



## Evaluation of Byproducts of Some Minor Millets for Chemical Composition, Mineral Profile and *In Vitro* Gas Production Kinetics

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### ABSTRACT

An *in vitro* evaluation of byproducts of selected minor millets by gas production technique followed by an *in vivo* evaluation of browntop millet (*Brachiaria ramosa*) byproduct-based CFM by twelve-week feeding and metabolism trial in sheep was conducted. *In vitro* study revealed that ME(MJ/kg) and IVOMD (%) of browntop (6.81 and 53.95) and little millet (6.81 and 53.09) byproduct were similar; whereas, lower values were found in foxtail (5.04 and 41.70), kodo millet (5.00 and 40.26), proso millet (5.23 and 43.47) and poor in barnyard (2.90 and 30.79). *In vitro* gas production kinetics of Millet-byproducts study revealed that readily soluble fraction 'a' value was not detectable while, insoluble but fermentable fraction "b" was significantly ( $P<0.01$ ) highest (34.87) in Browntop millet and lowest (7.98) in Barnyard millet. Among various minor millet milling byproducts, Browntop and Little millet by products found to be better whereas barnyard is poor in ME and IVDOM.

**KEYWORDS:** Digestibility, *in vitro*, Minor millet byproducts,

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In Indian subcontinent, since last many decades, millets are being grown and consumed traditionally due to their rich source of nutrients to human and their residues as fodder to ruminant livestock. Millets are excellent drought resistant crops where highly stainable under rain fed conditions and therefore millets crops are well suited for contingency crop planning in addition to address the issues of climate change (ICAR-AICRP, 2018). Minor millets have high nutritional value in terms of proteins, vitamins, minerals and fiber. Six species viz., brown top millet (*Brachiaria ramosa*), kodo millet (*Paspalum setaceum*), proso millet (*Panicum miliaceum*), foxtail millet (*Setaria italica*), little millet (*Panicum sumatrense*), and barnyard millet (*Echinochloa utilis*) are grown in Indian subcontinent mainly in mountain and hilly areas, semi-arid areas where soil fertility is poor and rain fall is limited. Several tons of millet byproduct is produced every year in India after thrashing and processing of millets traditionally by the farmers and about 20-30 per cent millet byproduct by processing in the milling industries (Nagaraju, 2017). The millet husks are among the millions of tons of agricultural wastes seeking ways

of disposal (Rosa et al., 2009). Important characteristics of millet husk include biodegradability, lighter weight and cost effectiveness. Hence, in addition to waste disposal, millet byproducts are found to be potential unconventional sources of feed ingredients in providing nutrients as well as producing cost effective livestock feeds for ruminant livestock. However, very limited information pertaining to nutrient composition, intake and utilization of minor millet byproducts as a potential feed resource are available. Therefore, the present study was conducted to evaluate various millet byproducts by *in vitro* gas production technique.

The minor millet milling byproducts comprised millet husk, small quantity of millet bran and broken grains produced during processing of millets grains from six varieties viz., Brown top millet (*Brachiaria ramosa*) (BTMBP) (Korale, Kan), Kodo millet (*Paspalum setaceum*) (KDMBP) (Haraka, kan.), Proso millet (*Panicum miliaceum*) (PSMBP) (Baragau, kan.), Foxtail millet (*Setaria italica*) (FXMBP) (Navane, kan.), Little millet (*Panicum sumatrense*) (LTMBP) (Same, kan.), and Barnyard millet (*Echinochloa utilis*) (BYMBP) (Oodalu,

kan.) were procured from millet processing plant of Shree Kshetra Dharmastala Rural Development Project (SKDRDP), Rayapura of Dharwad district., Karnataka. The byproduct mixture of these millets were ground through a 1-mm sieve by Cyclone sample mill (UDY, Corp., Fort Collins, Colorado, US) stored in airtight polythene bags for further chemical analysis. All the minor millet husks were subjected for chemical composition according to the procedures of AOAC (2016) and fiber fractions (Van Soest et al., 1991). The same were analysed for their mineral composition (Perkin Elmer, Analyst-400). The minor millets husks were subjected for rumen *in vitro* gas production technique (RIVGP) according to Menke and Steingass (1988) to estimate metabolisable energy, *in vitro* digestibility of organic matter and fermentation characteristics. The rumen fluid for *in vitro* gas production test was collected from the cannulated bull weighing 260 kg fed on maintenance ration consisting of concentrate feed mixture (0.75kg with 18% CP and 2600 kcal/kg ME), green super Napier fodder (5 kg twice a day) and *ad lib.* paddy straw. Data of gas kinetics (exponential decay equation model) and the rumen *in vitro* gas production kinetics were subjected to nonlinear regression by GraphPad Prism (version 7.0, La Jolla California USA, 2016).

The proximate composition and fiber fractions of selected minor millet milling byproducts (husk) are presented in Table 1. The DM and OM content of different minor millet milling byproducts were similar to milling products of pearl millet (Tran, 2015),

and sorghum ear husk (Gaur and Taparia, 1991). Whereas, crude protein contents were lower than traditional milling byproducts such as wheat bran and rice bran. The CP content of LTMBP and BTMBP were 8.03 and 7.47 per cent which were similar to CP content of finger millet husk (7.10%) (Tran, 2015) and CP of PSMBP and BYMBP were similar to foxtail millet bran (Kadirvel et al., 1994) but lower than for sorghum ear husk (5.38 %) (Gaur and Taparia, 1991) and oat hulls (5.20 %) Heuze et al. (2016). However, the CP values reported for the byproducts of all the millets recorded higher CP values than CP reported for rice husk (3.25%) by Okoruwa et al., (2012). This indicates that the CP values are at higher levels when compared to any byproducts of conventional cereals.

The higher ether extract (EE) level was noticed in BTMBP (3.34 %) and LTMBP (2.24%) when compared to other millet byproducts (0.23 to 1.35%). The EE content of BTMBP was similar to wheat bran (3.14%) as reported by Dineshkumar et al. (2015) and Heuze et al. (2015). The total ash was reported to be little bit higher in all the six varieties (8.76 to 13.13) of millet milling byproducts, however, the values were lower than the values reported for finger millet husk (17.60%) (Tran, 2015) and for foxtail millet bran (14.50%) (Kadirvel et al. 1994). The minor millet milling byproduct had significant crude fiber composition which is almost similar to any of the cereal hulls and the same is also true with NFE content.

Table 1. Chemical composition and fibre fractions (% DMB) of milling by-product of minor millets

Constituent	BTMBP	LTMBP	FXMBP	KDMBP	PSMBP	BYMBP
DM	89.45	88.37	89.81	92.65	93.61	92.23
OM	87.55	90.92	89.93	91.24	89.66	86.87
CP	7.47	8.03	4.67	4.39	6.05	6.85
EE	3.34	2.24	0.77	1.33	1.35	0.23
CF	24.32	25.01	31.32	24.53	34.00	40.78
TA	12.45	9.08	10.07	8.76	10.34	13.13
AIA	7.23	4.57	5.64	4.26	6.56	8.66
NFE	52.43	55.66	53.18	60.99	48.25	39.02
NDF	75.96	62.39	76.42	70.80	68.54	89.64
ADF	45.04	47.43	48.75	40.76	43.17	59.57
Hemicellulose	30.92	15.36	27.67	30.04	25.37	30.07
Cellulose	31.29	31.16	30.15	29.27	23.34	39.27
ADL	6.35	10.06	11.81	8.64	14.02	13.06

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The NDF contents were ranging from 62.39 % (LTMBP) to 89.64 per cent (BYMBP) and The ADF content (%) ranged from 40.76 (KDMBP) to 59.57 (BYMBP). These values were comparable to various cereal husks (Gaur and Taparia, 1991; Okoruwa et al., 2012; Akinfemi and Ayoade, 2017). The cellulose (%) and hemicellulose (%) contents of BTMBP, LTMBP, FXMBP, KDMBP, PSMBP and BYMBP were 31.29 and 30.92; 31.16 and 15.36; 30.15 and 27.67; 29.27 and 30.04; 23.34 and 25.37; 39.27 and 30.07 respectively. The ADL (%) of

different minor millet milling byproducts ranged from 6.35 per cent (BTMBP) to 14.02 per cent (PSMBP).

The calcium and phosphorus contents (g/kg DM) of BTMBP, LTMBP, FXMBP, KDMBP, PSMBP and BYMBP were 12.37 and 9.28, 13.12 and 9.57, 12.91 and 10.04, 14.07 and 8.66, 13.22 and 9.09, 16.47 and 6.73 respectively. The calcium and phosphorous levels were far higher than the milling byproducts of other major millets (Mopate et al., 2011; Heuze and Tran, 2015)

Table 2. Mineral composition of milling by-products of minor millets

Particular	Ca	P	Na	K	Mg	Co	Cu	Fe	Mn
	%				mg/kg				
BTMBP	1.24	0.93	0.010	0.59	0.24	2.47	9.01	243.10	40.11
LTMBP	1.31	0.96	0.014	0.64	0.23	1.97	8.89	238.10	36.20
FXMBP	1.29	1.00	0.019	0.50	0.29	2.09	12.50	216.08	38.79
KDMBP	1.41	0.87	0.013	0.56	0.30	1.86	8.70	208.79	35.52
PSMBP	1.32	0.91	0.017	0.65	0.29	2.45	9.95	217.86	42.45
BYMBP	1.65	0.67	0.013	0.86	0.31	3.03	7.78	239.77	41.06

The potassium, magnesium, cobalt, copper, iron and manganese for minor millet milling byproducts noticed in this study were similar to the values reported for brans of various cereals (Buerkert et al., 2001; Mopate et al., 2011).

The chemical composition of minor millet byproducts indicated that the fiber content and acid detergent lignin content were significantly of very high level. This was suggestive of these byproducts do not fall strictly under concentrate ingredient category. Due to this fact, the ME value calculated from *in vitro* gas production values using formulae prescribed for concentrates, roughages and also formula for combined category. Among the three formulae, the one used for roughages found to be more appropriate.

The ME values of byproducts were significantly different where BTMBP (6.81 MJ/kg) and LTMBP (6.81 MJ/kg) were similar to ME content of MTH (7.91 MJ/kg), whereas PSMBP (5.23), FXMBP (5.04 MJ/kg) and KDMBP (5.00 MJ/kg) had low ME content. Among all the byproducts, BYMBP (2.90 MJ/kg) was found to be very poor in ME content. BYMBP showed lesser gas production and ME values which might be due to higher levels of acid detergent lignin, crude fiber and lower level of EE and NFE. Akinfemi and Ayoade (2017) reported that RIVGP and ME values for maize husk were 15 ml and 5.39 (MJ/kg DM) respectively.

Table 3. Rumen *in vitro* gas production (ml/200mg DM) at 24 hours, ME (MJ/kg DM) and IVODM of CFM and by product of minor millets

Particular	24 h Total Gas (ml/200mgDM)	ME, MJ/kg DM			IVDOM, %
		A	b	C	
BTMBP	31.06 <sup>d</sup> ±0.25	6.29 <sup>d</sup> ±0.04	6.81 <sup>d</sup> ±0.04	7.05 <sup>d</sup> ±0.04	53.95 <sup>e</sup> ±0.22
LTMBP	32.28 <sup>d</sup> ±0.36	6.56 <sup>c</sup> ±0.06	6.81 <sup>d</sup> ±0.05	7.02 <sup>d</sup> ±0.05	53.09 <sup>e</sup> ±0.32
FXMBP	20.43 <sup>bc</sup> ±0.34	4.01 <sup>b</sup> ±0.05	5.04 <sup>b</sup> ±0.05	4.72 <sup>b</sup> ±0.05	41.70 <sup>c</sup> ±0.31
KDMBP	19.91 <sup>b</sup> ±0.34	4.14 <sup>b</sup> ±0.05	5.00 <sup>b</sup> ±0.04	4.75 <sup>b</sup> ±0.05	40.26 <sup>b</sup> ±0.30
PSMBP	21.52 <sup>c</sup> ±0.35	4.41 <sup>c</sup> ±0.05	5.23 <sup>c</sup> ±0.04	5.11 <sup>c</sup> ±0.04	43.47 <sup>d</sup> ±0.31
BYMBP	4.82 <sup>a</sup> ±0.16	1.38 <sup>a</sup> ±0.03	2.90 <sup>a</sup> ±0.02	2.48 <sup>a</sup> ±0.02	30.79 <sup>a</sup> ±0.14

\* Means bearing different superscripts (a,b,c,d) within the columns differ significantly (P<0.01)

IVDMD (%) was found to be higher in BTMBP (53.95) and LTMBP (53.09) as compared to PSMBP (43.47), FXMBP (41.70), KDMBP (40.26) and least in BYMBP (30.79). As the IVDOM values increased the gas production also increased and the ME values calculated based on all three equations followed the same trend where the millet byproducts which had higher IVDOM had higher values of ME. The IVDOM also directly correlated to the content of lignin in the by-products, the byproducts which had lower level of lignin had higher IVDOM values. Akinfemi and Ayoade. (2017) reported lower IVDOM value for maize husk (33.22 %) than the values reported for all byproducts except BYMBP. The 'a' values were negative in the present study (Table 3) for these minor millet byproducts indicating the fraction which could not be measured with non-linear equation used for various parameters of *in*

*vitro* gas kinetics (Blümmel,1994) and do not have any biological meaning -described by Krishnamoorthy et al. (1995). Similarly, 'b' values varied significantly (P<0.01) among various minor millet byproducts with higher values ranged from 34.87 (BTMBP) to 7.98 (BYMBP). Low level of 'b' values was due to higher levels of AIA, cellulose and ADL. The results also indicated that among various minor millet milling byproducts, BTMBP and LTMBP had higher fermentable fraction which was potential to provide higher ME values whereas FXMBP, KDMBP & PSMBP were medium and lowest in BYMBP in providing fermentable fraction. Akinfemi and Ayoade (2017) reported wide variations in the fermentation of the insoluble but degradable fractions (b, ml) with values ranging from 13 (UNMH) to 27.33 (PPMH).

Table 4. Kinetics of gas production of byproducts of minor millets as determined by *In vitro* Gas Production

Feed sample	96h Total Gas (ml/200mgDM)	a	b	D	k	t <sub>1/2</sub>
BTMBP	36.77 <sup>e</sup> ±0.7	-3.22 <sup>b</sup> ±0.2	34.87 <sup>d</sup> ±1.1	31.65 <sup>e</sup> ±1.3	0.082 <sup>bc</sup> ±0.0	8.66 <sup>bc</sup> ±0.6
LTMBP	33.46 <sup>d</sup> ±0.3	-6.36 <sup>a</sup> ±0.4	34.64 <sup>d</sup> ±0.9	28.29 <sup>d</sup> ±0.9	0.113 <sup>d</sup> ±0.0	6.37 <sup>a</sup> ±0.5
FXMBP	26.44 <sup>c</sup> ±0.3	-0.98 <sup>c</sup> ±0.1	24.83 <sup>c</sup> ±0.4	23.85 <sup>c</sup> ±0.4	0.072 <sup>b</sup> ±0.0	9.72 <sup>c</sup> ±0.4
KDMBP	24.25 <sup>b</sup> ±0.2	-2.04 <sup>c</sup> ±0.2	22.89 <sup>b</sup> ±0.5	20.85 <sup>b</sup> ±0.6	0.097 <sup>cd</sup> ±0.0	7.35 <sup>ab</sup> ±0.5
PSMBP	23.42 <sup>b</sup> ±0.4	-1.89 <sup>c</sup> ±0.2	22.35 <sup>b</sup> ±0.4	20.46 <sup>b</sup> ±0.6	0.119 <sup>d</sup> ±0.0	6.21 <sup>a</sup> ±0.6
BYMBP	8.13 <sup>a</sup> ±0.4	-0.95 <sup>c</sup> ±0.1	7.98 <sup>a</sup> ±0.4	7.03 <sup>a</sup> ±0.3	0.043 <sup>a</sup> ±0.0	15.12 <sup>d</sup> ±0.8

a- Rapidly produced gas (ml/200mg DM); b- gas volume from the insoluble but fermentable fraction (ml/200mg DM); D- potential gas production (ml/200mg DM); k- rate of gas production/h; t<sub>1/2</sub>- time at half asymptotic gas production. Means bearing different superscripts within the columns differ significantly (P<0.01)

Among minor millet byproducts, D value ranged from 7.03 (BYMBP) to 31.65 (BTMBP). Fidriyanto et al. (2020) reported that there were reductions in gas production potential (D value/200 mg) from 111.37 ml to 28.16 ml in determining fermentation characteristics of rice bran with various levels of rice husk as the level of rice husk was increased.

Among the minor millet byproducts, the rate gas production (k, h<sup>-1</sup>) values were comparable with BTMBP (0.0822), FXMBP (0.0722). The values were significantly lower for BYMBP (0.0433). However 'k' values were significantly higher for KDMBP (0.0976), LTMBP (0.1135) and PSMBP (0.1191). Although the 'k' values were high for KDMBP, LTMBP and PSMBP, the overall gas production, ME and IVDOM values significantly low in minor millet byproducts which did not reflect in terms of ME and IVDOM indicating that these minor millet milling byproducts are energetically poor and less digestible. The time at half asymptotic gas production 't<sub>1/2</sub>' value is an indicative of time to reach peak gas production or time taken to reach 50 per cent of the total fermentation of organic matter. In the present study, BTMBP (8.658) and FXMBP (9.718), had taken similar time as compared to other minor millets. Further BYMBP (15.12) took maximum time to attain half asymptotic gas production level while LTMBP (6.368), PSMBP (6.211) registered shortest time to attain half asymptotic gas production level. However, gas production kinetic parameters did not reflect on energetic worth of the feed ingredients and also potential digestibility value in the present study.

## CONCLUSION

Chemical composition of minor millet milling by products appears to be comparable with traditional crop residues. *In vitro* study revealed that among various minor millet milling byproducts, brown top and little millet by products found to be better whereas barnyard is poor in ME and IVDOM.

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