



Nutritive value of cowpea fodder cultivars and their effect on nutrients intake, digestibility and nitrogen balance in sheep

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ABSTRACT

Three cowpea fodder varieties (BL-1, BL-2 and BL-4) developed by IGFR were evaluated against check Kohinor for their nutritional attributes by *in vitro* and *in vivo* means. Varieties were grown under identical agronomic practices in *Kharif* 2016 and animal feeding was started at flower initiation stage. For feeding trial, 20 growing sheep (mean body weight 19.85±0.45 kg) were randomly distributed to 4 varieties (Kohinor, BL-1, BL-2 and BL-4) with 5 animals to each. After 3 weeks of feeding, a digestion cum- metabolism trial was conducted to assess the nutrients intake, digestibility and nitrogen balance in sheep. The cowpea fodder varieties CP, NDF and lignin contents differed and values ranged between 22.23–23.41, 50.54–55.10 and 8.48–10.76%, respectively. Protein and carbohydrate fractions of cowpea varieties were similar except the NSC (% DM) and C_C (% CHO) which were lower and higher, respectively in BL-2. Cowpea varieties energy values as TDN, DE, NE_L, NE_M and NE_G were identical. *In vitro* gas and methane production (ml/g DM) was lower from Kohinor (86.57 and 10.67) and BL-2 (90.79 and 11.40) than BL-1 (104.83 and 13.96) and BL-4 (98.86 and 13.08), respectively. Short chain fatty acids, partition factor and efficiency for microbial production differed significantly amongst the cowpea varieties. Sheep DM, CP and ME intake (% body wt and g/kg W^{0.75}) was comparable on evaluated cowpea varieties. Digestibility of DM, OM and CP in sheep was similar on cowpea varieties; however, NDF and ADF digestibility tended to be lower of BL-4 (63.88 and 61.70%) than BL-2. Sheep nitrogen balance was identical on all the cowpea varieties and ranged between 16.92–18.32 g/d. Cowpea varieties DCP and DE contents were similar and ranged between 18.36–20.30% and 13.63–14.72 kJoules/g DM, respectively. Results showed that nutritive value of cowpea varieties differed significantly in terms of CP, NDF, NSC%DM, fermentation pattern, and cell wall (NDF and ADF) digestibility.

Key words: Carbohydrate, Cowpea, Energy value, Nitrogen balance, Protein fraction, Sheep, Varieties

Cowpea (*Vigna unguiculata*) is one of the important fodder legume crops grown round the globe (Sebetha *et al.* 2010) for multiple uses such as green fodder and hay for livestock, green pods and grain rich in protein as vegetable and protein source for human consumption (Singh *et al.* 2003). As per one estimate, about 6.5 lakh hectare area is under different forms of cowpea where cowpea fodder share is 3 lakh ha (IGFRI 2013). Fodder cowpea is a legume genetically tolerant to drought than other fodder legumes (Fatokun *et al.* 2009) and provides nutritionally rich seasonal fodder to sustain livestock productivity. In rain deficit regions and relatively infertile soils, cowpea is wisely cultivated as fodder crop. Most of livestock owners grow fodder cowpea as an intercrop with other crops and fodder

cowpea forms an integral component of crop livestock farming system (Singh and Tarawali 2011). Samireddypalle *et al.* (2017) have stressed for multidimensional improvement of cowpea for mixed crop livestock systems in Africa. Cowpea is a fast growing leguminous fodder of *Kharif* season yielding 90–120qt fodder/acre. It can be grown as sole crop as well as mixed crop with sorghum, maize, pearl millet or other grasses and usually ready for feeding after 2 months of growth. Devasan *et al.* (2009) reported that cowpea varieties DCP-10, GC-11, DCP-2 and DCS-6 were better for livestock feeding than other varieties. The importance of any forage crop depends on the green fodder yield, chemical composition and nutritive value. The chemical composition and nutritive value are influenced by variety of crop and climatic factors (Fernandes and Waditake 2006). With the continuous and committed efforts of forage researchers, new cultivars of fodder crops are being developed with the objective to enhance yield, nutritive value, biotic and abiotic resistance. In the present study, fodder cowpea varieties developed by Indian Grassland and Fodder Research Institute, Jhansi, were

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evaluated for their nutritive value following *in vitro* and *in vivo* methods.

MATERIALS AND METHODS

Production of fodder cowpea varieties and animal trial: Cowpea fodder varieties, viz. BL-1, BL-2 and BL-4 developed by Indian Grassland and Fodder Research Institute (IGFRI) were grown along with Kohinoor (Check) under similar agronomic conditions in Kharif 2016 (25th July 2016) in plot size of 30×5 meter for their *in vitro* and *in vivo* evaluation. For *in vivo* feeding trial, 20 growing sheep with mean body weight of 19.86±0.453 kg were randomly distributed into 4 groups (Kohinoor, BL-1, BL-2 and BL-4) with 5 animals in each group. The feeding was started on the flower initiation stage (14th September 2016). The green fodder from each cowpea variety was harvested either in evening (for feeding following morning) or in the morning. The harvested green fodder from each cowpea variety was chaffed separately with manually operated chaff cutter in morning and then fed *ad lib.* to rams between 9:30 to 10:00 AM. The animals were watered twice daily at 11.30 h and 16.00 h.

After three weeks of feeding, a digestibility-cum metabolism trial was conducted when varieties had 50% or more flowering stage. Sheep were housed in metabolism cages for collecting faeces and urine separately. Individual animal faeces and urine were collected daily for 6 days and pooled in iron trays and plastic containers, respectively. Representative samples of faeces for DM (1/10 aliquot) and N (1/50 aliquot preserved in 20% H₂SO₄) estimation were collected from individual animals during the trial. For urine, an aliquot of 1/100 was kept for N estimation in glass bottles with 5 ml of concentrate H₂SO₄. Samples of feed offered (sorghum stover and concentrate mixture) and refusals were also collected daily and representative samples were kept for DM estimation. Samples collected for each cowpea fodder variety, refusal and faeces were dried at 80°C for 96 h for DM estimation and at 60–65°C for 96 h for chemical/biochemical estimations. Dried samples were ground through 1-mm sieve using an electrically operated Willey mill and then stored in Tarson make plastic containers for further nutritional and *in vitro* analysis.

Chemical analyses: Samples were analyzed according to the standard methods of AOAC (2005) for dry matter (DM), crude protein (CP), ether extract (EE) and ash. Neutral detergent fibre (NDF) and acid detergent fibre (ADF) were determined by the procedure of Van Soest *et al.* (1991) using Fiber Tech. Heat-stable alpha amylase and sodium sulfite were not used in NDF determination. Lignin was determined by solubilization of cellulose with sulfuric acid in the ADF residue. Hemicellulose was calculated as NDF minus ADF, and cellulose was estimated as the difference between ADF and lignin in the sequential analysis.

Crude protein fractionation: The CP fractions of cowpea fodder samples were partitioned into five fractions according to the Cornell Net Carbohydrate and Protein

System (CNCPS; Sniffen *et al.* 1992) as modified by Licitra *et al.* (1996). Neutral detergent insoluble protein (NDIP), acid detergent insoluble protein (ADIP) and non-protein nitrogen (NPN) of cowpea varieties were estimated following standard method (Licitra *et al.* 1996). Soluble protein (SP) was estimated by treating the samples in borate–phosphate buffer (pH 6.7–6.8). The N estimated in the residue gives the insoluble protein fraction. Soluble protein was calculated by subtracting insoluble protein from total CP.

Carbohydrate fractionation: The carbohydrate fractions of cowpea fodder samples were estimated as per Cornell Net Carbohydrate and Protein (CNCP) system (Sniffen *et al.* 1992). Total carbohydrate (CHO, %DM) was determined by subtracting CP, EE and ash contents from 100. Structural carbohydrates (SC) were calculated as the difference between NDF and NDIP and non-fiber carbohydrates (NFC) were estimated as the difference between total carbohydrate (CHO) and SC (Caballero *et al.* 2001). Starch in cowpea fodder samples was estimated as per Sastry *et al.* (1991).

Dry matter intake, digestibility and energy calculations: To calculate DDM, total digestible nutrients (TDN) and net energy of fodder cowpea varieties for different animal functions, i.e. lactation (NE_L), gain (NE_G), and maintenance (NE_M), equations of Undersander *et al.* (1993) were used. Digestible energy (DE) and metabolizable energy (ME) values were calculated using the equations of Fonesbeck *et al.* (1984) and Khalil *et al.* (1986), respectively.

Gas production and methane measurements: *In vitro* gas production was determined using pressure transducer technique of Theodorou *et al.* (1994). Ruminal fluid was collected before feeding from four adult Jalauni rams maintained solely on berseem hay. Rumen fluid was collected through mouth tube and filtered through a double layer of muslin cloth and bubbled with CO₂ before commencement of incubation. The incubation medium was prepared by sequential mixing of buffer solution, macro-mineral solution, micro-mineral solution and resazurin solution. Samples (0.200 g) of air dry cowpea fodder were weighed into three 100 ml serum bottles. Three serum bottles without substrate were used as blanks. Sample and control serum bottles were initially gassed briefly with CO₂ before adding 40 ml of medium. Bottles were continuously fluxed with CO₂, and then 1.2 ml of reducing solution was added in each. Gassing of bottles with CO₂ continued till the pink colour turned colourless. Before inoculation, the gas pressure transducer was used to adjust head space gas pressure in each bottle to adjust the zero reading on the LED display. Serum bottles were inoculated with 10 ml of ruminal fluid inoculum using a 10 ml syringe. Inoculated bottles were sealed and incubated at 39°C and with gas production (ml) measured at 24 h of incubation.

Methane in total gas was measured from 4 bottles (2 each from 2 separate batches) incubated for each cowpea variety at 24 h by gas chromatograph (Nucon 5765 Microprocessor controlled gas chromatograph) equipped with a stainless steel column packed with Porapak-Q and a

Flame Ionization Detector. Gas (1 ml) was sampled from gas produced using a Hamilton syringe and injected manually (pull and push method of sample injection) into the gas chromatograph, which was calibrated with standard CH₄ and CO₂. Methane was also measured from blanks and used for correction of CH₄ produced from the inoculum. Methane measured was related to total gas to estimate its concentration (Tavendale *et al.* 2005). Short chain fatty acids (SCFA) were calculated using 24 h gas production (Getachew *et al.* 2002), while the partition factor (PF) and microbial mass (MBM) were estimated as described by Blummel *et al.* (1997).

Statistical analysis: Data from *in vitro* and *in vivo* experiments were subjected to analysis of variance of SPSS 17.0 in a CRD using model

$$Y_{ijk} = \mu + s_i + \hat{a}_{ijk}$$

where, Y_{ij}, individual observation; μ, population mean; s_i, variety effect (i =1–4) and \hat{a}_{ij} , residual error used to test the variety variability for different nutritional traits. Duncan's multiple range test was carried out to determine significant differences for chemical composition, carbohydrate and protein fractions, energy values, nutrients intake and digestibility and nitrogen balance in sheep on different cowpea cultivars at P<0.05 level.

RESULTS AND DISCUSSION

Chemical composition: The DM content of the fresh cowpea fodder during feeding trial was similar and ranged between 13.90–15.55% amongst the varieties (Table 1). The CP, NDF and lignin contents of cowpea fodder varieties differed (P<0.05) and values ranged between 22.23–23.41, 50.54–55.10 and 8.48–10.76%, respectively. Etana *et al.* (2013) reported that CP contents of ten cowpea accessions differed (P<0.05) and ranged between 19.22–22.30% substantiates our findings. Similarly, the CP contents of seven promising cultivars evaluated for three consecutive years (2007–2009) by Bilatu *et al.* (2012) ranged between 22.4–25.5% are similar to our CP values. Our values of CP and OM were within the range of values reported by Ravuhali *et al.* (2011) for CP and OM (19.5–26 and 81.3–88.0%) of four cowpea hay cultivars. On the other hand, CP contents of thirteen cowpea varieties and five genotypes

Table 1. Chemical composition (%DM) of cowpea fodder varieties

Parameter	Kohinoor	BL-1	BL-2	BL-4	Pooled SEM	P value
DM (fresh)	13.90	15.43	15.55	14.67		
OM	85.91	86.10	85.12	86.93	0.321	0.291
Ash	14.09	13.90	14.88	13.07	0.321	0.291
CP	22.98 ^{ab}	22.40 ^a	22.23 ^a	23.41 ^b	0.180	0.002
EE	3.67	3.46	3.35	3.79	0.082	0.226
NDF	50.54 ^a	52.01 ^a	55.10 ^b	54.63 ^b	0.739	0.011
ADF	40.99	33.90	41.18	41.96	1.67	0.327
Cellulose	27.98	24.03	26.63	29.84	1.07	0.310
Lignin	9.51 ^{ab}	8.48 ^a	10.76 ^b	9.60 ^{ab}	0.346	0.081
Hemicellulose	9.56	18.11	13.92	12.67	1.61	0.354

Table 2. Carbohydrate and protein fractions of cowpea fodder varieties

Parameter	Kohinoor	BL-1	BL-2	BL-4	Pooled SEM	P value
<i>Protein fractions (% CP)</i>						
NDIP (% CP)	29.17	34.17	35.64	31.09	1.231	0.251
ADIP (% CP)	10.82	11.46	12.72	10.83	0.420	0.397
NPN (% CP)	18.80	16.57	14.76	25.77	1.94	0.187
SP (% CP)	63.77	65.77	66.39	65.08	0.605	0.564
P _A (% CP)	11.95	10.84	9.80	16.81	1.237	0.177
P _{B1} (% CP)	51.83	54.94	56.59	48.27	1.556	0.262
P _{B2} (% CP)	15.39	8.95	7.87	12.12	1.468	0.290
P _{B3} (% CP)	18.35	22.72	22.91	20.27	1.205	0.594
P _C (% CP)	2.49	2.57	2.83	2.54	0.087	0.612
<i>Carbohydrate fractions</i>						
TCHO (% DM)	59.26	60.23	59.55	59.73	0.244	0.656
SC (% DM)	43.84	44.35	47.18	47.36	0.704	0.118
NSC (% DM)	15.42 ^c	15.88 ^{bc}	12.37 ^a	12.37 ^{ab}	0.765	0.058
Starch (% NSC)	21.96	25.89	32.97	28.83	2.94	0.710
C _C (% TCHO)	38.51 ^{ab}	33.82 ^a	43.38 ^b	38.59 ^{ab}	1.46	0.097
C _A (% TCHO)	40.91	36.18	33.82	33.42	1.95	0.618
C _{B1} (% TCHO)	11.58	12.59	16.40	13.32	1.34	0.724
C _{B2} (% TCHO)	9.00	17.41	6.40	14.67	2.11	0.238

of cowpea fodder recorded by Devasena *et al.* (2009) and Solomon and Kibrom (2014) were relatively lower than CP contents of present study. The contents of OM, EE, ADF, cellulose and hemicelluloses were at par amongst the cowpea fodder varieties. The CP, EE, cellulose and OM contents of cowpea fodder varieties/cultivars reported earlier (Devasena *et al.* 2009) were within the range of values recorded in present study. From three years study of five cowpea fodder genotypes, NDF and ADF ranged between 56.3-60.7 and 47.0-57.2, respectively (Solmon and Kibrom 2014) were more or less similar to our NDF and ADF values while acid detergent lignin (11.6-14.1%) were relatively higher than present results. Mean content of NDF and ADF from seven cowpea varieties in range of 40.7–48.1 and 31.5–38.03% (Bilatu *et al.* 2012) were relatively lower than our results, while the hemicelluloses contents (9.2–13.22%) were within the range of our hemicelluloses values.

Carbohydrate and protein fractions: Crop species, variety, maturity, fertilization, environment condition during crop growth etc are the main factors which influence carbohydrate accumulation in plants (Buxton and Fales 1994). Protein fraction ADIP, SP, P_{B3} and P_C contents were similar among the evaluated cowpea fodder varieties

and ranged between 10.82–12.72, 63.77–66.39, 18.35–22.91 and 2.49–2.83%, respectively (Table 2). NDIN contents were lowest in Kohinoor (29.17) against highest in BL-2 (35.64); while NPN and P_A contents were highest in BL-4 (25.77 and 16.81) against lowest in BL-2 (14.76 and 9.80%), respectively. Total carbohydrate contents of cowpea varieties were similar; while, NSC contents were higher in Kohinoor and BL-1 (15.42 and 15.88% DM). Carbohydrate fractions C_A, C_{BI}, C_{B2} and C_C differed significantly (P<0.05) amongst the cowpea varieties from 33.42–40.91, 11.58–16.40, 6.40–17.41 and 33.82–43.38%, respectively (Table 2). Das *et al.* (2015) reported that TCHO (% DM), NSC (% DM) and SC (% DM) were 71.2, 31.5 and 39.7% which were higher than our values. Starch (% NSC) was marginal higher than our values. Carbohydrate fraction C_{BI} of cowpea (15.7%) reported by Das *et al.* (2015) was within our values while other fractions of carbohydrate were inconsistent with our values. Anele *et al.* (2011a) reported that P_A, P_{B1}, P_{B2}, P_{B3} and P_C protein fractions of commercial and improved cowpea varieties haulms ranged from 100–285, 106–114, 268–223 and 259–196, and 185–342, 140–109, 145–159, 310–218 and 220–172 g/kg CHO, respectively in wet and dry season. The NDIP and ADIP of cowpea hay reported by Gupta *et al.* (2011) was higher than our values and this may be due to higher NDF and ADF contents in hay than green cowpea fodder. On the other hand, SP (% CP) was lower than our values. Protein fractions (P_C, P_{B2} and P_{B3}) in cowpea hay reported by Gupta *et al.* (2011) were higher, while P_A and P_{B1} fractions were lower than cowpea fodder varieties of our study.

Intake, digestibility and energy value: The calculated DMI (% body weight) value of cowpea varieties was higher (P<0.05) for Kohinoor than other cowpea cultivars. The higher calculated DMI for Kohinoor may be due to its lower NDF contents than other cowpea varieties. The DDM, TDN and energy value (Table 3) of evaluated cowpea varieties in terms of DE, ME and net energy efficiency for maintenance (NE_M), growth (NE_G) and lactation (NE_L) were similar amongst the evaluated cowpea fodder varieties. Relatively higher TDN in BL-1 may be the result of 6–7% lower ADF contents recorded for this cultivar. The *IVDMD* in range of 60.1–68.5% of thirteen cowpea varieties was reported by Devasena *et al.* (2009). On the other hand, Bilatu *et al.* (2012) reported that DMD of cowpea varieties ranged

from 69.9–74.0% and the differences were non-significant. Mahala *et al.* (2014) reported that potential dry matter degradability of eight cowpea genotypes varied from 62.2 to 72.1% and differed at P<0.05 level. Babu *et al.* (2016) reported DDM and ME (MJ/kg DM) as 67.09 and 66.3%, and 9.37 and 9.51 MJ/kg DM for cowpea fodder varieties TNFC-0924 and CO (FC) 8, respectively. Pannu *et al.* (2008) reported that TDN contents of CL-367 and C-88 cowpea varieties were 71.7 and 64.9, respectively. Garg *et al.* (2012) reported TDN contents of cowpea variety (EC4216) between 48.76–53.59% which lies within the range of our values.

Gas and methane production: *In vitro* gas and methane production (ml/g DM) was significantly (P<0.05) lower from Kohinoor (86.57 and 10.67), BL-2 (90.79 and 11.40) than BL-1 (104.83 and 13.96) and BL-4 (98.86 and 13.08), respectively (Table 4). This may be due to lower contents of slowly degradable carbohydrate fraction C_{B2} in these cowpea cultivars. Differences in gas and methane production (ml/g DM) recorded for cowpea varieties may be attributed to the variability in their degradability and carbohydrate and protein fractions. Gas and methane production from feeds depend on their degradability and contents of carbohydrates and proteins (Paya *et al.* 2007). Methane is produced due to anaerobic microbial fermentation of fodder/feeds cell wall and cell contents during digestion and metabolism in the rumen. Chemical makeup with pattern and extent of nutrients degradability of a fodder/feed primarily influence methane production. Influence of carbohydrate nature (cellulose, hemicelluloses and soluble residue) and its digestibility on methane production has been reported (Santoso *et al.* 2003).

Short chain fatty acids (SCFA), partition factor (PF) and efficiency for microbial mass production differed significantly (P<0.05) amongst the cowpea varieties; while microbial biomass was at par and ranged from 381.29–417.70 mg/mg amongst the evaluated cowpea cultivars. Higher PF values for Kohinoor, BL-2 and BL-4 resulted in greater microbial mass and efficiency of microbial protein production than BL-1 in present study while such relation

Table 4. *In vitro* gas and CH₄ production, microbial mass and short chain fatty acids of cowpea cultivars (24 h)

Parameter	Kohinoor	BL-1	BL-2	BL-4	SEM	P value
Gas (ml/g)	86.57 ^a	104.83 ^b	90.79 ^a	98.86 ^{ab}	2.32	0.017
CH ₄ (ml/g)	10.67 ^a	13.96 ^b	11.40 ^a	13.08 ^b	0.33	0.000
CH ₄ (ml/g DDM)	17.37 ^a	22.90 ^b	18.44 ^a	21.07 ^b	0.56	0.000
Microbial mass (mg/g DM)	417.03	381.29	417.70	415.02	7.23	0.217
SCFA (mmol/g DM)	2.04 ^{ab}	2.32 ^b	2.01 ^a	2.07 ^{ab}	0.051	0.118
PF (mg DDM/ml)	6.77 ^b	5.87 ^a	6.99 ^b	6.74 ^b	0.159	0.054
EMBP (mg/mg)	0.69 ^b	0.62 ^a	0.68 ^b	0.65 ^{ab}	0.008	0.010

Table 3. Digestible dry matter and energy value of cowpea fodder cultivars

Parameter	Kohinoor	BL-1	BL-2	BL-4	Pooled SEM	P value
DDM (%)	56.97	62.49	56.82	56.21	1.30	0.327
TDN (%)	51.60	60.83	51.36	50.34	2.18	0.326
DE (kjoules/g)	9.53	11.21	9.45	9.28	0.40	0.325
ME (kjoules/g)	7.82	9.20	7.78	7.61	0.33	0.338
NE _L (kjoules/g)	4.77	5.73	4.77	4.64	0.23	0.47
NE _M (kjoules/g)	5.73	6.86	5.69	5.56	0.26	0.319
NE _G (kjoules/g)	2.05	3.14	2.01	1.88	0.26	0.319

was not recorded by Anele *et al.* (2011b) with cowpea haulms. Our results confirm that higher PF to translate to greater microbial mass as PF is the measure of efficiency of microbial production. Higher SCFA value recorded for BL-1 is consistent with previous report that microbial mass and SCFA are inversely related (Hungate 1966). It may be that BL-1 partitioned more energy into SCFA than microbial mass in present study.

Nutrients intake and digestibility: Dry matter intake of a feed/ fodder/diet governs its nutrients availability to animal for health, growth and reproduction (NRC 2001). The DMI (% body wt and g/kg W^{0.75}) of sheep from cowpea fodder cultivars was comparable and varied from 3.08–3.25% and 63.99–67.35, respectively (Table 5) among dietary groups. The DMI of 3.53 and 3.16% for cowpea fodder varieties TNFC-0924 and CO (FC) 8, respectively reported by Babu *et al.* (2016) substantiates our intake values. The DM, Ash, N and cell wall contents of any fodder/feed explain 0.70 of the variation in their intake (Meissner and Esterhuysen 1993). The comparable DCP and ME intake of sheep on cowpea fodder varieties is probably due to similar CP and ME contents of varieties along with their similar dry matter intake. Lambs on all the cowpea fodder varieties had similar DM, OM, CP and cellulose digestibility. Digestibility of NDF and ADF was lower (P<0.05) in sheep on BL-4 (63.88 and 61.70%) than BL-2 (72.67 and 70.55), respectively. This is probably due to lower (P>0.05) contents of lignin bound carbohydrate CC

in BL-4 than BL-2 cultivar. Further, the TDN contents of BL-4 are lower than BL-1 which further supports these observations on cell wall digestibility. Pannu *et al.* (2008) reported that DM and CP digestibility of two cowpea varieties CL-367 and C-88 was 77.0 and 66.5, and 86.5 and 75.9%, respectively and these values of DM and CP digestibility are within the range of our results. The DM, CP, NDF and ADF digestibility of cowpea fodder in sheep was 68.66, 75.78, 67.35 and 63.95%, respectively (Nasrullah *et al.* 2013).

Nitrogen balance and nutritive value: Sheep had similar N intake on tested cowpea fodder varieties which ranged between 21.05–23.53 g/d among dietary groups. Faecal N excretion in sheep was higher (P<0.05) on BL-4 (3.62) than BL-1 (2.47 g/d), while urinary N excretion was similar among dietary groups. Sheep nitrogen balance was identical on all the cowpea varieties and ranged between 16.92–18.32 g/d (Table 6). This is probably due to similar CP contents and dry matter intake from evaluated cowpea varieties in lambs. Nutritive value of cowpea varieties as DCP, DE and ME contents was comparable and ranged between 18.36–20.30%, 13.63–14.72 and 11.21–12.09 kJoules/g DM, respectively. Pannu *et al.* (2008) reported DCP contents of CL-367 and C-88 cowpea varieties as 16.8 and 13.1%, respectively. Garg *et al.* (2012) reported that ME contents of cowpea variety (EC4216) ranged between 7.20–8.10 MJ/kg which were marginally lower than our values. Babu *et al.* (2016) reported ME (MJ/kg DM) as 9.37 and 9.51 MJ/kg DM for cowpea fodder varieties TNFC-0924 and CO (FC) 8, respectively in sheep was at par with ME values of our cowpea fodder varieties.

Results showed that nutritive value of cowpea varieties was similar for *in vitro* and *in vivo* parameters except for CP, NDF, NSC%DM, gas production, methane production, partition factor, short chain fatty acids and cell wall digestibility (NDF and ADF). Based on *in vitro* and *in vivo* results, overall Kohinoor and BL-1 were superior to BL-2 and BL-4 cultivars.

Table 5. Nutrients intake and digestibility of cowpea varieties in sheep

Parameter	Kohinoor	BL-1	BL-2	BL-4	Pooled SEM	P value
Animal wt (kg)	19.70	18.68	19.44	20.06	0.453	0.722
Nutrients intake						
DMI (g/d)	602.50	604.24	579.11	621.67	19.39	0.911
DMI (% body wt)	3.11	3.25	3.08	3.11	0.137	0.978
DMI (g/kg W ^{0.75})	65.28	67.35	63.99	65.76	2.62	0.980
MEI (kJoules/d)	7084.08	7306.59	6901.51	6947.09	228.22	0.936
MEI (kJoules/766.44 kg W ^{0.75})	814.66	814.66	761.14	735.96	31.34	0.865
CP intake (g/d)	139.10	134.84	131.60	147.06	3.53	0.756
DCP intake (g/d)	119.41	117.04	113.21	124.44	4.36	0.657
Nutrients digestibility (%)						
DM	74.03	75.96	74.99	69.86	1.07	0.198
OM	75.71	77.44	76.50	71.36	1.01	0.144
CP	86.03	86.79	86.31	84.64	0.68	0.739
NDF	69.03 ^{ab}	70.97 ^{ab}	72.67 ^b	63.88 ^a	1.37	0.083
ADF	65.17 ^{ab}	61.49 ^a	70.55 ^b	61.70 ^a	1.36	0.033
Cellulose	77.10	74.53	76.64	71.52	1.25	0.403

Mean with different superscripts within rows differ at P<0.05.

Table 6. Nitrogen balance and nutritive value in sheep fed cowpea fodder varieties

Parameter	Kohinoor	BL-1	BL-2	BL-4	Pooled SEM	P value
Nitrogen balance						
N intake (g/d)	22.25	21.58	21.05	23.53	0.70	0.655
Faecal N (g/d)	3.15	2.47	2.94	3.62	0.21	0.284
N-retention (g/d)	19.11	19.10	18.11	19.91	0.62	0.813
Urinary-N (g/d)	1.62	1.62	1.19	1.59	0.10	0.412
N-absorption (g/d)	17.48	17.48	16.92	18.32	0.59	0.891
N-absorption (% TN)	78.83	80.65	80.38	77.89	0.94	0.725
Nutritive value						
DE (kJoules/g)	14.37	14.72	14.54	13.63	0.19	0.197
ME (kJoules/g)	11.80	12.08	11.94	11.19	0.16	0.194
DCP (%)	19.87	19.36	19.68	20.03	0.18	0.628

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