Nutritional Strategies to Optimize Milk Fat

Tom Jenkins
Professor Emeritus
Animal & Veterinary Sciences
Clemson University
Clemson, South Carolina, USA

1

Focus on the Rumen!

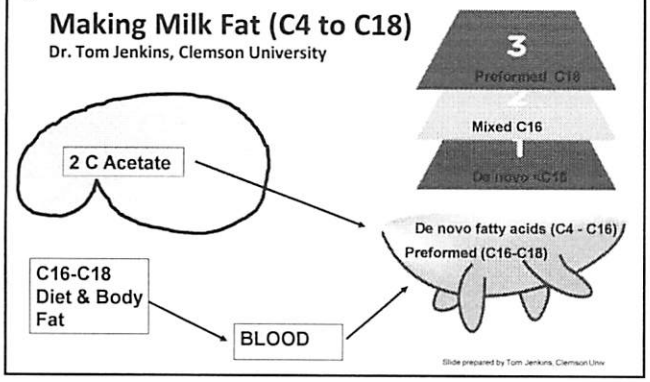
- Review the central role of the rumen in controlling milk fat synthesis.
- Deal with high fat and high starch diets
  - What causes their variability on milk fat as suggested by results from recent rumen microbiology studies.
- Discuss how diet management can position the rumen environment to optimize milk fat.

Slide prepared by Tom Jenkins, Clemson Univ

2

Making Milk Fat (C4 to C18)

Dr. Tom Jenkins, Clemson University



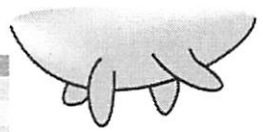
Slide prepared by Tom Jenkins, Clemson Univ

3

Takes all three to build milk fat

	% of total FA	g/100 g
De novo	24.6	0.97
Mixed	41.2	1.63
Preformed	34.4	1.36
total	100	3.96

Data from Woolpert et al. (2017)



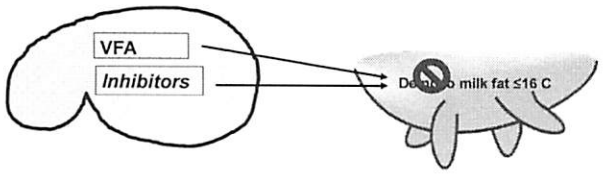
De Novo 1.8 g/100 g
Preformed 2.2 g/100 g

Slide prepared by Tom Jenkins, Clemson Univ

4

The Central Role of the Rumen!

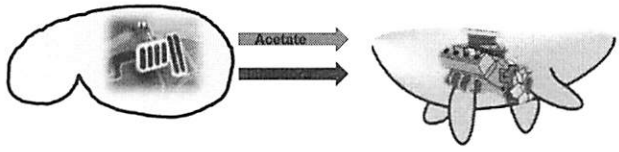
Dr. Tom Jenkins, Clemson University



Slide prepared by Tom Jenkins, Clemson Univ

5

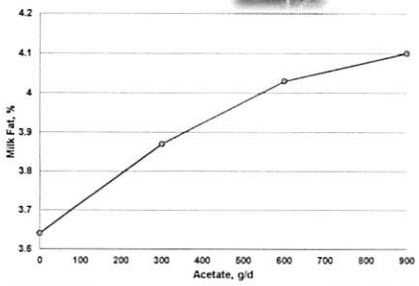
Why the rumen is important for milk fat?



Slide prepared by Tom Jenkins, Clemson Univ

6

Step on the gas!

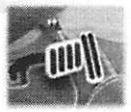


J. Nutr. (2017)

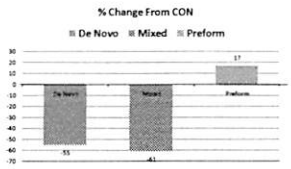
Slide prepared by Tom Jenkins, Clemson Univ

7

Stepping on the brakes!



	CON	5% SBO
Milk yield, kg/d	30.3	28.8
Fat, %	3.53	2.73*
Fat yield, kg/d	1.12	0.85*

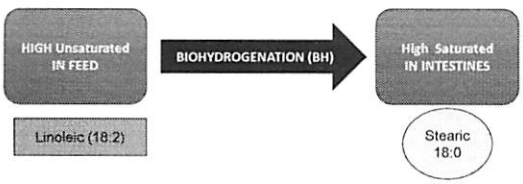


From J. Dairy Sci. (2008) 91:260.

Slide prepared by Tom Jenkins, Clemson Univ

8

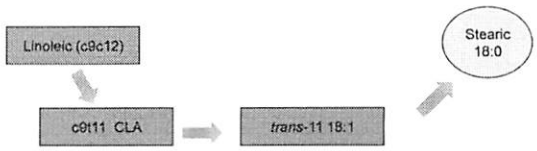
Stepping on the brakes!



Slide prepared by Tom Jenkins, Clemson Univ

9

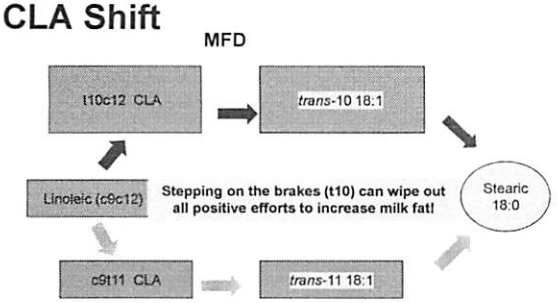
Intermediates



Slide prepared by Tom Jenkins, Clemson Univ

10

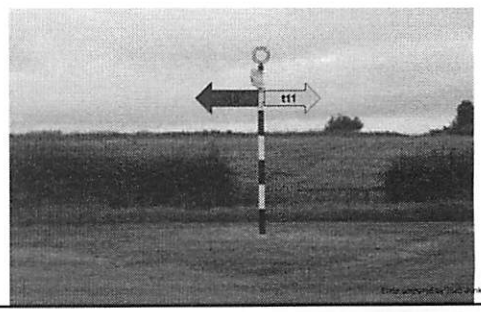
CLA Shift



Slide prepared by Tom Jenkins, Clemson Univ

11

t11/t10 Crossroads



Slide prepared by Tom Jenkins, Clemson Univ

12

2

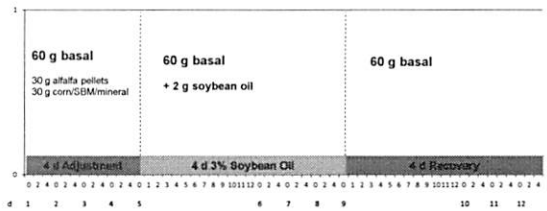
t11/t10 Sources

t11 Pathway	
Butyrvibrio fibrisolvens	J. Biol. Chem. (1967, 1971)
Pseudobutyrivibrio	Antonie van Leeuwenhoek (2007)
Bifidio	Appl Microbiol. Biotech (2010)
Lactobacillus	J. Functional Foods (2017)
Roseburia	Microbiology (2009)
Sharpea azabuensis	Unpublished reports
t10 Pathway	
Megasphaera elsdenii	J. Dairy Sci (2010)
Propionibacterium acnes	Proc. Natl. Acad. Sci (2006)
Some Lactobacillus spp.	Microbiology (2009)

Slide prepared by Tom Jenkins, Clemson Univ

13

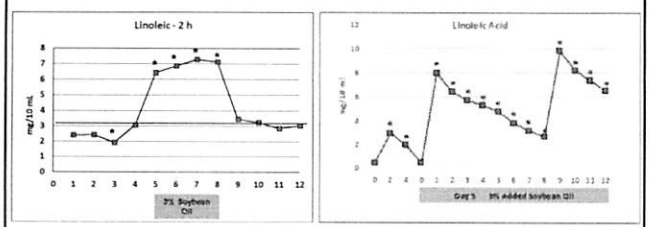
How quickly does t11/t10 change in continuous cultures?



Slide prepared by Tom Jenkins, Clemson Univ

14

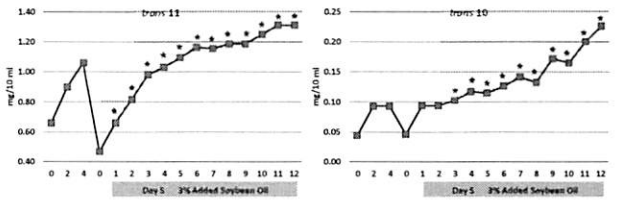
Linoleic acid – mg/10 mL



Slide prepared by Tom Jenkins, Clemson Univ

15

t11 and t10 before and after soy oil addition

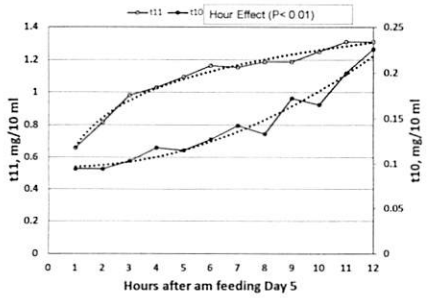


*Differed from 0 h on day 5 (P < 0.05).

Slide prepared by Tom Jenkins, Clemson Univ

16

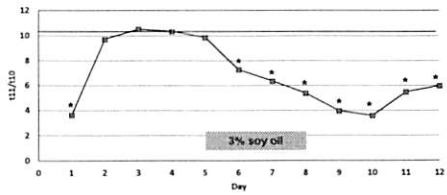
t11/t10 – 2 h after feeding



Slide prepared by Tom Jenkins, Clemson Univ

17

t11/t10 – 2 h after feeding



* Differed from d 4 baseline (P < 0.05).

Slide prepared by Tom Jenkins, Clemson Univ

18

t11/t10 Shift in Lactating Cows

Explanation for t11/t10 shift?
- **Responds quickly**
- **Targets t10 microorganisms**
- **Accounts for fat/starch interactions**

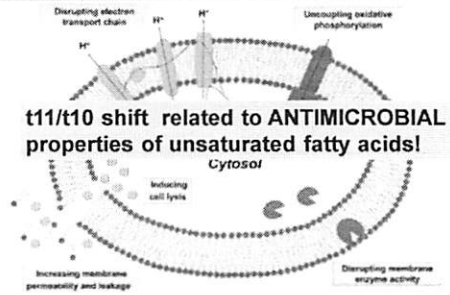
Adding 5% oil to TMR increased milk fat from 3.9 to 4.2% when starch was low (11 to14%).

Adding 5% oil to TMR reduced milk fat from 4.2 to 2.9% when starch was high (29 to 32%).

Ventto et al. (2012)

Slide prepared by Tom Jenkins, Clemson Univ

19



t11/t10 shift related to ANTIMICROBIAL properties of unsaturated fatty acids!

Figure 2. Schematic representation of mechanisms behind the antibacterial activity of fatty acids and monoglycerides.

Yoon et al. (2018). Int J Mol. Sci.

Slide prepared by Tom Jenkins, Clemson Univ

20

Table 2 Influence of LA on acyl CoA pools of *B. fibrisolvens* JW11 20 min after inoculation into fresh medium.

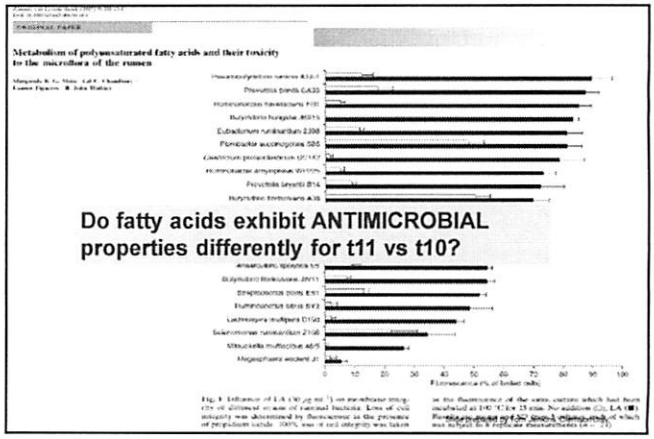
Acyl CoA	Acyl CoA concentration (pmol mg protein^{-1})			
	No addition		0.2 mg ml^{-1} LA	
	Mean	SD	Mean	SD
Isobutyryl	16	4	0	0
Butyryl	213	77	10	2
Crotonyl	10	6	0	0
Isovaleryl	8	2	0	0
Hexanoyl	2	1	0	0
Acetoacetyl	4	1	7	1

Do fatty acids exhibit ANTIMICROBIAL properties quickly?

J. Appl. Microbiol. (2017)

Slide prepared by Tom Jenkins, Clemson Univ

21



Do fatty acids exhibit ANTIMICROBIAL properties differently for t11 vs t10?

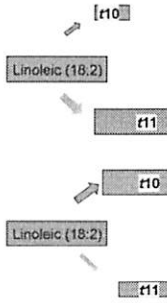
22

- Low pH enhanced antimicrobial effects (incr. lag) of linoleic on B. fibrisolvens (t11) but not P. acnes (t10) in recent abstracts by Maia et al.
- **Do fatty acids exhibit ANTIMICROBIAL properties differently depending on starch levels?** FA on t11 B. fibrisolvens (BMC Microbiol. 2010).

Slide prepared by Tom Jenkins, Clemson Univ

23

Antimicrobial Explanation



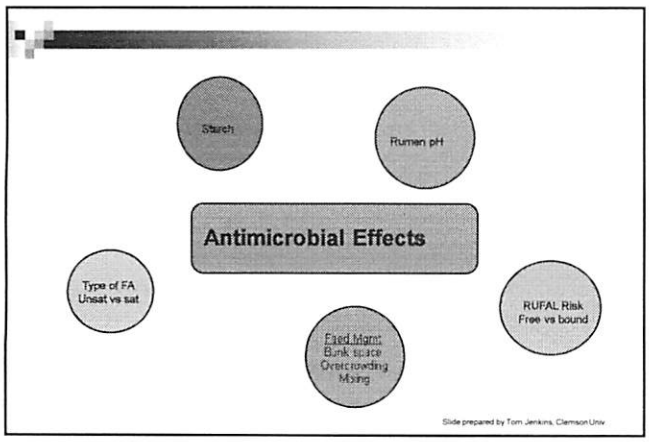
- Without antimicrobial effects
  - t11 and t10 microbes flourish
  - t11 outcompeting t10 for linoleic
    - Mass action
    - Δ-12 isomerase higher affinity
  - t10 microbes robbed of substrate
- With antimicrobial effects
  - t11 microbes suppressed more than t10

All results suggested that when Δ12 isomerization is lacking, Δ9 isomerization must then do the BH of PUFA. Frontiers in Microbiol. (2018)

  - t10 pathway continues to build until inhibitor lowers milk fat

Slide prepared by Tom Jenkins, Clemson Univ

24



25

Type of Fatty Acid – Bypass fats not a big concern!

	CON	PA	CaP	CON vs Fat	PA vs CaFA
Milk fat, %	3.40	3.57	3.50	<0.01	NS
g/100 g					
Mixed	1.11	1.28	1.18	<0.01	<0.01
Preform	1.39	1.43	1.51	0.047	<0.01

From J. Dairy Sci. (2018) 101:3110.

Slide prepared by Tom Jenkins, Clemson Univ

26

Rumen Unsaturated FA Load (RUFAL)

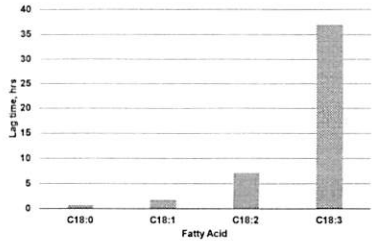
18:1 (oleic)
+ 18:2 (linoleic)
+ 18:3 (linolenic)

A Way to Monitor The High Risk Fatty Acids

Slide prepared by Tom Jenkins, Clemson Univ.

27

B. fibrisolvens JW11 antimicrobial responses to FA (0.5 mg/10 ml)



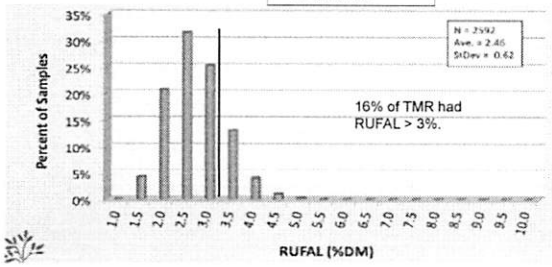
BMC Microbiol. (2010).

Slide prepared by Tom Jenkins, Clemson Univ

28

Distribution of RUFAL

Lactating Cow TMR
- 15-20% CP
- 28-35% NDF



Slide prepared by Tom Jenkins,

29

Example RUFAL Values[1]

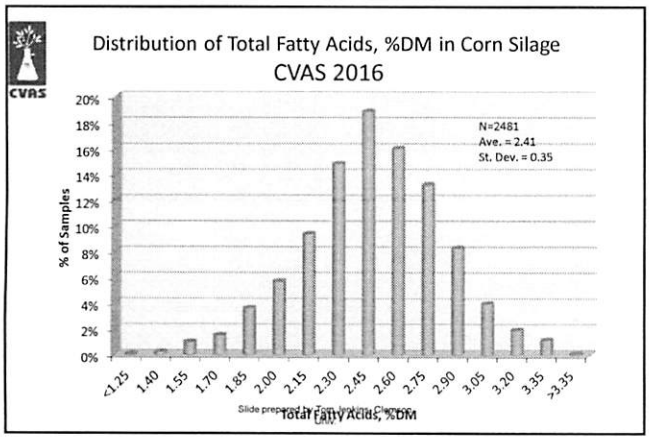
	16:0	18:0	18:1	18:2	18:3	Total FA, % DM	RUFAL, % DM
Corn sil						2.4	1.8
Alfalfa						3.2	2.4
Corn	12.4	1.1	26.0	54.8	1.7	4.1	3.4
Ryegrass	16.7	2.8	2.8	16.4	55.7	6.2	4.6
DDG	14.3	2.3	24.5	53.0	1.5	8.6	6.8
Cottonseed	23.9	2.3	15.2	56.5	0.2	16.9	12.2
Soybeans	10.6	4.3	21.5	54.1	8.6	17.9	15.1
Flaxseed	5.5	4.1	19.8	15.5	51.5	28.5	24.7

What are sources of RUFAL?

[1]Random selection of feeds analyzed at Clemson University

Slide prepared by Tom Jenkins, Clemson Univ.

30



31

RUFAL Risk for Antimicrobial Effects

1 lb fat	Microbial Exposure	t10 Risk
Corn Oil (1 lb)	Immediate	High
Corn silage (3		
Cottonseed (5		

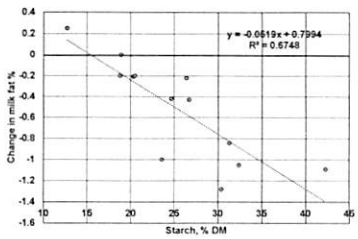
Low Risk RUFAL
hay, unproc corn, unproc cs, whole oilseeds, CaFA

High Risk RUFAL
Proc corn/cs, ground oilseeds, fats/oils, DDG

Slide prepared by Tom Jenkins, Clemson Univ

32

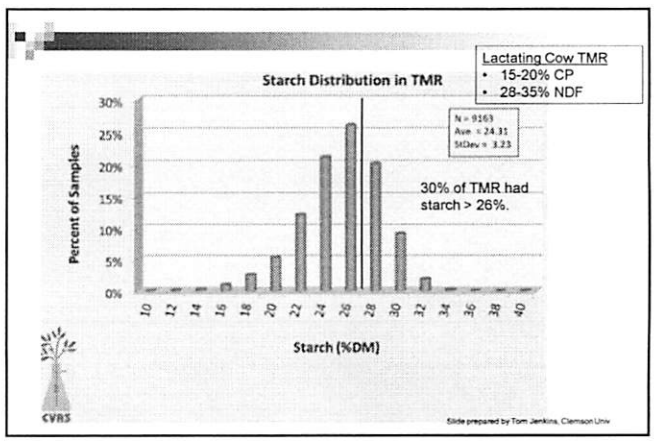
Change in milk fat % caused by added fat vs starch



corn oil, sunflower oil, DDG, soybean oil, linseed oil, fish oil

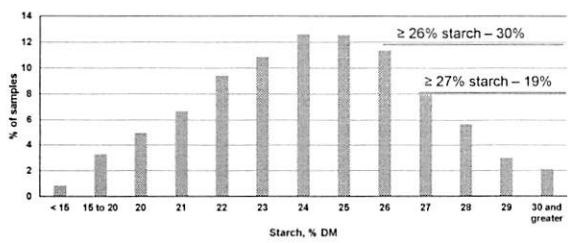
Slide prepared by Tom Jenkins, Clemson Univ

33



34

TMR starch with RUFAL > 3%



Slide prepared by Tom Jenkins, Clemson Univ

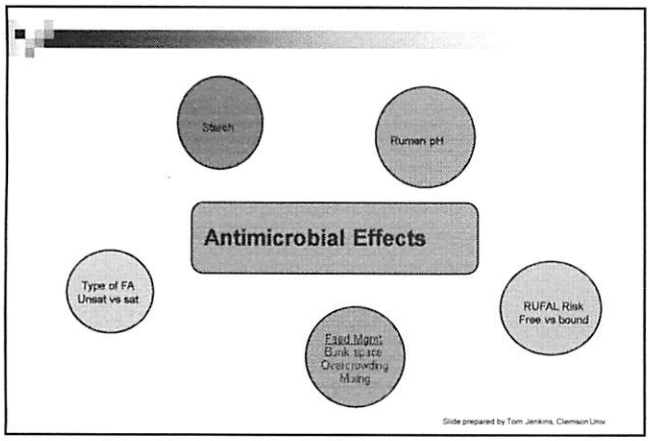
35

Main Points

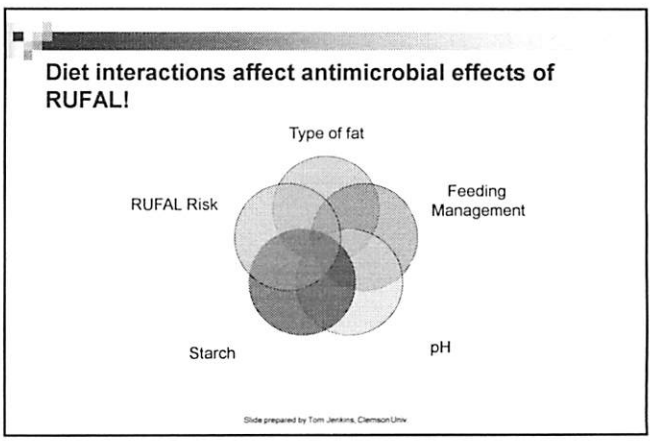
- Rumen plays a central role in efforts to optimize milk fat. AVOID t10 DE NOVO INHIBITORS
- RUFAL may suddenly increase t10 inhibitors by causing antimicrobial effects.
- Antimicrobial effects for any given level of RUFAL is influenced by diet.

Slide prepared by Tom Jenkins, Clemson Univ

36


Starch
Rumen pH
Antimicrobial Effects
Type of FA
Unsat vs sat
RUFAL Risk
Free vs bound
Feed Mgmt
Bunk space
Overcrowding
Mixing
Slide prepared by Tom Jenkins, Clemson Univ.

37


Diet interactions affect antimicrobial effects of RUFAL!
Type of fat
RUFAL Risk
Feeding Management
Starch
pH
Slide prepared by Tom Jenkins, Clemson Univ.

38


Thank You!!!
Slide prepared by Tom Jenkins, Clemson Univ.

39