was also found statistically insignificant indicating that the inclusion of DDGS did not affect the lactose content of the milk. Likewise, the SNF and TS of the milk resulted to statistically comparable values though numerically buffalo cows given 50% DDGS had highest SNF and TS in milk. The results clearly show that feeding diet with DDGS did not elicit favorable nor adverse effect on milk nutrient components.

Table 5. Effects of DDGS on the milk composition of dairy buffaloes

Composition	Treatment				
	RDC	RDC +25% DDGS	RDC+ 50% DDGS	± SE	*P*
Fat, %	6.36	6.00	7.18	0.38	0.68
Protein, %	4.37	4.37	4.39	0.09	0.99
Lactose, %	4.68	4.76	4.35	0.06	0.33
Solid Non-Fat, %	9.84	9.97	9.70	016	0.71
Total Solids, %	16.43	16.72	17.29	0.51	0.87

Table 6. Effects of DDGS on the body weight gain of dairy buffaloes

Month	Treatment, kg/day				
	RDC	RDC +25% DDGS	RDC+ 50% DDGS	± SE	*P*
1st month	0.02	0.73	0.15	0.38	0.03*
2nd month	0.44	0.17	-0.19	0.15	0.38ns
3rd month	0.32	0.59	0.55	0.17	0.73ns
4th month	0.23	-0.48	0.19	0.17	0.27ns

ns- not significant; * significant

Table 7. Effects of DDGS on income over feed cost in dairy buffaloes

Item	Treatment		
	RDC	RDC +25% DDGS	RDC+ 50% DDGS
Milk yield[1], kg/day	6.80	8.18	8.72
Sale value of milk[2], Php	340.00	409.00	436.00
Feed consumed[3], kg	3.68	5.37	4.40
Cost of feed consumed[4], Php	66.24	93.97	74.80
Feed cost to produce a kg of milk, Php	9.74	11.49	8.58
Income over feed cost, IOFC, Php	273.75	315.15	351.20

[1] Average milk production per cow per day
[2] Price per kg of raw milk is Php50.00
[3] Average feed consumed per cow per day
[4] Feed cost; T1 = Php18.00/kg; T2= Php17.50/kg; T3= Php17.00/kg

Table 8. Effects of DDGS on the incremental benefit cost analysis in dairy buffaloes[1]

Item	Treatment		
	25% vs 0%	50% vs 0%	50% vs 25%
Incremental benefit, PhP	69.00	96.00	27.00
Incremental cost, PhP	27.74	8.56	-19.18
Incremental net benefit, PhP	41.27	87.44	46.18

[1]Incremental benefit and incremental cost per cow per day

Change in Body Weight

Table 6 shows the mean effect on average daily gain fed with and without DDGS. The dairy buffaloes fed with 25% DDGS had the highest daily gain in weight during first month of lactation with 0.73 kg followed by those dairy buffaloes fed with 50% DDGS. The 1st month showed significant ($P<0.05$) differences between treatments while the rest of the month showed no significant differences ($P>0.05$) between treatments. Cows fed diet with 25% DDGS had the highest ADG, while cows fed diet without DDGS incurred a negative gain in weight during the first month of lactation.

Income over Feed Cost

The income over feed cost is presented in Table 7. The highest sale value of milk, Php436.00 was from buffaloes fed diet with 50% DDGS followed by the sale value of milk from buffaloes fed diet with 25% DDGS, Php409.00 and the least, Php340.00 from the buffaloes fed without DDGS. Noticeably, feed cost of buffalo cows without DDGS was recorded the least with Php66.24 followed by Php74.8 from those given 50% DDGS and the highest cost of feed from those given 25% Php93.97 DDGS corresponding to the amount of feed consumed. The least expensive to produce a kilogram of milk are those in 50% DDGS with Php8.58 followed by without DDGS with Php9.74 and 25% DDGS with Php11.49. The data revealed that 50% replacement level by DDGS in the diet was economically justifiable with the highest IOFC, followed by 25% DDGS and the least IOFC was from those cows fed without DDGS.

Incremental Net Benefit

The incremental benefit from sale value of milk in 25% and 50% compared to control is Php41.27 and Php87.44, respectively, Table 8. Replacement of concentrate with DDGS indicated reduction in the cost of diet and increase in IOFC which mean DDGS when used at 50% in the diet replacing dairy concentrate resulted to an economic advantage compared to 25% and without DDGS.

CONCLUSIONS

The study was conducted to determine the effect of replacing 25% and 50% of the dairy concentrate with DDGS in milk production, milk nutrient components, nutrient digestibility and economic viability in dairy buffaloes. Results disclosed that the milk production of the dairy buffaloes with 25 and 50% DDGS in the diet had numerically higher amount of production, however, statistical analysis showed no significant differences between the average milk production throughout the duration of the study. Likewise, average milk nutrient components of the milk such as fat, protein, lactose, SNF and TS did not show statistical differences. There were no differences in terms of DMI of the dairy buffaloes. However, CPI of buffaloes given 50% DDGS is significantly higher than those given 25% DDGS and without DDGS. In terms of NDF, buffaloes with 25% DDGS was found to have significantly higher than buffalo cows with 50% and without DDGS in the diet. Coefficient of digestibility was found to be insignificant in the DM, CP, and NDF. An economic advantage is manifested in the IOFC where more sale value of milk was realized from the dairy buffaloes given 50% DDGS. This was proven by the benefit cost analysis getting an incremental benefit of PhP87.44 from those given 50% versus without DDGS, PhP41.27 from buffaloes given 25% versus without and PhP46.18 benefit of 25% over the 50% DDGS. Longer feeding period of DDGS to lactating buffalo cows is recommended to get more conclusive results covering one cycle of milk production.

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