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Gram Screenings as Potential Feed Ingredient in the Ration of Pulikulam Cattle

K. Arivumani, V. Chinnamani*, G.. Srinivasan and S. Meignanalakshmi,
Tamil Nadu Veterinary and Animal Sciences University, Chennai- 600 051
* Correspondence: valliviba@yahoo.co.in

ABSTRACT

Black gram, green gram and red gram screenings were evaluated for their proximate composition, fibre fractions and mineral content. The *in vitro* gas production and IVADMD of the screenings were determined using Pulikulam cattle rumen liquor. Black gram (17.5 ± 1.09%) and red gram (18.6 ± 1.91%) screenings had significantly (P< 0.05) higher crude protein. Significantly (P<0.05) higher NDF (56.2 ± 1.20%), ADF (39.6 ± 0.89%), cellulose (25.6 ± 0.29%) and lignin (13.0 ± 0.92%) were present in black gram screenings. Significantly (P<0.01) higher Ca (0.59 ± 0.00 %), Na (0.02 ± 0.00 %), K (0.93 ± 0.00 %), Zn (41.3 ± 0.17 ppm) and Se (0.14 ± 0.00 ppm) was present in red gram screenings. At both 24 and 48 hours of incubation green gram screenings documented significantly (P<0.01) higher total gas production than black gram screenings and red gram screenings. Both red gram and black gram screenings at both 24 and 48 hours of incubation had significantly (P<0.01) lower methane production compared to green gram screenings. Black gram and red gram screenings are locally available in the Pulikulam cattle breeding tract and hence can serve as supplemental feed ingredients in Pulikulam cattle ration.

KEY WORDS: Black gram, Green gram, Gram screenings, Proximate composition Pulikulam cattle, Red gram

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INTRODUCTION

In India, pulses are generally produced in poor soils not suited to other crops, with a minimum use of resources and have a very low water footprint. In India, out of the total net sown area of 141.40 million hectares, 52 per cent i.e., 73.20 million hectares is rainfed and pulse cultivation occupies a major area under this ecology (Tiwari et al., 2019). In Tamil Nadu alone the gross total area under pulses ranges from 3.97 to 7.85 lakh hectares per and the average production of total pulses in the state ranged between 1.01 lakh tonnes to 3.37 lakh tonnes per annum (Sangeetha et al., 2020). Large quantities of pulse screenings, to the extent of 3 million tonnes per annum are available as waste, while processing the pulses in the mills in India (Ravi kumar, 1999). Pulse screenings consists of broken pieces of seed coat, germ and small pieces of broken cotyledons and is obtained during the processing of pulses in the preparation of dals for human consumption (NDDB, 2012) and it constitutes15-20 per cent of the total weight of pulses (Reddy et al., 2000). Despite availability in large quantities, pulse screenings are not efficiently used for livestock feeding (Kunja et al*.,* 2023). Pulikulam cattle is a popular draught and game breed of Tamil Nadu, India, these cattle are reared by nomadic rearers following low or zero input system of management. The herd size of the Pulikulam cattle was reported to be decreasing during last 2 to 3 decades mainly due to the shrinkage in grazing land (Singh et al., 2012), sustainable measures for the improvement and conservation of Pulikulam breed is highly essential. Adoption of balanced feeding could improve the performance of this breed, some farmers feed homemade concentrate mixture comprising of rice bran, oilcake locally available grains and gram dust (Srinivasan et al., 2021). The gram dust used by the farmers were locally sourced from mills processing red gram, green gram and black gram. To utilise gram screenings more effectively as feed for Pulikulam cattle it is essential to evaluate their composition and determine their potential in mitigating enteric methane emissions

MATERIALS AND METHODS

Samples (six in duplicate) of the gram screenings predominantly available in the Southern agroclimatic zone of Tamil Nadu, the breeding tract of Pulikulam cattle, were collected and brought to the laboratory for further processing and analysis. The moisture content of the samples was estimated as per AOAC (2019) and the samples were dried to a constant weight using a hot air oven at a temperature of 105°C. The samples were ground to pass through 1 mm sieve and stored in airtight containers for further analysis. The samples were analysed for proximate principles *viz.,* crude protein (CP), crude fibre (CF), ether extract (EE), total ash (TA) and nitrogen free extractives (NFE) as per AOAC (2019). The fibre fractions *viz.,* neutral detergent fibre (NDF), acid detergent fibre (ADF) hemicellulose, cellulose and lignin content of the samples were estimated as per the method described by Goering and Van Soest (1970). The major minerals (Ca, P, Na and K) and trace minerals (Zn, Cu and Se) present in the samples were estimated as per AOAC (2012) using Atomic Absorption Spectro photometer (AAS) model 3510.

The Hohenheim gas production technique as per the procedure of Menke et al. (1979) was adopted to determine total gas production, carbon dioxide, methane, *in vitro* pH and *in vitro* apparent digestibility of dry matter (IVADMD). The rumen liquor required for the experiment was obtained from Pulikulam cattle reared in Pulikulam Cattle Research Station, a constituent unit of Tamil Nadu Veterinary and Animal Sciences University, Tamil Nadu, India. The dried and ground samples (200 mg) were loaded in the 100mL glass syringes. The piston was lubricated with Vaseline. The glass syringes were pre warmed at 40°C, prior to the addition of inoculum. Twenty mL of buffer and 10mL of rumen liquor were then loaded into the 100mL syringes containing the respective substrates. The syringes were then incubated in a water bath shaker at temperature of 39°C for 24 and 48 hours. To ensure blank correction syringes with only buffer and rumen liquor were incubated at the same conditions. Total gas production was recorded at 24 and 48 hours incubation. The net gas volume at each incubation period for the respective samples were calculated by subtracting the gas production from blanks. The total gas production in the syringe was partitioned as carbon dioxide and methane. Methane concentration was estimated (Sitaula et al., 1992) using Gas chromatography fitted with Flame Ionization Detector (FID) and capillary column (30-meter length and 250 micrometre diameter). The incubation was terminated at chosen time (24 or 48 hours) using mercuric chloride. *In vitro* apparent digestibility of dry matter (IVADDM) was determined as per Blummel et al. (1997).

Data were analysed with analysis of variance (ANOVA) and linear regression analysis using IBM® SPSS® Statistics version 20.0 for Windows® software as per the Snedecor and Cochran (1989). The critical difference between the groups was analysed by Duncan's multiple range test.

RESULTS AND DISCUSSION

The proximate composition, fibre fractions, major and trace minerals in gram screenings determined in the study is presented in table 1. Among the short-listed gram screenings, black gram (17.6 ± 1.09%) and red gram (18.6 ± 1.91%) screenings had significantly ($P < 0.05$) higher crude protein compared to green gram screenings (6.99 ± 0.71%). Crude fibre was significantly ($P < 0.05$) higher in black gram screenings (18.29 ± 1.68%) but it was comparable to green gram screenings (17.55 ± 1.95%). Green gram screenings (59.14 ± 2.03%) and red gram screenings (58.65 ± 3.13%) had the significantly ($P<0.05$) higher NFE. Variations in the composition of gram screenings was evident between that observed in this study and that reported by other researchers. This can be attributed to genetic variations in the pulse seeds or the variations arising in the milling process of the pulses. The milling of whole pulses, leads to the production of unhusked whole grains, dehusked whole grains, split cotyledons, broken cotyledons, husk and powder. Whole grains are passed again for further dehusking and/or splitting after water treatment. Husk and powder produced during milling is generally separated with the help of aspiration and this forms the gram screenings or lentil screenings and they may consist of whole and broken lentils, cereal grains, weed seeds, chaff and dust (Stanford et al., 1999). Verma et al. (2022) had reported that pulse recovery of mung bean and its byproduct was found to vary according to cultivar. The by-product comprised of husk and broken seeds which was retained in 1 mm sieve size, the smallest size byproduct fraction was that that passed through 0.125 mm sieve. The upper two fractions mainly husk and broken seeds, were rich in fiber, and the finest fraction the cotyledon powder, was rich in proteins. All fractions of byproducts are either used separately or together in certain ratios. Hence depending on the ratio of byproducts the composition of gram screenings will vary.

Table 1 Proximate composition, fibre fractions, major and trace minerals in gram screenings

Parameters	Black gram	Green gram	Red gram
Dry matter (%)	92.1 ± 0.8	92.5 ± 0.91	93.8 ± 1.03
Crude protein (%)	$17.5^{b} \pm 1.09$	$6.99^{a} \pm 0.71$	$18.6^{b} \pm 1.91$
Crude fibre (%)	$18.3^{b} \pm 1.68$	$17.5^{b} \pm 1.95$	$15.01^{a} \pm 2.01$
Ether extract (%)	1.75 ± 0.28	1.29 ± 0.19	2.01 ± 0.97
Total ash (%)	$6.94^{b} \pm 0.64$	$3.94^{a} \pm 0.15$	$5.85^{b} \pm 0.91$
NFE (%)	$55.6^{a} \pm 1.08$	$59.1^{b} \pm 2.03$	$58.6^{b} \pm 3.13$
NDF (%)	$56.3^{b} \pm 1.2$	$46.4^{a} \pm 1.03$	$44.8^{a} \pm 0.43$
ADF (%)	$39.6^{b} \pm 0.89$	$31.4^{a} \pm 1.1$	$28.30^{a} \pm 0.91$
Cellulose (%)	$25.7^{c} \pm 0.29$	$23.6^{b} \pm 0.59$	$20.8^{a} \pm 0.91$
Hemicellulose (%)	16.6 ± 1.01	15.6 ± 0.23	16.91 ± 0.39
Lignin (%)	$13.05^{b} \pm 0.92$	$7.43^{a} \pm 0.58$	$6.61^{a} \pm 0.83$
Ca (%)	$0.57^{b} \pm 0.00$	$0.40^{a} \pm 0.00$	$0.59^{c} \pm 0.00$
P (%)	$0.27^{a} \pm 0.00$	$0.35^{b} \pm 0.00$	$0.34^{b} \pm 0.01$
Na (%)	$0.02^{b} \pm 0.00$	$0.01^{a} \pm 0.00$	$0.02^{c} \pm 0.01$
K (%)	$0.81^{b} \pm 0.00$	$0.59^{a} \pm 0.00$	$0.93^{c} \pm 0.00$
Zn (ppm)	$35.7^{b} \pm 0.11$	$28.9^{a} \pm 0.02$	$41.3^{c} \pm 0.17$
Cu (ppm)	$12.3^{c} \pm 0.31$	$9.00^{b} \pm 0.00$	$5.24^{a} \pm 0.02$
Se (ppm)	$0.11^{b} \pm 0.00$	$0.09^{a} \pm 0.00$	$0.14^{c} \pm 0.00$

Mean of four observations.
Mean values bearing different alphabetical superscript within column differ significantly ($p< 0.01$)

Significantly ($p<0.05$) higher NDF (56.2 ± 1.20%), ADF (39.6 ± 0.89%), cellulose (25.6 ± 0.29%) and lignin (13.0 ± 0.92%) were present in black gram screenings. Hemicellulose content was found not to vary significantly ($p<0.05$) between the gram screenings studied. The values for NDF, ADF, hemicellulose, cellulose and lignin in black gram screenings of the present study was higher than that reported respectively for these fractions (48.2 ± 1.10, 37.4 ± 1.23, 10.8 ± 0.28, 26.5 ± 0.57 and 9.64 ± 0.73 per cent) by Arulnathan et al. (2013). Sreerengaraju et al. (2000) however reported higher values for NDF (76.0), ADF (65.2) and lower value for lignin (6.10) in black gram screenings. NDF, ADF, cellulose and lignin were higher and hemicellulose lower than that reported (35.0, 17.4, 17.5, 13.4 and 3 % respectively for NDF, ADF, cellulose, hemicellulose and lignin) by Swain et al. (2016). With regard to green gram screenings the values for NDF and ADF reported in the present study was lower than that reported (54.6 and 49.9% respectively) by Neeta Chopra (2012). But was comparable with the values reported (NDF - 46.4, ADF - 22.7, HC - 23.7, Cellulose - 17.4 and Lignin - 4.2%) by Swain et al.

(2016) in green gram screenings, NDF was similar, ADF, cellulose and lignin were higher and hemicellulose was lower in the present study. In red gram screenings, Swain et al. (2016), reported similar NDF (46.6%), higher ADF (32.4%), cellulose (29.9%), hemicellulose (14.14%) and lower lignin (2.49%) than that reported in the present study. The variations in the observed versus reported fibre fractions in gram screenings could be attributed to the differences in variety or strain of the grams, stage of harvest, maturity and the proportion of pulse contained in the screenings (Patel, 1961). The presence of dried leaves and proportion of pods and broken pulses (Kernels) in the samples (Arulnathan et al., 2013) also might have contributed to the variation in fibre fractions.

Significantly (P<0.01) higher Ca (0.59 ± 0.00 %), Na (0.02 ± 0.00 %), K (0.93 ± 0.00 %), Zn (41.3 ± 0.17 ppm) and Se (0.14 ± 0.00 ppm) was present in red gram screenings. Both green gram and red gram screenings had significantly (p<0.01) higher P than black gram screenings. The calcium, phosphorus, copper and zinc content in the black gram screenings in the present study was well within the range reported by Arulnathan et al. (2013) *viz.*, Ca - 0.42 and 0.68, P - 0.21 and 0.33, Cu -12.26 and 14.84 ppm and Zn - 31.86 and 44.69 ppm. The Calcium and P content of green gram screening was similar to that reported by Bora and Kulshrestha (2015), *viz.,* 400 and 356 mg/100g. The calcium and phosphorus, content in the black gram, green gram and red gram screenings documented in this study was much lower than that reported by Swain et al. (2016). The variations observed among the minerals reported in the present study in comparison with that reviewed from earlier studies could be attributed to the mineral profile of the soil, level of fertilizer and manure application to the pulse crop (Patel, 1961).

At both 24 and 48 hours of incubation green gram screenings documented significantly (p<0.01) higher total gas production than black gram screenings and red gram screenings. Both red gram and black gram screenings at both 24 and 48 hours of incubation had significantly (p<0.01) lower methane production compared to green gram screenings. Black gram screenings contain total tannins to the tune of 3.67 per cent (Arulnathan et al., 2013) and the polyphenolic nature of this tannins along with high molecular weight of tannins results in the formation of complexes with rumen microbial enzymes or rumen microbial cell walls, which causes the inhibition of cellulolytic bacteria, proteolytic bacteria and methanogens (Mannelli et al., 2019 and McSweeney et al., 2001) resulting in lower methane production. Raw pulse extracts were reported to be high in flavonoid content and among them red gram was the pulse that had the highest flavonoids (Thummakomma and Meda, 2017). Patra et al. (2006) have indicated that plant extracts containing flavonoids could decrease the methane production. The values reported for *in vitro* rumen pH for gram screenings at both 24 and 48 hours in the present study coincided with the earlier reports of Sudhakara Reddy et al. (2002) and Arulnathan et al. (2013), for black gram screenings and with that of Radhakrishna et al. (2002) for green gram screenings. The mean *in vitro* rumen pH value for all shortlisted agro-industrial wastes studied, at both 24 and 48 hours of incubation was above 6.20. This value is considered as excellent for the development of ruminal bacteria, mainly cellulolytic bacteria (*Fibrobacter succinogenes*, *Ruminococcus albus* and *Ruminococcus flavefaciens*), which favours the digestion of fiber component of the diet (Van Soest, 1994).

At both 24 and 48 hours of incubation red gram screenings had the significantly (p<0.01) highest IVADMD (Table 2).The IVADMD for black gram screenings was significantly lower at both 24 and 48 hours of incubation. The presence of high level of total tannins in the raw husk (Arulnathan et al., 2013) could be attributed as the reason for the low IVADMD of black gram screenings. The possible inhibition of the activity of rumen microbes due to high level of tannins (Makkar et al., 1988) and reduced availability of nitrogen and amino acids required for rumen microbial growth (Reed, 1995) might have also resulted in the low IVADMD. Sreerengaraju et al. (2000) had reported that black gram husk contained 8.4 per cent tannin and this tannin was responsible for preventing nearly 21% of potentially digestible substrate from rumen fermentation. Moreover, black gram screenings in this study also had high level of lignin (13.08%). Lignin is a complex structural polymer that is resistant to microbial degradation, and its deposition in plant cell walls can make the cellulose and hemicellulose components of the cell wall less accessible to rumen microbial enzymes, which can reduce the efficiency of rumen fermentation (Damiran et al., 2023) and reduce the IVADMD.

Table 2. *In vitro* gas production, pH and IVDMD of gram screenings using rumen liquor from Pulikulam cattle (Mean* ± SE)

Parameters	Incubation hours	Black gram	Green gram	Red gram
Total gas (ml/200mg DM)	24**	$13.8^{a}\pm 2.59$	$22.6^{b}\pm 2.13$	$18.6^{ab}\pm 2.03$
	48**	$24.7^{a}\pm 3.81$	$42.6^{c}\pm 1.76$	$24.0^{a}\pm 2.31$
Carbon dioxide (ml/200mg DM)	24**	$9.65^{a}\pm 1.88$	$13.5^{a}\pm 1.22$	$12.9^{a}\pm 0.55$
	48*	$15.0^{abc}\pm 1.81$	$21.1^{cd}\pm 1.37$	$14.4^{ab}\pm 0.27$
Methane (ml/200mg DM)	24**	$4.18^{a}\pm 0.77$	$9.06^{b}\pm 0.99$	$5.80^{a}\pm 1.61$
	48**	$9.69^{a}\pm 2.00$	$21.5^{c}\pm 3.11$	$9.55^{a}\pm 2.04$
Per cent methane in total gas*	24*	$30.3^{a}\pm 2.22$	$40.0^{b}\pm 1.36$	$30.0^{a}\pm 5.09$
	48*	$38.2^{a}\pm 2.12$	$50.0^{abc}\pm 5.09$	$38.8^{a}\pm 4.84$
CO_2: CH_4	24^{NS}	2.34 ± 0.22	1.50 ± 0.08	2.51 ± 0.52
	48*	$1.64^{c}\pm 0.14$	$1.03^{abc}\pm 0.19$	$1.65^{c}\pm 0.35$
pH	24^{NS}	$6.61^{a}\pm 0.03$	$6.61^{a}\pm 0.03$	$6.94^{bc}\pm 0.04$
	48*	$6.35^{ab}\pm 0.07$	$6.42^{ab}\pm 0.04$	$6.27^{a}\pm 0.03$
IVDMD (%)	24**	$48.6^{a}\pm 2.58$	$56.7^{bc}\pm 2.85$	$62.2^{c}\pm 1.30$
	48**	$59.3^{b}\pm 0.86$	$56.7^{b}\pm 2.08$	$62.2^{c}\pm 1.30$

*Mean of 4 observations
Mean value having different alphabetical superscripts within columns differ significantly (NS Non significant, **P<0.01 *P< 0.05)

CONCLUSION

Black gram and red gram screenings are good source of protein, have high IVADMD and also lower methane production potential. Black gram and red gram screenings are locally available in the Pulikulam cattle breeding tract and hence, can serve as supplemental feed ingredients in Pulikulam cattle ration.

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