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RESEARCH ARTICLE

Colostrum quality and the neonatal calf nutrition and growth with or without a source of PUFA supplement

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Abstract: The calf acquires immunity from the colostrum only after birth, which protects for a few weeks but developing innate immunity after birth is essential for its lifetime performance. The present study aimed to supplement flaxseed oil (FSO) in neonatal calves as polyunsaturated fatty acids (PUFA) source. Twenty male and female Deoni calves were randomly distributed into four groups where a group of male (TGM) and female (TGF) calves were drenched with FSO daily from day 6 to 28 and compared with control; CGM, and CGF. After that, a bolus consisting of ground flaxseed was fed till 90 d besides mixed green fodder and concentrate mixture. Digestibility trial in neonates was carried out by indirect method. The colostrum quality or immunoglobulins (Ig) were reduced from 93 to 39 mg/mL on the second day. The total diet CP in neonatal age was 22%, and digestible CP was 13.2%. It was 18% and 9%, respectively, during preweaning. Weight gain in the male calves was higher than in the female calves, although their intake was statistically comparable. The weight gain in the TG was significant until the first fortnight and subsequently comparable, but the relative risk of disease in males and females of CG was 6.57 folds more than TG ($P < 0.001$). The study concluded that the FSO supplementation at neonatal age followed by supplementing ground flaxseed as bolus had no adverse influence on the diet intake, digestibility of nutrients, and energy balance. The marginal improvement in weight gains and reduced disease risk prompts the recommendation of the supplement/drench FSO 30 mL/d for neonatal calves.

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Introduction

The newborn calf's growth until puberty is the foundation and basis for the future production of the herd. The neonatal calf is born with little or no detectable immunoglobulins (Ig) in blood serum and is highly susceptible to many infectious diseases and retard growth (Arthur et al. 1996), particularly when their serum IgG levels are <10 g/L (Furman-Fratczak et al. 2011). According to Radostits (2007), 75% of the mortality of dairy heifers occurs during the first month of life. The daily gains in neonatal calves with higher diseases affect the weight gains during the first year (Trilk and Münch, 2010). The major challenge in newborn calf nutrition is at the time of the diet change from a high protein liquid milk to a solid diet with lesser quality crude protein (CP). Even when the neonatal calf is offered unlimited milk, begin to chew solid feed from the second week of the birth. Terré et al. (2007) reported an inverse relationship between milk and solid feed intake. A better health and quality diet translate into an efficient average daily gain (ADG) per unit feed consumption (Bishop et al. 1991). In neonates, ADG in the first two weeks has a cascading effect on gains at six, nine, and 12 mo of age, body weight at first insemination, first lactation milk yield, and lifetime efficiency (Volkmann et al. 2019). In the context of health, polyunsaturated fatty acids (PUFA) in general and omega-3 fatty acids in particular influence inflammation through various mechanisms known at least for three decades. PUFA or their derivatives' play role in signaling molecules in the immune system worth noting from the perspective of ameliorating symptoms in many diseases (Gutiérrez et al. 2019). Flaxseed oil (FSO), rich in PUFA, is known for its anti-inflammatory, antipyretic, antioxidant, and analgesic effect (Kaithwas et al. 2011). The body fat reserves in a newborn calf are just 3 to 4%; hence, dietary fat intake play an important role (Bascom et al. 2007). The present study aimed to supplement FSO to newborn calves orally, taking advantage of esophageal groove closure and dilation stimuli (Kaba et al. 2018) to ascertain better growth until preweaning such as 90 d of age.

Materials and methods

Experimental location and weather

The experiment was conducted at the Livestock Research Centre, Southern Regional Station, ICAR-NDRI, Bangalore, India. The location latitude, longitude, and elevation are 12.947014°N (12° 56' 49.2504" N), 77.607679 (77° 36' 27.6444" E), and 921m MSL, respectively. The tropical climate is considered Aw (Savanna, wet) according to the Köppen-Geiger climate classification, with a mean temperature of 23.6°C and 831mm annual rainfall. The variation in temperatures throughout the year is 6.4°C. During the experimental period, the relative humidity ranged from 59 to 72%, mean ambient temperature was as low as 15ºC and high as 31ºC. The experiment was carried out for three months (mo) with the approval of the Institute Animal Ethics Committee (IAEC) and reared as per the guidelines of the Committee for Control and Supervision of Experiments on Animals (CPCSEA), New Delhi, India.

Experimental calves care, groups and diets

Neonatal age

The calves born to Deoni (*Bos indicus*) breed of cows in fourth parity or less were selected for the study. As and when born on the farm, calves were randomly allocated into experiment based on birth weight and sex (male 21.88±0.68 kg, and female 19.49±0.85 kg). Soon after the birth, tincture iodine was applied to the naval card region and left the calf with the dam in a pen. Colostrum quality was tested according to Fleenor and Stott (1980) on the principle of specific gravity and IgG concentration using clostrometer (Kruus colostrum density meter, Denmark). Newborn calves were drenched colostrum *ad lib* 45 min of the birth. After the fifth day of calf birth, a total of ten female (F) and ten male (M) calves were randomly divided into four groups; control female (CGF) and male (CGM), and treatment female (TGF) and male (TGM) calf groups. All calves were kept as per the group under loose housing in calf pens. TGF and TGM calves were orally supplemented with 30 mL/d of FSO just before milk suckling in the morning. Calves were allowed suckling dam 3 min at the beginning and end of the manual milk at 6h00 and 17h00 daily for 28 d. The milk intake of calves was derived mathematically by multiplying milk flow rate (mL/strip), calf suckling rate (Numbers/min), and calf suckling duration (min). All the calves were offered weighed quantities of fresh mixed green fodder (MGF) consisted tender maize (*Zea mays*) fodder, para (*Brachariamutica*), and guinea (*Megathyruses Maximus*) grass in equal proportion and chaffed manually to 10 cm length.

Pre-weaner age

After a neonatal age of 28 d, the oral supplementation of FSO stopped, and milk suckling was restricted to 1 min before milking and 5 min after milking till 90 d. During the preweaner age, TGF and TGM were fed a bolus of 25 g of ground flaxseed mixed with 25 g of jaggery at 8h00 every day until 90 d of age. All calves were offered a concentrate mixture (CM) having 17% CP. All the calves fed CM 200 g/d at 9h00. Chaffed tender MGF was offered to calves at free choice during the neonatal and preweaning periods. When claves were 60 d old, they were confined in individual stalls for 2 wks but manually taken twice daily at the time of milking for suckling stimulus in their dams. All calves were offered drinking water four times daily at 9h00, 13h00, 18h00, and 21h00.

Digestibility trial by the indirect method in neonates

A digestibility trial was conducted on the neonates after 18 d age by the indirect double indicator method (Krishna et al. 1981). Chromic oxide (Cr_2O_3) was used as an external indicator for measuring the fecal output. Calves were dosed with 1 g of Cr_2O_3 daily at 9h00 for five days as a cellulose paper capsule, followed by collecting fecal samples from the rectum of the calves at 8h00 and 20h00 daily from day 2 of dosing to till 10 d. The fecal samples were collected daily for 10 d. Each day a 20 g sub-sample from pooled fecal samples was drawn after mixing separately for each calf. A part of the fecal sub-sample was dried in a drought oven at 100±1ÚC for DM (AOAC, 2012). Another sub-sample of the feces was kept in a glass bottle, acidified with 10% H_2SO_4 ($^v/_v$) to estimate the total N. A dried fecal sample of about 1 g was transferred to a 100 mL Kjeldahl flask to which 10 mL of concentrated nitric acid (N_2O) was added and kept overnight, followed by the addition of 10 mL of digestion mixture consisting of 10 g sodium molybdate dissolved in 150 mL of distilled water, 150 mL of concentrated H_2SO_4 and 200 mL of 70% perchloric acid (v/v). The contents in the flask were digested till a light yellowish tint appeared and then transferred to a 100 mL volumetric flask. Cr_2O_3 concentration in the sample was determined by the colorimetric method by reading the absorbance at 430 nm using a UV-visible spectrometer (LMSP-UV1200, M/s Labman Scientific Instruments Pvt., Ltd., India). A stock solution of 10 mg Cr_2O_3 was used to draw the standard curve. The fecal quantity excreted by the calves was estimated depending on the Cr_2O_3 dose and concentration in the fecal sample. Total DMI and digestibility were estimated using lignin as an internal marker.

Digestibility trial by the direct method in pre-weaner calves

The digestibility trial during the pre-weaning at 75 d age was carried for 5 d under confinement in individual calf pens. Daily faces excreted during the trial were collected, weighed, and sampled at 8h00. A part of the fecal sample was kept for oven drying at 100±1ÚC overnight, and another part was acidified with 10% H_2SO_4 (v/v) in a glass bottle for total N estimation. We collected 100 mL/d spot urine sample from each calf in a bucket acidified with 10% H_2SO_4 (v/v). Acidified urine samples were diluted with distilled water uniformly to 1.2 L, mixed thoroughly, filtered through glass wool, and stored 50 mL at –20^{Ú}C in polypropylene bottles till further analysis.

Feed, faces, and serum TVFAs analysis

Samples of MGF, CM, orts, and feces were processed through a cutting Willey mill (fitted with four steel knives) using a 1-mm sieve to screen the ground sample particle size. These samples were analyzed for DM, OM, CP, and EE (AOAC, 2012). The fat-free samples were treated with heat-stable α-amylase followed by reflex unit extraction for 60 min to estimate NDF. ADF and H_2SO_4 lignin in samples were analyzed sequentially to NDF (AOAC, 2012). Non-fibrous carbohydrates (NFC), hemicelluloses, and celluloses were mathematically calculated (Van Soest et al. 1991). The energy value of the diet was predicted from the amounts of digested nutrients, viz., CP, EE, and TCHO using the East German System for cattle (ARC, 1980).

Average daily gain (ADG) and feed efficiency

ADG during neonatal age was calculated based on the weekly weight gains till 28 d of age, followed by ADG during the preweaning period based on the fortnightly weight gains. Growth efficiency terms such as Kleiber ratio (KR), feed conversion ratio (FCR), relative growth rate and residual feed intake (RFI) were calculated (Arthur and Herd, 2008).

Statistical analysis

The weekly and fortnightly ADG in different groups were subjected to the MANOVA model, including the repeated measure. Data were subjected to variance tests using a completely randomized block design (CRD). Group means were compared by Duncan multiple range tests (DMRT). A significant difference between parameters was denoted by alpha superscripts when $0.10 > P > 0.01$ and validated against the null hypothesis (H_0). All analyses were made using a statistical package for social science (SPSS, Ver. 19.0. M/s IBM India Pvt., Ltd.).

Results and Discussion

Table 1 shows the colostrum quality. The IgG levels reduced to one-third on second day, whereas the protein content in colostrum declined 7%. All calves were left with the dam for five days with the liberty to suckle the mother at will. In our Deoni herd, the average colostrum production is only two kg/d and seldom beyond it. The mean birth weight of calves was 20 kg, and they could consume less than 10% of their body weight. The colostrometer estimates IgG concentration by measuring specific

Table 1: Colostrum composition

Parameter (%)	Day Zero	Day 1	Day 2	Day 3	Day 4
Specific gravity*	1063±1.05	1042±0.52	1038±0.40	1035±0.49	1032±0.45
Immunoglobulins mg/mL	92.51±2.88	39.12±1.35	28.95±0.86	21.68±1.25	14.16±1.05
Total solids, %	23.96±0.06	17.81±0.04	14.17±0.04	13.83±0.04	13.48±0.02
Protein, %	14.07±0.04	8.43±0.03	5.22±0.03	4.23±0.03	4.10±0.03
Fat, %	6.79±0.04	5.86±0.03	4.78±0.02	4.55±0.03	4.39±0.03
Lactose, %	2.63±0.02	3.90±0.02	4.29±0.03	4.53±0.03	4.61±0.02
Total ash, %	1.16±0.01	0.95±0. 01	0.85±0.01	0.81±0.01	0.79±0.01

* Kruus colostrum density meter reading is equivalent to specific gravity 1/1000

Table 2: Chemical composition of the diet (on a DM basis)

Parameter (%)	Green fodder	Concentrate Supplement	Whole Flax Seed	Whole milk
Moisture	74.07±0. 32	7.44±0. 19	7.00±0. 15	88.14±0.06
Dry Matter	25.93±0. 32	92.56±0.19	93.00±0.15	12.76±0.06
Organic Matter	93.00±0.06	90.40±0.21	95.63±0.15	12.05±0.05
Crude Protein	10.60±0.37	16.91±0.17	21.65±0.24	3.18±0.03
Ether Extract	1.80±0. 08	3.12±0. 04	37.67±0. 39	3.98±0.07
Total Carbohydrates	80.60±0.17	70.07±0.15	36.47±0.23	4.91±0.10
Neutral detergent fiber	76.87±0.20	33.07±0.15	35.07±0.32	
Acid detergent fiber	51.10±0. 68	13.33±0.03	19.33±1.04	
Hemicelluloses	26.37±0.70	19.73±0.20	18.90±0.17	
Celluloses	36.90±0.17	8.20±0.18	14.93±0.37	
Nonfibrous carbohydrates	4.10±0.11	37.23±0.09	1.40±0.11	

All the values were an average of 6 fortnightly samples in duplicates (N=12)

Table 3: Nutrient intake from the solid and liquid diet in Deoni neonates, g/kgw$^{0.75}$

Parameter	Female		Male		SEM	P-Value
	CG	TG	CG	TG		
Metabolic Body weight, kgW$^{0.75}$	12.01^{a}	12.69^{ab}	13.92^{b}	13.97^{b}	0.55	0.07
Solid feed intake: Green fodder, g/kgw$^{0.75}$						
Dry matter	18.81	18.41	16.65	16.73	0.78	0.16
Organic matter	17.69	17.30	15.64	15.73	0.78	0.16
Crude protein	4.08	3.99	3.61	3.63	0.17	0.15
Ether extract	3.54	3.47	3.14	3.15	0.15	0.15
Total carbohydrates	10.16	9.94	8.99	9.03	0.42	0.15
Neutral detergent fiber	5.07	4.96	4.49	4.51	0.21	0.15
Acid detergent fiber	3.36	3.28	2.97	2.98	0.14	0.16
Hemicelluloses	1.71	1.67	1.52	1.52	0.07	0.15
Cellulose	2.54	2.45	2.25	2.17	0.12	0.16
Nonfibrous carbohydrates	5.23	5.12	4.60	4.48	0.20	0.06
Liquid diet: Milk feeding, g/kgw$^{0.75}$						
Total milk intake	112	121	99	112	10.75	0.57
Dry matter	14.33	15.43	12.67	14.32	1.37	0.58
Organic matter	13.53	14.57	11.96	13.52	1.30	0.58
Protein	3.57	3.85	3.16	3.57	0.34	0.58
Fat	4.47	4.81	3.95	4.46	0.43	0.58
Carbohydrates	5.51	5.94	4.87	5.51	0.53	0.58
Total diet intake, g/kgw$^{0.75}$						
Dry matter	33.15	33.84	29.32	31.05	1.83	0.33
Organic matter	31.22	31.88	27.61	29.25	1.73	0.33
Crude protein	7.66	7.84	6.77	7.20	0.44	0.35
Ether extract	8.01	8.28	7.09	7.62	0.51	0.41
Total carbohydrates	15.67	15.88	13.86	14.54	0.80	0.28
Nonfibrous carbohydrates	10.74	11.06	9.48	9.99	0.63	0.32

Total diet PDF and the source of its constituents was only green fodder and similar to total intake from the diet.

Table 4: Digestible nutrient intake, nutritive value, and energy balance in Deoni neonates

Parameter	Female		Male		SEM	P-Value
	CG	TG	CG	TG		
Metabolic Body weight, kgW$^{0.75}$	12.01^{a}	12.69^{ab}	13.92^{b}	13.97^{b}	0.55	0.07
Dry matter, g/kgW$^{0.75}$	25.59	26.62	22.73	24.33	1.61	0.39
Organic matter, g/kgW$^{0.75}$	24.52	25.57	21.85	23.89	1.52	0.39
Crude protein, g/kgW$^{0.75}$	5.95	6.18	5.30	5.76	0.40	0.49
Ether extract, g/kgW$^{0.75}$	7.52	7.84	6.67	7.21	0.49	0.42
Total carbohydrates, g/kgW$^{0.75}$	11.24	11.64	9.92	10.41	0.65	0.28
Neutral detergent fiber, g/kgW$^{0.75}$	0.68	0.71	0.64	0.61	0.63	0.74
Acid detergent fiber, g/kgW$^{0.75}$	0.35	0.37	0.34	0.32	0.04	0.77
Hemicelluloses, g/kgW$^{0.75}$	0.26	0.30	0.31	0.33	0.04	0.55
Cellulose, g/kgW$^{0.75}$	0.24	0.28	0.27	0.25	0.02	0.51
Nonfibrous carbohydrates, g/kgW$^{0.75}$	10.37	10.84	9.23	9.81	0.60	0.31
Digestible CP%	17.93	17.99	18.00	18.36	0.21	0.50
Nutritive ratio	4.73	4.77	4.71	4.65	0.04	0.21
Energy Balance						
Gross energy, Kcal/kgW$^{0.75}$	165.44	169.40	146.31	155.50	9.45	0.35
Digestible energy, Kcal/kgW$^{0.75}$	143.37	148.99	127.14	136.20	9.05	0.39
Metabolizable energy, Kcal/kgW$^{0.75}$	118.12	123.02	104.03	111.89	7.85	0.39
Q-value (ME/GE)	0.71	0.72	0.71	0.71	0.01	0.79
Heat increment, Kcal/kgW$^{0.75}$	90.62	93.02	86.27	89.08	2.78	0.41
Energy retained, Kcal/kgW$^{0.75}$	27.51	30.00	17.77	22.81	5.08	0.38
Energy efficiency, %	22.97	25.27	19.36	21.75	1.93	0.23

gravity to differentiate high-quality having IgG >50 g/L with low-quality colostrum (Godden et al. 2019). After that, there was a decline in the milk protein but lactose increased. On day 5, we confirmed colostrum transition to milk from the composition. The fat and lactose digestibility in colostrum is more than 95% in neonates, but protein digestibility is only 83 to 86% but increases later to 93% (Kertz et al. 2017). The calves that suckle the dam for a long time have early puberty (Volkmann et al. 2019); thus, calves in TGF and TGM have a better edge than CGF or CGM.

The chemical composition of MGF and other diet components, including the whole milk fed to calves in neonatal and preweaning age, is shown in table 2. The results were expressed on a metabolic body weight basis to compare intake on the active tissue mass. The birth weight of female calves was lesser than male calves by 1.5 kg. The milk or MGF total or digestible nutrient intake in CGM or TGM during neonatal age was lesser than CGF or TGF, but differences were statistically insignificant (Table 3). The total diet CP intake in neonatal age was 22%, and digestible CP intake was 13.2%. High CP diets were recommended for neonates and preweaning calves than postweaning (Chapman et al. 2017). Maximizing the growth potential of calves in preweaning would determine the subsequent growth rate in postweaning (Volkmann *et al.* 2019). The CP intake of neonates was 7 to 8 g/kg $W^{0.75}$ and 5.3 to 6.2 in preweaning calves. Sharma et al. (2020) suggested a CP requirement of 5.20 g/kg $W^{0.75}$ and 0.40 g/g of ADG for maintenance and growth of Sahiwal (*Bos indicus*) breed calves.

Energy intake was comparable between CG and TG but higher in female than male calves. Heat increment was more than energy retained during neonatal age irrespective of gender, and noticed no significant difference between CG and TG groups (Table 4). Heat increment in newborn calves has been reported to be higher and decreases by 12 kcal/kg $W^{0.75}$ from the second week of birth

Table 5: Nutrient intake from the solid and liquid diet in preweaning Deoni calves

Parameter	Female		Male		SEM	P-Value
	CG	TG	CG	TG		
Metabolic Body weight, $kgW^{0.75}$	15.48[a]	16.09[ab]	17.56[b]	17.57[b]	0.68	0.12
Green fodder, $g/kgw^{0.75}$						
Dry matter	24.36	24.02	22.26	21.96	1.19	0.41
Organic matter	23.12	22.70	21.05	20.71	1.12	0.37
Crude protein	2.76	2.71	2.51	2.48	0.13	0.36
Ether extract	0.48	0.48	0.44	0.44	0.02	0.35
Total carbohydrates	19.85	19.50	18.08	17.79	0.96	0.38
Neutral detergent fiber	18.12	17.96	16.63	16.47	0.90	0.46
Acid detergent fiber	12.04	12.03	11.12	11.10	0.60	0.52
Hemicelluloses	6.08	6.28	5.75	5.94	0.32	0.68
Cellulose	8.21	8.18	7.58	7.52	0.42	0.52
Nonfibrous carbohydrates*	1.75[b]	1.55[ab]	1.46[a]	1.32[a]	0.08	0.02
Concentrate mixture, $g/kgw^{0.75}$						
Dry matter	10.22	9.82	9.02	9.20	0.45	0.25
Organic matter	9.25	8.89	8.16	8.32	0.40	0.25
Crude protein	1.77	1.70	1.56	1.59	0.08	0.26
Ether extract	0.32	0.31	0.29	0.29	0.01	0.25
Total carbohydrates	7.16	6.88	6.31	6.44	0.15	0.25
Neutral detergent fiber	3.39	3.26	2.99	3.06	0.15	0.26
Acid detergent fiber	1.37	1.32	1.21	1.23	0.06	0.26
Hemicelluloses	2.02	1.94	1.78	1.82	0.09	0.26
Cellulose	0.83	0.80	0.74	0.75	0.04	0.27
Nonfibrous carbohydrates	3.77	3.61	3.32	3.38	0.17	0.34
Liquid diet: Milk feeding, $g/kgw^{0.75}$						
Total milk intake	81.49	86.64	75.38	74.67	7.91	0.69
Dry matter	10.40	11.06	9.62	9.53	1.01	0.68
Organic matter	9.82	10.44	9.08	9.00	0.95	0.68
Protein	2.59	2.76	2.40	2.37	0.25	0.68
Fat	3.25	3.45	3.00	2.97	0.32	0.68
Carbohydrates	4.00	4.26	3.70	3.67	0.39	0.69

Values bearing different alpha superscripts differ significantly; *P< 0.05

(Arieli et al. 1995). The heat increment observed in the Deoni neonatal calves was lesser than in the *Bos taurus* calves reported, and the ME recommendation was 120 to 140 kcal/kg $W^{0.75}$ (Arieli et al. 1995). The ME intake was 118 to 123 kcal/kg $W^{0.75}$ in female calves of CG and TG but in males, it was about 10 kcal/kg $W^{0.75}$ lesser than female calves. The energy efficiency in neonatal age in Deoni calves was 20 to 25%, which was better than preweaning age.

During preweaning, total diet intake included MGF, concentrate mixture, and whole milk. Their intake was comparable between groups. Total milk intake was reduced by 30 to 50% in the preweaning compared to the neonatal period (Table 5). Nutrient intake in female calves was higher than in males even during preweaning age. The CP% of the diet in calves during preweaning was 18%, and digestible CP was 8 to 9%. Although no difference was observed in the ME intake in calves during neonatal and preweaning age, the heat increment was increased marginally in the preweaning. The energy efficiency in preweaning was less than 10% in CG or TG groups (Table 6). The 4th to 12th week after birth was the most critical period for the calves than the initial four weeks of the birth. At this age, immune cell functions are slower and lesser than in adults and depend on colostrum feeding (Trilk and Münch, 2010). If calves suffer from diseases due to their fragile immune system in the early stages, their growth at least lasts until 6 to 8 months and affects their lifetime performance ((Trilk and Münch, 2010; Furman-Fratczak et al. 2011; Volkmann et al. 2019). We observed that the disease incidence risk in TGM and TGF was reduced by 42%, and the relative risk of disease in CG groups was 6.57 folds more than TG groups ($P < 0.001$). Diarrhea, skin diseases, anorexia, eye infection, and profuse lacrimation were more frequently observed in CGF and CGM than TGF or TGM. The odds ratio for calf diarrhea in CG was 0.9 in contrast to 0.3 in TG.

Table 6: Total diet, Digestible nutrient intake, nutritive value, and energy balance in preweaning Deoni calves

Parameter	Female		Male		SEM	P-Value
	CG	TG	CG	TG		
Total diet and nutrient intake, g/kg$W^{0.75}$						
Dry matter	60.65	60.68	55.23	54.39	2.74	0.25
Organic matter	56.92	56.88	51.77	50.91	2.57	0.24
Crude protein	11.37	11.24	10.14	10.03	0.55	0.23
Ether extract	8.33	8.40	7.54	7.26	0.56	0.42
Total carbohydrates	37.22	37.27	34.11	33.68	1.58	0.26
Neutral detergent fiber	21.51	21.52	19.82	20.00	1.03	0.52
Acid detergent fiber	13.41	13.52	12.44	12.60	0.66	0.57
Hemicelluloses	8.10	8.39	7.65	8.03	0.41	0.65
Cellulose	9.03	9.12	8.04	8.48	0.45	0.59
Nonfibrous carbohydrates•	15.74	15.74	14.28	13.64	0.77	0.19
Digestible nutrients intake, g/kg$W^{0.75}$						
Dry matter	28.24	29.82	26.85	28.48	1.47	0.58
Organic matter	27.93	29.80	26.83	28.13	1.48	0.58
Crude protein	4.82	4.78	4.37	4.83	0.25	0.53
Ether extract	4.05	4.18	3.79	4.12	0.23	0.65
Total carbohydrates	19.03	20.21	18.11	18.67	0.97	0.50
Neutral detergent fiber	9.03	9.87	8.86	9.27	0.59	0.65
Acid detergent fiber	4.73	5.16	4.70	4.96	0.32	0.72
Hemicelluloses	4.27	5.05	4.36	4.75	0.38	0.46
Cellulose	3.47	3.96	3.63	3.61	0.27	0.64
Nonfibrous carbohydrates	8.27	8.46	7.60	7.84	0.45	0.54
Protein value and Energy Balance						
Digestible CP%	7.98	7.93	7.91	8.87	0.34	0.20
Nutritive ratio	5.84	6.21	6.12	5.79	0.13	0.12
Gross energy, Kcal/kg$W^{0.75}$	269.29	269.65	244.91	240.11	12.82	0.27
Digestible energy, Kcal/kg$W^{0.75}$	141.64	147.41	132.98	140.75	7.19	0.58
Metabolizable energy, Kcal/kg$W^{0.75}$	114.60	119.65	107.29	113.89	6.15	0.58
Q-value (ME/GE)	0.43	0.45	0.44	0.47	0.02	0.39
Heat increment, Kcal/kg$W^{0.75}$	107.69	108.24	102.84	102.37	2.56	0.27
Energy retained, Kcal/kg$W^{0.75}$	6.92	11.40	4.46	11.52	4.66	0.36
Energy efficiency, %	5.26	9.24	3.85	9.27	3.62	0.64

Values bearing different alpha superscripts differ significantly; •$P < 0.10$

Table 7: Average daily gain during neonatal and preweaning age in Deoni calves

Parameter	Female		Male		SEM	P-Value
	CG	TG	CG	TG		
Neonatal age (Birth to 28 d), g/d						
Birth weight	20.24	20.20	21.58	21.78	1.04	0.59
0 to 7 d (Wk1)*	245[a]	485[ab]	537[b]	720[b]	90	0.02
7 to 14 d (Wk2)*	392[a]	444[a]	629[b]	516[ab]	50	0.03
14 to 21 d (Wk3)	405	422	545	465	48	0.19
21 to 28 d (Wk4)	421	416	515	451	48	0.47
Preweaning age, g/d						
29 to 45 d (FN3)	367	365	413	400	31	0.62
45 to 60 (FN4)	386	380	401	426	26	0.62
60 to 75 d (FN5)	412	412	405	444	24	0.67
75 to 90 d (FN6)	431	450	414	463	21	0.42
Feed efficiency						
Kleiber ratio, ADG, g/kgW$^{0.75}$						
Neonatal age	30.29	34.87	39.67	38.09	2.84	0.15
Preweaning age	25.63	24.98	23.32	24.61	0.87	0.34
Residual feed intake (Regression method)						
Neonatal age	5.31	40.77	37.40	65.44	15.89	0.12
Preweaning age	-15.53	28.44	32.73	-5.62	22.74	0.38

Values bearing different alpha superscripts differ significantly; *P< 0.05; •P< 0.10

Weight gain in the male calves was higher than in the female calves, although their intake was statistically comparable (Table 7). The weight gained in the TGM and TGF was significant until the first fortnight but later comparable. Kertz et al. (2017) also explored fat supplements in neonates by adding 3.5% vegetable oils in milk replacers or skim milk, which aided in the improvement of growth, hair coat, and health of claves. The ADG recorded in Deoni calves was better than the Sahiwal calves reported by Sharma et al. (2020). The ADG was 1.17 in neonates and 1.07 g/g DMI in preweaning Deoni calve compared to 0.40, g/g DMI in Sahiwal calves. The Kleiber ratio was comparable between CGs and TGs of male and female calves. The negative RFI in CGM or CGF indicated lesser feed intake for a unit of growth compared to calves in TGM or TGF.

Conclusion

Colostrum quality reduces by one-third after 24 h of birth and IgG levels below 40 mg/mL. FSO supplementation from day five followed by supplementing ground flaxseed from day 28 until 90 d age had no adverse influence on the diet intake, digestibility of nutrients, and energy balance, but marginal improvement in weight gains was observed. Since FSO has health properties, it supports improving the calf's resistance to diseases early and facilitates weight gains; hence, drenching FSO 30 mL/d is recommended for neonatal calves.

References

AOAC (2012) *Official Methods of Analysis*. Association of Official Analytical Chemists. 18[th]Edn. Washington, DC

ARC (1980) *Nutrient requirements of ruminant livestock.* Supplement 1. Agriculture Research Council, Common Wealth Agricultural Bureaux, Farnham Royal, U.K

Arieli A, Schrama JW, Van der Hel W, Verstegen MWA (1995) Development of Metabolic Partitioning of Energy in Young Calves. J Dairy Sci 78:1154-1162. DOI: 10.3168/jds.S0022-0302(95)76732-7

Arthur GH, Noakes DE and Pearson H (1996) The development of the conceptus. *Pregnancy and Parturition in Veterinary Reproduction and Obstetrics.* 7th ed. Philadelphia, WB 51-109

Arthur JRF, Herd RM (2008) Residual feed intake in beef cattle. Rev Brasil de Zootech 37: 269-279

Bascom SA, James RE, McGilliard ML, Van Amburgh M (2007) Influence of dietary fat and protein on body composition of Jersey bull calves. J Dairy Sci 90:5600-5609. Doi:10.3168/jds.2007-0004

Bishop MD, Davis ME, Harvey WR, Wilson GR, Van Stavern BD (1991). Divergent selection for postweaning feed conversion in Angus beef cattle: II. Genetic and phenotypic correlations and realized heritability estimate. J Anim Sci 69:4360-4367.DOI: 10.2527/1991.69114360x

Chapman CE, Hill TM, Elder DR, Erickson PS (2017) Nitrogen utilization, preweaning nutrient digestibility, and growth effects of Holstein dairy calves fed 2 amounts of a moderately high protein or conventional milk replacer. J Dairy Sci 100:279–92. DOI: 10.3168/jds.2016-11886.

Fleenor WA, Stott GH (1980) Hydrometer test for estimation of immunoglobulin concentratin in bovine colostrum. J Dairy Sci 63:973-977. Doi.org/10.3168/jds.S0022-0302(80)83034-7

Furman-Fratczak K; Rzasa A, Stefaniak T (2011) The influence of colostral immunoglobulin concentration in heifer calves' serum on their health and growth. J Dairy Sci 94: 5536–5543. Doi: 10.3168/jds.2010-3253

Godden SM, Lombard JE, Woolums AR (2019) Colostrum management for dairy calves. Vet Clinic Food Anim 35: 535-556. DOI: 10.1016/j.cvfa.2019.07.005

Gutiérrez S, Svahn SL, Johansson ME (2019) Effects of Omega-3 fatty acids on immune cells. Int J Mol Sci 20:5028-5048. doi:10.3390/ijms20205028

Kaba T, Abera B, Kassa T (2018) Esophageal groove dysfunction: a cause of ruminal bloat in newborn calves. Vet Res 14:276-280. https://doi.org/10.1186/s12917-018-1573-2

Keith was G, Mukherjee A, Chaurasia AK, Majumdar DK (2011) Anti-inflammatory, analgesic and antipyretic activities of Linumusitatissimum L. (flaxseed/linseed) fixed oil. Indian J Experimental Biol 49: 932-938

Kertz AF, Hill TM, Quigley III JD, Heinrichs AJ, Linn JG, Drackley JK (2017) A 100- year review: Calf nutrition and management. J Dairy Sci 100:10151-10172. https://doi.org/ 10.3168/jds.2017-13062.

Krishna N, Bhandari, DS, Patnayak BC (1981) Double-indicator method of determining dry-matter intake and digestibility of nutrients in grazing sheep. Indian J Anim Sci 51:716-719

Radostits OM, Gay CC, Hinchcliff KW, Constable PD (2007) Veterinary Medicine. *A textbook of the diseases of the cattle, horses, sheep, pigs, and goats* **138** : 847-888 10th ed. Saunders.

Sharma B, Nimje P, Tomar SK, Dey D, Mondal S, Kundu SS (2020) Effect of different fat and protein levels in calf ration on the performance of Sahiwal calves. Asian-Australas J Anim Sci 33:53-60. https://doi.org/10.5713/ajas.18.0604

Terré M, Devant M, Bach A (2007) Effect of level of milk replacer fed to Holstein calves on performance during the preweaning period and starter digestibility at weaning. *Livestock Science*. **110**: 82–88.https://doi.org/10.1016/j.livsci.2006.10.001

Trilk J, Münch K, (2010) Connections between the health of calves, growth, and later milk yield of dairy cattle. Züchtungskunde, 80: 461–472.DOI: 10.2478/aoas-2018-0051

Van Soest PJ, Robertson JB, Lewis BA (1991) Methods for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. J Dairy Sci **74**: 3583-3597.DOI: 10.3168/jds.S0022-0302(91)78551-2

Volkmann N, Kemper N, Römer A (2019) Impacts of prepubertal rearing intensity and calf health on first-lactation yield and lifetime performance. Annals Anim Sci 19:201-214. DOI: 10.2478/aoas-2018-0051