动物营养学报
CHINESE JOURNAL OF ANIMAL NUTRITION

动物营养学报 » 2014, Vol. 26 » Issue (1) :115-124 DOI: 10.3969/j.issn.1006-267x.2014.01.016

高精料饲粮中添加烟酸对体外瘤胃发酵培养液pH及发酵参数动态变化的影响

欧阳克蕙, 张琪, 鲁友友, 瞿明仁, 熊小文, 潘珂

江西农业大学动物科学技术学院, 南昌 330045

Effects of Nicotinic Acid Supplementation in High Concentrate Diet on Dynamic Changes of Culture Solution pH and Fermentation Parameters of *in Vitro* Rumen Fermentation

OUYANG Kehui, ZHANG Qi, LU Youyou, QU Mingren, XIONG Xiaowen, PAN Ke

College of Animal Science and Technology, Jiangxi Agricultural University, Nanchang 330045, China

摘要 本试验旨在研究高精料饲粮中添加烟酸对体外瘤胃发酵培养液pH及发酵参数动态变化的影响。选用3头体重（275±20） kg、安装永久性瘤胃瘘管的锦江黄牛作为瘤胃液供体，培养底物为高精料饲粮（精粗比85：15）。Ⅰ、Ⅱ、Ⅲ、Ⅳ组分别在培养底物中添加0、400、800、1 200 mg/kg烟酸（干物质基础），每组4个重复。在培养0、0.5、1.0、2.0、4.0、6.0、8.0、12.0、18.0、24.0 h取样，测定培养液pH及瘤胃发酵参数。结果表明：1）与Ⅰ组相比，虽然在培养24.0 h时各组的培养液pH无显著变化（$P>0.05$），但Ⅲ组在6.0~18.0 h显著高于Ⅰ组（$P<0.05$）；培养24.0 h时，与其他各组相比，Ⅲ组显著提高了瘤胃微生物蛋白和氨态氮浓度（$P<0.05$），极显著提高了总挥发性脂肪酸浓度（$P<0.01$），对乙酸、丙酸、丁酸的浓度没有显著影响（$P>0.05$），显著降低了乙酸/丙酸和乳酸浓度（$P<0.05$）。2）整体上，烟酸对Ⅱ和Ⅳ组培养液pH和发酵参数的影响均较小，但在培养后期（12.0~24.0 h），Ⅳ组有降低微生物蛋白浓度的趋势，且在18.0 h时达到显著水平（$P<0.05$）。3）在培养0~2.0 h，随烟酸添加水平的提高，乳酸净生成速率的波动幅度减小；培养液乳酸浓度与pH呈极显著负相关（$R^2=-0.957$，$P<0.01$）。结果提示，高精料饲粮（精粗比85：15）中添加适量烟酸（800 mg/kg）可以促进瘤胃微生物的增殖，提高微生物蛋白浓度，促进挥发性脂肪酸产生，同时也提高了氨态氮的浓度，抑制了乳酸生成，减小了乳酸净生成速率的波动幅度，最终减缓了培养液pH的下降速率，避免了pH的剧烈变化，稳定了瘤胃内环境。

关键词： 高精料饲粮 烟酸 pH 瘤胃发酵参数 动态变化 体外法

Abstract： This study was conducted to investigate the effects of nicotinic acid (NA) supplementation in high concentrate diet on the dynamic changes of culture solution pH and fermentation parameters of *in vitro* rumen fermentation. Rumen fluid was collected from three *Jinjiang* cattle [(275±20) kg] fitted with permanent rumen fistulas. A high concentrate diet (the ratio of concentrate to forage was 85：15) was used. Four levels of NA [0, 400, 800 and 1 200 mg/kg (dry matter basis)] were supplemented in substrates of groups Ⅰ, Ⅱ, Ⅲ and Ⅳ, respectively, with 4 replicates in each group. The specimen was sampled after being cultured for 0, 0.5, 1.0, 2.0, 4.0, 6.0, 8.0, 12.0, 18.0 and 24.0 h to determine culture solution pH and fermentation parameters. The results showed as follows: 1) compared with group Ⅰ, although no significant difference was found in culture solution pH of different groups after being fermented for 24.0 h ($P<0.05$), but that of group Ⅲ was significantly higher after being fermented for 6.0 to 18.0 h ($P<0.05$); compared with the other groups, group Ⅲ significantly increased the concentrations of rumen microbial protein ($P<0.05$), ammonium nitrogen ($P<0.05$) and total volatile fatty acid ($P<0.01$), but significantly decreased acetate/propionate and lactic acid concentration ($P<0.05$), and no significant differences were found in the concentrations of acetate, propionate and butyrate ($P>0.05$). 2) Generally, the effects of NA on culture solution pH and fermentation parameters were not obvious in groups Ⅱ and Ⅲ, but microbial protein concentration of group Ⅳ showed a decreasing tendency in late period of fermentation (12.0 to 24.0 h), and the difference reached significant level at 18.0 h ($P<0.05$). 3) at 0~2.0 h of fermentation, the variation range of net production efficiency of lactate decreased with the increase of NA supplemental level; there was a significant negative correlation between lactic acid concentration and culture solution pH ($R^2=-0.957$, $P<0.01$). The results indicate that NA supplementation in the high concentrate diet (the ratio of concentrate to forage is 85：15) at a proper level (800 mg/kg) can promote rumen microbial proliferation, increase microbial protein concentration, stimulate volatile fatty acid generation, and improve ammonium nitrogen concentration, but inhibit lactic acid

generation, reduce the variation range of net production efficiency of lactate, ultimately decelerate the decline rate of culture solution pH, and avoid the dramatic change of pH to stabilize the ruminal environment.

Keywords: high concentrate diet, nicotinic acid, pH, rumen fermentation parameters, dynamic change, *in vitro* method

收稿日期: 2013-08-14;

基金资助:

国家现代农业产业技术体系项目（nycytx-38）；国家自然科学基金（31260561）；江西省教育厅项目（GJJ13274）

通讯作者 瞿明仁

引用本文:

欧阳克蕙, 张琪, 鲁友友等 . 高精料饲粮中添加烟酸对体外瘤胃发酵培养液pH及发酵参数动态变化的影响[J]. 动物营养学报, 2014,V26(1): 115-124

OUYANG Kehui, ZHANG Qi, LU Youyou etc . Effects of Nicotinic Acid Supplementation in High Concentrate Diet on Dynamic Changes of Culture Solution pH and Fermentation Parameters of *in Vitro* Rumen Fermentation[J]. Chinese Journal of Animal Nutrition, 2014,V26(1): 115-124.

链接本文:

http://118.145.16.228/Jweb_dwyy/CN/10.3969/j.issn.1006-267x.2014.01.016 或 http://118.145.16.228/Jweb_dwyy/CN/Y2014/V26/I1/115

[1] 王洪荣, 徐爱秋, 王梦芝, 等.氨基酸对体外培养瘤胃微生物生长及发酵的影响[J].畜牧兽医学报, 2010, 41(9):1109-1116.

[2] OWENS F N, SECRIST D S, HILL W J, et al.Acidosis in cattle:a review[J].Journal of Animal Science, 1998, 76(1):275-286.

[3] 董淑红, 王洪荣, 潘晓花, 等.硫胺素对亚急性瘤胃酸中毒状态下山羊瘤胃发酵特性的影响[J].动物营养学报, 2013, 25(5):1004-1009.

[4] FLACHOWSKY G.Niacin in dairy and beef cattle nutrition[J].Archives of Animal Nutrition, 1993, 43(3):195-213.

[5] 王菊花, 程茂基, 卢德勋.烟酸在反刍家畜饲养中的研究进展[J].动物营养学报, 1999, 11(增刊):76-83.

[6] 欧阳克蕙, 鲁友友, 瞿明仁, 等.烟酸对高精料饲粮肥育肉牛生长性能及血清生化指标的影响[J].动物营养学报, 2012, 24(9):1764-1769.

[7] 卢德勋, 谢崇文.现代反刍动物营养研究方法和技术[M].北京:农业出版社, 1991.

[8] MENKE K H, STEINGASS H.Estimation of the energetic feed value obtained from chemical analysis and *in vitro* gas production using rumen fluid [J].Animal Research and Development, 1988, 28:7-55.

[9] 冯宗慈, 高民.通过比色法测定瘤胃液氨氮含量方法的改进[J].内蒙古畜牧科学, 1993(4):40-41.

[10] 戈婷婷.不同组合的功能性寡糖对锦江黄牛瘤胃体外发酵的影响.硕士学位论文.南昌:江西农业大学, 2011.

[11] 王放.瘤胃细菌和原虫蛋白测定方法的初步研究[J].中国畜牧杂志, 1990(2):43-44.

[12] 韩昊奇, 刘大程, 高民, 等.不同NFC/NDF比对奶山羊瘤胃微生物及瘤胃pH变化的影响[J].动物营养学报, 2011, 23(4):597-603.

[13] 胡红莲.奶山羊亚急性瘤胃酸中毒营养生理机制的研究[D].博士学位论文.呼和浩特:内蒙古农业大学, 2008.

[14] CAMPBELL J M, MURPHY M R, CHRISTENSEN R A, et al.Kinetics of niacin supplements in lactating dairy cows[J].Journal of Dairy Science, 1994, 77(2):566-575.

[15] DOREAU M, OTTOU J F.Influence of niacin supplementation on *in vivo* digestibility and ruminal digestion in dairy cows[J].Journal of Dairy Science, 1996, 79(12):2247-2254.

[16] 赵芸君, 孟庆翔.日粮添加烟酸对活体外瘤胃发酵和纤维降解的影响[J].中国农业大学学报, 2006, 11(5):46-50.

[17] HORNER J L, WINDLE L M, COPPOCK C E, et al.Effect of whole cottonseed, niacin and nicotinamide on *in vitro* rumen fermentation and on lactating Holstein cows[J].Journal of Dairy Science, 1988, 71(12):3334-3344.

[18] OTTOU J F, DOREAU M.Influence of niacin on *in vitro* ruminal fermentation and microbial synthesis depending on dietary factors[J].Animal Feed Science and Technology, 1996, 58(3/4):187-199.

[19] 杨艳, 瞿明仁, 欧阳克蕙, 等.烟酸对锦江黄牛瘤胃乳酸、挥发性脂肪酸浓度及相关酶活性的影响[J].动物营养学报, 2013, 25(7):1610-1616.

[20] ERICKSON P S, TRUSK A M, MURPHY M R.Effects of niacin source on epinephrine stimulation of plasma nonesterified fatty acid and glucose concentrations, on diet digestibility and on rumen protozoal numbers in lactating dairy cows[J].Journal of Nutrition, 1990, 120(12):1648-1653.

[21] KUMAR R, DASS R S.Effect of niacin supplementation on rumen metabolites in Murrah buffaloes (*Bubalus bubalis*)[J].Asian-Australia Journal of Animal Science, 2005, 18(1):38-41.

[22] SAMANTA A K, KEWALRAMANI N, KAUR H.Effect of niacin supplementation on VFA production and microbial protein synthesis in cattle[J].Indian Journal of Dairy Science, 2000, 53(2):150-153.

[23] CHRISTENSEN R A, OVERTON T R, CLARK J H, et al.Effects of dietary fat with or without nicotinic acid on nutrient flow to the duodenum of dairy cows[J].Journal of Dairy Science, 1996, 79(8):1410-1424.

[24] NIEHOFF I D, HVTHER L, LEBZIEN P.Niacin for dairy cattle:a review[J].British Journal of Nutrition.2009, 101(1):5-19.

[25] RIDDELL D O, BARTLEY E E, DAYTON A D.Effect of nicotinic acid on microbial protein synthesis *in vitro* and on dairy cattle growth and milk production[J].Journal of Dairy Science, 1981, 64(5):782-791.

[26] SCHAETZEL W P, JOHNSON D E.Nicotinic acid and dilution rate effects on *in vitro* fermentation efficiency[J].Journal of Animal Science, 1981,

53(4):1104-1108.

[27] 陆治年, 金立志.烟酸对奶牛一些生理参数及生产性能的影响[J].中国动物营养学报, 1991, 3(2):34-40.

[28] BENDER D A.Niacin in nutritional biochemistry of the vitamins[M].2nd ed.Cambridge:Cambridge University Press, 2003:200.

[29] NAGARAJA T G.Ruminal acidosis in beef cattle:the current microbiological and nutritional outlook[J].Journal of Animal Science, 2007, 90 (Suppl.1):17-38.

[30] ENENMARK J M, JRGENSEN R J, ENEMARK P.Rumen acidosis with special emphasis on diagnostic aspects of subclinical rumen acidsis:a review [J].Veterinary Zootechnique, 2002, 20(42):16-29.

[31] 潘晓花, 王梦芝, 付聪, 等.饲粮精粗比和添加硫胺素对奶牛体外瘤胃发酵参数及菌群结构的影响[J].动物营养学报, 2013, 25(1):88-99.

[32] 郑集, 陈钧辉.普通生物化学[M].4版.北京:高等教育出版社, 2007:354-355.

[1] 叶慧, 郑玲玲, 雷建平, 冯定远, 左建军.25羟基维生素D_3和1α羟基维生素D_3代替维生素D_3对42~63日龄黄羽肉鸡生长性能、血清生化指标和胫骨发育的影响[J]. 动物营养学报, 2013,25(8): 1752-1761

[2] 杨艳, 瞿明仁, 欧阳克蕙, 赵向辉, 易中华, 宋小珍.烟酸对锦江黄牛瘤胃乳酸、挥发性脂肪酸浓度及相关酶活性的影响[J]. 动物营养学报, 2013,25(7): 1610-1616

[3] 杨竹青, 瞿明仁, 赵向辉, 欧阳克蕙, 杨艳.烟酸对反刍动物脂类代谢和肉质的影响及其作用机制[J]. 动物营养学报, 2013,25(6): 1150-1157

[4] 王明昊, 李垚, 赵伟, 欧阳文文, 金芳.槲皮素对肉鸡脂肪细胞内分泌因子水平的影响[J]. 动物营养学报, 2013,25(3): 587-594

[5] 位莹莹, 徐奇友, 李晋南, 王常安, 罗亮, 赵志刚.不同蛋白质水平饲料中添加α-酮戊二酸对松浦镜鲤生长性能、体成分和血清生化指标的影响[J]. 动物营养学报, 2013,25(12): 2958-2965

[6] 王红卫, 孙敏敏, 孟晓, 王纪亭, 万文菊.不同分子质量壳寡糖对蛋鸡生产性能、肠道微生物及脾脏白细胞介素-2和肿瘤坏死因子-α基因表达的影响[J]. 动物营养学报, 2013,25(11): 2660-2667

[7] 杨璐玲, 吕永艳, 张杰杰, 孙国强.啤酒糟对瘤胃发酵参数及纤维素酶活性的影响[J]. 动物营养学报, 2013,25(10): 2414-2421

[8] 欧阳克蕙, 鲁友友, 瞿明仁, 黎观红, 游金明, 熊小文.烟酸对高精料饲粮肥育肉牛生长性能及血清生化指标的影响[J]. 动物营养学报, 2012,24(9): 1764-1769

[9] 张玉伟, 罗海玲, 贾慧娜, 常彦飞, 矫丽娟, 陈勇.肌肉系水力的影响因素及其可能机制[J]. 动物营养学报, 2012,24(8): 1389-1396

[10] 刘虎传, 张敏红, 李素霞, 冯京海, 姜海龙, 杨家军, 殷瑞娟.益生菌制剂对早期断奶仔猪肠道pH、黏膜形态结构和挥发性脂肪酸含量的影响 [J]. 动物营养学报, 2012,24(7): 1329-1335

[11] 刘洁, 刁其玉, 赵一广, 姜成钢, 李艳玲, 屠焰.饲粮不同NFC/NDF对肉用绵羊瘤胃pH、氨态氮和挥发性脂肪酸的影响[J]. 动物营养学报, 2012,24(6): 1069-1077

[12] 周帅, 韩兆玉, 刘军彪, 王群, 唐波.蛋氨酸羟基类似物异丙酯对瘤胃体外发酵参数的影响[J]. 动物营养学报, 2012,24(6): 1105-1109

[13] 陈小玲, 黄志清, 贾刚, 郭秀兰, 唐仁勇, 吴秀群.磷酸酪氨酸互作结构域1基因对肉质性状的调控[J]. 动物营养学报, 2012,24(4): 591-594

[14] 陈伟, 林映才, 马现永, 蒋宗勇.一些抗氧化剂的抗/促氧化作用及其机制[J]. 动物营养学报, 2012,24(4): 595-605

[15] 谢明, 韩旭峰, 侯水生, 黄苇, 喻俊英.1~14日龄北京鸭烟酸与色氨酸互作关系的研究[J]. 动物营养学报, 2012,24(12): 2335-2341