



Rumen microbial protein and milk production on different source of oilseed meals in mixed diet

S MOHANAVEL¹ and B SRINIVAS²

ICAR-National Dairy Research Institute, Bengaluru, Karnataka 560 030 India

Received: 27 January 2016; Accepted: 3 June 2016

ABSTRACT

Effects of different oilseed meals (OSM) in concentrate supplement (CS) on rumen microbial protein (MBP) and milk composition were evaluated. Deoni cows (20) were distributed to 5 equal groups. CS consisted 90% of maize grain alone (control; CG) or 30% maize grain and 60% of any one type of OSM viz., groundnut (GNM; T1), cottonseed (CSM; T2), copra (CM; T3) or mustard (MSM; T4). The rest of CS was urea, mineral mixture and common salt. Roughage fed was hybrid napier and *ragi* straw. DM intake (DMI) was lesser in T4 than CG. Feed efficiency was comparable between CG and TGs. Digestible and metabolizable energy were higher in T1, T2 and T3 than CG or T4. MBP in T1 (224 g/d) was 11 and 13% higher than T2 and T4, respectively. MBP in CG was comparable to T2 and T4. MBP efficiency was higher in T1 and least in T3 (40 vs. 26 g/kg DOMI). Fat corrected milk (FCM) yield was comparable between CG and TGs. Milk composition in TGs improved from third week. TS was 348, 457, 441, 358 and 339 g/d, respectively, and SNF was 237, 303, 312, 243 and 238 g/d, respectively in CG, T1, T2, T3 and T4. The study concluded that MBP was higher with GNM followed by CSM and MSM but poor with CM. GNM and CSM improved SNF and TS in milk while CM and MSM improved milk fat.

Key words: Dairy cow, Diet, Microbial, Oilseed meal, Production, Protein

Groundnut (GNM), mustard (MSM), cottonseed (CSM), copra (CM) and soya (SM) are edible oilseed meals (OSM) contributing 90% of the dairy farmers requirement (Mohanavel and Srinivas 2015). Distinctive CP characteristics of OSM are resulting in varying amounts of degradation (RDP) or bypass degradation (UDP) in rumen. True protein source in RDP is useful because amino acids (AA) or peptides are utilized more efficiently for microbial protein (MBP). UDP source improve availability of dietary amino acids (AA) for milk protein at abomasum (Brito *et al.* 2007). Milk protein composition is mirror image of rumen MBP. The objectives of the study were to evaluate the impact of type of OSM in mixed diets on rumen MBP, milk yield and milk composition.

MATERIALS AND METHODS

Experimental design, animals and diets: Deoni (*Bos taurus indicus*) cows (parity 2.85±0.17 lactations, body weight 359±11 kg and milk yield 5.25±0.92 kg/d) in early lactation (80 to 120 d) were randomized using milk yield and body weight to 5 groups of 4 each. Cows were fed mixed roughage consisting finger millet straw (*Elusine coracana*) *ad lib.* and 10 kg green Hybrid (Bajra × Napier Var. CO-3) napier. Control group (CG) were offered OSM

free concentrate supplement (CS) consisting maize 90% urea 6%, mineral mixture 2% and common salt 2%. Test groups (TG) were fed CS consisting only 30% maize grain and 60% of any one OSM, viz. GNM (T1), CSM (T2), CM (T3) or MSM (T4) and mineral mixture 2%. CS of TGs were made isonitrogenous with urea @ 3.8% (T1), 5.3% (T2), 6.6% (T3) or 5% (T4), respectively, with a care to restrict urea-N intake to less than 33% of the total N in the diet (ARC 1984). Common salt was added to make total ingredients in the CS of TG to a cent. Diets were made isonitrogenous by urea N.

Experimental trial: Cows were housed in individual pens and provided water 4 times a day. CS and roughage were offered twice a day at 6 and 17 h and 9 and 18 h, respectively. Daily feed intake was recorded for 3 consecutive days in a week during 6 weeks of lactation trial. After 4 weeks of preliminary period of feeding, digestibility trial for 5 d was conducted. Feed offered and orts samples were collected daily, dried and stored for chemical analysis. Urine from each cow was collected 100 ml/d during the trial in a bucket and acidified with 10% H₂SO₄ (v/v). Faeces and urine were sampled once daily at 8 h. Part of faecal sample was kept for oven drying at 100±5°C for 12 h and other part acidified with 25% H₂SO₄ (v/v) in glass bottle for N estimation. Acidified sample of 100 ml urine was diluted with distilled water (DW) uniformly to 1.2 l, mixed thoroughly, filtered through glass wool and 50 ml was stored at -20°C in polypropylene bottles till further analysis.

Present address: ¹Zonal Manager (mohuvet@gmail.com), Shanthi Feeds Pvt. Ltd., Ondipudur, Coimbatore. ²Principal Scientist (bandla_srinivas@rediffmail.com).

Feed, faeces and milk analysis: Feed, faeces and orts were analysed for proximate (AOAC 2005) and cell wall constituents (Van Soest *et al.* 1991). Organic matter (OM), total carbohydrates (TCHO), non fibrous carbohydrates (NFC) and hemicelluloses were mathematically calculated. Gross (GE), digestible (DE) and metabolizable (ME) energy, heat increment, energy retention and energy efficiency were calculated using empirical formulae (ARC 1984). Daily milk yield was recorded and expressed as 4% fat corrected milk (FCM). Milk samples were analysed for total solids (TS), fat, protein and inorganic elements (AOAC 2005). Milk lactose was calculated mathematically.

Rumen microbial protein production (MBP): Urine samples were thawed and treated with uricase to degrade uric acid to allantoin and other compounds. Uricase (U-9375) was prepared in phosphate buffer (0.67 M KH₂PO₄, adjusted the pH with KOH) to obtain a concentration of 0.12 units/ml. One ml of phosphate buffer was added to 2.5 ml of diluted urine sample in test tube and mixed thoroughly to add 150 µl of uricase solution with pH adjusted to 9.0 by NaOH. Tubes were incubated for 2 h at 37°C. Total allantoin and creatinine in urine samples were determined by colorimetric method. Duodenal flow of MBP was calculated based on PD and creatinine (PDC) index. Endogenous contribution of PD in indigenous cattle was taken as 0.147 W^{0.75}/day (Chen and Ørskov 2003). Efficiency of MBP production (EMBP) was expressed as gN/kg of digestible OM intake (DOMI) and gN/MJ ME.

Statistical analyses: Data were subjected to variance test using completely randomized/ block design (CRD). Pair-wise comparison between group means was tested by Duncan multiple range test (DMRT). Weekly milk yield and composition of treatment groups were subjected to ANOVA model included the repeat measure. These analyses were carried with statistical packages for the social sciences (SPSS v 14.0).

RESULTS AND DISCUSSION

Chemical composition of green fodder and ragi straw offered and orts is presented in the Table 1. Leftover feed contained more TCHO and less cell contents because dairy cows selectively consume leaves and nodes leaving stems and internodes. Orts of green fodder had significantly lesser CP, EE and, cell contents but OM, TCHO, NDF and ADF were higher. *Ragi* straw orts consisted higher OM (P<0.05), NDF (P<0.01) and ADF (P<0.05) than fed. CS fed to CG had 4 and 8% lesser OM and CP compared to TGs. Green fodder and *ragi* straw intake were not significant in CG and TGs. CS intake in CG, T1, T2, T3 and T4 was 160, 198, 183, 177 and 151 g/kg FCM yield, respectively. DMI was 9 to 12% lesser in T4 than CG and other TGs due to bitterness of MSM. Feed efficiency (FE) for FCM yield (kg/kg DMI) showed the trend as T2>T1>T4>CG>T3 (P, 0.87). This was contrary to FE to synthesize milk TS (T3>T4=CG>T1>T2) thus, indicating an inverse relation of OSM on milk yield and TS. Milk yield and composition is sensitive to quantity and quality of feed, particularly to

Table 1. Chemical composition of roughage

Parameter	Green fodder		SEM	Ragi straw		SEM
	Offered	Orts		Offered	Orts	
DM	26.9	31.8	0.34**	89.5	89.5	0.48
OM	89.2	91.3	0.15**	93.2	94.9	0.15*
CP	6.3	4.3	0.27*	3.7	3.3	0.05**
EE	2.2	1.3	0.09*	1.5	1.5	0.04
TCHO	80.6	85.7	0.42*	90.2	90.2	0.23
Total ash	10.8	8.7	0.15**	6.7	5.1	0.15*
AIA	4.2	3.4	0.12*	2.4	1.0	0.01**
Cell contents	40.9	33.1	0.48**	35.5	24.6	0.68**
NFC	21.5	18.9	0.77	25.7	14.9	0.86*
NDF	59.1	66.9	0.48**	64.5	75.4	0.68**
ADF	37.6	44.0	0.88*	37.1	50.1	1.70*
Hemi-celluloses	21.5	22.8	0.40	27.4	25.3	1.02
Celluloses	29.5	36.5	2.25	31.5	46.6	2.16*
ADL	8.2	7.5	1.64	5.6	2.4	0.24*

SEM with *P<0.05 and **P<0.01 indicate significant difference in green fodder/*ragi* straw between offered and orts.

Table 2. Chemical composition of concentrate supplements

Parameter	Concentrate supplement					SEM
	Control	T1	T2	T3	T4	
DM	95.2 ^b	92.9 ^a	93.2 ^a	93.3 ^a	93.0 ^a	0.37*
OM	86.9 ^a	90.6 ^b	90.6 ^b	90.8 ^b	90.3 ^b	0.17 **
CP	25.8 ^a	33.8 ^b	33.3 ^b	33.3 ^b	33.1 ^b	0.33 **
EE	2.6 ^b	5.5 ^c	1.5 ^a	7.1 ^d	1.3 ^a	0.09 **
TCHO	58.5 ^c	51.3 ^a	55.8 ^b	50.3 ^a	55.9 ^b	0.40 **
Total ash	13.0 ^a	9.4 ^b	9.4 ^b	9.2 ^b	9.7 ^b	0.17 **
AIA	2.0 ^c	1.9 ^b	0.7 ^a	0.6 ^a	0.7 ^a	0.03 **
Cell contents	73.4 ^c	86.0 ^c	65.8 ^b	62.4 ^a	77.5 ^d	0.93**
NFC	31.9 ^c	37.3 ^d	21.7 ^b	12.7 ^a	33.4 ^c	1.01 **
NDF	26.5 ^c	13.9 ^a	34.1 ^d	37.5 ^e	22.4 ^b	0.93**
ADF	5.3 ^a	6.9 ^a	17.9 ^d	15.3 ^c	9.8 ^b	0.54 **
Hemi-celluloses	21.2 ^d	7.0 ^a	16.1 ^c	22.2 ^d	12.6 ^b	0.83 **
Celluloses	4.7 ^a	5.2 ^a	13.5 ^d	12.0 ^c	6.9 ^b	0.39 **
ADL	0.6 ^a	1.8 ^b	4.5 ^d	3.3 ^c	2.8 ^c	0.28 **

a, b, c, d, e Values bearing different superscripts in a row indicates significant difference between treatment supplement. *P<0.05 and **P<0.01.

CS. Fat yield was influenced by OSM in the CS (Sawal and Kurar 1998). It was 112, 155, 129, 115 and 101 g/d, respectively, in CG, T1, T2, T3 and T4.

Except EE, NDF and cellulose (P<0.05), digestibility coefficient of nutrients was not significantly different between groups. EE digestibility was significantly higher in T3 (81%) because of higher fat content and fat characteristics (Ehrlich *et al.* 1990). CM contains saturated, polyunsaturated

Table 3. Nutrient intake and digestibility

Parameter	Control	T1	T2	T3	T4	SEM
Metabolic body weight (kg)	78.32	80.25	81.19	83.37	78.76	4.26
Ragi straw intake (kg/d)	3.56	3.58	3.53	3.54	3.45	0.07
Green fodder intake (kg/d)	2.58	2.59	2.59	2.52	2.56	0.04
Concentrate intake (kg/d)	1.17	1.52	1.37	0.84	1.29	0.15
Total DM intake (kg/d)	7.32	7.68	7.49	6.91	7.30	0.19
g/kg W ^{0.75}	91.79	94.53	92.25	84.40	91.86	4.69
Feed efficiency (g)	373	474	482	408	368	99
FCMY/kg DMI g milk solids/kg DDMI	293	288	269	293	300	13
DM	58.30	57.53	61.62	59.29	60.85	1.41
OM	60.42	59.67	63.30	61.17	62.69	1.34
CP	57.06	64.78	62.59	54.35	60.04	2.52
EE	61.48 ^a	70.61 ^{ab}	68.38 ^a	65.69 ^a	80.81 ^b	3.69*
TCHO	60.68	58.70	63.26	61.66	62.26	1.34
Total ash	37.10	36.17	43.79	39.65	41.94	2.50
Energy	58.41	61.11	63.58	58.40	60.72	1.21
Cell contents	69.13	71.29	71.32	69.58	70.44	1.24
NFC	84.78	85.10	85.01	84.44	84.22	1.07
NDF	49.88 ^{ab}	45.32 ^a	54.27 ^b	51.65 ^b	53.90 ^b	1.80*
ADF	43.69	38.94	47.36	45.61	47.48	2.49
Hemi-celluloses	58.09 ^{ab}	54.65 ^a	64.26 ^c	60.38 ^{bc}	62.67 ^{bc}	1.65*
Celluloses	51.12	46.16	54.41	53.72	53.95	2.51

a, b, cValues bearing different superscripts of a parameter in row indicates significant difference. *P<0.05 and **P<0.01.

and monounsaturated fatty acids (FA) in the ratio of 91:2:7 as against 19:33:48 in GNM. Numerically, OM digestibility in T1 was reduced by 4% although CP digestibility increased by 10%. According to Cruywagen *et al.* (2003), higher fat in ration reduces fiber digestion but, increases CP digestibility. EE content in CS with GNM was 5.5% which might be a reason for reduced fiber digestion in T1 than other TGs. Although T3 contained higher EE% in CS, it did not show any relational impact on fiber or CP digestibility which is contrary to T1. It appears that saturated FA may less interfere in fiber digestion and affect CP digestion as was with CM than GNM. DE and ME were higher in T1, T2 and T3 than CG or T4 (P<0.05) mainly due to EE. Energy retention, efficiency and heat increment were comparable between CG and TGs (Table 4).

PDC index, MBP production and duodenal flow were higher in T1 and least in T4 (P, 0.10). Compared to CG (191 g/d), difference in the MBP production in T1, T2, T3 and T4 were 17, 6, -18 and 4%, respectively (P, 0.10). According to Russell (1998), fermentation heat losses are more on diets containing more NFC. It was higher on CG, T1 and T4. MBP production was higher in CG, T1, T2 and T3 but less in T4. MBP production of 224 g/d on T1 was 11 and 13% higher than T2 and T4. This indicated that GNM supported more MBP production. MBP production was 191 g/d on CG which was statistically comparable to T2 or T4. It provided phenomenal observation that urea as sole N source in the CS in CG was efficiently utilized in the presence of maize grain as good as CSM (T2) and MSM (T4). It may be useful in minimizing the feed cost when cost of OSM was higher. According to Luc *et al.* (2009), energy source from maize grain utilizes more efficiently for MBP production than readily fermentable molasses. MBP production on CM was lesser than other OSM. Probably it had less NFC and fat was higher. Fat is not efficient energy source for MBP synthesis (Dewhurst *et al.* 2000) but NFC is highly preferred (Russel 1998). EMPB was 40 g/kg DOMI in T1 was 10 g/kg DOMI higher than

Table 4. Energy (MJ) utilization and rumen microbial protein production

Parameter	Control	T1	T2	T3	T4	SEM
DE (MJ)	74.59 ^{ab}	79.67 ^b	80.95 ^b	71.47 ^a	79.08 ^b	2.10*
ME (MJ)	60.93 ^{ab}	64.93 ^b	65.98 ^b	58.22 ^a	64.77 ^b	1.78*
Q-value (ME/GE)	0.48	0.50	0.52	0.48	0.50	0.01
Energy retention (MJ)	34.18	36.71	36.26	30.76	36.86	1.71
Energy efficiency (%)	56.10	56.52	54.97	52.63	56.79	1.68
Heat increment (MJ)	26.76	28.22	29.71	27.46	27.91	0.95
Purine derivatives (mmol/l urine)	16.31	19.55	16.66	18.65	16.46	2.38
Creatinine (mmol/l urine)	3.75	4.01	3.65	4.29	4.85	0.44
PD:creatinine (PDC) ratio	4.30	4.94	5.42	4.30	3.53	0.44
PDC index	336.99 ^{ab}	394.79 ^b	355.45 ^{ab}	350.96 ^{ab}	277.44 ^a	27.11•
PD production (g/d)	190.74 ^{ab}	223.96 ^b	201.35 ^{ab}	198.77 ^{ab}	156.52 ^a	15.58•
MBP flow to duodenum (g/d)	137.36 ^{ab}	165.14 ^b	145.49 ^{ab}	142.56 ^{ab}	107.94 ^a	13.40•
MBP efficiency (gN/kg DOMI)	34.33 ^{ab}	39.52 ^b	33.62 ^{ab}	37.13 ^b	25.53 ^a	2.89*
MBP efficiency (gN/MJ ME)	2.26 ^b	2.55 ^b	2.20 ^{ab}	2.46 ^b	1.64 ^a	0.19*

a, bValues bearing different superscripts of a parameter in a row indicates significant difference. •P<0.10, *P<0.05 and **P<0.01.

Table 5. Milk yield and composition

Treatment	Week						Mean
	1 st	2 nd	3 rd	4 th	5 th	6 th	
	<i>4% FCM yield (kg/d)</i>						
Control	3.46	2.69	2.39	2.35	2.73	2.85	2.74
T1	4.08	3.64	3.25	3.49	3.76	3.56	3.63
T2	4.29	3.95	3.54	3.18	3.36	3.33	3.61
T3	4.17	3.10	2.76	2.32	2.35	2.33	2.84
T4	3.66	2.97	2.50	2.35	2.44	2.47	2.73
SEM	0.57	0.63	0.78	0.81	0.92	0.87	0.75
	<i>Total solids (%)</i>						
Control	12.63	12.50	12.24	12.50 ^b	12.53 ^{bc}	12.45 ^b	12.47 ^{ab}
T1	12.94	12.72	12.91	12.64 ^b	12.42 ^b	12.41 ^b	12.67 ^{ab}
T2	12.64	12.71	12.72	12.01 ^a	12.02 ^a	12.11 ^a	12.37 ^{ab}
T3	11.80	11.89	11.77	12.15 ^a	12.06 ^a	12.05 ^a	11.95 ^a
T4	13.43	12.92	13.01	13.30 ^b	13.21 ^c	13.28 ^c	13.19 ^b
SEM	0.46	0.47	0.37	0.42 [*]	0.40 [*]	0.41 [*]	0.30 [*]
	<i>Fat (%)</i>						
Control	3.81	3.81	3.80	4.29 ^{ab}	4.26 ^{ab}	4.25 ^{ab}	4.04 ^b
T1	4.21	4.10	4.11	4.48 ^b	4.43 ^b	4.41 ^b	4.29 ^b
T2	3.93	3.88	3.88	3.31 ^a	3.30 ^a	3.32 ^a	3.61 ^a
T3	3.67	3.65	3.65	3.37 ^a	3.36 ^a	3.37 ^{ab}	3.51 ^a
T4	4.28	4.34	4.35	4.20 ^{ab}	4.24 ^{ab}	4.26 ^{ab}	4.28 ^b
SEM	0.33	0.35	0.35	0.31 [*]	0.30 [*]	0.29 [*]	0.18 [*]
	<i>Protein (%)</i>						
Control	3.62	3.61	3.65 ^b	3.75 ^c	3.69 ^b	3.70 ^b	3.67 ^b
T1	3.33	3.35	3.37 ^{ab}	3.27 ^{ab}	3.27 ^{ab}	3.27 ^{ab}	3.31 ^a
T2	3.33	3.32	3.33 ^{ab}	3.31 ^{ab}	3.34 ^{ab}	3.34 ^{ab}	3.33 ^a
T3	3.27	3.33	3.30 ^{ab}	3.16 ^a	3.18 ^a	3.16 ^a	3.24 ^a
T4	3.25	3.24	3.22 ^a	3.67 ^{bc}	3.65 ^b	3.65 ^b	3.45 ^{ab}
SEM	0.12	0.12	0.12 ^{†*}	0.13 [*]	0.13 [*]	0.13 [*]	0.10 [*]
	<i>Lactose (%)</i>						
Control	4.47	4.33	4.10	3.72 ^a	3.86 ^a	3.77 ^a	4.04 ^a
T1	4.68	4.51	4.73	4.16 ^{ab}	3.98 ^a	4.01 ^a	4.35 ^{ab}
T2	4.72	4.83	4.84	4.70 ^{bc}	4.64 ^b	4.70 ^b	4.74 ^b
T3	4.17	4.21	4.07	4.89 ^c	4.80 ^b	4.77 ^b	4.49 ^{ab}
T4	5.23	4.66	4.69	4.73 ^{bc}	4.60 ^b	4.67 ^b	4.76 ^b
SEM	0.35	0.27	0.28	0.21 ^{**}	0.20 ^{**}	0.20 ^{**}	0.18 [*]
	<i>Inorganic elements (%)</i>						
Control	0.74	0.72 ^{ab}	0.73	0.74	0.72	0.74 ^{bc}	0.73
T1	0.71	0.75 ^b	0.72	0.72	0.73	0.72 ^{ab}	0.73
T2	0.66	0.67 ^a	0.68	0.69	0.74	0.75 ^c	0.70
T3	0.69	0.71 ^{ab}	0.72	0.73	0.72	0.74 ^{bc}	0.72
T4	0.67	0.69 ^a	0.72	0.71	0.72	0.71 ^a	0.70
SEM	0.03	0.02 [*]	0.02	0.02	0.02	0.02 [*]	0.01

Values bearing different superscripts of a parameter in a row indicate significant difference. *P<0.05 and **P<0.01.

the optimum suggested by ARC (1984) and comparable to T4. Least EMBP in T3 with 26 g/kg DOMI indicated that higher fat% in the diet had negative effect on MBP production as well as efficiency. EMBP in CG, T2 and T4 was marginally higher than optimum (30 g/kg DOMI) efficiency (ARC 1984).

Although FCM yield was comparable between groups, milk TS, fat, protein and lactose (%) changed significantly from third week (P<0.05 to 0.10). Thus, the impact of OSM in CS was very significant on milk composition, particularly on fat and SNF (Sawal and Kurar 1998). Often in the field, livestock farmers wish to feed additional OSM to milking

animals to get advantage of 2 axis pricing (Fat and SNF) for their produce (Nagarathna *et al.* 2007). FCM yield was noticeably reduced in T4. It was constantly higher and comparable between T1 and T2 (Table 5). Generally, AA composition of milk and MBP are comparable. Hence, FCM yield was apparently higher in T1, T2 and T4 where MBP production was also higher. Mean TS yield in CG, T1, T2, T3 and T4 was 348, 457, 441, 358 and 339 g/d, respectively (P, 0.80). Milk SNF yield was 237, 303, 312, 243 and 238 g/d, respectively (P, 0.83). OSM enhanced milk TS and SNF compared to maize grain with only urea as N source although later supported comparable MBP production. OSM

supplements have positive effect on feed intake, milk yield and milk protein (Rego *et al.* 2008).

Study concluded that rumen MBP production and EMBP would be higher with GNM followed by CSM and MSM on mixed rations but, poor with CM. Increased MBP with GNM and CSM enhanced TS and SNF in milk. CM and MSM had impact on milk fat but not on TS and SNF. OSM supplementation only would increase TS and SNF content of milk but not maize grain with only urea as N source even though it supports MBP production comparable to CM and MSM.

ACKNOWLEDGEMENT

The authors are thankful to the Director, ICAR-NDRI, Karnal and Head, SRS, ICAR-NDRI, Bengaluru for providing necessary facilities for conducting this experiment.

REFERENCES

- AOAC. 2005. *Official Methods of Analysis*. 18th edn. Association of Official Analytical Chemists, Arlington, VA. USA.
- ARC, 1984. *Nutrient Requirements of Ruminant Livestock*. Suppl 1. Commonwealth Agricultural Bureaux, England, UK.
- Brito AF, Broderick G A and Reynal S M. 2007. Effect of different protein supplements on omasal nutrient flow and microbial protein synthesis in lactating dairy cows. *Journal of Dairy Science* **90**: 1828–41.
- Chen X B and Ørskov E R. 2003. Research on urinary excretion of purine derivatives in ruminants: past, present and future. *Development, Standardization and Validation of Nuclear-Based Technologies for Estimating Microbial Protein Supply in Ruminant Livestock for Improving Productivity* (Ed.) Makkar H P S. International Atomic Energy Agency, Vienna. pp. 1–34. www.macaalay.ac.uk.
- Cruywagen C W, Lategan E L and Hoffman L C. 2003. The effect of rumen inert fat supplementation and protein degradability in starter and finishing diets on veal calf performance. *South Africa Journal of Animal Science* **33**: 257–63.
- Dewhurst R J, Davies D R and Merry R. 2000. Microbial protein supply from the rumen. *Animal Feed Science and Technology* **85**: 1–21.
- Ehrlich W K, Upton P C, Cowan R T and Moss R J. 1990. Copra meal as a supplement for grazing dairy cows. *Proceedings of the Australian Society of Animal Production* **18**: 196–99.
- Luc D H, Thu N Y and Preston T R. 2009. Feed intake, rumen fermentation, microbial protein synthesis and nitrogen retention in growing cattle given maize or molasses with two levels of crude protein as supplements to a basal diet of rice straw and grass. *Livestock Research for Rural Development* **21**: Article #111. <http://www.lrd.org.lrrd21/7/luc21111.htm>
- Mohanavel S and Srinivas Bandla. 2015. Oilseed meal requirement and livestock sector growth. *Indian Dairy Man* **67**:76–79.
- Nagarathna B, Ramesh C R and Pathak P S. 2007. Traditional livestock practices in Northern Karnataka. *Indian Journal of Traditional Knowledge* **6**: 459–62.
- Rego O A, Regalo S M M, Rosa H J D, Alves S P, Borba A E S, Bessa R J B, Cabrita A R J and Fonseca A J M. 2008. Effects of grass silage and soybean meal supplementation on milk production and milk fatty acid profiles of grazing dairy cows. *Journal Dairy Science* **91**: 2736–43.
- Russell J B. 1998. Strategies that ruminal bacteria use to handle excess carbohydrate. *Journal of Animal Science* **76**: 1955–63.
- Sawal R K and Kurar C K. 1998. Milk yield and its fat content as affected by dietary factors: A Review. *Asian Australasian Journal of Animal Science* **11**: 217–233.
- Van Soest P J, Roberson J B and Lewis B A. 1991. Methods for fibre, neutral detergent fibre and non starch polysaccharides in relation to animal nutrition. *Journal of Dairy Science* **74**: 3583–97.