HMSeBA or Seleno-hydroxy-methionine: an efficient selenium source for pigs

M. Briens*, M. Jlali, F. Couloigner, P.A. Geraert and Y. Mercier

Adisseo France SAS ; *Strasbourg University, France
Selenium: key for the anti-oxidant value of sulphur amino acids

Sulfur amino acids, involved against oxidative stress

Oxidative stress induced more Cys consumed through GSH (Glu-Cys-Gly)

HMTBA induces more Cys produced, thus more anti-oxidant than Methionine
Selenium: key for the anti-oxidant value of sulphur amino acids

Msr system
MsrB: a selenoprotein

Met is not only oxidized, it has its own regeneration system

Met preserves Cys from oxidation

Methionine in proteins

‘Methionine Sulfoxide Reductases’ System

Methionine Sulfoxides (Met-S-(O) & Met-R-(O))

ROS

Native Protein

Oxidized Protein

Oxidative stress

REPAIR

+ + +

NATIVE PROTEIN

Met preserves Cys from oxidation

Selenium: key for the anti-oxidant value of sulphur amino acids
Se: key for selenoproteins

- Desiodinase isoforms: T4 to T3 conversion
- Glutathione peroxidase with tissue specificity depending on isoform
- MSR B: Reduction of methionine sulfoxide
- Selenium transport and possible peroxidase activity
- Sel W muscle metabolism and function
- Thioredoxin: antioxidant function

Seleno-protein characterized by a seleno-cysteine
Specific metabolism of selenium and seleno-amino acids AA

SeMet

Se-Cys

Selenite

Selenate

Intestinal barrier

Body proteins:
Se-containing proteins
1 Se-Met: 6-8000 Met

Se-Met → Transselenation → SeCystathionin → SeCys

SeCys β-lyase

Methyltransferase → Methylated selenol products

Methylation → Seleno-sugar

Excretion

Se-Cys

Selenide

H₂Se

Selenide

GSH blood
Reduction

Se-P

Se-Cys

UGA

Se-Cys residue

Selenoproteins:
GPx, TR, Desiodases, Selenoprotein P, ...

Adapted from Suzuki et al. 2005 and Thiry et al. 2012

Se-P: selenophosphate
Why Se-OH-Methionine?

Seleno-Hydroxy-Methionine (HMSeBA)

2-Hydroxy-4-MethylSelenoButanoic Acid

A source of Se-methionine  A source of Se-cysteine
Experimental design

- 7 treatments x 8 pens x 2 pigs/pen (112 pigs in total)
- Gilts of 26.73 ± 3.15 kg BW
- NC (no Se added), Sodium Selenite (SS), Seleno-yeast (SY), HMSeBA (SO)

<table>
<thead>
<tr>
<th>Se source</th>
<th>NC</th>
<th>SS-0.1</th>
<th>SS-0.3</th>
<th>SY-0.1</th>
<th>SY-0.3</th>
<th>SO-0.1</th>
<th>SO-0.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Se supplementation (ppm)</td>
<td>0</td>
<td>0.1</td>
<td>0.3</td>
<td>0.1</td>
<td>0.3</td>
<td>0.1</td>
<td>0.3</td>
</tr>
<tr>
<td>Measured Se (ppm)</td>
<td>0.11</td>
<td>0.20</td>
<td>0.38</td>
<td>0.22</td>
<td>0.42</td>
<td>0.21</td>
<td>0.41</td>
</tr>
</tbody>
</table>

- Growth Performance after 32 days of supplementation
- At d 32, all pigs for blood, liver and muscle (Psoas major) sampling
- Total Se concentration in plasma, liver and muscle
Methods

<table>
<thead>
<tr>
<th>%</th>
<th>Diet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barley</td>
<td>33.4</td>
</tr>
<tr>
<td>Wheat</td>
<td>20.0</td>
</tr>
<tr>
<td>Corn</td>
<td>15.0</td>
</tr>
<tr>
<td>Soybean meal (48% CP)</td>
<td>8.5</td>
</tr>
<tr>
<td>Wheat bran</td>
<td>8.0</td>
</tr>
<tr>
<td>Canola meal</td>
<td>6.2</td>
</tr>
<tr>
<td>Sunflower meal (36% CP)</td>
<td>2.8</td>
</tr>
<tr>
<td>Se free premix</td>
<td>0.55</td>
</tr>
</tbody>
</table>

NE (MJ/kg) 9.48
Protein (%) 15.5

Statistics
✓ SAS 9.1.3
✓ Relative bioavailability by slope ratio method (PROC NLIN SAS)

Se = a + a° X° + b_S x (b_TS x dose_SO + dose_SY)

Total Se analysis
✓ According to Mester et al., 2006
✓ Mineralisation with HN03 & H2O2
✓ ICP-MS

Tissue speciation (Se-Met & Se-Cys)
✓ According to Bierla et al., 2008
✓ Se-Cys is reduced and alkylated to be stabilised
✓ Then proteolytic digestion to release free AA, purified by size-exclusion HPLC
✓ Quantification of Se-Met and Se-Cys by reversed phase HPLC-ICP-MS
✓ HMSeBA was also quantified (Vacchina et al., 2010)
# Growth performance

<table>
<thead>
<tr>
<th>Treatment</th>
<th>NC</th>
<th>SS-0.1</th>
<th>SS-0.3</th>
<th>SY-0.1</th>
<th>SY-0.3</th>
<th>SO-0.1</th>
<th>SO-0.3</th>
<th>SEM</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>BW (kg)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial</td>
<td>26.79</td>
<td>26.91</td>
<td>26.84</td>
<td>27.00</td>
<td>26.34</td>
<td>26.76</td>
<td>26.48</td>
<td>0.34</td>
<td>0.81</td>
</tr>
<tr>
<td>Final</td>
<td>52.89</td>
<td>53.65</td>
<td>52.22</td>
<td>50.72</td>
<td>52.55</td>
<td>52.58</td>
<td>52.33</td>
<td>0.94</td>
<td>0.51</td>
</tr>
<tr>
<td>ADG (kg)</td>
<td>0.831</td>
<td>0.855</td>
<td>0.810</td>
<td>0.761</td>
<td>0.819</td>
<td>0.820</td>
<td>0.813</td>
<td>0.030</td>
<td>0.50</td>
</tr>
<tr>
<td>ADFI (kg)</td>
<td>1.834</td>
<td>1.874</td>
<td>1.792</td>
<td>1.734</td>
<td>1.801</td>
<td>1.804</td>
<td>1.788</td>
<td>0.040</td>
<td>0.44</td>
</tr>
<tr>
<td>FCR</td>
<td>2.21</td>
<td>2.19</td>
<td>2.21</td>
<td>2.28</td>
<td>2.19</td>
<td>2.20</td>
<td>2.20</td>
<td>0.01</td>
<td>0.78</td>
</tr>
</tbody>
</table>

Under experimental conditions, Se supplementation did not significantly change growth performance.
Higher circulating Se with organic Se source

**Plasma**

- Similar plasma Se for all diets at 0.1 mg Se/kg
- Increase dietary Se from 0.1 to 0.3 mg Se/kg increases plasma Se content only for organic Se sources (SY and SO)
- At 0.3 mg Se/kg SO had higher plasma Se content than SY
Se supplementation increases liver Se content
At 0.3 mg Se/kg organic Se source had higher liver Se content than inorganic
At all level, SO allows higher liver Se content than SY
Pigs fed HMSeBA show higher muscle Se deposition

Organic Se allows a better Se content compared to NC or inorganic Se
Increase of dietary Se level for organic Se source increases muscle Se
SO diets had higher muscle Se deposition than SY at all doses

Muscle Se concentration (mg Se/kg dry product)
HMSeBA is 100% efficient compared to seleno-yeast and selenite

- Inorganic Se is unable to increase muscle Se content
- In muscle, selenium from SO was 162% more deposited than SY
HMSeBA is 100% efficient compared to seleno-yeast

Based on iso-Se-Met (measured values)

- with 100% Se-OH-Met = 100% Se-Met
- and 60% Se-Met in selenized yeast
Higher SeCys in tissues with HMSeBA

Se species depending on the Se supply

✓ SeMet + SeCys allowed 100 % recovery of total Se in all treatments
✓ HMSeBA was not found in the muscle of broilers fed SO diets
✓ HMSeBA allowed a better content of SeCys than Seleno-Yeast

Bar chart showing Se speciation in muscle, mg/kg DM:
- Total Se
- SeMet
- SeCys
- SeMet + SeCys

Broiler trial

# x2 Se-Cys
Take Home Messages

- A new organic selenium source has been developed based on HMSeBA: 100% pure and reliable.
- This HMSeBA appears 100% efficient compared to Se-yeasts where Se-Met is the only active part.
- HMSeBA was more effective than SY to improve liver and muscle Se deposition in pigs.
- HMSeBA is 100% transformed into seleno-amino acids and allowed higher Se-Cys (in Se-proteins) and Se (deposition) in tissues compared to Se-Yeasts, demonstrated in broilers.
- Benefits of organic Se in animal nutrition will now be better demonstrated with this pure organic Se source.