RESPONSE OF GROWING DAIRY CALVES TO STARTER DIETS WITH VARYING ENERGY AND PROTEIN LEVELS

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ABSTRACT

This study was conducted to determine the optimum growth performance and nutrient digestibility of dairy calves fed starters containing high or low energy and protein. Ten male and ten female growing Holstein-Friesian x Sahiwal calves (n=20) initially weighing 42.9±15.1 kg at 2±0.98 months were divided into four groups and blocked by weight. Starter feeds containing ME at 3.11 and 2.83 Mcal ME/kg and CP at 19 and 16% were used in a 2 x 2 factorial arrangement in 5 randomized complete blocks, where each block consisted of calves in the same weight range. Body weight (BW), BW gain, and feed conversion ratio (FCR) of calves were not affected by both levels of energy and protein in starter diets. Calves fed low energy starter diets have better fecal scores (P<0.05). Energy levels mainly influenced energy and nutrient digestibility. Feeding calves high energy starter feeds could generate higher income which requires lesser cost to gain 1kg of live weight per kg BW. However, calves can still be fed cheaper concentrates containing 2.83 Mcal ME/kg and 16% CP without any adverse effect on growth performance.

Key words: calf starter, dairy, digestibility, energy and protein nutrition, growth performance

INTRODUCTION

Rearing of young dairy stocks require the greatest time span between financial investment and return. As a result, dairy calves and growing heifers receive least attention and are often neglected in most dairy farms. However, raising healthy replacement heifers with body conditions fit for breeding and production is the key for a profitable dairy operation (Moran, 2012). Feeding calves according to their protein and energy requirements is a practical nutritional tool in improving profitability of dairy operations. Dietary protein and energy is essential for ruminant productivity. However, protein and energy requirements are dependent on the feeding system, rumen ecology, animal productivity and efficiency of nutrient utilization (Taquir *et al*., 2011). This study was conducted to determine the response of dairy calves to different levels of energy and protein concentrations by

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observing dry matter intake, growth performance and nutrient digestibility in order to know the optimal energy and protein concentration for growth and development. Total feed cost and income based from feed cost was also determined.

MATERIALS AND METHODS

Ten male and ten female Holstein-Friesian x Sahiwal dairy calves (n=20) initially weighing 42.9±15.1 kg at 2±0.98 months were divided to into four groups and randomly assigned to one of four treatments. Dietary treatments were calf starters containing ME at 3.11 and 2.83 Mcal ME/kg and CP at 19 and 16% in a 2 x 2 factorial arrangement in 5 randomized complete blocks. Each block was represented by calves in the same weight range. Calves were equally divided by sex and blocked by weight. The four treatments were high energy-high protein (HEHP), high energy-low protein (HELP), low energy-high protein (LEHP) and low energy-low protein (LELP) starters. The ingredients and nutrient composition of experimental diets are shown in Table 1.

The calves were fed experimental diets for 56 days. Calves were placed in elevated individual pens (1.5 m x 2.5 m) to account individual feeding. Feeding of calves followed the feeding guide for dairy cattle according to the Philippine Society of Animal Nutritionists (PHILSAN, 2010). The amount of starter and forage provided to calves was changed every two weeks to supply 3.0% required DM of calves based on the body weights of calves. The amount of milk given was dependent on the age of calves. Milk was provided to calves at 6-4% of the live weight of calves until calves reach 13 weeks old. Calves were fed morning and afternoon at 08:00 am and 01:00 pm. Starter concentrate and milk were given to calves in the morning while starter and forage were provided on the afternoon. Forage provided to calves were a mixture of improved grasses and legumes. Starter and forage were placed separately in feeding buckets to allow for separate collection of starter and forage refusals. Calves were also provided *ad libitum* water and regular supplementation of with B Vitamins weekly and Vitamins ADE monthly.

Body weight (BW) of calves were monitored every two weeks while feed intake was recorded daily. Feed refusals were weighed and discarded at 08:00 am the following morning. Sub-samples of the concentrates and forage offered and refused from each animal were weighed and then analyzed for nutrient and fiber contents. Starter samples were oven dried at 105°C for at least 5 hours or until constant weight while forage samples were dried to constant weight at 70°C. Starters and dried forage samples were ground using a Wiley mill through a 1-mm screen and stored until analyzed for proximate, fiber and mineral contents following methods of AOAC (1990) and Van Soest *et al*. (1991). Chemical composition of calf starters and forage offered every two weeks is presented in Table 2.

Percent dry matter intake (DMI) of calves from starter and forage were calculated at the end of the feeding trial. BW gain, total DMI and feed conversion ratio (kg of BW gain/kg of total DMI) were calculated on monthly basis. The digestive health of calves was monitored through fecal scores using the procedure of Larson *et al*. (1977) and Heinrichs *et al*. (2003). Fecal scores were recorded daily on a 1- 5 scoring system based on fecal fluidity wherein 1= normal, 2= soft to loose, 3= loose to watery, 4= watery, mucous, slightly bloody, 5= watery, mucous, bloody. Fecal scoring was done by a panel of three members to minimize error of subjectivity. Mean fecal scores were determined every two weeks.

All calves (n=20) were prepared for digestibility trial after the conclusion of the

Table 1. Ingredients (% as fed) and calculated percent nutrient composition of experimental diets in dry matter basis.

Ingredients, %	Treatments[1]			
	HEHP	HELP	LEHP	LE-LP
Wheat grain	46.08	56.11	10.00	10.00
Copra meal, ground	20.00	15.00	20.00	15.00
Rice bran D1	20.00	20.00	20.00	21.62
Wheat pollard	0.00	0.00	42.54	51.28
Soybean meal	9.98	5.23	5.32	0.00
Palm oil	1.65	1.32	0.00	0.00
Cane molasses	1.50	1.50	1.50	1.50
Refined iodized salt	0.30	0.30	0.30	0.30
Limestone, fine	0.19	0.24	0.04	0.00
Mineral premix	0.10	0.10	0.10	0.10
Vitamin premix	0.10	0.10	0.10	0.10
Anti-oxidant	0.05	0.05	0.05	0.05
Mold inhibitor	0.05	0.05	0.05	0.05
Total	100.00	100.00	100.00	100.00
Nutrient Composition, %				
Dry matter	89.13	89.08	89.44	89.56
Metabolizable energy, Mcal/kg	3.11	3.11	2.83	2.80
Crude protein	19.00	16.80	19.00	16.81
Neutral detergent fiber	14.49	14.68	26.65	29.38
Acid detergent fiber	5.76	5.82	9.75	10.80
Calcium	0.60	0.60	0.53	0.55
Phosphorous, total	0.70	0.67	0.80	1.02

[1]Wheat based mashed starter diets formulated to have different energy and protein concentrations where HE=High energy, LE= Low energy, HP= High protein and LP= Low protein.

feeding trial at day 56 following the same 2 x 2 factorial arrangement of treatments using the total collection technique. Milk feeding of calves was concluded. The calves were placed in individual cages with enough room to stand up and lie down, but side to side and back and forth movements were restricted. The calves were secured and tied with a halter to prevent unnecessary movement that may alter collection of fecal output. Calves were provided free access to water.

The calves were fasted for 24 hours to allow for quantification of fecal samples during digestibility trial but water was provided. Total fecal collection of feces was conducted for five days. Total collection of fecal samples was done directly from polythene sheets attached under the cages adjacent to the rear side of the calves. Collection sheets

were checked daily and the total daily fecal output were weighed and a subsample of the daily fecal output was obtained. Fecal samples were composited by calf and were dried for 72 hours at 60°C to constant weight. Dried fecal samples per calf were homogenized in a blender for one to two minutes and were ground to pass through a 1-mm screen in a Wiley Millthen stored in containers for laboratory analysis.

During the collection period, daily feed intake and refusals of each calf were recorded and sampled for nutrient analysis. Feed, refusals and fecal samples were analyzed for DM, organic matter (OM), gross energy (GE), crude protein (CP) and neutral detergent fiber (NDF). Apparent nutrient digestibility was calculated as the quantity of nutrient consumed minus the quantity of nutrient defecated divided by the quantity of nutrient consumed (Castells *et al*., 2012).

Cost of starter diets were based only on direct material cost. These costs were derived from individual prices of raw materials. The income is based upon the assumption that calves are raised to be sold as next generation stocks to other dairy farms. Calf selling price was based on the total body weight gain at 130.00 pesos per kg live weight. Total forage and starter where accounted for feed costs. This study was focused mainly on feed cost. The costs of labor, utilities and fuel, supplies, other variables and fixed expenses (i.e., depreciation, interest and taxes) were not included.

Percent DMI from starter and forage, BW, BW gain, FCR, fecal scores and nutrient digestibility were analyzed using the MIXED procedure of SAS (SAS University, 2016) with calves as the experimental unit. The model included energy, protein and energy x protein as fixed effect and block as the random effect. Least square means was calculated for each independent variable and means were separated using the PDIFF option. Statistical significance and tendencies were set at $P \leq 0.05$ and $P < 0.10$, respectively.

RESULTS AND DISCUSSION

Table 2 shows the nutrient composition of starters and forage offered to calves. Dry matter (DM), CP, crude fat (EE), calcium (Ca) and phosphorous (P) of starters were almost the same with the formulated nutrient values except for NDF which is relatively higher than the formulated NDF values. Higher values for NDF would indicate variation of fiber content of the raw materials used which could affect nutrient composition and utilization in calf starters. Forage DM ranged from 27- 38% during the feeding trial while CP ranged from 6-9% and NDF from 22-35%. Different nutrient values of forage every two weeks show the variability forages quality which could affect forage intake and subsequently nutrient intake of calves.

Calves fed LELP mostly obtained DM from starter and less DM from forage while calves fed HEHP mostly obtained DM from forage (Table 3). This observation was affected by dietary energy levels ($P<0.05$). Hill *et al*. (2008) observed that greater forage intake reduced starter intake in calves while Khan *et al*. (2011) and Castells *et al*. (2012) observed greater forage intake along with greater starter intake. The consumption of more forage DMI among HEHP fed calves may be attributed to more energy and protein available from the diet that encouraged greater ruminal protein degradation and growth of microbes that efficiently digest fiber and cellulose providing greater ruminal physical capacity to accommodate more feed bulk from forage (Khan *et al*., 2008). Forage consumption in calves stimulates rumen development, encouraged rumination and reduces non-nutritive oral

Table 2. Mean (±SD) chemical composition of starters and forage offered in dry matter basis.

Feed Offered	Chemical Composition[2], in DM basis (%)						
	DM	GE, Mcal/kg	CP	NDF	EE[3]	Ca	P
Starter[1]							
HEHP	88.28±0.26	4.63±0.01	18.85±0.19	22.55±1.05	7.08±0.09	0.79±0.00	0.83±0.01
HELP	89.26±0.14	4.58±0.01	16.67±0.46	22.00±1.24	6.98±0.18	0.56±0.00	0.68±0.03
LEHP	89.50±0.37	4.65±0.02	19.54±0.61	35.76±0.77	7.94±0.92	0.34±0.00	0.64±0.03
LELP	88.46±0.26	4.61±0.01	17.44±0.96	31.96±0.42	6.60±0.45	0.34±0.00	0.99±0.04
Forage offered every two weeks							
Wk 0-2	27.23±3.35	3.73±0.06	8.76±0.33	74.26±0.81	0.53±0.14	0.54±0.00	0.25±0.01
Wk 2-4	35.14±5.73	3.88±0.07	9.88±0.15	68.71±1.00	0.22±0.00	0.76±0.00	0.35±0.02
Wk 4-6	38.46±7.34	3.95±0.08	7.59±0.03	71.19±0.33	1.41±0.01	0.54±0.15	0.26±0.01
Wk 6-8	33.08±6.18	3.82±0.02	6.53±0.24	77.51±0.21	1.08±0.04	1.03±0.08	0.30±0.00

[1]Wheat based starter in mash form; HEHP- High energy, high protein; HELP- High energy, low protein; LEHP-Low energy, high protein; LELP-Low energy, low protein.

[2]Analyzed using standard methods of AOAC (1990) and Van Soest *et al*. (1991).

[3]Also referred to as Crude fat.

Table 3. Percent dry matter intake (DMI), and growth performance of Holstein-Sahiwal calves fed starter diets with varying levels of energy and protein.

Parameter	Treatments				SEM	*P*-value		
	HEHP	HELP	LEHP	LELP		Energy x Protein	Energy	Protein
DMI[1], %								
Starter	71.92^{c}	72.79^{bc}	81.28^{ab}	86.30^{a}	3.12	0.3245	0.0001	0.1714
Forage	28.07^{a}	27.21^{ab}	18.72^{bc}	13.70^{c}	3.12	0.3245	0.0001	0.1714
BW, kg								
Initial	42.00	42.60	43.60	43.50	6.82	0.9299	0.7540	0.9499
Week[2] 2	47.26	45.30	45.44	44.02	7.53	0.9247	0.6809	0.6541
Week 4	55.08	52.08	52.90	55.10	8.19	0.4859	0.9094	0.9137
Week 6	62.48	59.70	60.60	61.60	8.36	0.6977	0.9501	0.7806
Week 8	71.00	66.60	66.78	66.88	8.92	0.6078	0.6528	0.6237
BW gain, kg								
Week 2	5.26	2.70	1.84	0.52	1.59	0.7016	0.0972	0.2399
Week 4	13.08	9.48	9.30	11.60	2.60	0.2472	0.7381	0.7932
Week 6	20.48	17.10	17.00	17.56	2.90	0.4817	0.5881	0.4817
Week 8	29.00	24.00	23.18	23.38	3.13	0.3727	0.2738	0.4094
Feed Conversion Ratio[3]								
Week 2	4.29	3.18	2.39	3.98	0.52	0.5897	0.4043	0.7171
Week 4	2.93	4.04	13.22	3.79	5.13	0.3193	0.3418	0.4289
Week 6	3.37	3.65	3.94	4.14	0.82	0.9471	0.4311	0.7127
Week 8	3.35	3.69	3.95	4.40	0.19	0.9068	0.2056	0.4305
Fecal Scores[4]								
Wk 0-2	1.57	1.71	1.25	1.68	0.17	0.3759	0.2915	0.1141
Wk 2-4	1.50^{a}	1.56^{a}	1.15^{b}	1.23^{b}	0.05	0.8983	0.0001	0.2249
Wk 4-6	1.48^{a}	1.37^{a}	1.12^{b}	1.15^{b}	0.07	0.4701	0.0067	0.6624
Wk 6-8	1.52^{a}	1.38^{ab}	1.11^{b}	1.17^{b}	0.08	0.2009	0.0014	0.6122

Means within row bearing different superscripts differ significantly ($P<0.05$)

SEM- Standard error of mean

[1]Percent starter DMI from the total DMI and percent forage DMI from the total DMI.

[2]Period of the feeding trial to which calculation of a growth parameter was based.

[3]Feed conversion ratio= DMI/ BW gain.

[4]Fecal scores 1= normal; 2= soft to loose; 3= loose to watery; 4= very watery; 5= very watery and bloody (Heinrichs *et al*., 2003).

behaviors in calves (Castells *et al*., 2012; Beiranvand *et al*., 2014).

No significant differences were observed between BW, BW gain and FCR in calves across treatments. The calves in this study were already at their weaning weights. Weaning weights of male and female Sahiwal calves ranged from 45 to 56 kg (Bhatti *et al*., 2012). The calves had an overall average daily gain of 0.42 kg which is slightly lower from the computed growth rate values for Holstein-Friesian x Sahiwal calves at 0.44 and 0.58 kg per day for female and male crosses (Zamman, 1983). Taquir *et al.* (2011) observed that varying levels of dietary energy and protein in concentrates did not affect BW, BWG and FCR of calves and daily gain of buffalo calves at 0.32 to 0.47 kg. Lee *et al.* (2008) also observed no differences in the performance of Holstein calves fed milk replacer with varying levels of protein and energy. Calves in this study had lower FCR than that of Sahiwal calves of Bhatti *et al.* (2012) fed with milk replacer. Feeding calves starter ration is more economical than milk replacer.

Fecal score of calves were within the acceptable scores of <2.0 according to the standards of Heinrichs *et al*. (2003) and were consistent throughout the feeding trial. However, calves fed LEHP and LELP starters have significantly better fecal scores than calves HEHP and HELP starters and was affected mainly by energy levels. High fecal scores obtained by calves fed HE diets were the same with the findings of Brown *et al*. (2005) and Raeth-Knight *et al*. (2009) wherein calves fed high energy milk replacers or starter had higher scores. Increasing the energy and protein intake of calves resulted in higher fecal scores and more days with loose stool (Davis Rincker *et al*., 2011).

Digestibility (%) of DM, GE, NDF and OM were mainly affected by energy levels (P<0.05) and was greater in calves fed HE starters while CP digestibility was the same across treatments (Table 4). Dry matter and OM digestibility of calves was greatest in calves fed HELP starter. Protein levels in the diet tend to affect digestibility but it was observed that energy levels influenced percent digestibility whether calves were fed HP or LP starter. Nutrient digestibility of calves in this study was lower than the digestibility values of Hill *et al*. (2010) and Castells *et al*. (2012) which ranges from 80% nutrient digestibility in calves fed forage, milk replacer and starter. Lesser nutrient digestibility might have been due to greater NDF contents of the total diet consumed by calves (Porter *et al*., 2007).

Table 4. Percent nutrient digestibility in calves fed starter diets with varying energy and protein levels.

Digestibility, %	Treatments				SEM	*P*-value		
	HEHP	HELP	LEHP	LELP		Energy x Protein	Energy	Protein
DM	51.63^{a}	56.32^{a}	36.30^{b}	47.00^{ab}	2.97	0.3299	0.0013	0.0239
GE	50.18^{a}	53.60^{a}	41.09^{b}	46.28^{b}	3.30	0.7916	0.0286	0.2170
CP	54.12	48.57	45.55	52.50	3.10	0.0671	0.4696	0.8259
NDF	30.78^{a}	35.00^{a}	20.18^{b}	27.17^{b}	4.13	0.7257	0.0396	0.1178
OM	51.41^{ab}	57.36^{a}	34.79^{c}	44.10^{bc}	3.06	0.5942	0.0004	0.0284

Means within row bearing different superscripts differ significantly (P<0.05)
SEM- Standard error of mean

Gabler and Heinrichs (2003) fed high grain diets to calves and reported an increase in DM digestion as dietary ME and CP levels were increased. DM digestibility of animals fed high-fiber, 27% NDF was lower than that of calves fed low-fiber, 20% NDF diets (Castells *et al*., 2012) Digestibility of energy and NDF of calves were greater when fed starters in mash form containing low fiber and high energy (Porter *et al*., 2007). Differences in OM digestibility among calves can be attributed to the variation of rumen microorganisms and the capacity of rumen to digest OM which seems to be affected by energy and protein levels in the diet (Khan *et al*., 2008).

Calves fed HE starters had the highest total feeding cost but also had the highest income return provided that cost to gain 1 kg live weight was lesser compared to feeding calves with LE and LP starters. Starter diets (Table 5) with high ME and CP levels can bring about higher economic returns considering feed costs alone. Feed costs were found to contribute 60 to 70% of the total cost incurred in rearing calves (Iqbal *et al*., 2014). If one would opt to save for feed costs, calves can still be fed LE and LP starters as low as ME level of 2.83 Mcal/kg and a CP of 16.9% without compromising calf growth and performance.

The overall growth performance of calves was not affected by energy nor protein levels in the diet. Moreover, starter DMI and forage DMI as well nutrient digestibility were mainly influenced by energy levels. Feeding calves HE and HP starters could generate higher income based on calf selling price per kg BW and the cost required to gain 1kg of live weight. However, calves can still be fed cheaper diets containing energy and protein levels of as low as 2.83 Mcal ME/kg and 16% CP without any adverse effect on growth performance since a practical ration formulation is based on the selection of the most appropriate feedstuffs to meet the nutrient requirements of an animal at the lowest cost.

Table 5. Income over feed cost of calves fed different treatment starter diets containing varying level of metabolizable energy and crude protein.

Digestibility, %	Treatments			
	HEHP	HELP	LEHP	LELP
Price of Starter[1]	15.53	14.96	13.65	12.95
Starter Intake	76.61	84.17	78.41	87.14
Forage Intake	57.45	54.19	51.25	58.06
Feed Costs[1,2]	30.78	35.00	20.18	27.17
Forage[3]	114.91	108.39	102.51	116.12
Starter	1189.73	1259.19	1070.32	1128.52
Total	1304.64	1367.58	1172.83	1244.64
Total BW gain, kg	29.00	24.00	23.18	23.38
Calf selling price[4]	3770.00	3120.00	3013.40	3039.40
Income1 over feed cost	2465.35	1752.44	1840.60	1797.36

[1]Prices, costs and income are expressed in Philippine peso (Php)
[2]Feed cost are based on the overall starter and forage consumption of calves in as fed basis
[3]Selling price of forage is at 2.00 Php/kg
[4]Selling price of calves at Php 130.00/kg

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