



EAAP 2013
64th

AUGUST 26TH - 30TH, 2013
NANTES, FRANCE

ANNUAL MEETING
OF THE EUROPEAN FEDERATION OF ANIMAL SCIENCE



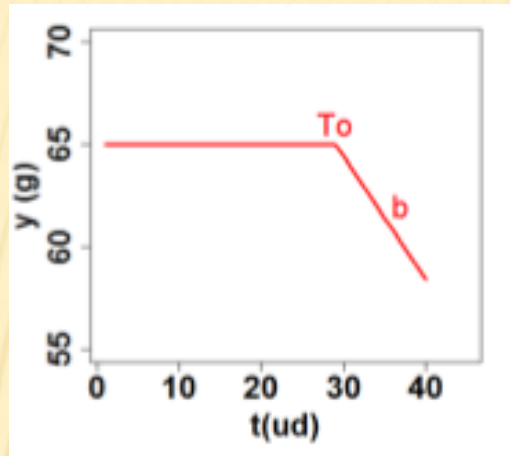
Effect of climate conditions on fat and protein yields in small dairy ruminants

Ramón, M., Abo-Shady, H.M., Díaz, C., Molina, A., Pérez-Guzmán, M.D., Serradilla, J.M., Serrano, M., **Carabaño, M.J.**,



INTRODUCTION

- ✘ Traditional model for heat stress (Splines – 1 knot)



To = Comfort Threshold

b = slope (production decay with t)

- ✘ Alternative? Flexible functions - Polynomials (Legendre)

$$P_0(x) = 1$$

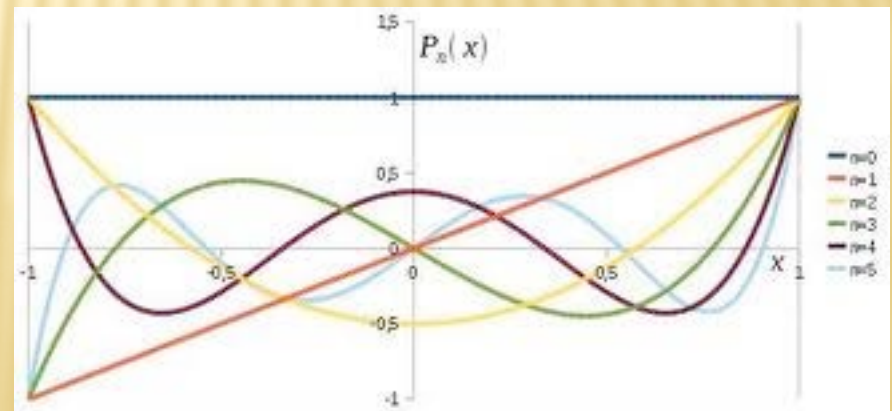
$$P_1(x) = x$$

$$P_2(x) = \frac{1}{2}(3x^2 - 1)$$

$$P_3(x) = \frac{1}{2}(5x^3 - 3x)$$

$$P_4(x) = \frac{1}{8}(35x^4 - 30x^2 + 3)$$

$$P_5(x) = \frac{1}{8}(63x^5 - 70x^3 + 15x)$$



AIM


- ✘ **To examine the shape of response on production traits associated with increasing values of temperature in two breeds of small ruminants.**
 - ▣ **Determine Tolerance threshold + decline in production (Splines vs. Polynomials)**
 - ▣ **Highly producing animals**

DATA

TWO DAIRY (CHEESE) SPANISH (LOCAL) BREEDS



DATA – DAILY MILK, FAT AND PROTEIN PRODUCTION

Breed	Records		Animals		MILK (kg/d)		FAT (g/d)		PROTEIN (g/d)	
	TOTAL	HP	TOTAL	HP	TOTAL	HP	TOTAL	HP	TOTAL	HP
 Manchega	1,675,886	231,002	191,641	19,802	1.13	1.64	79.57	111.62	64.82	92.15
P1%, P99%					0.25, 3.00	0.33, 3.67	17.75, 217.60	22.89, 276.12	15.10, 163.54	19.36, 200.00

TOTAL = All animals

HP = Highly Producing animals (1.5SD above average)




DATA – DAILY MILK, FAT AND PROTEIN PRODUCTION

Breed	Records		Animals		MILK (kg/d)		FAT (g/d)		PROTEIN (g/d)	
	TOTAL	HP	TOTAL	HP	TOTAL	HP	TOTAL	HP	TOTAL	HP
Manchega	1,675,886	231,002	191,641	19,802	1.13	1.64	79.57	111.62	64.82	92.15
P1%, P99%					0.25, 3.00	0.33, 3.67	17.75, 217.60	22.89, 276.12	15.10, 163.54	19.36, 200.00
Florida	100,835	22,476	10,283	1,538	2.35	3.02	106.45	130.41	72.29	90.41
P1%, P99%					0.50, 5.60	0.80, 6.40	0.70, 262.54	0.90, 300.57	0.50, 176.50	0.64, 200.17



DATA- METEOROLOGICAL RECORDS

✘ Daily Temperatures from the Spanish meteorological agency (AEMET).


Region	Temp're		Percentiles						
		Avg	0%	10%	50%	75%	90%	99%	100%
 CLM	Tave	14.91	-6.20	5.00	14.00	21.50	26.00	30.00	34.50
	Tmax	21.21	-3.00	9.40	20.20	29.00	34.20	39.00	44.50

CLM=Castilla-La Mancha (Manchega-sheep)



DATA- METEOROLOGICAL RECORDS

✘ Daily Temperatures from the Spanish meteorological agency (AEMET).


Region	Temp're		Percentiles						
 CLM		Avg	0%	10%	50%	75%	90%	99%	100%
	Tave	14.91	-6.20	5.00	14.00	21.50	26.00	30.00	34.50
	Tmax	21.21	-3.00	9.40	20.20	29.00	34.20	39.00	44.50

CLM=Castilla-La Mancha (Manchega-sheep)



DATA- METEOROLOGICAL RECORDS

✘ Daily Temperatures from the Spanish meteorological agency (AEMET).

Region	Temp're		Percentiles						
 CLM		Avg	0%	10%	50%	75%	90%	99%	100%
	Tave	14.91	-6.20	5.00	14.00	21.50	26.00	30.00	34.50
	Tmax	21.21	-3.00	9.40	20.20	29.00	34.20	39.00	44.50

CLM=Castilla-La Mancha (Manchega-sheep)



DATA- METEOROLOGICAL RECORDS

× Daily Temperatures from the Spanish meteorological agency (AEMET).

Region	Temp're	Avg	Percentiles						
			0%	10%	50%	75%	90%	99%	100%
CLM	Tave	14.91	-6.20	5.00	14.00	21.50	26.00	30.00	34.50
	Tmax	21.21	-3.00	9.40	20.20	29.00	34.20	39.00	44.50
AND	Tave	17.77	1.00	9.00	18.00	24.00	28.00	31.00	35.00
	Tmax	23.86	5.00	13.00	23.00	31.00	36.00	40.00	43.00

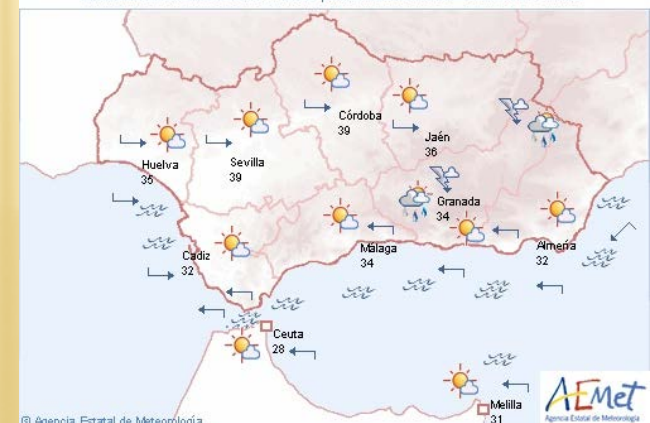


CLM=Castilla-La Mancha (Manchega-sheep)

AND=Andalucía (Florida-goat)



Elaborado el 21/08/2013. Válido para el 22/08/2013 de 12 a 24 horas



MODELS OF ANALYSES

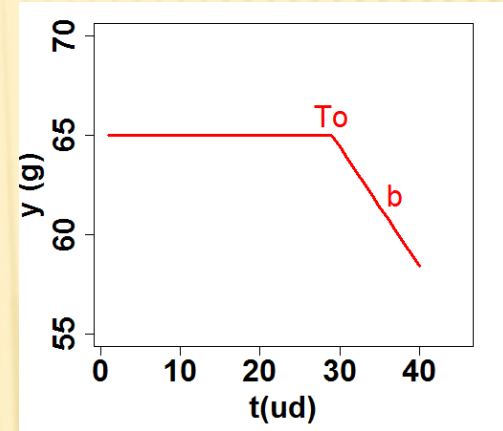
$$y_{ijkl_T} = HY_i + LADIM_j + PR_k + MT_l + f(T) + a_k + e_{ijk_Tl},$$

- × y_{ijkl_T} : FAT or PROTEIN yield at a certain temperature, T,
- × HY_i : herd-year of lambing/kidding
- × $LADIM_j$: lactation-age-days in milk combination
- × PR_k : Prolificacy (only for sheep)
- × MT_l : Milking time (morning/evening)
- × $f(T)$: function of temperature that differs between the splines and polynomial models; $T = T_{ave}, T_{max}$
- × a_k : animal effect; $\text{var}(a) = I\sigma_p^2$
- × e_{ijk_Tl} : residual; $\text{var}(e) = I\sigma_e^2$

f(T)

× Splines:

$$f(T) = \begin{cases} 0, & \text{if } T \leq T_0 \\ b(T - T_0), & \text{otherwise} \end{cases}$$



× Polynomials

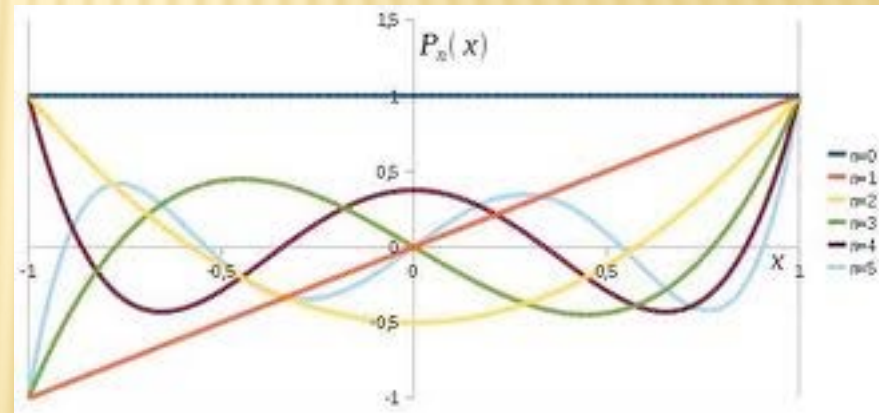
$$f(T) = \sum_{i=0}^q b_i P_i(T)$$

$$P_0(x) = 1$$

$$P_1(x) = x$$

$$P_2(x) = \frac{1}{2}(3x^2 - 1)$$

$$P_3(x) = \frac{1}{2}(5x^3 - 3x)$$



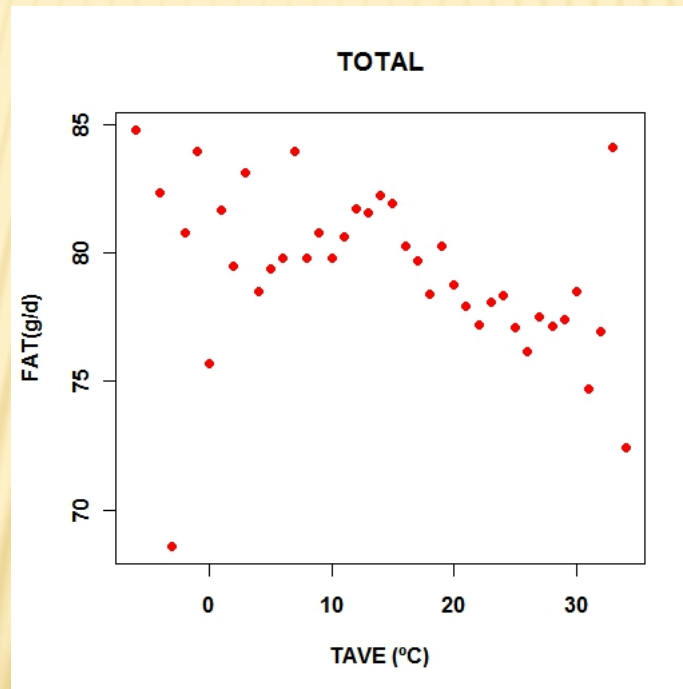
Quadratic and Cubic polynomials were fitted (n=2,3)

RESULTS-MANCHEGA



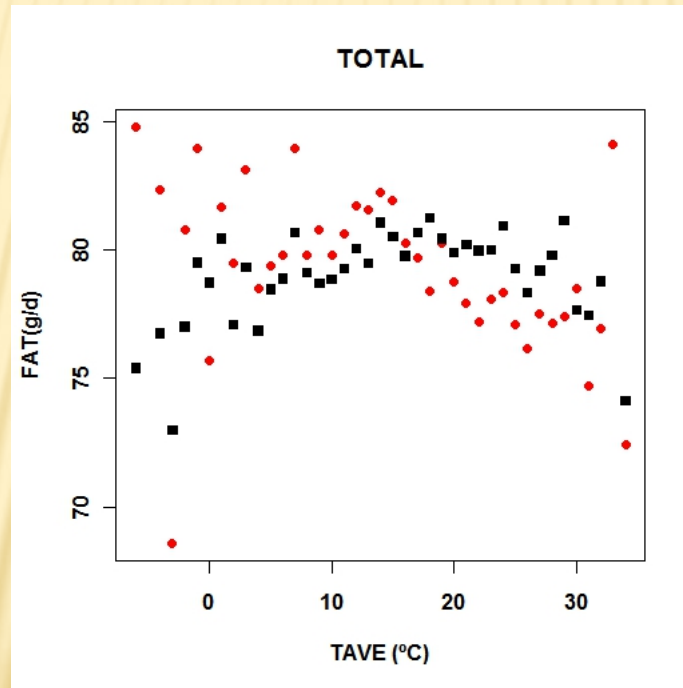
RESULTS - Average yields (red dots) per temperature degree

× FAT vs. TAVE



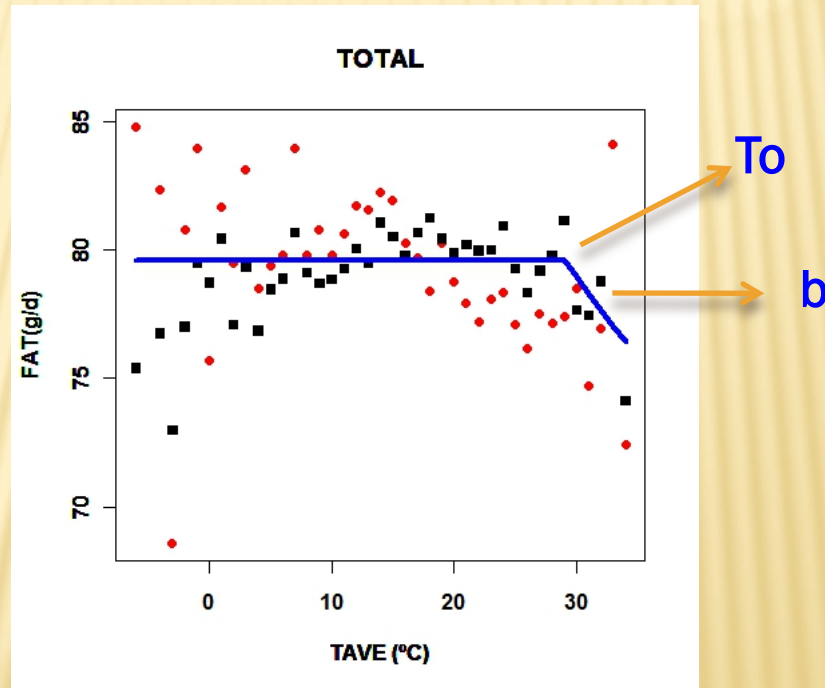
RESULTS - Average yields (red dots), Corrected yields (black squares) per temperature degree

× FAT vs. TAVE



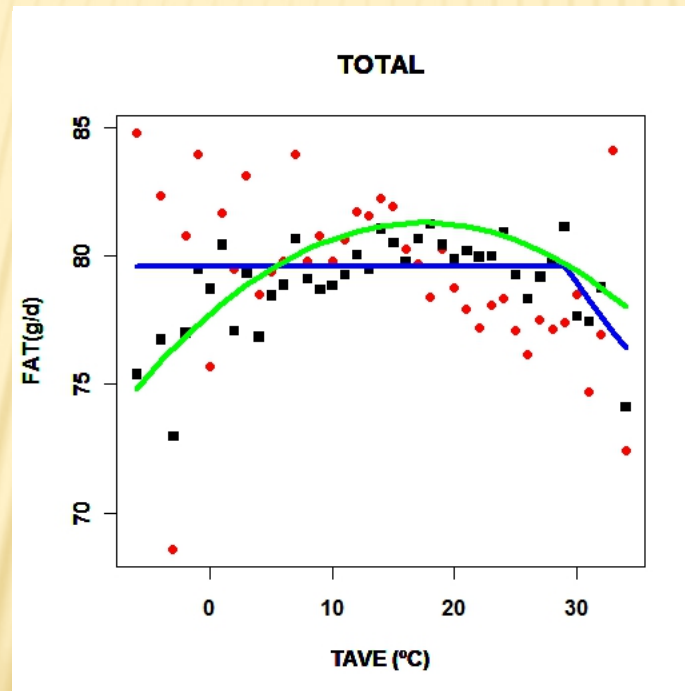
RESULTS - Average yields (red dots), Corrected yields (black squares), Splines (blue line) per temperature degree,

× **FAT vs. TAVE**



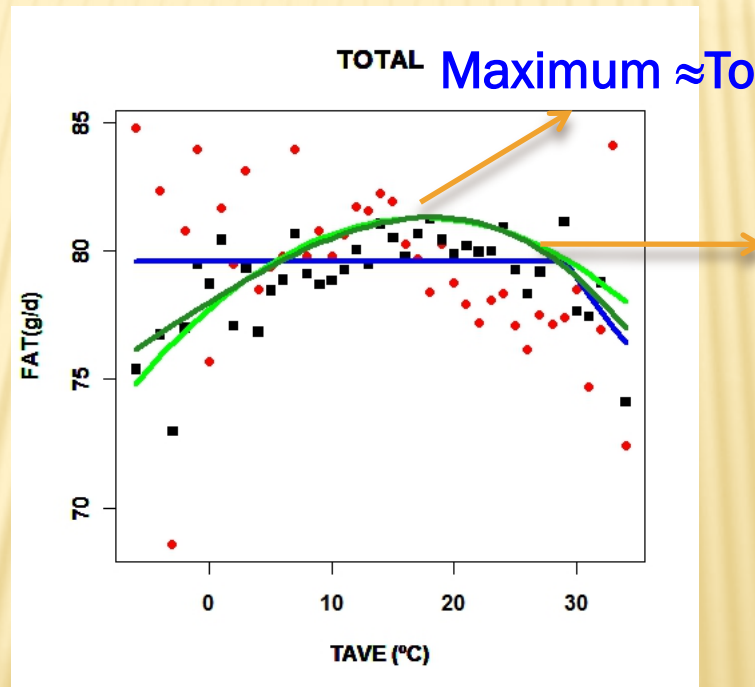
RESULTS - Average yields (red dots), Corrected yields (black squares), Splines (blue line), Quadratic (light green) per temperature degree

× FAT vs. TAVE



RESULTS - Average yields (red dots), Corrected yields (black squares), Splines (blue line), Quadratic (light green) and cubic (dark green) polynomials per temperature degree

× FAT vs. TAVE



RESULTS - Thermotolerance **THRESHOLD AND SLOPE** of decay for the Spline model for FAT and PROTEIN yields vs. average (TAVE) and maximum (TMAX) temperature for TOTAL and highly producing (HP) animals

TRAIT	TEMP	SPLINES			
		THRESHOLD (°C)		SLOPE (g/d/°C)	
		TOTAL	HP	TOTAL	< HP ?
FAT	→ TAVE	28,78	28.39	-0,63	-0.91
	→ TMAX	30.19	37.54	-0.10	-1.05
PROTEIN	TAVE	29.06	28.77	-0.69	-1.52
	TMAX	37.28	37.92	-0.39	-1.65


ESTIMATED THRESHOLD AND SLOPES HIGHLY DEPENDENT ON STARTING VALUES FOR T !!!!!!!

RESULTS - MAXIMA of the polynomial functions for FAT and PROTEIN yields vs. average (TAVE) and maximum (TMAX) temperature for TOTAL and high producing (HP) animals




TRAIT	TEMP	SPLINES				POLYNOMIALS' MAXIMA			
		THRESHOLD (°C)		SLOPE (g/d/°C)		QUADRATIC(°C)		CUBIC(°C)	
		TOTAL	HP	TOTAL	HP	TOTAL	HP	TOTAL	HP
FAT	TAVE	32.74	28.39	6.16	-0.91	17.61	19.90	18.37	18.55
	TMAX	30.19	37.54	-0.10	-1.05	24.50	26.75	25.27	25.79
PROTEIN	TAVE	29.06	28.77	-0.69	-1.52	20.20	23.68	20.61	22.47
	TMAX	5.44	37.92	0.09	-1.65	27.70	32.20	28.20	30.16

RESULTS - DERIVATIVES of the polynomial functions for FAT and PROTEIN yields vs. average (TAVE) and maximum (TMAX) temperature for TOTAL and high producing (HP) animal



	FAT (g/d)				PROTEIN (g/d)			
	Quadratic		Cubic		Quadratic		Cubic	
	TOTAL	HP	TOTAL	HP	TOTAL	HP	TOTAL	HP
TAVE (°C)								
20	-1.11	-0.04	-0.92	-0.41	0.09	1.24	0.41	2.55
25	-3.42	-2.30	-4.13	-1.15	-2.21	-1.21	-3.35	-3.21
30	-5.74	-4.55	-7.96	-0.86	-4.52	-3.66	-8.09	-11.33
TMAX(°C)								
30	-2.05	-0.25	-2.18	-1.14	-0.81	1.84	-1.12	0.17
35	-3.92	-2.65	-4.83	-2.05	-2.56	-0.31	-4.81	-6.25
40	-5.78	-5.06	-7.84	-2.48	-4.32	-2.46	-9.39	-14.83



RESULTS - DERIVATIVES of the polynomial functions for FAT and PROTEIN yields vs. average (TAVE) and maximum (TMAX) temperature for TOTAL and high producing (HP) animal

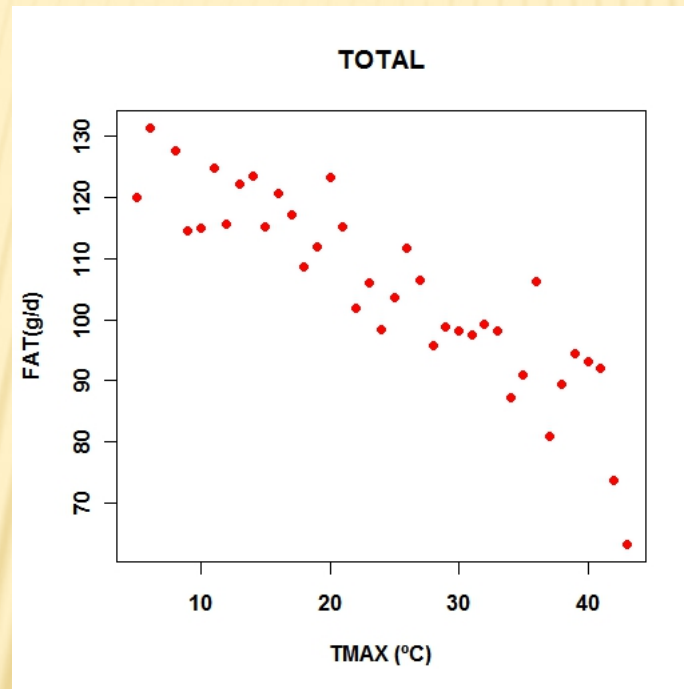
		FAT (g/d)				PROTEIN (g/d)			
		Quadratic		Cubic		Quadratic		Cubic	
		TOTAL	HP	TOTAL	HP	TOTAL	HP	TOTAL	HP
→	TAVE (°C)								
	20	-1.11	-0.04	-0.92	-0.41	0.09	1.24	0.41	2.55
	25	-3.42	-2.30	-4.13	-1.15	-2.21	-1.21	-3.35	-3.21
	30	-5.74	-4.55	-7.96	-0.86	-4.52	-3.66	-8.09	-11.33
→	TMAX(°C)								
	30	-2.05	-0.25	-2.18	-1.14	-0.81	1.84	-1.12	0.17
	35	-3.92	-2.65	-4.83	-2.05	-2.56	-0.31	-4.81	-6.25
	40	-5.78	-5.06	-7.84	-2.48	-4.32	-2.46	-9.39	-14.83

RESULTS-FLORIDA



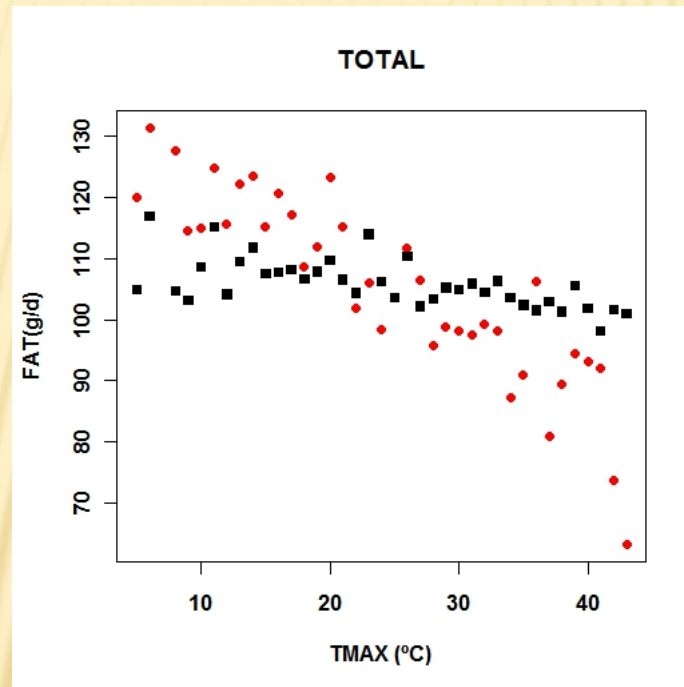
RESULTS - Average yields (red dots) per temperature degree

× FAT vs. TMAX



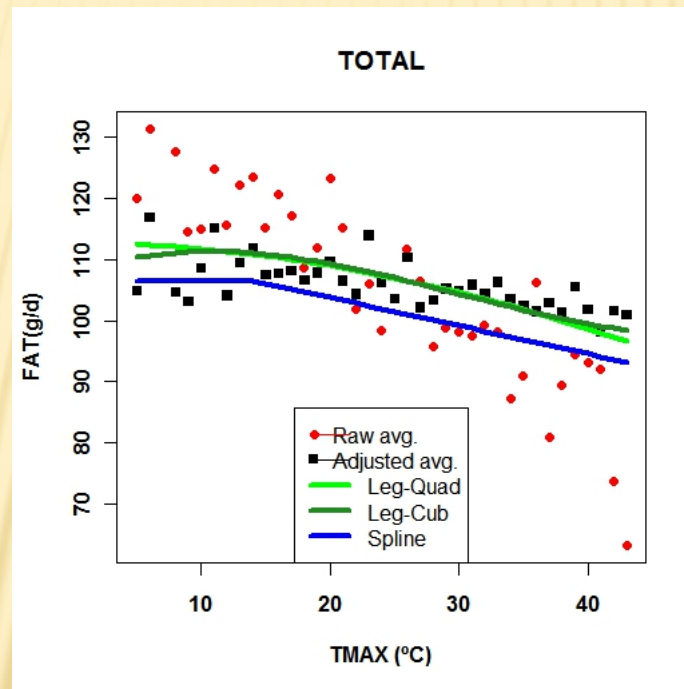
RESULTS - Average yields (red dots) per temperature degree

× FAT vs. TMAX



RESULTS - Average yields (red dots) per temperature degree

× FAT vs. TMAX



RESULTS - Thermotolerance **THRESHOLD AND SLOPE** of decay for the Spline model for FAT and PROTEIN yields vs. average (TAVE) and maximum (TMAX) temperature for TOTAL and highly producing (HP) animals

TRAIT	TEMP	SPLINES			
		THRESHOLD (°C)		SLOPE (g/d/°C)	
		TOTAL	HP	TOTAL	< HP?
FAT	TAVE	32.00	9.24	-12.42	-0.84
	TMAX	14.20	14.23	-0.46	-0.60
PROTEIN	TAVE	8.87	8.43	-0.19	-0.32
	TMAX	16.41	10.69	-0.14	-0.20

LOW COMFORT THRESHOLDS (????)

RESULTS - MAXIMA of the polynomial functions for FAT and PROTEIN yields vs. average (TAVE) and maximum (TMAX) temperature for TOTAL and high producing (HP) animals

TRAIT	TEMP	SPLINES				POLYNOMIALS			
		THRESHOLD (°C)		SLOPE (g/d/°C)		QUADRATIC(°C)		CUBIC(°C)	
		TOTAL	HP	TOTAL	HP	TOTAL	HP	TOTAL	HP
FAT	TAVE	32.00	9.24	-12.42	-0.84	-2.97	-0.24	8.09	9.21
	TMAX	14.20	14.23	-0.46	-0.60	-2.46	-11.35	10.63	10.77
PROTEIN	TAVE	8.87	8.43	-0.19	-0.32	6.20	-1347.67	10.82	9.02
	TMAX	16.41	10.69	-0.14	-0.20	11.59	-119.26	16.25	10.48

RESULTS - DERIVATIVES of the polynomial functions for FAT and PROTEIN yields vs. average (TAVE) and maximum (TMAX) temperature for TOTAL and high producing (HP) animal

	FAT (g/d)				PROTEIN (g/d)			
	Quadratic		Cubic		Quadratic		Cubic	
	TOTAL	HP	TOTAL	HP	TOTAL	HP	TOTAL	HP
TAVE (°C)								
10	-5.98	-7.10	-3.51	-2.57	-0.90	-4.79	0.89	-1.71
20	-10.58	-14.04	-12.83	-18.62	-3.26	-4.83	-4.91	-7.95
25	-12.88	-17.50	-11.79	-15.38	-4.45	-4.84	-3.65	-3.40
30	-15.19	-20.97	-6.95	-4.63	-5.63	-4.86	0.39	6.26
TMAX(°C)								
15	-5.27	-7.66	-4.08	-5.74	-0.52	-3.95	0.93	-2.79
20	-6.77	-9.11	-7.48	-10.39	-1.29	-3.76	-2.17	-4.53
30	-9.79	-12.01	-10.19	-12.73	-2.82	-3.38	-3.33	-3.81
35	-11.30	-13.47	-9.50	-10.42	-3.58	-3.19	-1.38	-1.35
40	-12.81	-14.92	-7.45	-5.80	-4.35	-3.00	2.25	2.52

RESULTS - DERIVATIVES of the polynomial functions for FAT and PROTEIN yields vs. average (TAVE) and maximum (TMAX) temperature for TOTAL and high producing (HP) animal

	FAT (g/d)				PROTEIN (g/d)			
	Quadratic		Cubic		Quadratic		Cubic	
	TOTAL	HP	TOTAL	HP	TOTAL	HP	TOTAL	HP
TAVE (°C)								
10	-5.98	-7.10	-3.51	-2.57	-0.90	-4.79	0.89	-1.71
20	-10.58	-14.04	-12.83	-18.62	-3.26	-4.83	-4.91	-7.95
25	-12.88	-17.50	-11.79	-15.38	-4.45	-4.84	-3.65	-3.40
30	-15.19	-20.97	-6.95	-4.63	-5.63	-4.86	0.39	6.26
TMAX(°C)								
15	-5.27	-7.66	-4.08	-5.74	-0.52	-3.95	0.93	-2.79
20	-6.77	-9.11	-7.48	-10.39	-1.29	-3.76	-2.17	-4.53
30	-9.79	-12.01	-10.19	-12.73	-2.82	-3.38	-3.33	-3.81
35	-11.30	-13.47	-9.50	-10.42	-3.58	-3.19	-1.38	-1.35
40	-12.81	-14.92	-7.45	-5.80	-4.35	-3.00	2.25	2.52

CONCLUSIONS

- × **Splines vs. Polynomials:**
 - + **For Splines, convergence was not always reached and estimates of threshold and slope highly depended on starting temperature**
 - + **Polynomials always provided estimates of regression coefficients and showed good convergence**
- × **Cold and heat stress (more in Manchega) -> Cubic polynomials needed**
- × **Comfort thresholds lower for Florida (10°C for Tave, 15°C for Tmax!!!) than for Manchegas (25°C for Tave, 35°C Tmax)**
- × **Larger decays in Florida (for fat yield) than in Manchega (similar for fat and protein)**
- × **High producers more affected by heat stress in Florida, not so much in Manchega (not highly productive breed)**

ACKNOWLEDGMENTS



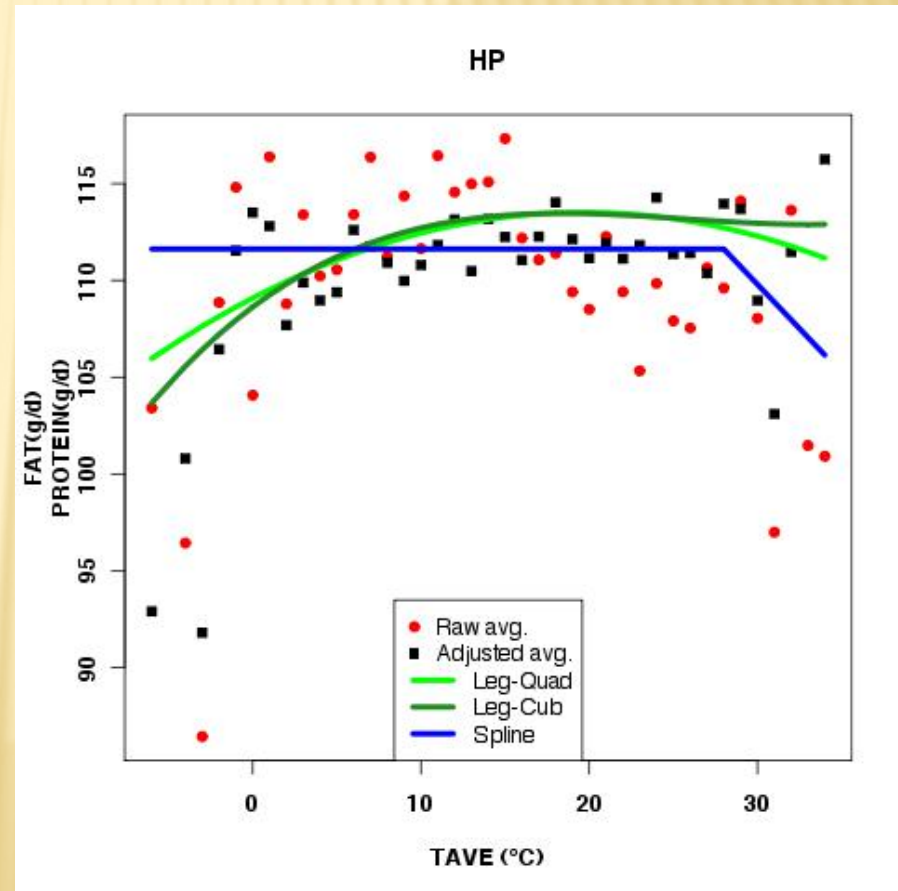
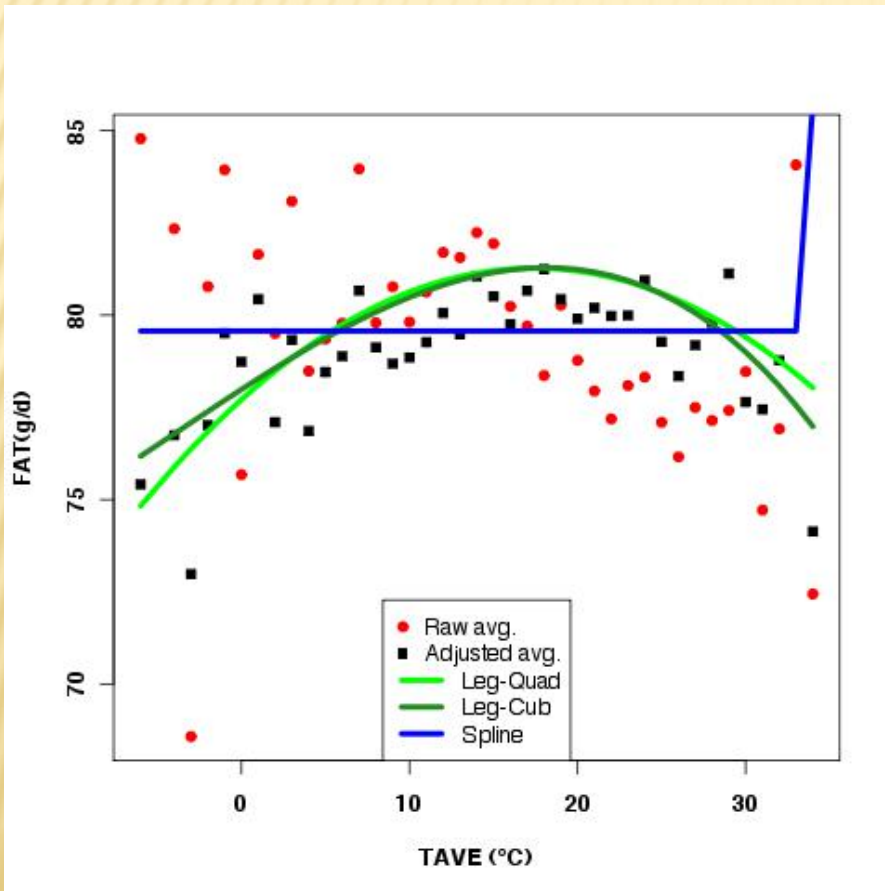
This research was funded by the project INIA – FEDER: RTA2011-00108

THANK YOU!



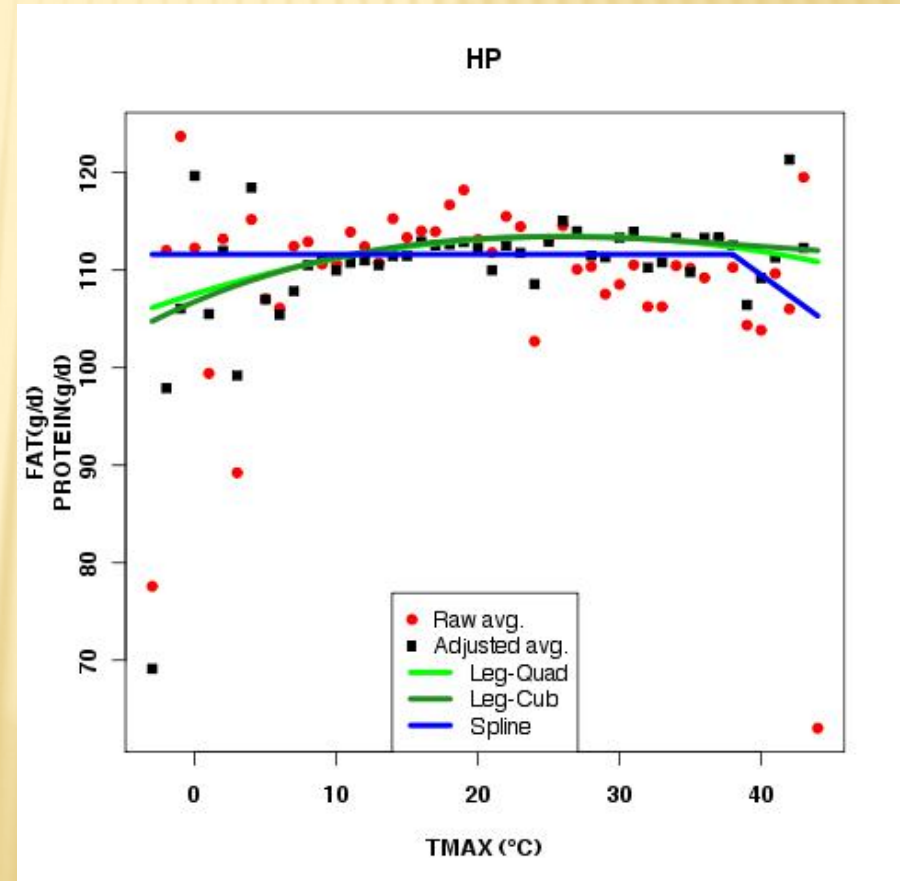
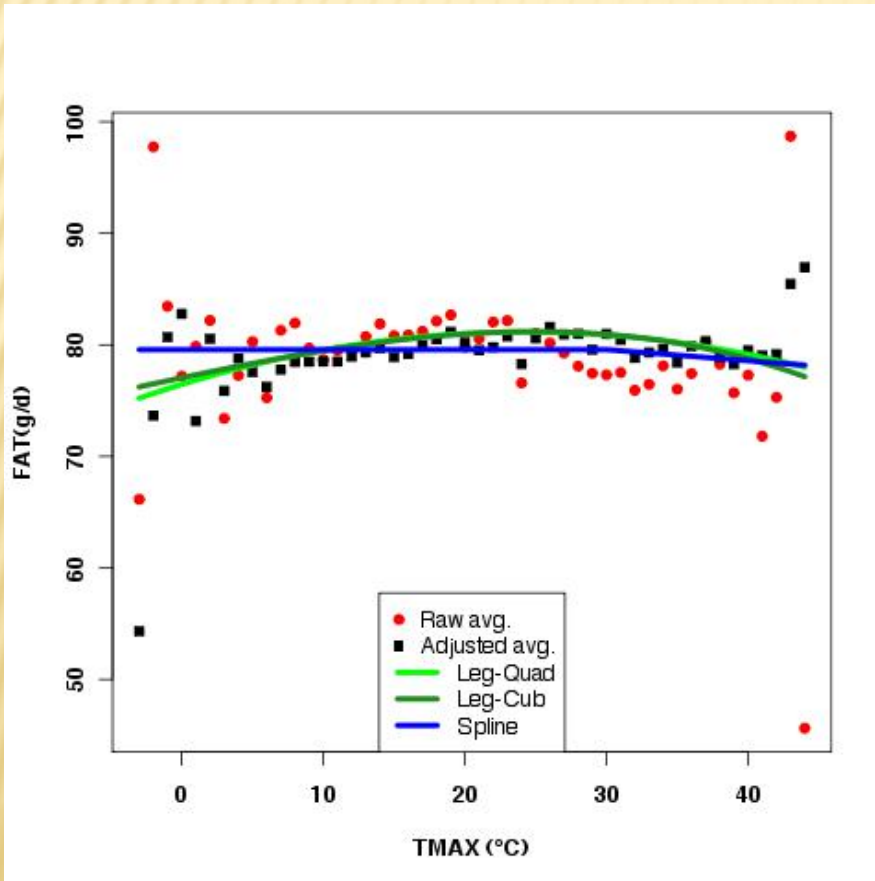
RESULTS - Average yields (red dots) Corrected yields (black squares), Splines (blue line), Quadratic (light green) and cubic (dark green) polynomials per temperature degree

× FAT vs. TAVE



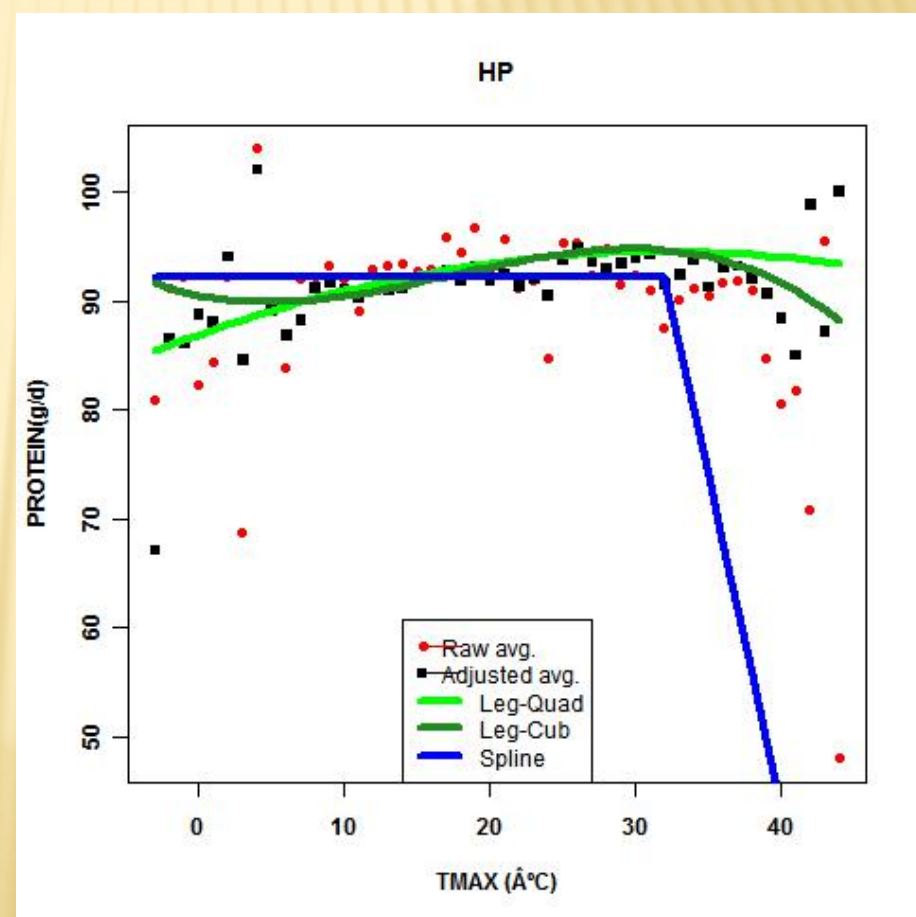
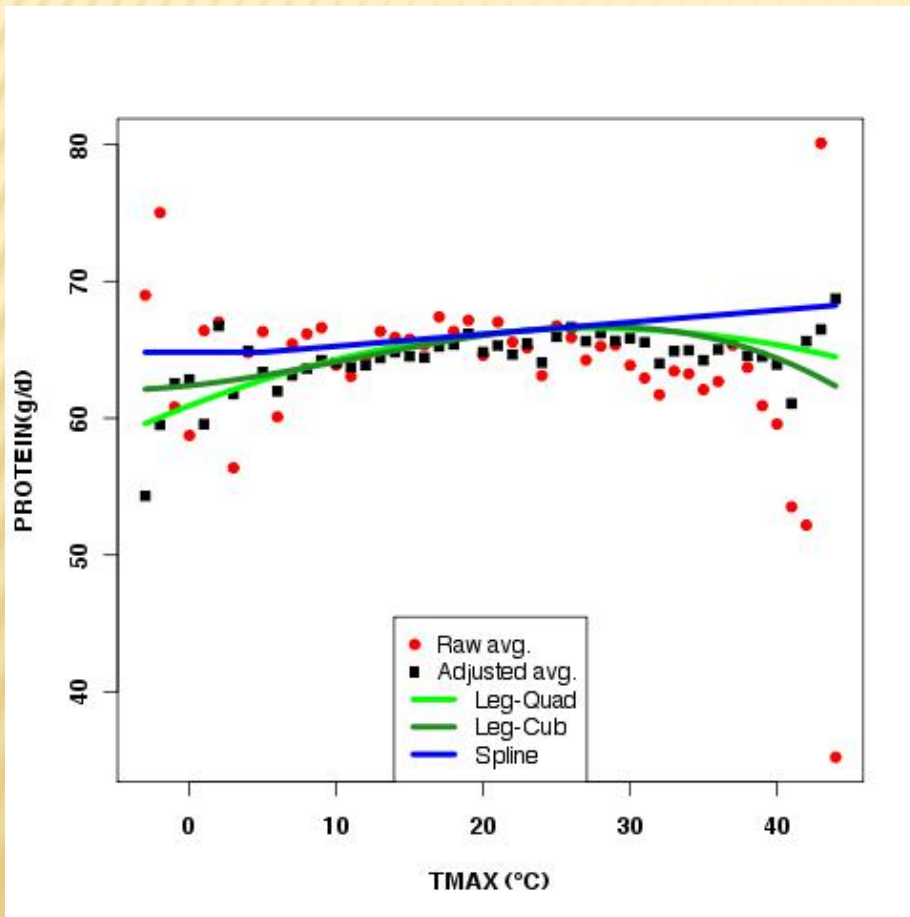
RESULTS - Average yields (red dots), Corrected yields (black squares), Splines (blue line), Quadratic (light green) and cubic (dark green) polynomials per temperature degree

× FAT vs. TMAX



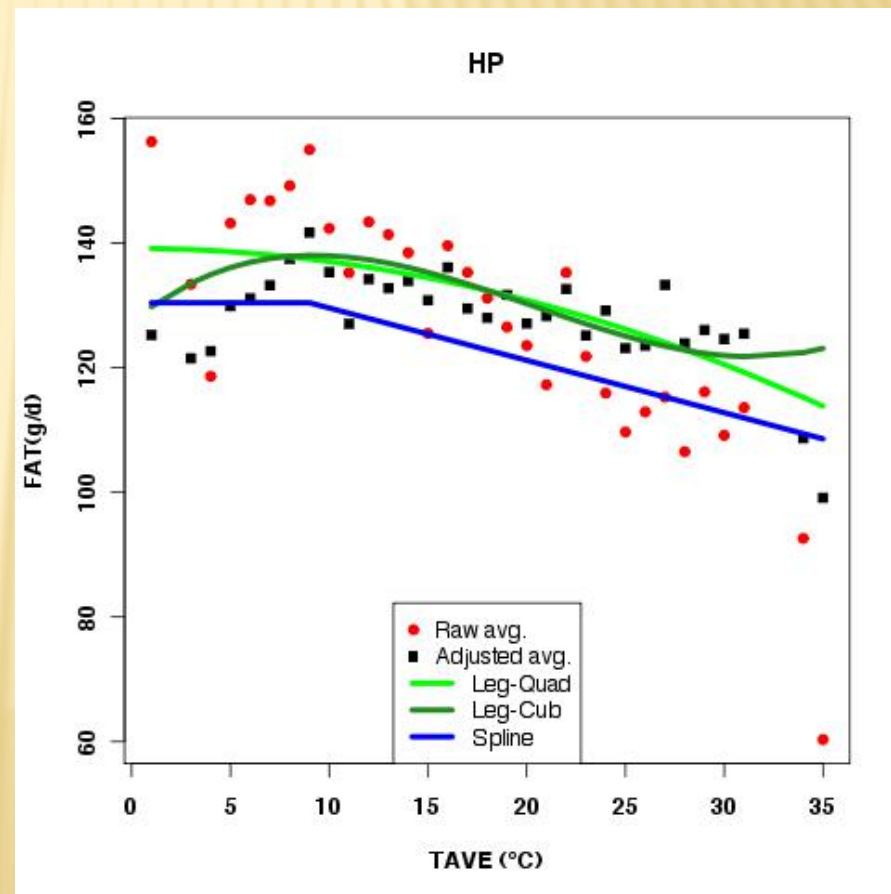
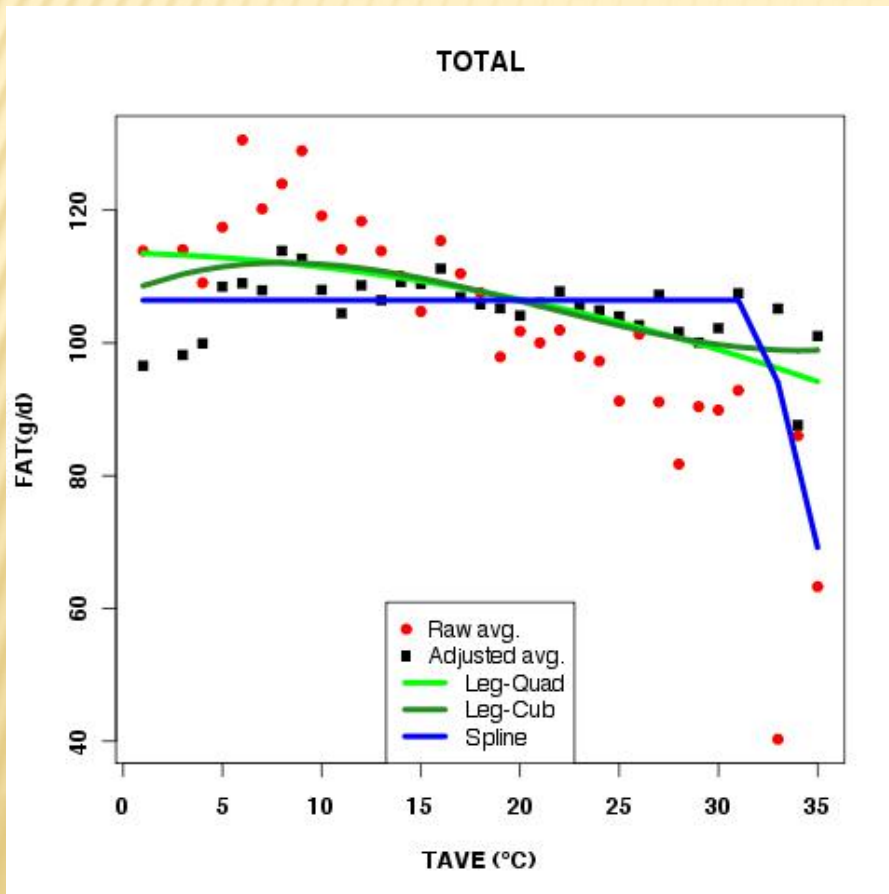
RESULTS - Average yields (red dots), Corrected yields (black squares), Splines (blue line), Quadratic (light green) and cubic (dark green) polynomials per temperature degree

× PROTEIN vs. TMAX



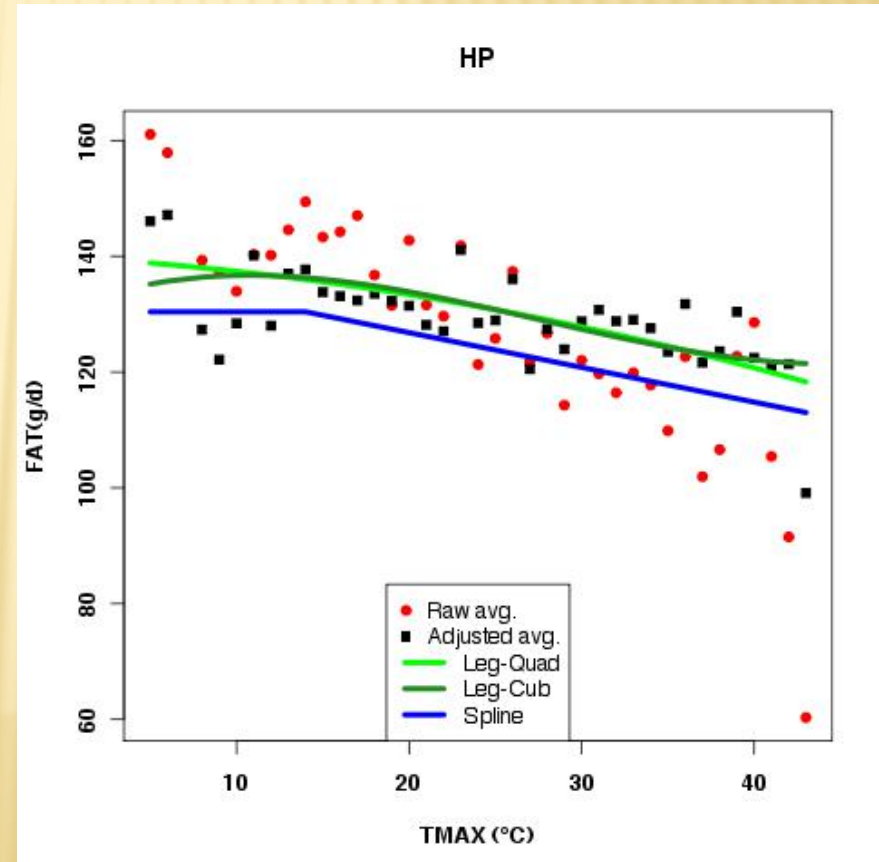
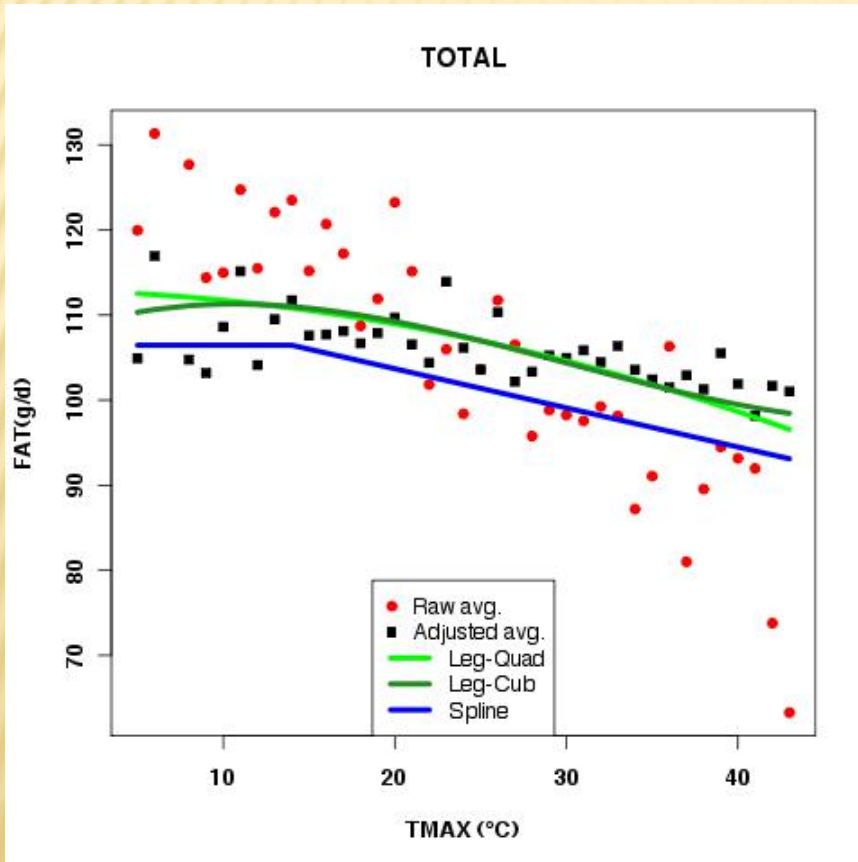
RESULTS - Average yields (red dots), Corrected yields (black squares), Splines (blue line), Quadratic (light green) and cubic (dark green) polynomials per temperature degree

× FAT vs. TAVE



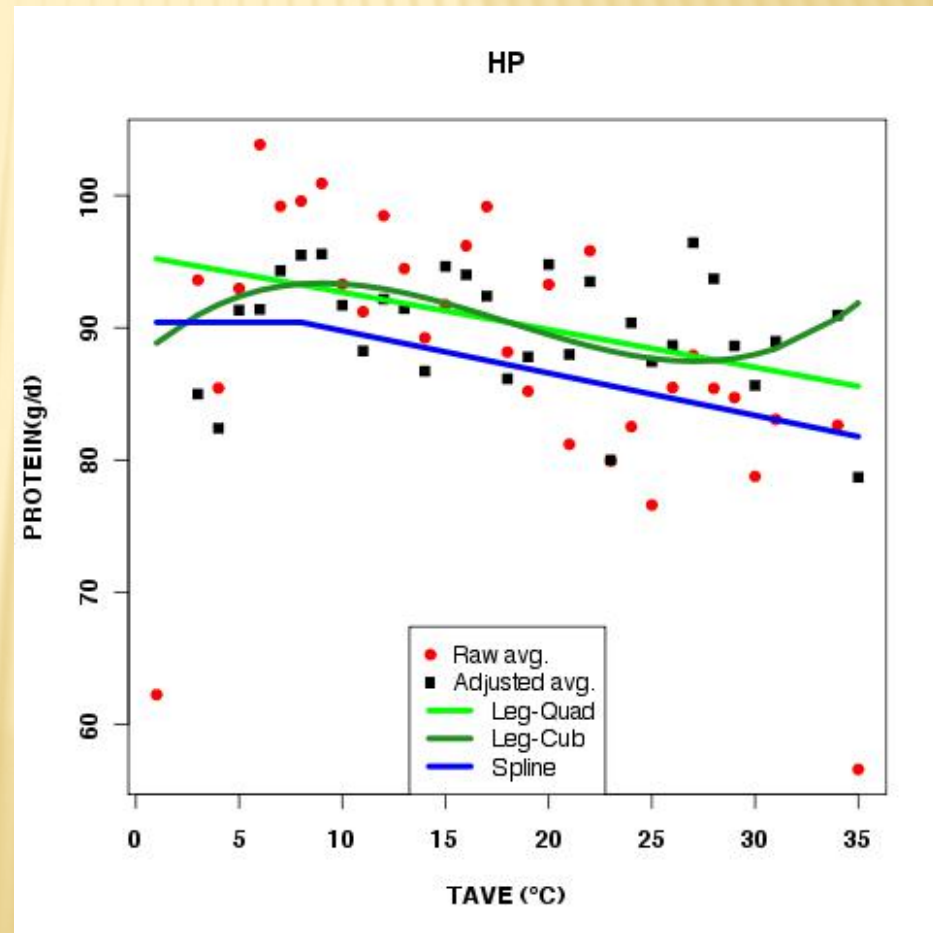
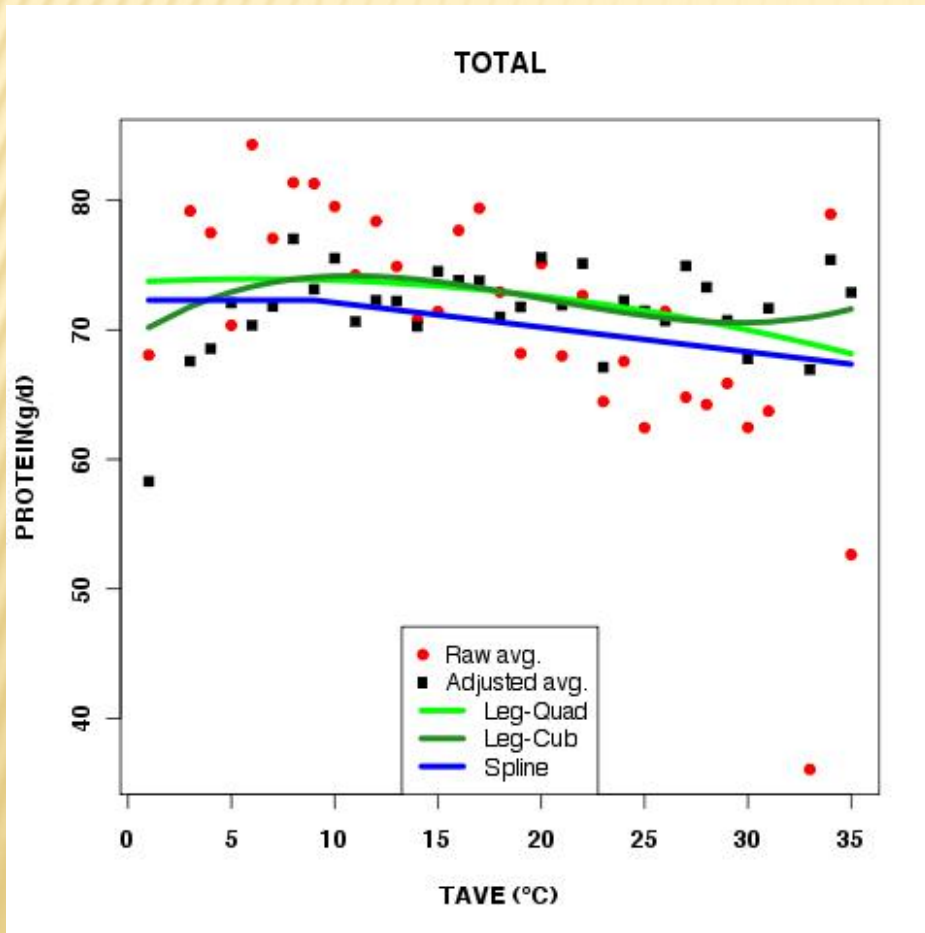
RESULTS - Average yields (red dots), Corrected yields (black squares), Splines (blue line), Quadratic (light green) and cubic (dark green) polynomials per temperature degree

× FAT vs. TMAX



RESULTS - Average yields (red dots), Corrected yields (black squares), Splines (blue line), Quadratic (light green) and cubic (dark green) polynomials per temperature degree

× PROTEIN vs. TAVE



METHODS - COMPUTATION

- ✘ **Bayesian approach to solve for the unknowns**
- ✘ **Samples used to obtain posterior features:
2000 (after burn-in discarded)**
- ✘ **Software used:**
 - + **Splines by Sánchez JP (personal comm)**
 - + **Polynomials by Gibbsf90 (Misztal et al.,)**