Original Research

Chemical Composition and Macro and Micro Mineral Profile of Crop Residues Based Livestock Feed Ingredients in the Gangetic Plains of Varanasi, India

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Abstract

Analysis of nutrient composition in terms of chemical constituents and macro and micro mineral profile of crop residues used in livestock feeding in dairy farms of Varanasi was performed so as to explore the suitable nutritional intervention for optimum and efficient utilization of these crop residues for maximum production. A total of 70 samples of 8 different crop residues were collected from dairy farms which farmers were feeding to their dairy animals and these samples were investigated for macro and micro mineral profile along with chemical constituents. All the crop residues based roughages contained major nutrients and fibre fractions within the normal range. Among, macro-minerals, calcium and phosphorus content in the dry roughages ranged from 0.21 – 2.01 and 0.13 – 0.33%, respectively. Mg content in the dry roughages ranged from 0.15% in Triticum aestivum straw to 0.48% in Pennisetum glaucum stover. Na and K content were highest (0.31 and 3.22%), respectively in Pennisetum glaucum straw however, lowest Na and K content (0.01 and 0.41%) were found in Sorghum bicolor stover and Zea mays stover, respectively. S content (0.49%) was highest in Pisumsativum straw; while, least S content (0.07%) was observed in Zea mays stover. Among the micro-minerals in the dry roughages, Cu content varied from 0.24 ppm in Triticum aestivum straw to 7.89 ppm in Cajanus cajan straw. Concentration (ppm) of other micro-minerals viz., Zn, Mn, Fe, Co, Mo and Se ranged from 3.68-35.77, 5.65-202.00, 64.15-569.00, 0.00-819.00, 0.00-1.12 and 0.00-0.91, respectively in these crop residues based dry roughages.

Key words: Crop Residues, Dry Roughages, Macro Minerals, Micro Minerals, Mineral Profile

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Introduction

Crop residues are traditionally utilized as animal feed as such or by supplementing with some additives i.e. mixing with wheat and rice bran and green grasses. However, crop residues, being unpalatable and low in digestibility cannot form a sole ration for livestock**.** Crop residues are low-density fibrous materials, low in nitrogen, soluble carbohydrates, minerals and vitamins with varying amounts of lignin which acts as a physical barrier and slow the process of microbial breakdown (Yadav *et al.*, 2017). They are rich source of energy because up to 80% of their dry matter (DM) consists of polysaccharides. However, they are not all well utilized as energy sources as their digestibility is often low. Various crop residues have their own nutritional values and are used for different animal species. In India, approximately 500-550 Mt of crop residues are produced per year. With increased production of rice and wheat, residue production of dry roughages has also increased substantially. Crop residues produced from wheat, maize, rice, oat and barley has been used as fodder for livestock.

Minerals are the inorganic components and make up only a relatively small portion of the animal diet, but are vital to the animal. Twenty-one minerals are considered to be nutritionally essential for animals. Minerals are classified as major (Ca, P, Mg, Na, Cl, K and S) and trace (Cu, Fe, I, Mn, Se, Zn and Co). It is widely distributed in the herbage and the other feed-stuffs; however, their concentration remains uncertain depending upon the location, soil type, herbage type, maturity and many more factors (Kumar, 2015). Therefore, the research paper attempts to investigate the nutrient composition in terms of chemical constituents and macro and micro mineral profile of crop residues used in livestock feeding in dairy farms of Varanasi so as to explore the suitable nutritional intervention for optimum and efficient utilization of these crop residues for maximum production of dairy animals in the Gangetic plains of India.

Materials and Methods

Collection of Sample

Varanasi district has 8 blocks in total. Among these, area under Varanasi district (Varanasi Municipal Corp) was divided in to 3 zones distributed evenly from each direction of the Varanasi district. Further, from each zone 5 each of small size (<5 dairy animals), medium size (5-10 animals) and large size (>10 animals) dairy farms were selected for sample collection. In total 15 farms from each zone and 45 farms from the city were selected for collection of samples. Seventy samples of 8 different crop residues based dry roughages were collected from these dairy farms which farmers were feeding to their dairy animals and these samples were investigated for macro and micro mineral profile along with chemical constituents.

Analytical Procedures

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Chemical Composition of Crop Residues

The ground samples of feed stuffs were analyzed for different proximate constituents *viz.* dry matter (DM), crude protein (CP), ether extract (EE), ash and acid-insoluble ash (AlA) (AOAC. 2016). The organic matter (OM) and total carbohydrates (TCHO) of the samples were calculated by difference. The fiber constituents, viz. neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were also analyzed (Van Soest *et al.*, 1991) and the content of hemicellulose (HC) and cellulose (C) were calculated by difference.

Mineral Analysis

Both major and micro minerals were analyzed in feeds collected from dairy farms of the study area. Analysis of minerals and heavy metals were done as per (AOAC. 1990) using AAS after triple acid digestion.

Digestion of Feedstuffs

Digestion of feedstuffs was done as per Patnia and Saha (2012) and Mohanta *et al*. (2016). Dried and grounded sample of 1-2 g was transferred to a 250 ml Kjeldahl flask. The material was moistened with 2 ml of sulphuric acid and added with 2 glass beads. The mixture was gently heated over an electrical micro-digestion bench till a homogenous dark brown liquid was formed. After cooling the flask, 0.5 ml perchloric acid and 5.0 ml nitric acid were added and heated again till the dark brown colour became faint. The flask was cooled again and added with 2.5 ml nitric acid and heated again till the material changed to light yellow or colour less mass. At this stage, 5 drops of perchloric acid (after removing from the heaters) was added to ensure the removal of even the traces of organic matter. The flask was heated again until thick white fumes of perchloric acid no longer came out. Little water was added to flask, while still warm, to keep the solid salt (formed in the final stages of digestion) as solution. When the solution was clear following cooling, it was filtered through <0.45 µm Millipore filter paper and transferred to volumetric flask. The contents of the beaker were brought to the required volume with distill water and were examined by atomic absorption spectrophotometer.

Atomic Absorption Spectrophotometer

Both major (Ca, P, Mg, Na, K and S) and micro minerals (Cu, Zn, Mn, Fe, Co, Mo and Se) were analyzed using flame atomic absorption spectrophotometer (FAAS), Model AA-7000, Shimadzu, Japan except for P, which was analyzed spectrophotometrically as per (AOAC, 2005). The instrument (FAAS) was equipped with photo-multiplier tube (PMT) detector and capable of auto switch-over between air-C_2H_2 / N_2O-C_2H_2 flame with flow rate monitoring using optical sensor.

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Result and Discussion

Chemical Composition of Crop Residues

The results on major chemical composition of crop residues collected from dairy farms are presented in Table 1. Among dry roughages *Cajanus cajan* (Arhar) straw had the highest CP of 14.23%. CP content of arhar straw was less than the black gram husk (CP = 15.70-22.56%) collected from different regions of Tamil Nadu (Arulnathan *et al.*, 2013).

Among non-leguminous roughages, barley hay had the highest CP of 9.52%. In terms of CP content, jowar and bajra straws were poor which had 3.96 and 3.45% CP content, respectively. NDF and ADF content were highest in wheat straw (73.38 and 51.27%, respectively) while both NDF and ADF were lowest in barley straw (47.63 and 28.38%, respectively). Chemical composition in terms of proximate principles and fibre fractions of all the crop residues based dry roughages were within the normal range. Ruminants are mostly fed on low quality dry roughages, which are poor in protein, energy, minerals and vitamin contents. Mixing green fodders and/or concentrates in ruminant diets can improve the utilization of such low quality dry roughages mainly through supply of nitrogen to rumen microbes. Chemical treatment of such crop residues increases their feeding potential. Alkali treatment of fibrous materials has been well investigated and the possibility of using urea as a source of ammonia is documented (Owen and Jayasuriya, 1989).

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Table 1: Chemical composition (% DM basis) of crop residues collected from dairy farms of Varanasi

S. No.	Scientific Name	Attributes	*DM*	*CP*	*EE*	*TA*	*AIA*	NDF	ADF	Hemicellulose	Cellulose	Lignin
1	*Triticum aestivum*	Mean±SD	84.04±1.01	5.03±0.08	1.25±0.25	7.09±0.08	5.06±0.06	73.38±0.23	51.27±0.17	22.11±0.40	44.87±1.08	6.40±1.00
	Wheat straw (n=06)	Range	(82.12-86.54)	(3.96-6.12)	(0.96-1.68)	(6.59-8.16)	(4.56-5.97)	(72.45-74.56)	(50.12-52.45)	(21.67-22.44)	(43.72-45.85)	(5.40-7.40)
2	*Hordeum vulgare*	Mean±SD	82.00±0.12	9.52±0.28	2.47±0.39	9.29±0.07	3.56±0.06	47.63±0.65	28.38±0.23	19.26±0.45	26.04±0.52	2.33±0.38
	Barley hay (n=10)	Range	(80.12-84.75)	(8.23-10.78)	(2.01-3.09)	(8.23-10.36)	(1.34-1.96)	(46.89-48.12)	(27.32-28.96)	(18.77-19.67)	(25.12-27.06)	(1.90-2.60)
3	*Pisum sativum*	Mean±SD	87.34±0.48	7.71±0.23	2.32±0.19	8.40±0.05	1.05±0.09	49.26±0.46	37.94±0.79	11.32±0.39	31.64±1.26	6.30±1.84
	Pea straw (n=10)	Range	(85.31-88.87)	(6.45-8.43)	(1.02-2.96)	(7.98-8.93)	(0.89-1.39)	(48.56-50.39)	(36.12-38.70)	(10.09-11.77)	(30.41-32.92)	(4.20-7.60)
4	*Cajanus cajan*	Mean±SD	86.75±0.46	14.23±0.04	1.65±0.31	7.53±0.08	1.38±0.05	54.00±0.42	36.27±0.16	17.73±0.44	21.97±5.44	14.3±5.54
	Arhar straw (n=06)	Range	(85.12-87.89)	(13.36-15.23)	(1.23-2.13)	(6.46-7.86)	(1.12-1.59)	(52.54-55.35)	(35.18-37.31)	(16.33-18.20)	(17.05-27.81)	(8.40-19.40)
5	*Pennisetrumglaucum*	Mean±SD	89.41±0.27	3.45±0.06	0.89±0.06	7.26±0.22	3.09±0.21	61.56±0.16	36.89±1.82	24.54±0.89	31.01±2.09	5.64±2.01
	Bajra straw (n=09)	Range	(87.01-90.12)	(2.78-3.75)	(0.78-1.58)	(6.89-8.12)	(2.45-3.98)	(59.12-63.78)	(34.51-38.45)	(23.56-25.87)	(29.39-32.87)	(4.21-7.45)
6	*Oryza sativa*	Mean±SD	86.52±0.39	4.92±0.06	1.64±0.07	10.54±0.12	2.38±0.46	65.22±0.68	48.04±0.17	17.18±0.75	43.34±1.54	4.70±1.71
	Paddy Straw (n=10)	Range	(84.89-87.64)	(3.87-5.23)	(1.36-1.96)	(8.89-11.98)	(1.97-2.87)	(64.54-65.89)	(47.89-48.23)	(16.53-18.00)	(41.73-44.79)	(3.10-6.50)
7	*Sorghum bicolor*	Mean±SD	88.19±0.34	3.96±0.06	0.93±0.06	8.29±0.24	3.19±0.23	64.83±0.06	38.79±0.89	26.04±0.92	32.12±2.40	6.67±2.31
	Jowar stover (n=07)	Range	(87.41-89.19)	(2.87-4.00)	(0.89-1.68)	(7.65-8.96)	(2.64-3.98)	(63.79-65.45)	(37.86-39.80)	(25.00-26.77)	(29.35-33.62)	(4.50-9.10)
8	*Zea mays*	Mean±SD	87.01±0.27	5.08±0.13	1.27±0.15	12.04±0.17	4.01±0.11	52.30±0.18	31.49±0.34	20.81±0.17	26.23±2.31	5.27±1.97
	Maize stover (n=12)	Range	(86.69-88.00)	(9.89-12.23)	(1.01-1.69)	(10.89-12.96)	(3.21-4.56)	(51.39-52.89)	(30.12-32.45)	(20.67-21.00)	(23.62-28.00)	(3.80-7.50)

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Mineral Composition of Crop Residues

All the samples of crop residues based dry roughages collected from dairy farms were analyzed for major minerals and micro minerals. The macro-mineral composition of the crop residues are presented in Table 2.

Table 2. Macro mineral composition of crop residues collected from dairy farms of Varanasi

S. No.	Scientific Name	Attributes	Macro-minerals (% DM)					
			Ca	P	Mg	Na	K	S
1	*Triticum aestivum*	Mean±SD	0.21±0.06	0.23±0.04	0.15±0.03	0.18±0.03	1.07±0.49	0.26±0.07
	Wheat straw (n=06)	Range	(0.15-0.26)	(0.2-0.28)	(0.12-0.18)	(0.16-0.21)	(0.50-1.40)	(0.18-0.32)
2	*Hordeum vulgare*	Mean±SD	0.25±0.11	0.31±0.07	0.19±0.06	0.08±0.06	1.82±0.48	0.19±0.04
	Barley hay (n=10)	Range	(0.12-0.32)	(0.25-0.38)	(0.14-0.26)	(0.02-0.14)	(1.50-2.37)	(0.15-0.22)
3	*Pisum sativum*	Mean±SD	2.01±0.19	0.33±0.07	0.24±0.11	0.1±0.07	1.61±0.54	0.49±0.07
	Pea straw (n=10)	Range	(1.86-2.23)	(0.25-0.39)	(0.13-0.34)	(0.03-0.16)	(1.05-2.12)	(0.43-0.56)
4	*Cajanus cajan*	Mean±SD	0.68±0.15	0.19±0.06	0.22±0.07	0.03±0.01	1.24±0.34	0.46±0.04
	Arhar straw (n=06)	Range	(0.56-0.85)	(0.13-0.24)	(0.15-0.29)	(0.02-0.03)	(0.91-1.58)	(0.42-0.49)
5	*Pennisetrum glaucum*	Mean±SD	0.35±0.04	0.27±0.05	0.48±0.05	0.31±0.06	3.22±0.20	0.36±0.04
	Bajra straw (n=09)	Range	(0.31-0.39)	(0.22-0.32)	(0.43-0.52)	(0.25-0.36)	(3.08-3.45)	(0.32-0.39)
6	*Oryza sativa*	Mean±SD	0.36±0.07	0.24±0.03	0.31±0.03	0.12±0.02	1.63±0.05	0.13±0.01
	Paddy Straw (n=10)	Range	(0.28-0.41)	(0.21-0.26)	(0.28-0.34)	(0.10-0.14)	(1.59-1.69)	(0.13-0.14)
7	*Sorghum bicolor*	Mean±SD	0.30±0.02	0.13±0.02	0.30±0.02	0.01±0.01	2.02±0.02	0.19±0.03
	Jowar stover(n=07)	Range	(0.28-0.31)	(0.11-0.14)	(0.29-0.32)	(0.01-0.03)	(2.01-2.04)	(0.17-0.22)
8	*Zea mays*	Mean±SD	0.40±0.02	0.19±0.02	0.30±0.03	0.02±0.01	0.41±0.04	0.07±0.06
	Maize stover (n=12)	Range	(0.39-0.42)	(0.17-0.21)	(0.28-0.33)	(0.01-0.03)	(0.38-0.45)	(0.01-0.11)

Calcium and phosphorus content in the dry roughages ranged from 0.21 – 2.01 and 0.13 – 0.33%, respectively. Mg content in the dry roughages ranged from 0.15% in *Triticum aestivum straw* to 0.48% in *Pennisetrum glaucum* stover. Na and K content were highest (0.31 and 3.22%, respectively) in *Pennisetum glaucum* straw however, lowest Na and K content (0.01 and 0.41%) were found in *Sorghum bicolor* stover and *Zea mays* stover, respectively. S content (0.49%) was highest in *Pisum sativum* straw; while, least S content (0.07%) was observed in *Zea mays* stover. The micro-mineral composition of the crop residues are presented in Table 3. Among the micro-minerals in the dry roughages, Cu content varied from 0.24 ppm in *Triticum aestivum* straw to 7.89 ppm in *Cajanus cajan* straw. Concentration (ppm) of other micro-minerals viz., Zn, Mn, Fe, Co, Mo and Se ranged from 3.68-35.77, 5.65-202.00, 64.15-569.00, 0-819.0, 0-1.12 and 0-0.91, respectively in the dry roughages.

Level of major and trace mineral indicates deficiency of Ca, P, Mg, Zn and several other micro-minerals in wheat straw and other dry roughages when compared with the recommended critical level (McDowall. 1985; Blood *et al*., 1983; Underwood, 1971). P deficiency in straw might be due to its low absorption from soil as its availability to plants is controlled mainly by soil pH, soluble Al, Fe and Ca and organic matter content (Sefidkoohi and Sepanlou, 2013). Low content of Zn in wheat straw may be due to agronomical

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practices like long term cropping and increased crop yield per unit land (Yadav *et al*., 1998; Sharma *et al*., 2002).

Table 3. Micro mineral composition of crop residues collected from dairy farms of Varanasi

S. No.	Scientific Name	Attributes	Micro-minerals (ppm in DM)						
			Cu	Zn	Mn	Fe	Co	Mo	Se
1	*Triticum aestivum*	Mean±SD	0.24±0.08	3.68±0.26	15.57±4.28	64.15±7.77	819.00±7.14	1.12±0.60	0.48±0.20
	Wheat straw (n=06)	Range	(0.15-0.31)	(3.44-3.96)	(11.89-20.26)	(56.46-72.00)	(812.00-826.00)	(0.45-1.60)	(0.28-0.67)
2	*Hordeum vulgare*	Mean±SD	5.83±0.57	7.88±0.38	21.33±4.04	192.00±8.02	0.15±0.10	1.07±0.15	0.07±0.05
	Barley hay (n=10)	Range	(5.20-6.30)	(7.50-8.25)	(17.00-25.00)	(185.00-201.00)	(0.07-0.26)	(0.90-1.20)	(0.01-0.11)
3	*Pisum sativum*	Mean±SD	3.50±0.90	9.87±1.55	5.65±0.76	166.00±1.95	<0.001	<0.001	<0.001
	Pea straw (n=10)	Range	(2.60-4.40)	(8.60-11.60)	(4.90-6.42)	(162.00-170.00)	(0-0)	<0.001	<0.001
4	*Cajanus cajan*	Mean±SD	7.89±0.46	32.67±7.09	74.00±1.00	198±21.36	0±0	<0.001	<0.001
	Arhar straw (n=06)	Range	(7.50-8.40)	(25.00-39.00)	(73.00-75.00)	(183.00-223.00)	(0-0)	<0.001	<0.001
5	*Pennisetrum glaucum*	Mean±SD	7.08±1.91	18.89±3.28	72.19±16.18	569.00±14.05	0±0	<0.001	<0.001
	Bajra straw (n=09)	Range	(4.95-8.64)	(16.25-22.56)	(54.00-85.00)	(556.00-584.00)	(0-0)	<0.001	<0.001
6	*Oryza sativa*	Mean±SD	2.72±0.14	35.77±0.72	202.00±5.26	198.00±5.69	0.28±0.01	0.22±0.02	0.91±0.02
	Paddy Straw (n=10)	Range	(2.56-2.84)	(35.12-36.54)	(198.00-208.00)	(192.00-204.00)	(0.27-0.29)	(0.20-0.23)	(0.89-0.93)
7	*Sorghum bicolor*	Mean±SD	4.85±0.08	16.74±0.18	35.72±0.25	277.00±0.22	0.32±0.03	0.07±0.01	0.29±0.02
	Jowar stover (n=07)	Range	(4.21-5.01)	(16.54-16.87)	(35.46-35.95)	(277.00-277.00)	(0.29-0.34)	(0.06-0.07)	(0.28-0.31)
8	*Zea mays*	Mean±SD	6.05±0.03	18.00±0.07	40.41±0.13	254.00±0.25	0.23±0.03	0.69±0.02	0.07±0.01
	Maize stover (n=12)	Range	(6.01-6.08)	(17.94-18.08)	(39.32-41.56)	(241.00-274.00)	(0.20-0.26)	(0.67-0.72)	(0.06-0.08)

Further, Zn was found to be deficient in many geographical zones of India (Ramana *et al*., 2001; Udar *et al*., 2003). The concentration of Fe was found high in all analyzed roughages. Even wheat straw was found quite rich in Fe content. These findings were also reported from other part of country like in Karnataka (Ramana *et al*., 2001), Haryana (Yadav *et al*., 2002) and Haridwar (UK) (Tiwary *et al*., 2007).

Conclusion

The crop residues of the Varanasi have all the nutritive value in terms of proximate principles and fibre fractions within the normal range. However, these crop residues are low quality dry roughages poor in major nutrients and minerals contents reflected by poor digestibility and low productivity in livestock. Although, both macro and micro minerals are invariably present in crop residues, however their levels are insufficient to meet the optimum requirement of livestock. Therefore, additional supplementation of area

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specific mineral mixture is necessary to meet the optimum requirement of all the minerals for optimum health and enhanced milk production.

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