Effect of methionine level on body amino acid composition and protein metabolism in piglets

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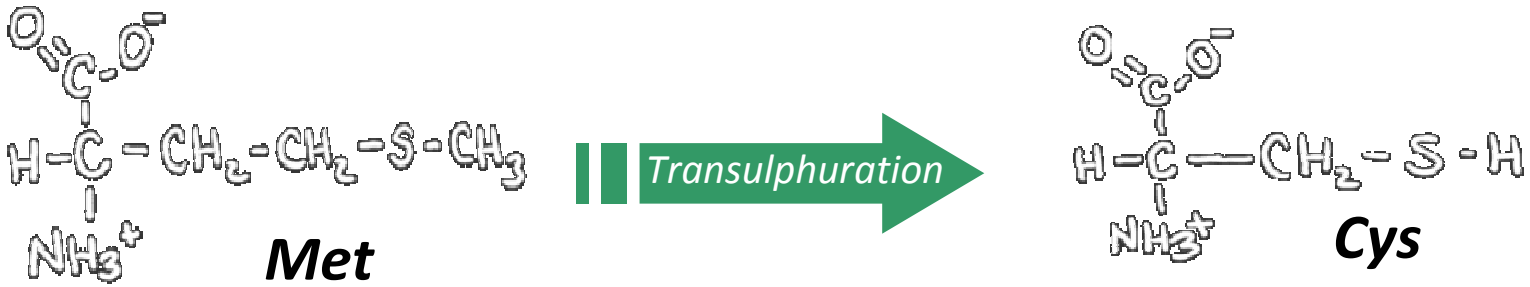
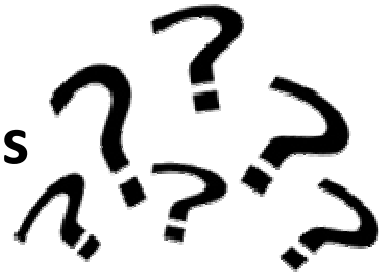
- **Methionine is an essential amino acid:**
  - **Cysteine can be synthesized from Met**
  - **Requirement for Met and (Met+Cys)**



- **Amino acid requirements are often evaluated through BW gain or N retention**
- **The amino acid composition of whole body protein is often assumed to be constant**

- **Doubts on the validity of this hypothesis**



Kyriazakis *et al.* (1993)
Bikker *et al.* (1994)

1. **Evaluate if (and how)**

a total sulfur AA deficiency

affects the body composition

Composition of the experimental diets

	Diet-	Diet+
Nutritional values, %		
SID Lys	1.17	1.16
SID Met	0.20	0.46
SID (Met + Cys)	0.45	0.70

43% and 36% requirements for Met and Met+Cys

Peas
25 %

Cereals
41 %

Soybean meal
19 %

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•18 Piétrain × (LW×LD) barrows

6 weeks of age
(~14 kg)

DIET -

75 % ad libitum

DIET +

19 days

N balance trial and a comparative slaughter study

Longissimus dorsi *Liver* *Blood*

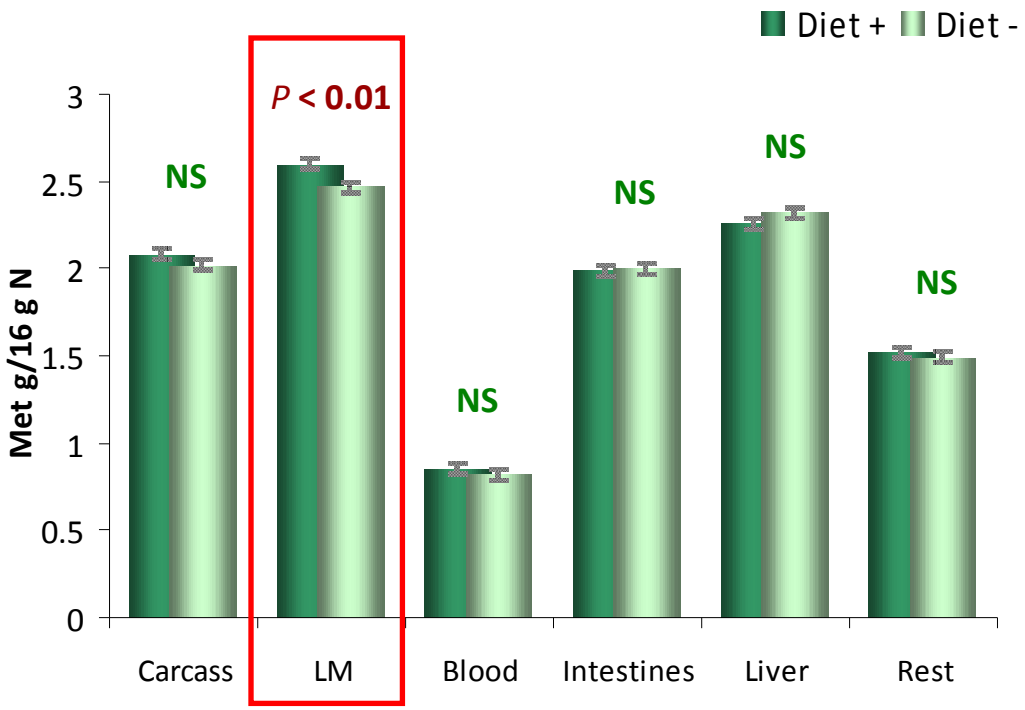
Rest *Intestines* *Carcass*

Chemical composition of empty body, carcass and *Longissimus dorsi muscle* in piglets

	Diet-	Diet+	*P* -value
Daily feed intake (g/d)	602	612	NS
Daily gain (g/d)	336	403	0.08
Chemical body composition (g/kg)			
Whole body			
Protein[2]	151	161	< 0.01
Lipid	111	100	0.05
Mineral	26.3	24.4	< 0.01
Water	718	727	0.02
Carcass			
Protein[2]	152	165	< 0.01
Lipid	129	111	0.01
Mineral	25.7	23	< 0.01
Water	702	717	< 0.01
Longissimus dorsi muscle			
Protein[2]	176	192	0.01
Lipid	25.7	22.8	0.10
Mineral	11.8	12.6	0.04
Water	793	786	NS

[2]Expressed as nitrogen x 6.25.

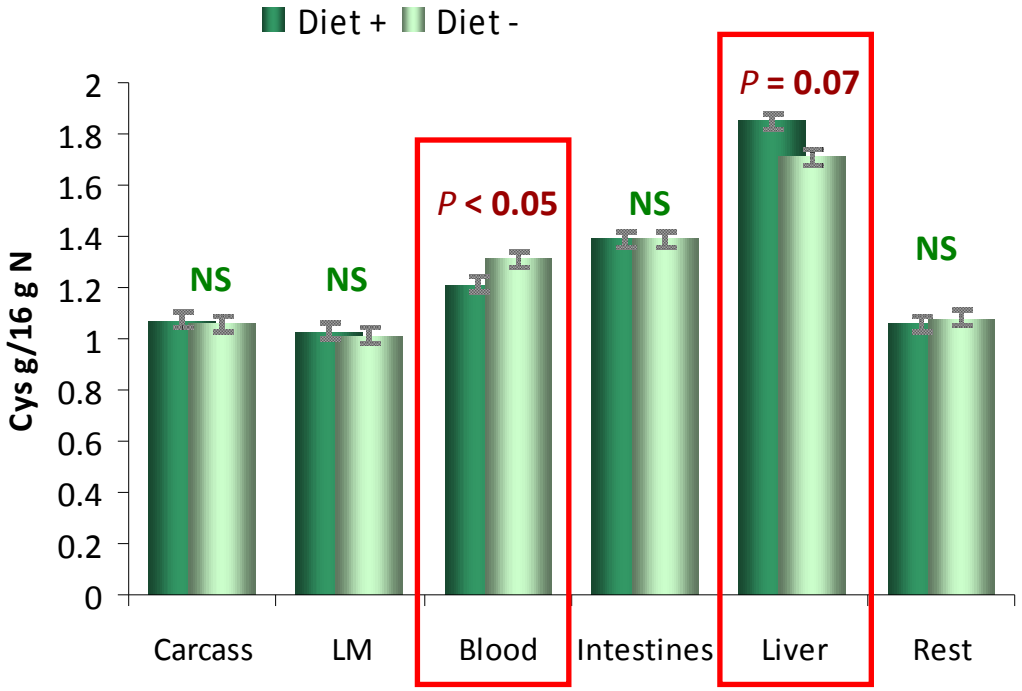
Methionine content in protein of body tissues



NS = not significant

LM = *longissimus dorsi* muscle

Cysteine content in protein of body tissues



NS = not significant

LM = *longissimus dorsi* muscle

Weight gain and composition of weight gain of whole body, carcass and *Longissimus dorsi* muscle

		Diet-	Diet+	*P*-value
	Whole body			
19%	Gain , g/d	314	390	0.05
14%	Protein content of gain, %	15.7	18.2	< 0.01
9%	Met content of protein gain, %	1.78	1.96	0.01
	Cys content of protein gain, %	1.1	1.09	0.89
	Carcass			
28%	Gain , g/d	211	292	0.01
17%	Protein content of gain, %	15.5	18.6	< 0.01
8%	Met content of protein gain, %	1.96	2.12	0.08
	Cys content of protein gain, %	1.04	1.08	NS
	LD muscle			
47%	Gain , g/d	5.4	10.2	< 0.01
20%	Protein content of gain, %	16.3	20.5	0.04
12%	Met content of protein gain, %	2.38	2.69	0.01
	Cys content of protein gain, %	0.94	1.03	< 0.05

The gain was LOWER

The gain contained LESS PROTEIN

The protein contained LESS MET

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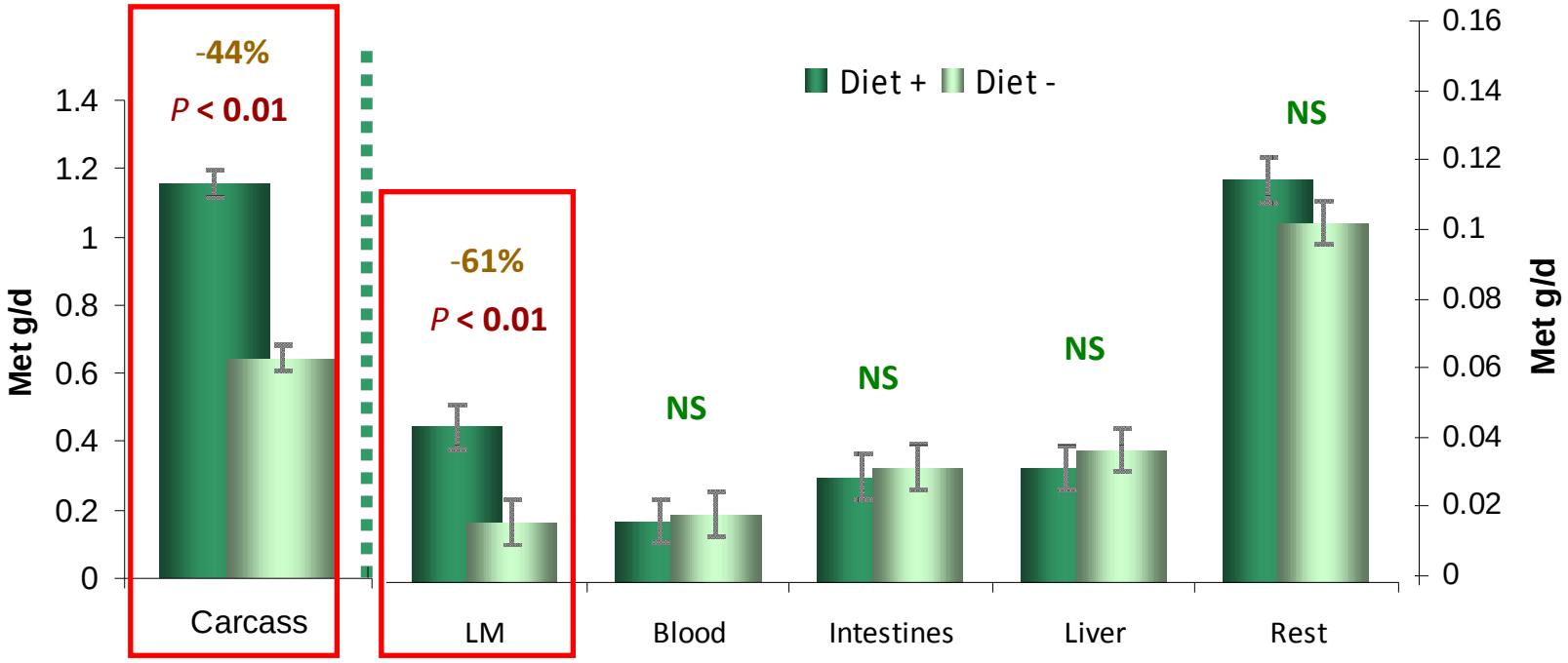
Weight gain and composition of weight gain of blood, intestine, liver and rest

	Diet-	Diet+	*P* -value
Blood			
Gain , g/d	14.1	14.7	< 0.05
Protein content of gain, %	15.0	18.5	< 0.05
Met content of protein gain, %	0.78	0.86	0.06
Cys content of protein gain, %	1.4	1.15	0.01
Intestine			
Gain , g/d	14.7	14.7	NS
Protein content of gain, %	14.4	13.2	NS
Met content of protein gain, %	1.98	1.97	NS
Cys content of protein gain, %	1.47	1.48	NS
Liver			
Gain , g/d	10.2	8.7	NS
Protein content of gain, %	19.5	20.9	NS
Met content of protein gain, %	2.40	2.28	NS
Cys content of protein gain, %	1.59	1.98	0.04
Rest			
Gain , g/d	56.6	59.6	NS
Protein content of gain, %	16.3	17.3	< 0.05
Met content of protein gain, %	1.30	1.41	NS
Cys content of protein gain, %	1.04	0.97	NS

Total methionine gain in body components



NS = not significant

LM = *Longissimus dorsi* muscle

These tissues maintain their composition

May be a priority for the animal

The amino acid composition of different proteins

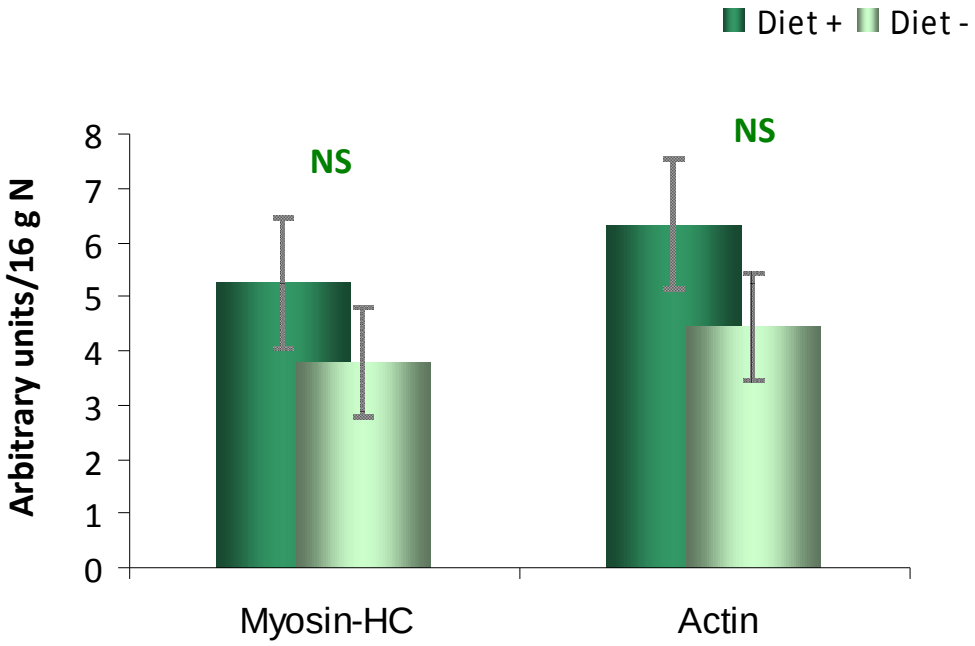
(Pearson & Young, 1989)

	MHC	Actin	Collagen
% Amino acid			
Lys	10.7	7.0	2.8
Met	1.8	4.1	0.8
Cys	0.9	1.4	-
Thr	5.5	6.9	2.0
Trp	0.5	1.2	-
Val	4.6	5.4	2.4
Ile	4.4	-	1.1
Leu	11.3	7.6	2.4
Phe	3.1	3.1	1.1
Tyr	2.2	4.0	0.2
His	2.0	2.0	0.5
Arg	5.6	4.8	5.1
Ser	5.6	5.9	4.3
Gly	3.3	7.5	33.1
Ala	8.0	8.0	10.6
Asp	5.3	9.0	4.6
Glu	13.3	11.3	7.1
Pro	1.5	4.9	12.1
Asn	3.8	-	-
Gln	6.4	-	-
Hyp	-	-	9.3
Hyl	-	-	0.6

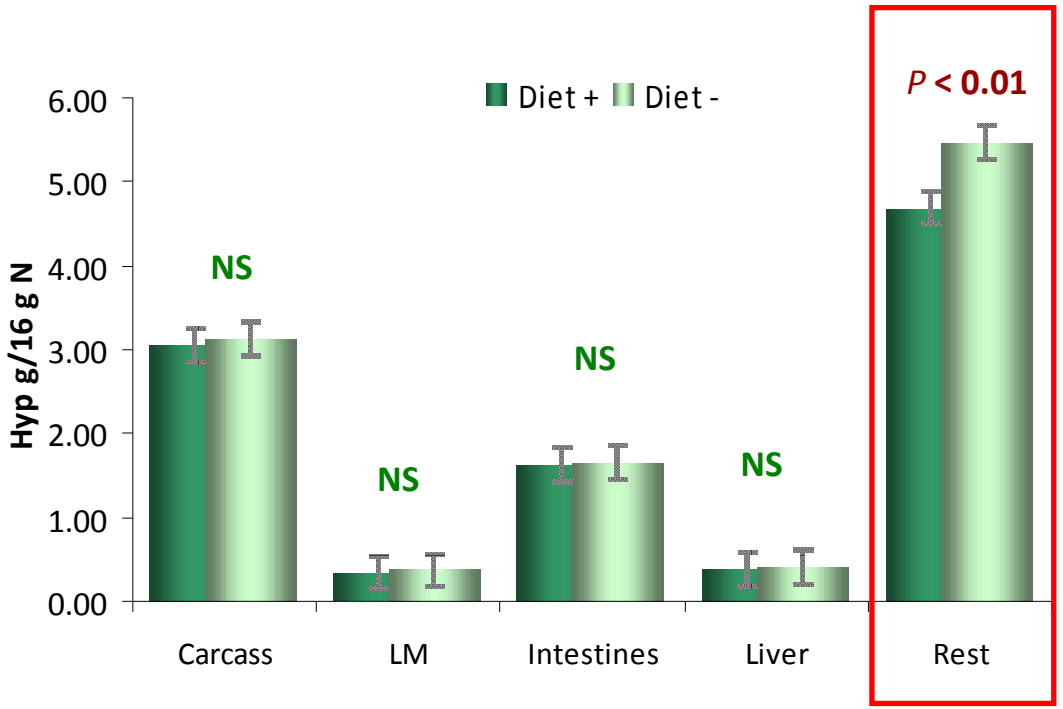
Change in the Met content in LM

Contribution of ≠ muscle proteins HAS CHANGED

Myosin-HC & actin contents in *Longissimus dorsi* muscle



Hydroxyproline content in protein of body tissues
(as an indicator for collagen)

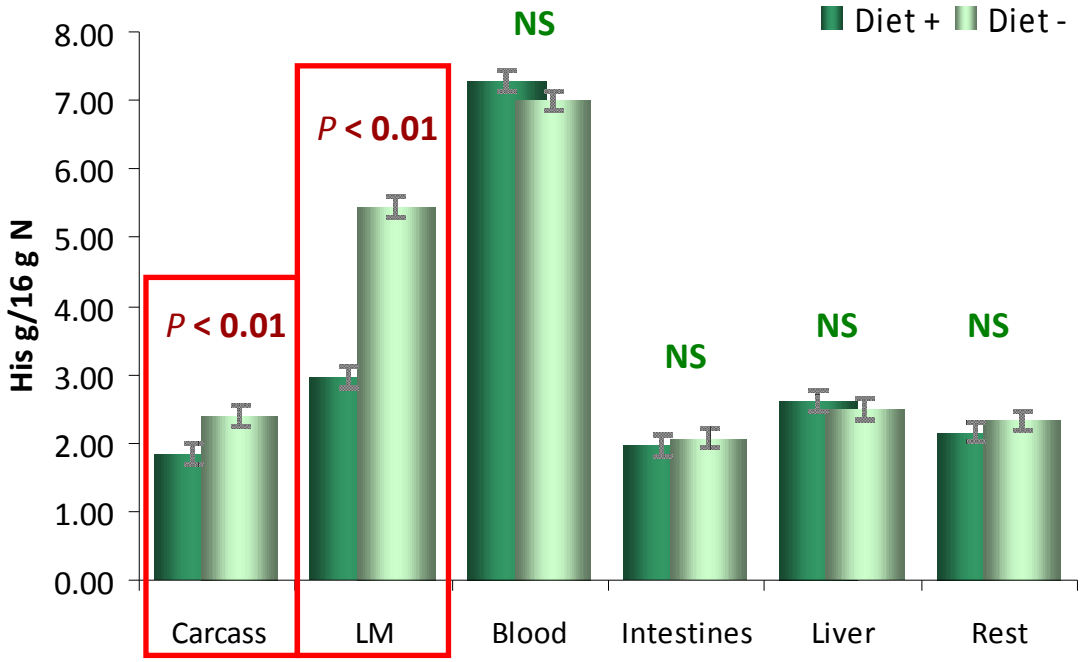


NS = not significant

LM = *longissimus dorsi* muscle

Histidine content in protein of body tissues

(as an indicator for protein degradation)



NS = not significant

LM = *longissimus dorsi* muscle

2. **Evaluate if (and how)**

a total sulfur AA deficiency

affects the protein synthesis

and proteolysis

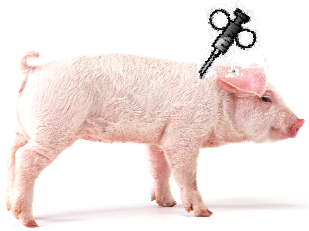
•12 Piétrain × (LW×LD) barrows

6 weeks of age
(~14 kg)

DIET -

75 % ad libitum

DIET +



(^{13}C)-Valine

10 days

N balance trial and a comparative slaughter study

Semitendinous *Rhomboid* *Liver* *Skin*

Longissimus dorsi *Small intestine* *Kidneys*

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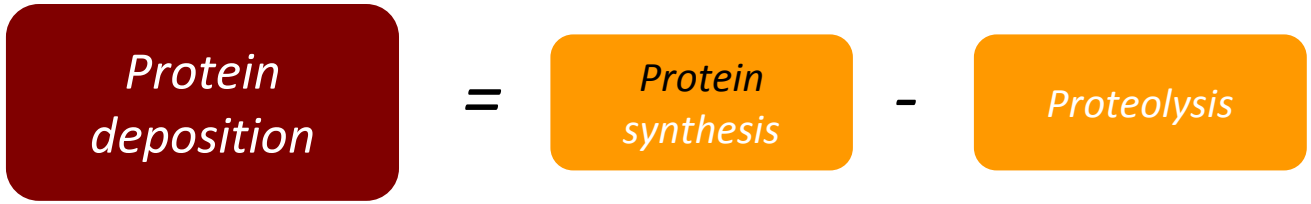
Relative weight of body tissues in piglets

	Diet -	Diet +	*P* -value
Tissue (g/kg BW)			
BW (kg)	12.5	13.0	NS
Semitendinous	3.45	3.43	NS
Longissimus dorsi	15.4	17.1	0.09
Rhomboid	0.42	0.42	NS
Liver	24.6	24.1	NS
Proximal jejunum	11.7	11.2	NS
Distal jejunum	13.2	10.8	<0.001
Ileum	13.5	12.4	NS
Kidneys	5.55	5.45	NS

BW = body weight

NS = not significant

Protein turnover
(Bergen, 2008)



Activity of proteolysis enzymes of body tissues in piglets

	Diet -	Diet +	*P*-value
Proteasome activity*			
Semitendinous	2.28	1.91	<0.05
Longissimus dorsi	2.17	1.96	NS
Rhomboid	2.74	2.79	NS
Liver	99	106	NS
Proximal jejunum	234	244	NS
Distal jejunum	243	253	NS
Ileum	192	206	NS
Kidneys	48.8	56.8	NS
Skin	*in process*		

*** Relative fluorescence units/min/mg protein**

NS = not significant

	Diet -	Diet +	*P*-value
Calpain activity*			
Semitendinous	1.40	1.27	NS
Longissimus dorsi	1.67	1.50	NS
Rhomboid	1.59	1.76	NS
Liver	34.1	33.4	NS
Proximal jejunum	57.8	55.3	NS
Distal jejunum	52.2	44.9	NS
Ileum	45.7	46.7	NS
Kidneys	18.3	17.9	NS
Skin	*in process*		

*** Relative fluorescence units/min/mg protein**

NS = not significant

Fractional synthesis rate (ks) and efficiency for protein synthesis (K_{RNA}) of body tissues in piglets

	Diet -	Diet +	*P*-value
ks (%/day)			
Semitendinous	2.98	3.57	NS
Longissimus dorsi	3.14	4.58	<0.05
Rhomboid	3.07	2.76	NS
Liver	45.5	45.5	NS
Proximal jejunum	52.1	55.1	NS
Distal jejunum	*in process*		
Ileum	*in process*		
Kidneys	25.4	24.2	NS
Skin	*in process*		

% of protein mass synthesized per day

NS = not significant

	Diet -	Diet +	*P*-value
K_{RNA} (g / g/d)			
Semitendinous	2.16	2.74	0.06
Longissimus dorsi	2.14	3.54	<0.001
Rhomboid	3.14	2.90	NS
Liver	7.26	6.82	NS
Proximal jejunum	14.2	15.8	NS
Distal jejunum	*in process*		
Ileum	*in process*		
Kidneys	7.14	6.61	NS
Skin	*in process*		

g protein synthesized per ribosomal RNA and day

NS = not significant

CONCLUSIONS

- The methionine content in body protein is not constant
- Different tissues respond differently to a deficient TSAA supply (total Met gain):
  - Blood, intestines and liver respond little
  - Carcass, *longissimus dorsi* muscle, and Rest respond much more
- The *longissimus dorsi* muscle has a great plasticity:
  - Weight gain
  - Protein content in weight gain
  - Met content in protein gain
  - Fractional synthesis rate (ks) and efficiency for protein synthesis (K_{RNA})

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