Rhodimet®

# BROILERS

2025

# RHODIMET® AT88
# EFFICACY



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Methionine source supplementation, under Rhodimet® AT88, Adisseo liquid OH-Methionine, plays a beneficial role in sustaining broiler growth performance. It is illustrated by numerous *in vivo* trials in various experimental facilities worldwide and in Adisseo own research facilities, but also in large-scale field trials. Work was also conducted on aggregated available trial data via meta-analysis and powerful modeling & statistical approaches to demonstrate the efficacy of OH-Methionine.

## CONTENT



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# 1 *In vivo* trials in various conditions

## A. Trial conducted at BARC, Thailand

### Context

- Trial conducted at Bangkok Animal Research Center (BARC in Thailand) in 2014

### Objective

- To compare DL-Methionine (DL-Met at 99%) and OH-Methionine (OH-Met at 88%) in diets using the same proportional amino acid to energy ratio in a two-phase feeding program up to 35 days

### Animal & experimental diets

- 256 male ROSS 308 broilers divided into 2 treatments: 8 replicates of 16 birds per treatment
- Reared up to 35 days
- Two experimental diets (in 2 phases) based on maize and soybean meal at requirement for Total Sulfur Amino Acids level supplemented either with DL-Met or liquid OH-Met

### Results

No differences were observed between the two sources of methionine for Body weight gain, Feed intake or Feed Conversion Ratio (FCR).

**Table 1**

**EFFECTS OF METHIONINE SOURCES ON BROILER PERFORMANCE (0-35 DAYS OF AGE)**

| METHIONINE SOURCES | INITIAL BODY WEIGHT (G) | FINAL BODY WEIGHT (G) | BODY WEIGHT GAIN (G) | FEED INTAKE (G) | FCR[1] | FCR[2] | LIVABILITY (%) |
|---|---|---|---|---|---|---|---|
| DL-MET | 45 | 2784 | 2740 | 3984 | 1.454 | 1.464 | 97.66 |
| OH-MET | 45 | 2791 | 2747 | 3994 | 1.454 | 1.454 | 100.00 |

[1] *Feed Conversion Ratio uncorrected for mortality and culls*
[2] *Feed Conversion Ratio corrected for mortality and culls*

**OH-Methionine and DL-Methionine,** when **supplemented on an equimolar basis,** are **equally effective in improving performance of broilers** (weight gain and Feed Conversion Ratio).


**References**

*Short Report n°0: The 100% efficacy of DL-Methionine and DL-hydroxy-methionine confirmed by trials using practical diets in independent research facilities (Bangkok Animal Research Center and Schothorst Feed Research)*

## B. Trial conducted at Schothorst Feed Research, The Netherlands

### Context

- Trial run at Schothorst Feed Research (The Netherlands) in 2014

### Objective

- To compare OH-Methionine (OH-Met) and DL-Methionine (DL-Met) in diets based on standard Total Sulfur Amino Acids (TSAA) recommendations (Aviagen, 2010) and using different levels of methionine sources supplementation in practical range, above or below requirements

### Animal & experimental diets

- 1680 male and female Ross 308 broilers
- Reared up to 28 days
- A basal diet deficient in TSAA
- Supplemented diets formulated using different levels of methionine (Met) supplementation around: below (-20% and -10%), adequate for the starter period (0-10 days) and below (-20% and -10%), adequate or above (+10%) for the grower period (10-28 days)

### Results

During the starter phase, no effects relating to methionine sources or methionine sources doses were observed, suggesting that the methionine requirement for this period was probably lower than expected. No methionine sources effect was observed irrespective of the TSAA level.

On the overall growing period, TSAA levels significantly affected body weight gain and Feed Conversion Ratio. No significant effects relating to methionine source or interaction between Met source dose and Met source were observed except for the European Poultry Efficiency Factor (EPEF) and the FCR adjusted at 1500 g of body weight, which appeared significantly better with OH-Met at the higher TSAA level when compared to DL-Met. As expected, a significant sex effect and interaction between sex and methionine levels was observed. However, no interaction between sex effect and methionine source was detected confirming that methionine sources efficacy was independent of sex.

The methionine efficiency, which is calculated in mg of extra methionine, providing 1 gram of extra gain in comparison to the non-supplemented control diet with no added methionine sources, was calculated for the different TSAA levels. For the overall growing period, the methionine efficiency was equivalent between sources for the first two doses but significantly better at requirement level and above with OH-Methionine compared to DL-Methionine.

When compared over a **practical range of doses on equimolar basis,** both **methionine sources sustain similar growth** performances and their **relative biological values are similar.**

**References**

*Scientific publication: Comparison of methionine sources around requirement levels using a methionine efficacy method in 0 to 28-day-old broilers, Agostini et al., 2016, Poultry Science*

*Short Report n°0: The 100% efficacy of DL-Methionine and DL-hydroxy-methionine confirmed by trials using practical diets in independent research facilities (Bangkok Animal Research Center and Schothorst Feed Research)*

## C. 3 trials performed at CERN (Adisseo), France

### trial 1 OH-METHIONINE AND L-METHIONINE EFFECT ON BROILER GROWTH PERFORMANCE

### Context

- Trial conducted at CERN (Center of Expertise and Research in Nutrition) facilities, Adisseo, France in 2017

### Objectives

- To compare the effects of L-Methionine and OH-Methionine on broiler performance at different Total Sulfur Amino Acids (TSAA) levels around the requirement
- To determine the bioequivalence of these two methionine sources.

### Animal & experimental diets

- 630 Ross PM3
- Reared from 1 to 36 days
- A basal diet deficient in TSAA and six supplemented treatments with either L-Methionine (L-Met at 99%) or OH-Methionine (OH-Met at 88%) with equimolar doses of methionine sources around the requirement in TSAA to the deficient basal diet in the starter phase (0.16, 0.36 and 0.46%), the grower phase (0.15, 0.33 and 0.42%) and the finisher phase (0.07, 0.22 and 0.29%)

### Results

**Broilers' growth performance with L-Methionine or OH-Methionine**

In supplemented treatments, feed intake was not affected by the methionine dose and was similar between OH-Met and L-Met-fed birds. Body weight, body weight gain, Feed Conversion Ratio and methionine efficacy were significantly improved when methionine level was increased. No significant difference of performance was found between L-Met and OH-Met-fed birds. These results are consistent with previous findings which demonstrated that OH-Met is efficiently converted into L-Methionine in the body and is as good as other methionine sources at sustaining animal growth performance

**Determination of OH-Methionine bio-efficacy**

Exponential models with separate plateaus have been applied to growth performance from 1 to 36 days to determine the bioequivalence between L-Methionine and OH-Methionine. Results are shown in Figure 1 and demonstrated that no difference of growth response exists between the two methionine sources. The biological value of both OH-Methionine and L-Methionine was determined to have a confidence interval of [98.2%; 102.4%].

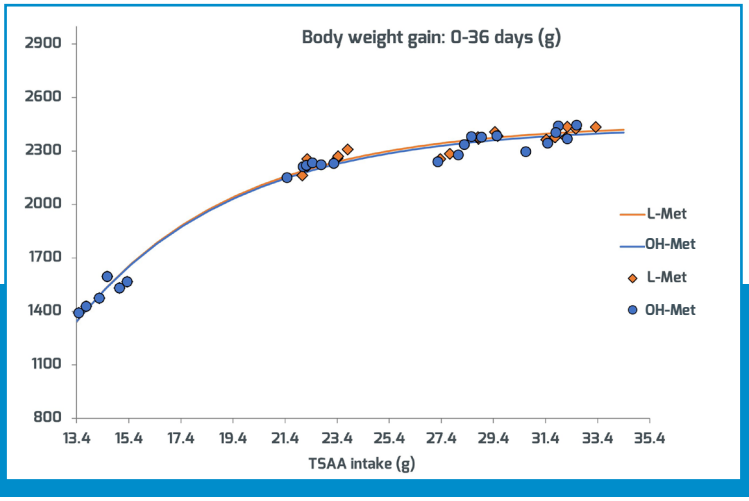



**Figure 1**

**Exponential of body weight gain as response to TSAA intake of broilers fed either L-Methionine or OH-Methionine from 1 to 36 days**

**OH-Methionine is as efficacious as L-Methionine** in sustaining broiler growth performance, when supplied at doses around TSAA requirement. The **bioequivalence** of **OH-Methionine relative to L-Methionine is 100%.**

**References**

*Short Report n°8: OH-Methionine and L-Methionine are equivalent for broilers*

## trial 2 L-METHIONINE, DL-METHIONINE AND OH-METHIONINE EFFECT ON BROILER GROWTH PERFORMANCE

### Context

Trial conducted at CERN facilities (Center of Expertise and Research in Nutrition), Adisseo, France in 2017

### Objectives

- To compare the effect of L-Methionine (L-Met at 99%), OH-Methionine (OH-Met at 88%) and DL-Methionine (DL-Met at 99%) on growth performances of broilers reared from 0 to 42 days
- To assess the bio-efficacy of these methionine (Met) sources using an exponential model with separate plateaus

### Animal & experimental diets

- 1,365 ROSS PM3 broilers
- Reared from 0 to 42 days old, divided into three periods: 0-14 d, 15-28 d and 29-42 d
- Basal diet deficient in methionine, with corn and soybean meal
- 4 increasing doses of methionine sources were supplemented on equimolar basis to a basal diet deficient in Met, using either DL-Methionine, OH-Methionine or L-Methionine.

### Results

**OH-Methionine, L-Methionine and DL-Methionine sources result in the same broiler growth performance**
No difference between the three methionine sources is observed over the 0-42 d period.

**Determination of OH-Methionine bio-efficacy**
There is no significant difference between methionine sources (P = 0.52). The relative efficacy of OH-Met vs DL-Met is 101% [97.8; 105%], and the relative efficacy of OH-Met vs L-Met is 102% [98.0; 105%].

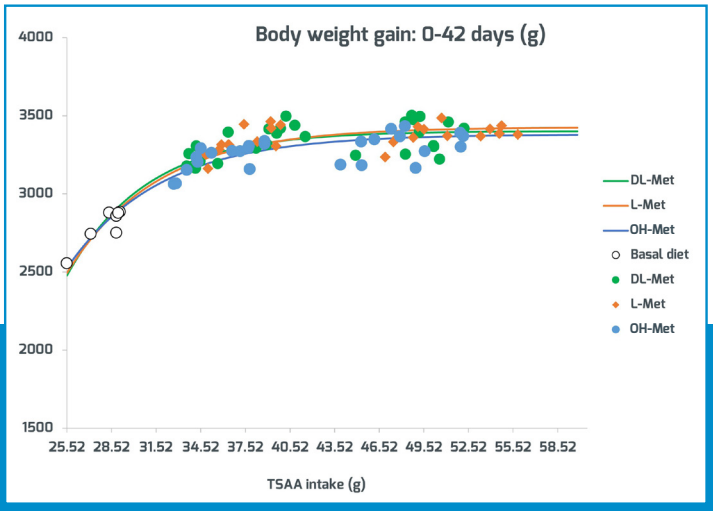



**Figure 2**

**Body weight gain vs TSAA intake**

The conclusion is: **efficacy of OH-Methionine to sustain broiler growth** performances

**References**

*Short Report n°9: L-Methionine, DL-Methionine and DL-Hydroxy Methionine are equivalent to sustain broiler growth performance*

*Poster at WPC, September 2016 in Beijing (China)*
*Magazine article: Dolores I. Batonon-Alavo & Yves Mercier. 2017. Different methionine sources: same broiler performance. All about feed, Vol 25, N°2, 2017.*
*Presented at JRA (Journées de la Recherche Avicole), March 2019 in Tours (France)*
*Presented at PSA, July 2019 in Montreal (Canada)*

## C. 3 trials performed at CERN (Adisseo), France

trial 3

# OH-METHIONINE UNDER POWDER OR LIQUID FORM AND DL-METHIONINE: EFFECT ON BROILER GROWTH PERFORMANCE

## Context

Trial conducted at CERN facilities (Center of Expertise and Research in Nutrition), Adisseo, France in 2018

## Objective

- To compare the effects of OH-Methionine (OH-Met at 88%) in liquid or powder form and DL-Methionine (DL-Met at 99%) on broiler performance when provided at Total Sulfur Amino Acids (TSAA) requirement level.

## Animal & experimental diets

- 480 Ross PM3 male chickens
- Reared for 35 days
- A basal diet based on corn, soybean meal and wheat
- 4 diets were formulated according to Aviagen (2014) amino acids recommendations: one basal diet and 3 supplemented treatments with OH-Met in powder, OH-Met in liquid or DL-Met

## Results

There is a significant difference of performance (on Figure 3 on Feed Conversion Ratio) between the negative control diet and supplemented diets during the full 35 days. All methionine sources are similar in terms of efficacy.

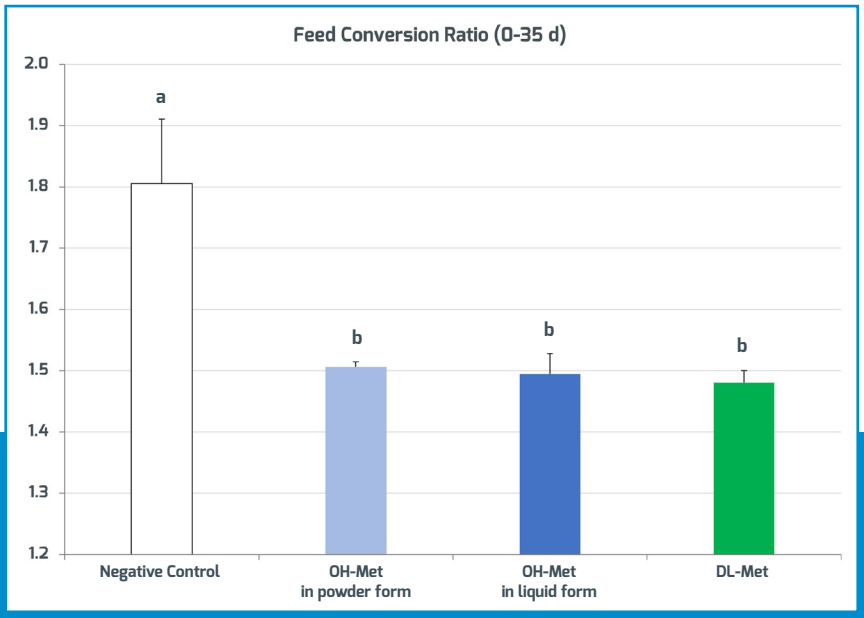



**Figure 3**

**Feed Conversion Ratio (0-35 days)**

**OH-Methionine** (powder or liquid form) is **an efficient methionine source** that increases **broiler growth performance.**

**References**

*Short Report n°12: Liquid OH-Methionine, a formulation of OH-Met calcium salt & liquid OH-Met and DL-Methionine have the same bio-efficacy to sustain broiler performances*

## D. Trial conducted on yellow-feathered broilers with South China Agricultural University, China

### DETERMINATION OF TOTAL SULFUR AMINO ACIDS REQUIREMENT & COMPARISON OF METHIONINE SOURCES ON FAST-GROWING, YELLOW-FEATHERED CHICKENS AT GROWER STAGE

### Context

- Trial conducted in collaboration with South China Agricultural University (China) at the test site of one of the biggest yellow-feathered broiler integrators in China

### Objective

- To investigate the effects of different levels of Total Sulfur Amino Acids (TSAA) of diets on growth performance of Lingnan yellow-feathered broilers

### Animal & experimental diets

- 1,440 male Lingnan yellow-feathered broilers
- Reared during the grower phase (22 to 42 days)
- Corn-soybean meal based diet with nutritional levels referenced to the Chinese chicken feeding standards (NY/T33-2004) for yellow-feathered broiler chickens, and feed formulation was calculated according to the Chinese Feed Composition Table (15th edition)

### Results

**Improved performance with TSAA level in a similar way for methionine sources**

With the increase of TSAA level in the diet, there were significant changes in daily weight gain, daily feed intake, and carcass trait compared to basal diet. It indicates that the reasonable addition of sulfur amino acids in the diet can effectively reduce the feed intake (ADFI), increase daily weight gain (ADG) and improve feed to gain ratio (F/G) of Lingnan yellow-feathered broiler chickens between 22-42 days of age.

**Determination of TSAA requirement by modeling**

We built mathematical models to simulate the relationship between requirements and growth curves. Generally, as nutrients are continuously added into diet, animal growth reaches a plateau where changes are no longer significant. In this experiment, we applied a mathematical model on growth performance indicators responding to dietary level of sulfur amino acids.

The TSAA requirement of yellow-feathered chicken using broken-line model was 0.44% and 0.51% for ADG and Feed Conversion Ratio (FCR) respectively. Likewise, TSAA requirement of yellow-feathered chicken using quadratic plateau model was 0.45% and 0.52% for ADG and FCR, respectively.

The results calculated were slightly different from NRC (1994) and yellow-feathered broiler feeding standards (2004, China), which increasingly highlight the significance of precisely measuring the TSAA requirement of yellow-feathered chickens and could possibly be linked with factors such as yellow-feathered broiler breeds and feeding conditions.

These results re-emphasise that the **amount of TSAA in the diet should be adjusted in practical production to accurately meet animal requirements.**

**References**

*Short Report n°28: Determination of Total Sulfur Amino Acids requirement of fast-growing yellow-feathered chickens at grower stage*

## E. Trial conducted at the University of Veterinary and Animal Sciences Lahore, Pakistan

### Context

- Trial conducted at the University of Veterinary and Animal Sciences Lahore, Pakistan in 2022

### Objective

- To compare the bio-efficacy of OH-Methionine to DL-Methionine on growth performance of broiler chickens

### Animal & experimental diets

- 720 broilers
- Reared for 35 days
- Basal diet with mainly corn and soybean meal (3 feeding phases: starter, grower and finisher)
- 6 dietary treatments: basal diet supplemented with either DL-Methionine (DL-Met at 99%) or OH-Methionine (OH-Met at 88%), at 3 levels: 90% of Total Sulfur Amino Acids (TSAA) requirement level, at TSAA requirement level and 115% of TSAA requirement level

### Results

Similar growth performance was observed with both Met sources and at all three levels of TSAA (Table 2). Importantly, there was a tendency (P=0.06) towards lower feed intake and improved Feed Conversion Ratio (P=0.09) by around 2% with OH-Met compared with DL-Met.

**Table 2**

**GROWTH PERFORMANCE OF BROILERS ON THE PERIOD: 1 TO 35 DAYS**

| SOURCE | TSAA LEVEL (%) | FEED INTAKE (g) | BODY WEIGHT GAIN (g) | FEED CONVERSION RATIO |
|---|---|---|---|---|
| DL-MET | | 3338.25 ↓ | 2330.04 | 1.43 ↓ |
| OH-MET | | 3287.17 ↓ | 2335.00 | 1.40 ↓ |
| *P-VALUE* | | *0.067* | *0.872* | *0.092* |
| DL-MET | 0.72 | 3315.25 | 2295.25 | 1.44 |
| | 0.80 | 3308.75 | 2344.75 | 1.41 |
| | 0.92 | 3390.75 | 2350.12 | 1.44 |
| OH-MET | 0.72 | 3252.87 | 2322.25 | 1.40 |
| | 0.80 | 3340.00 | 2363.50 | 1.41 |
| | 0.92 | 3268.00 | 2319.25 | 1.41 |
| *P-VALUE* | | *0.078* | *0.707* | *0.447* |

The data showed that **OH-Met is an efficient source of methionine.**

## F. Trial conducted at SCEA (Société Civile d'Exploitation Agricole), Kériotel Pluzerec, France

### Context

- Trial conducted at the SCEA of Kériotel Pluzerec, Plussulien, France in 2022

### Objective

- To determine the efficacy of OH-Methionine in broiler diets compared to the DL-Methionine using a traditional and an innovative statistical approaches

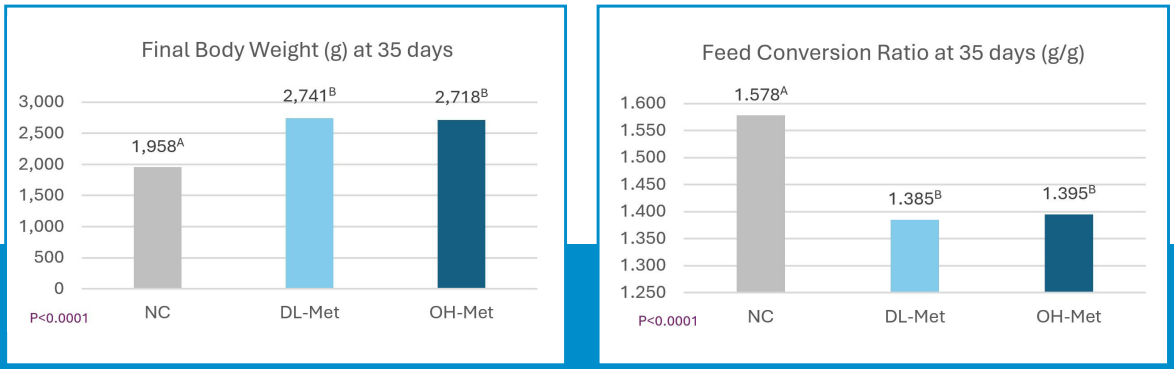
### Animal & experimental diets

- 4,200 broilers evenly distributed in 3 groups with 35 replicates of 40 birds each
- Reared for 35 days
- Basal diet with corn, wheat and soybean meal (3 feeding phases: starter, grower and finisher)
- 3 dietary treatments: a negative control (NC) diet formulated to be deficient in methionine+cysteine (Met+Cys), two treatment diets (DL-Met and OH-Met) formulated to match the Aviagen suggested recommendations for Met+Cys adding respectively DL-Methionine or OH-Methionine (two methionine sources) at equimolar basis.

### Results

Feeding broilers with diet deficient in methionine resulted in a statistically significant ($p<0.0001$) worsening of all zootechnical performance (Figure 4), compared to broiler fed balanced diets for Methionine content. Comparing the performances of groups receiving DL-Met or OH-Met via a classic but robust (35 replicates) statistical approach (ANOVA) or via an innovative one (noninferiority or equivalence test), no statistical differences were recorded.

**Figure 4**




**Final Body Weight and global Feed Conversion Ratio of broilers fed for 35 days negative control and methionine sources added diets.**
**Means with different letters differ statistically, $p<0.0001$.**

Both statistical approaches confirm the **same efficacy of both (DL-Met and OH-Met) sources of methionine.**

**References**

*Short Report n°34: 100% efficacy of OH-Methionine in 35-day-old broilers confirmed by traditional (one way ANOVA) and new (non-inferior) statistical approaches*

# 2 Large scale field trial: Trial on more than 1 million broilers conducted with a poultry production organisation in France

## Context

- Trial conducted at a French poultry production organisation from July 2019 to May 2020

## Objective

- To compare the performance of broilers fed with either DL-Methionine (DL-Met) or OH-Methionine (OH-Met) under field conditions

## Animal & experimental diets

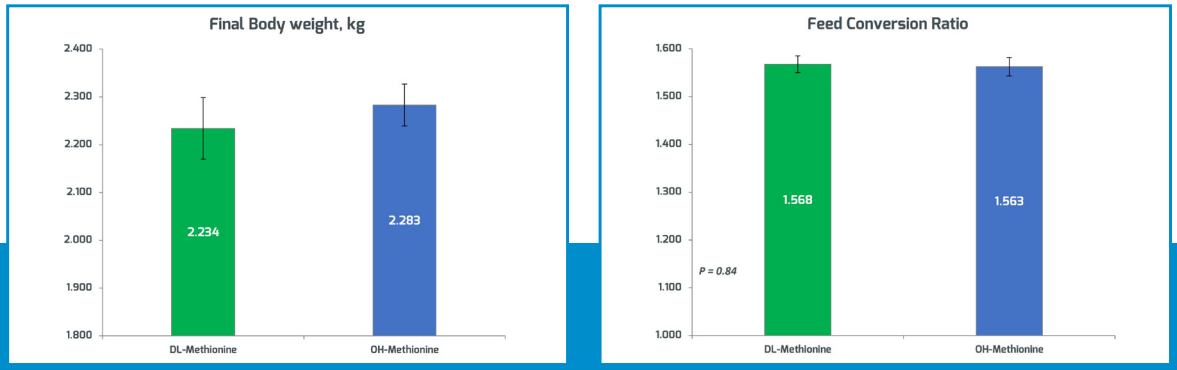
- 1,189,000 day-old Ross 308 male broiler chickens
- Reared for 35 days +/-1 day
- Diets formulated in a feed plant using corn, soybean meal, wheat and other local ingredients. The feed ingredients were subject to change; but nutrients levels remained constant.
- Diets supplemented at the recommended levels in sulfur amino acids for four feeding phases: starter (0 to 9 days old), grower 1 (10 to 19 days old), grower 2 (20 to 28 days old) and finisher (29 to 35 days old)
- Diets supplemented either with DL-Methionine or OH-Methionine (100% Methionine value for feed formulation i.e. 1 kg DL-Met = 1.12 kg OH-Met)

➝ **It means: ~500,000 birds per methionine source and ~25 replicates per methionine source**

## Results

After removal of outliers, a total of 24 farms (475,389 broilers) received the DL-Met treatment whereas 26 farms (562,400 broilers) received the OH-Met based treatment. No significant effect of the farm was observed on the performance criteria. Daily feed intake (P = 0.46), daily weight gain (P = 0.61) and final body weight (P = 0.58) were not significantly different between DL-Met and OH-Met. This results in a similar Feed Conversion Ratio (P = 0.84) for both DL-Met and OH-Met. Mortality rate was 4.72% and 4.17%, for DL-Met and OH-Met respectively and was considered acceptable for the different farms.

**Figure 5**




**Growth performance results for birds fed with either a DL-Met or OH-Met based treatments in a field trial involving 50 farms**

DL-Met and OH-Met are equivalent for sustaining **broiler growth performance as shown by 1,038,000 birds. OH-Methionine is an efficient source of methionine.**

### References

*Short Report n°23: The 100% efficiency of OH-Methionine confirmed by more than 1,000,000 birds Presented as a poster at WPC, August 2022 in Paris (France)*

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# 3 Meta-analysis, data analysis & modeling

## A. Statistical method to determine the efficacy of methionine sources in broilers

### Context

- Desk study conducted at CERN (Center of Expertise and Research in Nutrition), Adisseo, France, in collaboration with UC Davis, USA, in 2019

### Objective

- To determine the most accurate statistical method for comparing the efficacy of methionine (Met) sources: L-Methionine (L-Met), DL-Methionine (DL-Met) and OH-Methionine (OH-Met)

### Animal & experimental diets

- New datasets were generated through two experiments (Trial 1 and Trial 2) on Male Ross PM3 broiler chickens
- The first trial aimed to compare L-Met and OH-Met at three equimolar doses on broiler growth performance (plus a Control diet deficient in sulfur amino acids).
- The second compared L-Met and DL-Met.

For each trial, male Ross PM3 broiler chickens were reared for 36 days and each dietary treatment consisted of 6 replicates with 15 birds each. Growth performance criteria were measured for each rearing period (0-10 d, 11-24 d and 25-35 d): feed intake, body weight gain and Feed Conversion Ratio.

### Results

Body weight gain of each rearing phase for the two experiments was fitted to different models: linear plateau, quadratic plateau and exponential models. Three explanatory variables were used in each model: the theoretical Met doses, the analysed Met doses and the analysed Met intake. The analysed equivalent Met intake was calculated as the product of the analysed doses and the feed intake. Overall, nine different models were compared in each trial. The effect of the Met sources was tested on the different parameters of the models. The best models were selected using the Bayesian Information Criteria (BIC); the lower the BIC, the better was the modeling.

Overall, for the two trials, the statistical equation was not the most relevant criteria to evaluate the goodness-of-fit: the widest discrepancies between BIC were observed when the explanatory variables were compared. The lowest BIC were obtained when Met intake was used (with an exponential model). This demonstrated that Met intake was the most relevant factor for comparing methionine sources, in comparison to the theoretical and analysed Met levels. In addition, the bio-efficacy determined for OH-Met and DL-Met respectively relative to L-Met were of 100% when the best model was used.

**Body weight gain as response to analysed Met intake (Trial 1)**

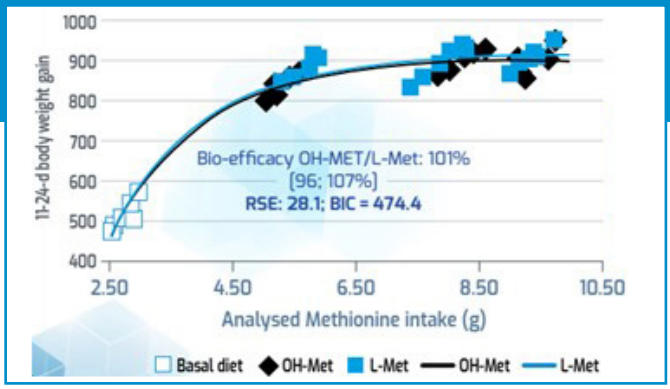


**Figure 6**

The **three methionine sources** (L-Met, DL-Met and OH-Met) are equivalent for **sustaining performance and can be considered as efficient.**


**References**

*Short Report n°21: Statistical method to determine the efficacy of methionine sources in broilers*

*Presented at ModNut (9th Workshop on Modelling Nutrient Digestion and Utilization in Farm Animals), September 2019, in Brazil by Prof Ermias Kebreab (UC Davis)*


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# B. Meta-analysis: growth response of broiler chickens fed with DL-Methionine or OH-Methionine using a powerful statistical approach

## Context

- Meta-analysis, a product of the collaboration between UC Davis university (USA) and Adisseo, in 2022

## Objective

- To compare methionine (Met) sources efficacy to sustain broiler growth performance on a huge number of publications and data, with the help of powerful modeling approaches

## Experimental design

A number of authors gathered several studies to examine the comparison of DL-Methionine (DL-Met) and OH-Methionine (OH-Met) on broiler growth performances using meta-analysis (Sauer et al.2008; Vazquez-Anon et al. 2006) with conflicting results.

Compared to the existing meta-analysis, this new meta-analysis benefits from 4 main improvements:

1. **Improvements in statistical methods and software packages.** These two aspects make it possible to apply more complex and powerful mathematical models for more reliable results.
2. **The explanatory variable** considered. Efficacy modelling is based on growth performance (body weight gain, Feed Conversion Ratio, etc) vs supplemental methionine intake. This last parameter is more accurate than the theoretical dose of synthetic methionine added in the diet, that did not capture variability during feed manufacturing and consumption.
3. **A focus on trials with broilers fed below and around Total Sulfur Amino Acids Requirements, taking into account comparisons performed in the past.** Indeed some authors suggested a lower bio-efficacy of OH-Methionine relative to DL-Methionine when sulfur amino acids levels are below requirement. The study provides an opportunity to look specifically at this point, on top of feed supplemented at a level to fit the Total Sulfur Amino Acids requirement level.
4. **Inclusion of more recent studies**

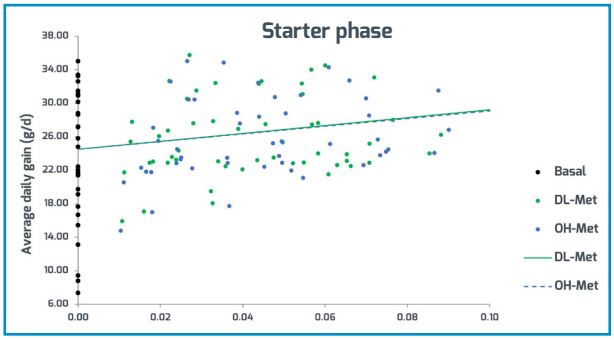
In terms of modeling, the piecewise-linear model showed poor fits compared to quadratic plateau models for all growing phases. Only results obtained with the linear-plateau and the quadratic-plateau are considered.

**Figure 7**


**Flowchart of the modeling steps followed in the meta-analysis**

## Results

**Figure 8**
Effect of synthetic methionine sources on the average daily gain expressed as a response to supplemental digestible Methionine intake (g/d)




**No significant difference between the methionine sources was determined.**

Using powerful **meta-analysis approach including the most recent studies, no significant difference in weight gain was detected in response to DL-Met and OH-Met** at or below the requirement.

**References**

*Short Report n°31: Growth response of broiler chickens fed with DL-Methionine or DL-Hydroxy-Methionine using powerful statistical approach*

*Scientific publication: Evaluating growth response of broiler chickens fed diets supplemented with synthetic DL-methionine or DL-hydroxy methionine: A meta-analysis, Uddin et al. Poultry Science, 2022*

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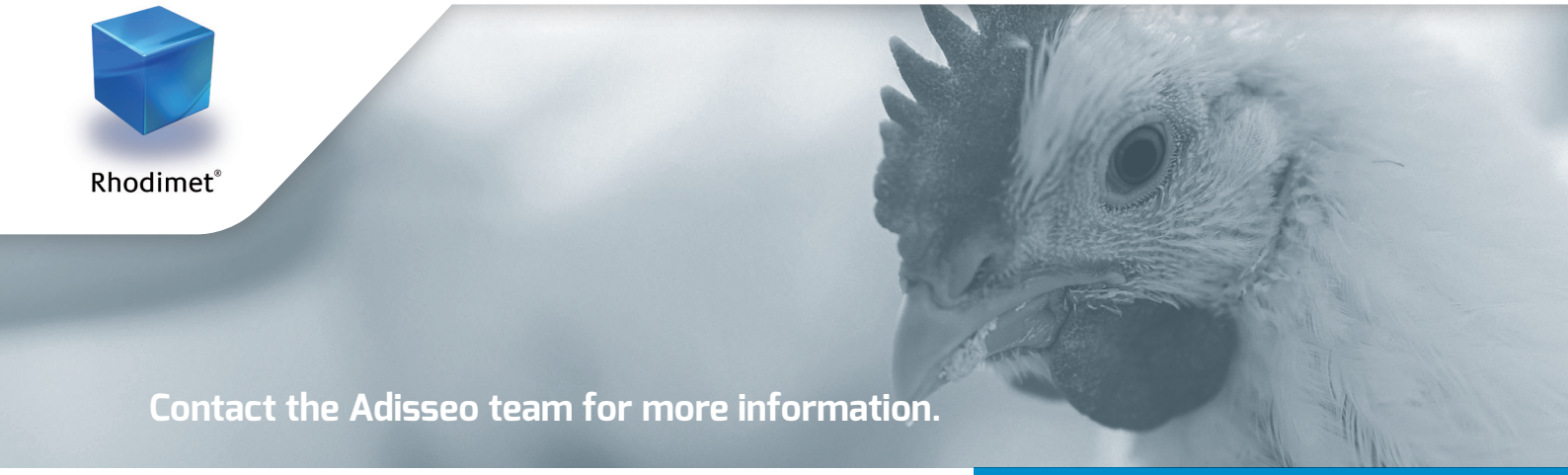

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