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Effect of Partial Substitution of Conventional Protein Source with Duckweed on Digestibility and Nitrogen Retention in Beetal Goat

K. Subbaiah, J.S Lamba*, Jasmine Kaur, R.S Grewal, Sandeep Kaswan[1] and M.D Ansal[2]

Department of Animal Nutrition, Guru Angad Dev Veterinary and Animal Sciences University (GADVASU), Ludhiana-141 004, India
[1]College of Veterinary Science, Rampura Phul-151 103, India
[2]College of Fisheries, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana-141 004, India
**E-mail: jaspalsinghgadvasu@rediffmail.com*

***Abstract*:** Duckweed is the common name used to refer to members of the aquatic plant family *Lemnaceae*. A duckweed feeding trial was carried out at Goat Farm of the Department of Livestock Production and Management, Guru Angad Dev Veterinary and Animal Sciences University (GADVASU), Ludhiana with 20 male goats fed on four different diets. The objective of the trial was to evaluate duckweed (*Spirodela polyrhiza*), duckweed based TMRs (total mix ration) and use as a protein supplement for ruminants. The hypothesis was that duckweed is a suitable protein source for goats and will serve in a similar fashion to soybean meal. The diets included a control having supplemental protein from soybean meal; 1/3, 2/3 and 100% duckweed supplemental protein. The goats were fed equal amounts of fodder and concentrate ration in 50: 50 R: C **(**roughage: concentrate ratio**)** at 4% of body weight as fed. Duckweed supplementation did not have a significant effect on digestibility of acid detergent fiber, crude protein, nitrogen intake, faecal nitrogen outgo, urinary nitrogen and percent nitrogen retention in male goats. Digestibility of dry matter, organic matter digestibility, neutral detergent fiber, hemi-cellulose digestibility, total carbohydrate digestibility and non-fiber carbohydrates were significantly higher in control group and decreased as the level of duckweed supplementation increased in the total mix ration. Duckweed can be incorporated in ruminant diet without any detrimental effects.

***Keywords*:** Duckweed (*Spirodela polyrhiza*), Goats, Rumen fermentation, Retention

One of the most expensive operational costs in livestock production is feed. Duckweed plants can improve the quality of feed thereby increasing consumption and digestibility as well as the balance of protein and energy feed for goats (Rostini et al 2016). In all diet formulations, soybean meal is the most widely used protein supplement as the protein component acts as a critical nutrient in ruminant rations. This expensive universal ingredient has a high amino acid profile. Duckweed can have similar crude protein levels and essential amino acids required in ruminant rations. Dried duckweed protein content varies from 25.2-36.5% (Rusoff et al 1990). The aim of the present study is to compare the nutritional quality of TMR containing degraded levels of duckweed replacing the total crude protein of soybean as the protein source in goats on digestibility and nitrogen retention.

MATERIAL AND METHODS

The duckweed sample used in the study was obtained from the College of Fisheries, Guru Angad Dev Veterinary and Animal Sciences University (GADVASU), Ludhiana and were sun/ air-dried and then ground in a Wiley mill through a 2 mm screen. The total mixed rations (TMR) were prepared by using various duckweed levels sources i.e. control; 1/3, 2/3 and 100% duckweed replacing the total CP of soybean in 50:50 ratio (roughage: concentrate) (Table 1). All the TMR prepared were iso-nitrogenous having approximately 15% CP.

Conduction of metabolic trial: Twenty male goats (15 kg body weight each) were divided into 4 equal groups and were offered with 4 different TMRs *viz*. TMR1 (control), TMR2 (1/3 duckweed), TMR3 (2/3 duckweed) and TMR4 (100% duckweed) for 120 days. During this period, digestibility coefficients of various nutrients, nitrogen balance were observed.

Housing: The male goats were housed in a concrete shed and were stall fed in groups, at 9:00 am daily and had free access to water twice a day and were allowed in the yard daily for an hour.

Metabolism trial: The 7-day metabolic trial was conducted on all the animals in between the growth trial. During metabolic trial, the animals were kept in specially designed metabolic cages where a metallic pipe led the excreted urine into a narrow mouth plastic container (5 liters capacity) containing 100 ml of 20% H_2SO_4. The faeces were collected manually throughout the day. The collection of faeces and urine were done for 7 days. The combined residue of green

and concentrate mixture, if any, were weighed at 9:00 am prior to the following day's ration.

Chemical Analysis: Samples of feed, faeces and orts were analyzed for proximate constituents (AOAC 2000), cellulose (Crompton and Maynard 1938) and cell wall constituents (Robertson and Van Soest 1981).

Statistical Analysis: The data were analysed using SPSS Version 19. The differences in means were tested by Tukey B.

RESULTS AND DISCUSSION

Chemical composition of total mixed ration (TMR) (DM basis -R: C 50:50): The CP content of all TMRs having different levels of duckweed supplementation varied from 14.87 to 15.27%. All the rations prepared were iso-nitrogenous in nature (Fig. 1). The NDF (neutral detergent fiber) content varied from 49.70 to 51.50% while ADF (acid detergent fiber) varied from 26.50 to 34.0%. The fat content of ration was between 2.01 to 2.55%. The ash content in all TMRs varied from 10.20 to 14.37% and OM (organic matter) content from 85.62 to 89.80%. The concentration of total carbohydrates (TCHO) was 67.95 to 72.91% and non-fiber carbohydrates (NFC) was 17.02 to 23.21% with varying levels of duckweed supplementation (Fig. 1).

The DM (dry matter) intake was similar in all the groups (Table 2). There was significant difference in the dry matter

Table 1. Composition of different total mixed rations containing duckweed in 50:50 (R: C)

Ingredient	Control (TMR1)	1/3 duckweed (TMR2)	2/3 duckweed (TMR3)	100% duckweed (TMR4)
Bajra fodder	50	50	50	50
Maize	17.5	17.5	17.5	17.5
Soybean	14	9.3	4.65	0
Duckweed	0	7.75	15.5	23
Wheat bran	8.5	6.5	4	2
Rice bran	7.37	6.3	5.75	4.75
Mineral mixture	1	1	1	1
Salt	0.5	0.5	0.5	0.5
Urea	0	0.15	0.35	0.5
Bypass fat	1.125	1	0.75	0.75

Table 2. Digestibility parameters (% DM basis)

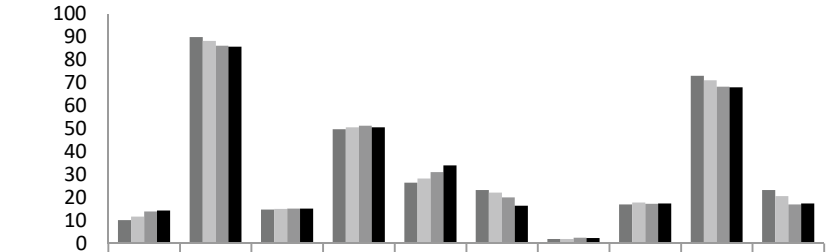
Parameters	Group 1	Group2	Group 3	Group 4	SEM
DM intake (g /d)	458.79	478.54	427.63	458.34	9.48
DMD	65.55^{c}	56.92^{b}	52.26^{a}	52.36^{a}	1.71
NDFD	50.06^{c}	42.84^{b}	40.20^{ab}	37.76^{a}	1.43
ADFD	39.32	35.37	38.83	39.20	0.74
EED	78.23^{b}	74.22^{ab}	75.41^{ab}	72.25^{a}	0.87
Cellulose digestibility	46.51	42.82	42.90	43.86	0.75
HCD	64.52^{d}	52.32^{b}	58.45^{c}	36.83^{a}	3.07
OMD	67.36^{c}	60.12^{b}	54.90^{a}	54.54^{a}	1.60
CPD	80.34	78.12	76.87	77.39	0.59
TCHOD	61.15^{c}	51.43^{b}	44.67^{a}	45.05^{a}	2.08
NFCD	80.90^{c}	78.24^{bc}	74.19^{b}	68.37^{a}	1.54
Nutritive value					
Total TDN digested	274.73^{c}	244.61^{b}	200.90^{a}	214.16^{a}	9.36
TDN%	59.96^{c}	51.10^{b}	46.98^{a}	46.72^{a}	1.66
DCP%	80.34	78.12	76.87	77.39	0.59
DCP (g)	62.47	63.11	58.07	60.49	1.07
Actual CP intake	77.79	80.76	75.54	78.14	1.19

Means bearing different superscripts in a row differ significantly ($P<0.05$)

digestibility (DMD), ADF, NDF, hemicellulose, OMD, total carbohydrate digestibility (TCHOD) and total non-fiber carbohydrate digestibility (NFCD) in control and duckweed supplemented groups. The significant difference in the digestibility (%) of OM was among the four groups and varied from 54.54 in 100% duckweed group to 67.36 in control group. No significant effect on CP digestibility was observed in control and duckweed supplemented group and varied from 76.87 to 80.34% in four groups (Fig. 2).

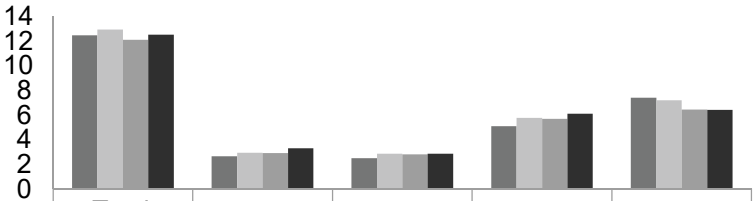
There were no significant differences in the mean values of EE (energy expenditure) digestibility (%) among the groups. The digestibility coefficients EE (%) were 75.44, 68.56, 68.74 and 68.91, respectively in the four groups. The TCHO digestibility (%) differ significantly may be due to different OM, CP, EE intake (g/d), digested (g/d) and digestibility (%) among the four groups. The corresponding values for digestibility (%) were significantly lowest in 2/3 (44.67) and 100% duckweed supplemented groups (45.05) and significantly higher in control group (61.15%) (Figure 2). There was significant difference in digestibility (%) of NDF in all the groups excluding control. The NDF digestibility was lowest in 100% duckweed supplemented group (37.76%) and highest in control group (50.06%). The NFC digestibility was significantly lower in 2/3 duckweed supplemented group (54.19%) and highest was in control (82.57%) and 1/3 duckweed supplemented group (79.57%). The digestibility of cellulose was similar in all the four groups and varied from 42.90 to 46.51%. However, diet type and experimental conditions may influence the results of digestibility studies which may explain the inconsistent findings considered above.

The nutrient requirements of a 20 kg goat at maintenance level to be 267 g TDN (total digestibility nutrient), 22 g CP, 1 g Ca and 0.7 g P (NRC 1981). The average DMI (dry Matter



	Ash	OM	CP	NDF	ADF	HC	EE	Cellulose	TCHO	NFC
TMR 1	10.2	89.8	14.87	49.7	26.5	23.2	2.01	17	72.91	23.21
TMR 2	11.8	88.2	15.07	50.5	28.35	22.15	2.01	17.8	71.11	20.61
TMR 3	13.95	86.05	15.27	51.2	31.1	20.1	2.55	17.3	68.22	17.02
TMR 4	14.37	85.62	15.27	50.5	34	16.5	2.4	17.5	67.95	17.45

Fig. 1. Chemical composition of TMR fed to male goats, % DM basis (R: C 50:50)



	Total nitrogen intake (g/day)	Urinary N (g/day)	Fecal N output (g/day)	Total N outgo (g/day)	N retention (g/day)
Group 1	12.44	2.62	2.45	5.07	7.37
Group2	12.92	2.91	2.82	5.73	7.18
Group 3	12.08	2.87	2.79	5.66	6.42
Group 4	12.5	3.27	2.82	6.09	6.4

Fig. 2. Nitrogen balance

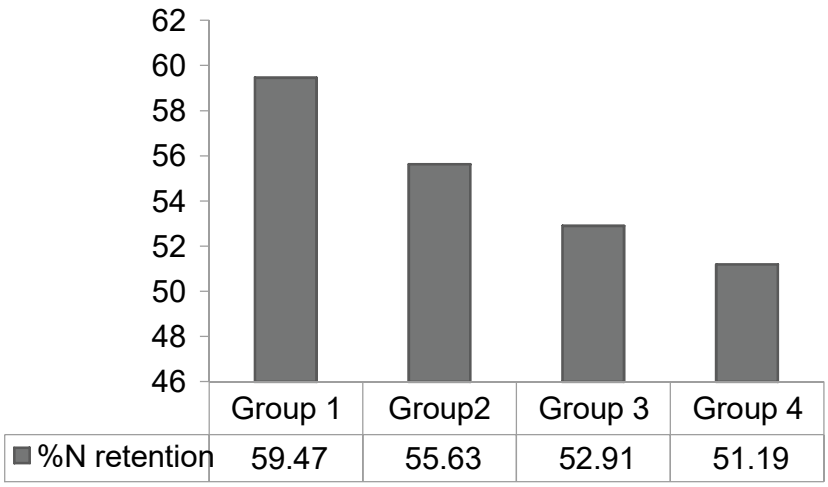


Fig. 3. % N retention

Intake) for the 5 days metabolism trial was 455.34 g/day. There was no significant difference among DMI for the four groups thereby showing that duckweed, when included at 1/3 and 2/3 protein and 100% is palatable as soybean meal. The maintenance requirement of TDN for a 20 kg goat is 267 g. The average weight of the goats fed with the supplemented diets was 16 kg with a TDN of 434 g which fulfilled the maintenance and growing requirement of the animals. All the goats achieved the maintenance requirement of CP which is 38 g for a 20 kg goat. The CP intake of goats on the control was only 77.79 g while the positive control, 1/3 duckweed, 2/3 duckweed and 100% duckweed diets produced intakes of 80.76 g, 75.54 g and 78.14 g respectively. Moore et al 3(2002) and Luginbuhl et al (2000) observed low DMD and fiber digestibility which is in accordance with the present study, i.e., DM and fiber digestibility was lower in duckweed supplemented groups as compared to soybean meal control treatment. Moore et al (2002) reported higher apparent digestibility of DM, NDF, ADF and cellulose for both diets containing hay with soybean meal and soybean hull diet. The higher digestibility reported can be linked to the higher quality hay used in their respective studies.

Nitrogen balance in male goats: The intake of N (g/d) in the groups varied from 12.08 to 12 .92 with non-significant differences. Faecal, urinary and total nitrogen excreted (g/d) were statistically similar among the four groups as no significant effect was seen in control and duckweed supplemented groups. Animals in all the four groups were in positive N balance (Fig. 2). The nitrogen balance studies revealed that nitrogen intake was comparable between all the groups (Fig. 2). The daily total excretion of nitrogen was maximum in 100% duckweed supplemented group followed by 1/3 duckweed, 2/3 duckweed and control groups. The N out go (g/day) was 5.07, 5.73, 5.66 and 6.09 in all four groups. The urinary nitrogen (UN) excretion was highest in goats feed 100% duckweed supplemented group and lowest in control groups. This trend of UN resulted in lowest retention of nitrogen in animals fed with 2/3 and 100% duckweed supplemented diet. The nitrogen retention was highest in control group than that in the other groups, though the results were non-significant (Fig. 2). There was no significant difference in the amount of fecal N, UN and N retention (% and g/day) in soybean supplemented control group and varying levels of duckweed supplemented groups in this study (Fig. 3). Maye et al (2002) observed lower N retention than in current study which suggests that duckweed is comparable to soybean hulls as a protein supplement for growth of goats. Although the N digested and the N retained was numerically lower for the duckweed supplemented groups as compared to control, the N retained as a percent of digested was higher in control group was due to the decreased UN output.

CONCLUSIONS

Duckweed supplementation did not have a significant effect on digestibility of ADF, CP, nitrogen intake, faecal nitrogen outgo, UN and %N retention in male goats. DMD, OMD, NDFD, HCD, TCHOD and NFCD was significantly higher in control group which decreased with the increase of duckweed supplementation in the ration. Therefore, duckweed can be incorporated in ruminant diet without any detrimental effects.

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