United States
Department of
Agriculture

Using Propionic Acid to Preserve More Hay

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Marshfield, WI

Riley, KS – 1991

100°F, 20 mph winds

Unfortunately, harvests of alfalfa or other hays are frequently complicated by poor drying conditions, or unexpected rainfall events.

Therefore, hay producers often must choose between subjecting their valuable hay crops to rain damage, or accepting inadequate desiccation and spontaneous heating.

Fayetteville, AR - 2003

Marshfield, WI - 2006

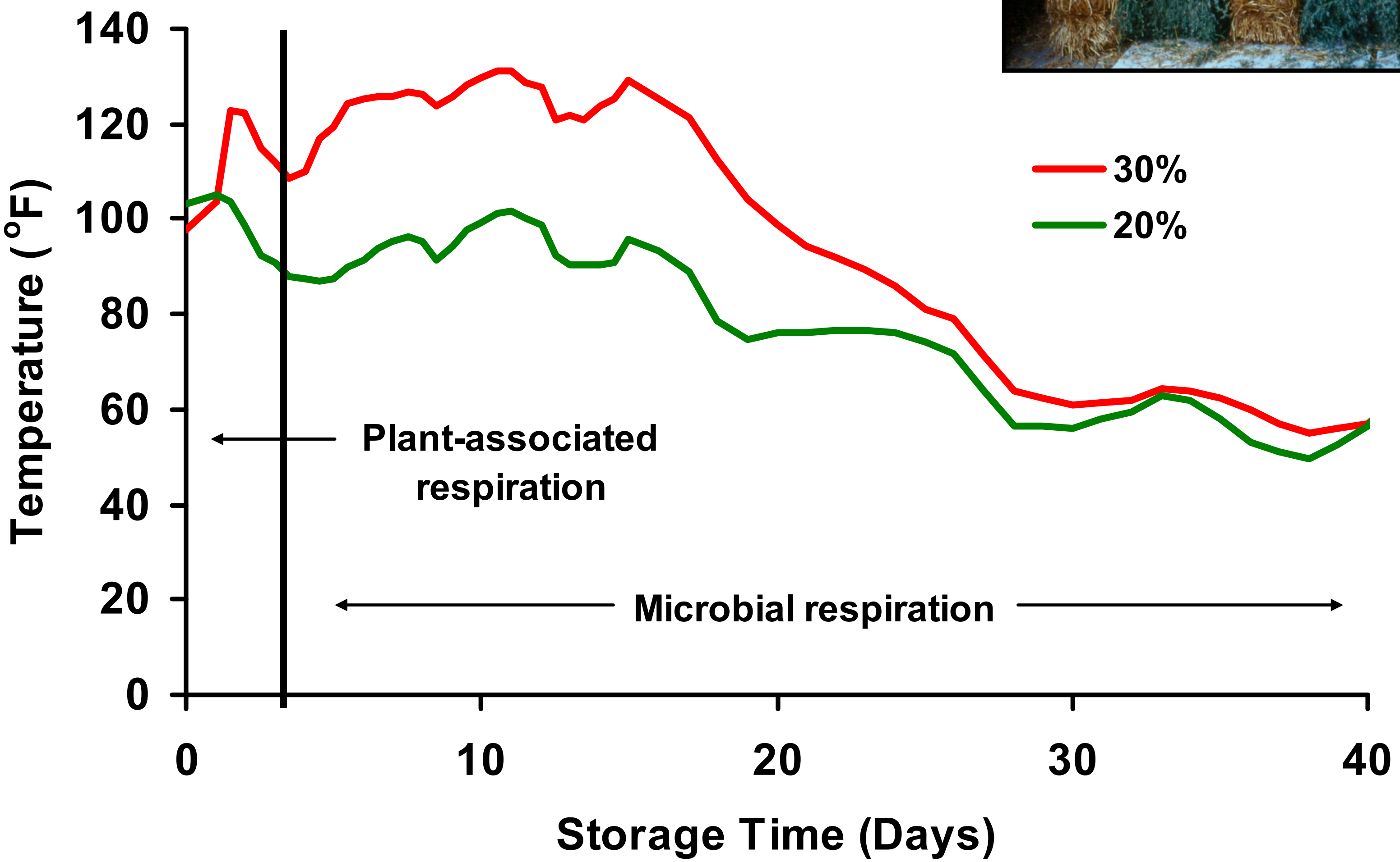
Spontaneous Heating

- result of plant and microbial respiration
- occurs in consistent patterns across forages
- many contributing factors
  - moisture
  - bale density and/or size
  - environmental factors
  - storage site
  - preservatives
- *very good predictor of changes in forage quality!*

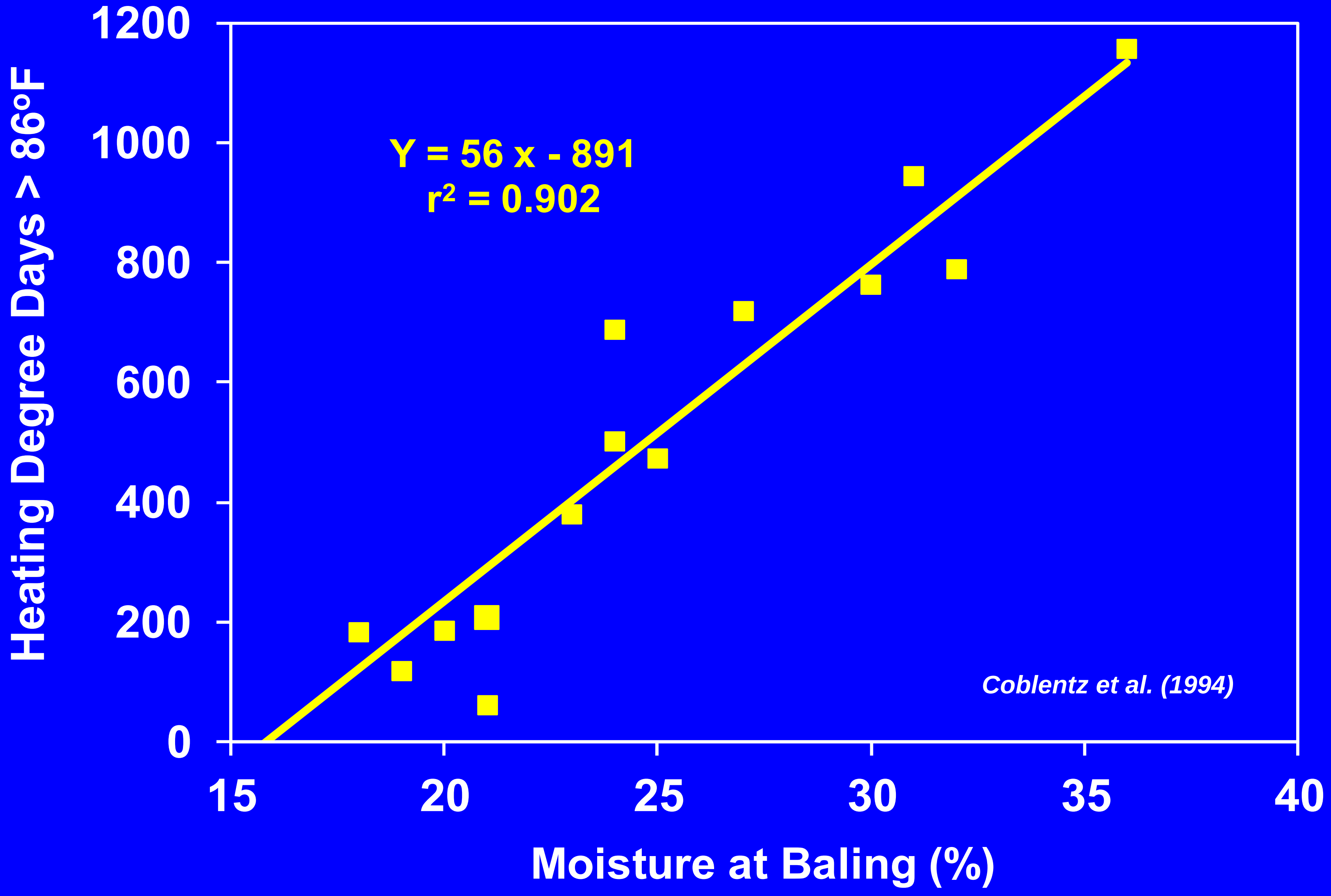
(changes are almost entirely negative)

Patterns of Spontaneous Heating in Alfalfa Hay (45-kg bales)

Coblentz et al. (1996)



Heading Degree Days vs. Initial Bale Moisture Alfalfa Hay (Small Rectangular Bales) - 1991

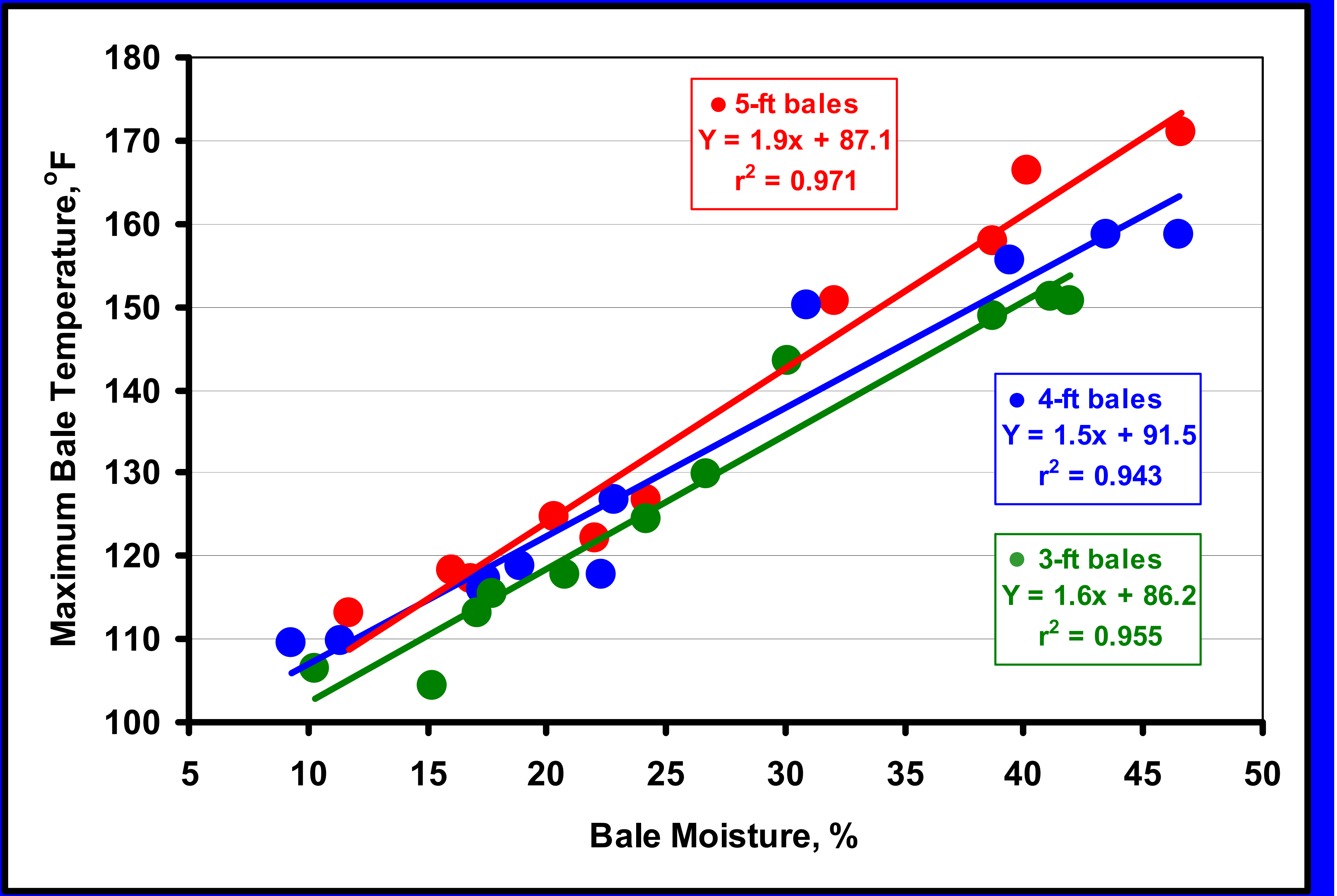


Coblentz et al. (1994)

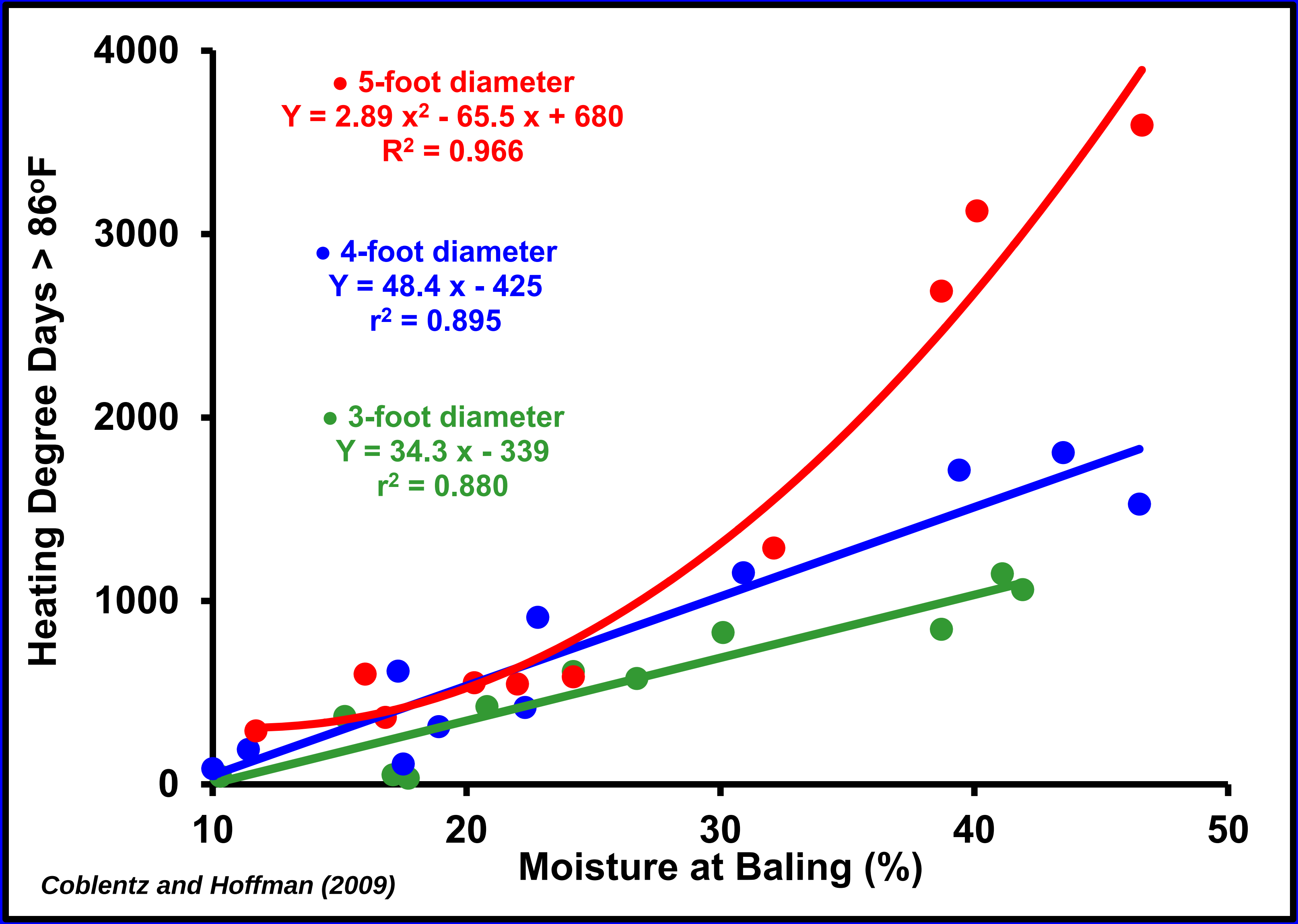
Wisconsin Round-Bale Studies

- alfalfa- orchardgrass hays from 3 harvests
- 3 bales/interactive treatment (3, 4, or 5-ft diameter)
- storage was outdoors on wooden pallets
- bales were monitored daily until internal bale temperatures indicated no further spontaneous heating
- bales were sampled rigorously on a pre- and post-storage basis

Maximum Internal Bale Temperature (Coblentz and Hoffman, 2009)

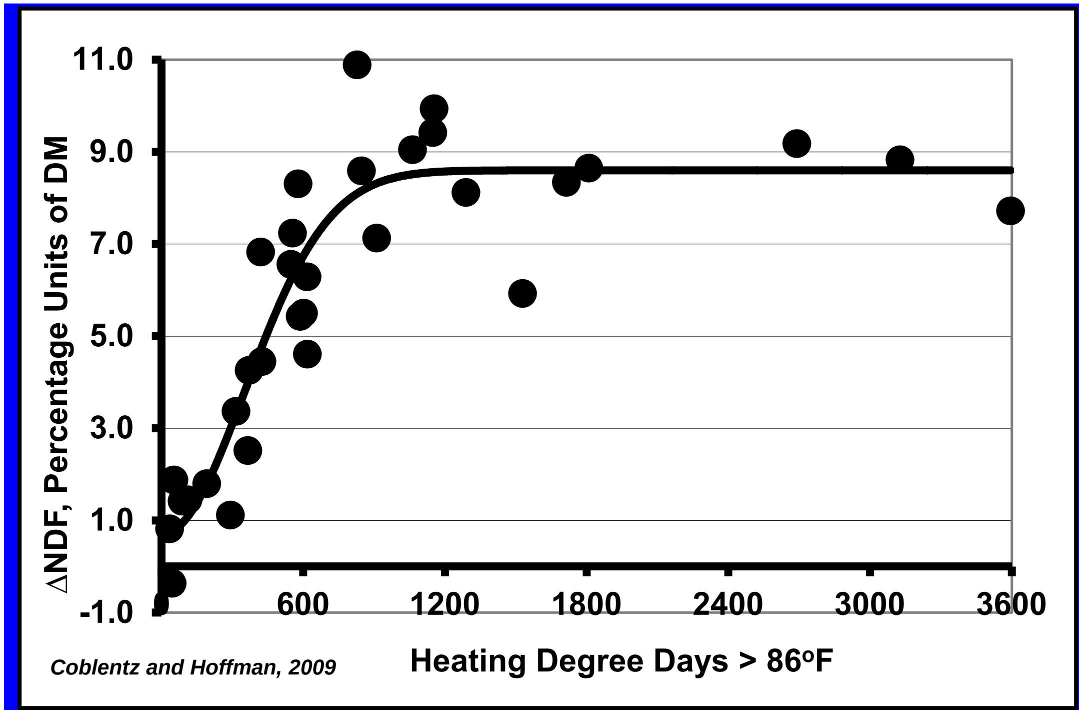


Cost and availability of labor has forced the dairy and hay industries towards larger hay packages, and these bales are far more likely to exhibit spontaneous heating.



Coblentz and Hoffman (2009)

Wisconsin Round Bale Study (2006-07)



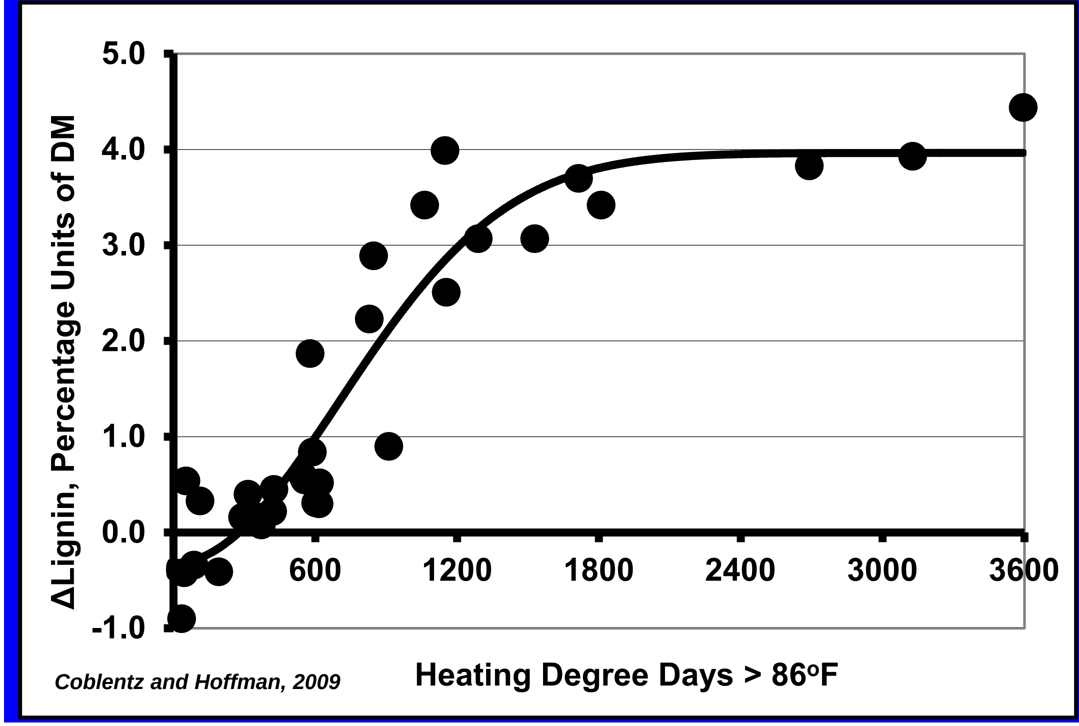
Coblentz and Hoffman, 2009

NDF

N = 32 baling treatments

Initial = 46.5%, which corresponds generally to ΔNDF = 0 on the y-axis

Fiber Components



Coblentz and Hoffman, 2009

Acid-Detergent Lignin

N = 32 baling treatments

Initial = 5.54%, which corresponds generally to ΔLIG = 0 on the y-axis

Heat Damaged Protein (ADICP)

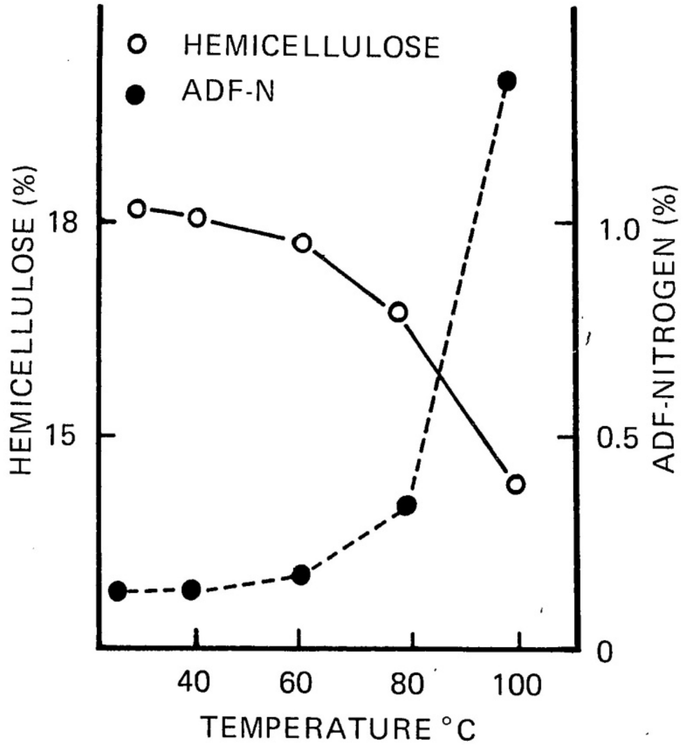
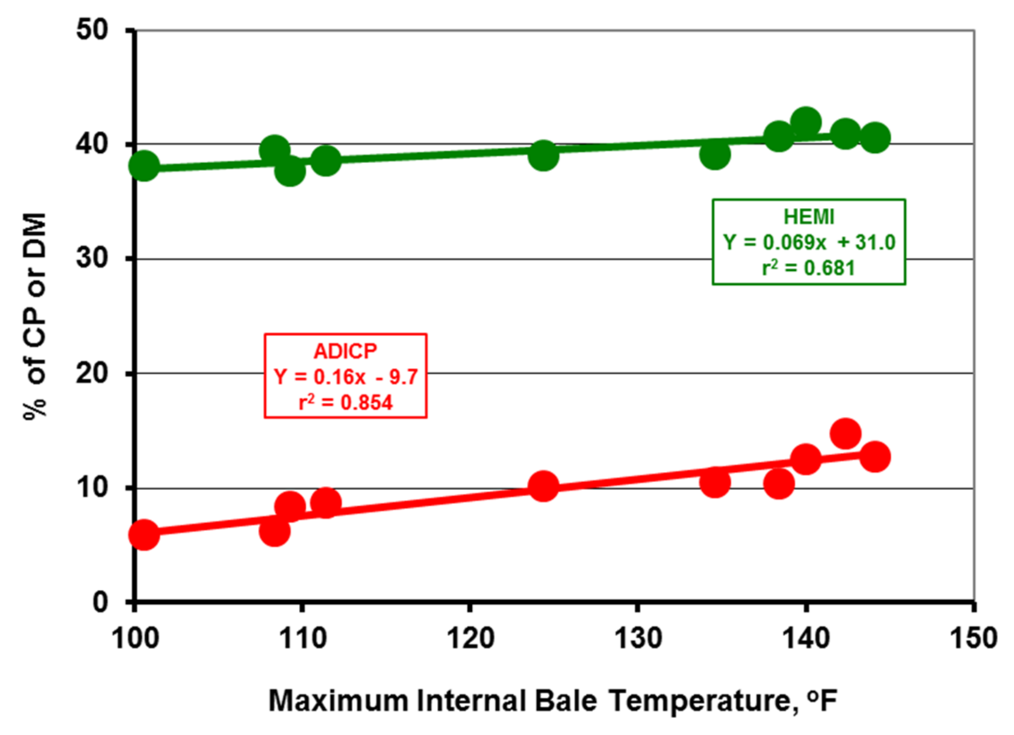


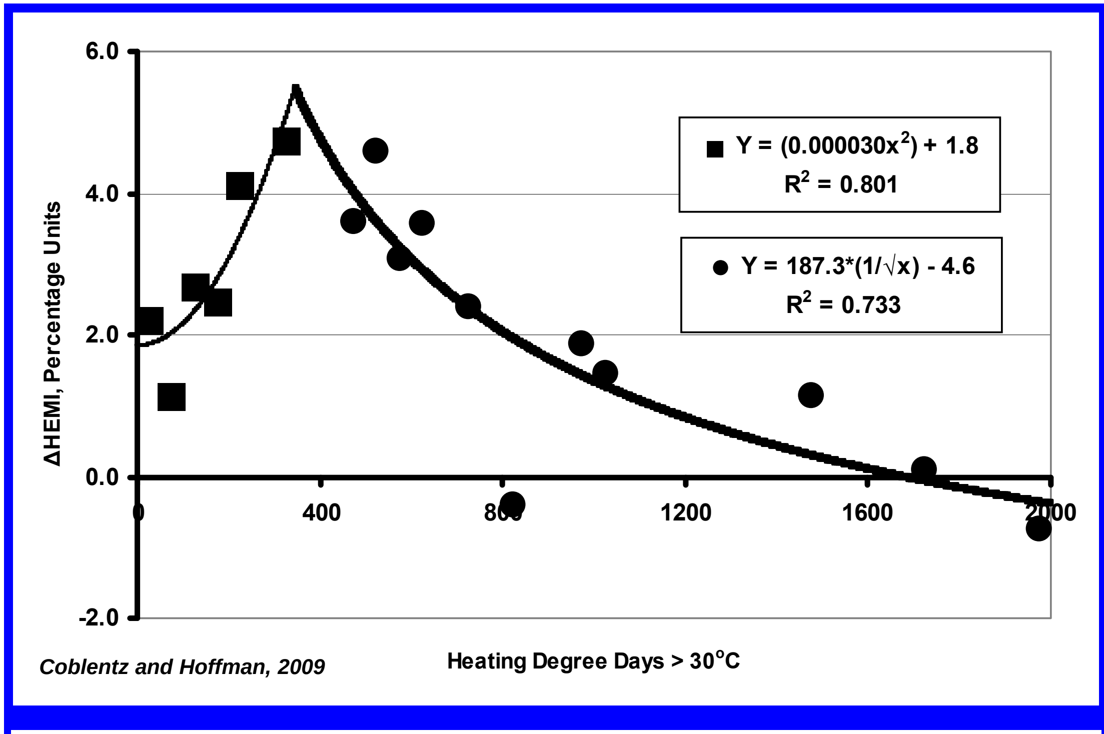
Figure 7.12. The relationship between the hemicellulose content of orchardgrass and the extent of the Maillard reaction. Hemicellulose declines as it is used in the heat damage reaction (Goering et al, 1973). Damaged carbohydrates no longer analyze as such and appear in the lignin fraction.

Van Soest, 1982



Bermudagrass Hay (Small Square Bales)
(*Coblentz et al., 2000*)

Wisconsin Round Bale Study (2006-07)



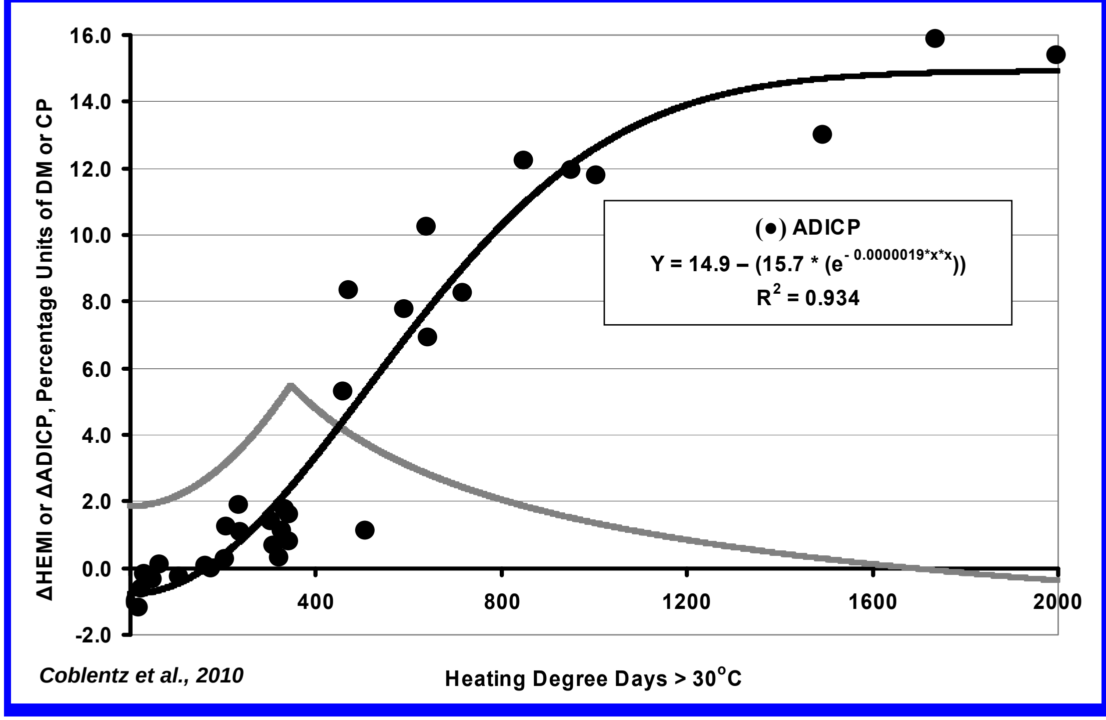
Coblentz and Hoffman, 2009

Hemicellulose

N = 32 baling treatments

Initial = 15.1%, which corresponds generally to ΔHEMI = 0 on the y-axis

Intersection of regression lines occurred at 347 HDD > 30°C

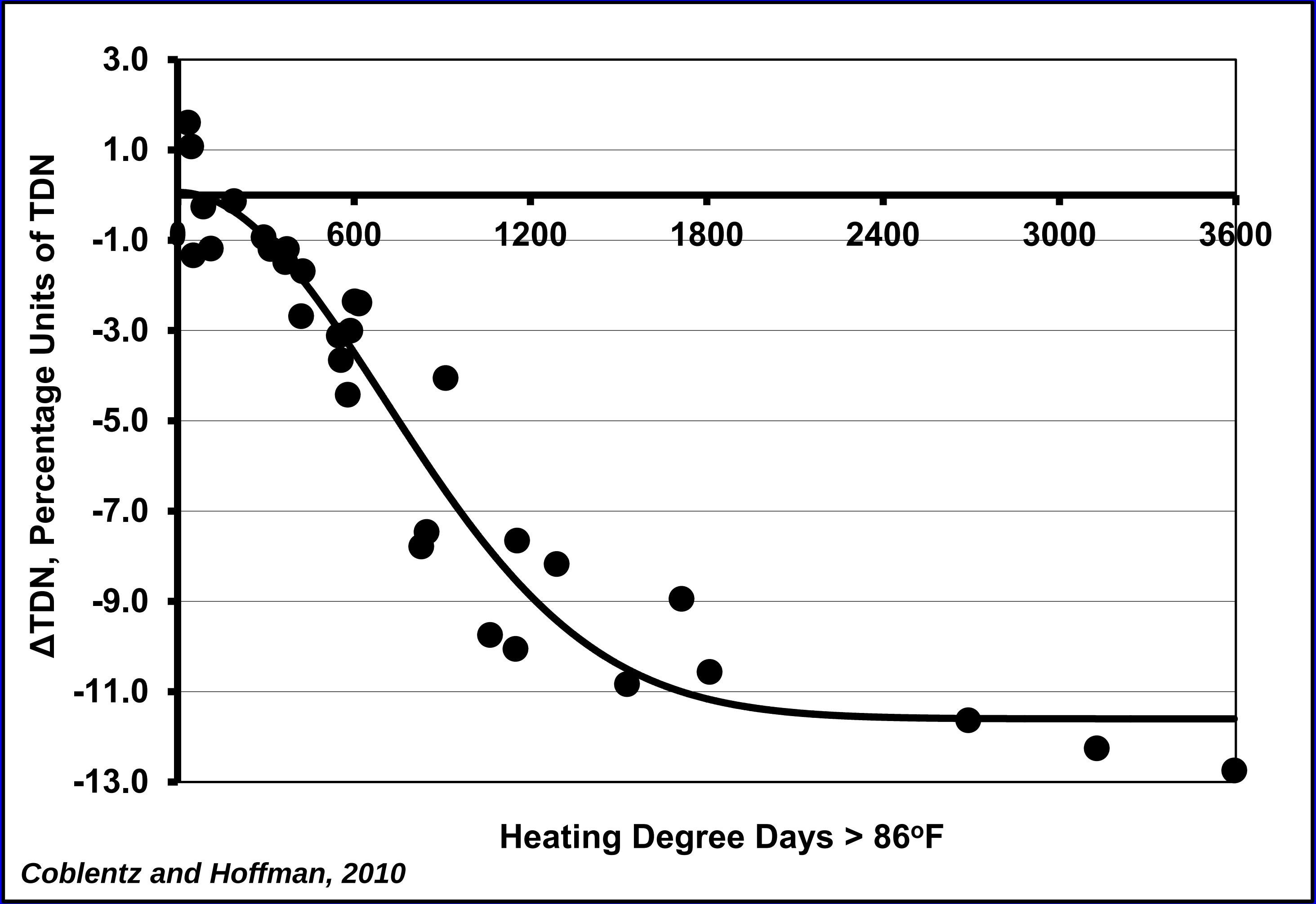


Coblentz et al., 2010

Acid Detergent Insoluble Crude Protein (ADICP)

N = 32 baling treatments

Initial = 6.3% of CP and 15.1% of DM, which correspond generally to ΔADICP = 0 and ΔHemicellulose (gray line) = 0, respectively, on the y-axis



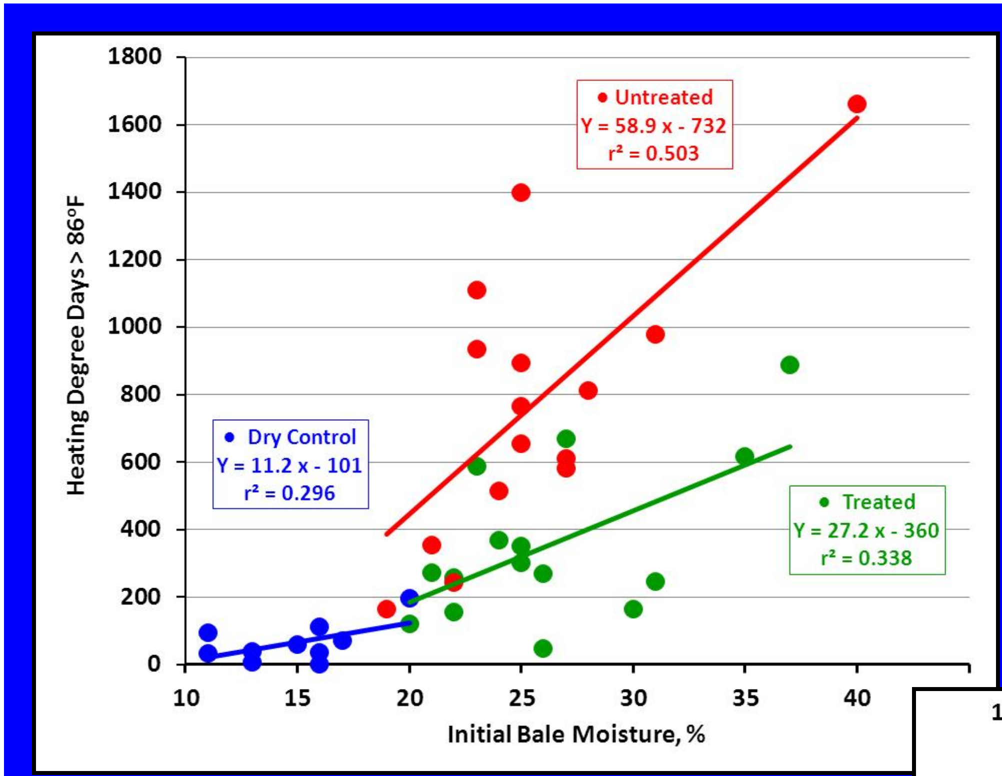
Coblentz and Hoffman, 2010

TDN

N = 32 baling treatments

Initial = 57.9%, which corresponds generally to ΔTDN = 0 on the y-axis

Use of Propionic Acid-Based Preservatives

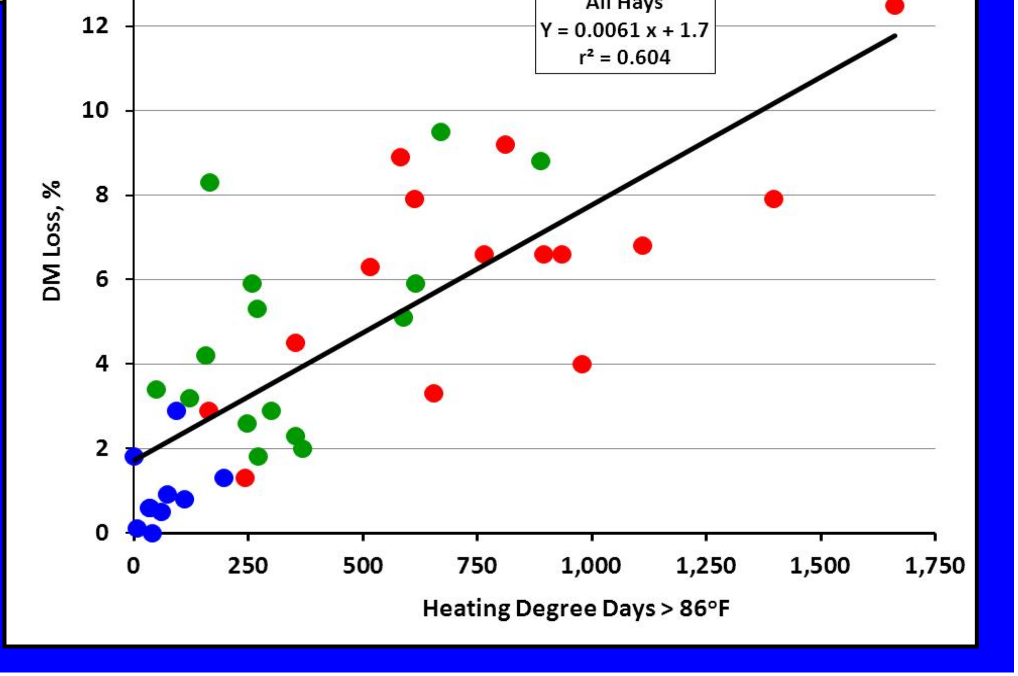


Summary of 10 Experiments
Rotz et al. (1991)

- each experiment contained:
  - positive (dry) hay control (10 to 20%)
  - treated hays (20 to 37%)
  - untreated hays (19 to 40%)
  - small rectangular bales
- application rates ranged from 1.0 to 2.3% of bale weight (50% dilution)
- some experiments contained more than one treated vs. untreated comparison

Conclusions

- results were inconsistent across studies
- spontaneous heating was reduced, but not eliminated within treated hays
- regardless of treatment, HDD > 86°F were positively related to initial bale moisture
- losses of DM were positively related to HDD > 86°F accumulated during the first 30 to 45 days of storage



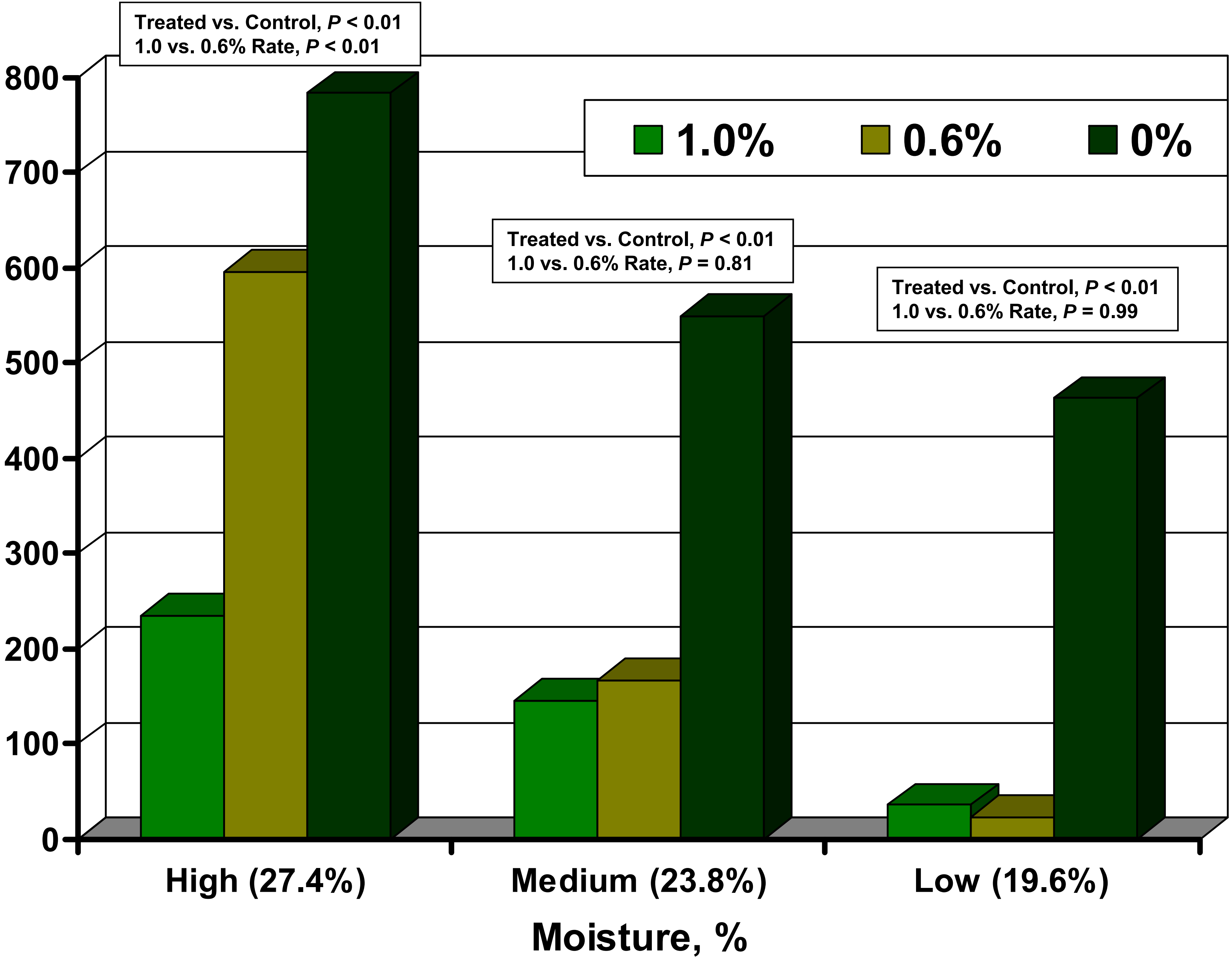
Application of Propionic Acid Preservative[1] to Large Square Bales[2] of Alfalfa-Orchardgrass Hay (*Coblentz et al., 2013*)

Group	Moisture	Volume	Wet Weight	Dry Weight	DM Density
	%	ft³	lbs	lbs	lbs DM/ft³
High	27.4	40.7	644	467	11.5
Medium	23.8	40.7	626	476	11.8
Low	19.6	42.1	613	494	11.7
SEM	0.80	0.39	9.3	10.4	0.20

[1] Rates: 0, 0.6, or 1.0% of fresh weight.

[2] Large square bales were 3 x 3 x 6 ft.

Heating Degree Days > 86^{o}F



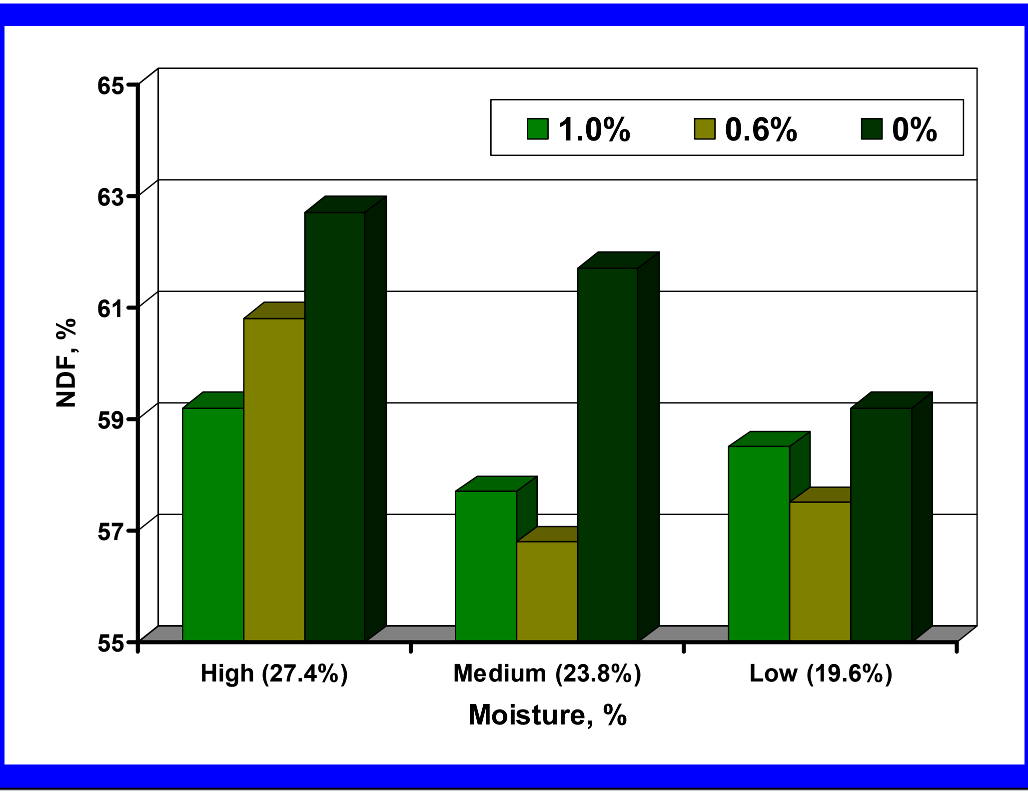
Treated vs. Control, *P* < 0.01
1.0 vs. 0.6% Rate, *P* < 0.01

Treated vs. Control, *P* < 0.01
1.0 vs. 0.6% Rate, *P* = 0.81

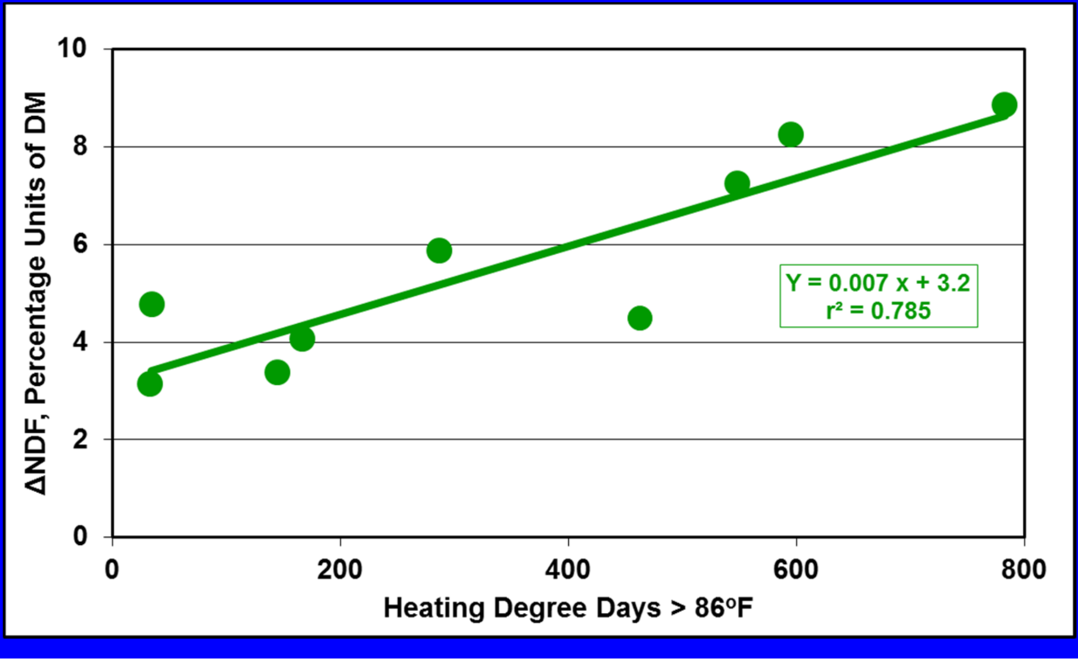
Treated vs. Control, *P* < 0.01
1.0 vs. 0.6% Rate, *P* = 0.99

Coblentz et al. (2013)

NDF



Contrasts	*P > F*
HM: Acid-Treated vs. Control	< 0.01
HM: 1.0 vs. 0.6% Rate	0.14
MM: Acid-Treated vs. Control	< 0.01
MM: 1.0 vs. 0.6% Rate	0.46
LM: Acid-Treated vs. Control	0.29
LM: 1.0 vs. 0.6% Rate	0.50

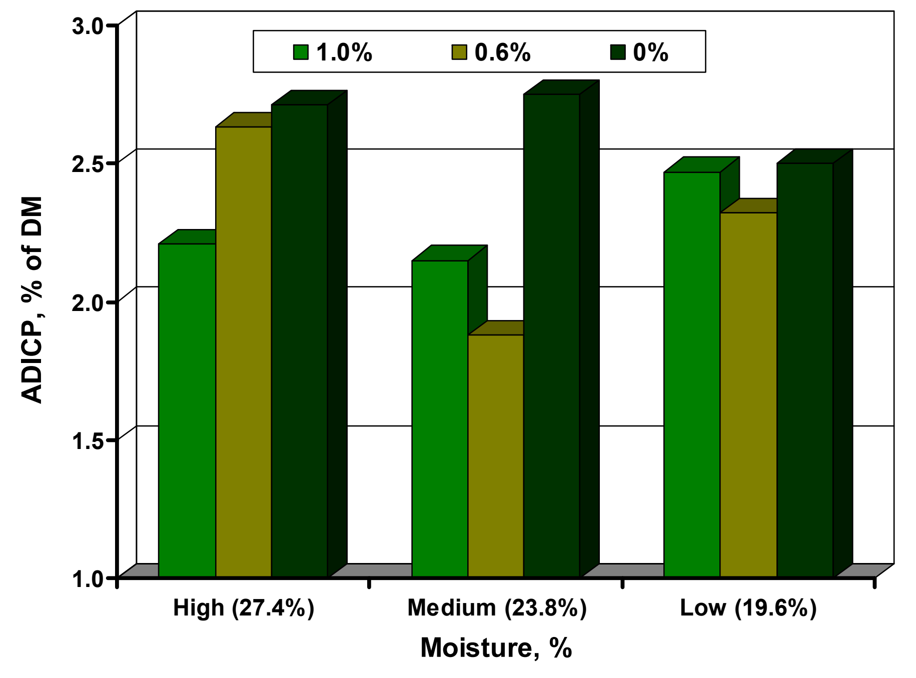


N = 9 baling treatments

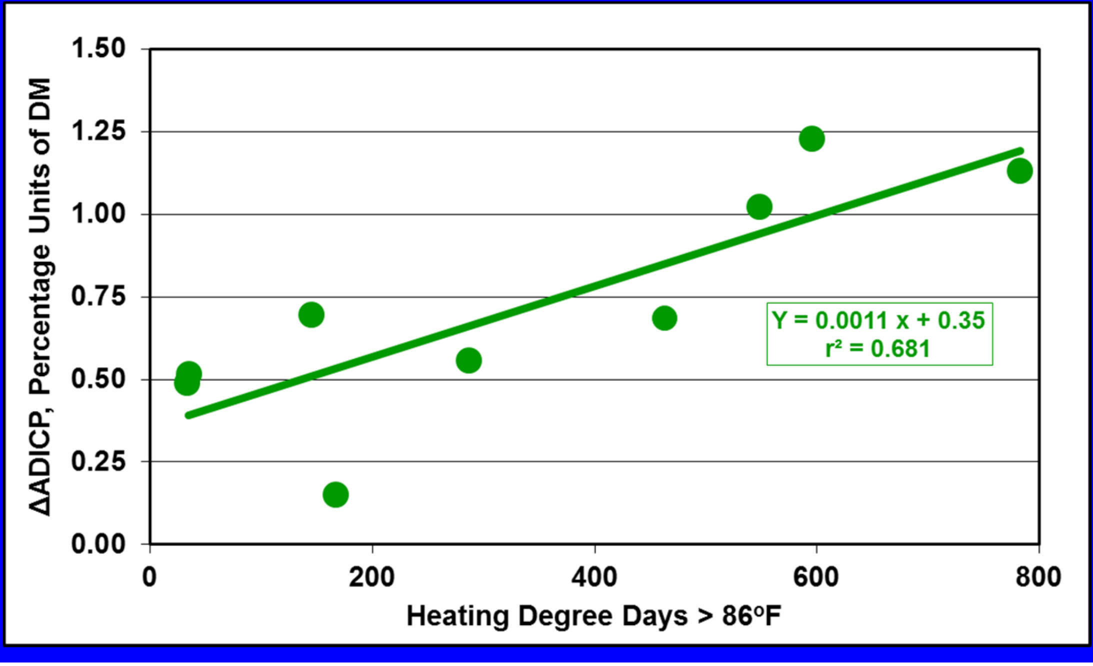
Prestorage NDF = 53.7%, which corresponds generally to ΔNDF = 0 on the y-axis

Coblentz et al. (2013)

ADICP



Contrasts	*P > F*
HM: Acid-Treated vs. Control	0.16
HM: 1.0 vs. 0.6% Rate	0.13
MM: Acid-Treated vs. Control	0.01
MM: 1.0 vs. 0.6% Rate	0.39
LM: Acid-Treated vs. Control	0.72
LM: 1.0 vs. 0.6% Rate	0.70

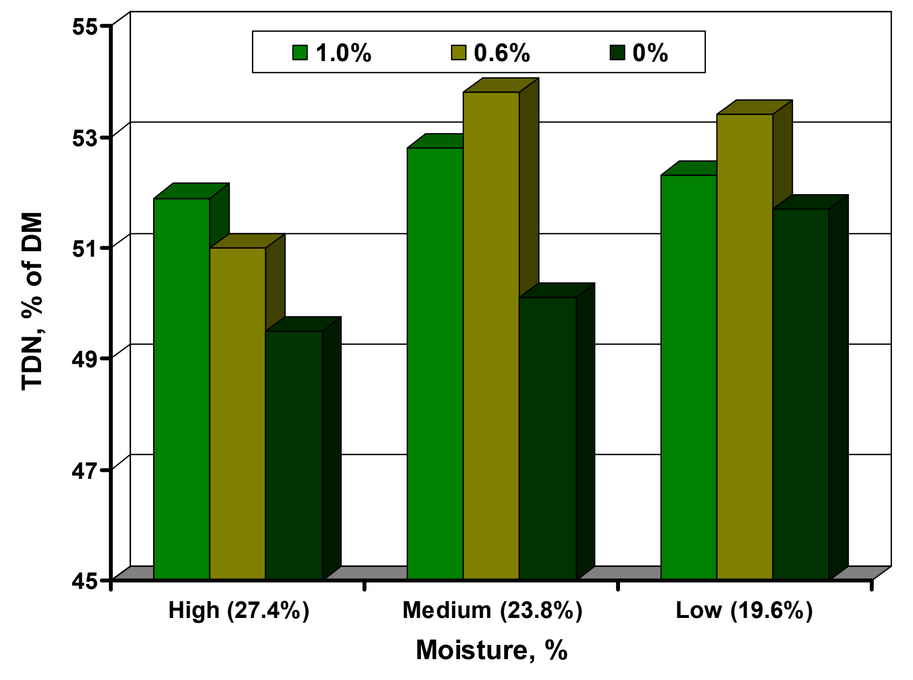


N = 9 baling treatments

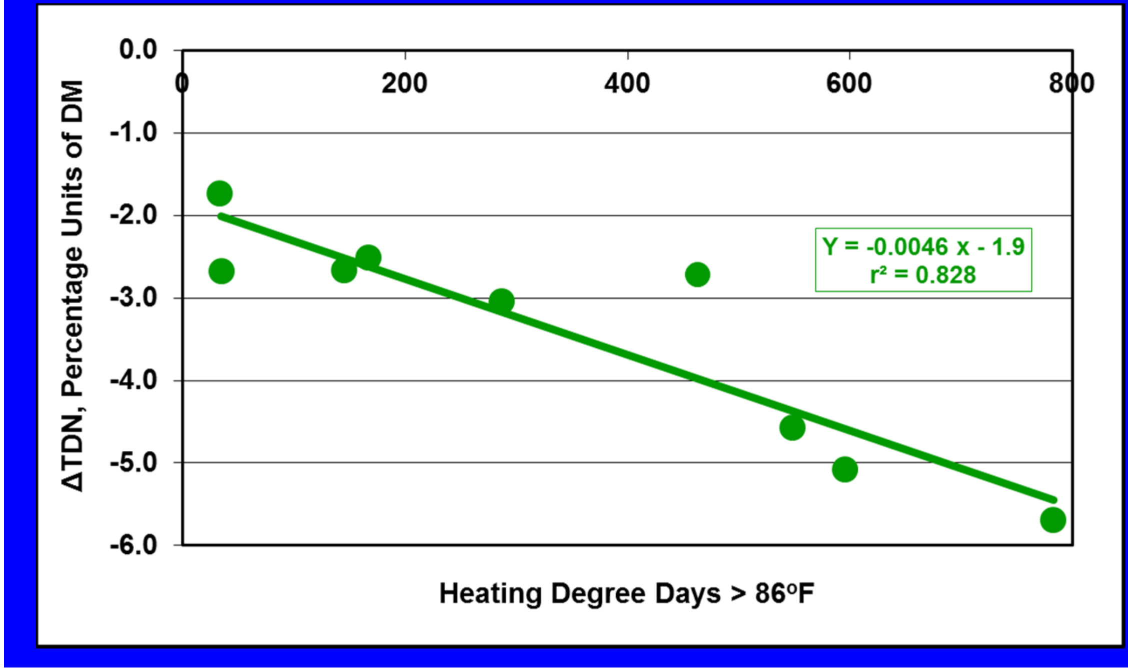
Prestorage ADICP = 1.70%, which corresponds generally to ΔADICP = 0 on the y-axis

Coblentz et al. (2013)

Energy (TDN)



Contrasts	*P > F*
HM: Acid-Treated vs. Control	0.01
HM: 1.0 vs. 0.6% Rate	0.37
MM: Acid-Treated vs. Control	< 0.01
MM: 1.0 vs. 0.6% Rate	0.35
LM: Acid-Treated vs. Control	0.27
LM: 1.0 vs. 0.6% Rate	0.38

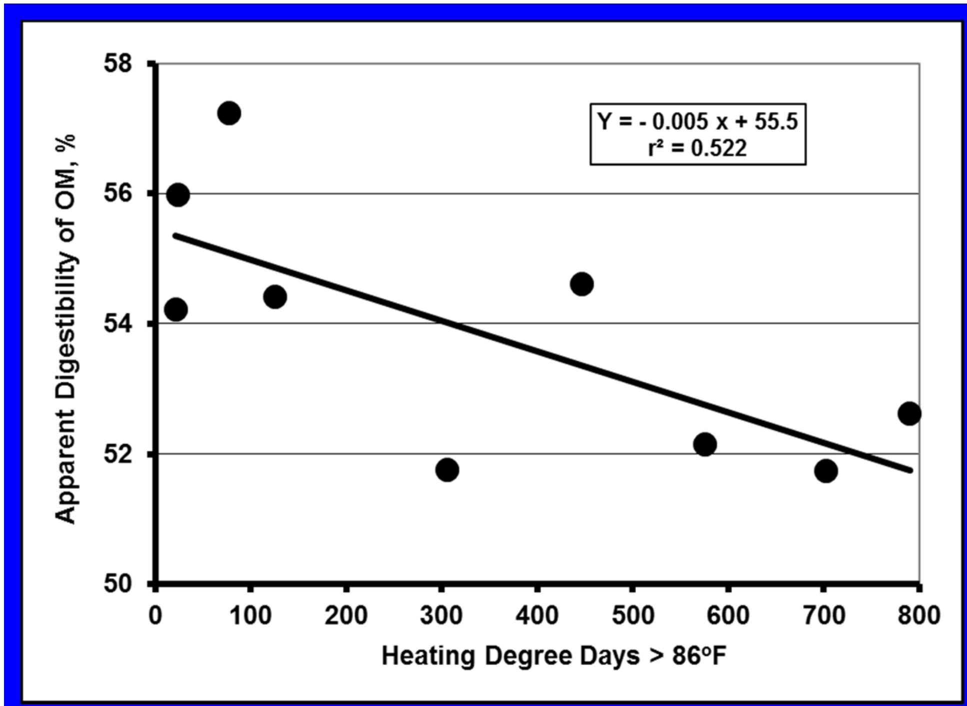


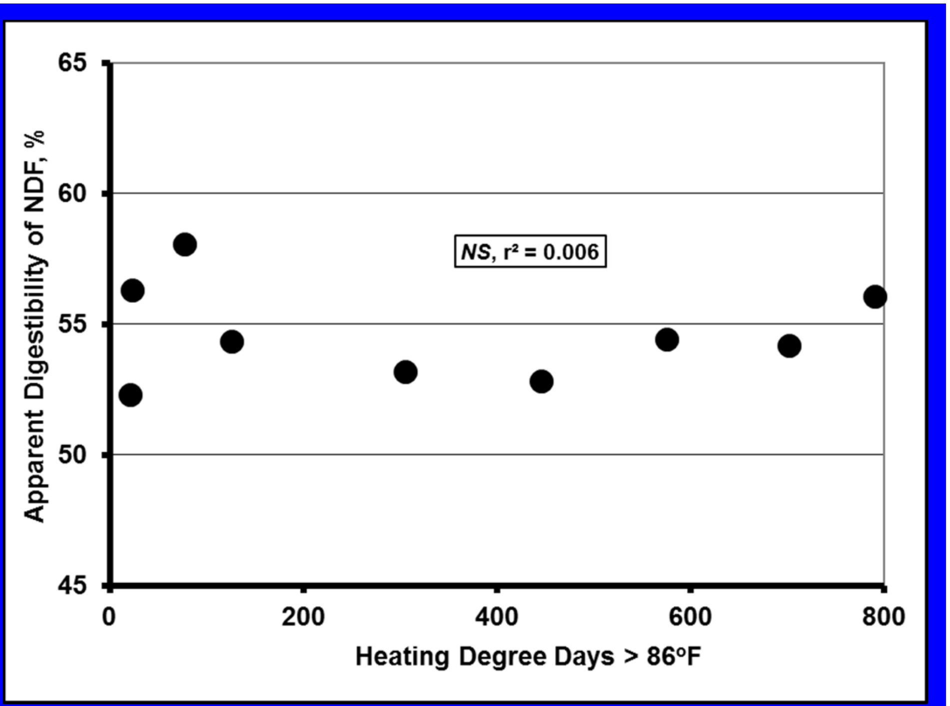
N = 9 baling treatments

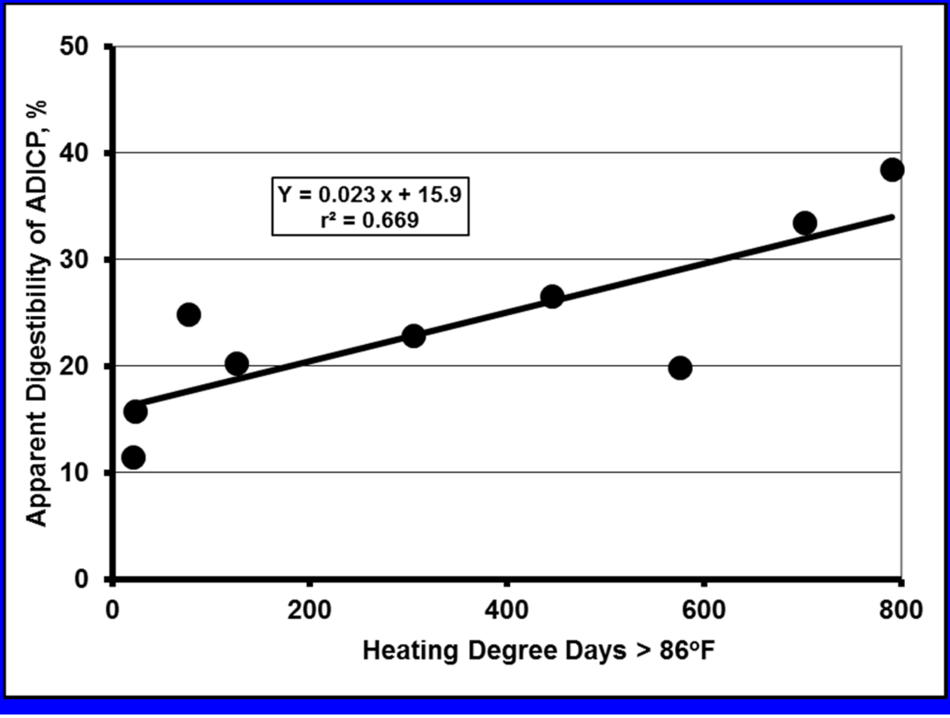
Prestorage TDN = 55.3%, which corresponds generally to ΔTDN = 0 on the y-axis

Coblentz et al. (2013)

In Vivo Digestibility in Growing Lambs







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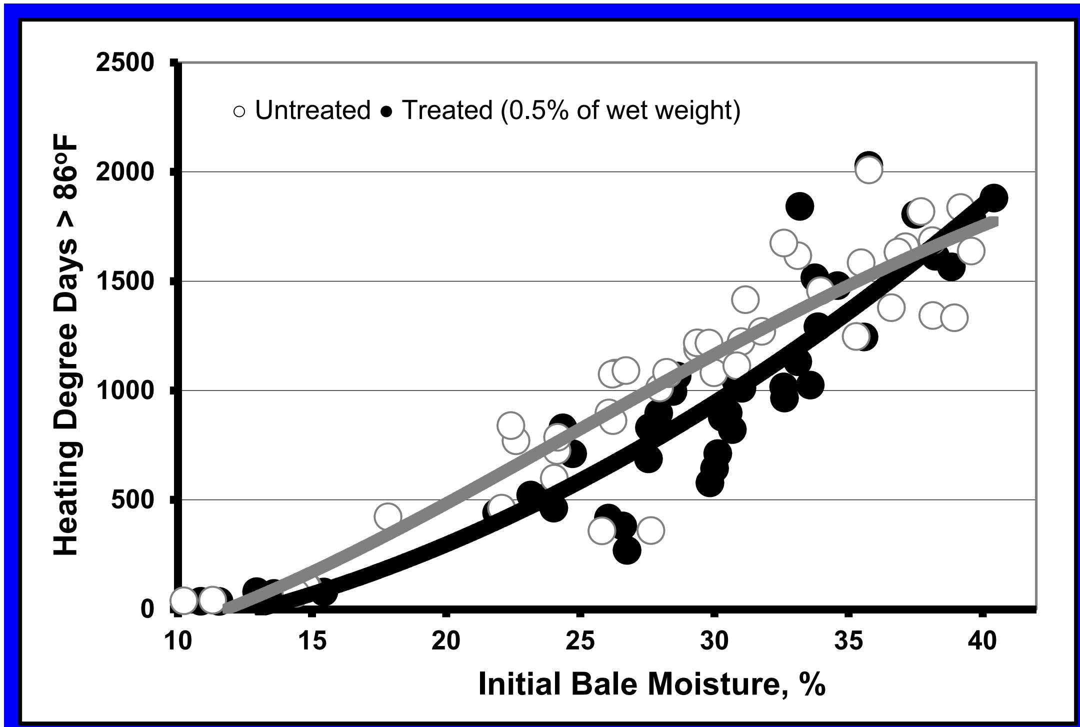
Coblentz et al. (2013)

Propionic Acid Preservative on Round Bales of Alfalfa Hay

Coblentz and Bertram (2012)

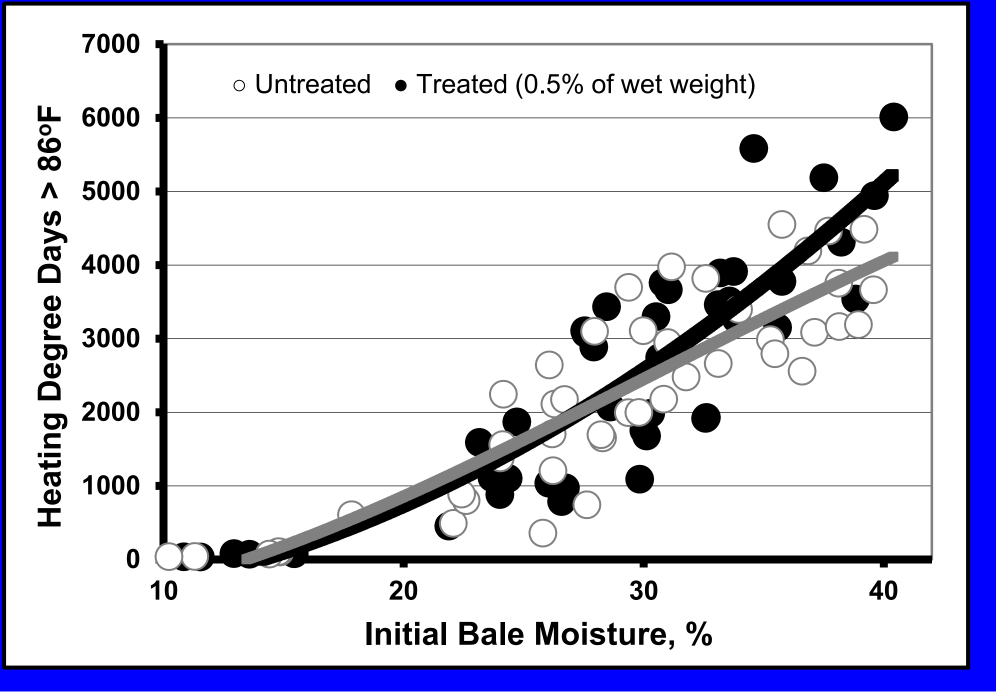


Propionic Acid on Round Bales of Alfalfa Hay

Heating Degree Days > 86ºF vs. Initial Bale Moisture

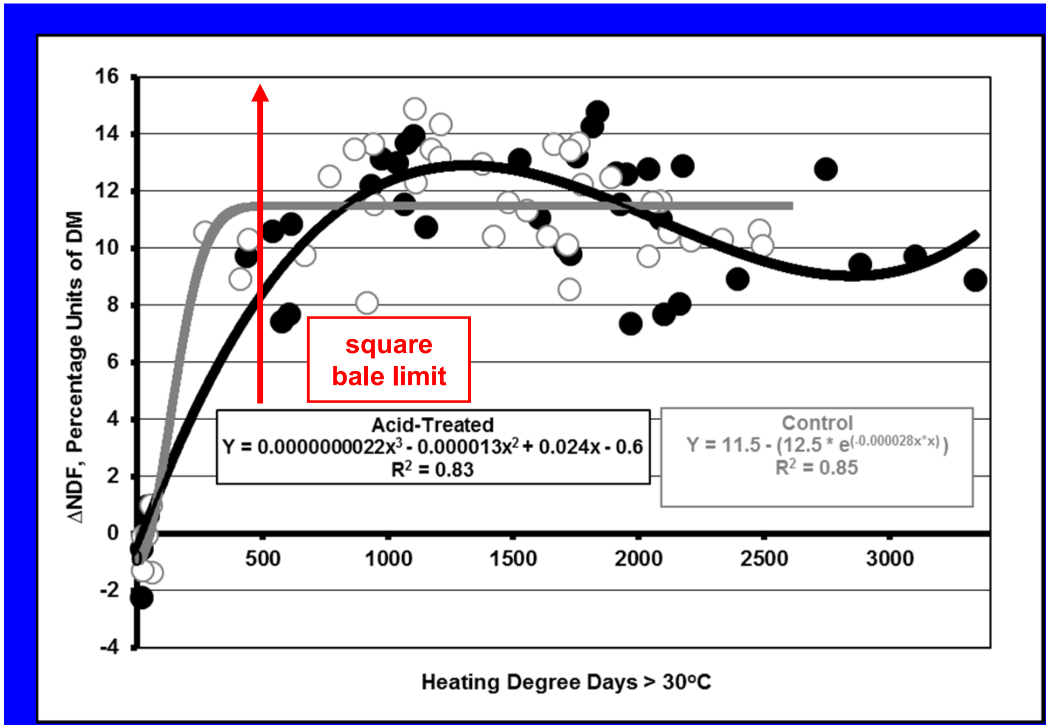
First 28 Days

Entire Storage Period



Coblentz and Bertram (2012)

NDF

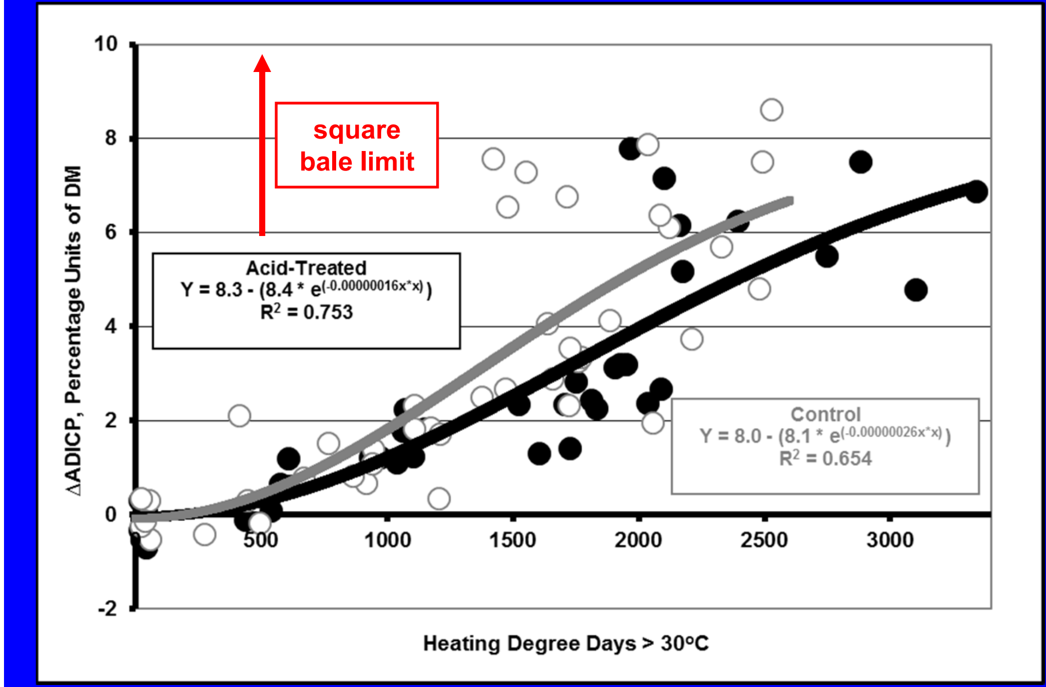


○ Control, N = 42 bales

● Acid-treated, N = 38 bales

Prestorage NDF = 38.4%, which corresponds generally to ΔNDF = 0 on the y-axis

ADICP

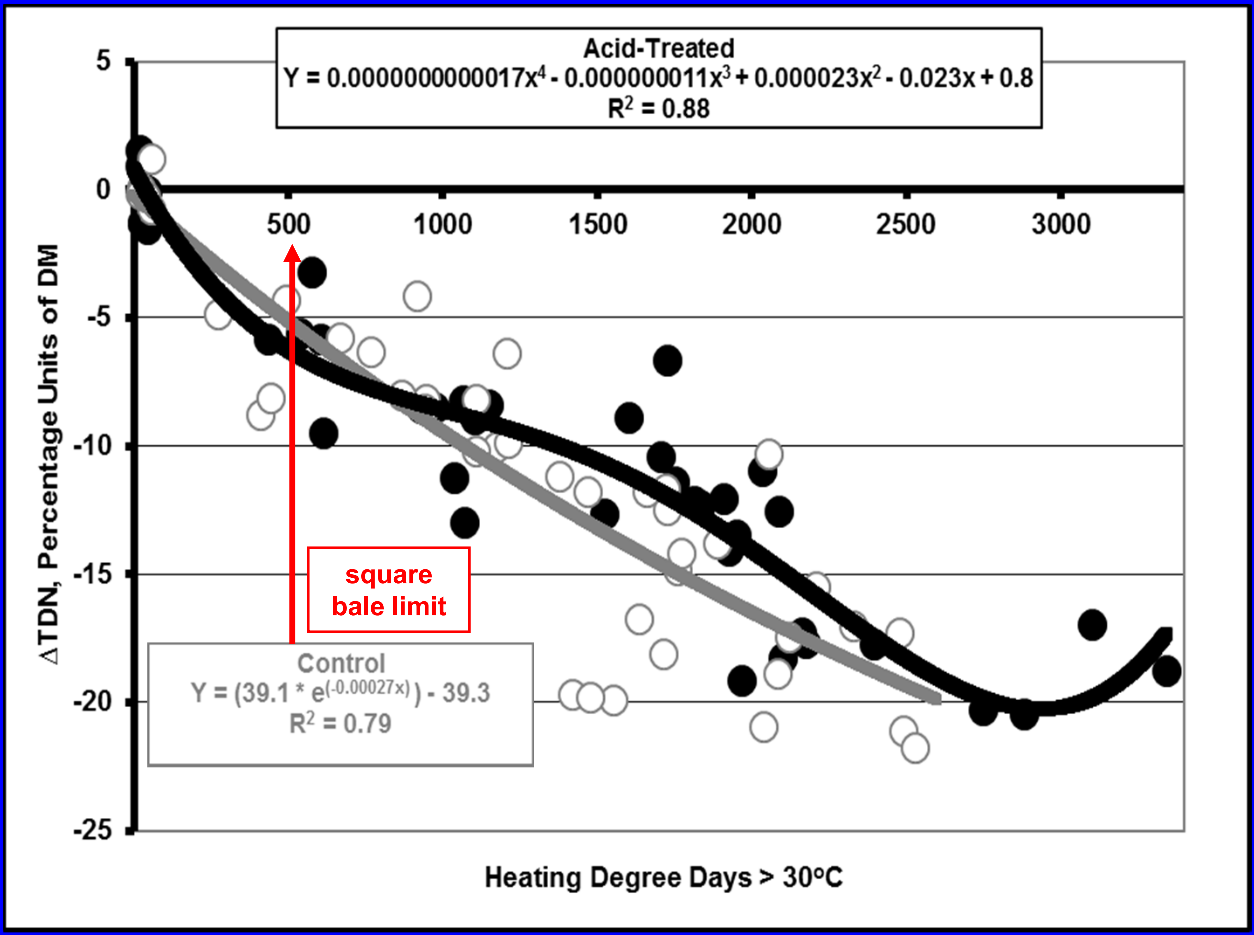


○ Control, N = 42 bales

● Acid-treated, N = 38 bales

Prestorage ADICP = 1.57%, which corresponds generally to ΔADICP = 0 on the y-axis

Coblentz and Bertram (2012)



○ **Control, N = 42 bales**

● **Acid-treated, N = 38 bales**

Prestorage TDN = 61.5%, which corresponds generally to ΔTDN = 0 on the y-axis

Coblentz and Bertram (2012)

Summary

- **Propionic acid-based preservatives will not eliminate spontaneous heating, and effectiveness will decline as bale moisture increases.**
- **Effectiveness will be greatest when moisture concentrations are < 25%; however, *it should not be assumed that these products will be as effective within large stacks of bales.***

≠

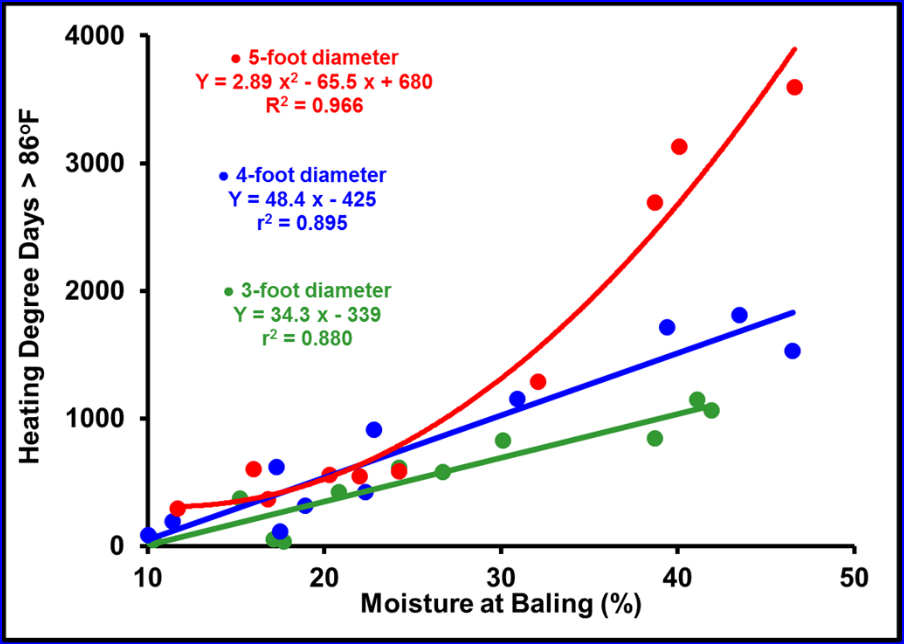
Summary

- Based on our work, propionic acid-based preservatives are more likely to be effective within rectangular bales in which the preservative is applied in the bale chamber.

- Keep a written log of baling conditions, initial bale moisture, acid-application rates, and stacking/storage management in order to assess effectiveness of these products under routine production management.

Summary

- Hays baled in large hay packages have a much greater likelihood of heating spontaneously, and catching fire.
  - *Be cautious!*




Source: Oklahoma State University

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Questions ?