RESEARCH ARTICLE

Effect of Rumen Protected Niacin Supplementation on Blood Biochemical Analytes during Transition Period in Surti Goats

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Abstract

The present study was conducted to evaluate the effect of rumen protected niacin (RPN) supplementation on blood biochemical analytes during transition phase in Surti goats. Eighteen pregnant Surti goats were divided into two groups as control (CON, n=9) and treatment (RPN, n=9). RPN group was supplemented with RPN @ 1.5 g/animal/day from -2 to +8 weeks of kidding. Biweekly blood samples were collected from -2 to +10 weeks of kidding for analyzing biochemical parameters. Significant ($p \leq 0.05$) beneficial effects of RPN supplementation in lowering of pyruvate and lactate was observed at 0, +4 and +6 week; hepatic enzymes (GGT, ALT, AST, GDH) at 0, +2, +4 and +6 week; Urea at 0 and +6 week, whereas creatinine at 0, +2 and +6 weeks. RPN supplementation was also advantageous in significantly ($p \leq 0.05$) elevating triglycerides at 0 and +6 week, cholesterol at 0, 4 and +6 week, whereas LDL-C and HDL-C at 0 week. It was thus concluded that rumen protected niacin supplementation @ 1.5 g/day during transition period in Surti goats mitigates metabolic dysregulation.

Key words: Biochemical parameters, Rumen protected niacin, Surti goats, Transition.

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Introduction

Goats comprising 27.80% (188.88 million as per 20th Livestock census) of Indian livestock are preferred to rear owing to their efficient and economical production and reproduction performance. However, physiological stages like transition owing to higher metabolic demands (for developing fetus and mammary milk biosynthesis) may disrupt energy homeorhesis via excess negative energy balance and increased gluconeogenesis followed by extensive lipolysis and fatty liver. Such glucose partitioning is facilitated by peripheral insulin resistance and disrupted glucose uptake thereby elevating pyruvate and lactate (key intermediates of glycolysis and anaerobic metabolism). Metabolic dysregulation presents as hepatic dysfunction, dyslipidemia and deranged nitrogen balance metabolites. Aiming to alleviate negative energy balance, strategic intervention such as supplementation of niacin seems beneficial. Its requirement is minimal for cellular metabolism (NRC, 2001). Being antilipolytic, it affects insulin levels and gluconeogenesis (Cincović *et al*., 2018). As NAD precursor along with capability to sustain redox reactions (Bender and Mayes, 2003), niacin's antilipolytic effect can prevent adipose breakdown and decrease NEFA release (Pires and Grummer, 2007; Morey *et al*., 2011). Owing to insufficient endogenous synthesis from tryptophan in ruminants, varying response to supplemental niacin, beneficial effects like mitigating insulin resistance along with optimizing energy and protein balance, the present study was conducted on native breed of Surti goats to study effect of rumen protected niacin supplementation on blood biochemical analytes during transition period in Surti goats.

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Materials and Methods

The study was conducted at Department of Veterinary Physiology and Biochemistry, College of Veterinary Science and Animal Husbandry, Navsari (Kamdhenu University), Gujarat, India, following approval of Institutional Animal Ethics Committee (vide No.093-VCN-VPY-2022). Eighteen apparently healthy Surti goats in advanced gestational stage were selected and maintained under standard housing, feeding and management practices at Livestock Research Station (Navsari, Gujarat). They were divided into two groups, *i.e.,* control (n=9) and treatment (n=9). Goats in treatment group were supplemented with rumen protected niacin @ 1.5 g/animal/day from -2 weeks (pre-kidding) to +8 week (post-kidding).

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At -2, 0 (at kidding), +2, +4, +6,+8 and +10 week of kidding whole blood samples were collected from jugular vein using vacutainer without anticoagulant and serum was separated for analysis of pyruvate, lactate, total cholesterol (TC), low density lipoprotein- cholesterol (LDL-C), high density lipoprotein-cholesterol (HDL-C), triglycerides (TG), total protein (TP), albumin, globulin, urea, creatinine, γ-glutamyl transferase (GGT), alanine aminotransferase (ALT), aspartate aminotransferase (AST) and glutamate dehydrogenase (GDH). All the biochemical metabolites were analyzed on semi-automated clinical chemistry analyzer (Merck, Vital Scientific NV, the Netherlands) using Randox kits following the manufacturer's instructions. Results obtained were analysed using descriptive statistics and presented as Mean ±SE. Means of both the groups were compared using student t-test for differences at 5% level of significance ($p \leq 0.05$).

Results and Discussion

Effect of RPN Supplementation on Pyruvate and Lactate

The results for changes in serum pyruvate and lactate are presented in Table 1. Pyruvate and lactate levels between groups were significantly ($p \leq 0.05$) lower in RPN supplemented group as compared to control group at 0, +4 and +6 week of kidding.

Table 1: Changes in serum pyruvate and lactate (Mean ±SE) in control and RPN treated groups of Surti goats during transition phase

Parameters	Peripartum period	Control Gp	RPN Treated Gp
Pyruvate (mg/dL)	-2 Week	0.585±0.019	0.570±0.022
	0 Week	0.651^{a}±0.020	0.596^{b}±0.016
	+2 Week	0.600±0.028	0.580±0.029
	+4 Week	0.672^{a}±0.013	0.609^{b}±0.024
	+6 Week	0.675^{a}±0.017	0.609^{b}±0.020
	+8 Week	0.628±0.024	0.601±0.026
	+10 Week	0.612±0.017	0.575±0.025
Lactate (mg/dL)	-2 Week	5.79±0.27	5.32±0.31
	0 Week	6.27^{a}±0.31	5.55^{b}±0.10
	+2 Week	5.68±0.37	5.40±0.35
	+4 Week	6.54^{a}±0.27	5.63^{b}±0.29
	+6 Week	6.95^{a}±0.31	5.70^{b}±0.34
	+8 Week	6.33±0.21	5.65±0.29
	+10 Week	6.13±0.25	5.53±0.17

Means with different superscripts differ significantly ($p \leq 0.05$) between groups.

During glycolysis, conversion of glucose-6-phosphate to 1,3 bis-phosphoglycerate generates NADH that is utilized by pyruvate to yield lactate that is catalyzed by lactate dehydrogenase under anaerobic conditions simultaneously generating NAD. Exercise and anoxia gives rise to lactate owing to anaerobic glycolysis. Dynamic normal equilibrium of lactate to pyruvate (10:1) was observed in present study. Increased glycolytic activity during diabetes and insulin resistance (IR) with more pyruvate and NADH, but lower NAD^{+} have been reported (Del Prato *et al*., 1993; Simoneau *et al*., 1995). Thus, sustained flow of pyruvate and lactate was probably the cause of their elevated levels in control group. Lactate being key source for hepatic gluconeogenesis during transition and early lactation (Drackley *et al*., 2001; Reynolds *et al*., 2003) is likely to rise during insulin resistance. This explains higher pyruvate and lactate in control group. As niacin supplementation increases NAD and NADP (Hristovska *et al*., 2018) thereby reducing dependency on NADH for NAD, it led to lower pyruvate and lactate in RPN group. Due to lack of studies for effects of RPN supplementation on pyruvate and lactate, present results could not be discussed adequately however their lower levels could broadly be attributed to effect of niacin to increase insulin sensitivity and its biological efficiency.

Effect of RPN Supplementation on Lipid Profile

The results for changes in triglycerides, total cholesterol, LDL-C and HDL-C are presented in Table 2. Comparison between groups for concentration of lipid profile parameters revealed that triglycerides at 0 and +6 week, cholesterol at 0, 4, +6 week, and LDL-C as well as HDL-C at 0 week were significantly ($p \leq 0.05$) lower in control and higher in RPN supplemented group.

In concurrence Wei *et al*. (2021) reported that nicotinamide supplementation in goats during transition period improved liver energy efficiency and benefitted lipid metabolism. Adipose mobilization and lipolysis degrades triglycerides and produces NEFA that is oxidised or re-esterified to triglycerides, however excess NEFA overwhelms such hepatic capacity (Grummer, 1993). Thus, excess triglyceride accumulation and reduced extrahepatic transport of triglycerides, as VLDL and cholesterol, leads to fatty liver (Goff and Horst, 1997). Moreover, during negative energy balance of transition, dietary fatty acid partitioning for milk fat biosynthesis devoid the maternal body of triglyceride biosynthesis. These could be underlying reasons for lower TG, cholesterol, LDL-C and HDL-C in control group of the present study.

Conversely higher triglyceride, total cholesterol, LDL-C and HDL-C in blood of RPN supplemented group suggests its beneficial effect during IR dominated phase *i.e*. transition. Such benefits in dairy cows have been reported to reduce lipolysis, ketogenesis, fatty liver as well as insulin resistance and either maintain or increase glycemia (Tunaru *et al*., 2003; Pires and Grummer, 2007; Hristovska *et al*., 2018). Hristovska *et al*. (2017) also reported increased triglyceride and cholesterol after niacin supplementation in dairy cows. Increased insulin responsiveness favours propionate for gluconeogenesis (Brockman, 1990). Moreover reduction or reversal in IR promotes insulin dependent glucose uptake thus inhibiting protein and triglyceride catabolism for gluconeogenesis. As decreased serum triglycerides and total cholesterol indicates

poor hepatic synthesis function (Chamberlin *et al*., 2013; Djoković *et al*., 2011), their increase in RPN supplemented group on the other hand indicates improved hepatic function.

Table 2: Changes in serum lipid profile (Mean ±SE) in control and RPN treated groups of Surti goats during transition phase

Parameters	Peripartum period	Control Gp	RPN Treated Gp
Triglycerides -TG (mg/dL)	-2 Week	38.07±1.13	37.96±1.13
	0 Week	32.25^{b}±0.82	35.19^{a}±0.83
	+2 Week	31.37±0.68	32.67±1.08
	+4 Week	28.19±0.83	31.92±1.68
	+6 Week	26.21^{b}±0.59	29.58^{a}±1.06
	+8 Week	24.95±1.05	28.27±1.47
	+10 Week	26.22±0.53	27.99±1.65
Total cholesterol -TC (mg/dL)	-2 Week	98.77±3.24	95.82±2.36
	0 Week	83.86^{b}±2.14	91.23^{a}±2.36
	+2 Week	69.78±8.84	84.88±4.31
	+4 Week	73.31^{b}±2.15	83.00^{a}±3.58
	+6 Week	68.14^{b}±2.88	77.02^{a}±2.70
	+8 Week	64.87±3.61	67.51±8.77
	+10 Week	68.07±2.76	72.775.01
Low density Lipoprotein-LDL- C (mg/dL)	-2 Week	30.33±0.68	30.59±0.59
	0 Week	27.01^{b}±1.12	31.19^{a}±1.34
	+2 Week	26.81±0.90	26.25±1.12
	+4 Week	26.35±1.24	26.14±1.42
	+6 Week	25.37±1.23	25.96±1.44
	+8 Week	27.84±1.63	29.92±1.26
	+10 Week	29.72±0.46	30.45±0.63
High density Lipoprotein - HDL-C (mg/dL)	-2 Week	31.06±1.61	32.15±1.82
	0 Week	26.59^{b}±1.27	29.97^{a}±0.92
	+2 Week	29.54±1.49	32.24±1.35
	+4 Week	30.10±1.23	31.71±1.19
	+6 Week	28.26±1.01	30.39±1.00
	+8 Week	29.02±1.17	32.04±1.58
	+10 Week	28.93±1.05	29.18±1.08

Means with different superscripts differ significantly (p≤0.05) between groups.

Effect of RPN Supplementation on Protein Metabolites

The results for changes in total protein, albumin, globulin, urea and creatinine are presented in Table 3. Comparison between groups revealed significantly (p≤0.05) increased total protein and albumin at 0 and +6 week in RPN supplemented group, whereas non-significant difference for globulin. Urea levels at 0 as well as +6 week and creatinine levels at 0, +2 and +6 weeks were significantly (p≤0.05) lower in RPN supplemented group (treatment) as compared to control.

Table 3: Changes in protein metabolites (Mean ±SE) in control and RPN treated groups of Surti goats during transition phase

Parameters	Peripartum period	Control Gp	RPN Treated Gp
Total protein (g/dL)	-2 Week	6.97±0.21	6.94±0.25
	0 Week	5.67^{b}±0.12	6.08^{a}±0.14
	+2 Week	5.75±0.11	6.05±0.13
	+4 Week	5.68±0.14	5.99±0.12
	+6 Week	5.70^{b}±0.16	6.18^{a}±0.15
	+8 Week	5.91±0.15	6.17±0.15
	+10 Week	6.20±0.14	6.36±0.14
Albumin (g/dL)	-2 Week	4.65±0.14	4.63±0.17
	0 Week	3.69^{b}±0.10	4.05^{a}±0.06
	+2 Week	3.83±0.08	4.01±0.10
	+4 Week	3.79±0.08	4.00±0.09
	+6 Week	3.79^{b}±0.11	4.09^{a}±0.08
	+8 Week	3.94±0.10	4.11±0.10
	+10 Week	4.13±0.11	4.24±0.08
Globulin (g/dL)	-2 Week	2.32±0.26	2.31±0.30
	0 Week	1.98±0.13	2.03±0.17
	+2 Week	1.92±0.14	2.04±0.15
	+4 Week	1.89±0.15	2.00±0.17
	+6 Week	1.92±0.20	2.09±0.15
	+8 Week	1.97±0.21	2.06±0.14
	+10 Week	2.07±0.16	2.12±0.12
Urea (mg/dL)	-2 Week	32.43±1.33	31.15±1.03
	0 Week	33.26^{a}±2.08	27.85^{b}±1.30
	+2 Week	32.05±1.50	31.51±1.71
	+4 Week	33.18±1.52	31.89±1.39
	+6 Week	37.57^{a}±1.83	32.57^{b}±1.39
	+8 Week	35.48±2.24	33.36±1.23
	+10 Week	33.45±1.25	34.67±1.40
Creatinine (mg/dL)	-2 Week	0.67±0.01	0.66±0.01
	0 Week	0.71^{a}±0.01	0.67^{b}±0.01
	+2 Week	0.73^{a}±0.01	0.68^{b}±0.01
	+4 Week	0.72±0.02	0.70±0.01
	+6 Week	0.74^{a}±0.03	0.68^{b}±0.01
	+8 Week	0.75±0.02	0.70±0.02
	+10 Week	0.74±0.03	0.70±0.03
	+10 Week	40.98±1.29	41.95±1.38

Means with different superscripts differ significantly (p≤0.05) between groups.

Insulin causes inhibition of lipolysis (Danfaer *et al*., 1994), stimulates protein synthesis (Sjaastad *et al*., 2010) and inhibits its degradation (Sjaastad *et al*., 2010). However during transition period, prevailing insulin resistance and negative energy balance necessitates gluconeogenesis. Diminished insulin sensitivity/efficiency decreases anabolism and increases protein catabolism (Drackley *et al*., 2001; Bell *et al*., 2000) yielding amino acid (alanine and glutamine) that serves as substrate for hepatic gluconeogenesis (Kuhla *et al*., 2011). Albumin being a major fraction of total protein corroborates well with each other. Hristovska *et al*. (2017) in early lactating dairy cows reported similar increase in albumin and decrease in urea after RPN supplementation. As urea and creatinine are catabolic by-products generated by nitrogenous metabolites like protein, they increase during negative energy balance such as transition phase.

As niacin may be attributed to increased insulin sensitivity mediated effects, *viz.,* higher anabolism (lower catabolism) of proteins maintaining positive nitrogen balance RPN supplemented group demonstrated higher total protein and albumin as well as lower urea and creatinine. Lowering of blood urea and creatinine (that also serve as markers of renal function) indicated absence of any adverse impact of RPN on renal functions.

Effect of RPN Supplementation on Hepatic Enzymes

The results for changes in GGT, ALT, AST and GDH are presented in Table 4. Comparative analysis between groups showed significantly ($p \leq 0.05$) lower levels of GGT, ALT, AST and GDH at 0 week (at kidding), +2 week, +4 week and +6 week in RPN supplemented group.

ALT mediates conversion of alanine to pyruvate, for cellular energy production, whereas AST plays role in gluconeogenesis in liver. GDH is involved in catalysis of glutamate to α-ketoglutarate and ammonia while reducing $NAD(P)^+$ to NAD(P)H. GGT plays role in extracellular breakdown as well as intracellular synthesis of glutathione, detoxification of drugs and xenobiotics. As hepatic biomarkers they are commonly assessed in transition dairy animals (Osorio *et al.,* 2014) and their elevation indicates hepatic damage (*i.e.,* lysis and necrosis) (Batistel *et al.,* 2017). In control group of present study, negative energy balance induced hepatic gluconeogensis along with other adaptive changes may have overwhelmed hepatic capacity. Chances of fat infiltration (fatty liver) are high during such period that may cause hepatic dysfunction and enzyme leakage of AST and GGT (Lubojacka *et al*., 2005) in ruminants. Lowering of these enzymes in RPN supplemented group indicates beneficial effect of niacin in successfully ameliorating hepatic overload by reducing IR intensity and negative energy balance. Such benefits after niacin supplementation have also been reported by Hristovska *et al.* (2017).

Table 4: Changes in hepatic enzymes (Mean ±SE) in control and RPN treated groups of Surti goats during transition phase

Parameters	Peripartum period	Control Gp	RPN Treated Gp
Gamma-glutamyl transferase - GGT (U/L)	-2 Week	29.38±1.22	27.65±1.74
	0 Week	35.80^{a}±1.62	30.14^{b}±1.38
	+2 Week	34.83^{a}±1.36	30.58^{b}±0.94
	+4 Week	33.53^{a}±1.41	29.86^{b}±0.99
	+6 Week	34.12^{a}±1.69	29.39^{b}±1.17
	+8 Week	31.10±1.53	29.90±1.43
	+10 Week	29.80±1.23	29.97±1.57
Alanine amino transferase-ALT (U/L)	-2 Week	24.63±1.15	23.98±0.73
	0 Week	29.20^{a}±1.04	25.73^{b}±1.05
	+2 Week	30.61^{a}±2.45	24.76^{b}±0.89
	+4 Week	28.67^{a}±0.90	25.64^{b}±0.93
	+6 Week	35.63^{a}±2.61	26.88^{b}±1.11
	+8 Week	30.16±0.74	30.78±0.56
	+10 Week	29.53±0.88	30.35±0.80
Aspartate aminotransferase -AST (U/L)	-2 Week	39.02±1.70	37.83±0.57
	0 Week	47.22^{a}±2.06	41.39^{b}±1.58
	+2 Week	40.64^{a}±0.86	38.12^{b}±0.38
	+4 Week	42.87^{a}±1.39	38.80^{b}±1.24
	+6 Week	45.82^{a}±1.87	39.66^{b}±0.87
	+8 Week	42.85±2.30	41.60±1.31
	+10 Week	40.98±1.29	41.95±1.38
Glutamate dehydrogenase-GDH (U/L)	-2 Week	21.55±0.70	22.97±0.81
	0 Week	31.69^{a}±2.07	25.94^{b}±1.49
	+2 Week	29.73^{a}±1.92	24.68^{b}±1.30
	+4 Week	33.34^{a}±2.69	25.27^{b}±2.18
	+6 Week	33.87^{a}±2.61	26.84^{b}±1.76
	+8 Week	32.71±2.11	29.86±1.57
	+10 Week	33.30±2.34	28.35±1.76

Means with different superscripts differ significantly ($p \leq 0.05$) between groups.

Conclusion

Rumen protected niacin supplementation @ 1.5 g/day in Surti goats during transition period decreased serum levels of pyruvate, lactate, urea, creatinine, GGT, ALT, AST and GDH, whereas increased total protein and albumin thereby emphasizing its role in mitigating metabolic dysregulation by improving energy and protein balance, minimizing dyslipidemia and improving hepatic function.

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