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

**J. Alberto Conde-Aguilera**

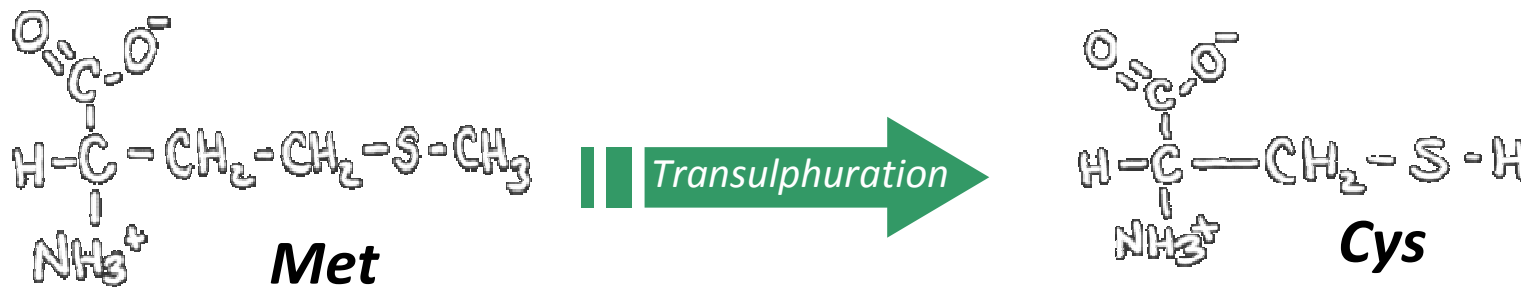
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Institute of Animal Nutrition, Estación Experimental del Zaidín (CSIC), Granada, Spain



ADVANCIA

INRA  
AGRO  
CAMPUS  
OUEST

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

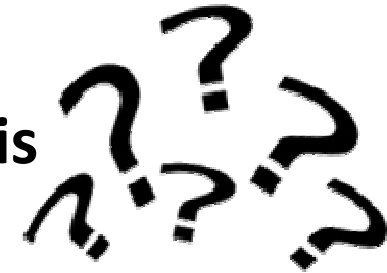


- Amino acid requirements are often evaluated through BW gain or N retention
- The amino acid composition of whole body protein is often assumed to be constant

- 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+
<b>Nutritional values, %</b>		
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

Cereals

41 %



Peas

25 %



Soybean meal

19 %



•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*

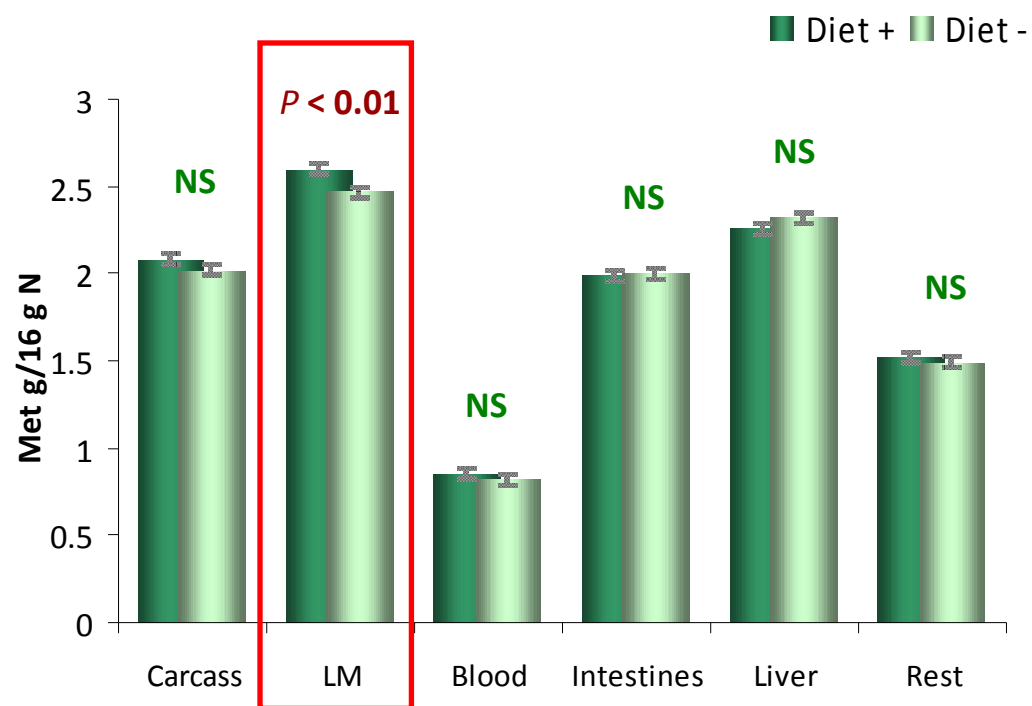
## Chemical composition of empty body, carcass and *Longissimus dorsi* muscle in piglets

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

<sup>2</sup>Expressed as nitrogen x 6.25.



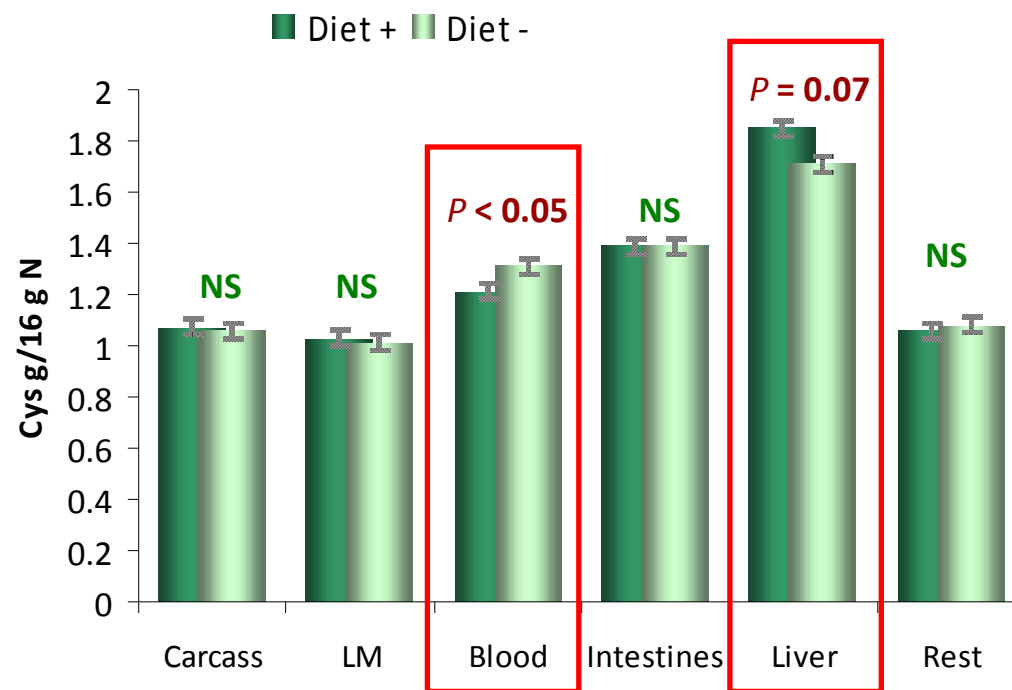
## Methionine content in protein of body tissues



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
<b>Whole body</b>				
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
<b>Carcass</b>				
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
<b>LD muscle</b>				
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

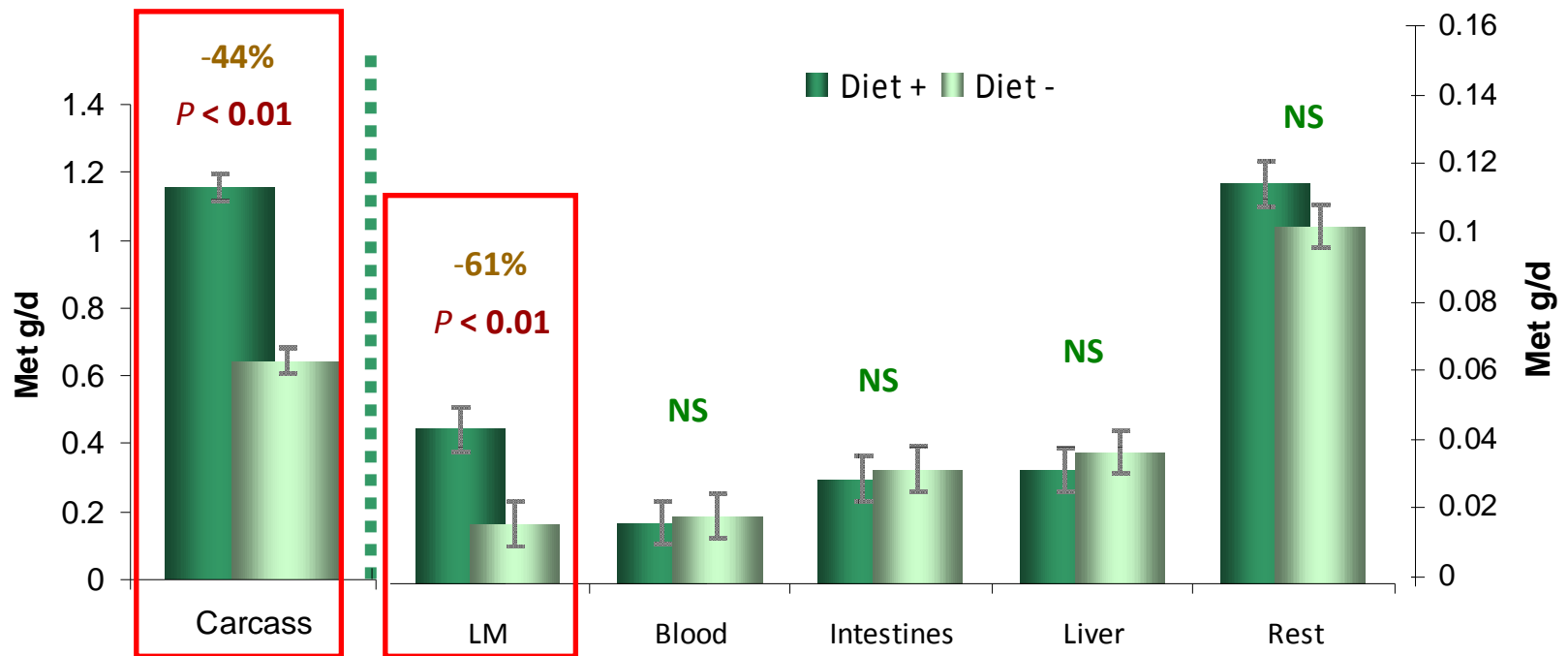
The gain contained LESS PROTEIN

The protein contained LESS MET

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

	Diet-	Diet+	P -value
<b>Blood</b>			
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
<b>Intestine</b>			
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
<b>Liver</b>			
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
<b>Rest</b>			
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

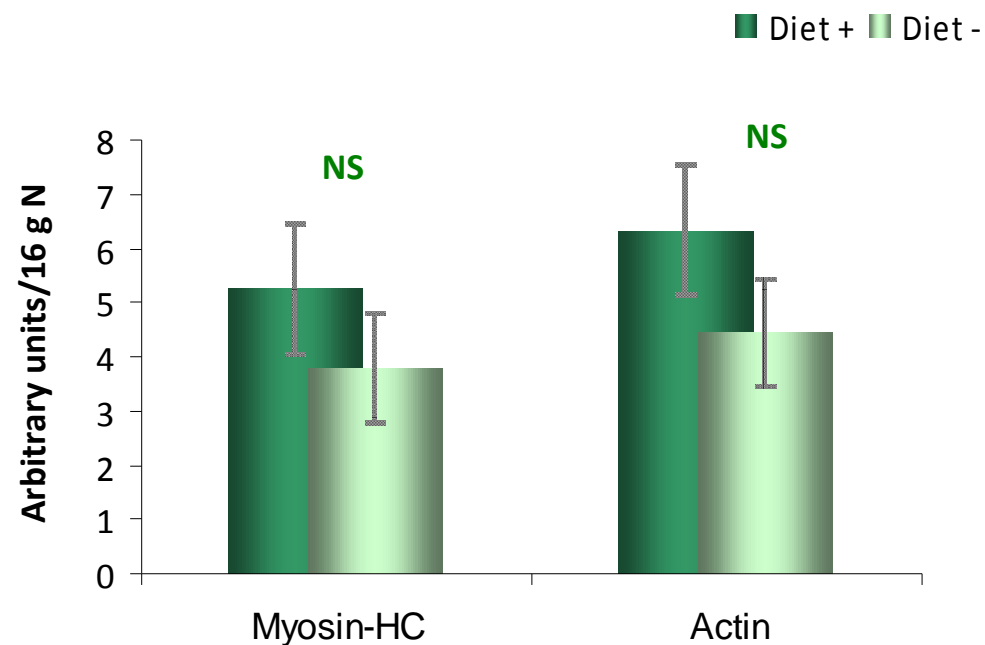
(Pearson & Young, 1989)

	MHC	Actin	Collagen
<b>% Amino acid</b>			
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

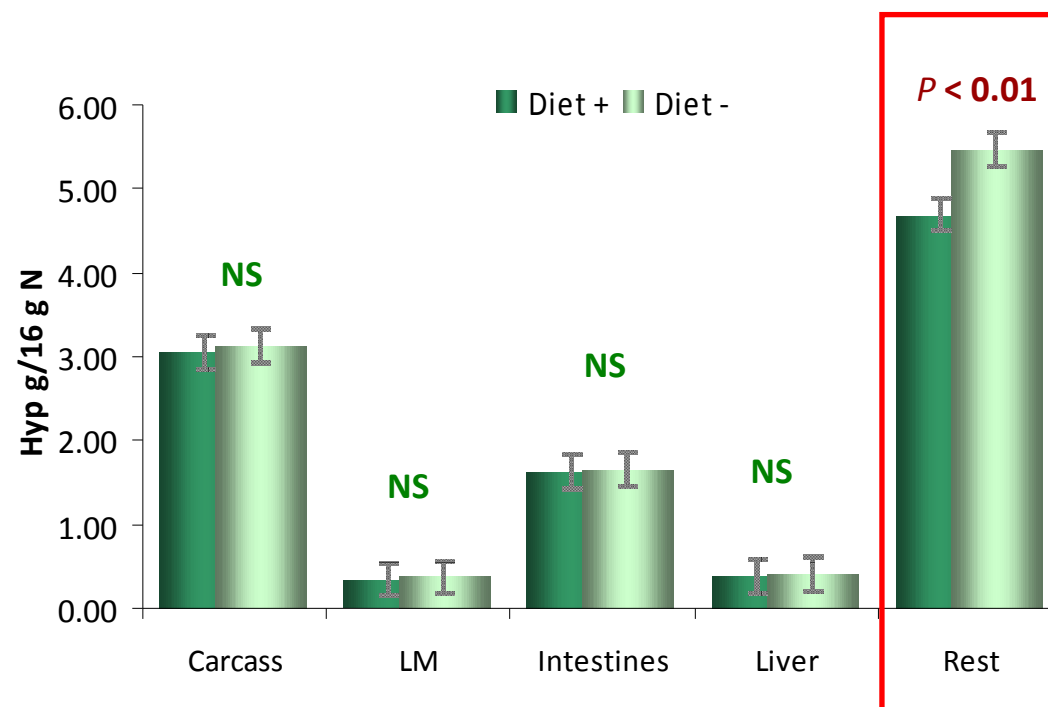
*Change in the Met  
content in LM*

*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)

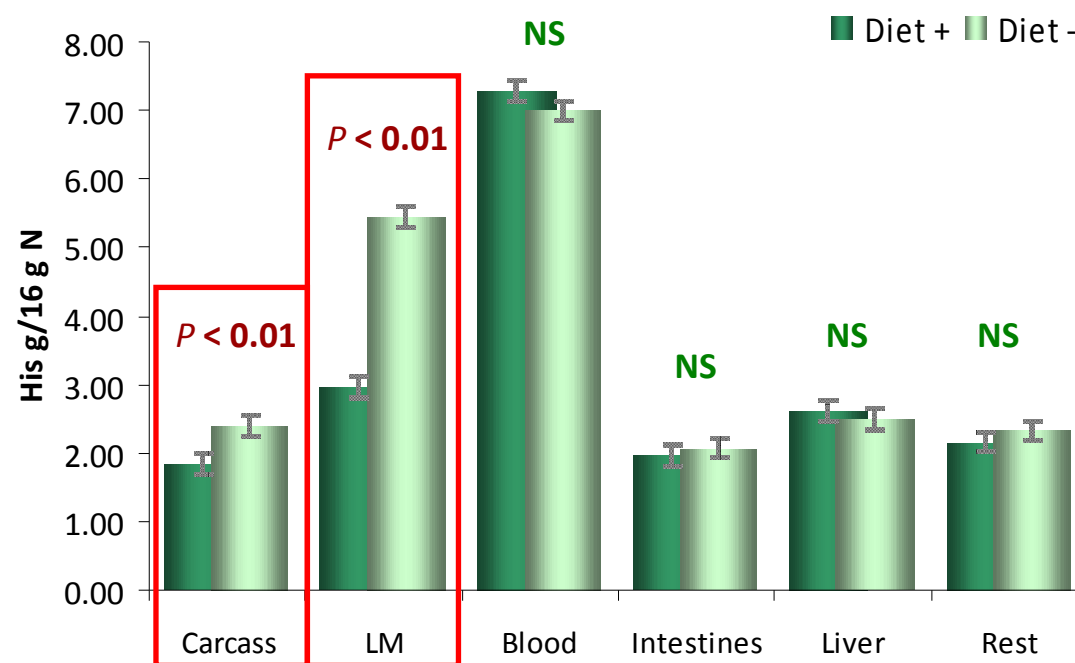


NS = not significant

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

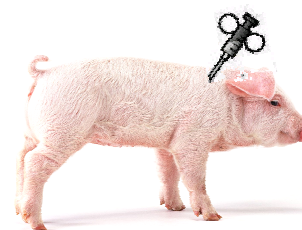


6 weeks of age  
(~14 kg)

DIET -

75 % *ad libitum*

DIET +



<sup>13</sup>C-Valine



← 10 days →

N balance trial and a comparative slaughter study

*Semitendinosus*

*Rhomboid*

*Liver*

*Skin*

*Longissimus dorsi*

*Small intestine*

*Kidneys*

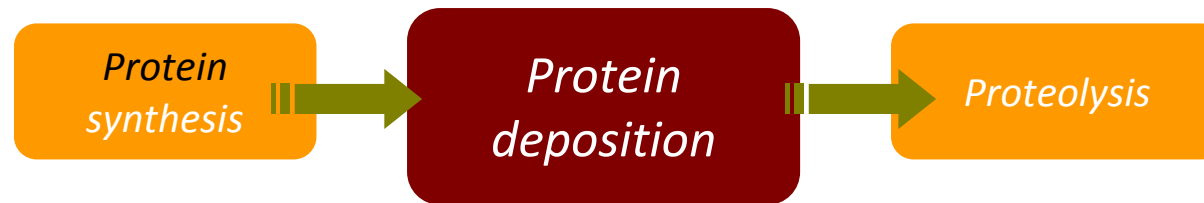
## Relative weight of body tissues in piglets

	Diet -	Diet +	<i>P</i> -value
<b>Tissue (g/kg BW)</b>			
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)



$$\text{Protein deposition} = \text{Protein synthesis} - \text{Proteolysis}$$

## Activity of proteolysis enzymes of body tissues in piglets

	Diet -	Diet +	P-value
<b>Proteasome activity*</b>			
<i>Semitendinous</i>	2.28	1.91	<0.05
<i>Longissimus dorsi</i>	2.17	1.96	NS
<i>Rhomboid</i>	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	<i>in process</i>		

\* Relative fluorescence units/min/mg protein

NS = not significant

	Diet -	Diet +	P-value
<b>Calpain activity*</b>			
<i>Semitendinous</i>	1.40	1.27	NS
<i>Longissimus dorsi</i>	1.67	1.50	NS
<i>Rhomboid</i>	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	<i>in process</i>		

\* 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
<b>ks (%/day)</b>			
<i>Semitendinous</i>	2.98	3.57	NS
<i>Longissimus dorsi</i>	3.14	4.58	<0.05
<i>Rhomboid</i>	3.07	2.76	NS
Liver	45.5	45.5	NS
Proximal jejunum	52.1	55.1	NS
Distal jejunum	<i>in process</i>		
Ileum	<i>in process</i>		
Kidneys	25.4	24.2	NS
Skin	<i>in process</i>		

% of protein mass synthesized per day

NS = not significant

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

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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