Relative bioavailability of methionine hydroxy analog calcium salt compared to DL-methionine in broilers under heat stress

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- Introduction
- Objective
- Materials and Methods
- Results and Discussion
- Conclusions
Introduction

- Methionine is an essential and first limiting amino acid in poultry

- In order to meet the bird’s Met need, nutritionists commonly supplement methionine in broiler diets in order to balance the dietary amino acids.

- Methionine products commercially available include DL-methionine, liquid methionine-hydroxy analogue (MHA-FA), & methionine hydroxy analogue calcium salt (MHA-Ca).
Chemically, MHA is not an amino acid but it can be converted to Met in animals.

However, studies in poultry have indicated that inferior digestion and transformation of MHA-FA to L-Met reduces their Met value (Koban and Koberstein, 1984; Lemme, 2001; Drew et al., 2005).
Physiological evidences why MHA is less effective compared to DLM

- MHA is less efficiently incorporated into muscle tissue.
- Substantial fraction of MHA is lost via microbial degradation.
- MHA-di and -oligomers are poorly absorbed.
- Mechanism of absorption for MHA is less efficient.
- MHA is not an amino acid and hence, losses during the process of bio-conversion are inevitable.

(Saunderson, 1991; Lingens and Molnar, 1996; Maenz and Engele-Schaan, 1996; Drew and Maenz, 2001; Mitchell, 1996)
Average relative biological efficacy of MHA-Ca and liquid MHA-FA in broilers and layers on weight-to-weight basis compared to DL-Met

<table>
<thead>
<tr>
<th>Species</th>
<th>Parameter</th>
<th>MHA-Ca (Lemme, 2004; Elwert et al., 2008; Evonik, 2012a, b)</th>
<th>MHA-FA (Lemme et al., 2011)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of data sets</td>
<td>Relative effectiveness Wt./Wt. basis*</td>
<td>No. of data sets</td>
</tr>
<tr>
<td>Broilers + Layers</td>
<td>BWG and Egg mass</td>
<td>77</td>
<td>63.8</td>
</tr>
<tr>
<td>Broilers</td>
<td>FCR</td>
<td>74</td>
<td>63.2</td>
</tr>
</tbody>
</table>

* based on assumed purity of 85% for MHA-Ca
** based on assumed purity of 88% for MHA-FA
Overall, the relative biological effectiveness of MHA-FA/MHA-Ca compared with DL-Met has been considered to be about 65% on a product-to-product basis.

However, it is sometimes debated that methionine value of MHA-FA or MHA-Ca are higher than 65% during summer conditions.

Evaluation of bioefficacy or nutritional value under heat stress condition comparing MHA-Ca with DL-Met are limited.
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Objective

- Determine the bioavailability of MHA-Ca relative to DL-methionine under heat stress conditions using a simultaneous dose-response trial.
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**Experimental Design**

- **Birds**: 450 male Arbor Acres Plus broilers
- **Housing**: 9 treatments with 10 replicates per treatment & 5 birds per replicate. Rice hull littered pens in an open house (temperature was recorded twice daily)
- **Period**: Starter (day 1 to 14), grower (day 15 to 28), & finisher (day 29 to 42)
- **Diets**: Corn-soybean meal based, mash feed
- **Treatments**:
  - 1: control, deficient in dietary Met+Cys, w/o supplementation of any Met sources
  - 2-5: control diet plus 4 graded levels of DL-methionine (0.03 %, 0.06 %, 0.10 % and 0.15 %)
  - 6-9: control diet plus 4 graded levels of MHA-Ca (0.03 %, 0.06 %, 0.10 % and 0.15 %)
- **Parameters**: Body weight gain, feed intake, feed conversion ratio, carcass yield and breast meat yield
### Basal Diets: Ingredient and nutrient compositions

<table>
<thead>
<tr>
<th>Ingredients, %</th>
<th>Period</th>
<th>Nutrient Composition, % (calculated)</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Starter 1-14 days</td>
<td>Grower 15-28 days</td>
<td>Finisher 29-42 days</td>
</tr>
<tr>
<td>Corn</td>
<td>52.94</td>
<td>55.79</td>
<td>55.62</td>
</tr>
<tr>
<td>SBM, 48 % CP</td>
<td>34.60</td>
<td>28.60</td>
<td>27.10</td>
</tr>
<tr>
<td>Rice bran</td>
<td>4.98</td>
<td>8.00</td>
<td>9.36</td>
</tr>
<tr>
<td>Soybean oil</td>
<td>3.53</td>
<td>3.73</td>
<td>4.40</td>
</tr>
<tr>
<td>L-Lysine*HCl</td>
<td>0.13</td>
<td>0.18</td>
<td>0.10</td>
</tr>
<tr>
<td>L-Threonine</td>
<td>0.08</td>
<td>0.10</td>
<td>0.06</td>
</tr>
<tr>
<td>Mineral &amp; vitamin</td>
<td>3.69</td>
<td>3.55</td>
<td>3.31</td>
</tr>
<tr>
<td>Coccidiostat</td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>Total</td>
<td>100.00</td>
<td>100.00</td>
<td>100.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>

*Percentage values are rounded to two decimal places.*
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Recorded temperatures compared with the recommended optimum for Arbor Acres Plus (2009)

- Housing temperature in this trial was higher than optimal according to Arbor Acres performance guidelines.
- As a result FCR increased for all the treatments (2.1-2.4).
- However, currently obtained relative bioavailability values for MHA-Ca (~65%) suggest no benefit of feeding MHA-Ca during a heat stress event.
## Effects of DL-Met or MHA-Ca on growth performances of male Arbor Acres Plus broilers (1 to 42 days of age)

<table>
<thead>
<tr>
<th>Trt.</th>
<th>Supplemental methionine source</th>
<th>Addition of product, %</th>
<th>Weight gain, g</th>
<th>Feed intake, g</th>
<th>FCR</th>
<th>Carcass yield, g</th>
<th>Breast meat yield, g</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-</td>
<td>0.00</td>
<td>1658&lt;sup&gt;d&lt;/sup&gt;</td>
<td>3692</td>
<td>2.39&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1220&lt;sup&gt;c&lt;/sup&gt;</td>
<td>365&lt;sup&gt;c&lt;/sup&gt;</td>
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<tr>
<td>2</td>
<td>DL-Methionine</td>
<td>0.03</td>
<td>1756&lt;sup&gt;bcd&lt;/sup&gt;</td>
<td>4006</td>
<td>2.29&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>1260&lt;sup&gt;bcd&lt;/sup&gt;</td>
<td>390&lt;sup&gt;bcd&lt;/sup&gt;</td>
</tr>
<tr>
<td>3</td>
<td>DL-Methionine</td>
<td>0.06</td>
<td>1830&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>3946</td>
<td>2.16&lt;sup&gt;bcd&lt;/sup&gt;</td>
<td>1350&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>427&lt;sup&gt;ab&lt;/sup&gt;</td>
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<tr>
<td>4</td>
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<td>0.10</td>
<td>1852&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>3952</td>
<td>2.14&lt;sup&gt;d&lt;/sup&gt;</td>
<td>1325&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>421&lt;sup&gt;ab&lt;/sup&gt;</td>
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<tr>
<td>5</td>
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<td>1908&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4021</td>
<td>2.11&lt;sup&gt;d&lt;/sup&gt;</td>
<td>1383&lt;sup&gt;a&lt;/sup&gt;</td>
<td>444&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>6</td>
<td>MHA-Ca</td>
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<td>3964</td>
<td>2.29&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>1268&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>387&lt;sup&gt;bc&lt;/sup&gt;</td>
</tr>
<tr>
<td>7</td>
<td>MHA-Ca</td>
<td>0.06</td>
<td>1769&lt;sup&gt;bcd&lt;/sup&gt;</td>
<td>3940</td>
<td>2.23&lt;sup&gt;bcd&lt;/sup&gt;</td>
<td>1278&lt;sup&gt;abc&lt;/sup&gt;</td>
<td>402&lt;sup&gt;abc&lt;/sup&gt;</td>
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<tr>
<td>8</td>
<td>MHA-Ca</td>
<td>0.10</td>
<td>1839&lt;sup&gt;abc&lt;/sup&gt;</td>
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<td>2.17&lt;sup&gt;bcd&lt;/sup&gt;</td>
<td>1295&lt;sup&gt;abc&lt;/sup&gt;</td>
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<tr>
<td>9</td>
<td>MHA-Ca</td>
<td>0.15</td>
<td>1873&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>4009</td>
<td>2.14&lt;sup&gt;cd&lt;/sup&gt;</td>
<td>1353&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>433&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

* Means with different superscripts within the same column differ significantly (P < 0.05).
MHA-Ca was 68 % as effective as DL-Met on product basis for weight gain in broilers

Weight gain = 1659 + 277 (1 – exp (−14.3 DL-Met − 9.7 MHA-Ca))

$R^2 = 0.99$

Relative bioavailability:
DL-Met: 100 %
MHA-Ca: 68 %
MHA-Ca was 67 % as effective as DL-Met on product basis for FCR in broilers

\[
\text{FCR} = 2.40 - 0.30 \left(1 - \exp(-20.2 \text{ DL-Met} - 13.5 \text{ MHA-Ca})\right)
\]

\[R^2 = 0.98\]

Relative bioavailability:
- DL-Met: 100 %
- MHA-Ca: 67 %
MHA-Ca was 56 % as effective as DL-Met on product basis for carcass weight in broilers.

Carcass weight (g) = 1222 + 189 (1 – exp (–11.5 DL-Met – 6.5 MHA-Ca))

$R^2 = 0.87$

Relative bioavailability:
DL-Met: 100 %
MHA-Ca: 56 %
MHA-Ca was 57 % as effective as DL-Met on product basis for breast meat in broilers

Breast meat (g) = 365 + 86 (1 – exp (–14.4 DL-Met – 8.4 MHA-Ca))

\( R^2 = 0.91 \)

Relative bioavailability:
DL-Met: 100 %
MHA-Ca: 57 %
Summary and conclusions

- Slope-ratio analysis revealed that bioefficacy of MHA-Ca relative to the DL-Met was 68 and 67 % for weight gain and FCR, on a product basis, respectively.

- Similarly, MHA-Ca was 56 and 57 % as efficient as DL-Met for carcass weight and breast meat yield, respectively, on weight to weight basis.

- These estimates are significantly lower than the active portion of 84% in MHA-Ca.

- Overall, bioefficacy values for MHA-Ca relative to DL-Met obtained from this trial did not differ from those (~65%) obtained in the previous studies, suggesting that there is no additional benefit of feeding MHA during heat stress event.
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