International Journal of Advanced Research in Biological Sciences
ISSN: 2348-8069
www.ijarbs.com
Coden: IJARQG(USA)

Research Article

SOI: http://s-o-i.org/ 1.15/ijarbs-2-11-5

Efficiency of nutrient utilization and cost of rearing of buffalo calves fed restricted milk diet with volatile fatty acids

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Abstract

The objectives of this study were to evaluate the effects of restricted milk feeding with volatile fatty acids to male Murrah buffalo calves on intake, digestibility, efficiency of nutrient utilization and overall cost of production of the calves. Eighteen male Murrah buffalo (*Bos bubalis*) calves were randomly allotted to three groups of six calves each on body weight basis. The calves in group 1 (Control, T_1) were fed with whole milk, skim milk, calf starter and green maize fodder along with 24 ml butyric acid / day/ calf for a period of 120 days. The calves in group 2 and 3 were also fed with the same feeding schedule as in T_1 up to 60 days; however, from 61 day onwards till 120 days, the quantity of milk (whole milk plus skim milk) was reduced to half (T_2) and completely stopped (T_3) without reducing the quantity of butyric acid (24 ml/day/ calf). The concentrate mixture and green maize fodder were fed adlibitum to all the calves. Body weight and gain in weight were significantly ($P<0.05$) higher in T_2 over other groups. Digestibility coefficient of nutrients was comparable and the treatment had no effect on digestibility. Conversion efficiency of dry matter (DM), digestible crude protein (DCP), total digestible nutrients (TDN) and metabolizable energy (ME) was better in T_2 as compared to other groups. Retention of nitrogen and protein efficiency ratio were significantly ($P<0.05$) higher in T_2 followed by T_3 and the lowest in T_1 group; however, the balance of metabolizable energy was not affected due to treatments. Cost of feed per unit of live weight gain was the lowest in group 2. It was concluded that feeding of buffalo calves after 60 days on restricted milk (@ 50 percent level of the milk feeding schedule) with dietary addition of butyric acid (24 ml/day) was economical and had positive effect on the performance of Murrah buffalo calves.

Keywords: Conversion Efficiency, Metabolizable Energy, Hemicellulose, Nitrogen Retention.

1. Introduction

There is still wide gap between the supply and demand of milk and milk products for human consumption as the human population is increasing at a much faster rate than the milk production. During summer months, the shortage of milk is greatly felt. One of the methods to save milk for human consumption is shifting of calves from milk feeding to starch and fibre based diets at early ages. It had already been established that end products of rumen fermentation, i.e. volatile fatty acids were responsible for early development of rumen function (Flatt et al., 1958 and Vidyarthi and Kurar, 2008) and also resulted in enhanced body weight gain as compared to feeding of milk alone or different additives .The present work was thus carried out to assess overall performance of buffalo calves viz. nutrients intake, their digestibility, efficiency of utilization of different nutrients and overall cost of production of the calves on restricted milk feeding along with butyric acid so that they can be enabled on starch and fibrous diets at early ages and sparing milk for human consumption.

2. Materials and Methods

2.1. Animals and diets

Eighteen male Murrah buffalo calves at 11 days of age were selected from the calf pen of cattle yard, National Dairy Research Institute, Karnal, Haryana, India. They were distributed randomly on body weight (ranged between 35-42 kg) basis into three groups of six each. They were fed whole milk, skim milk, calf starter and green maize fodder as per the feeding schedule for feeding of buffalo calves followed at N. D.R. I., Karnal, India (Table 1). The calf starter was prepared by mixing 40 parts crushed maize, 16 parts wheat bran, 40 parts ground nut cake and 2 parts each of mineral and vitamin mixtures and common salt.

Table 1: Feeding schedule for feeding of buffalo calves at NDRI, Karnal

Age of calves (days)	Milk as proportion of BW (Kg / day)	Skim milk as proportion of BW (Kg / day)	Calf starter (Kg / day)	Green fodder
0-5	Colostrum - 1 / 10th	NIL	NIL	*Ad lib*
6-30	Whole milk - 1 / 10th	NIL	0.050	*Ad lib*
31-60	Whole milk - 1 / 15th	Skim milk - 1/25th	0.120	*Ad lib*
61-90	Whole milk - 1 / 25th	Skim milk - 1/15th	0.250	*Ad lib*
91-120	NIL	6.50	0.650	*Ad lib*

2.2. Feeding and treatment

The calves in all the three groups were fed with basal feed, i.e. whole milk, skim milk, calf starter and green maize fodder individually. The total quantity of feed items was divided into two and the calves were fed twice per day. The calves in group 1 (Control, T_1) were fed with basal feed along with 24 ml butyric acid / day (12 ml/ feeding time) for a period of 120 days experiment. The calves in group 2 (T_2) were also fed with the same feeding schedule as in T_1 up to 60 days but from 61 day onwards till 120 days, the quantity of milk (whole milk plus skim milk) was reduced to just half for feeding to the calves ; however, the quantity of butyric acid (24 ml/day) remained unchanged. The calves in group 3 (T_3) were also fed with the same feeding schedule as in, T_1 for a period of 60 days. From 61 day onwards till 120 days, milk feeding (whole milk plus skim milk) was completely stopped; however, the quantity of butyric acid (12 ml/feeding time) was mixed with water and was being fed to calves. The concentrate mixture and green maize fodder were fed in *ad libitum* quantity to all the calves irrespective of groups. The quantity of whole milk and/or skim milk equally divided into two halves with view of two times feeding was taken into plastic bucket; half quantity of concentrate mixture was mixed into milk and was provided to calf feeding. Simultaneously, the quantity of butyric acid (12 ml/feeding time) was slowly incorporated into milk to avoid sudden change in the taste. The quantity of butyric acid to a higher level of 24 ml/calf/day (12ml/calf/feeding time) was stabilized by a pre experimental trial on the basis of calf acceptability and 24 ml was observed to be the higher level of acceptability and above that level it was refused. The higher level was adjusted within 5 days of onset of experiment.

2.3. Sampling procedures and digestion trial

The calves in the three groups were fed as per the schedule. Any feed and fodder residue was also weighed in order to record the daily intake of feed. The calves were fed daily at 9:00 am in the morning and 4:00 pm in the evening. Body weight was taken on two consecutive days at weekly intervals up to 120 days of experimental period. The records of intakes of whole milk, skim milk, calf starter and green fodder were carefully and precisely maintained in order to calculate cost of feed per kg gain in live weight. The market rates of all feed ingredients fed to the calves in all the three groups were procured and the total cost of every calves raising for 120 days was calculated on the basis of per kg gain. In order to determine the digestibility coefficient of nutrients, a metabolism trial of 7 days collection period was conducted at 120 day. The samples of whole milk, skim milk, calf starter, green maize fodder offered, residue left over, faeces voided and urine excreted on daily basis recorded and preserved for further analysis.

2.4. Chemical analysis

The samples of whole milk and skim milk were analyzed for total solids, protein, fat and ash as per the procedure based on I.S.I. (1961).The samples of calf starter and green maize fodder offered, feed residue left over and faeces voided were analyzed for proximate principles as per the method of A.O.A.C. (2005) and cell wall and cell content by Van Soest *et al.* (1991) method. Gross energy (GE) values of feeds, faeces, whole milk and skim milk were estimated by the use of Bomb Calorimeter (Gallen Kamp) described by Anon (1981). Digestible energy (DE) was estimated by subtracting the gross energy excreted in faeces from gross energy intake from feedstuffs. Metabolizable energy (ME) was calculated as 82% of digestible energy as per NRC (2001).Conversion efficiency of nutrients was calculated as the ratio between weight gains to intake of respective nutrients.

2.5. Statistical analysis

A randomized block design was used in the study. Data were analyzed to test the significance of the differences between means using ANOVA as described by Snedecor and Cochran (1994).

3. Results and Discussion

3.1. Digestibility coefficients of nutrients

The chemical composition of different feedstuffs had been presented in Table 2**.** The values of digestibility coefficients of nutrients, viz.organic matter (OM), dry matter (DM), crude protein (CP), crude fibre (CF), nitrogen free extract (NFE), neutral detergent fibre (NDF), acid detergent fibre (ADF) and hemicellulose (Table 3) were comparable and were non-significant (P>0.05) among their selves (Table 3); however, the values of ether extract (EE) digestibility was significantly (P<0.05) higher in T_1 group and the lowest in T_3 group. Comparable digestibility coefficients of nutrients (except EE digestibility) might be due to better structural development of rumen and early establishment of rumen functions (Vidyarthi and Kurar, 2008) probably due to presence and better effectiveness of butyric acids in stimulating rumen mucosal growth (Sander et al., 1959; Gilliland et al.,1962) and sufficient amount of butyric acid for effective stimulation (Tamate et al.,1962; Le Du and Baker, 1979; Petit et al., 1988; Broesder et al., 1990; Vidyarthi and Kurar, 2008). The calves of T_2 and T_3 consumed higher levels of fibre and starch through concentrate mixture and green fodder from 61 days onwards and attained more or less similar digestibilities of nutrients explained that the calves could be shifted to starch and fibre diets well in advance i.e. from 61 days onwards . The results of the present study were in agreement with the findings of previous workers (Conrad and Hibbs, 1956; Pres and Kroliczek, 1971).

Table 2: Chemical Composition of different feedstuffs (% DM)

Items	Whole milk	Skim milk	Calf starter	Green maize
Dry matter	12.25	9.90	90.40	25.00
Crude protein	28.80	36.80	20.20	8.35
Crude fibre	…	…	6.42	30.15
Ether extract	30.90	1.00	4.45	2.05
Total ash	6.50	8.90	10.40	10.70
Nitrogen free extract	33.80	53.30	58.53	48.75

Table 3: Digestibility coefficients (%) of different nutrients in buffalo calves in different treatments

Parameter	Dietary treatments		
	T_1	T_2	T_3
Organic matter	72.57	68.62	67.13
Dry matter	68.57	64.86	62.73
Crude protein	74.26	72.80	66.76
Crude fibre	59.21	63.57	64.77
Ether extract	72.10^b	68.90^b	56.60^a
Nitrogen free extract	74.42	68.82	68.78
Neutral detergent fibre	67.42	64.13	69.51
Acid detergent fibre	67.47	65.25	64.72
Hemicellulose	75.58	76.05	76.01

a, b means bearing different superscripts in a row differ significantly (P< 0.05).

3.2. Conversion efficiency of nutrients

It was revealed that the overall gain in body weight of buffalo male calves (Table 4) was significantly (P<0.05) higher in group T_2 followed by T_1 and the least in T_3 group. The higher body weight gain of buffalo calves in T_2 as compared to T_1 and T_3 might be due to treatment effects, digestibility coefficients of nutrients and their retention in the respective group of calves. The results of the present study were well corroborated with the findings of Hibbs et al. (1956), Le Du and Baker (1979) and Morrill et al. (1981). The overall DMI for each kg gain in weight of live calves was significantly (P<0.05) higher in T_3 followed by T_1 and the least in T_2 group. The values obtained in each group in the present investigation were also in normal ranges as reported by Hibbs *et al.* (1956), Pennington and Pfander (1957), Godfrey (1961b), Morrill *et al.* (1981), Anderson *et.al.* (1988) and Veira *et al.* (1980); however, contradicted those of Flatt *et al.* (1958), Martin *et al.* (1959) and Singh *et al.* (1973). The protein required for one kg live weight gain in term of DCP was significantly (P<0.05) higher in T_1 followed by T_3 and the least in T_2 group. The values of TDN and GE required for one kg live weight gain were significantly (P<0.05) higher in T_3 followed by T_1 and the least in T_2 group ; however, the values of DE and ME required for one kg live weight gain were significantly (P<0.05) higher in T_1 followed by T_3 and the least in T_2 group.

Table 4: Conversion efficiency of different nutrients in buffalo calves of different treatments

Parameter	Dietary treatments		
	T_1	T_2	T_3
Initial body weight (kg)	33.65	35.45	32.58
Final Body weight (kg)	69.15^b	81.77^c	59.83^a
Gain in body weight (kg)	35.50^b	46.32^c	27.25^a
DM intake (kg |kg gain)	3.70^b	2.77^a	5.79^c
CP intake (g | kg gain)	855.21^c	680.05^a	831.93^b
DCP intake (g |kg gain)	638.03^c	495.03^a	555.23^b
TDN intake (kg |kg gain)	3.36^b	2.93^a	3.92^c
GE intake (Mcal | kg gain)	16.24^b	12.17^a	25.41^c
DE intake (Mcal | kg gain)	5.15^c	2.76^a	3.84^b
ME intake (Mcal | kg gain)	4.22^c	2.26^a	3.15^b

a, b, c means bearing different superscripts in a row differ significantly (P< 0.05).

3.3. Balance of nutrients

The values for total N_2 intake per kg metabolic body size (Table 5) was significantly (P<0.05) higher in T_1 followed by T_2 and the least in T_3. The N_2 intake through milk was significantly (P<0.05) lowest in T_3 as compared to T_1 and T_2 groups. The share of N_2 intake through concentrate mixture was significantly (P<0.05) lower than the other two groups; however, there was no variation between groups T_2 and T_3. The values for N_2 intake through green maize fodder was significantly (P<0.05) higher in T_3 and there was non-significant variation between T_1 and T_2 groups. The N_2 loss through faeces and urine was more or less the same in all the three groups. N_2 retention in terms of either gram per kg metabolic body size or percentage was significantly (P<0.05) higher in T_2; though the values in T_1 and T_2 were not different significantly. The overall protein efficiency ratio (PER) was affected due to variation in the treatment and it was significantly (P<0.05) higher in T_2; however, there was no difference between T_1 and T_3 groups. The values for protein efficiency ratio were better in T_2 as compared to other two groups. From the results, it was perused that overall performance in terms of nitrogen retension and efficiency of protein utilization were higher in T_2 group than the other groups which might be due to better conversion efficiency of nutrients into product. The mean values for gross energy (GE) intake per kg metabolic body size (Table 5) was numerically higher in the calves of group T_3 as compared to T_1 and T_2 groups; however, the values were non-significant amongst them selves. Energy loss through faeces in all the three groups was not different significantly and there was only numerical variation. The digestible energy (DE) and metabolizable energy (ME) intake in terms of either per kg metabolic body size or percentage of GE intake were also more or less same and did not vary significantly (P>0.05) ; however, numerically the values of DE and ME intake were less in T_2 groups as compared to T_3 and T_2 groups.

Table 5: Balances of nutrients in buffalo calves in different treatments

Parameters	Dietary treatments		
	T_1	T_2	T_3
N intake (g/kg $w^{0.75}$/d)	2.14^c	1.92^b	1.68^a
Faecal N (g/kg $w^{0.75}$/d)	0.67	0.53	0.57
Urinary N (g/kg $w^{0.75}$/d)	0.81	0.51	0.52
N retention (g/kg $w^{0.75}$/d)	0.66^b	0.88^c	0.60^a
N-intake by milk (%)	34.35^c	26.95^b	0.00^a
N-intake by calf starter (%)	33.48^a	37.94^b	37.54^b
N-intake by fodder (%)	32.19^a	35.12^b	62.46^c
Faecal N (%)	31.12	27.66	33.29
Urinary N (%)	37.94	26.63	31.02
N-retention (%)	30.94^a	45.71^c	35.69^b
Protein efficiency ratio	2.85^a	3.95^c	3.10^b
G E intake (Kcal/kg $w^{0.75}$/d)	370.00	346.67	403.33
Faecal Energy (Kcal/kg $w^{0.75}$/d)	73.33	100.00	123.33
D E intake (Kcal/kg $w^{0.75}$/d)	296.67	246.67	280.00
M E intake (Kcal/kg$w^{0.75}$/d)	243.33	206.67	230.00
D E intake (% of GEI)	80.89	71.08	69.17
M E intake (% of GEI)	66.34	58.27	56.71

a, b, c means bearing different superscripts in a row differ significantly (P< 0.05).

3.4. Economics of rearing buffalo calves

The overall gain in weight (g|d) was significantly (P<0.05) higher in T_2; however, the values of T_1 and T_3 groups were not different significantly. The consumption of whole milk during first 60 days was quite substantial and thereafter, it decreased; while, the quantity of skim milk showed decreased trend into T_1 to T_3. In contrary to this, the consumption of concentrate mixture and green maize fodder showed increasing trends from T_1 to T_3 groups. Butyric acid consumption was constant. From the data (Table 6), it was perused that the total expenditure was US $ 9.22, 6.61 and 7.72 per kg live weight gain in the three groups, viz., full milk offered (T_1), half milk restricted (T_2) and full milk restricted (T_3) groups, respectively.

The values for total cost of feed per unit gain was significantly (P<0.05) lowest in T_2 group followed by group T_3 and the highest in group T_1. Higher cost of feed in T_3 group might be due to poor growth rate as compared to T_2. The findings were in agreement with the results of Khoury *et al.* (1967) and Arora *et al.* (1979.) who had reported higher cost per unit gain in the milk fed calves than either milk substitute fed or early weaned calves. Better performance in the restriction of milk and milk substitute to calves after 61 days onwards (T_2) probably caused the lower cost per unit gain. However, higher cost per unit gain in the present study compared with past experiments might be due to higher prices of different items of feeds probably due to wide gap in time of present and past experiments.

Table 6: Intake of different feed items (kg) and their cost ($) for production of per kg buffalo calves in different treatments

Parameters	Dietary treatments		
	T_1	T_2	T_3
Average daily gain (g)	298.00^b	389.00^c	228.00^a
Whole milk consumed	8.07	6.26	8.21
Skim milk consumed	9.78	4.81	2.28
Conc. mixture consumed	0.65	0.87	1.35
Green maize consumed	4.86	5.64	9.12
Butyric acid consumed (ml)	76.76	58.83	100.00
Cost of whole milk	4.44	3.33	4.44
Cost of skim milk	3.33	1.67	0.78
Cost of conc. mixture	0.67	0.89	1.33
Cost of green maize	0.33	0.39	0.61
Cost of butyric acid	0.44	0.33	0.56
Total cost of feed	9.22^c	6.61^a	7.72^b

a, b, c means bearing different superscripts in a row differ significantly ($P< 0.05$).

4. Conclusion

From on the results, it is concluded that overall conversion efficiency of DM, DCP, TDN and ME was better in half milk fed calves. Digestibility coefficients of nutrients were also comparable; balances of nitrogen and energy were better and overall cost of feed was also cheaper in calves fed half quantity of milk. So, after 60 days, half milk restriction system of milk feeding schedule should be followed for buffalo calves.

Acknowledgments

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