DR-2008
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RESEARCH ARTICLE   Asian Journal of Dairy and Food Research

The Nutrient Dynamics of Major and Minor Nutrients on Pelleted and Unpelleted Dry Fodders

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10.18805/ajdfr.DR-2008

ABSTRACT

Background: Farmers are facing the challenges to providing adequate availability of feed and fodders to livestock during dry period (lean period) which poses a major threat in livestock productivity. This study delineates, pelleting of feed and fodder helps to meet out the fodder requirement during lean period consequently improving the livestock productivity.

Methods: The experiment was conducted at Forage Pelleting Unit, Department of Forage Crops in Agricultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu from March 2020 to June 2022 to identify the best suitable dry fodder crops for quality pellets production. The laboratory experiment was conducted and laid out in completely randomized block design with 11 treatments and three replications. The treatment consists of D_1: Rice straw, D_2: Maize stover, D_3: Maize husk, D_4: Sorghum straw, D_5: Ragi straw, D_6: Pearl millet stover, D_7: Wheat straw, D_8: Groundnut haulms, D_9: Groundnut shells, D_{10}: Sugarcane tops, D_{11}: Blackgram husk were selected and produced into individual dry fodders pellets. Then, the selected dry fodders were harvested with the help of fodder harvester cum chaffer. The chaffed material was then dried using a solar drier at 70°C for one day to attaining the ideal moisture of 12%. Then, dried materials were grinded by fodder pulverizer and then grinding material was conveyed through conditioning with passing the steam at 60 to 70°C. Then, the conditioning material was passes through a pelletizer with 6 mm die diameter.

Result: The observation on macro minerals (calcium, magnesium, potassium) and micro minerals (cobalt, zinc, manganese) were analyzed by using an Inductive Coupled Plasma Mass Emission Spectroscopy. The unpelleted and pelleted dry fodders showed a significant variation in the major and minor nutrients. In this regards, the calcium content recorded higher in groundnut haulms (D_8) with 1.027 per cent and whereas ragi straw (D_5) were recorded higher magnesium and potassium contents with 0.433 per cent and 2.178 per cent respectively. The minor nutrients like cobalt, manganese and zinc contents varied significantly due to pelleting process. From this study, rice straw (D_1) recorded higher cobalt content with 0.378 per cent and whereas, ragi straw (D_5) recorded higher zinc content (16.45 per cent) and while, manganese contents were registered higher in pearl millet straw (D_6) with 54.88 per cent.

Key words: ICPMES, Major nutrients, Pelleted dry fodders, Ragi straw pellets, Unpelleted dry fodders.

INTRODUCTION

Forage crops are a crucial component of livestock production, they serve as a primary source of minerals for cattle nutrition (Suttle, 2010). Although minerals only required for minor amount of an animal's diet, but they are highly essential for growth, reproduction and overall health. Minerals are inorganic substances that are necessary for the metabolic and physiological processes of the animal body. The mineral matter constitutes about 4% of the animal body's weight and they are essential for maintaining the animal health (Singh *et al.,* 2021).

More than any other category of nutrient, minerals play a crucial role in every biological process that occurs in the body. The function includes vitamin activity and functioning, osmotic balance, detoxification, immunity, cell membrane function, acid-base balance, structural support and growth.

Minerals are classified into two groups-macro and micro (trace) minerals-based on the amounts needed in diet rather than the importance for physiological functions. Macro-minerals are required in high concentrations in the ration and are highly required for livestock growth and development. The macro minerals include calcium (Ca), magnesium (Mg), phosphorus (P), sodium (Na) and potassium (K). On the other hand, trace minerals are needed in the ration in low concentrations. Micro/Trace minerals include copper (Cu), manganese (Mn), zinc (Zn), iron (Fe), cobalt (Co), molybdenum (Mo), selenium (Se) and iodine (I) as suggested by Saha *et al.,* (2021). However, ruminant's mineral nutrient requirements are insufficient during the dry season. Therefore, more high-quality feed must be produced

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How to cite this article: Amutham, G.T., Sakthivel, N., Sivakumar, S.D., Ganesan, K.N. and Thirunavukkarasu, M. (2022). The nutrient Dynamics of Major and Minor Nutrients on Pelleted and Unpelleted Dry Fodders. Asian Journal of Dairy and Food Research. doi: 10.18805/ajdfr.DR-2008.

Submitted: 31-08-2022 **Accepted:** 26-11-2022 **Online:** 27-01-2023

sustainably in order to meet the increasing demand for meat and milk (Delgado *et al.,* 1999). Forage conservation is a best option to redistribute the feed supply throughout the year. The forage conservation methods are hay making, silage making and fodder pellet production which can be used to store the green and dry fodders during the dry season for animal feeding. However, conservation as hay and silage making did not meet the nutritional requirements of the ruminant. Hence, production of homogeneous feed-forage pellet became essential. In this regard, fodder pelletization is an innovative method for improving nutrient availability in roughages by grinding and conditioning the material at 75 to 80°C. This increased the available surface area of the material and increased the drymatter content, which ultimately improved nutrient availability in the fodder pellets and had a significant impact on animal diets. In this paper, the major and minor nutrient availability in pelleted and unpelleted dry fodders were discussed.

MATERIALS AND METHODS

The experiment was conducted at Forage Pelleting Unit, Department of Forage Crops in Agricultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu during March 2020 to June 2022 to identify the best suitable dry fodders for fodder pellets production. Based on the availability, the dry fodders were selected for fodder pellet production. The laboratory experiment was conducted and laid out in completely randomized block design (CRBD) with 11 treatments and three replications. The treatment consists of D_1: Rice straw, D_2: Maize stover, D_3: Maize husk, D_4: Sorghum stover, D_5: Ragi straw, D_6: Pearl millet stover, D_7: Wheat straw, D_8: Groundnut haulms, D_9: Groundnut shells, D_{10}: Sugarcane tops, D_{11}: Blackgram husk were identified and produced into individual dry fodders pellets. Then, the selected dry fodders were harvested with the help of fodder harvester cum chaffer. The chaffed material was then dried using a solar drier at 70°C for one day for attaining the ideal moisture of 12%. Then, dried materials were grinded by fodder pulverizer and then grinding material was conveyed through conditioning with passing the steam at 60 to 70°C. Then, the conditioning material was passes through a pelletizer with 6mm die diameter. The observation on macro minerals (calcium, magnesium, potassium) and micro minerals (cobalt, zinc, manganese) were analysed by using an Inductive Coupled Plasma Mass Emission Spectroscopy (ICPMES). All macro and micro minerals had showed significant variation in both pelleted and unpelleted condition ($p<0.05$).

Instrumentation - ICPMES

Single Quadrapole Inductively Coupled Plasma-Mass Spectrometry [SQ-ICPMS], Thermo Scientific™ iCAP™ RQ, equipped with micro mist borosilicate glass nebulizer; quartz cyclonic spray chamber; ICP torch, nickel sampler cone and skimmer cone, Quadrapole mass analyser and mass spectrometry detector. All the samples were analysed in Kinetic Energy Discrimination (He KED) mode using pure He as the collision gas in the collision/reaction cell (CRC) under optimized auto tune conditions of the equipment directly from Quality control with Qtegra™ Intelligent Scientific Data Solution™ (ISDS) Software. To automate the sampling process, an ASX 560 Auto sampler (Omaha, NE, USA) was used. Sample digestion was performed through a closed-vessel microwave digestion system-Multiwave GO (Anton Paar) with a multi wave pro rotor, temperature and pressure sensor, provided with an auto pressure vent PTFE vessel.

Preparation of calibration standard solutions

Pipetting precisely 1 ml of the combined standard reference solution into a 100 ml volumetric flask and make upto the volume by using Milli-Q water. This was utilised as the stock solution for the calibration preparation and was appropriately stored. To create a series of calibration standard solutions with concentration ranges of 1.0 g/l, 20.0 g/l, 50.0 g/l and 100.0 g/l, appropriate aliquots were obtained and further diluted with 5 percent nitric acid in milli-Q water.

Preparation of sample solutions

Approximately 0.20±0.01 g of dried homogenized powder samples were accurately weighed, (already milled with Teflon mortar to avoid metal contamination) and take 0.2 g dried plant sample with 6.0 ml of concentrated, ultra-pure HNO_3 in a PTFE vessel that was firmly closed and it was digested in a microwave digester. The digestion was carried out in three steps with a constant microwave power. The programme was designed to raise the temperature to 160°C in 10 minutes and hold it there for 5 minutes, then cool down the digester to room temperature and dilute the digested samples with Milli-Q water up to 50 ml. For analysis, three replicate samples were prepared.

Statistical analysis

To test the significant difference between treatments was analysed by one way analysis in a completely Randomised Block Desigh using the OPSTAT software and also test the significant difference between unpelleted and pelleted dry fodders was employed by paired t-test in SPSS software. Differences between means were ranked using Duncan's new multiple range test in SPSS software (Duncan, 1955).

RESULTS AND DISCUSSION

Major nutrients

Calcium content

It is the most abundant macromineral in the body of animals since it constitutes the essential material to form structures such as bones and teeth. The calcium content had significantly differ between pelleted and unpelletd dryfodders ($P<0.05$) and presented in Table 1. The per cent increased in pelleted and unpelleted dry fodders ranged from 5.1% to 9.8%. Among all the dryfodders tested, goundnut haulms had recorded higher calcium content in both pelleted and unpelleted condition. In case of unpelleted dry fodders, the calcium content had higher in groundnut haulms (D_8) was 1.027 per cent and it was followed by blackgram husk (D_{11}) of 0.974 per cent. The lowest calcium content was recorded in maize husk (D_3) of 0.075 per cent. In comparison with unpelleted dry fodders, the calcium content was significantly increased in pelleted dry fodders. In case of pelleted dry fodders, the higher calcium content was recorded in groundnut haulm pellets of 1.119 per cent. The lowest calcium was recorded in maize husk of 0.078 per cent.

Magnesium

Magnesium (Mg) is the second most abundant element in the body. Half of Mg can be found in bone and teeth and the other half is used as a cofactor for various phosphatases and also plays an important role in energy generation. The magnesium content also significantly differ between pelleted and unpellleted dryfodders ($P<0.05$) and results were given in Table 2. In case of unpelleted dry fodders, the higher magnesium content was recorded in ragi straw with 0.433 percent and it was followed by pearl millet straw (D_6). The least magnesium content was recorded in maize husk (D_3) with 0.092 per cent. Whereas, in pelleted dry fodders, ragi straw pellets (D_5) also in recorded higher magnesium content of 0.474 per cent. Least magnesium content was recorded in maize husk pellets (D_3) with 0.094 per cent.

Potassium

The third most abundant mineral in the body. Essential for the maintenance of osmotic and fluid balance in the body. The potassium content also significantly differ ($P<0.05$) in pelleted and unpelleted dryfodders (Table 3). In this regard, in both pelleted and unpelleted condition the potassium content was noticed higher in ragi straw (D_5) and which was recorded with 2.178 per cent and 2.454 per cent respectively, whereas least potassium content was observed in groundnut shell (D_9) and which was recorded with 0.461 per cent and 0.472 per cent respectively.

Minor nutrients

Cobalt

Cobalt is a component of vitamin B_{12} (cyanocobalamin), which is involved in the formation of red blood cells and nerve cell functions. During pelleted and unpelleted condition, the cobalt showed significant variation ($P<0.05$) and the results are presented in Table 4. In case of unpelleted dry fodders, cobalt was recorded higher in rice straw pellets (D_1) of 0.378 percent. Least cobalt was noticed in black gram husks (D_{11}) and which was recorded with 0.113 per cent. Whereas pelleted dry fodders, the significantly higher cobalt was noticed in rice straw pellets (D_1) and which was registerd with 0.399 per cent and it was statistically on par with ragi straw pellets (D_5) of 0.397 per cent. Least cobalt was observed in blackgram haulm pellets (D_{11}) with 0.118 per cent.

Table 1: Effect of calcium on unpelleted and pelleted dry fodders.

Treatments	Unpelleted dry fodders	Pelleted dry fodders
D_1: Rice straw	0.196±0.03[f]	0.212±0.006[f]
D_2: Maize stover	0.259±0.006[e]	0.278±0.006[e]
D_3: Maize husk	0.075±0.003[h]	0.078±0.001[h]
D_4: Sorghum straw	0.126±0.003[g]	0.135±0.003 [g]
D_5: Ragi straw	0.847±0.021[c]	0.909±0.015[c]
D_6: Pearl millet straw	0.383±0.009[d]	0.421±0.001[d]
D_7: Wheat straw	0.208±0.003[f]	0.223±0.006[f]
D_8: Groundnut haulm	1.027±0.015[a]	1.119±0.019[a]
D_9: Groundnut shell	0.404±007[d]	0.424±0.003[d]
D_{10}: Groundnut shell	0.147±0.003[g]	0.156±0.003[g]
D_{11}: Blackgram husk	0.974±0.09[b]	1.029±0.003[b]
C.D	0.027	0.024
SE(m)	0.009	0.008
SE(D)	0.013	0.011

Table 2: Effect of magnesium on unpelleted and pelleted dry fodders.

Treatments	Unpelleted dry fodders	Pelleted dry fodders
D_1: Rice straw	0.215±0.003[d]	0.232 ±0.006[d]
D_2: Maize stover	0.207±0.003[d]	0.217±0.003[d]
D_3: Maize husk	0.092±0.001f[e]	0.094±0.003[f]
D_4: Sorghum straw	0.113±0.001[e]	0.120±0.001[e]
D_5: Ragi straw	0.433±0.009[a]	0.474±0.012[a]
D_6: Pearl millet straw	0.332±0.006[b]	0.363±0.007[b]
D_7: Wheat straw	0.106±0.003[e]	0.111±0.001[ef]
D_8: Groundnut haulm	0.256±0.003[c]	0.270±0.001[c]
D_9: Groundnut shell	0.210±0.003[d]	0.229±0.001[d]
D_{10}: Groundnut shell	0.112±0.003[e]	0.119±0.001[e]
D_{11}: Blackgram husk	0.116±0.003[e]	0.120±0.003[e]
C.D	0.012	0.014
SE(m)	0.004	0.005
SE(D)	0.006	0.007

Table 3: Effect of potassium on unpelleted and pelleted dry fodders.

Treatments	Unpelleted dry fodders	Pelleted dry fodders
D_1: Rice straw	0.517±0.009[i]	0.591±0.006[g]
D_2: Maize stover	1.004±0.018[e]	1.048±0.009[d]
D_3: Maize husk	0.514±0.012[i]	0.528±0.003[h]
D_4: Sorghum straw	0.769±0.00[g]	0.851±0.012[f]
D_5: Ragi straw	2.178±0.026[a]	2.454±0.039[a]
D_6: Pearl millet straw	2.126±0.048[b]	2.392±0.015[b]
D_7: Wheat straw	1.067±0.006[d]	1.194±0.012[c]
D_8: Groundnut haulm	0.554±0.009[h]	0.616±0.012[g]
D_9: Groundnut shell	0.461±0.009[j]	0.472±0.006[h]
D_{10}: Groundnut shell	1.148±0.001[c]	1.189 ±0.030[c]
D_{11}: Blackgram husk	0.980±0.021[f]	0.993±0.015[e]
C.D	0.057	0.052
SE(m)	0.019	0.018
SE(D)	0.028	0.025

Table 4: Effect of cobalt on unpelleted and pelleted dry fodders.

Treatments	Unpelleted dry fodders	Pelleted dry fodders
D_1: Rice straw	0.378±0.001[a]	0.399±0.004[a]
D_2: Maize stover	0.235±0.006[d]	0.255±0.003[c]
D_3: Maize husk	0.177±0.002[f]	0.187±0.001[fg]
D_4: Sorghum straw	0.194±0.001[e]	0.204±0.002[d]
D_5: Ragi straw	0.366±0.007[b]	0.397±0.007[a]
D_6: Pearl millet straw	0.279±0.006[c]	0.304±0.008[b]
D_7: Wheat straw	0.175±0.001[f]	0.191±0.001[ef]
D_8: Groundnut haulm	0.168±0.004[f]	0.177±0.001[g]
D_9: Groundnut shell	0.150±0.002[g]	0.158±0.003[h]
D_{10}: Groundnut shell	0.190±0.002[e]	0.199±0.002[de]
D_{11}: Blackgram husk	0.113±0.001[h]	0.118±0.001[i]
C.D	0.011	0.011
SE(m)	0.004	0.004
SE(D)	0.005	0.005

Table 5: Effect of manganese on unpelleted and pelleted dry fodders.

Treatments	Unpelleted dry fodders	Pelleted dry fodders
D_1: Rice straw	42.33±0.820[c]	46.15±0.780[c]
D_2: Maize stover	31.21±0.016[g]	34.26±0.624[g]
D_3: Maize husk	19.11±0.438[i]	20.67±0.205[j]
D_4: Sorghum straw	33.45±0.313[f]	36.45±0.702[f]
D_5: Ragi straw	54.53±0.908[a]	59.93±1.029[a]
D_6: Pearl millet straw	54.88±1.399[a]	59.85±0.312[a]
D_7: Wheat straw	52.13±0.217[b]	56.77±0.650[b]
D_8: Groundnut haulm	39.25±0.511[d]	42.54±0.775[d]
D_9: Groundnut shell	35.77±0.279[e]	39.16±0.244[e]
D_{10}: Groundnut shell	23.97±0.100[h]	26.35±0.398[h]
D_{11}: Blackgram husk	21.10±0.516[i]	22.854±0.535[i]
C.D	1.869	1.828
SE(m)	0.633	0.619
SE(D)	0.895	0.876

Table 6: Effect of zinc on unpelleted and pelleted dry fodders.

Treatments	Unpelleted dry fodders	Pelleted dry fodders
D_1: Rice straw	6.89±0.113[g]	7.60±0.188[f]
D_2: Maize stover	10.31±0.188[d]	11.43±0.161[d]
D_3: Maize husk	8.71±0.118[f]	9.48±0.232[e]
D_4: Sorghum straw	13.76±0.179[b]	15.26±0.151[b]
D_5: Ragi straw	16.45±0.334[a]	18.20±0.246[a]
D_6: Pearl millet straw	13.25±0.269[b]	14.70±0.077[b]
D_7: Wheat straw	11.93±0.230[c]	13.22±0.186[c]
D_8: Groundnut haulm	10.65±0.100[d]	11.44±0.280[d]
D_9: Groundnut shell	10.45±0.114[d]	11.41±0.012[d]
D_{10}: Groundnut shell	10.68±0.033[d]	11.72±0.268[d]
D_{11}: Blackgram husk	9.42±0.079[e]	9.99±0.120[e]
C.D	0.535	0.565
SE(m)	0.181	0.192
SE(D)	0.256	0.271

Manganese

Manganese acts as a cofactor for several enzyme systems (Table 5). Manganese content significantly differ in pelleted and unpellleted condition ($P<0.05$). Among unpelleted dry fodders, the manganese content was significantly increased in pearl millet straw (D_6) of 54.88 percent and it was as on par with ragi straw (D_5) of 54.53 per cent. Similar trend was also observed in pelleted dry fodders.

Zinc

Zinc is a micromineral that makes up many enzymes as a cofactor. It plays an important role in stress management, immune response, enzyme systems and protein synthesis (Table 6). Zinc content in pelleted and unpelleted condition had significantly increased ($P<0.05$). Among all the unpelleted dry fodders, the zinc was recorded higher in ragi straw (D_5) and which was registered with 16.45 per cent and whereas, lowest zinc content was observed in rice straw (D_1) with 6.89 per cent. In case of pelleted dry fodders, zinc was observed higher in ragi straw pellets (D_5) and which was recorded with 18.20 per cent and least zinc content was observed in rice straw pellets (D_1) with 7.60 per cent.

The presence of mineral elements in animal feed is vital for the metabolic processes of the animals (Akinsoyinu and Onwuka 1988). The major minerals (calcium, magnesium and potassium) and minor minerals (cobalt, manganese and zinc) were significantly increased in individual pelleted dry fodders than unpelleted dry fodders. The increased trend was observed in pelleted dry fodders might be due to grinding and conditioning of material at 75 to 80°C enhanced the available surface area of the material and which ultimately increased the nutrients availability. Oyewole and Aderinola, (2019) found that pellet produced from 30% *Panicum maximum* + 30% *Stylosanthes hamata* had highest ($p<0.05$) iron (18.48 mg/kg), copper (0.86 mg/kg) and chlorine (190.78 mg/kg) whereas 60% *Panicum maximum* and 40% *Panicum maximum* and 20% *Lablab purpureus* had least values (Iron: 17.27 and 17.47; Copper: 0.60 and 0.65 mg/kg) while chlorine content (mg/kg) was least ($p<0.05$) for 60% *Panicum maximum.* This finding are line with the observations of Garg *et al.* (2002); Garg *et al.* (2010); Singh *et al.* (2011).

CONCLUSION

According to this study, the pelleting process caused a significant variation in the major and minor nutrients. In this regard, the major nutrients (calcium, magnesium and potassium) and minor nutrients (cobalt, manganese and zinc) were significantly higher in ragi straw pellets, pearl millet straw pellets and groundnut haulm pellets. These dry fodder pellets can be stored for a longer period of time and have a significant replacement on the animal diet during dry periods.

Conflict of interest: None.

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