Pakistan J. Zool., vol. 44(3), pp. 625-634, 2012.

Evaluating Varying Dietary Energy Levels for Optimum Growth and Early Puberty in Sahiwal Heifers

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Abstract.- The study was designed to examine the effect of feeding diets with different energy levels for optimum growth and early puberty of heifers. Twenty Sahiwal heifers (Age = 12 ± 2 months and avg. wt = 125 kg) were assigned to four dietary treatments having five animals on each treatment. Iso-nitrogenous (CP=13.7%) diets having varying energy, viz; ME 100% (Control), ME 88%, ME 112% and ME 124% of NRC (2001) recommended level for small breed non bred heifers were fed to the respective groups until the onset of puberty . Dry matter and protein intakes were similar (P>0.05) across the dietary treatments. The optimum average daily gain (ADG) was achieved during the period from 13 to 18 months of age. The overall ADG was higher (571±15 g/d) in ME 124% than of ME 100, 88 and 112%, whereas ADG found to be lowest in ME 88% (397±07 g/d). Similar trend was observed in feed efficiency for different treatment groups. Heifers fed dietary level of ME 124% of NRC (2001) acquired higher body length, height and heart girth as compared to those fed other dietary energy levels. The digestibility of nutrients, age at puberty, age at 1st conception and serum progesterone were not influenced by dietary treatments (P>0.05). It is concluded that provision of higher dietary energy level (ME 124% of NRC, 2001 recommendation) enhanced growth parameters and feed efficiency but adequate reproductive performance of Sahiwal heifers in terms of age at puberty was achieved even at lower dietary energy level (ME 88% of NRC, 2001 recommended level) under local environmental conditions of Pakistan.

Key words: Dietary energy, weight gain, body measurements, puberty, Sahiwal heifers.

INTRODUCTION

Sahiwal is a renowned tropical dairy cattle breed of Pakistan due to its excellent heat and tick resistance (Khan *et al*., 2008; Rehman *et al*., 2006). Although Sahiwal cattle may outperform in tropical environment but its production level is much lower as compared to the dairy breeds of the developed world (Khan, 2002). Average age at first calving in Sahiwal cattle is 46 months which is much higher when compared to 29 months in Holstein (Rehman, 2006). The future of any dairy operation depends upon a successful program for raising calves and heifers which equal or exceed the current level of milk production. Unfortunately, this is the most neglected stage because during the non-lactating period heifers are not generating any direct income as well as require feeding, housing and veterinary care expenses with no visible returns. The positive approach to decrease this cost is to lessen age at sexual maturity alone (Ettema and Santos, 2004). Feeding management of heifers during growing period minimizes its age at puberty and consequently cuts down non-producing period (Le Cozler *et al*., 2008).

Nutrient requirements recommended by NRC (2001) are widely adopted to formulate diets for ruminant animals around the world but these were based on *Bos taurus* cattle. The question arises for optimum nutrients requirements of Sahiwal cattle. Scientific literature regarding the influence of varying level of dietary energy on performance of Sahiwal cattle in tropical and sub tropical countries is very limited. The current study was designed to evaluate performance of Sahiwal heifers fed varying dietary energy levels during pubertal period under sub tropical environmental conditions of Pakistan which might make a significant addition to existing knowledge. The specific objectives of current study were to determine optimum energy requirement of Sahiwal heifers during pre pubertal period and to

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0030-9923/2012/0003-0625 $ 8.00/0
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Abbreviations: CP, crude protein; NDF, neutral detergent fibre; ADF, acid detergent fibre; ADG, average daily gain; DM, dry matter; TMR, totally mixed ration; NRC, national research council; ng, nanogram; mL, mili litre; TDN, total digestible nutrients; ME, metabolizable energy ADL, acid detergent lignin

study the influence of varying dietary energy levels on its growth and age at puberty.

MATERIALS AND METHODS

Experimental animals and dietary treatments

Twenty Sahiwal heifers (Age, 12±2 months and avg. wt, 125±10 kg) having similar body condition were selected and divided into four equal groups; A, B, C and D on the basis of similar average body weight. Before the start of experiment all the animals were injected Ivomec (Ivermectin) for deworming against internal and external parasites. The animals were assigned to four dietary treatments having five animals on each treatment. Iso-nitrogenous (CP, 13.7%) diets having varying energy, viz; ME 100% (control), ME 88%, ME 112% and ME 124% of NRC (2001) recommended level for small breed non bred heifers were fed to respective groups until the onset of puberty. Ingredient and nutrient composition is mentioned in Table I.

Table I.- Ingredient and nutrient composition for pre-pubertal experimental diets.

Ingredients	Inclusion level			
	100% NRC	88% NRC	112% NRC	124 % NRC
Cotton seed cake	18.00	23.50	10.00	10.00
Sunflower meal	6.00	6.00	6.00	5.00
Maize gluten 30	6.00	6.00	3.75	3.00
Maize grain broken	15.00	0.00	15.00	15.00
Wheat bran	12.00	22.00	10.00	8.50
Wheat straw	33.00	40.00	27.00	21.00
Rice polishing	0.00	0.00	13.00	14.00
Molasses	6.00	0.00	10.00	15.00
Mega lac™	1.00	0.00	2.00	5.00
Urea	1.00	0.50	1.25	1.50
Mineral mixture *	2.00	2.00	2.00	2.00
Total	100.00	100.00	100.00	100.00
CP (%)	13.70	13.71	13.70	13.70
ME (M Cal/Kg)	1.99	1.77	2.24	2.48
NDF (%)	42.00	52.00	34.00	28.00
ADF (%)	27.00	34.00	22.00	18.00

*100 kg mineral mixture included DCP 70.81Kg, NaCl 18.91Kg, $MgSO_4$ 8.64Kg, $FeSO_4$ 0.89Kg, $MnSO_4$ 0.49Kg, $ZnSO_4$ 0.22Kg, $CuSO_4$ 0.03Kg, KI 8.77g, $CoCl_2$ 0.89g and NaSiO3 1.50gm.

Housing and feeding

Experimental heifers were kept under the same roof in one shed having separate pen & mangers for individual feeding. Rubber made water tubs were fixed besides feeding mangers in front of each animal for provision of fresh water. The quantity of diet offered was calculated for each individual animal keeping its body weight into consideration according to NRC (2001) recommendations for small breed non-bred heifers weighing 100 to 300 kg. The quantity of feed offered to animals was increased as they gained weight and again recalculated on the day of body weight recording. Each individual animal consumed quantity of diet (dry matter basis) according to their relative body weight as recommended by NRC (2001) throughout the feeding trial.

Measured quantity of diet was offered individually to animals of group A, B, C and D daily in the morning and evening and orts were measured next morning throughout the study period. A period of 14 days was given as adjustment period so that animals could adapt to the experimental conditions before the observations were recorded.

Data recorded and parameters studied

Feed intake of each experimental animal was recorded daily. Body weight and blood samples were taken fortnightly while body measurements (length, height and girth) were taken monthly. Estrus signs were detected twic a day with the help of teaser bull. The age at sexual maturity was recorded when animals showed estrus and got inseminated, whereas age at conception was recorded when declared pregnant through monthly routine pregnancy diagnosis. The effect of varying dietary energy levels was observed on weight gain and body (length, height and girth) measurements during different phases; phase 1 (13^{th} to 15^{th} months), phase 2 (16^{th} to 18^{th} months), phase 3 (19^{th} to 21 months) and phase 4 (22^{nd} month to age at puberty). However, overall performance of heifers fed varying dietary energy levels was also observed on dry matter intake (kg/d), average daily gain (g/d), feed efficiency (ratio), body (length, height and girth) measurements (cm), nutrients digestibility (%), age at puberty (days) and serum progesterone (ng/mL).

Digestibility trials

The digestibility studies were carried out

three times at 8th, 24th and 36th week of experiment. During the digestibility trial fecal "grab" samples were taken three days of the week at 6 hour intervals. Sample collection times were staggered for 2 hours daily to have a representative sample for every 2 hours interval during 24 hours. For each collection, 50 g sample was weighed and composited to form one sample per animal. Samples were dried in the oven at 60 ˚C and stored at room temperature till further analysis. The acid insoluble ash was used as a digestibility marker (Van Keulen and Young, 1977).

Blood samples

Blood samples were collected fortnightly by jugular venipuncture after two hours of morning feeding fortnightly throughout the study period. Samples were allowed to clot at room temperature and centrifuged at 1500 rpm for 20 minutes. Serum was harvested, and stored at -20°C until analysis (Schoonmaker *et al.*, 2003).

Laboratory analysis

Proximate analysis of feeds and fecal samples was conducted according to the procedures of AOAC (2000), whereas, analysis of fiber fractions were made as described by the procedures of Van Soest *et al*. (1991). The progesterone concentrations were measured by radioimmunoassay through commercially available ELISA Kit (Biocheck, USA) by using Multiskan® Ex ELISA reader (Model 355, Thermo Electric Corporation, Shangai, China). These analyses were performed in laboratory of Department of Food and Nutrition and Quality Operation Labs at University of Veterinary and Animal Sciences, Lahore, Pakistan.

Statistical analysis

Data regarding daily weight gain and body measurements were analyzed through repeated measures ANOVA techniques, whereas data of dry matter intake, feed efficiency, nutrient digestibility, age at puberty and serum progesterone were analyzed through one way ANOVA technique under CRD using SAS 9.1.3 portable software. Difference among treatment means were tested through DMRt. Mathematical model assumed was:

$$\mathbf{Y_{ij}} = \mu + \tau_i + \varepsilon_{ij}$$

where, $\mathbf{Y}_{ij}$ is the observation on i^{th} treatment due to j^{th} animal

μ = overall mean

τ_i = effect of i^{th} treatment ($\sum \tau_i = 0$ and i = 1, 2, 3, 4)

ε_{ij} = random error associated with i^{th} treatment with the restriction that variance σ^2 and mean zero.

RESULTS

Dry matter intake and nutrients digestibility

Dry matter intake (DMI) in Sahiwal heifers fed on different levels of dietary energy during pre pubertal period was not different (P>0.05) and values of DMI ranged from 4.66 ± 0.10^a to 4.85 ± 0.09^a kg/d. The CP intake was also not different with treatments and overall average CP intake was 662 ± 19 g/d. The digestibility percentages of DM, CP, NDF and ADF were similar among treatment groups. The overall DM, CP, NDF and ADF digestibility percentages were 65, 72, 59 and 52, respectively.

Average daily gain

Average daily gain (ADG) in heifers fed on varying levels of dietary energy during different phases is mentioned in Table I. The heifers fed dietary level of ME 124% of NRC (2001) gained overall higher ADG than those fed on other diets during pre pubertal period, whereas it was similar between ME 112% and control ME 100% but higher in low energy ME 88%. However, during phase-1, the value of ADG in ME 124% was significantly higher followed by ME 112% and control diet ME 100%, whereas lowest ADG was observed in ME 88%. The same pattern of ADG was observed during phase-2 (16 to 18^{th} month of age) except non-significant difference between ME 112 and 124% of NRC. However, the value of ADG in ME 124% was only significantly higher during period of phase-3 than other diets. Same pattern of ADG was also found during phase-4. The effect of varying dietary energy levels on increase in body weight at different months of age in heifers is presented in Figure 1.

Different phases also influenced ADG in heifers (p<0.05). Significantly high value of ADG was observed during Phase-1 and phase-2 followed

by phase-3, while lowest ADG was observed during phase-4 as shown in Figure 2.

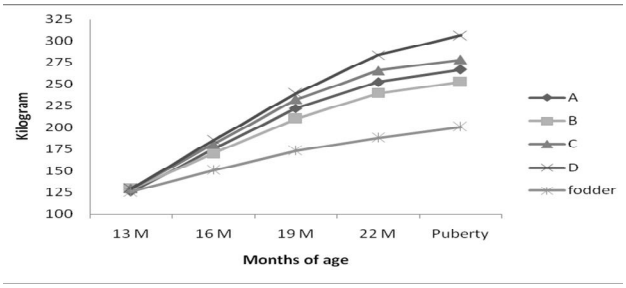

Fig. 1. Effect of dietary energy levels on body weight during pre pubertal phases in Sahiwal heifers

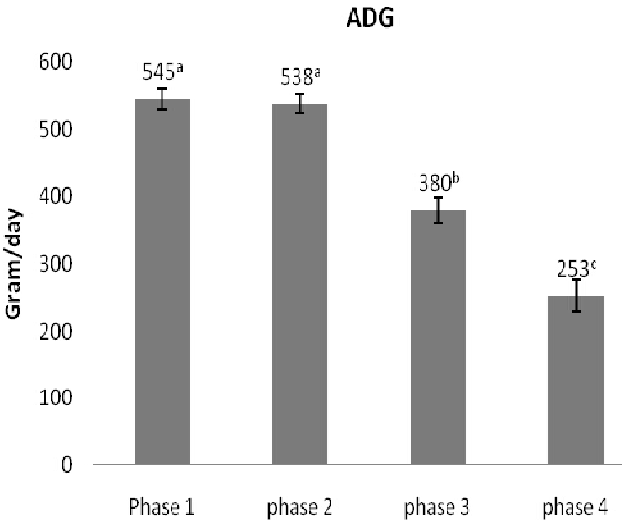

Fig. 2. Effect of phases on average daily gain in Sahiwal heifers

Feed efficiency

The efficiency of diet was increased in current study by provision of extra dietary energy than recommended by NRC (2001). The diet having energy 124% of NRC (2001) was more efficient (0.099 ± 0.001^{a}) than other diets, whereas control diet (ME 100%) and ME 112% were similar in terms of feed efficiency (0.092 ± 0.0006^{b} and 0.091 ± 0.0005^{b}, respectively) but efficiency of diet having ME 88% was lowest (0.085 ± 0.0009^{c}) as compared to other diets.

Body measurements

Body length in heifers fed different levels of dietary energy during different phases of pre pubertal period is given in Table II. At the age of puberty, body length of heifers fed ME 124% was higher than other diets, whereas difference in body length among heifers fed ME 100% and ME 112% was non-significant but body length was lower in ME 88% than other treatments. The effect of phases on change in body length is presented in Figure 3. The change in body length was higher during phase-1 and 2 than phase-3 and 4.

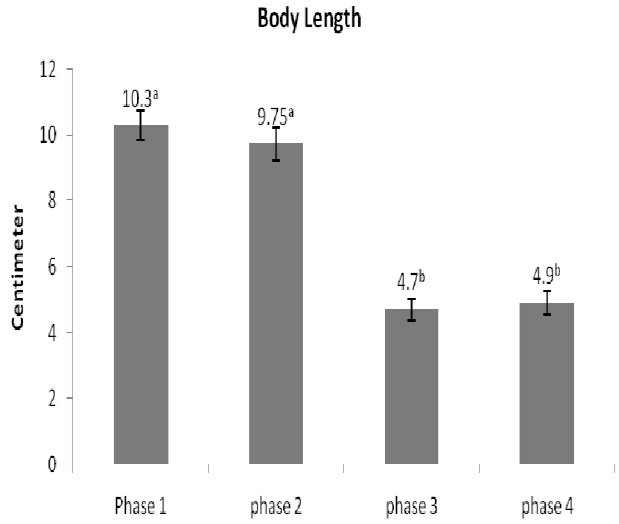

Fig. 3. Effect of phases on change in body length in Sahiwal heifers

Effect of varying dietary energy levels on body height during different phases is presented in Table III. Heifers fed ME 124% at the end of phase-4 acquired higher body height than other diets, whereas it was similar among heifers fed other dietary energy levels. The effect of phases on change in body height is presented in Figure 4. The body height was significantly increased during 3rd and 4th phase than of phase-1 and 2, whereas it was comparatively also higher in phase-1 than phase-2.

Age at puberty and serum progesterone

The age at sexual maturity was not influenced ($P>0.05$) by different levels of dietary energy during pre pubertal period and ranged from 801 ± 27^{a} to 851 ± 22^{a} days. Similarly, age at conception was also not ($P>0.05$) influenced by dietary energy levels and ranged from 810±31 to 867±12 days. The serum progesterone concentration in Sahiwal heifers was

Table I.- Effect of dietary energy levels on average daily gain (g/day, Mean±SE) in Sahiwal heifers during different pre-pubertal phases

		Treatments			
		(ME 100%)	(ME 88%)	(ME 112%)	(ME 124%)
Phase 1	(13 to 15th month age)	542 ± 09^{c}	447 ± 11^{d}	571 ± 03^{b}	622 ± 08^{a}
Phase 2	(16 to 18th month age)	524 ± 04^{b}	451 ± 23^{c}	575 ± 06^{a}	602 ± 21^{a}
Phase 3	(19 to 21 month age)	340 ± 11^{b}	324 ± 13^{b}	366 ± 17^{b}	488 ± 51^{a}
Phase 4	(22 M to age at puberty)	209 ± 50^{b}	216 ± 38^{b}	210 ± 41^{b}	380 ± 20^{a}
	Overall	442 ± 11^{b}	397 ± 07^{c}	450 ± 05^{b}	571 ± 15^{a}

Mean values having different superscript letters in a row are significantly different ($P < 0.05$).

Table II.- Effect of varying dietary energy levels on body length (cm, Mean±SE) in Sahiwal heifers during different phases of pre-pubertal period.

		Treatments			
		(ME 100%)	(ME 88%)	(ME 112%)	(ME 124%)
Phase 1	(At 13th month age)	096.5 ± 1.1^{a}	096.5 ± 0.8^{a}	096.5 ± 1.3^{a}	097.0 ± 0.9^{a}
Phase 2	(End of 15th month age)	107.2 ± 0.9^{a}	106.4 ± 0.8^{a}	107.4 ± 0.8^{a}	107.7 ± 0.5^{a}
Phase 3	(End of 18th month age)	117.3 ± 0.9^{ab}	115.3 ± 1.0^{b}	116.8 ± 0.8^{ab}	118.3 ±0.6^{a}
Phase 4	(End of 21 month age)	122.2 ± 0.5^{b}	118.3 ± 0.5^{c}	121.7 ± 0.5^{b}	124.1 ± 0.6^{a}
	(At the age of puberty)	126.7 ± 0.3^{b}	121.9 ± 0.7^{c}	126.7 ± 0.2^{b}	130.5 ± 0.3^{a}

Mean values having different superscript letters in a row are significantly different ($P < 0.05$).

Table III.- Effect of varying dietary energy levels on body height in Sahiwal heifers during different phases of pre-pubertal period.

Body height (cm)		Treatments			
		(ME 100%)	(ME 88%)	(ME 112%)	(ME 124%)
Initial	(At 13th mo of age)	097.5 ± 1.0^{a}	096.5 ± 0.1^{a}	098.0 ± 1.0^{a}	098.0 ± 0.4^{a}
Phase 1	(End of 15th mo age)	102.8 ± 0.8^{a}	102.1 ± 0.3^{a}	104.1 ± 0.8^{a}	103.6 ± 0.5^{a}
Phase 2	(End of 18th mo age)	108.2 ± 0.6^{a}	106.6 ± 0.0^{b}	108.4 ± 0.5^{a}	108.9 ± 0.5^{a}
Phase 3	(End of 21 mo age)	116.9 ± 0.5^{b}	116.2 ± 0.3^{b}	117.3 ± 0.5^{b}	119.1 ± 0.6^{a}
Phase 4	(At age of puberty)	125.7 ± 0.8^{b}	125.7 ± 0.5^{b}	126.2 ± 0.8^{b}	130.0 ± 0.5^{a}

Mean values having different superscript letters in a row are significantly different ($P < 0.05$).

also not influenced by different levels of dietary energy fed during pre pubertal period. The overall average of progesterone level was 0.44±0.005 and 1.48±0.03 ng/mL serum during one month before and after puberty, respectively.

DISCUSSION

Dry matter intake and nutrients digestibility

The similar DMI in present study might be attributed to factors that animals under experiment were of similar age, size and weight and consumed similar quantities of their respective diets because measured quantity of diets were offered daily according to body weight of animals. Few workers also reported previously (Pirlo *et al*., 1997; Jabbar *et al*., 2009; Singh *et al.*, 2009) that varying dietary energy levels did not influence dry matter intake. However, the report of Bethard *et al*. (1997) was contrary while determining the effect of energy and RUP (Rumen undegradable protein) that dry matter intake was higher (7.38 kg/day) in heifers receiving high energy diets as compared to 4.46 kg/day of low energy diet. The possible reason for this discrepancy

might be limited exercise and ad libitum feeding that may contribute to higher DMI.

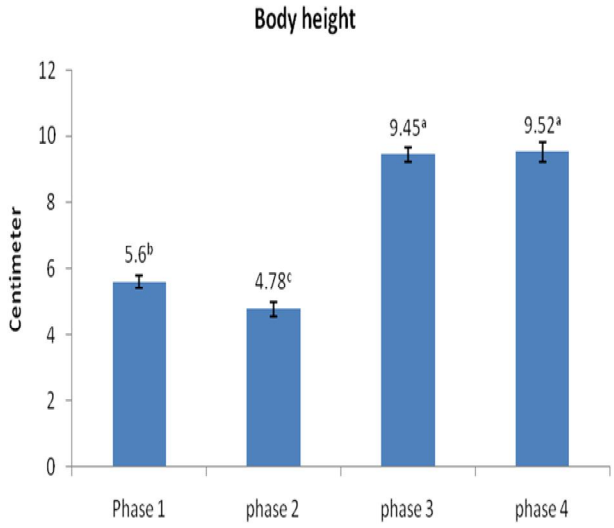

Fig. 4. Effect of phases on change in body height in Sahiwal heifers

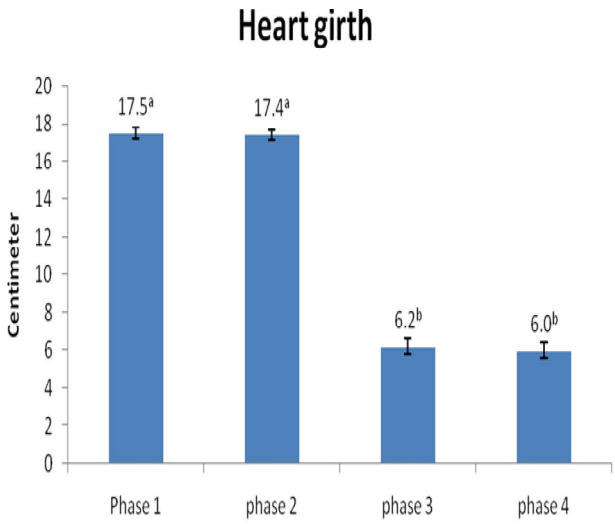

Fig. 5. Effect of phases on change in heart girth in Sahiwal heifers

The effect of different levels of dietary energy on heart girth is given in Table IV. Heart girth at the end of phase-4 was higher in heifers fed ME 124% than all other dietary energy levels. The effect of phases on change in heart girth is presented in Figure 5. The increase in heart girth between phase-1 and 2 was not different (P>0.05) but higher than phase-3 and 4, while the difference between phase-3 and 4 was also non-significant.

No influence of dietary energy levels on digestibility of nutrients in present study might be attributed to best adaptability of Sahiwal heifers to utilize diet under local environment. The results of present study were in agreement with findings of Jabbar *et al.* (2000) who observed non- significant results in digestibility of DM, CP, CF and EE coefficients among Sahiwal heifers fed different levels of energy (ME 100, 80 and 120% of NRC, 2001). Similarly, Singh *et al.* (2009) also affirmed that varying dietary energy levels did not influence nutrients digestibility.

Average daily gain and feed efficiency

The period of six months from 13 to 18 months of age during phase 1 and 2 was observed more promising time when heifers gained body weight at higher rate than phase 3 and 4 as it is evident from higher performance of heifers in all diets during this period. This might be attributed to propitious physiological conditions under which heifers grow at faster rate. Energy available in the body of animal is utilized first to carry on basal metabolism and fulfill its maintenance requirements and then for growth (Ensminger, 1993). The improvement in ADG of heifers fed high energy ME 124% might be attributed to availability of excess energy nutrient for heifers to fulfill not only maintenance requirements but also to grow and develop body reserves.

Improvement in ADG through provision of extra dietary energy than recommended by NRC (2001) during pre pubertal period in present study was ascertained by findings of Bortone *et al.* (1994) while evaluating growth of Holstein heifers fed 100 or 115% of NRC requirements. Similarly, Pirlo *et al.* (1997) also substantiated that higher level of energy than recommended by NRC improved ADG in heifers during pre-pubertal period. However, Jabbar *et al.* (2000) reported divergent results in similar type of study. The possible reason for this discrepancy could have shorter period of experiment; 90 days period in that study.

The efficiency of diet was increased in current study by provision of extra dietary energy than recommended by NRC (2001). This improvement might be attributed to availability of

Table IV.- Effect of varying dietary energy levels on heart girth in Sahiwal heifers during different phases of pre pubertal period

Heart girth (cm)		Treatments			
		(ME 100%)	(ME 88%)	(ME 112%)	(ME 124%)
Initial	At 13th month age	104.1 ± 1.1 [a]	105.1 ± 0.6 [a]	105.4 ± 0.6 [a]	103.1 ± 0.6 [a]
Phase 1	End of 15th month age	121.9 ± 1.5 [a]	121.6 ± 0.6 [a]	122.8 ± 0.9 [a]	121.4 ± 1.0 [a]
Phase 2	End of 18th month age	139.7 ± 2.0 [a]	138.1 ± 1.2 [a]	140.2 ± 1.3 [a]	139.7 ± 1.5 [a]
Phase 3	End of 21 month age	145.0 ± 1.4[ab]	143.2 ± 0.8[b]	145.6 ± 0.9[ab]	147.9 ± 0.8[a]
Phase 4	At the age of puberty	150.3 ± 0.9[bc]	148.3 ± 0.6[c]	151.1 ± 0.6[b]	156.2 ± 0.6[a]

Mean values having different superscript letters in a row are significantly different ($P < 0.05$).

Table V.- Effect of dietary energy levels on age at puberty, conception and serum progesterone concentration in Sahiwal heifers.

Parameters		Treatments			
		(ME 100%)	(ME 88%)	(ME 112%)	(ME 124%)
Age at puberty (days)		851 ± 22	801 ± 27	847 ± 18	835 ± 16
Age at conception (days)		860 ± 17	810 ± 31	867 ± 12	855 ± 19
Progesterone	Pre puberty (one month)	0.45 ± 0.004	0.44 ± 0.007	0.44 ± 0.006	0.45 ± 0.004
	Post puberty (one month)	1.43 ± 0.01	1.43 ± 0.008	1.53 ± 0.041	1.53 ± 0.07

surplus dietary energy enabling heifers to convert feed into live body mass more efficiently. Results of previous studies (Bethard *et al.*, 1997; Singh *et al.*, 2009) corroborated that high dietary energy increased feed efficiency in heifers as compared to that of lower dietary energy level. However, Jabbar *et al*. (2009) reported discrepant results. It was found that feed efficiency was similar in heifers fed different levels of dietary energy and overall feed efficiency was 0.06 or FCR 15.45 kg/kg weight gain. The possible reason for this discrepancy might be due to factor that varying dietary energy levels could have different effect in heifers of Buffalo species.

Body measurements

The improvement in body structural measurement by feeding extra dietary energy (ME 124% of NRC) than recommended by NRC (2001) during pre pubertal period might be attributed to availability of excess energy enabling heifers not only to fulfill their basal and maintenance requirements but also develop their body structure (length, height and heart girth). The optimum increase in body length and heart girth was achieved during first two phases (13 to 18 months of age), whereas optimum increase in body height was achieved during 3rd and 4th phase. The optimum increase in heart girth during first two phases might be attributed to faster muscle growth in body than bone growth as it is common observation especially for Sahiwal heifers.

Results of present study were strengthened by Bortone *et al*. (1994) that provision of extra nutrients beyond NRC (2001) recommendation increased more (163.5 ± 0.8 cm) heart girth in heifers than of those fed nutrients according to NRC (2001) recommendations. Similarly, Bethard *et al*. (1997) also affirmed that wither height was higher (109.2±0.09 cm) for heifers receiving high energy diets supporting 0.9 kg of ADG from 6 to 13 months of age as compared to 104.4±0.09 cm of those fed low energy diet supporting 0.6 kg ADG. Results of current study were also in agreement to Abeni *et al*. (2000); heifers fed 115% of NRC recommendations gained more (159.5 cm) heart girth than 155.2 cm of those fed 100% of NRC (2001) recommendations.

However, Zanton and Heinrichs (2007) while evaluating effects of feeding of high forage or high concentrate rations on heifers growth reported

differently that gain in structural measurements (wither height, heart girth, and body length) were not affected by dietary treatments. The possible reason for this discrepancy might be due to different dietary treatments in that study. Animals in that study were fed high forage or high concentrate ration for similar levels of ADG. Similarly, Lammers and Heinrichs (2000) also reported inconsistent results that growth of wither height and heart girth were not different in Holstein Friesian heifers fed different ratio of dietary CP to ME. The possible reason for this divergence might be due to factor that diets were iso-caloric in nature with varying levels of crude protein in that study.

Age at puberty and serum progesterone

No influence of dietary energy levels on age at sexual maturity in present study might be attributed to similar dry matter intake and nutrients digestibility. It depicted that ME 88% of NRC (2001) is sufficient for Sahiwal heifers to attain puberty under local environmental conditions of Pakistan. Results of present study were in line to findings of Jabbar *et al*. (2009) who demonstrated that the age at puberty among heifers fed different levels of energy (ME 80, 100 and 120% of NRC, 2001 recommended level) was similar (698, 679 and 659 days, respectively). Similarly, Abeni *et al*. (2000) also affirmed that dietary energy levels did not influence age at puberty in heifers. In another study, Bethard *et al*. (1997) corroborated that different levels of energy did not influence age at conception (543 vs. 518 days) and calving (841±23 vs. 808±24 days).

However, findings of Bortone *et al*. (1994) were contradictory with the results of present study that heifers fed diet containing ME 115% of NRC (2001) recommendations reached puberty 22 days earlier than those fed diet having ME 100% of NRC. The possible reason for this discrepancy might be due to factor that feeding management was started in that study from 3 months of age and ended 21 days before calving. Dietary energy levels could have different effect on onset of sexual maturity in Holstein Friesian heifers if feeding management started just after weaning. Likewise, Chelikani *et al*. (2003) also reported inconsistent results that high energy diet reduced age at puberty in heifers as compared to medium and low energy diets. The possible reason for this difference might be due to different dietary treatments having multiple combinations of protein and energy.

The similar progesterone concentration among dietary treatments in present study might be attributed to similar age at puberty in Sahiwal heifers fed varying dietary energy levels. The pre pubertal concentration was less than 0.5ng/ml, whereas it was increased after puberty upto 1.5 ng/ml. The increase in serum progesterone during post pubertal period (more than 1 ng/ml) might be attributed to development of corpus luteum (CL) at ovary, principal progesterone production site in heifers. In a study, Lacasse *et al*. (1994) substantiated the results of present study that previous plan of nutrition did not affect concentration of progesterone in heifers during the period from one year of age to 3 months of gestation.

Similarly, Mackey *et al*. (2000) while studying effect of acute nutritional change on follicular wave turnover, gonadotropin and steroid hormone also reported similar findings that progesterone concentration was not affected even in cyclic heifers by diet. Likewise, Cooke *et al*. (2007) also reported that plasma progesterone concentration did not differ between dietary treatments. In another study, Yung *et al*. (1996) also reported that serum progesterone concentration was not influenced by energy status of heifers. They found similar level of serum progesterone in heifers under negative and positive energy balance. However, results of Jabbar *et al*. (2009), while comparing different energy levels were not compatible with those in present study. They reported that provision of extra energy than recommended by NRC (2001) raised concentration of progesterone in serum. The possible reason for this discrepancy might be due to different physiological conditions in buffalo.

CONCLUSIONS

It is concluded that growth performance of Sahiwal heifers was optimum during the phase of 13 to 18 months of age fed varying dietary energy levels from 13 months of age till puberty. Provision

of higher dietary energy level (ME 124% of NRC, 2001 recommendation) enhanced growth parameters and feed efficiency but adequate reproductive performance of Sahiwal heifers in terms of age at puberty was achieved even at lower dietary energy level (ME 88% of NRC, 2001 recommended level) under local environment conditions of Pakistan.

ACKNOWLEDGEMENTS

Authors would like to appereciate efforts of Mr. Ghulam Mohyudin and Mr. Khizer Hayat at Livestock Experiment Station Jahangirabad, District Khanewal Punjab, Pakistan for their kind cooperation regarding supply of research material and fasilities provided at research site. The trial was funded by Higher Education Commision, Islamabad.

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(Received 25 October 2010, revised 26 May 2011)