BARD

**FINAL REPORT
PROJECT NO. US-2155-92**

**Effect of Rumen Available Protein Amino Acids
and Carbohydrates on Microbial Protein Synthesis,
Amino Acid Flow and Performance of High Yielding
Cows**

G.A. Varga, L.D. Muller, A. Arieli, H. Tagari, I. Bruckental, Y. Aharoni

1997

47007

Date: 11/25/97

BARD Project Number: US-2155-92R

Project Title:

Effect of rumen available protein amino acids and carbohydrates on microbial
protein synthesis, amino acid flow and performance of high yielding cows.

Investigators:
(Principal first)

Affiliated Institution:

Gabriella A. Varga

The Pennsylvania State University,

Lawrence D. Muller

The Pennsylvania State University

Amichai Arieli

Hebrew University

Haim Tagari

Hebrew University

Israel Bruckental

The Volcani Center

Yoav Aharoni

The Volcani Center

Project Start Date: August 18, 1993

Type of Report: 1st Annual _____ 2nd Annual _____ Final ✓

Gabriella A. Varga
Signature:
Principal Investigator

R. Kilbom 12/1/97
Signature:
Authorizing Official, Affiliated Institution

הספריה המרכזית
למדעי החקלאות
בית דגן

630.72
BAR/EFF
2nd am

TABLE OF CONTENTS

	Page
Abstract	3
Objectives, Achievements, Conclusions, and Cooperation	4-5
The Israeli Report	1
Effect of the Synchronization of Degradation Dietary Crude Protein and Organic Matter and Feeding Frequency on Ruminal Fermentation and Abomasal Digesta Flow in Dairy Cows	1
Effects of Extrusion of Corn Grains and Feeding Frequency on Rumen Fermentation, Nutrient Digestibilities and Milk Yield and Composition in Dairy Cows	1
Effects of Extrusion of Corn Grains and Feeding Frequency on Rumen Fermentation, and Nitrogen Metabolism in Continuous Culture Fermenters	2
In vivo determination of urea recycling and ammonia absorption in the rumen of dairy cows using ^{15}N - labeled ammonia.	2
In Situ Assessment of Rumen Organic Matter Degradability in the Dairy Cow	2
Effect of Ruminal Degradability of Crude Protein and Nonstructural Carbohydrates on the Efficiency of Bacterial Crude Protein Synthesis and Amino Acid Flow to the Abomasum of Dairy Cows	2
The Effect of the Number of Daily Meals on Milk Yield and Composition of Dairy Cows	3
The US Report	3
Effect of Processing Method on Degradation Characteristics of Protein and Carbohydrate Source in Situ	3
Effect of Ruminally Degradable Protein and carbohydrate on Microbial Fermentation and Nitrogen Metabolism in Continuous Culture Fermenters	3
Varying Degradation Rates of Total Nonstructural Carbohydrates: Effects on Ruminal Fermentation, Blood Metabolites, and Milk Production and Composition in High Producing Holstein Cows	4
Varying Degradation Rates of Total Nonstructural Carbohydrates: Effects on Nutrient Uptake and Utilization by the Mammary Gland in High Producing Holstein Cows	4
List of Publications	6

הספריה
למדעי ה
בית ד

ABSTRACT

The effect of rumen available protein, amino acids and carbohydrates on microbial protein synthesis, amino acid flow and performance of high yielding dairy cows was studied.

A significant relationships between the effective degradabilities of OM in feedstuffs and the in vivo ruminal OM degradation of diets of dairy cows was found. The in situ method enabled the prediction of ruminal nutrients degradability response to processing of energy and nitrogenous supplements. The AA profile of the rumen undegradable protein was modified by the processing method.

In a continuous culture study total N and postruminal AA flows, and bacterial efficiency, is maximal at rumen degradable levels of 65% of the CP. Responses to rumen degradable non carbohydrate (NSC) were linear up to at least 27% of DM.

Higher CP flow in the abomasum was found for cows fed high ruminally degradable OM and low ruminally degradable CP diet. It appeared that in dairy cows diets, the ratio of rumen degradable OM to rumen degradable CP should be at least 5:1 in order to maximize postruminal CP flow. The efficiency of microbial CP synthesis was higher for diets supplemented with 33% of rumen undegradable protein, with greater amounts of bacterial AA reaching the abomasum. Increase in ruminal carbohydrate availability by using high moisture corn increased proportions of propionate, postruminal nutrients flow, postruminal starch digestibility, ruminal availability of NSC, uptake of energy substrates by the mammary gland. These modifications resulted with improvement in the utilization of nonessential AA for milk protein synthesis, in higher milk protein yield. Higher postruminal NSC digestibility and higher efficiency of milk protein production were recorded in cows fed extruded corn.

Increasing feeding frequency increased flow of N from the rumen to the blood, reduced diurnal variation in ruminal pH and ammonia, and of plasma urea, and improved postruminal NSC and CP digestibility and total tract digestibilities. Milk and constituent yield increased with more frequent feeding.

In a study performed in a commercial dairy herd, changes in energy and nitrogenous substrates level suggested that increasing feeding frequency may improve dietary nitrogen utilization and may shift metabolism toward more glucogenesis.

It was concluded that efficiency of milk protein yield in high producing cows might be improved by an optimization of ruminal and post-ruminal supplies of energy and nitrogenous substrates. Such an optimization can be achieved by processing of energy and nitrogenous feedstuffs, and by increasing feeding frequency. In situ data may provide means for elucidation of the optimal processing conditions.

OBJECTIVES

1. Determine diets that will optimize microbial protein synthesis during continuous culture and characterize AA flow.
2. Define the effect of synchronization of dietary and carbohydrate and timing of feeding on non-ammonia nitrogen flow and animal performance.
3. Utilize availability of AA (in situ studies) and outflow (continuous culture study) data to formulate diets that will improve the profile of AA (microbial and dietary origin) flowing to the small intestine in lactating cows.
4. Refinement of diet formulation by introduction of novel terms pertinent for duodenal AA supply.

ACHIEVEMENTS

The project was very fruitful, and most of the original goals of the research proposal were attained. The main achievements are listed below.

The in situ method was found to be a useful tool for providing reliable estimates of rumen degradability of OM in dairy cows. This technique can therefore aid in predicting the amounts of microbial and total intestinal nitrogen flow in the dairy cow. The in situ method may enable also to predict the response in ruminal nutrients degradability to processing of energy and nitrogenous supplements. The AA profile of the rumen undegradable protein differed from that of the original feedstuff and was affected by the processing method.

A continuous culture and in vivo studies revealed that total N and postruminal AA flows, as well as bacterial efficiency, is maximal at rumen degradable levels of 65% of the CP whereas responses to rumen degradable NSC were linear up to at least 27% of DM.

Increase in ruminal carbohydrate availability by means of extrusion of corn or by using high moisture corn was associated with increased proportions of propionate, increase in postruminal nutrients flow, increased postruminal starch digestibility, increased ruminal availability of NSC, increased uptake of energy substrates by the mammary gland. Altogether, these modifications resulted with improvement in the utilization of nonessential AA for milk protein synthesis, and in higher milk protein yield.

Increasing feeding frequency was associated, in vitro as well as in vivo, with reduced diurnal variation in ruminal pH, reduced ratio of acetate to propionate, reduced ammonia, and

Nov 25 1971 17:05 P.3
of reduced plasma urea. More frequent feeding increase DMI, more considerably in the animals fed ground corn and improved postruminal NSC and CP digestibility and total tract digestibility of OM, CP and fiber.

Yield and percentages of milk protein, fat and lactose, and efficiency of milk energy and protein production increased with more frequent feeding. In vitro and in vivo data suggest that this responses may involve a shift in metabolism toward more glucogenesis. Production responses to more frequent feeding is more likely to be revealed in high yielding dairy cows, maintained on high concentrate diets. In these cows availability of energy in apparently the most limiting factor for N utilization.

CONCLUSIONS

Efficiency of milk protein yield in high producing cows might be improved by an optimization of ruminal and post-ruminal supplies of energy and nitrogenous substrates. Such an optimization can be achieved by increasing rumen availability of carbohydrate and reducing rumen degradability of protein in energy and nitrogenous feedstuffs, respectively, and by increasing feeding frequency. In situ data may provide means for elucidation of the optimal processing conditions.

COOPERATION

The research program conducted in Israel and the US was coordinated. The research in the two labs overlap various aspects of ruminal and postruminal digestion in high yielding dairy cow. In the US emphasis was given on studying a large spectrum of degradability of feedstuffs, whereas in Israel the combination between feedstuffs degradability and feeding frequency was examined.

Prof. G.A. Varga visited Israel, and Dr A. Arieli visited the US, for discussing and evaluating the project. Mr. Z. Shabi run in the lab of Prof. G. Varga the continuous culture experiment in which fermentability of feedstuffs employed in the Israeli in vivo trial were examined.

NOV 23 1997 11:05

LIST OF PUBLICATIONS

Lykos T. and Varga G. A. 1995. Effect of processing method on degradation characteristics of protein and carbohydrate source in situ. *J. Dairy Sci.* 78:1789-1801.

Mabjeesh S. J., Arieli A., Bruckental I., Zamwell S. and Tagari H. 1997. Effect of ruminal degradability of crude protein and nonstructural carbohydrates on the efficiency of bacterial crude protein synthesis and amino acid flow to the abomasum of dairy cows. *J. Dairy Sci.* 80:2939-2949.

T. Lykos, G. A. Varga and D. Casper. 1997. Varying degradation rates of total nonstructural carbohydrates: effects on ruminal fermentation, blood metabolites, and milk production and composition in high producing Holstein cows. *J. Dairy Sci.* 80:3341-3355.

T. Lykos and G. A. Varga. 1997. Varying degradation rates of total nonstructural carbohydrates: effects on nutrient uptake and utilization by the mammary gland in high producing Holstein cows. *J. Dairy Sci.* 80:3356-3367.

Shabi Z., Arieli A., Bruckental I., Aharoni Y., Zamwell S., Bor A., and Tagari H. Effect of the synchronization of degradation dietary crude protein and organic matter and feeding frequency on ruminal fermentation and abomasal digesta flow in Dairy Cows (*J. Dairy Sci.*, submitted).

Arieli A., Mabjeesh S. J., Shabi Z., Bruckental I., Aharoni Y., Zamwel S. and Tagari H. In situ assessment of rumen organic matter degradability in the dairy cow (*J. Dairy Sci.*, submitted).

T. Lykos, G. A. Varga and M. L. Risius. Effect of ruminally degradable protein and carbohydrate on microbial fermentation and nitrogen metabolism in continuous culture fermenters. (*J. Dairy Sci.*, submitted).