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Potentiality of nano minerals to combat ill effect of rice gruel feeding in ruminants

Pratik Balkrishna Shete, J. Ramesh, R. Karunakaran, P. Raja, C. Bandeswaran

Abstract

The study was carried out to assess the potentiality of nano minerals to prevent the negative impact of the rice gruel diet on the ruminants by conducting two experiments. In the first experiment, the pH and gas production of rice gruel was determined on the graded level of rice gruel gas production technique. In the second experiment, the level showing the lowest pH and highest gas production was selected for the demonstration of the effect of supplementing nano minerals (nano copper and nano cobalt) along with urea on pH, gas production and total volatile fatty acid. In the first experiment, it was found that the pH was lowest ($p<0.05$) and gas production was highest ($p<0.05$) for 80% rice gruel + 20% green grass, which was selected as basal diet in the second experiment. In the second experiment, the nano minerals at 12.22 mg/kg of copper and 0.25 mg/kg of cobalt and 7.5 mg / 100 g of urea were found to resist ($p<0.05$) the pH change, decreased (0.05) gas production and improved ($p<0.05$) total volatile fatty acid production. From this study, it can be inferred that the negative impact of the rice gruel-based diet can be reduced by supplementing the nano forms of copper and cobalt along with the urea.

Keywords gas production, In vitro gas production technique, pH, volatile fatty acid

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Authors:
P. B. Shete
Department of Animal Nutrition, Madras Veterinary College, Tamil Nadu Veterinary and Animal Sciences University,
Chennai, India

J. Ramesh
Veterinary University Training and Research Centre, Tamil Nadu Veterinary and Animal Sciences University, India

R. Karunakaran
Madras Veterinary College, Tamil Nadu Veterinary and Animal Sciences University,
Chennai, India

P. Raja
Department of Animal Biotechnology, Madras Veterinary College, Tamil Nadu Veterinary and Animal Sciences University,
Chennai, India

C. Bandeswaran
Department of Animal Nutrition, Madras Veterinary College, Tamil Nadu Veterinary and Animal Sciences University,
Chennai, India

rameshnutrition@gmail.com

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Introduction

Farmers in India frequently feed their animals with a diet based on rice gruel. The small-scale farmers tend to feed their ruminant livestock with rice gruel along with daily grazing. In the Villupuram District of Tamil Nadu, according to Suresh et al. (2018), 55% of farmers feed rice gruel and bran to their livestock [1]. Out of them, 73 % of farmers feed 2.5 litres of rice gruel per animal per day. Unchecked rice gruel feeding can cause a negative impact on ruminant livestock by causing subacute ruminal acidosis and a drop in milk production in lactating animals [2-6]. The protein content of rice gruel is very low with high carbohydrates [7]. Also, the copper and cobalt content of rice gruel is low [7], and it does not fulfil the requirement of animal and ruminal microbes. Copper and cobalt are vital trace minerals. Copper is an essential part of many metalloenzymes which requires for normal physiological processes [8]. Cobalt is a component of vitamin B_{12} and is necessary for the metabolism of propionate (adenosyl-cobalamine) and serves as a methyl donor (methyl-cobalamine) [9]. Previous study shows that the addition of these trace minerals can improve the performance of ruminant livestock [10]. Due to the nutritional profile of rice, the addition of urea in the diet of ruminants can be beneficial as the ruminal microbes can utilise the nitrogen from urea and readily fermentable energy for protein production, which can ultimately improve the performance of an animal [11]. Nanotechnology is an advanced and reliable technology, which offers a larger surface area of nano minerals, reduced dose, easy absorption, and less environmental pollution [12]. In light of this, the current investigation was conducted to determine how nano scale copper and cobalt affected ruminal parameters as compared to their respective inorganic sources and when added to a rice gruel-based diet together with urea.

Methodology

The present study was carried out at the Department of Animal Nutrition, Madras Veterinary College, Chennai. The investigation was split into two experiments. In the first experiment, the pH and gas production of the graded levels of rice gruel and green grass (Table 1) were assessed by in vitro gas production technique [13]. From the Perambur slaughterhouse in Chennai, the rumen liquor needed for the experiment was procured. It was then transported and kept at 39˚C until it was needed. The standard buffer was created in accordance with the protocol of Blummel et al., [13]. The Hohenheim glass syringe was filled with rumen liquor and standard buffer. At predetermined levels with 4 replicates for each level, 200 mg of substrate including dried green grass and cooked rice was added. The material was incubated in a Hohenheim gas production shaker for 24 hours. The rumen liquor's pH was assessed using a pH metre right after following a 24-hour incubation period. After 24 hours of incubation, the total gas production was calculated by subtracting the initial syringe reading from the final reading following gas production.

Table 1. Graded levels of rice gruel and green grass for first experiment

Treatment groups	**Proportion of rice gruel and green grass**
Level 1	80 % Rice gruel + 20 % Green grass
Level 2	70 % Rice gruel + 30 % Green grass
Level 3	60 % Rice gruel + 40 % Green grass
Level 4	50 % Rice gruel + 50 % Green grass

The combination of rice gruel and green grass with the lowest pH and maximum gas production was chosen as the substrate for the second experiment. Copper and cobalt were determined to have elemental concentration levels of 12.22 mg/kg and 0.2 mg/kg, respectively, for supplementation. It was agreed that 7.5 mg of urea should be incorporated per gramme of additional rice. Treatments T1 - Control, T2 - Control + Inorganic Copper + Inorganic Cobalt + Urea, T3 - Control + Nano Copper (100%) + Nano Cobalt (100%) + Urea, and T4 - Control + Nano Copper (50%) + Nano Cobalt (50%) + Urea were chosen for the experiment. The in vitro gas production technique was used in the same way as in the earlier experiment. As previously mentioned, measurements of the pH and gas production were made at 12- and 24-hour intervals.

The entire contents of the syringes were transferred into 45 ml capped centrifuge tubes at the end of 12 hours and 24 hours of incubation for the determination of total volatile fatty acid (VFA). At 4°C for 30 minutes, residues were centrifuged in an ultracentrifuge at 20,000 rpm. According to Li et al., [14], 2.5 ml of supernatant was taken for VFA analysis. This was put into glass centrifuge tubes that already included 0.5 ml of metaphosphoric acid (25%). Gas chromatography (Trace GC 700, Thermo Scientific, USA) having a flame ionisation detector and a capillary column with a length of 30 metres and a diameter of 0.25 millimetres, was used to measure the total VFA content. The intake sample was split in half (1:38), and nitrogen gas was employed as the carrier gas with a flow rate of 1.20 mL/min. The initial oven temperature was set at 90 °C for 1 minute, with a temperature ramp of 10°C/min to 140°C held for 5 minutes, which sets the run time to 11 minutes. The temperatures of the injector and detector were both adjusted at 210˚C. Flow rates of air and hydrogen were chosen to be 400 and 30 mL/min, respectively. According to Snedecor and Cochran [15], all the data were statistically analysed using analysis of variance (ANOVA) using the statistical analysis system (IBM SPSS Version 20.0 for Windows).

Results and Discussion

In the first experiment, the pH was found to be lowest ($p<0.05$) and gas production was found to be highest ($p<0.05$) for 80% rice gruel + 20% green grass (Table 2). The rice gruel and other cereal provided in their ration are the sources of readily fermentable carbohydrates. Rice is major consists of starch [16]. High grain diets have been linked to increased gas generation [17-18], and Axe et al., [19] found that increasing the amount of wheat in the diet resulted in a drop in ruminal pH, which is consistent with our findings.

Table 2. Gas production and pH in second experiment conducted to establish the basal diet (Mean# ± SE)

Treatment	Gas production (ml)	pH
Level 1 – 80 % Rice gruel + 20 % Green grass	52.33 ± 0.33^{b}	6.53 ± 0.04^{a}
Level 2 – 70 % Rice gruel + 30 % Green grass	47.33 ± 2.60^{b}	6.55 ± 0.04^{a}
Level 2 – 60 % Rice gruel + 40 % Green grass	38.66 ± 1.76^{a}	6.59 ± 0.02^{a}
Level 2 – 50 % Rice gruel + 50 % Green grass	38.00 ± 1.73^{a}	6.76 ± 0.02^{b}

Mean of three observations
Means bearing different superscript in the same column differ significantly ($p<0.05$)

In the second experiment, it was found that the pH was considerably resisted ($p<0.05$) in the inorganic mineral supplemented and 100% nano mineral supplemented groups (Table 3). The gas production was found to be lowest ($p<0.05$) in the 100% nano mineral supplemented group. The total VFA was also found to be improved most ($p<0.05$) in the 100% nano mineral supplemented group compared to other groups. When the urea is hydrolyses in the rumen by the action of urease, two moles of ammonia will be released, acting as a weak base in the rumen. Thus, the supplementation of dietary urea may have an alkalizing effect on ruminal pH. Although the mere addition of urea may not have the total impact on ruminal pH resistance, compared to 50% nano mineral

Table 3. Effect of supplementation of inorganic / nano copper sulphate and cobalt sulphate at graded levels in basal diet on pH, gas production and total volatile fatty acid at 12th and 24th hours of incubation by *in vitro* gas production technique (Mean# ± SE)

Treatment	pH		Gas production		Total volatile fatty acid	
Incubation hour	**12**	**24**	**12**	**24**	**12**	**24**
T1 - Basal diet – Negative control	6.92 ± 0.01^{a}	6.58 ± 0.02^{a}	28.50 ± 1.50^{b}	47.33 ± 1.45^{c}	35.69 ± 0.28^{a}	37.63 ± 0.49^{a}
T2 - Basal diet + Inorganic Cu +Inorganic Co + Urea	7.07 ± 0.04^{a}	6.98 ± 0.05^{b}	17.00 ± 1.00^{a}	40.00 ± 1.15^{ab}	62.64 ± 1.06^{c}	66.25 ± 0.71^{c}
T3 - Basal diet + Nano Cu (100%) +Nano Co (100%) + Urea	7.30 ± 0.29^{a}	6.94 ± 0.02^{b}	13.50 ± 0.50^{a}	39.00 ± 1.73^{a}	67.09 ± 0.87^{d}	68.83 ± 0.10^{d}
T4 - Basal diet + Nano Cu (50%) +Nano Co (50%) + Urea	6.92 ± 0.01^{a}	6.87 ± 0.01^{c}	24.00 ± 2.00^{b}	42.33 ± 1.20^{bc}	44.47 ± 0.47^{b}	47.39 ± 0.50^{b}

Mean of three observations
Means bearing different superscript in the same column differ significantly ($p<0.05$)

supplementation, the 100% nano mineral supplementation group have shown less pH resistance. When fed with a diet that contains readily fermentable energy, Tiffany et al., [20].and Cameron et al., [21]. have observed that the addition of cobalt and urea to the diet influences the pH in the rumen. The improved pH in rumen liquor is beneficial for the proliferation of ruminal microbes. The production of volatile fatty acids may have benefited from microbial growth. Since the dietary carbohydrate has fluxed towards the volatile fatty acids, the gas production was lesser in the 100% nano mineral supplemented group than in the control group. The diversion of carbon to fermentation products like fatty acids than the gas production like carbon dioxide and methane is beneficial to the animal. According to Ampapon and Wanapat [22] and

Rebelo et al., [23], the addition of copper, cobalt, and nitrogen source, respectively, resulted in a decrease in gas production, which is consistent with our research findings. Also, it was reported that the individual addition of copper cobalt and urea in the feed has favoured the VFA concentration in the rumen [24-26] which is in accordance with our findings.

Hence, it may be concluded that the supplementation of nano copper and nano cobalt along with the urea, in the rice gruel diet will prevent acidosis and there will be improved production from livestock.

Conclusion

Rice feeding has a negative impact on ruminants. The acidosis tends to affect ruminal microbes, thereby causing decreased animal production. The addition of minerals like copper and cobalt along with urea can improve ruminal fermentation and ultimately may increase animal production. The nano minerals have been reported to be effective in the animal diet. Although, there is a need for more research in this area.

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Conflict of interest

The authors declare that they have no conflict of interest.

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