Original Research

Nutritional Composition of Cooked Rice Fed to Dairy Cattle of Tamil Nadu

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Abstract

As the study focused on arriving at an ameliorative measure for disorders arising on cooked rice-based feeding regimen cooked rice samples were estimated for their proximate principles soluble and insoluble ash and mineral profile. Rice samples for chemical analysis were collected throughout Tamil Nadu from dairy farmers who were following rice-based feeding regimen. Samples were collected from all the 32 districts of the state. In each district samples (100g of rice) were collected from four different locations. No significant (p>0.05) variation existed in the proximate composition, soluble ash and acid insoluble ash of cooked rice across districts of Tamil Nadu. Cooked rice was found to be an optimum source of crude protein. Across districts the crude protein ranged between 9.2 to 12.6 per cent. The cooked rice samples were a very poor (below (1%)) source of crude fibre. The soluble carbohydrate as indicated by nitrogen free extracts (NFE) was above 84 per cent in the samples analyzed. No significant (p>0.05) variation existed in the major mineral composition of cooked rice across districts of Tamil Nadu. No significant (p>0.05) variation existed in the trace mineral composition of cooked rice across districts of Tamil Nadu. Cooked rice had a low crude protein ranging between (9.2 to 12.6%) but had a very high nitrogen free extract (NFE) of (above 84%) indicating a very wide gap in the available nitrogen to available soluble carbohydrate. Hence, it is advocated to provide adequate degradable protein to ferment available carbohydrate in the cooked rice to increase microbial protein production and reduce the fermentation of energy to lactic acid and thereby reduce the risk of acidosis. Cooked rice was also a very poor source of sulphur (0.68ppm on DMB). Hence, when nitrogen supplementation is carried out, the maintenance of N: S ratio of 12:1 is critical. Cooked rice was also a very poor source of copper (0.01ppm on DMB) and cobalt (0.006ppm on DMB) necessitating its supplementation.

Key words: Cooked Rice, Energy, Nitrogen, Proximate, Tamil Nadu

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Introduction

Dairy farmers of southern India, especially Tamil Nadu, have been feeding their dairy cattle with cheap and abundantly available feed resources, which includes cooked rice, as it is available at a very subsidized cost to economically weaker sections, who also largely depend on cows for their survival. The ever-rising cost of oil cakes has resulted in farmers feeding their animals more of rice causing lower protein intake and consequently leading to a mismatch between energy and nitrogen supply in the rumen (Murugeswari *et al.*, 2013). In a survey to determine traditional feeding practices for cross bred dairy cattle reared in Tamil Nadu, it was found that the animals were being fed on gruel based unbalanced feed, the gruel included kitchen waste, table waste etc., apart from the decanted gruel on cooking rice (Suresh *et al.,* 2016). Inspite of the widespread prevalence of feeding cooked rice in the state, systematic research on documenting its chemical composition has not been carried out. Understanding the chemical composition of cooked rice will help in identifying supplemental nutrients that could be given to animals where cooked rice-based feeding is adopted. Hence, a study was undertaken to determine the chemical composition of cooked rice collected from all over Tamil Nadu.

Materials and Methods

Rice samples for chemical analysis were collected throughout Tamil Nadu from dairy farmers who were following rice-based feeding regimen. Samples were collected from all the 32 districts of the state. In each district samples (100g of rice) were collected from four different locations. All rice samples were stored in airtight containers at 4 $^{\circ}$C in refrigerator till further studies. Rice samples prior to analysis were cooked with water in the ratio of 1:10, in boiling water bath to a gel like consistency (Oko *et al.,* 2012) which was similar to cooked rice fed by farmers of Tamil Nadu.

Proximate Composition, Soluble and Insoluble Ash of Cooked Rice

Proximate analysis (moisture, crude protein, crude fibre, ether extract, nitrogen free extract and total ash) and acid insoluble ash content of the cooked rice samples were estimated according to AOAC (2012). Acid soluble ash was calculated by subtracting acid insoluble ash from total ash content. Proximate principles, soluble ash and acid insoluble ash were expressed as per cent on dry matter basis.

Mineral Profile of Cooked Rice

Mineral analyses were carried out on samples (0.5g) that were weighed into teflon digestion vessels, 6ml of concentrated nitric acid and 1ml of a 30 % (v/v) hydrogen peroxide was added. Vessels were closed, and the reaction mixtures were immediately subjected to microwave heating at a maximum power of

600W for 45 minutes. After cooling, the colourless solutions were transferred into 25ml volumetric flasks and volume made up to with de-ionized water, prior to multi-element analysis by ICP-OES (Szymczycha *et al.*, 2014). Phosphorus was determined calorimetrically using Ammonium Vanadate (AOAC, 2012).

Statistical Analysis

Data were analysed with analysis of variance (ANOVA) and linear regression analysis using IBM® SPSS® Statistics version 20.0 for Windows® software as per the Snedecor and Cochran (1989). The critical difference between the groups was analysed by Duncan's multiple range test.

Results and Discussion

Cooked rice samples were estimated for their proximate principles soluble and insoluble ash and mineral profile, the results of which are presented in this section.

Proximate Composition, Soluble and Insoluble Ash of Cooked Rice

The proximate composition, soluble and acid insoluble ash (% DMB) of cooked rice from 32 districts of Tamil Nadu is presented in Table 1. No significant ($p>0.05$) variation existed in the proximate composition, soluble ash and acid insoluble ash of cooked rice across districts of Tamil Nadu. Cooked rice was found to be an optimum source of crude protein. Across districts the crude protein ranged between 9.2 to 12.6 per cent. The cooked rice samples were a very poor (below 1%) source of crude fibre. The soluble carbohydrate as indicated by nitrogen free extracts (NFE) was above 84 per cent in the samples analyzed. Mir *et al.* (2017) also stated that starch is the major constituent of rice and protein is the second highest component after starch in rice kernel. Thus, excess feeding of cooked rice predisposes to ruminal acidosis, which requires synchronized release of nitrogen to divert carbon and hydrogen present in fermentable organic matter to synthesize microbial protein (Murugeswari *et al.*, 2013). It is advocated to provide adequate degradable protein to ferment available carbohydrate in the cooked rice to increase microbial protein production and reduce the fermentation of energy to acids (De Ondarza, 2000) and thereby reduce the risk of acidosis (Hardy, 2016).

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Table 1: Proximate composition, soluble ash and acid insoluble ash (%DMB) of cooked rice collected from 32 districts of Tamil Nadu (Mean* ± SE)

S. No.	District	Proximate Composition, Soluble Ash and Acid Insoluble Ash % Dry Matter Basis (NS**)						
		Crude Protein	Ether extract	Crude Fibre	Nitrogen Free Extract	Total Ash	Acid soluble ash	Acid insoluble ash
1	Ariyalur	9.52 ± 0.09	2.14 ± 0.10	0.85 ± 0.04	86.39 ± 4.05	1.10 ± 0.06	0.71 ± 0.04	0.39 ± 0.02
2	Chennai	12.60 ± 0.08	1.27 ± 0.06	0.73 ± 0.04	84.54 ± 3.89	0.86 ± 0.04	0.57 ± 0.02	0.29 ± 0.01
3	Coimbatore	10.35 ± 0.09	1.09 ± 0.04	0.70 ± 0.03	87.11 ± 5.12	0.75 ± 0.04	0.67 ± 0.03	0.08 ± 0.005
4	Cuddalore	11.07 ± 0.07	2.14 ± 0.11	0.78 ± 0.03	84.96 ± 4.75	1.05 ± 0.05	0.70 ± 0.03	0.35 ± 0.03
5	Dharmapuri	11.82 ± 0.10	1.34 ± 0.07	0.70 ± 0.04	85.39 ± 6.01	0.75 ± 0.03	0.73 ± 0.03	0.02 ± 0.005
6	Dindigul	9.69 ± 0.07	1.18 ± 0.06	0.72 ± 0.02	87.71 ± 3.88	0.70 ± 0.03	0.66 ± 0.03	0.04 ± 0.005
7	Erode	12.15 ± 0.08	2.08 ± 0.11	0.72 ± 0.03	84.03 ± 4.23	1.02 ± 0.05	0.74 ± 0.03	0.28 ± 0.01
8	Kancheepuraam	12.45 ± 0.11	1.19 ± 0.05	0.71 ± 0.04	84.99 ± 3.45	0.66 ± 0.03	0.51 ± 0.02	0.15 ± 0.01
9	Kanyakumari	10.03 ± 0.08	1.22 ± 0.06	0.80 ± 0.02	87.11 ± 3.42	0.84 ± 0.04	0.78 ± 0.03	0.06 ± 0.003
10	Karur	9.20 ± 0.07	1.04 ± 0.05	0.71 ± 0.03	88.39 ± 4.22	0.66 ± 0.03	0.60 ± 0.03	0.06 ± 0.008
11	Krishnagiri	12.41 ± 0.11	1.33 ± 0.06	0.97 ± 0.05	84.45 ± 4.34	0.84 ± 0.02	0.65 ± 0.03	0.19 ± 0.02
12	Madurai	8.90 ± 0.08	1.03 ± 0.05	0.60 ± 0.03	88.62 ± 5.12	0.85 ± 0.03	0.78 ± 0.04	0.07 ± 0.001
13	Nagapattinam	10.02 ± 0.09	1.03 ± 0.05	0.70 ± 0.04	87.57 ± 6.77	0.68 ± 0.04	0.59 ± 0.03	0.09 ± 0.006
14	Namakkal	9.35 ± 0.07	1.28 ± 0.06	0.73 ± 0.04	87.93 ± 5.54	0.71 ± 0.07	0.67 ± 0.03	0.04 ± 0.004
15	Perambalur	9.49 ± 0.05	1.49 ± 0.07	0.88 ± 0.04	87.24 ± 5.21	0.90 ± 0.04	0.55 ± 0.02	0.35 ± 0.01
16	Pudhukottai	9.21 ± 0.07	1.23 ± 0.06	0.69 ± 0.02	88.14 ± 4.36	0.73 ± 0.03	0.62 ± 0.03	0.11 ± 0.03
17	Ramanathapuram	10.24 ± 0.06	1.05 ± 0.05	0.76 ± 0.03	87.29 ± 7.01	0.66 ± 0.03	0.53 ± 0.02	0.13 ± 0.02
18	Salem	9.25 ± 0.07	1.01 ± 0.05	0.67 ± 0.03	88.39 ± 7.98	0.68 ± 0.03	0.64 ± 0.02	0.04 ± 0.005
19	Sivagangai	11.10 ± 0.70	1.18 ± 0.05	0.69 ± 0.02	86.30 ± 6.52	0.73 ± 0.04	0.61 ± 0.02	0.12 ± 0.04
20	Thanjavur	11.79 ± 0.07	1.04 ± 0.05	0.68 ± 0.02	85.68 ± 5.01	0.81 ± 0.04	0.75 ± 0.03	0.06 ± 0.006
21	The Nilgiris	9.66 ± 0.09	1.29 ± 0.07	0.71 ± 0.01	87.60 ± 6.08	0.74 ± 0.03	0.64 ± 0.02	0.10 ± 0.006
22	Theni	12.41 ± 0.11	1.36 ± 0.08	0.77 ± 0.03	84.63 ± 5.99	0.83 ± 0.04	0.66 ± 0.03	0.17 ± 0.02
23	Thiruvallur	11.22 ± 0.12	1.74 ± 0.51	0.81 ± 0.04	85.24 ± 7.01	0.99 ± 0.05	0.71 ± 0.04	0.28 ± 0.007
24	Thiruvannamalai	11.32 ± 0.10	1.33 ± 0.56	0.66 ± 0.03	85.93 ± 6.85	0.76 ± 0.03	0.57 ± 0.02	0.19 ± 0.02
25	Thoothukudi	11.75 ± 0.10	1.07 ± 0.51	0.68 ± 0.03	85.68 ± 5.65	0.82 ± 0.04	0.77 ± 0.04	0.05 ± 0.005
26	Tiruchirappalli	9.25 ± 0.07	1.06 ± 0.51	0.69 ± 0.03	88.30 ± 6.07	0.70 ± 0.03	0.62 ± 0.03	0.08 ± 0.005
27	Tiruppur	9.25 ± 0.08	1.84 ± 0.91	0.73 ± 0.04	87.52 ± 7.54	0.66 ± 0.03	0.59 ± 0.03	0.07 ± 0.008
28	Tiruvarur	11.65 ± 0.06	1.03 ± 0.52	0.66 ± 0.04	85.90 ± 6.22	0.76 ± 0.04	0.70 ± 0.05	0.06 ± 0.008
29	Trinelveli	9.66 ± 0.07	1.29 ± 0.63	0.71 ± 0.04	87.60 ± 6.01	0.74 ± 0.03	0.64 ± 0.04	0.10 ± 0.01
30	Vellore	10.47 ± 0.09	1.79 ± 0.71	0.79 ± 0.03	86.40 ± 7.15	0.55 ± 0.02	0.40 ± 0.02	0.15 ± 0.01
31	Villupuram	11.13 ± 0.09	1.35 ± 0.07	0.72 ± 0.04	86.05 ±6.421	0.75 ± 0.03	0.69 ± 0.02	0.06 ± 0.007
32	Virudhunagar	12.15 ± 0.10	2.08 ± 0.122	0.72 ± 0.02	84.03 ± 5.66	1.02 ± 0.05	0.74 ± 0.02	0.28 ± 0.04
Overall Mean		10.64 ± 0.11	1.36 ± 0.08	0.73 ± 0.02	86.47 ± 4.98	0.79 ± 0.04	0.65± 0.05	0.14± 0.01

**Mean of 4 samples **NS – No significant (p>0.05) variation*

The ether extract of cooked rice was below 3 per cent as the rice was a milled variety, and milled rice only contains negligible amounts of lipids. Almost all of the rice's oil content is located in the outer layers of the

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grain, which are removed during milling (Oko *et al.*, 2012). The highest total ash documented was only 1.1 per cent with only 0.71 per cent of acid soluble ash. The low acid soluble ash content of cooked rice documented in this study is a proof to its low mineral content. The mineral composition of the rice grain depends considerably on the availability of soil nutrient during crop growth and variety (Heinemann *et al*., 2005 and Wang *et al*., 2011). The crude protein and soluble carbohydrate of cooked rice reported in this study was similar to that reported by Ali *et al.* (2008). As in this study, Shiela *et al.* (2016) also reported very low crude fibre and similar values for ether extract and total ash in rice.

Variation has been reported in chemical composition of rice; Factors such as diversity in the genetic background, climatic and soil conditions during the rice grain development, affect the physicochemical, functional and nutritional properties of a particular variety (Dendy, 2005 and Singh *et al*., 2011). However, the present study documented no significant ($p>0.05$) variation in the proximate composition, soluble ash and acid insoluble ash of cooked rice across districts of Tamil Nadu, indicating that the rice procured by farmers of the state for feeding their animals was the one available at subsidized cost to economically weaker sections, and this belonged to the same variety in all the districts.

The optimum level of soluble carbohydrate and crude protein (1000kcal energy to 33g nitrogen) is required for microbial protein synthesis in the rumen. Nevertheless, cooked rice had a low crude protein ranging between 9.2 to 12.6 per cent and had a very high nitrogen free extract (NFE) of above 84 per cent indicating a very wide gap in the available nitrogen to available soluble carbohydrate. High level of soluble carbohydrates / starches may have negative effects on the microbial synthesis in the rumen because their fermentation diminishes the rumen pH, affects the fiber degradation, increases the energy losses in the microbes, and declines the de novo synthesis of amino acids (Russell and Wallace, 1997). The possibility of supplementing nitrogen sources allows the rumen microbes to utilize them for synthesis of microbial protein, when enough energy is available (Rodriguez *et al.*, 2007). Hence, nitrogen supplementation needs to be considered in cooked rice-based feeding regimen.

Mineral Profile of Cooked Rice

The major minerals present in cooked rice collected from 32 districts of Tamil Nadu is presented in Table 2.

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Table 2: Major mineral (%DMB) present in cooked rice from 32 districts of Tamil Nadu (Mean* ± SE)

S. No.	Place	Major Minerals% Dry Matter Basis (NS**)					
		Ca	P	Mg	K	Na	S
1	Ariyalur	0.26 ± 0.01	1.52 ± 0.03	0.01 ± 0.005	0.41 ± 0.02	0.02 ± 0.005	0.59 ± 0.05
2	Chennai	0.29 ± 0.02	1.84 ± 0.05	0.01 ± 0.005	0.26 ± 0.01	0.02 ± 0.005	0.69 ± 0.04
3	Coimbatore	0.18 ± 0.01	1.37 ± 0.04	0.01 ± 0.004	0.18 ± 0.01	0.01 ± 0.006	0.56 ± 0.03
4	Cuddalore	0.26 ± 0.02	1.58 ± 0.03	0.01 ± 0.004	0.40 ± 0.03	0.01 ± 0.006	0.75 ± 0.04
5	Dharmapuri	0.28 ± 0.02	2.41 ± 0.03	0.02 ± 0.003	0.45 ± 0.01	0.02 ± 0.004	0.69 ± 0.06
6	Dindigul	0.18 ± 0.01	0.93 ± 0.01	0.01 ± 0.003	0.54 ± 0.03	0.01 ± 0.004	0.59 ± 0.02
7	Erode	0.29 ± 0.01	1.52 ± 0.02	0.01 ± 0.004	0.71 ± 0.05	0.02 ± 0.004	0.64 ± 0.03
8	Kancheepuraam	0.24 ± 0.02	1.35 ± 0.03	0.01 ± 0.004	0.39 ± 0.01	0.01 ± 0.005	0.62 ± 0.04
9	Kanyakumari	0.23 ± 0.01	1.62 ± 0.01	0.01 ± 0.005	0.52 ± 0.03	0.02 ± 0.002	0.79 ± 0.01
10	Karur	0.18 ± 0.01	1.36 ± 0.02	0.01 ± 0.004	0.32 ± 0.01	0.01 ± 0.003	0.55 ± 0.05
11	Krishnagiri	0.25 ± 0.02	1.52 ± 0.03	0.01 ± 0.005	0.65 ± 0.05	0.02 ± 0.005	0.61 ± 0.07
12	Madurai	0.20 ± 0.01	1.75 ± 0.01	0.02 ± 0.003	0.25 ± 0.01	0.02 ± 0.005	0.62 ± 0.03
13	Nagapattinam	0.20 ± 0.01	1.42 ± 0.02	0.01 ± 0.005	0.39 ± 0.01	0.01 ± 0.004	0.53 ± 0.06
14	Namakkal	0.19 ± 0.02	1.17 ± 0.01	0.01 ± 0.005	0.46 ± 0.03	0.01 ± 0.005	0.64 ± 0.04
15	Perambalur	0.25 ± 0.01	1.26 ± 0.02	0.01 ± 0.004	0.42 ± 0.02	0.01 ± 0.004	0.76 ± 0.03
16	Pudhukottai	0.19 ± 0.01	1.14 ± 0.01	0.01 ± 0.006	0.37 ± 0.01	0.01 ± 0.007	0.72 ± 0.03
17	Ramanathapuram	0.21 ± 0.02	1.57 ± 0.03	0.01 ± 0.007	0.49 ± 0.03	0.02 ± 0.007	0.69 ± 0.01
18	Salem	0.20 ± 0.02	1.25 ± 0.01	0.01 ± 0.004	0.39 ± 0.01	0.01 ± 0.004	0.66 ± 0.05
19	Sivagangai	0.22 ± 0.01	1.48 ± 0.01	0.01 ± 0.004	0.24 ± 0.01	0.01 ± 0.001	0.54 ± 0.04
20	Thanjavur	0.19 ± 0.01	1.55 ± 0.03	0.01 ± 0.001	0.28 ± 0.01	0.02 ± 0.005	0.72 ± 0.02
21	The nilgiris	0.19 ± 0.02	1.62 ± 0.04	0.01 ± 0.003	0.26 ± 0.01	0.01 ± 0.001	0.62 ± 0.02
22	Theni	0.22 ± 0.01	1.51 ± 0.02	0.02 ± 0.003	0.49 ± 0.03	0.02 ± 0.006	0.64 ± 0.04
23	Thiruvallur	0.22 ± 0.02	1.42 ± 0.01	0.01 ± 0.002	0.61 ± 0.05	0.01 ± 0.006	0.59 ± 0.01
24	Thiruvannamalai	0.27 ± 0.01	1.71 ± 0.04	0.01 ± 0.001	0.55 ± 0.04	0.02 ± 0.001	0.69 ± 0.05
25	Thoothukudi	0.19 ± 0.01	1.48 ± 0.01	0.01 ± 0.005	0.36 ± 0.01	0.01 ± 0.005	0.77 ± 0.01
26	Tiruchirappalli	0.19 ± 0.01	1.62 ± 0.03	0.01 ± 0.006	0.26 ± 0.01	0.02 ± 0.001	0.62 ± 0.06
27	Tiruppur	0.21 ± 0.02	1.1 ± 0.01	0.01 ± 0.004	0.38 ± 0.02	0.01 ± 0.002	0.58 ± 0.04
28	Tiruvarur	0.19 ± 0.01	1.57 ± 0.01	0.01 ± 0.005	0.34 ± 0.01	0.02 ± 0.002	0.62 ± 0.05
29	Trinelveli	0.27 ± 0.02	2.46 ± 0.05	0.02 ± 0.006	0.37 ± 0.03	0.02 ± 0.005	0.59 ± 0.01
30	Vellore	0.18 ± 0.01	1.39 ± 0.01	0.01 ± 0.006	0.52 ± 0.04	0.01 ± 0.005	0.64 ± 0.03
31	Villupuram	0.25 ± 0.02	1.80 ± 0.03	0.01 ± 0.004	0.58 ± 0.01	0.02 ± 0.004	0.59 ± 0.07
32	Virudhunagar	0.23 ± 0.01	1.62 ± 0.02	0.01 ± 0.007	0.52 ± 0.04	0.01 ± 0.004	0.58 ± 0.06
Overall Mean		0.22 ± 0.01	1.53 ± 0.03	0.01 ± 0.005	0.42 ± 0.03	0.01 ± 0.005	0.68 ± 0.02

**Mean of 4 samples **NS – No significant variation*

No significant (p>0.05) variation existed in the major mineral composition of cooked rice across districts of Tamil Nadu. Similar values for calcium and phosphorus was also observed by Adepoju *et al.* (2016). The trace mineral profile of cooked rice collected from 32 districts of Tamil Nadu is presented in Table 3.

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Table 3: Trace mineral (ppm on DMB) present in cooked rice from 32 districts of Tamil Nadu (Mean* ± SE)

S. No.	Place	Trace Minerals ppm on Dry Matter Basis (NS**)				
		Cu	Zn	Fe	Mn	Co
1	Ariyalur	0.008± 0.007	0.05 ± 0.01	0.254 ± 0.041	0.02 ± 0.02	0.006 ± 0.003
2	Chennai	0.010 ± 0.08	0.05 ± 0.01	0.257 ± 0.061	0.02 ± 0.01	0.006 ± 0.002
3	Coimbatore	0.010 ± 0.05	0.05 ± 0.01	0.265 ± 0.032	0.02 ± 0.04	0.006 ± 0.002
4	Cuddalore	0.009 ± 0.005	0.06 ± 0.01	0.304 ± 0.041	0.01 ± 0.02	0.006 ± 0.003
5	Dharmapuri	0.010 ± 0.04	0.05 ± 0.01	0.287 ± 0.051	0.02 ± 0.01	0.006 ± 0.003
6	Dindigul	0.009 ± 0.007	0.06 ± 0.01	0.275 ± 0.053	0.01 ± 0.04	0.005 ± 0.003
7	Erode	0.01 ± 0.06	0.06 ± 0.01	0.289 ± 0.054	0.01 ± 0.01	0.007 ± 0.003
8	Kancheepuraam	0.010 ± 0.04	0.06 ± 0.01	0.235 ± 0.032	0.01± 0.02	0.007 ± 0.002
9	Kanyakumari	0.01 ± 0.05	0.06 ± 0.01	0.247 ± 0.033	0.01 ± 0.01	0.006 ± 0.004
10	Karur	0.009 ± 0.003	0.06 ± 0.01	0.274 ± 0.054	0.02 ± 0.06	0.005 ± 0.002
11	Krishnagiri	0.010 ± 0.04	0.06 ± 0.01	0.246 ± 0.022	0.02 ± 0.01	0.007 ± 0.002
12	Madurai	0.009 ± 0.006	0.05 ± 0.01	0.254 ± 0.032	0.01 ± 0.03	0.007 ± 0.003
13	Nagapattinam	0.010 ± 0.05	0.06 ± 0.01	0.264 ± 0.035	0.02 ± 0.01	0.006 ± 0.003
14	Namakkal	0.009 ± 0.004	0.06 ± 0.01	0.258 ± 0.036	0.01 ± 0.06	0.005 ± 0.003
15	Perambalur	0.009 ± 0.002	0.06 ± 0.01	0.241 ± 0.042	0.02 ± 0.03	0.006 ± 0.0
16	Pudhukottai	0.009 ± 0.004	0.06 ± 0.01	0.301 ± 0.031	0.01 ± 0.04	0.006 ± 0.003
17	Ramanathapuram	0.01 ± 0.06	0.05 ± 0.01	0.275 ± 0.017	0.01 ± 0.03	0.006 ± 0.001
18	Salem	0.009 ± 0.004	0.05 ± 0.01	0.251 ± 0.021	0.02 ± 0.06	0.006 ± 0.003
19	Sivagangai	0.010 ± 0.06	0.06 ± 0.01	0.255 ± 0.001	0.01 ± 0.02	0.006 ± 0.003
20	Thanjavur	0.010 ± 0.03	0.06 ± 0.01	0.261 ± 0.016	0.01 ± 0.06	0.007 ± 0.004
21	The nilgiris	0.009 ± 0.004	0.05 ± 0.01	0.252 ± 0.016	0.01 ± 0.07	0.007 ± 0.001
22	Theni	0.01 ± 0.03	0.06 ± 0.01	0.253 ± 0.031	0.02 ± 0.06	0.006 ± 0.005
23	Thiruvallur	0.010 ± 0.02	0.06 ± 0.01	0.274 ± 0.015	0.02 ± 0.05	0.006 ± 0.002
24	Thiruvannamalai	0.009 ± 0.004	0.05 ± 0.01	0.287 ± 0.016	0.02 ± 0.06	0.006 ± 0.003
25	Thoothukudi	0.010 ± 0.01	0.05 ± 0.01	0.295 ± 0.015	0.01 ± 0.05	0.007 ± 0.004
26	Tiruchirappalli	0.009 ± 0.004	0.05 ± 0.01	0.285 ± 0.031	0.01 ± 0.05	0.006 ± 0.003
27	Tiruppur	0.009 ± 0.004	0.06 ± 0.01	0.302 ± 0.001	0.01 ± 0.03	0.006 ± 0.003
28	Tiruvarur	0.010 ± 0.06	0.06 ± 0.01	0.313 ± 0.061	0.02 ± 0.03	0.005 ± 0.002
29	Trinelveli	0.01 ± 0.04	0.06 ± 0.01	0.259 ± 0.016	0.01 ± 0.02	0.006 ± 0.004
30	Vellore	0.010 ± 0.06	0.06 ± 0.01	0.242 ± 0.014	0.01 ± 0.05	0.006 ± 0.003
31	Villupuram	0.010 ± 0.03	0.05 ± 0.01	0.270 ± 0.013	0.02 ± 0.06	0.007 ± 0.003
32	Virudhunagar	0.009 ± 0.004	0.05 ± 0.01	0.304 ± 0.051	0.01 ± 0.03	0.006 ± 0.003
Overall mean		0.010 ± 0.05	0.05 ± 0.01	0.270 ± 0.089	0.02 ± 0.03	0.006 ± 0.001

**Mean of 4 samples; **NS – No significant variation*

No significant ($p>0.05$) variation existed in the trace mineral composition of cooked rice across districts of Tamil Nadu. Cooked rice was also a very poor source of sulphur (0.68ppm on DMB). Hence, when nitrogen supplementation is carried out, the maintenance of N: S ratio of 12:1 is critical; therefore, sulphur

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supplementation needs to be considered. Cooked rice was also a very poor source of copper (0.010ppm on DMB), but it has been reported that 10 and 20mg Cu/kg dry matter had a positive influence on rumen fermentation (Zhang *et al.*, 2007). Hence copper supplementation also needs to be considered. Cooked rice was also a very poor source of cobalt (0.006ppm on DMB). Significance of cobalt in ruminant nutrition as a critical nutrient for vitamin B_{12} synthesis is well documented (Stemme *et al.*, 2008). Hence, cobalt supplementation also needs to be considered.

Lopez and Satter (1992) reported that the supplementation of cobalt and copper in combination with other trace elements *viz.*, Fe, Zn and I in the basal ration, favoured the growth of rumen microorganisms, resulting in increased digestibility of cellulose. A probably overlooked aspect by which microelements can affect rumen digestion is by facilitating bacterial attachment to plant cell walls. Copper and cobalt may act as bridge between bacteria and plant cell walls, allowing a negative charged microorganism to attach to fiber particle of the same charge by using a bivalent cation bridges.

Conclusion

The optimum level of soluble carbohydrate and crude protein (1000kcal energy to 33g nitrogen) is required for microbial protein synthesis in the rumen. Nevertheless, cooked rice had a low crude protein ranging between (9.2 to 12.6%) and had a very high nitrogen free extract (NFE) of (above 84%) indicating a very wide gap in the available nitrogen to available soluble carbohydrate. Likewise, copper, cobalt and sulphur are essential nutrient for microbial multiplication in the rumen and also sulphur is needed for proper utilization of nitrogen. But cooked rice was also a very poor source of sulphur (0.68ppm on DMB). Hence, when nitrogen supplementation is carried out, the maintenance of N: S ratio of 12:1 is critical. Cooked rice was also a very poor source of copper (0.01ppm on DMB) and cobalt (0.006ppm on DMB) necessitating its supplementation. Hence, it is advocated to provide adequate degradable protein to ferment available carbohydrate in the cooked rice, adequate sulphur for maintaining the N:S ratio, copper and cobalt to increase microbial protein production and reduce the fermentation of energy to lactic acid and thereby reduce the risk of acidosis. Other microminerals may also be supplemented to animals for good health.

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