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Research Article

MICROBIAL PROTEIN SYNTHESIS IN NELLORE RAMS FED BROKEN RICE AND SORGHUM AS REPLACEMENT TO MAIZE GRAIN DIET

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ABSTRACT

In vitro studies were performed to find out the best cereal grains that could be used to replace maize grain in complete diet. While there was a significant difference (p<0.01) in the true digestible organic matter (TDOM) % values of the cereal grains, the percentages of broken rice were greater for both *in vitro* dry matter degradability (IVDMD) and *in vitro* organic matter degradability (IVOMD). Complete feed with jowar grain (CFJG) had higher IVGP, IVDMD and IVOMD values; on the other hand, TDOM varied considerably (P<0.01) between the diets and was greater for CFJG (73.53 %). Broken rice was found to have higher metabolizable energy (ME) (MJ/kg DM) value (P<0.01) in comparison to maize and jowar grain whereas complete feed jowar grain had the highest (ME) (MJ/kg DM) value among complete feed maize grain and complete feed broken rice (P<0.01). In a fully randomized design, eighteen Nellore rams were split into three groups of six animals each. Complete feeds were prepared utilizing sorghum stover, broken rice and maize were combined in a 50:50 (concentrate: roughage) ratio. Rams' purine derivatives showed no discernible change. This study recommends the use of sorghum and broken rice to replace maize grain in complete feed.

Keywords: Broken rice, Jowar, Purine derivatives

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According to the 20th livestock census (DAHD 2019), there are 536.76 million animals in India, of which 74.26 million are sheep. People's purchasing power has increased due to the rapid population growth and urbanization, which has raised demand for meat and meat products. Due to this, there is a greater need in agriculture for feed ingredients to fuel the cattle industry. The production capacity of cereal crops is around 144.52 million tons. Over the past five years, maize has grown at a pace of 11% annually on average in India (Reddy *et al.*, 2022). According to Maize Vision 2022, the amount of maize crop that can be produced every year is expected to be 26 million metric tons (MMT), whereas the required amount is 45 MMT. In an effort to replace maize grain, nutritionists have been searching for alternative cereal sources. As a result, appropriate substitutes have to be found in order to reduce the gap between the maize supply chain and demand.

The most significant staple food crop grown in India is paddy, which accounts for almost 40% of the nation's food grain production and yields an estimated 112 million metric tons annually (Santosh, 2019). The by-product of paddy milling is broken rice, which is more nutritious than brown rice because all of the bran and germ stay with it. Jowar, sometimes referred to as sorghum, is the fifth most significant cereal crop, with a yield of up to 1000 kg/ha (ICAR-CCARI, 2019). Sorghum has more crude protein and less ADF wheat. In comparison to maize or wheat, the ADF in sorghum and barley varies and might be an indication of a higher percentage of seed coat on the endosperm and germ (Kannan *et al.*, 2017). Not much research has been done on feeding alternate cereal sources to breeding rams, such as broken rice and jowar grain. Hence present study was planned to use broken rice and jowar grain in place of maize for breeding ram and study their effect on microbial protein synthesis.

MATERIALS AND METHODS

Place of work

The experiment was carried out with ethical committee clearance via proc no 21/24/C.V.Sc., Hyd. IAEC-sheep/ 12.06.2021 at the Department of Animal Nutrition, College of Veterinary Science, Rajendranagar, Hyderabad.

In vitro studies

In vitro gas production technique (IVGP) was used to evaluate the cereal grains and complete diets according to Menke and Steingass (1988) for *in vitro* dry matter degradability (IVDMD), *in vitro* organic matter degradability (IVOMD), truly digested organic matter (TDOM), and metabolizable energy (ME).

The formulas used for calculation were as follows:

IVDMD% = DM% of the substrate - NDF % of the residue

IVOMD%= OM% of substrate incubated on DM basis- OM %of the residue

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$$\text{TDOM (\%)} = \frac{\text{Organic matter digested}}{\text{Total organic matter in feed}} \times 100$$

In vitro ME (MJ/kg DM) = 2.20 + 0.1357 GP + 0.0057 × CP (DM/kg) +0.0002859× CP2 (Menke *et al.*, 1988)

Where, GP = Net gas production at 24h fermentation (ml/0.2g DM), CP DM/kg=Crude protein on DM basis×10

Experimental design

Three groups of six adult Nellore rams were randomly selected from a total of eighteen (1 year old) animals, with an average body weight of 25.00 ± 0.57 kg.

Experimental diet

Using maize, broken rice, and jowar as cereal sources and sorghum stover as roughage source, three different types of complete diets were prepared. The diets had a 50:50 concentrate to roughage ratio, meaning that the total digestible nutrients and crude protein were at 60% and 12%, respectively as per ICAR (2013). The ingredient composition of experimental rations is presented in Table 1.

Metabolic trial

After completion of first 45 days of the research trial of 90 days duration, a 7-day metabolic trial was carried out (two days for adaption and five days for collection) to assess the effects of treatments on purine derivatives when 15% of broken rice and jowar grain was added to concentrate mixtures. Urine production was documented for 24 hours during the course of the 5-day collection period. To estimate Nitrogen in the urine sample an aliquot of 1/50 was composited in several plastic containers, combined with 10% (v/v) sulphuric acid, and refrigerated. In order to evaluate the rumen fermentation pattern, 150 cc of rumen liquor were collected at 0, 3, and 6 hours after feeding using a stomach tube at the end of the trial.

Analysis of the experiment

The AOAC (2019) method was used to perform proximate principles of cereals, cereal grains, faecal and urine samples. NDF and ADF fractions of diet were also estimated (Van Soest *et al.*, 1991).

Microbial Nitrogen Supply

Utilizing the PD works of IAEA (2001), the daily intestinal flow of microbial nitrogen (in grams/day) from total urinary purine derivatives (PD) (in millimoles/day) was computed (IAEA-TECDOC-945 1997). To break up the urinary precipitates, the frozen, diluted urine samples were thawed and ultrasonically treated for 20 minutes. Using the formula 0.84 Y + (0.150 W 0.75 e−0.25X), the absorption of microbial purines (X, in millimoles/litre) and the excretion of PD in urine (Y, in millimoles/litre) were calculated. The Newton-Raphton iteration procedure was used to calculate X from Y (IAEA-TECDOC-945 1997).

Statistical analysis

The collected set of data was subjected to the statistical analysis with the aid of software(SPSS, Version 17). With a significance level of $P<0.05$, the treatment means were sorted using Duncan's multiple range test (Duncan 1955). Every statistical procedure followed Snedecor and Cochran's (1994) guidelines.

RESULTS AND DISCUSSION

Chemical composition of cereal grains and complete diet

The dry matter (DM) per cent of maize; broken rice and jowar were 89.58, 89.32 and 90.6, respectively while the organic matter (OM) per cent was 98.66, 98.95 and 97.93, respectively whereas crude protein (CP) per cent in cereal grains was 10.0, 11.06 and 8.80, respectively. The ether extract (EE) per cent was 3.50, 3.53 and 3.38, respectively. Similarly, the percentages of crude fibre (CF), nitrogen free extract (NFE) and total ash (TA) were 1.25, 1.20 and 1.81; 83.90, 83.16 and 83.72 and 1.34, 1.05 and 2.28, respectively. The percentage of cell wall constituents *viz*. neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) of these cereal grains were 12.20, 13.85 and 14.70; 3.70, 3.60 and 4.30 and 1.20, 1.05 and 1.10, respectively. The percentage of calcium (Ca) and phosphorus (P) in cereal grains was 0.20, 0.06 and 0.03 and 0.36, 0.11 and 0.23, respectively.

The DM% of the three complete diets was 92.70, 92.00 and 92.50, respectively, while the OM% was 90.05, 90.86 and 90.44 and the CP% was 11.19, 11.08 and 11.46, respectively. The EE, CF, NFE and TA was 3.29, 2.83 and 2.71; 24.23, 24.37 and 24.29; 51.34, 51.80 and 51.98 and 9.95, 9.91 and 9.56, respectively. The Ca and P% were 0.87, 0.79 and 0.76 and 0.45, 0.42 and 0.44, respectively. The percentages of the cell wall constituents *viz*. NDF, ADF, hemi cellulose cellulose, ADL and silica were 55.99, 55.39 and 56.83; 32.53, 34.65 and 33.52; 23.46, 20.74 and 23.31; 24.20, 24.50 and 24.33; 6.02, 5.98 and 6.07; and 3.55, 3.59 and 3.56, respectively.

***Invitro* gas production of cereal grains and complete diet**

Each cereal grain had a different IVGP volume (ml/200 mg) that varied considerably ($p<0.01$) (Table 2). In comparison to jowar and broken rice, the IVGP volume for maize grain was lowest ($p<0.01$). In contrast to CFBR and CFMG, the IVGP volume (ml/200 mg) for CFJG was the highest ($p<0.01$).

***In-vitro* degradabilityof cereal grains and complete diet**

IVDMD (%) and IVOMD (%) varied significantly

Table 1. The ingredient composition (kg/100kg) of experimental complete diets

Ingredient	Complete Feed Maize Grain	Complete Feed Broken Rice	Complete Feed Jowar Grain
Sorghum Stover	50	50	50
Maize	15	-	-
Broken rice	-	15	-
Jowar	-	-	15
De-oiled Rice Bran	17.5	18.5	17.5
Cottonseed Cake	7.5	7.5	7.5
Soybean meal	9	8	9
Salt	0.5	0.5	0.5
Mineral Mixture	0.5	0.5	0.5
Total	100	100	100

Mineral and vitamin mixture provided per kg diet: Calcium 2.5 g, Phosphorus 1.275 g, Magnesium 0.065 g, Iron 0.0175 g, Sulphur 0.092 g, Zinc 0.096 g, Copper 0.042 g, Manganese 0.015 g, Potassium 1.5 mg, Sodium 0.2 mg, Iodine 3.5 mg, Cobalt 1.5 mg, Vitamin B6 0.2 mg, Vitamin A 7500 IU, Vitamin D3 750 IU, Vitamin E 3 mg, Niacinamide 0.012 g. CFMG complete feed maize grain containing 50% Sorghum stover as Roughage, CFBR complete feed broken rice containing 50% Sorghum stover as Roughage and CFJG complete feed jowar grain containing 50% Sorghum stover as Roughage.

(P<0.01), but they were similar (P>0.05) for jowar (86.05 and 88.38) and broken rice (86.08 and 88.53) and lowest for maize (83.02 and 85.53). The IVDMD (%) for CFJG (68.30) was the greatest (P<0.01), with lowest values recorded for CFBR (65.58) and CFMG (63.57). CFJG (71.30) had the greatest IVOMD (%) (P<0.01), followed by CFBR (67.26) and CFMG (63.57). The TDOM% was lowest (P<0.01) for maize (87.35) but comparable for jowar (89.12) and broken rice (89.39). There was a significant difference (P<0.01) in TDOM% between diets; the highest percentage was found in CFJG (73.53), followed by CFBR (68.88) and lowest in CFMG (66.76).

Metabolizable energy

Cereal grains varied considerably (P<0.01) in their metabolizable energy (ME) (MJ/kg DM), with maize having the lowest ME (10.48). The ME (MJ/kg DM) for the whole diet was lowest in CFMG (7.77), intermediate in CFBR (7.96) and highest (P<0.01) in CFJG (8.45).

Microbial Nitrogen Supply

Complete feed broken rice and complete feed jowar grain both had comparable total PD (measured in millimoles/day) and allantoin excretion (P<0.01) when fed to rams (Table 3). The current assertion runs counter to the findings of Nalini *et al.* (2013), who observed an increase in urine PD excretion (P<0.01) in processed diets that included sweet sorghum stover as roughage coupled with maize, groundnut cake, de-oiled rice bran, steam flaked corn, molasses, urea, mineral combination and salt.

Table 2. ***In vitro*** **studies on cereal grains and complete diet**

Cereal grains	IVGP	IVDMD	IVOMD	TDOM	ME
Maize	28.43[b]	83.02[b]	85.53[b]	87.35[b]	10.48[b]
Broken rice	35.20[a]	86.08[a]	88.53[a]	89.39[a]	11.06[a]
Jowar	35.03[a]	86.05[a]	88.38[a]	89.12[a]	11.02[a]
SEM	4.112	0.575	3.710	1.742	0.692
P Value	0.001	0.001	0.001	0.001	0.001
Complete diets					
CFMG	36.15[b]	63.57[c]	65.86[c]	66.76[c]	7.77[b]
CFBR	37.73[b]	65.58[b]	67.26[b]	68.88[b]	7.96[b]
CFJG	40.03[a]	68.30[a]	71.30[a]	73.53[a]	8.45[a]
SEM	0.611	0.864	1.371	0.635	0.104
P value	0.004	0.001	0.001	0.001	0.001

CFMG: Complete Feed Maize Grain; SEM: Standard Error Mean
CFBR: Complete Feed Broken Rice; P value: Probability value
CFJG: Complete Feed Jowar grain

Table 3. Purine derivatives in rams

Attribute	CFMG	CFBR	CFJG	SEM	P-value
DOMI (kg/d)	0.68	0.64	0.67	0.028	0.227
Purine derivative excretion (Mmol/d)					
Allantoin	10.58[b]	10.82[a]	10.99[a]	0.088	0.001
Uricacid	1.46	1.41	1.48	0.020	0.521
Xanthine+ Hypoxanthine	0.33	0.34	0.33	0.040	0.567
Total	12.37[b]	12.57[a]	12.81[a]	0.146	0.001
Microbial nitrogen supply					
g/d	10.67[c]	10.89[b]	11.06[a]	0.079	0.001
Microbial nitrogen (g/ kg DOMI)	21.22[c]	21.58[b]	21.79[a]	0.065	0.001
Microbial protein supply					
g/d	66.72[c]	68.06[b]	69.40[a]	0.513	0.001
Microbial protein (g/ kg DOMI)	132.88[c]	134.88[b]	136.18[a]	0.800	0.001

Each mean value is an average of six observations.
P-value: Probability value, P>0.05
CFMG: Complete feed with maize grain
DOMI: Digestible organic matter intake
CFBR: Complete feed with broken rice
SEM: Standard Error of Mean
CFJG: Complete feed with jowargrai

Comparable excretions were found for uric acid, xanthine, and hypoxanthine. Reduced allantoin excretion resulted in a reduced total protein digestibility (PD) for whole maize grain. When comparing the Complete feed jowar grain diet to other diets in the current study, the higher (P<0.01) microbial N supply (in grams/day) was noted with increasing N consumption (P<0.01). It was observed that the whole feed jowar grain diet had a greater microbial nitrogen output, the microbial protein supply (measured in grams per day and grams per kilogram DOMI) was highest.

In vitro studies

The findings of the current study are consistent with Singh *et al.* (2015), who reported that when broken rice and maize were compared, the percentage of IVDMD in broken rice was higher (84.47%). The fact that broken rice had a greater IVOMD than corn and sorghum may be a result of its lower prolamin content (Giuberti *et al.*, 2014). Corn and sorghum grains have a large proportion of peripheral and horny endosperm and more prolamins, which increases their resistance to microbial activity. This is why feeds containing corn and sorghum grains have lower IVOMD levels. The current findings are consistent with the findings of Yang *et al.* (2020), who observed that the IVGP value was higher for the total mixed ration of rice than for the total mixed ration of maize. According to Yoo *et al.* (2020) and Yang *et al.* (2020), found a significant difference ($P<0.05$) in gas output, gas emissions and Vmax rose when rice was substituted for maize at 33% DM in TMR. To estimate the DM degradability of cereal grains used as ruminant feed, the amount of gas released during in vitro ruminal fermentation is determined. Additionally, it was concluded that the degradability of feed directly relates to gas output. The higher TDOM in the diets of CFJG and CFMG in this study may have resulted from a denser protein matrix, while the lower TDOM in the rice complete diet compared to the corn and jowar complete diets was likely caused by a lower protein matrix. The results on ME levels provide information about the grains' chemical makeup, rate of gas production and crude protein content. By plotting the relationships, it was evident that the broken rice grain had a higher ME due to its higher CP content compared to the jowar and maize grains. Owing to the dearth of data in the available literature, the present findings could not be compared to the previous studies.

Microbial Nitrogen Supply

The microbial nitrogen supply in lambs fed jowar grain diets was shown to be similar by Nalini *et al.* (2012). Contrary statements were reported by Chowdhury (1997) which involved twelve bulls, each weighing 272±31.5 kg at 33 months and fed rice milled feed (RMF) consisting of rice hulls, bran, and polished rice grains, as well as RMF combined with silage and basal diet. The urinary purine excretion in this trial was 15.35, 26.56 and 38.44 g/d for rice hulls, bran and polished rice grains, respectively. Since the diets were crop-based, the majority of the results fell below the mean value (32 gN/kg of rumen digestible organic matter) for sheep fed with varied diets set by the ARC (1984). The absorption of microbial purines is a major factor in the daily excretion of Parkinson's disease (PD). Moreover, there is a linear association between microbial purine intake and total PD excretion. It appeared that the excretion of PD was dependent on both N consumption ($P<0.01$) and digestible organic matter intake (DOMI) ($P>0.05$).

CONCLUSION

The *in vitro* degradability and gas production were much slower for broken rice grain than that of maize and jowar grain. In case of diets, the *in vitro* rumen degradability was higher in complete feed, jowar grain which could be a suitable replacement for maize grain. The results of this investigation demonstrated that the microbial nitrogen supply and purine derivatives of rams fed full meals consisting of maize, broken rice and jowar grain was comparable. Since they had no negative impacts on purine metabolism, CFJG (complete feed with jowar grain) and CFBR (complete feed with broken rice) would be the best options to replace CFMG (complete feed with maize grain). Consequently, jowar and broken rice may be used in place of maize.

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