Methionine, even more important under heat stress

What is the relationship between methionine and heat stress?

When summer heat and humidity peak, production levels for dairy cows drop to seasonal lows with significant impact on farm economics.

In the Dairy Market News reports – USDA, we can see the annual rhythms of milk protein and fat production in dairy cattle in the United States (Figure 1 and 2). Considering the complete year of 2021, during the summer months milk protein yield drops around 0.03 % (Figure 1) and milk fat around 0.04% (Figure 2). The drop can be significantly higher according to the region.

Figure 1: U.S. Average Protein Test

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2018	3.23	3.19	3.16	3.15	3.08	3.04	3.02	3.05	3.11	3.22	3.28	3.25
2019	3.23	3.23	3.22	3.16	3.13	3.09	3.03	3.07	3.13	3.22	3.27	3.24
2020	3.22	3.20	3.18	3.17	3.13	3.08	3.06	3.08	3.16	3.24	3.28	3.29
2021	3.26	3.26	3.23	3.20	3.18	3.12	3.10	3.13	3.18	3.26	3.33	3.34

DATA SOURCE: USDA,AMS, Dairy Programs, FMMO

FEDERAL MILK ORDERS INCLUDED ARE: 1, 30, 32, 33, 51, 124, 126

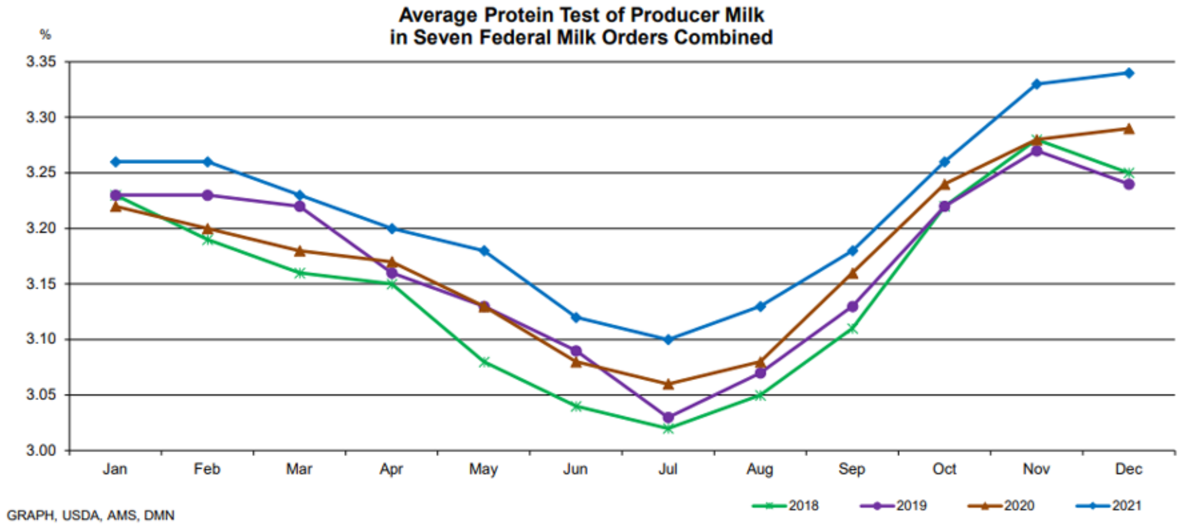
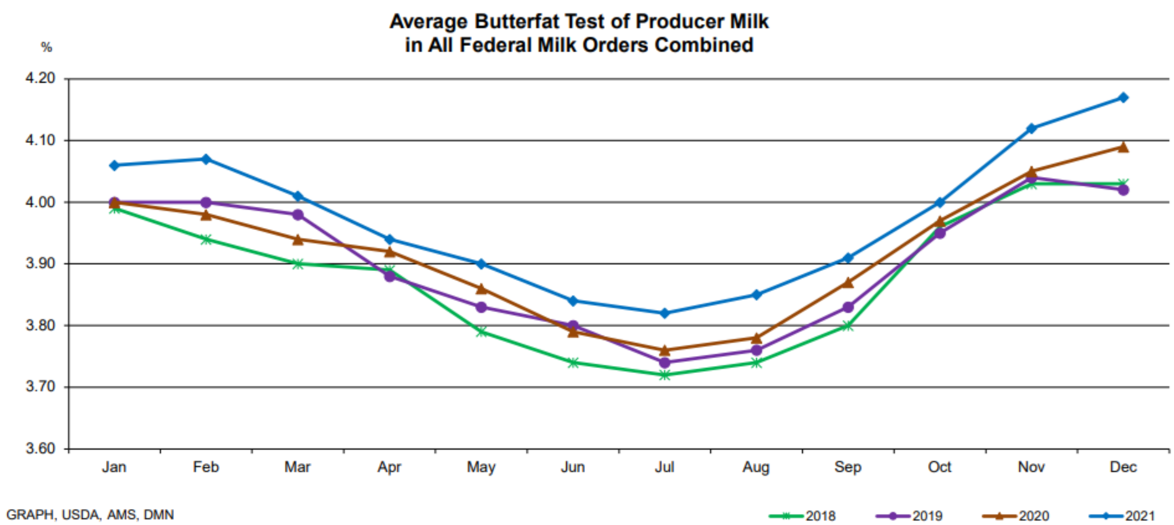


Figure 2: U.S. Average Butterfat Test

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2018	3.99	3.94	3.90	3.89	3.79	3.74	3.72	3.74	3.80	3.96	4.03	4.03
2019	4.00	4.00	3.98	3.88	3.83	3.80	3.74	3.76	3.83	3.95	4.04	4.02
2020	4.00	3.98	3.94	3.92	3.86	3.79	3.76	3.78	3.87	3.97	4.05	4.09
2021	4.06	4.07	4.01	3.94	3.90	3.84	3.82	3.85	3.91	4.00	4.12	4.17

DATA SOURCE: USDA,AMS, Dairy Programs, FMMO

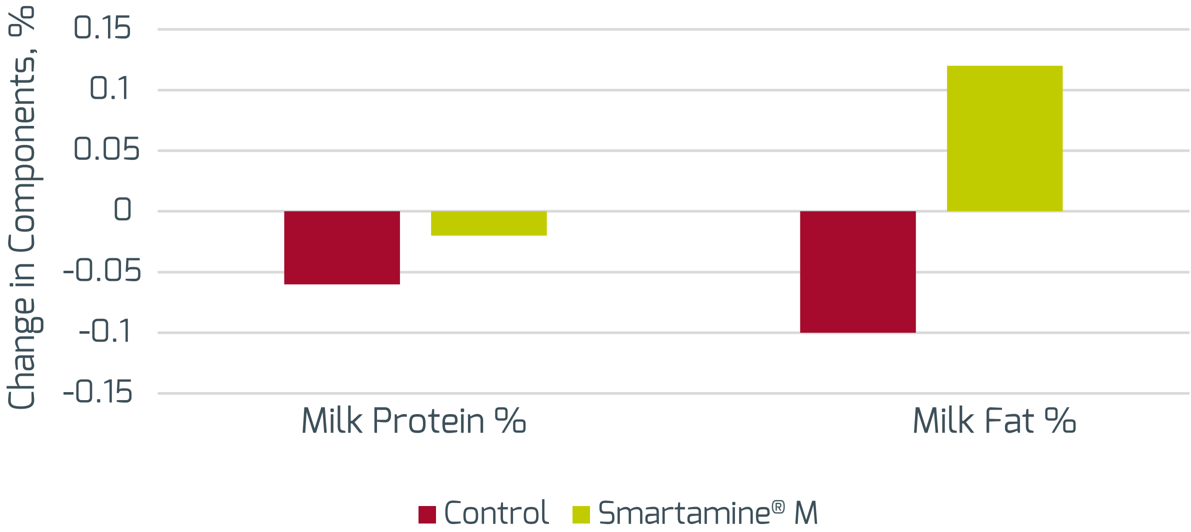
FEDERAL MILK ORDERS INCLUDED ARE: 1, 5, 6, 7, 30, 32, 33, 51, 124, 126, 131



By focusing attention on meeting essential or functional nutrient requirements, seasonal lows in milk production can be minimized. Research has highlighted the role of functional amino acids, such as methionine, as key nutrients to limit the negative effects of heat stress.

Recent research by Pate et al. (2020) measured the effect of heat stress on lactation performance when fed with supplemental methionine as Smartamine® M (RPmet) or without (CONTROL). Heat stress had a significant negative effect on milk protein and milk fat content, whereas supplemental methionine mitigated the negative affect on milk production and increased milk fat. Cows being impacted by heat stress when supplemented RPmet showed an increase in 0.12%, and cows without RPmet had a decrease in -0.10% in milk fat (Figure 3). Milk protein was negatively impacted in both groups by heat stress, however cows on RPmet had less decline (-0.02 %) compared to cows without (-0.05 %) methionine.

Figure 3: Change in Component Concentration ± Supplemental Methionine during a heat stress challenge



Considering the actual price of milk yield and components, a simulation using the MilkPay by Adisseo, we can see the economic impact of heat stress on milk components and yield. Using the USDA average data, during the summer the economic losses will be around -$0.21/cow day. When we compared the trial data from Pate et al. (2020), cows exposed to heat stress without RPmet had an economic impact of -$1.94/cow/day, when cows exposed to the same heat stress environment the losses was around of -$0.57/cow/day. Smartamine M supplementation helps to minimize the economic loss in $1.37/cow/day. When consider just the gain in milk components on Pate et al. (2020) with RPmet supplemention the is around $0.04/cow/day.

Adisseo MilkPay Calculations

	USDA	Pate et al. (2020) - Con	Pate et al. (2020) - RPmet	Pate et al. (2020) RPmet - Comp Only
Milk Volume	78.5	88.2	88.2	88.2
Milk Fat %	3.92	3.70	3.70	3.70
Mik Protein %	3.17	3.20	3.20	3.20
Adj Volume	0.00	-5.73	-1.98	0.00
Adj Fat%	-0.04	-0.10	0.12	0.12
Adj Protein %	-0.03	-0.05	-0.02	-0.02
RP Cost	$ -	$ -	$ 0.30	$ 0.30
$ Fat	$ (0.12)	$ (0.31)	$ 0.37	$ 0.37
$ Protein	$ (0.12)	$ (0.19)	$ (0.08)	$ (0.08)
$ / cow / day	$ (0.21)	$ (1.94)	$ (0.57)	$ 0.04

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Going a little deeper on metabolism, (Coleman et al., 2019, 2020 and 2021) studied the mammary and liver tissue of cows exposed to heat stress with or without RPmet supplementation. Overall results with RPmet during the heat stress showed:

- Increased abundance of phosphorylated mTOR (controls protein synthesis) in mammary tissue with RPmet during heat stress => greater milk protein synthesis

- Heat stress had negative effects on liver insulin and antioxidant signaling (greater insulin signaling during a time when DMI is decreased and glucose synthesis increased, and less antioxidant signaling). However, supplying RPmet maintained insulin and antioxidant signaling protein abundance => better liver metabolism and less oxidative stress.

- Liver tissue 1-carbon metabolism enzyme activity increased with RPmet => greater antioxidant production to alleviate oxidative stress.

- Immune cell function was down-regulated by heat stress, but RPmet supplementation helped to maintain whole blood antioxidant gene expression => lower oxidative stress.

Such changes in oxidative stress, insulin signaling and mTOR signaling help to support cow health and production during periods of heat stress.

Han et al. (2009) reported that cows challenged at temperatures up to 36°C (96.8°F) displayed blood biomarker levels typical of heat stress. Providing methionine, typically the first limiting amino acid in rations, to balance ration amino acid levels stabilized heat stress biomarkers, further suggesting that balancing rations by adding methionine helped counteract heat stress.

Biomarker levels of animals under heat stress conditions supplemented with MetaSmart® Dry

Biomarker	Why this biomarker is important?	Control 0*	Treatment 1 13 grams*	Treatment 2 30 grams*	*P* Value
Creatine Phosphokinase (CPK)	Marker of cellular damage (lower is better)	170.17[a]	112.98[b]	111.89[b]	<0.001
Glutathione Peroxidase (GSH-Px)	Helps to decrease oxidative stress (higher is better)	139.43[a]	148.95[b]	148.51[b]	<0.001
Super Oxide Dismustase (SOD)	Helps to decrease oxidative stress (higher is better)	136.99[a]	153.38[b]	153.91[b]	<0.001
Heat Shock Protein[1] (HSP 70)	Cellular defense protein (higher is better)	17.53[a]	25.47[b]	25.52[b]	<0.001
Thyroid Hormone T3[2]	Metabolic hormone (higher is better)	1.89[a]	2.64[b]	2.66[b]	<0.001
Thyroid Hormone T4[2]	Metabolic hormone (higher is better)	90.62[a]	118.02[b]	117.73[b]	<0.001

*grams of MetaSmart® Dry
Note: Numbers in the same row with different superscript are significantly different
Han et al., 2009

[1] Heat shock proteins increase during heat stress when protein synthesis is disrupted. Their increase in heat stress likely serves as a cellular defense/repair mechanism to protect against increased damaged proteins. We can also speculate that the increase in HSP70 with RPmet could be an important cellular protection mechanism.

[2] The thyroid hormones play important roles in metabolism. Heat stress in known to decrease their concentrations. Increases in them with RPmet likely suggests better metabolism, which can contribute to better milk production.

Methionine is an essential nutrient that is best known for its effect on yields of milk, protein, and fat during lactation. Its impacts on health and reproduction pre- and post-calving have been established more recently. The most recent research further explores the interconnections between meeting dairy cow methionine requirements and the ability to perform at her best during heat stress.

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