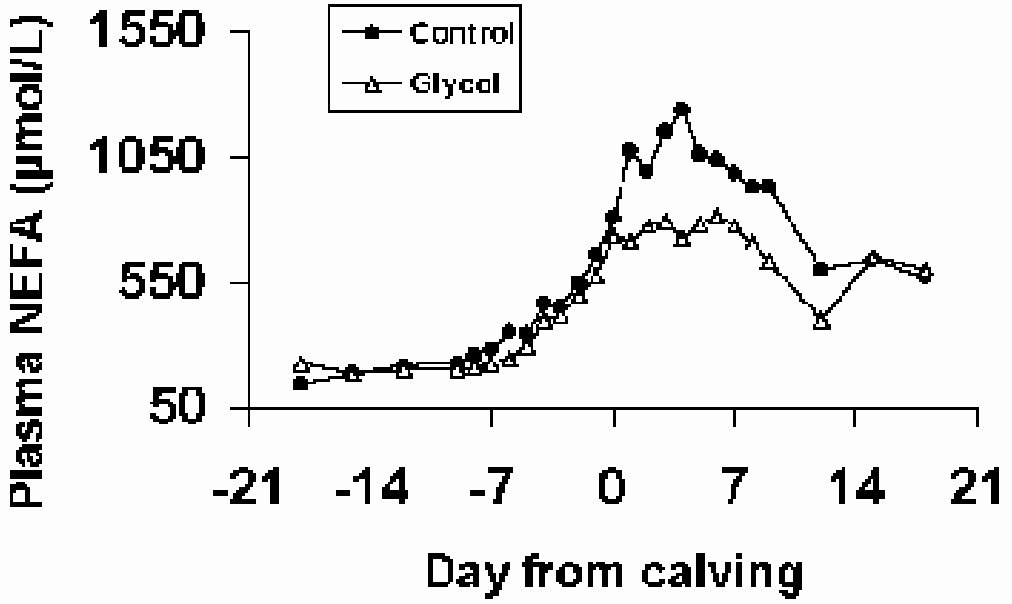
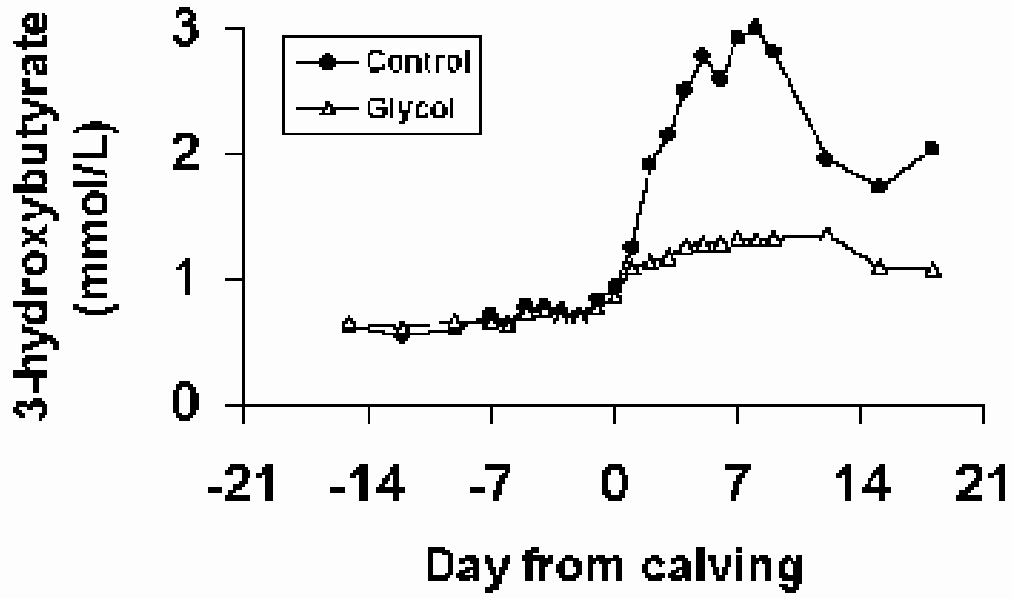
# Glucogenic precursors for transition dairy cows

# What we know about propylene glycol (PG)

- Increases blood glucose and insulin and in reducing plasma NEFA and BHBA (Grummer et al, 1994).
- Studer et al (1993) determined that 1 L of PG administered during the last 10 d before parturition increased blood glucose and insulin and decreased NEFA and BHBA before parturition.
- Short-term drenching of PG effectively decreased NEFA in plasma during early lactation (Pickett et al, 2003)





Burhans et al, 1997

# Objective

- To determine the efficacy of **dry** PG provided through different methods of delivery on energy status as indicated by blood metabolic profiles and lactational performance of Holstein dairy cows during the first three weeks of lactation.

# Experimental Protocol

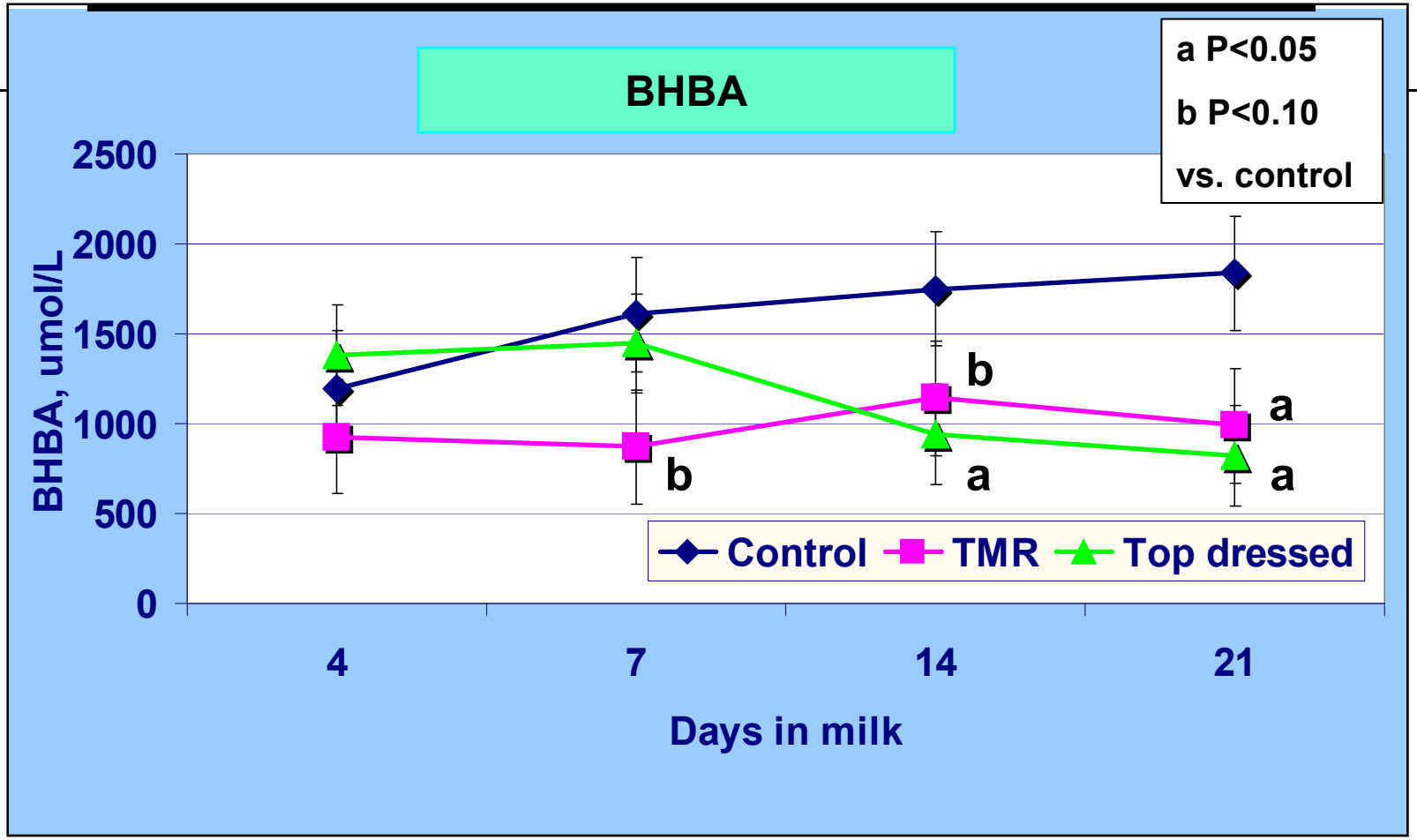
Treatments:

1) control
2) premix with Pro-Pylene 65 at 250g/d in the **total mixed ration**
3) Pro-Pylene 65 at 250g/d **top-dressed.**

Propylene glycol was a dry product containing 65% pure PG and 35% silicon dioxide as the dry carrier.

- Cows were fed the treatments for 21 days post calving.

# Effects of feeding dry propylene glycol to early postpartum Holstein dairy cows on production and blood parameters.




2009.Y.-H. Chung, I. D. Girard, and G. A. Varga. (In Press, ANIMAL).

# Beta-hydroxybutyrate concentrations, umol/L

| Day | Control | TMR | Top dress |
|---|---|---|---|
| 4 | 1199 | 928 | 1382 |
| 7 | 1606 | 873 | 1445 |
| 14 | 1747 | 1143 | 940 |
| 21 | 1837 | 990 | 824 |
| **Overall mean** | **1587a** | **983b** | **1148b** |

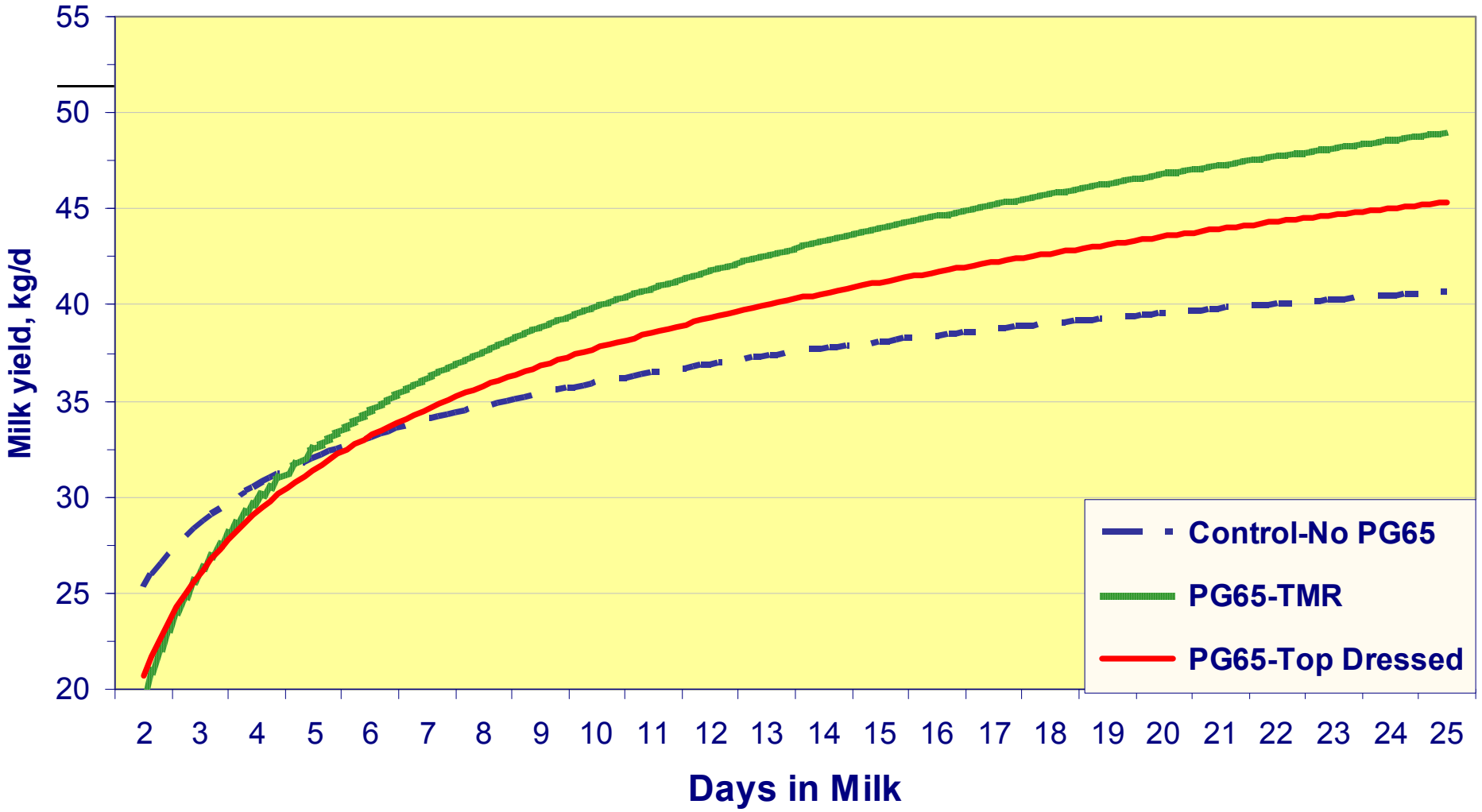
Trt = P<0.05; Lact X DIM, P<0.02

**Indicator for ketosis:**

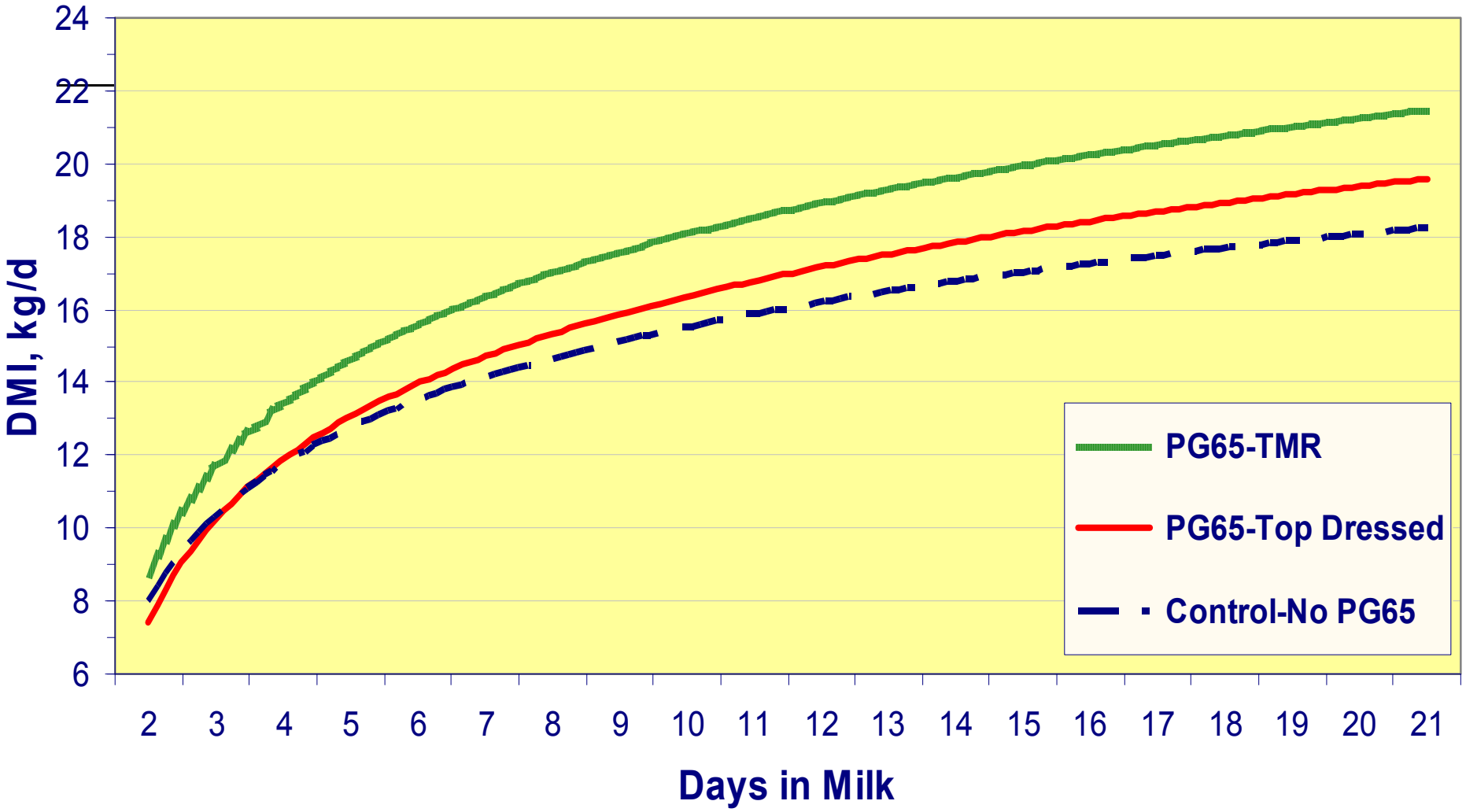
**BHBA >1400 umol/L: Control, 22; TMR, 7; Top dressed, 12**

**BHBA >1000 umol/L: Control, 29, TMR, 14; Top dressed, 20**

## Average daily milk yield for the adult cows



# Average daily DMI for the adult cows



# Conclusions

- Supplementation of dry PG by top dressing onto or incorporating into the TMR had no effects on DMI, milk yield and composition, serum insulin, serum and plasma metabolites, and milk ketones.
- Concentrations of urine ketones tended ($P = 0.10$) to be reduced by PG supplementation from 41.5 to 15.2 mg/dL.
- Supplementation of PG tended ($P = 0.07$) to decrease the incidence for subclinical ketosis from 39 to 24 and 13% for cows fed a TMR supplemented with no dry PG, with dry PG as a top dress and dry PG as a part of the TMR, respectively.

- It is concluded that supplementing PG as a dry product via incorporating into the TMR is as effective as when used as a top dress based on the efficacies of both delivery methods to numerically reduce urine ketones concentrations and therefore the incidence for subclinical ketosis during the first 21 days of lactation.

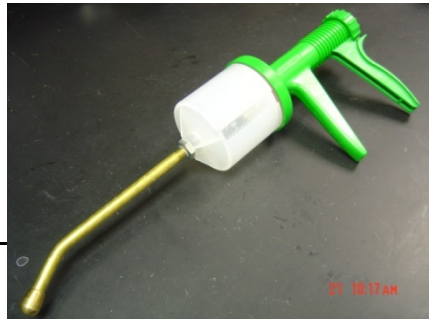
# Responses of Rumen and Blood Metabolites of Holstein Dairy Cows to Propylene Glycol during Frequent Feeding


Y.-H. Chung, C. M. Martinez, N. E. Brown, T. W. Cassidy and G. A. Varga

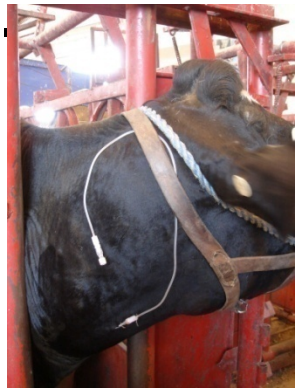
# Effect of Propylene Glycol method of delivery on rumen and blood metabolites

- We hypothesized that **dry** PG provided as a top dress will be as effective as PG provided as a liquid drench in alleviating ketosis and that cows will use a **slow-release** of energy more efficiently than a **pulse-dose** of energy
- The objective of this study was to characterize the metabolic adaptation of cows in response to propylene glycol under different methods of delivery during steady state feeding

# Experimental design



- **control**: no PG,
- **oral-drench**: 162.5g/cow/d of liquid PG (100% purity) oral drenched
- **pulse-dose**: 250g/cow/d of dry PG (65% purity) into the rumen
- **slow-release:** 250g/cow/d of dry PG fed as a part of the TMR (mixing into the TMR).



**COWS WERE FED EVERY 2 HOURS FOR 3 DAYS**

# Materials & Methods

- The **dry** PG product used was a nonacidogenic dry product (Gly-Tran 65, NutriLinx LLC, Montpelier, VT;
- $NE_L$ = 2.6 Mcal/kg), which was composed of 65% PG and 35% silicon dioxide as the carrier

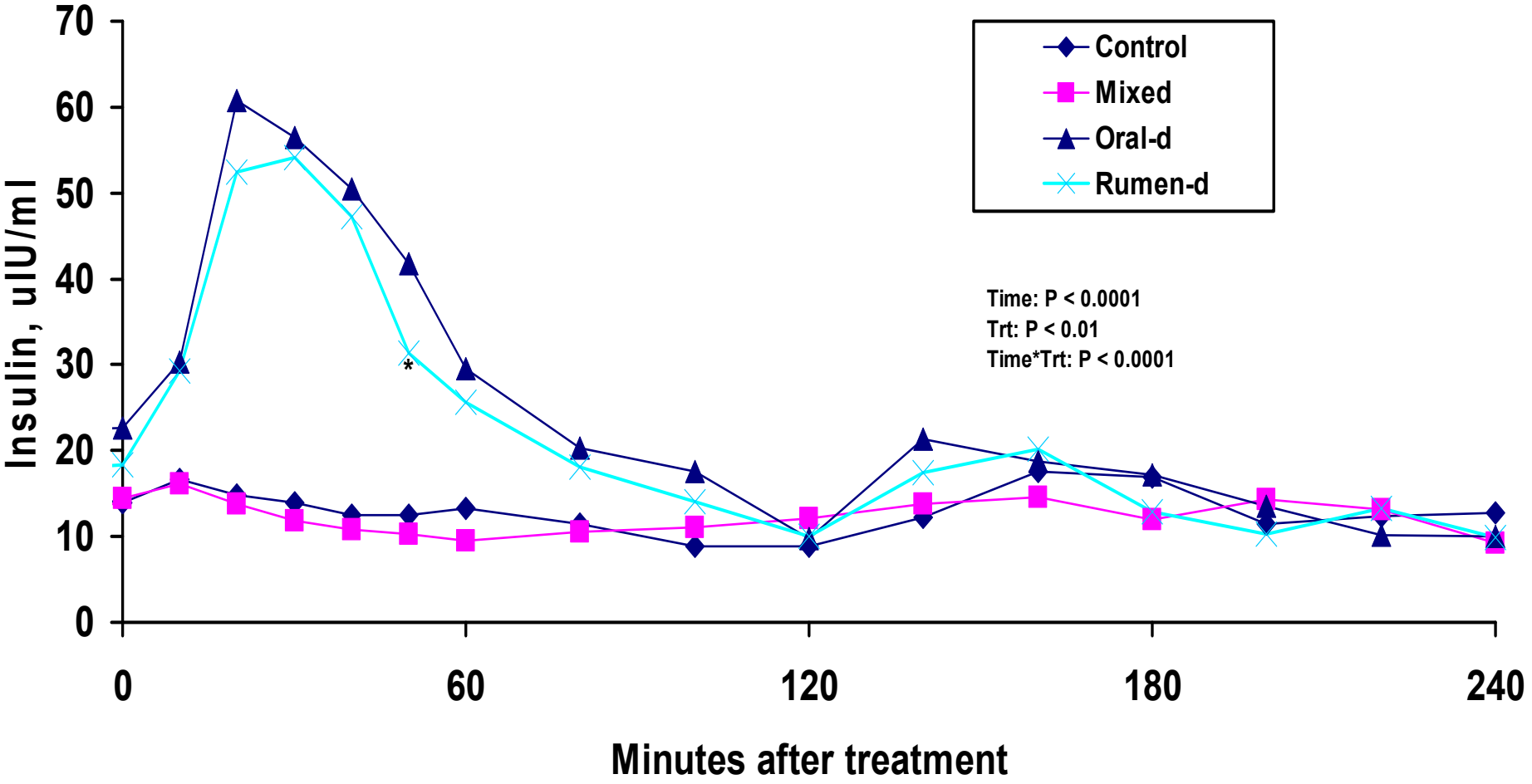
- 8 rumen cannulated multiparous dairy cows
- Replicated 4 x 4 Latin square design

# Feed intake and milk yield were similar

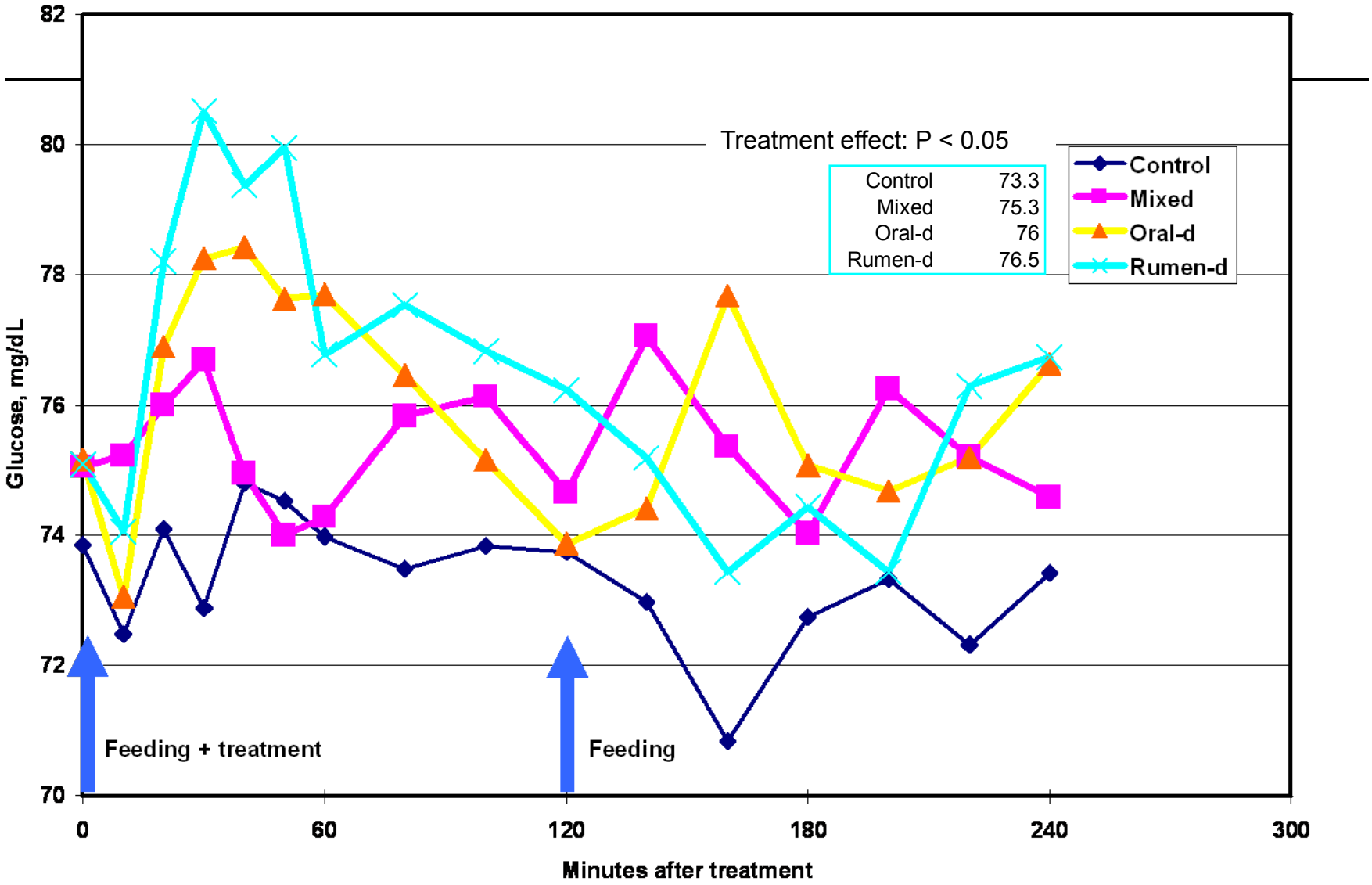
| Variable | Control | TMR | Oral | Rumen | SEM |
|---|---|---|---|---|---|
| DMI, kg/d | 25.3 | 24.7 | 24.9 | 24.3 | 0.9 |
| DMI, % of BW | 3.6 | 3.5 | 3.6 | 3.5 | 0.2 |
| Milk yield, kg/d | 39.0 | 38.9 | 39.6 | 37.7 | 3.3 |
| 3.5% FCM, kg/d | 36.5 | 34.1 | 39.1 | 36.7 | 3.6 |
| EB,* Mcal/d | $5.7^{ab}$ | $7.3^{a}$ | $3.4^{b}$ | $4.5^{ab}$ | 1.4 |

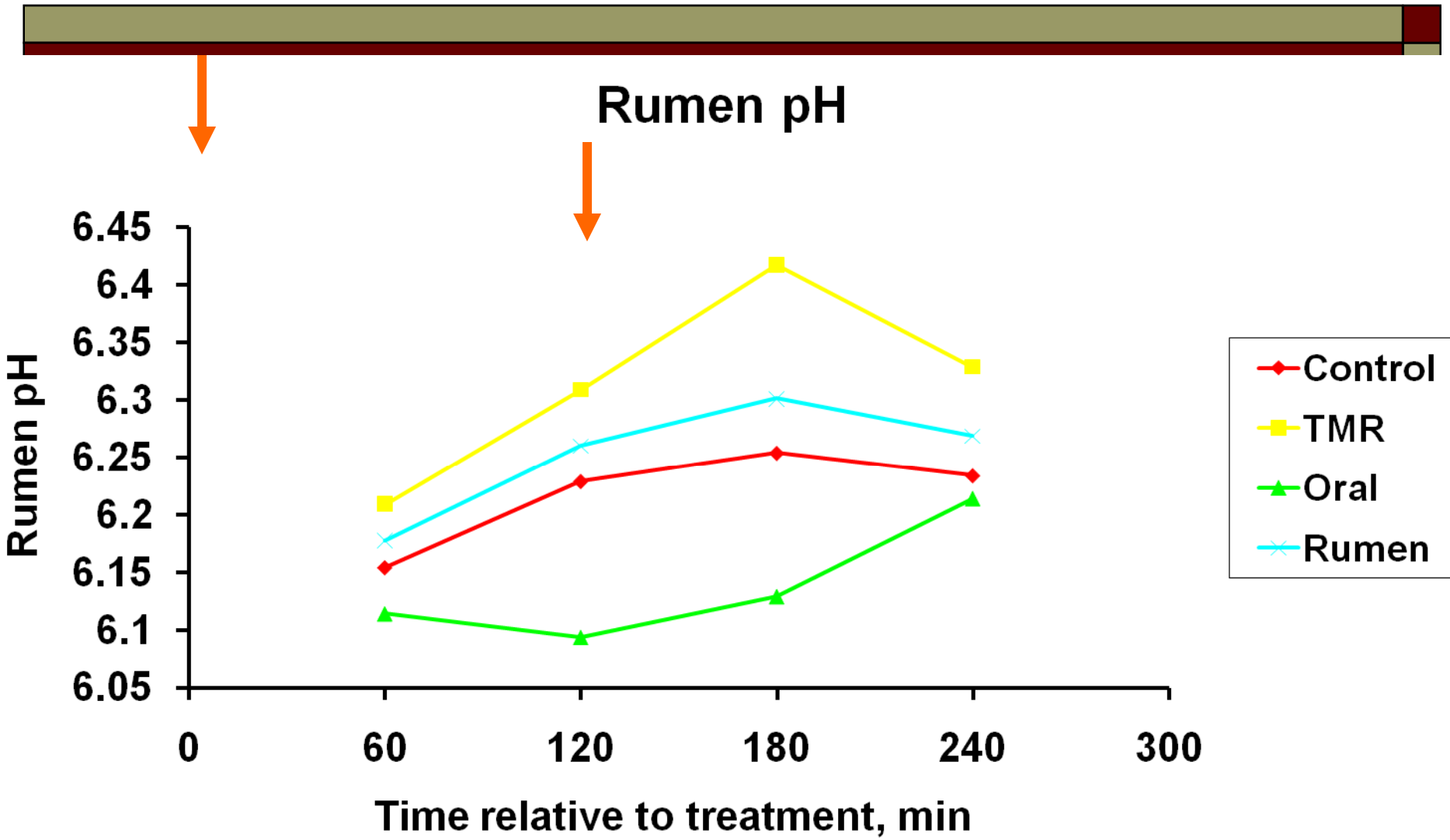
*Tendency for delivery method effect: $0.05 < P \leq 0.15$ ab: $P \leq 0.05$

## Blood insulin concentration of cows fed every 2 hours for 3 days



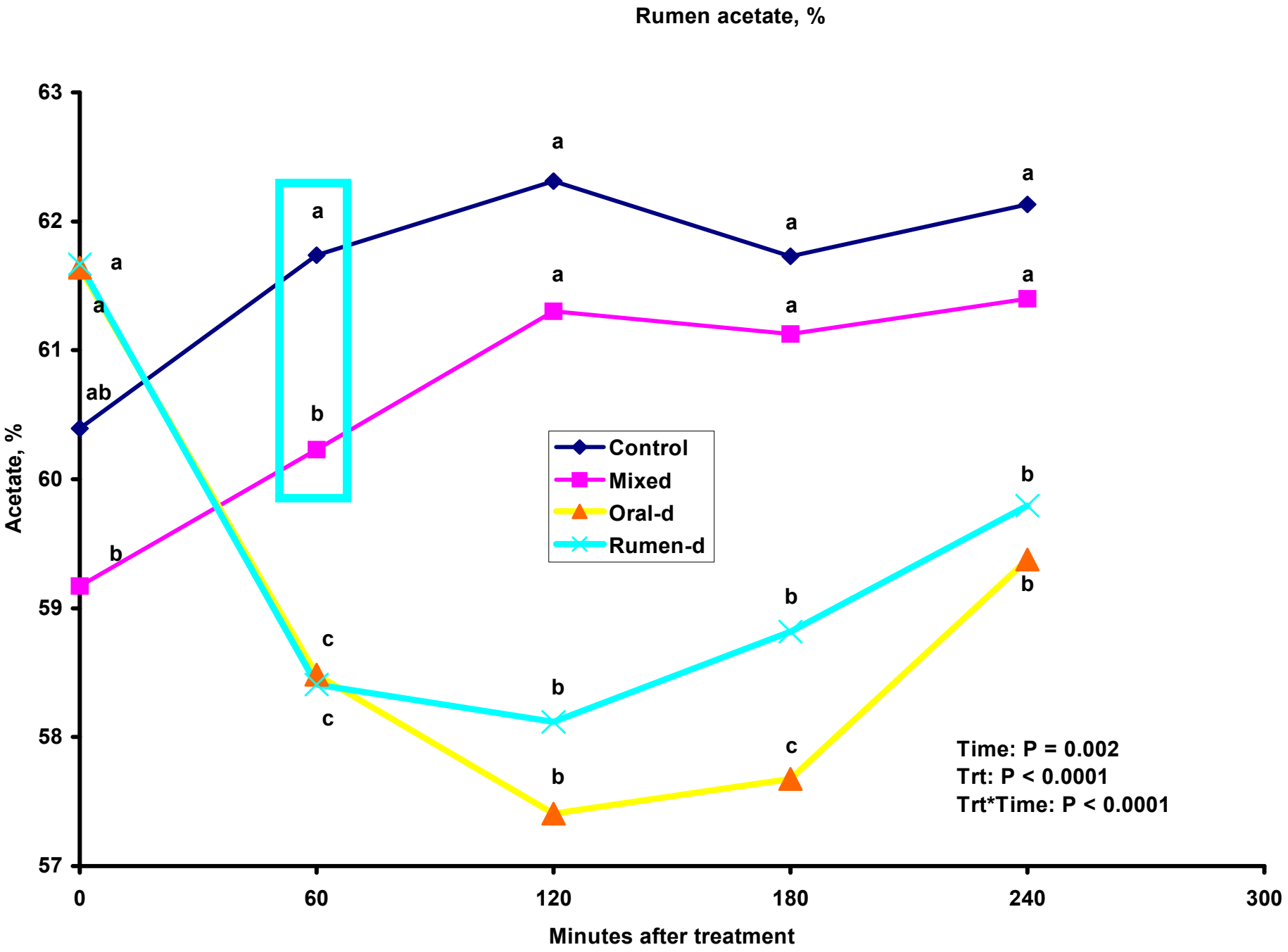
# Blood glucose concentration of cows fed every 2 hours for 3 days

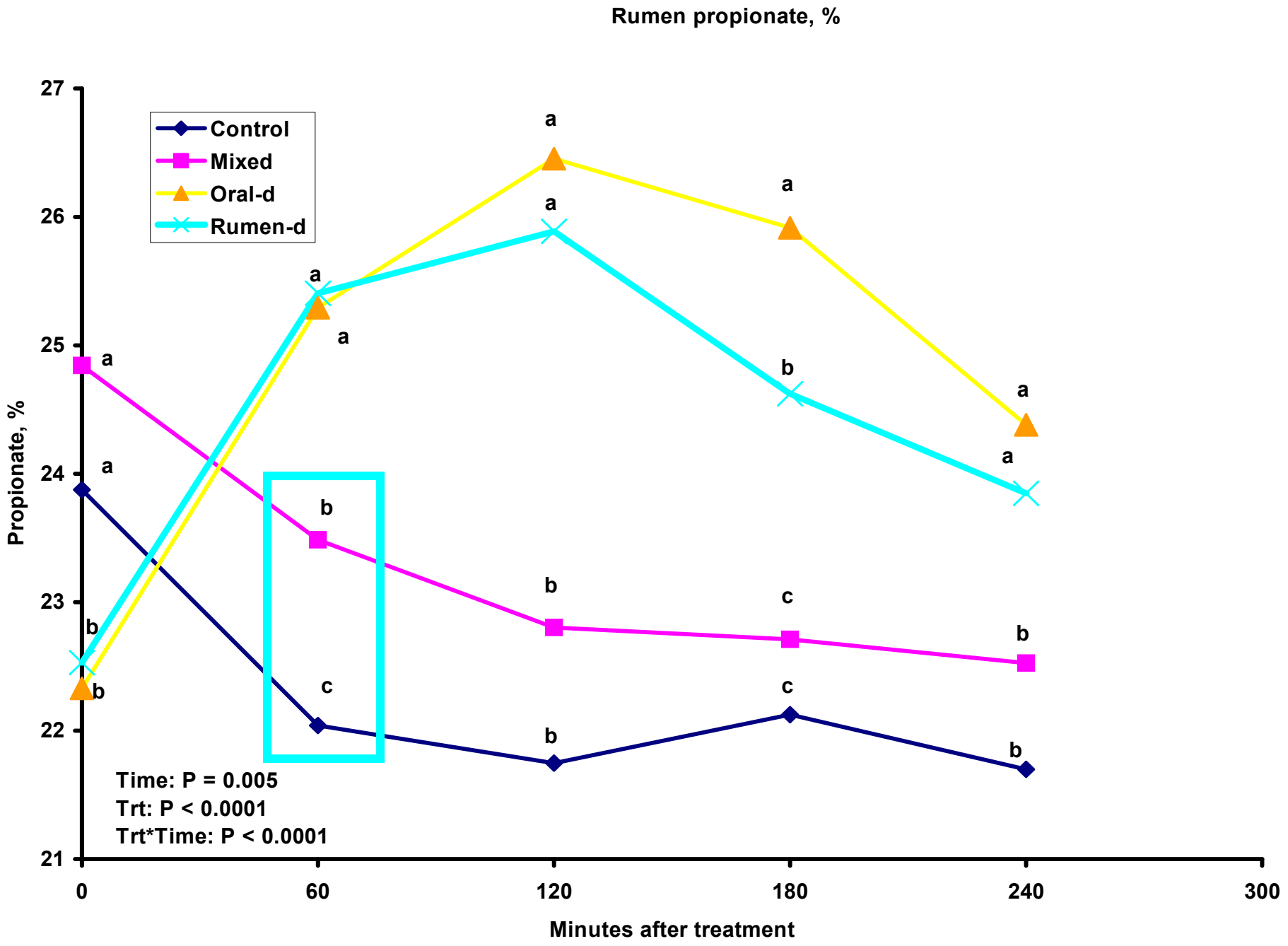





| Average | Control | TMR | Oral | Rumen | SEM |
|---|---|---|---|---|---|
| Rumen pH** | $6.22^{ab}$ | $6.32^{a}$ | $6.14^{b}$ | $6.25^{a}$ | 0.10 |

**Significant delivery method effect: P ≤ 0.05 ab: P ≤ 0.05


Rumen acetate, %
Acetate, %
63
62
61
60
59
58
57
0
60
120
180
240
300
Minutes after treatment
Control
Mixed
Oral-d
Rumen-d
a
a
a
a
a
a
a
a
ab
b
b
b
c
c
b
b
b
b
c
b
Time: P = 0.002
Trt: P < 0.0001
Trt*Time: P < 0.0001


Rumen propionate, %
Control
Mixed
Oral-d
Rumen-d
Propionate, %
Minutes after treatment
27
26
25
24
23
22
21
0
60
120
180
240
300
Time: P = 0.005
Trt: P < 0.0001
Trt*Time: P < 0.0001

# Summary & Conclusions

- Rumen and blood metabolites responded similarly to liquid or dry PG drench indicating top dressing dry PG is as effective as oral drenching liquid PG

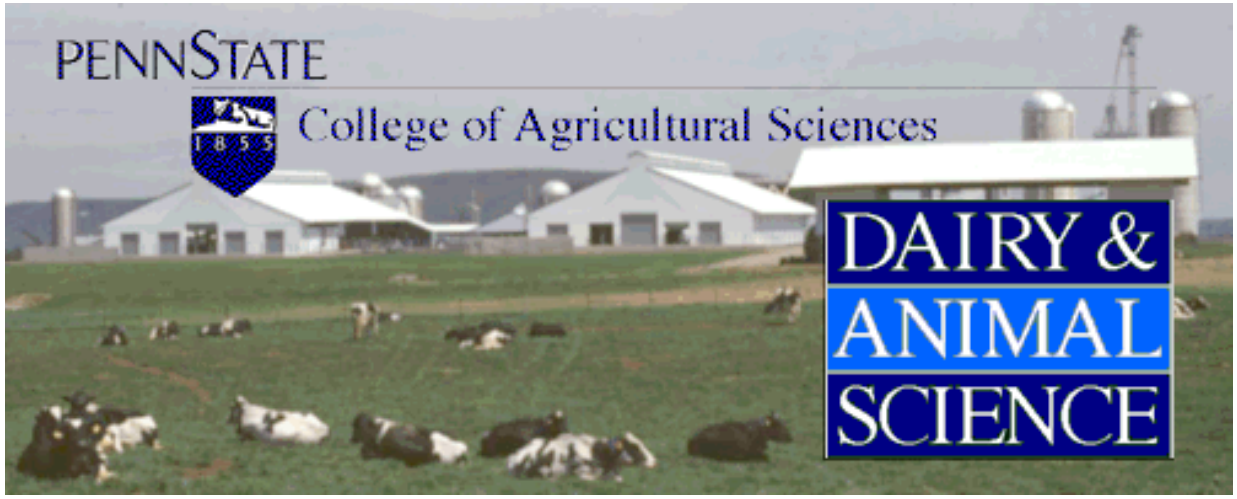
- Feeding dry PG via incorporating into the TMR during frequent feeding altered the rumen VFA patterns toward a more glucogenic environment without stimulation of insulin

# Economics

- Cost of Pro-Pylene 65 is $0.70/cow/d
- Incidence of subclinical ketosis =
  - 40% first 8 weeks of lactation
  - Impact on milk composition long term
- Cost of subclinical ketosis = ~$78/cow
- Cost of clinical ketosis =~$150/cow
- 50% reduction in subclinical ketosis

# Questions???

# Effects of feeding dry glycerin to early postpartum Holstein dairy cows on lactational performance and metabolic profiles



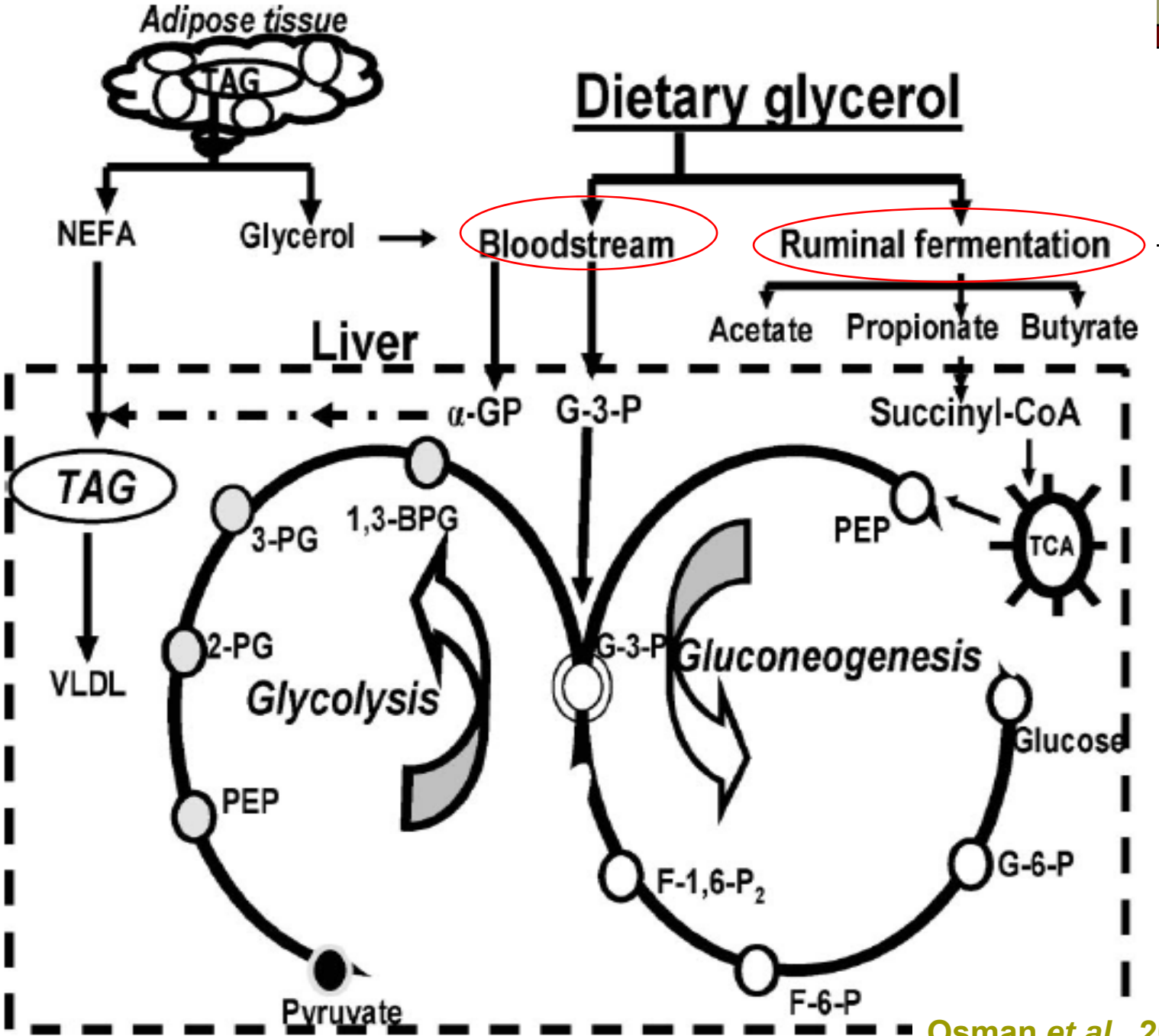

Y.-H. Chung, D. E. Rico, A. Martinez, K. S. Heyler, C. M. Martinez, T. W. Cassidy, V. Noirot, A. Ames and G. A. Varga

# Responses to glycerol

- **Three fates** of **glycerol** in the rumen have been estimated and include passage (13%), fermentation (44%) and absorption (43%) (Remond, 1993).
- Different response to method of administration (Linke *et al., 2004*).
- Acute responses in blood metabolites when given as oral drenches (Bodarsky *et al*, 2005; Linke *et al,* 2004).

# Responses to glycerol

- Glycerol fermentation increased molar proportions of propionic and butyric acid, and total VFA production (Kijora *et al.*, 1997; Schröder and Südekum, 1999; Wang *et al.*, 2009)
- No effects on lactation performance when used as a macro ingredient (Donkin *et al., 2007;* Shröeder and Südekum, 1999)




Osman *et al.*, 2008

# Hypothesis and objectives

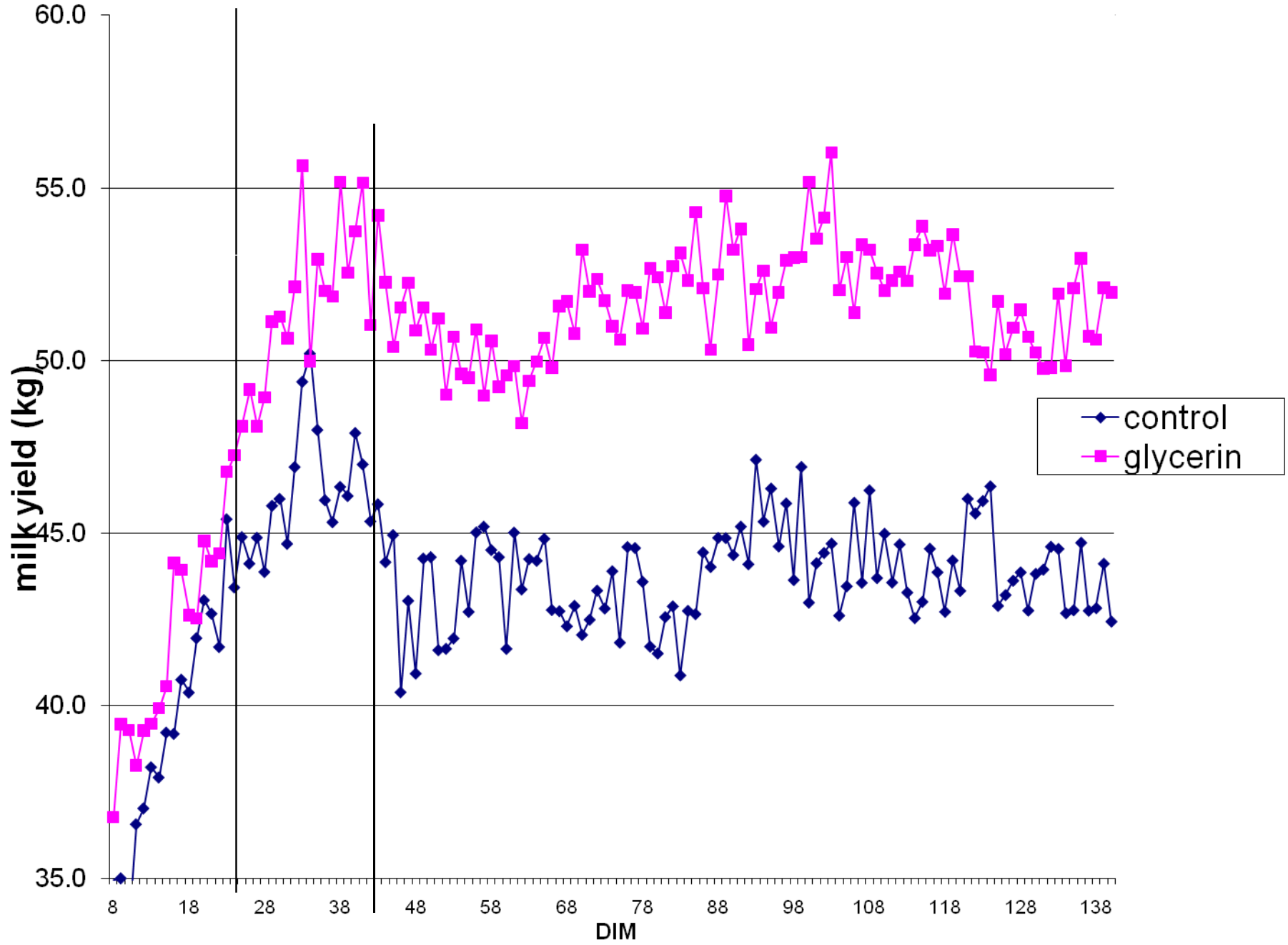
- Although rumen degradation of glycerin is inevitable, we **hypothesized** that the metabolic status of dairy cows when they are in negative energy balance such as the time immediately after calving or in early lactation, still can be improved from propionate produced in the rumen from fermentation of glycerin.
- Our **objective** therefore was to study effects of feeding a dry glycerin product as a top dress to Holstein dairy cows for the first 3 wks of lactation on lactation response and metabolic status.

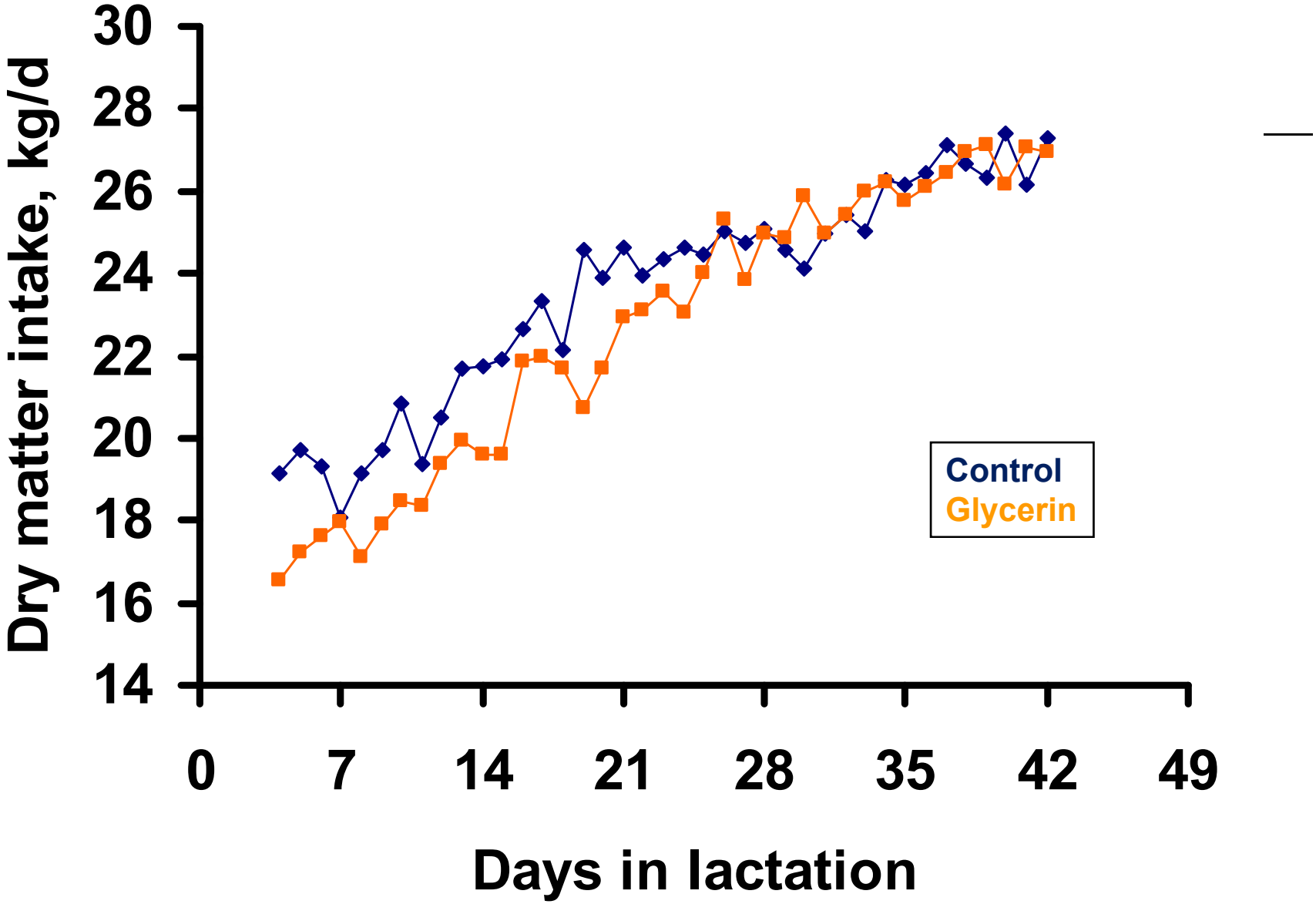
# Experimental protocol

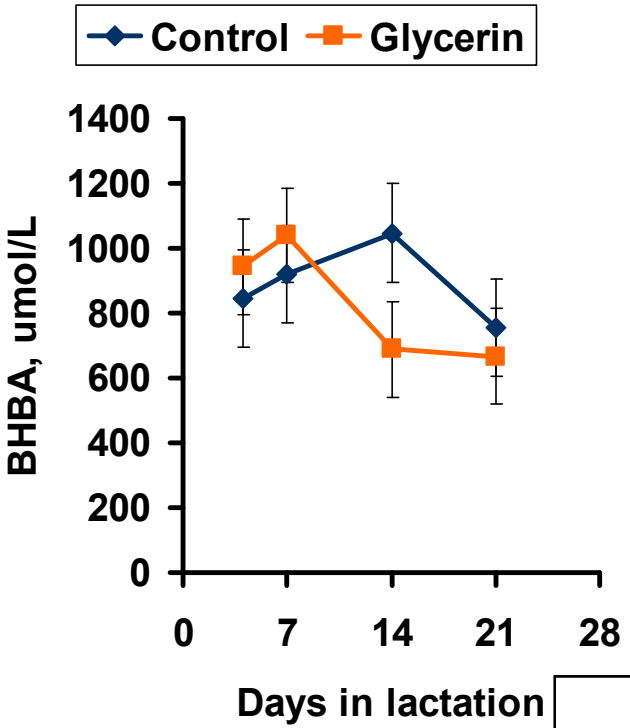
- 39 multiparous Holstein dairy cows were balanced for lactation number (2.2 ± 1.3 SD), previous 305 d ME and expected calving date
- fed a TMR once daily top dressed with or without 250 g/d of dry glycerin (corresponding to 162.5 g glycerol/d) from parturition to 21 d postpartum. Responses of feed intake and milk yield were monitored for an additional 3 wks.
- Dry glycerin contained a minimum of 65% pure glycerol (Phoderush®, Phodé, France; $NE_L$ = 2.6 Mcal/kg DM ) with 33% ash, < 2% fatty acid esters, < 2% water and flavoring substances and was stabilized on a dry mineral carrier.
- DMI and milk yield were measured daily, and urine ketones sampled weekly
- Blood was sampled from the coccygeal vein on 4, 7, 14 and 21 DIM and analyzed for urea nitrogen, glucose, insulin, NEFA and BHBA.
- Data were analyzed using MIXED procedure of SAS.

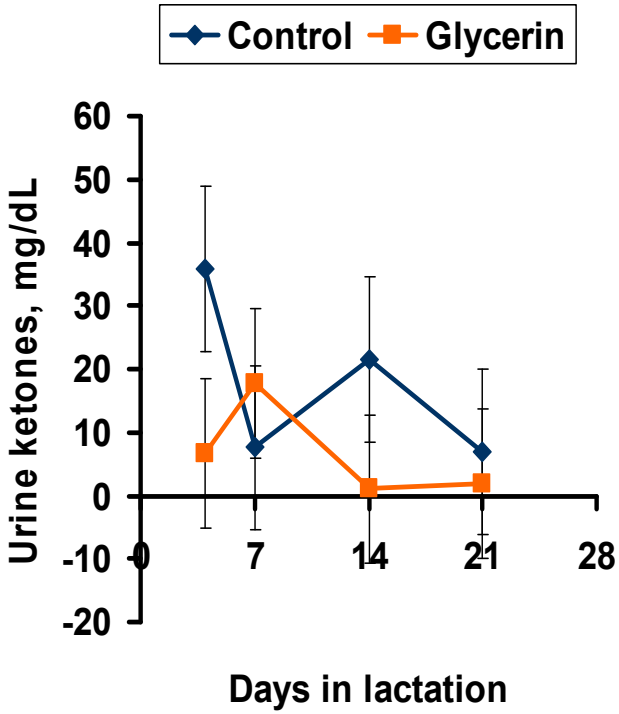
# Intake, milk yield and composition were similar

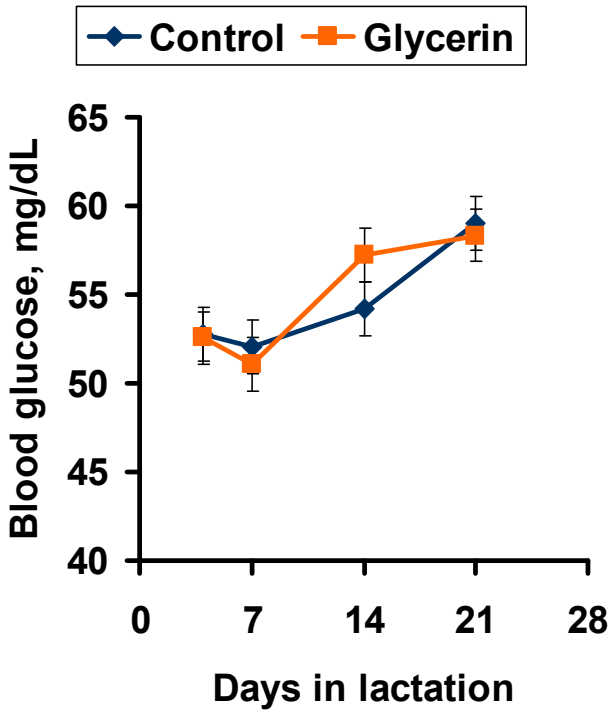
| Variable | Treatment | | SEM | P-value | |
|---|---|---|---|---|---|
| | Control | Glycerin | | Trt | Week |
| DMI, kg/d | 21 | 19 | 1.1 | 0.25 | <0.01 |
| Milk yield, kg/d | 38 | 39 | 2.0 | 0.75 | <0.01 |
| 4% FCM, kg/d | 42 | 42 | 2.2 | 0.92 | 0.31 |


60.0
55.0
50.0
45.0
40.0
35.0
milk yield (kg)
8
18
28
38
48
58
68
78
88
98
108
118
128
138
DIM
control
glycerin


Dry matter intake, kg/d
30
28
26
24
22
20
18
16
14
0
7
14
21
28
35
42
49
Days in lactation
Control
Glycerin


Control
Glycerin
BHBA, umol/L
1400
1200
1000
800
600
400
200
0
0
7
14
21
28
Days in lactation


Control
Glycerin
Urine ketones, mg/dL
60
50
40
30
20
10
0
-10
-20
0
7
14
21
28
Days in lactation


Control
Glycerin
Blood glucose, mg/dL
65
60
55
50
45
40
0
7
14
21
28
Days in lactation

# Conclusions

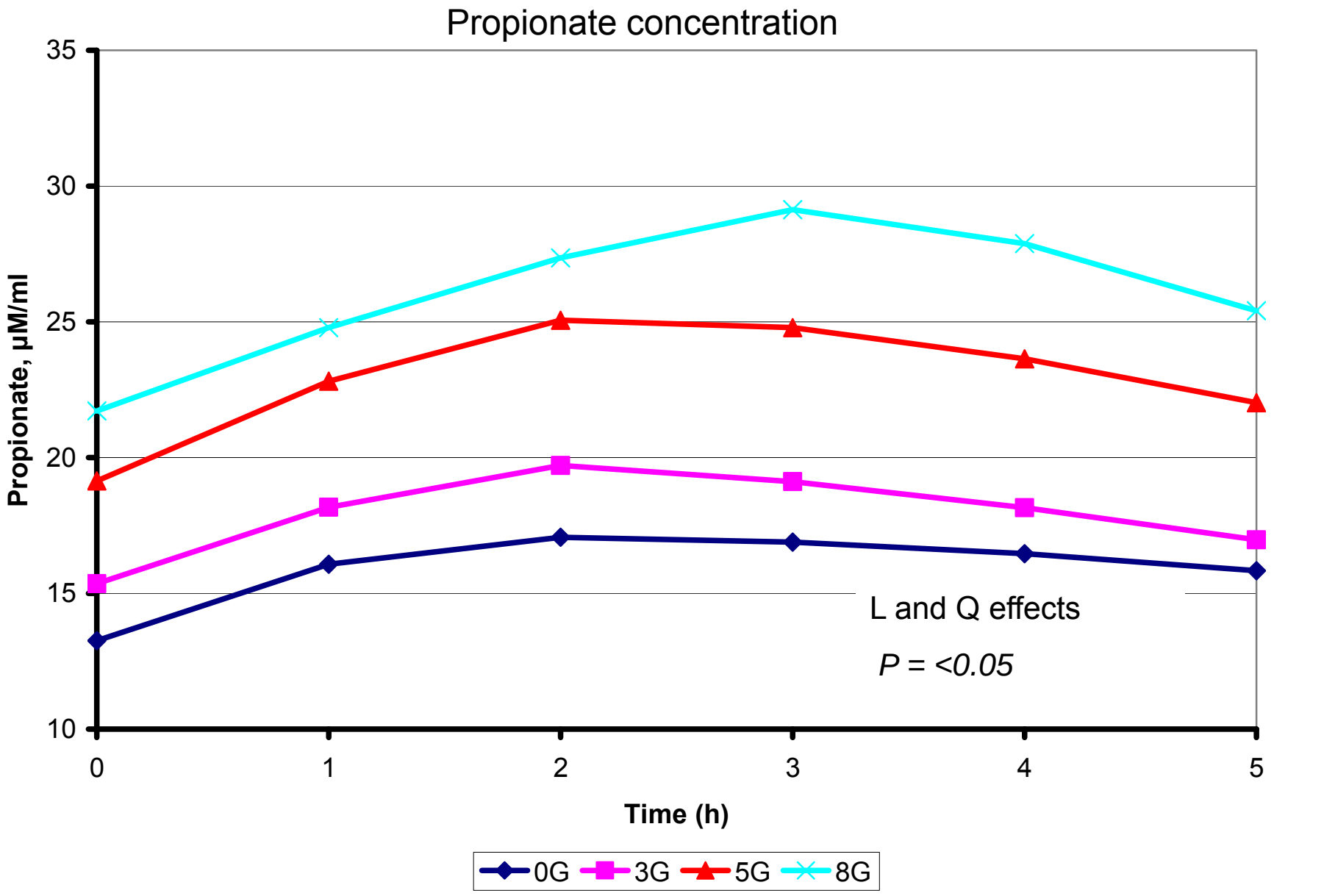
- **Dry glycerin tended to improve metabolic status during the 2nd wk of lactation suggesting that gluconeogenesis may have been enhanced.**
- **This glucogenic effect of glycerin did not effect milk yield during the first 3 wks of lactation likely due to the overall good health of cows transitioning into lactation.**
- **The tendency toward higher milk yield (52 vs. 46 kg/d on wk 6 of lactation) observed in glycerin-fed cows after the supplementation period suggested a beneficial effect of this dry glycerin product on long-term lactational performance perhaps through changes in metabolism, which requires further investigation.**

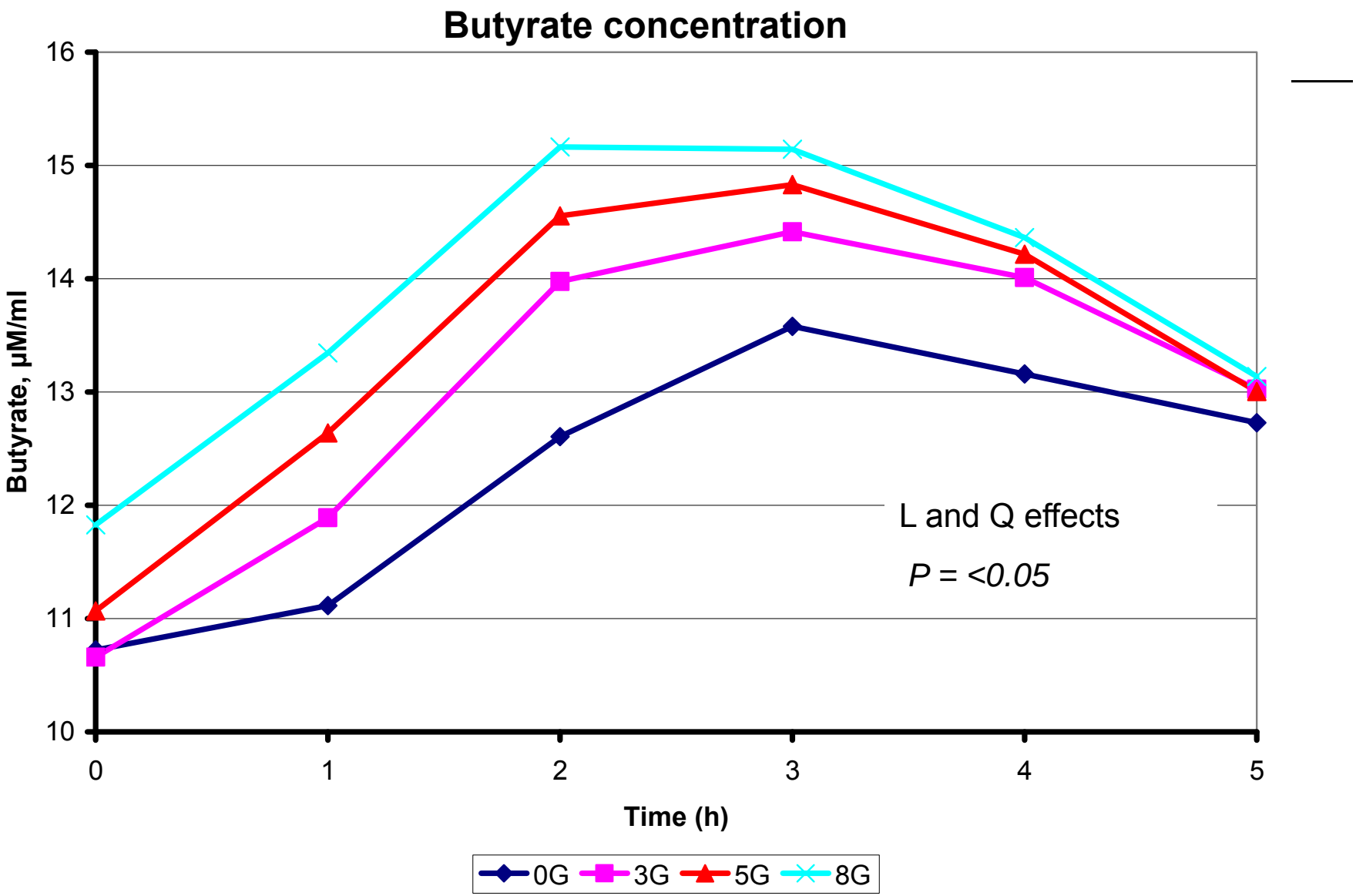
# To evaluate the effects of using **dry** glycerin to replace starch at different levels in the diet on fermentation during continuous culture.


**D. Rico and G. A. Varga**

# Materials and Methods

- Experimental diets (0,3,5,8% glycerol)
- Additional samples were taken hourly for 5 h post-feeding on day 9 for VFA and ammonia analysis.
- Data were analyzed using the MIXED procedure of SAS (The SAS institute, 2009)


Propionate concentration
Propionate, µM/ml
35
30
25
20
15
10
0
1
2
3
4
5
Time (h)
L and Q effects
P = <0.05
0G
3G
5G
8G


Butyrate concentration
Butyrate, µM/ml
16
15
14
13
12
11
10
0
1
2
3
4
5
Time (h)
L and Q effects
P = <0.05
0G
3G
5G
8G

# Apparent nutrient digestibilities

| Item | Treatments | | | | SE | *P* | |
|---|---|---|---|---|---|---|---|
| | 0G | 3G | 5G | 8G | | L | Q |
| % Digestibility | | | | | | | |
| DM | 37.06 | 38.20 | 41.61 | 40.64 | 1.36 | 0.004 | 0.16 |
| OM | 54.09 | 55.04 | 56.66 | 56.18 | 0.94 | 0.05 | 0.34 |
| CP | 53.27 | 52.92 | 53.98 | 52.32 | 1.03 | 0.53 | 0.39 |
| NDF | 56.68 | 63.86 | 68.25 | 67.95 | 1.38 | 0.010 | 0.15 |


# Evaluation Of The Use Of Glycerin From Biodiesel Production In Diets For Dairy Cows

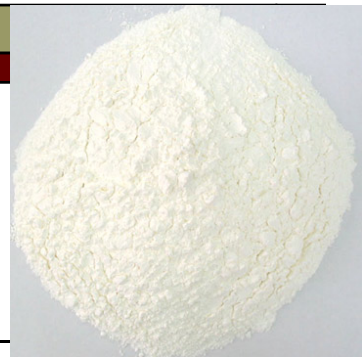
D. Rico, R Chung, and G. A. Varga

# Hypothesis and objectives

- Our hypothesis was that the effect of glycerin (as a liquid) would be similar to sugar and starch in the diet such and that there would be no differences in lactational performance in dairy cows

- Our objective was to evaluate glycerin as a feed ingredient replacing sugar or starch in diets for dairy cows on lactation performance

# Materials and Methods



- 6 multiparous Holstein dairy cows (112 ±8.6 DIM )
- Average milk yield of 83 lbs/d
- Replicated 3X3 Latin square
- 14 d periods (1-9 d for adaptation)
- DMI and milk yield recorded daily
- Final day intensive blood sampling
- Milk was sampled for composition analyses
- Data were analyzed using the mixed procedure of SAS.

# Experimental diets

| Item | Treatment | | |
|---|---|---|---|
| | Glycerin | Molasses | Starch |
| Corn silage | 34.76 | 34.76 | 35.09 |
| Corn Starch | 0.00 | 0.00 | 1.82 |
| Corn grain | 11.26 | 11.26 | 8.59 |
| Canola meal | 9.03 | 9.03 | 9.12 |
| Alfalfa Haylage | 9.83 | 9.83 | 9.92 |
| Soy beans | 7.38 | 7.38 | 7.45 |
| Cookie meal | 6.04 | 6.04 | 6.10 |
| Turbo Meal | 3.61 | 3.61 | 3.65 |
| Cottonseed hulls | 4.46 | 4.46 | 4.50 |
| Sugar molasses | 0.00 | 4.29 | 4.33 |
| Hay/straw combo | 5.96 | 5.96 | 6.02 |
| Mineral and Vitamins mix | 3.38 | 3.38 | 3.41 |
| Glycerin | 4.29 | 0.00 | 0.00 |

# Chemical composition

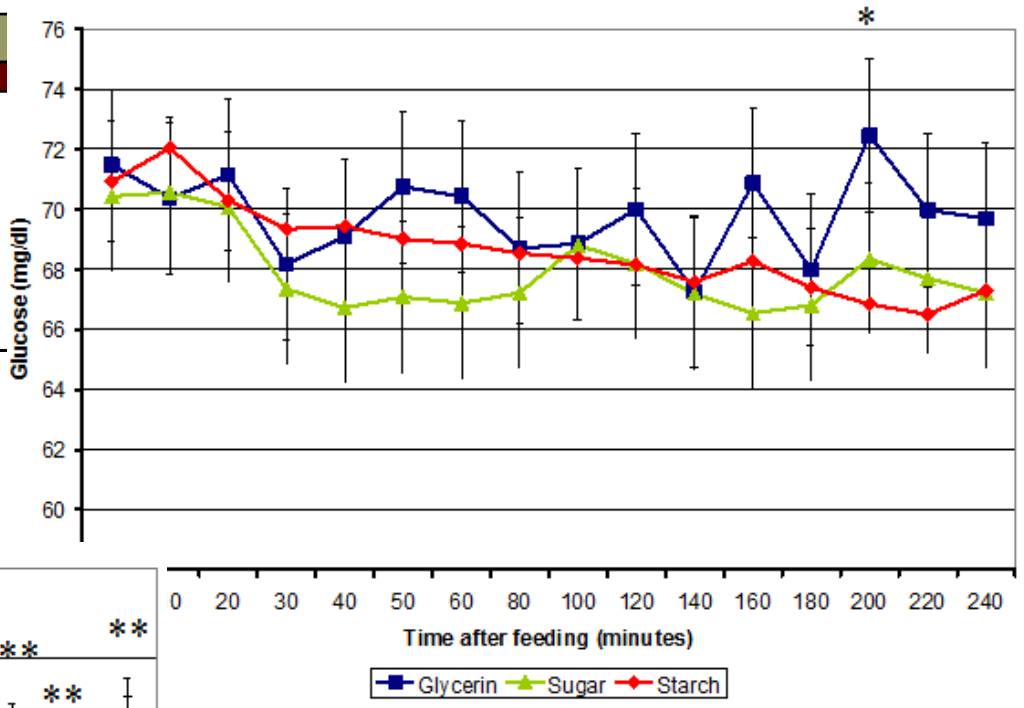
| | Treatment | | |
|---|---|---|---|
| **Item** | **Glycerin** | **Sugar** | **Starch** |
| CP, % of DM | 15.48 | 15.58 | 15.5 |
| SP, % of CP | 30.22 | 30.03 | 30.21 |
| RDP, % of CP | 54.57 | 54.58 | 54.58 |
| NDF, % of DM | 32.36 | 32.36 | 32.4 |
| ADF, % of DM | 20.08 | 20.08 | 20.15 |
| EE, % of DM | 4.99 | 4.99 | 4.92 |
| Starch, % of DM | 25.47 | 25.47 | 25.41 |
| Sugar, % of DM | 8.72 | 8.63 | 8.7 |
| NFC, % of DM | 43.72 | 43.63 | 43.72 |
| Ash, % of DM | 7.71 | 7.77 | 7.83 |
| NEL, Mcal/kg | 1.76 | 1.76 | 1.76 |

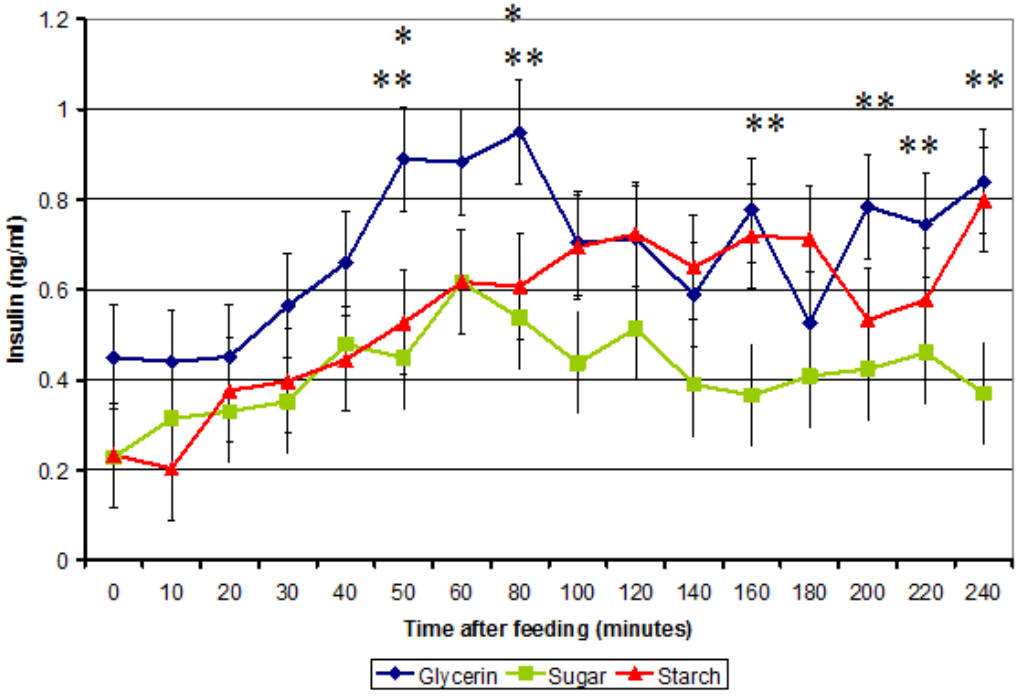
Glycerin in liquid molasses

# DMI and milk yield and composition

| | | | | | *P* | |
|---|---|---|---|---|---|---|
| | **Glycerin** | **Sugar** | **Starch** | **SEM** | **G vs. S[1]** | **G vs. St[2]** |
| **DMI kg/d** | 27.7 | 28.4 | 27.1 | 0.76 | 0.26 | 0.35 |
| **Milk yield,kg/d** | 40.86 | 43.14 | 41.37 | 3.45 | 0.08 | 0.66 |
| **3.5% FCM/kg/d** | 42.59 | 43.71 | 42.96 | 2.75 | 0.40 | 0.79 |
| **Feed Effciency, kg/d** | 1.45 | 1.48 | 1.5 | 1.5 | 0.67 | 0.58 |
| **Fat, %** | 3.19 | 3.01 | 3.03 | 0.19 | 0.35 | 0.41 |
| **Fat, Kg/d** | 1.42 | 1.43 | 1.33 | 0.11 | 0.91 | 0.29 |
| **Protein, %** | 2.95 | 3.03 | 3.02 | 0.07 | <0.001 | <0.01 |
| **Protein, kg** | 1.32 | 1.46 | 1.35 | 0.13 | 0.06 | 0.63 |

1Glycerin vs. Sugar
2Glycerin vs. Starch




*Denotes significance (P < 0.05) for the glycerin vs. starch contrast.

*Denotes significance (P < 0.05) for the glycerin vs. starch contrast.
** Denotes significance (P < 0.05) for the glycerin vs. sugar contrast.

# Conclusions

- At the level of inclusion used in this experiment, glycerin did not affect DMI, FCM or feed efficiency.
- However, milk yield and milk protein content were lower for glycerin fed cows, compared to cows fed either sugar or starch. Its is possible that insulin may have played a role in lowering milk protein by increasing tissue competition for amino acids.
- Rumen bacterial species and/or end products of ruminal fermentation may also have been altered and reduced nutrients available to those cows under the conditions of this study.

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# Notes: