Nannochloropsis oculata microalgae as a natural source of rumen-protected eicosapentaenoic acid in diets of lactating Nubian goats

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Introduction

- Dietary omega-3 fatty acids have been associated with decreased risk of several chronic diseases.
- Most people do not get enough omega-3 fatty acids from their diets.
- Microalgae are a good source of omega-3 fatty acids and has the potential to increase meat and milk content of omega-3 fatty acids.
- *Nannochloropsis oculata* is a rich source of rumen-protected EPA, DHA and CLA as well as essential amino acids.
- Our objective was to evaluate the effects of *N. oculata* microalgae at 5 or 10 g/doe/d on feed intake, digestibility, ruminal fermentation, blood chemistry, lactational performance and milk fatty acid profile of Nubian goats.

Materials and Methods

- Fifteen multiparous lactating Nubian goats, weighing 33.0±1.3 kg in their first week of lactation, were randomly assigned to three treatments.
- Treatments were a basal diet (control), control + 5 g (NO5 treatment) or 10 g (NO10 treatment) of *N. oculata* microalgae.
- The study was arranged in a quintuplicated 3 × 3 Latin Square design, resulting in 15 replicates per treatment.
- We estimated DMI, nutrient intake and digestibility.
- Blood, milk and rumen fluid samples were collected and evaluated for blood parameters, milk composition and fatty acid profile, and ruminal pH, ammonia-N and volatile fatty acids .

Results

Table 1 Feed intake, nutrients digestibility, nutritive value and ruminal fermentation parameters of lactating Nubia goats fed a basal diet supplemented with *Nannochloropsis oculata*.

	Treatments[1]			SEM	*P* value				
	Control	NO5	NO10		Treatment	Period	Control vs. Others	Linear	Quadratic
Intake, g/d	1067	1075	1072	17.0	0.944	0.282	0.755	0.837	0.788
Digestibility, g/kg									
DM	581[b]	623[a]	627[a]	5.3	<0.001	0.019	<0.001	<0.001	0.006
OM	574[b]	608[a]	609[a]	1.5	<0.001	<0.001	<0.001	<0.001	<0.001
CP	579[b]	615[a]	621[a]	5.8	<0.001	<0.001	<0.001	<0.001	0.043
EE	591	607	605	5.4	0.078	<0.001	0.026	0.067	0.175
NSC	549[b]	603[a]	613[a]	5.7	<0.001	0.152	<0.001	<0.001	0.003
NDF	555[b]	592[a]	604[a]	6.9	<0.001	0.002	<0.001	<0.001	0.170
ADF	542[b]	583[a]	584[a]	7.5	0.003	0.151	<0.001	0.004	0.039
Digestible nutrients and energy value[2]									
DCP, g/kg DM	73.8[b]	78.4[a]	79.2[a]	0.74	<0.001	<0.001	<0.001	<0.001	0.043
DE, MJ/kg DM	2.36[b]	2.52[a]	2.54[a]	0.017	<0.001	0.484	<0.001	<0.001	0.008
ME, MJ/kg DM	2.38[b]	2.55[a]	2.56[a]	0.018	<0.001	0.457	<0.001	<0.001	0.009
NEl, MJ/kg DM	1.19[b]	1.28[a]	1.29[a]	0.010	<0.001	0.419	<0.001	<0.001	0.001
pH	5.94	6.03	6.14	0.060	0.078	0.077	0.057	0.025	0.904
Ammonia-N, g/L	25.3	26.3	27.3	0.79	0.239	0.357	0.148	0.093	0.973
VFA, mmol/L	115c	124b	133a	2.700	0.002	<0.001	0.002	<0.001	0.901
C_2, mmol/100 mmol	56.5	57.4	55.1	1.63	0.617	0.799	0.918	0.565	0.430
C_3, mmol/100 mmol	25.0b	27.4a	27.8a	0.850	0.045	0.468	0.022	0.031	0.356
C_4, mmol/100 mmol	16.4	13.5	13.5	1.29	0.201	0.381	0.077	0.120	0.372
C_2/C_3 ratio	2.31	2.11	2.00	0.123	0.223	0.413	0.110	0.090	0.799
CH_4[2], mmol/L	25.1a	23.7ab	22.5b	0.670	0.045	0.943	0.026	0.014	0.882

Means in the same row with different superscripts differ (P<0.05). SEM, standard error of the mean.
[1]The control diet based on (per kg DM): 600 g of concentrates feed mixture, 200 g berseem clover and 200 g wheat straw without addition of supplements (Control treatment) or with addition of 5 g (NO5 treatment) or 10 g of *Nannochloropsis oculata*/doe/d (NO10 treatment).
[2]Calculated according to NRC (NRC, 2001).

Table 2 Weight changes, milk yields, composition and fatty acid profile of lactating Nubian goats fed a basal diet supplemented with *Nannochloropsis oculata*.

	Treatments[1]			SEM	*P* value				
	Control	NO5	NO10		Treatment	Period	Control vs. Others	Linear	Quadratic
Body weight, kg									
Initial	32.9	33.2	32.9	0.31	0.797	0.725	0.821	0.904	0.510
Final	31.6	31.9	31.8	0.47	0.896	0.024	0.672	0.789	0.702
Changes, g/d	-16.0	-14.9	-13.2	5.55	0.938	0.063	0.781	0.725	0.959
Production, g/d									
Milk	1034b	1144a	1185a	30.7	0.004	0.091	0.001	0.001	0.368
ECM	973b	1073a	1110a	29.4	0.006	0.042	0.002	0.002	0.392
FCM (4%)	989b	1088a	1118a	29.5	0.010	0.045	0.003	0.004	0.348
Total solids	126b	140a	145a	3.8	0.003	0.064	0.009	0.008	0.365
Solids not fat	87.4b	97.8a	102a	2.7	0.001	0.095	0.004	0.003	0.384
Protein	34.0	36.0	37.6	1.06	0.065	0.018	0.036	0.021	0.875
Fat	38.3b	42.0a	42.9a	1.19	0.023	0.032	0.007	0.009	0.351
Lactose	45.0b	52.4a	54.9a	1.48	<0.001	0.283	<0.001	<0.001	0.198
Ash	8.45b	9.46a	9.84a	0.28	0.003	0.158	0.001	0.001	0.365
Milk efficiency									
Milk/DMI	0.98b	1.07a	1.11a	0.032	0.019	0.061	0.007	0.006	0.501
ECM/DMI	0.92b	1.00a	1.04a	0.031	0.033	0.035	0.012	0.011	0.519
SFA	70.8	68.9	67.5	1.58	0.303	0.650	0.402	0.116	0.775
UFA	29.6b	31.4a	32.9a	0.58	0.002	0.667	0.002	0.006	0.776
MUFA	28.2b	30.0a	31.4a	0.57	0.003	0.629	0.002	0.007	0.777
PUFA	1.35b	1.42ab	1.48a	0.035	0.049	0.368	0.029	0.015	0.908
Total CLA	0.44	0.47	0.49	0.047	0.059	0.035	0.771	0.153	0.057
Omega-6/omega-3	2.32	2.28	2.34	0.101	0.896	0.515	0.965	0.847	0.673
UFA/SFA	0.42b	0.46a	0.49a	0.012	0.003	0.659	0.002	0.007	0.827
Atherogenic index[2]	2.28a	2.10b	1.92b	0.068	0.004	0.912	0.002	0.001	0.730

Means in the same row with different superscripts differ (P<0.05).
DMI, dry matter intake; ECM, energy corrected milk; FCM, fat corrected milk; SEM, standard error of the mean.
[1]The control diet based on (per kg DM): 600 g of concentrates feed mixture, 200 g berseem clover and 200 g wheat straw without addition of supplements (Control treatment) or with addition of 5 g (NO5 treatment) or 10 g of *Nannochloropsis oculata*/doe/d (NO10 treatment).
[2]Calculated according to Ulbricht and Southgate (Ulbricht et al., 1991): atherogenic index = (C12:0 + 4 × C14:0 + C16:0)/∑ of UFA.

- Dietary treatments did not affect feed intake.
- Greater (P<0.001) energy value in form of DE, ME and NEl were noted in *N. oculata dietary* treatments.
- Apart from EE digestibility, *N. oculata* inclusion increased (P<0.01) nutrient digestibility.
- But the increased nutrient digestibility did not result in any change in final BW or ADG.
- *N. oculata* inclusion had a linear effect on total volatile fatty acids (P=0.002) and propionic acid.
- *N. oculata* inclusion did not have any effect on rumen pH.
- Dietary treatments linearly increased (P<0.01) daily milk production and the concentration of lactose.
- Treatments did not affect the concentration of individual fatty acids in milk.
- Increased concentrations of MUFA, PUFA and C20:5n3 (EPA) were noted with *N. oculata* inclusion.
- Both NO5 and NO10 treatments decreased atherogenic index (P=0.004).
- Except for glucose concentration, dietary treatments did have any effect on blood parameters.
- In conclusion, supplementing the diet of lactating Nubian goats with N. oculata microalgae at 5 and 10 g daily enhanced milk production and altered milk fatty acid composition.
- Both concentrations evaluated in the present study had similar effects; therefore, the lower dose of 5 g daily is recommended for practical use in lactating does.