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Effect of red seaweed *Kappaphycus alvarezii* based feed additive on feed intake, nutrient utilization and nitrogen balance in lactating crossbred cows

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Abstract
The present study was conducted to see the effect of supplementation of *Kappaphycus alvarezii* based seaweed product on feed intake, nutrient digestibility and nitrogen balance in crossbred cattle. In this study, 18 lactating crossbred (Karan fries) cows were divided into 3 groups of 6 animals each based on milk yield, body weight, parity and days in milk. The cows in treatment T_1 were fed rations as per their nutrient requirements. The cows in treatments T_2 and T_3 were fed the similar rations in control (T_1), however, the diets were supplemented with *K. alverazii* based sea weed powder (*K. alvarezii* powder: *Gracilaria salicornia powder*: *K. alvarezii* sap powder in 1: 1: 1 ratio) @ 1.5 and 3% of ration (on dry matter basis), respectively. The study lasted for 150 days. The feed intake, digestibility of nutrients and nitrogen balance were not influenced by sea weed powder supplementation.

Keywords: Seaweed, lactating, crossbred cows, nutrient digestibility, feed additive

Introduction
Seaweeds have been used as livestock feed for so many years. *Kappaphycus alvarezii* is red seaweed which belongs to the class rhodophyceae. It is versatile and easy to cultivate plant and is one of the most important commercial sources of carrageenans (Mondal *et al*., 2015) [1]. This huge population has to sustain with adequate feed ingredients in developed counties, whereas they face huge shortage of feeds and supplements in developing and poor countries. The cost of conventional feeds and more particularly the mineral ingredients is also high and increasing day-by-day (Lopez-Alonso M, 2012) [2].
Therefore, the shift in attention goes to the by-products and non-conventional feed ingredients. Aquatic plants like seaweeds are the classic example of this type of feed resources, which are available in coastal areas even during draught period (Christaki *et al*., 2010) [3]. Seaweed extracts contain major and trace nutrients, amino acids, vitamins and biologically active compounds. Seaweeds contain growth promoting substances which stimulate the growth and yield of plants. The consumption of seaweed by human beings proved to be health-promoting and its benefits are well documented (El Gamal, 2012) [4] (Evans *et al*., 2014) [5]. Seaweed is a rich source of natural antioxidants (Matanjun *et al*., 2008) [6]. Sulfated polysaccharides present in *K. alvarezii* inhibit activity of many bacterial species (Leonard *et al*., 2010) [7]. In view of these facts, the present experiment was conducted to see the effect of supplementation of *Kappaphycus alvarezii* based seaweed product on feed intake, nutrient digestibility and nitrogen balance in crossbred cattle.

Materials and Methods
Animals, grouping and management
Eighteen lactating Karan fries cows were selected from the Livestock Research Centre of ICAR-National Dairy Research Institute, Karnal and divided randomly into three equal groups on the basis of their milk yield, body weight, parity and days in milk (Table 1). Animals in control (T1) group were fed concentrate mixture along with sugargraze green fodder (concentrate mixture and roughages as 40:60) for 150 days of feeding trial. While cows in T2 and T3 group were offered ration consisting of 1.5 and 3% of sea weed powder (*K. alvarezii* powder: *Gracilaria salicornia powder*: *K. alvarezii* sap powder in 1: 1: 1 ratio) in their concentrate mixture (Table 2). All the cows were fed individually to meet their nutritional requirement (NRC, 2001) [8]. Concentrate mixture and green sugargraze fodder were offered at

9.00 A.M. in morning and at 4.00 P.M. in evening daily. Clean drinking water was offered ad libitum individually thrice a day at the time of milking, i.e. 6 A.M., 12 noon and 6 P.M. Proper deworming and vaccination was done to prevent occurrence of diseases. Dry matter (DM) intake of each animal was recorded fortnightly for five consecutive days during which weighed amount of concentrate mixture, green sugargraze fodder were offered daily and the residue was collected after 24 h. The animals were weighed before the start of experiment and thereafter at fortnightly intervals.

Metabolism trial

A metabolism trial of 7 days collection period was conducted on all the experimental animals after 3 months of preliminary supplementation. The body weight of the animals was recorded before and after the metabolism trial for two consecutive days. Faeces and urine were collected on 24 h basis along with the feed offered and orts. Dry matter was recorded by drying in a hot air oven (AOAC, 2005) [9], pooled for all the days of collection, ground to pass 1 mm sieve and kept in airtight containers for further analysis.

Table 1: Description of experimental animals at the beginning of the feeding trial

Parameters	Treatments		
	T_1	T_2	T_3
Initial Body Weight (kg)	415.86±13.10	403.38±14.10	406.63±10.15
Average Milk Yield (kg/d)	14.58±1.51	13.58±1.82	13.20±0.74
Days in milk	52.66±5.99	52.16±3.33	51.83±0.60
Parity	2.16±0.30	2.00±0.25	1.83±0.30

T_1 refer to control group, T_2 and T_3 refer to groups supplemented with 1.5 and 3% of Sea Weed Powder, respectively.

Table 2: Chemical composition (% Dry Matter basis) of feed ingredients

Parameters	Concentrate mixture	Sugar graze	Seaweed product
Dry matter	89.05	30.99	94.6
Organic matter	93.12	92.83	27.45
Crude Protein	19.16	7.31	5.58
Total ash	6.88	7.17	72.55
Ether extract	4.76	2.44	1.98
Neutral detergent fibre	27.37	56.72	15.03
Acid detergent fibre	13.33	32.69	9.92
Calcium (g/kg)	0.95	0.29	0.46
Phosphorus(g/kg)	0.76	0.23	0.056
Iron (mg/kg)	449.45	342.35	222
Copper (mg/kg)	28.33	7.15	*BDL
Zinc (mg/kg)	62.56	24.79	14
Manganese (mg/kg)	60.45	25.95	37

*BDL refer to below detectable limit

Analytical techniques

The dried and ground representative samples of concentrate mixtures, green fodder, orts and faeces from each cow were analysed for proximate (AOAC, 2005) [9] and cell wall constituents (Van Soest *et al*., 1991) [10].

The feed samples were analyzed for minerals (Ca, Fe, Cu, Zn, Mn) by atomic absorption spectrophotometer (AAS, ZEEnit 700P) using acetylene as fuel and air as oxidant. Specific hollow cathode lamps were used for the determination of each element.

Statistical analysis

Data were statistically analysed by one-way analysis of variance technique using SPSS software (version 20.0, IBM SPSS Inc, USA) in accordance with Snedecor and Cochran (Snedecor *et al*., 1994) [11].

Results and Discussion

Intake and utilization of nutrients

The intake of different nutrients by cows in different treatment groups are presented in Table 3 and Dry Matter intake at fortnightly intervals in Fig. 1.

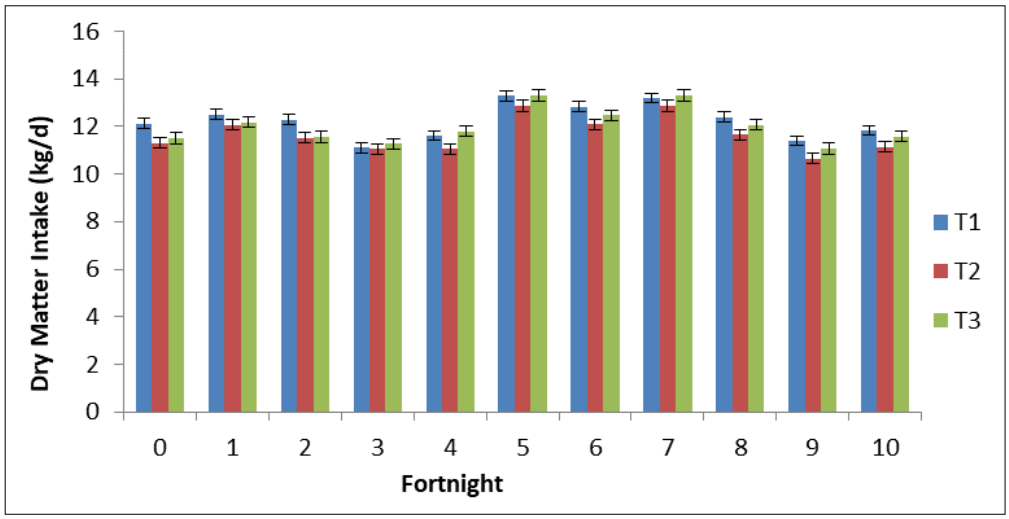

Fig 1: Dry matter intake of animals at different fortnights. T1 refer to control group, T2 and T3 refer to groups supplemented with 1.5 and 3% Sea Weed Powder in ration.

The dry matter intake was found to be 13.19, 12.86 and 13.30 kg/d in treatments T1, T2 and T3, respectively with corresponding values of 3.10, 3.11 and 3.21% body weight. The crude protein intake was found to be 1.62, 1.49 and 1.52 kg/d in treatments T1, T2 and T3, respectively with corresponding values of 0.38, 0.36 and 0.37% body weight. In treatments T1, T2 and T3, the total digestible nutrient intake was 8.24, 8.19 and 8.60 kg/d with respective values of total digestible nutrient intake to be 1.94, 1.98 and 2.07 expressed as % body weight.

It revealed that the intake of nutrients (kg) like dry matter, crude protein and total digestible nutrients was statistically similar ($P<0.05$) in all 3 treatments irrespective of level of seaweed product supplementation (Table 3). Singh *et al*. also reported no significant effect on dry matter intake in lactating Sahiwal cows given *Sargassum wightii* sea weed powder in concentrate mixture at 20% level (Singh *et al*., 2016) [12]. Leupp *et al*. found positive effects on dry matter intake when brown seaweed meal was included in the diet of steers fed low-quality hay (Leupp *et al*., 2005) [13]. Similar to authors' findings, feeding of seaweed extract (Gracilaria spp.) did not affect the dry matter intake in lactating cross-bred cows when fed 0, 10 and 20 g of seaweed extract per day in different treatment groups (Bobade *et al*., 1998) [14].

Table 3: Intake of nutrients (on kg/d and % body weight basis) in different groups

Parameters	Treatments		
	T_1	T_2	T_3
Intake of nutrients			
Dry matter intake (kg/d)	13.19±1.05	12.86±0.55	13.30±0.76
Dry matter intake (% B. wt.)	3.10±0.19	3.11±0.09	3.21±0.16
CP intake (kg/d)	1.62±0.14	1.49±0.08	1.52±0.10
CP intake (% BW)	0.38±0.03	0.36±0.02	0.37±0.02
TDN intake (kg/d)	8.24±0.71	8.19±0.42	8.60±0.60
TDN intake (% BW)	1.94±0.15	1.98±0.08	2.07±0.12

Values expressed as mean ± standard deviation. T1 refer to control group, T2 and T3 refer to groups supplemented with 1.5 and 3% sea weed powder in ration.

When intakes of nutrients during metabolic trial were compared with those of requirements as per ICAR (2013) standards (Table 4), it was observed that dry matter (DM) intake was 105.66, 101.50 and 106.09% in treatments T1, T2 and T3, respectively in comparison to ICAR (2013) requirements. The crude protein (CP) intake was 93.09, 88.55 and 87.35% in treatments T1, T2 and T3, respectively in comparison to ICAR (2013) requirements. In comparison to ICAR (2013) requirements, the total digestible nutrient (TDN) intake was 104.36, 107.65 and 109.80% in treatments T1, T2 and T3, respectively.

The intakes of dry matter and total digestible nutrients were slightly above while the intake of crude protein was slightly lower compared to ICAR (2013) standards. The plane of nutrition was not affected in lactating Sahiwal cows given *Sargassum wightii* sea weed powder in concentrate mixture at 20% level (Singh *et al*., 2015) [15].

Table 4: Intake of nutrients during metabolic trial in comparison to Indian Council of Agriculture Research (2013) standards

Attribute	Treatment		
	T_1	T_2	T_3
DMI (kg/d)	13.19±1.05	12.86±0.55	13.30±0.76
DMI required (as per ICAR, 2013)	12.41±0.41	12.65±0.37	12.51±0.45
% of ICAR (2013)	105.66±5.93	101.50±2.02	106.09±2.87
CP Intake (Kg)	1.62±0.14	1.49±0.08	1.52±0.10
CP required (as per ICAR, 2013)	1.75±0.17	1.68±0.07	1.74±0.10
% of ICAR (2013)	93.09±2.05	88.55±1.67	87.35±1.40
TDN Intake (Kg)	8.24±0.71	8.19±0.42	8.60±0.60
TDN required (as per ICAR, 2013)	7.87±0.60	7.59±0.26	7.79±0.35
% of ICAR (2013)	104.36±3.81	107.65±2.93	109.80±3.28

Nutrient digestibility and nitrogen balance

The digestibility coefficients of various nutrients in all treatment groups of lactating Karan Fries cows, were also statistically insignificant ($P<0.05$) indicating that supplementation of *Kappaphycus alvarezii* based feed additive at levels 1.5 and 3% in the ration had no significant effect on nutrient digestibility coefficients. The values for nitrogen intake and nitrogen voided through faeces, urine and milk were also similar ($P<0.05$) in all the groups, hence, nitrogen balance did not differ among 3 groups (Table 5).

Table 5: Digestibility of nutrients and balance of nitrogen in different groups.

Parameters	Treatments		
	T_1	T_2	T_3
Nutrient digestibility (%)			
Dry matter	62.46±1.89	61.45±1.52	62.47±1.56
Organic matter	65.98±1.44	64.61±1.28	64.93±1.37
Crude protein	69.64±3.56	65.66±1.22	64.07±1.77
Ether extract	74.56±2.70	75.73±2.60	77.53±2.73
Neutral detergent fibre	54.81±2.29	54.07±1.71	55.48±1.83
Acid detergent fibre	35.59±2.79	36.20±2.70	37.29±2.10

Nitrogen balance (g/d)			
N intake	248.03±26.07	238.82±13.41	243.21±15.38
N voided in faeces	85.36±3.59	81.28±2.07	86.30±3.28
N voided in urine	91.01±6.78	71.88±2.05	67.65±4.74
N voided in milk	74.54±9.18	72.19±3.62	74.90±4.58
Total N outgo	250.92±18.63	225.35±5.85	228.85±10.94
Absorbed N	177.59±21.02	157.54±11.83	156.91±13.58
N balance	12.03±5.41	13.47±7.86	14.36±4.91
N absorbed as % intake	66.74±1.94	65.67±1.22	64.07±1.78
N retention as % Intake	3.90±1.57	4.93±2.54	5.42±1.71

Values expressed as mean ± standard deviation. T1 refer to control group, T2 and T3 refer to groups supplemented with 1.5 and 3% sea weed powder in ration.

There were no significant changes in digestibility of nutrients and nitrogen balance in Sahiwal cows when mineral mixture (3%) in the concentrate was replaced by 20% *Sargassum wightii* (Singh *et al*., 2015) [15]. It was evaluated brown kelps (Laminaria digitata and Laminaria hyperborea) in North Ronaldsay sheep and suggested that these seaweeds can be used as alternative feed source for ruminants. (Hansen *et al*., 2003) [16]. However, the sea weed product used in this study is unique and has not been tried earlier under any circumstances for lactating crossbred cows. Though sporadic studies including evaluation of single sea weed under in vitro/in vivo system exist. (Arieli *et al*., 1993) [17].

Conclusion

The supplementation of sea weed powder at 1.5 or 3.0% of ration had no significant effect on feed intake, nutrient digestibility, nitrogen utilisation and plane of nutrition in crossbred cows.

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